Project NO：

Instalation Site：

1 X 6 Array

Solar Bracket Strength Calculation Document

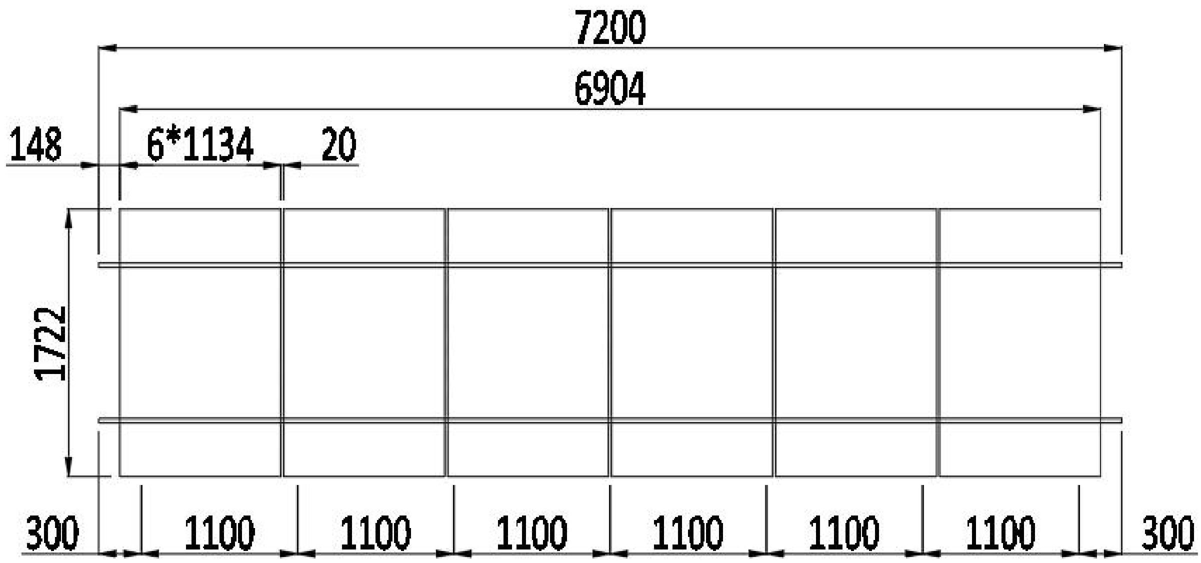
Approved by	Checked by	Made by

I.Mounting structure technical specification：

1、Module specification：	1722	x	1134	x	30	mm
2、Module weight：	20.8	KG				
3、Module array：	1	x	6	=	6	
4、Installation Angle： θ=	10	°				
5、Wind speed： Vo=	40	m/s				
6、Ground Vertical snow volume:	70	cm				
7、Site altitude: H2=	10.00	m				
8、Ground surface coarse-grained differentiation coefficient:	II					

9、Calculation standard：BS-EN-1991-1-4：2005（European wind load standard specification）

Structure general drawing：



II. Load calculation：

1 Constant load：

a. PV module weight：	G1=	1223.04 N
b. Bracket weight：	G2=	97.2447 N
c. constant load：	G3=	1320.28 N

2 Wind load：

According to the force coefficient method formula of shape coefficient:

$$Fw=CsCd*\sum_{elements} Cf*qp(z)*Aref$$ 《BS-EN-1991-1-4:2005》-(5.0)

CsCd: Structure coefficient - according to the following conditions, the structure coefficient can be positior 1.0

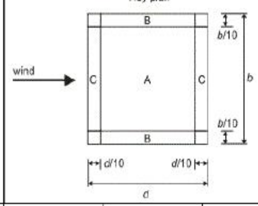
1.For buildings or projects below 15M in height, the CsCd value can be 1

2.For frame buildings with structural walls and height less than 100m, less than 4 times the wind depth, CsCd can be 1

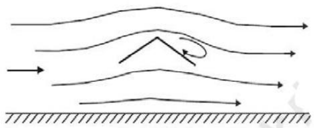
Cf： The coefficient of force of the structure or structural member. This project is a multi-span structure. The values are as follows:

When downwind condition Cf downwind=	0.5
When downwind condition Cf downwind=	0.9

