STRUCTURAL CALCULATION

Solar Panel Array	3x6 5d
Calculation Standard	ASCE7-10/AISC360
Date	2025/11/24

CONTENTS

1.Basic information and design standards

1.1 Standard code

- ASCE 7-10/AISC360

1.2 Design condition and technical parameters