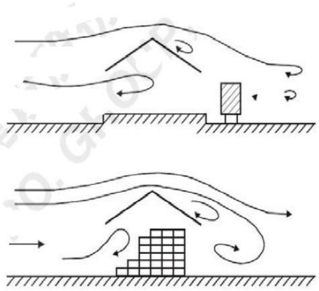
Table 7.6 — $c_{p,net}$ and c_f values for monopitch canopies

			Net Pressure coefficients $c_{p,net}$		
					
Roof angle α	Blockage φ	Overall Force Coefficients c_f	Zone A	Zone B	Zone C
0°	Maximum all φ	+ 0,2	+ 0,5	+ 1,8	+ 1,1
	Minimum φ = 0	- 0,5	- 0,6	- 1,3	- 1,4
	Minimum φ = 1	- 1,3	- 1,5	- 1,8	- 2,2
5°	Maximum all φ	+ 0,4	+ 0,8	+ 2,1	+ 1,3
	Minimum φ = 0	- 0,7	- 1,1	- 1,7	- 1,8
	Minimum φ = 1	- 1,4	- 1,6	- 2,2	- 2,5
10°	Maximum all φ	+ 0,5	+ 1,2	+ 2,4	+ 1,6
	Minimum φ = 0	- 0,9	- 1,5	- 2,0	- 2,1
	Minimum φ = 1	- 1,4	- 1,6	- 2,6	- 2,7
15°	Maximum all φ	+ 0,7	+ 1,4	+ 2,7	+ 1,8
	Minimum φ = 0	- 1,1	- 1,8	- 2,4	- 2,5
	Minimum φ = 1	- 1,4	- 1,6	- 2,9	- 3,0
20°	Maximum all φ	+ 0,8	+ 1,7	+ 2,9	+ 2,1
	Minimum φ = 0	- 1,3	- 2,2	- 2,8	- 2,9
	Minimum φ = 1	- 1,4	- 1,6	- 2,9	- 3,0
25°	Maximum all φ	+ 1,0	+ 2,0	+ 3,1	+ 2,3
	Minimum φ = 0	- 1,6	- 2,6	- 3,2	- 3,2
	Minimum φ = 1	- 1,4	- 1,5	- 2,5	- 2,8
30°	Maximum all φ	+ 1,2	+ 2,2	+ 3,2	+ 2,4
	Minimum φ = 0	- 1,8	- 3,0	- 3,8	- 3,6
	Minimum φ = 1	- 1,4	- 1,5	- 2,2	- 2,7
NOTE	+ values indicate a net downward acting wind action - values represent a net upward acting wind action				

Block ratio ϕ



Free-standing canopy（φ=0）



Canopy full of storage downwind cornice（φ=1）

Remark： The confirmation method is as follows:If there are no obstacles under the stent, select the option with the force coefficient being the block ratio value of

qp(z)：Peak velocity pressure, which can be known according to the European formula；

qp(z) = ｛1+7*lv(z)｝*1/2*ρ*Vm(z)² 《BS-EN-1991-1-4:2005》-(4.8)

lv(z): Turbulence intensity, the confirmation rules for turbulence intensity are as follows

When Zmin≤Z≤Zmax，lv(z)= ki /｛Co(z)*Ln(Z/Zo)｝

《BS-EN-1991-1-4:2005》-(4.7)

WhenZ＜Zmin，lv(z)=lv(Zmin)

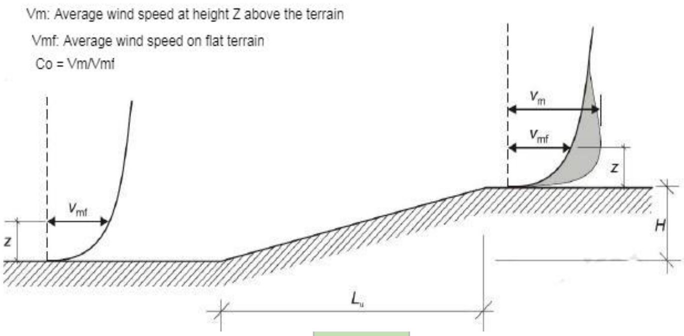
Here lv(z)= ki /｛Co(z)*Ln(Z/Zo)｝

In the above formula；

ki：Turbulence coefficient, recommended value is 1

Co：Mountain-shaped coefficient. If the site is flat terrain, the recommended value is 1 terrain, calculate the terrain slope according to the slope ϕ=H/Lu，Calculate the slope《BS-EN-1991-1-4:2005》-(A.3)

According to the information below ϕ=H/Lu = 0 / 0 = 0.00



0

0

When ϕ＜0.05,	Co	=	1	
When 0.05＜ϕ＜0.3，	Co=1+2*S*ϕ =		1.0000	(Downwind)
	Co=1+2*S*ϕ =		1.0000	(Deadwind)
When ϕ＞0.3，	Co=1+0.6*S=		1	

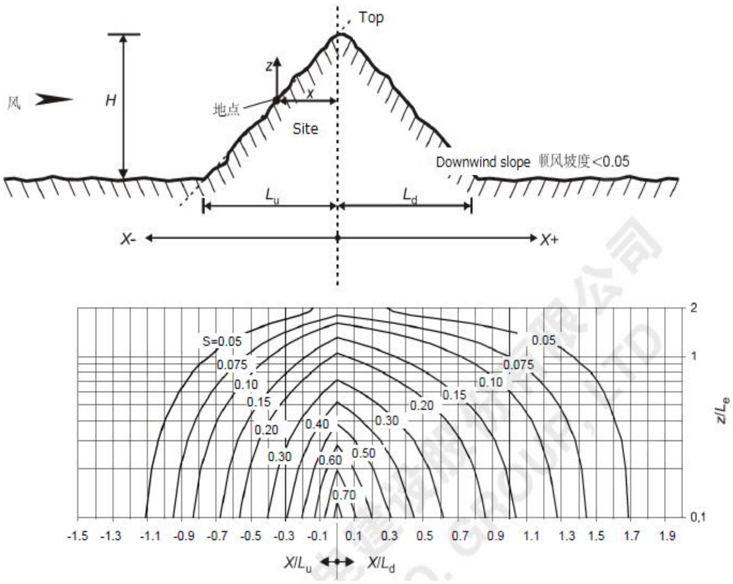
Here S is the mountain-shaped coefficient position coefficient, which is proportional to the effective headwind slope length Le

The value of Le is as follows:

When 0.05＜ϕ＜0.3，	Le	=	Lu	=	0.00
When ϕ＞0.3，	Le	=	H/0.3	=	0.00

The S value is divided into the downhill section and the upwind section of the hillside. The values are as follows, where

X / Lu	=	0.000	Z/ Le	=	0.000	(Highest place)
X	=	0.000	Z	=	0.000	
Lu	=	0.000	Le	=	0.000	



Downwind When -1.5≤ X / Lu ≤ 0， 且 0≤ Z / Le ≤ 2.0

S = A*e$^{(B*X/Lu)}$ = 1

Among：

$$A = 0.1552\cdot\left(\frac{z}{L_e}\right)^4 - 0.8575\cdot\left(\frac{z}{L_e}\right)^3 + 1.8133\cdot\left(\frac{z}{L_e}\right)^2 - 1.9115\cdot\left(\frac{z}{L_e}\right) + 1.0124$$ = 1.012

$$B = -0.3056\cdot\left(\frac{z}{L_e}\right)^2 + 1.0210\cdot\left(\frac{z}{L_e}\right) - 1.7637$$ = -1.76

When X / Ld ＞ 2.0， or Z / Le ＞ 2.0 S = 0

Deadwind When $0 \le X / Ld \le 2$ ， 且 $0 \le Z / Le \le 2.0$

S = A*e^(B*X/Ld) = 1

Among：

$$A = 0.1552\cdot\left(\frac{z}{L_e}\right)^4 - 0.8575\cdot\left(\frac{z}{L_e}\right)^3 + 1.8133\cdot\left(\frac{z}{L_e}\right)^2 - 1.9115\cdot\left(\frac{z}{L_e}\right) + 1.0124 = 1.012$$

$$B = 0.3542\cdot\left(\frac{z}{L_e}\right)^2 - 1.0577\cdot\left(\frac{z}{L_e}\right) + 2.6456 = 2.65$$

When X / Lu ＜ -1.5， Or Z / Le ＞ 2 S = 0

Zo：roughness length

First make sure the terrain is	II	Type
Then confirm that the rough length Zo is	0.050	
Then confirm that the rough length Z is	2.000	

Table 4.1 Terrain Category and Terrain data

Terrain category	Z0 M	Zmin m	
0 An area or coastal area near the open sea	0.003	1	
I flat area or a lake producing little vegetation and free of obstructions	0.01	1	
II A separate obstacle area with low vegetation (such as grass) and at least 20 obstacle heights apart	0.05	2	
III An area uniformly covered with vegetation or buildings, or with individual obstacles spaced at a maximum of 20 obstacle heights	0.30	5	
IV At least 15% of the surface is covered with buildings, and the average height of buildings exceeds 15m	1.00	10	

Based on the above results,

Lv(z)= ki /｛Co(z)*Ln(Z/Zo)｝ = 0.188739166 (Downwind)

Lv(z)= ki /｛Co(z)*Ln(Z/Zo)｝ = 0.188739166 (Deadwind)

Vm(z): average wind speed. Confirm the average wind speed based on the basic wind speed and the occasion. The confirmation rules are as follows;

Vm(z)= Cr(z)*Co(z)*Vb,in the formula；

Cr(z):roughness coefficient

When Zmin≤Z≤Zmax， Cr(z)=kr*Ln（Z/Zo）,in the formula；

kr：Terrain factor，by formula kr=0.19*（Zo/ZoⅡ）^0.07= 0.19

It can be known from the above dataCr(z)=kr*Ln（Z/Zo）= 1.0066803

Vb:Basic wind speed，by formula Vb=Cdir*Cseason*Vbo,in the formula：

Cdir is the direction coefficient, please refer to the national appendix, recommended value 1

Cseason is the seasonal coefficient, which can be given in the appendix of the national version. The recommended value is 1

Vbo is the 10-minute average wind speed at Z≤10m

Confirm basic wind speed Vb=Cdir*Cseason*Vbo= 40.00 m/s

The average wind speed can be obtained from the above data Vm(z)= Cr(z)*Co(z)*Vb= 40.27 m/s

qp(z) = ｛1+7*lv(z)｝*1/2*ρ*Vm(z)² = 2352.290024 N/M²

qp(z) = ｛1+7*lv(z)｝*1/2*ρ*Vm(z)² = 2352.290024 N/M²

A_a A_b Wind area of the array surface（m2）（Total area of overall module ）

Stress area of pvpanel ＝ 1.722 × 1.134 × 6 = 11.7165 [m²]

Therefore, the wind pressure load (Wa) acting on the array is, (acting vertically on the component surface)

Downwind(positive pressure)		CsCd	×	downwir	×	qp(z)	×	Aa			
		1.00	×	0.5	×	2352	×	11.7165	=	13780.29	[N]
Deadwind(negative pressure)		CsCd	×	deadwir	×	qp(z)	×	Aa			
	=	1.00	×	0.9	×	2352	×	11.7165	=	24804.52	[N]

CsCd is the structural factor, taken as 1

Cf is the force coefficient, taken as 1.8

3. Snow load:

Sk= 1.4 KN/㎡

According to the European Standard (BSEN1991-1-3-2003), the formula for snow cover is as follows:

$$s = \mu_i C_e C_t s_k$$

where:

μ_i is the snow load shape coefficient (see Section 5.3 and Annex B)

s_k is the characteristic value of snow load on the ground

s_{Ad} is the design value of exceptional snow load on the ground for a given location (see 4.3)

C_e is the exposure coefficient

C_t is the thermal coefficient

Among them, the value of μ1 is as follows:

Table 5.2: Snow load shape coefficients

Angle of pitch of roof α	$0° \le \alpha \le 30°$	$30° < \alpha < 60°$	$\alpha \ge 60°$
μ_1	0,8	0,8(60 - α)/30	0,0
μ_2	0,8 + 0,8 α/30	1,6	--

μ1= 0.8

The values of Ce are as follows:

Table 5.1 Recommended values of C_e for different topographies

Topography	C_e
Windswept [a]	0,8
Normal [b]	1,0
Sheltered [c]	1,2

[a] *Windswept topography*: flat unobstructed areas exposed on all sides without, or little shelter afforded by terrain, higher construction works or trees.

[b] *Normal topography*: areas where there is no significant removal of snow by wind on construction work, because of terrain, other construction works or trees.

[c] *Sheltered topography*: areas in which the construction work being considered is considerably lower than the surrounding terrain or surrounded by high trees and/or surrounded by higher construction works.

0.8

Ce= 1

The values of Ct are as follows:

(8) The thermal coefficient C_t should be used to account for the reduction of snow loads on roofs with high thermal transmittance (> 1 W/m²K), in particular for some glass covered roofs, because of melting caused by heat loss.

For all other cases:

$C_t = 1{,}0$

Ct= 1

The snow load is $s = \mu_i\ C_e\ C_t\ s_k$

= 0.8 X 1 X 1 X 1.4

= 1.12 KN/ ㎡

The total snow load on the bracket S= 13.12 KN

= 13122 N

4 Seismic load

According to the above、 Gen $K_P = k_p \times G$

Snov $K_P = k_p \times (G + 0.35S)$

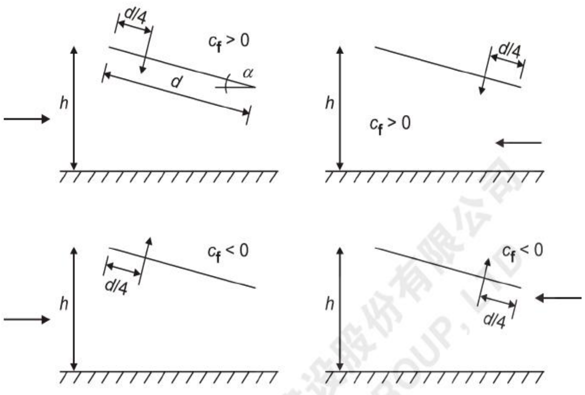
According to the above、： $k_P = k_H \times Z \times I_K$

kH	*Each part seismic degree (structure and foundation)*		0.3	
Z	Earthquake region coefficient（1.0~0.7）		1	
IK	Usage coefficient		1	
kP	Design level shock = kH × Z × IK		0.3	
G	Fixed load（N）		1320.284705	N
S	Snow load（N)		13122.46656	N
KP	Earthquake load(general) ＝ kp × G		396.0854114	N
KP	Earthquake load(snowy) ＝ kp × (G+0.35S)		1773.9444	N

Solar PV system type	Use coefficient
Vital solar PV power system	1.5
Common solar PV power system	1

Ⅲ，Load combination

Each load condition combination is decomposed into a vertical direction qv and a parallel direction qH with the panel, and uniformly acts on the rail. When strong winds (upwind) are considered as concentrated loads for calculation.



Load condition		Vertical direction F (N)		Vorizontal Direction F (N)
Availability status	Self weight	G	1300.23	229.27
	Downwind	1.35G+1.5S+0.9Fw	31729.78	5702.95
	Deadwind	1.35G+1.5S-0.9Fw'	-2468.97	-327.21
Ultimate status	Deadwind	1.35G-1.5Fw	-35341.30	-5160.66
	Downwind	1.35G +1.05S+ 1.5Fw	35680.97	7737.32
	Deadwind	1.35G+1.05S-1.5Fw'	-21316.96	-2312.96

IV，Component tolerance table

4.4.1. Material: Structural Aluminum Alloy AL6005-T5 (General Components)

Young's modulus 70000 [N/mm2]

The allowable stress is as follows:

Tensile Stress σB＝ 245 [N/mm2]

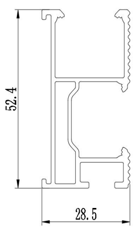
Yield Strength σy＝ 205 [N/mm2] (σ0.2）

	Under long-term load,σz: shall take smaller value below	Under short-term load, σz
(1) allawable tensile stress	σy/1.5= 137 [N/mm2] 5σB/6x(1/1.5)= 136 [N/mm2]	long-term load allowable stressx1.5 136 x1.5= 204 /mm2]
(2) allowable compressive stress	σy/1.5= 137 [N/mm2] 5σB/6x(1/1.5)= 136 [N/mm2]	long-term load allowable stressx1.5 136 x1.5= 204 /mm2]
(3) allowable bending stress	σy/1.5= 137 [N/mm2] 5σB/6x(1/1.5)= 136 [N/mm2]	long-term load allowable stressx1.5 136 x1.5= 204 /mm2]
(4) allowable discontinuous stress	σy/(1.5x√3)= 79 [N/mm2] 5σB/6x{1/（1.5x√3)}= 79 [N/mm2]	long-term load allowable stressx1.5 79 x1.5= 118 /mm2]
(5) allowable axis stress	σy/1.1= 186 [N/mm2] 5σB/6x(1/1.1)= 186 [N/mm2]	long-term load allowable stressx1.5 186 x1.5= 278 /mm2]

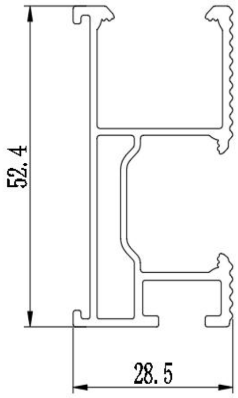
4.4.3. Short rail calculation

4.4.3.1.Rail datasheet

28.5 × 52.4



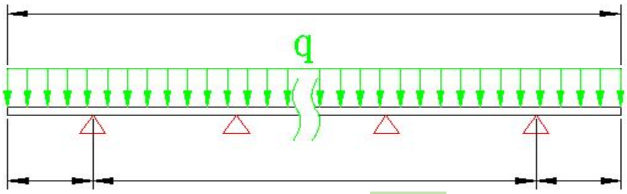
A	254.2776	Ip	99553.2500
Ix	74814.2500	Iy	24739.0000
ix	17.1529	iy	9.8636
Wx (Top)	2584.4132	Wh（Left）	1774.0275
Wx (Bottom)	3190.1357	Wh（Right）	1700.5334



截面几何参数表

A	254.2776	Ip	99553.2500
Ix	74814.2500	Iy	24739.0000
ix	17.1529	iy	9.8636
Wx(上)	2584.4132	Wy(左)	1774.0275
Wx(下)	3190.1357	Wy(右)	1700.5334
绕X轴面积矩	1951.1399	绕Y轴面积矩	1140.9867
形心离左边缘距离	13.9451	形心离右边缘距离	14.5478
形心离上边缘距离	28.9483	形心离下边缘距离	23.4517
主矩I1	74848.758	主矩1方向	(1.000,-0.026)
主矩I2	24704.117	主矩2方向	(0.026,1.000)

L = 7200 mm



300 mm 6 × 1100 mm 300 mm

The amount of force on the rail= 2 ，The rail force is as follows：

q_v	=	F_v	/	2	/	7200	[N/mm]
q_H	=	Fh	/	2	/	7200	[N/mm]
Mv	=	1/8	×	q_v	×	1100^2	[N*mm]
Mh	=	1/8	×	q_H	×	1100^2	[N*mm]

$$\sigma = \frac{M_V}{W_V} + \frac{M_H}{W_H}$$ [N/mm²]

Load conditions		Vertical Direction v				Horizontal Direction v				σ[N/mm²]	σz[N/mm²]	Judge
long term	normal time	qv=	0.090293515	Mv=	10925.52	qv=	0.01592	Mv=	1926.46	4.56	136.11	σ<[σz]→OK
	snow load	qv=	2.203457111	Mv=	266618.31	qv=	0.39604	Mv=	47920.61	111.76	136.11	σ<[σz]→OK
short term	snow load	qv=	-0.171456579	Mv=	-20746.25	qv=	-0.0227	Mv=	-2749.51	-8.12	204.17	σ<[σz]→OK
	tail wind	qv=	-2.454256867	Mv=	-296965.08	qv=	-0.3584	Mv=	-43363.90	-118.59	204.17	σ<[σz]→OK
	head wind	qv=	2.477845217	Mv=	299819.27	qv=	0.53731	Mv=	65014.95	132.22	204.17	σ<[σz]→OK
	earthquake	qv=	-1.480344265	Mv=	-179121.66	qv=	-0.1606	Mv=	-19435.26	-67.58	204.17	σ<[σz]→OK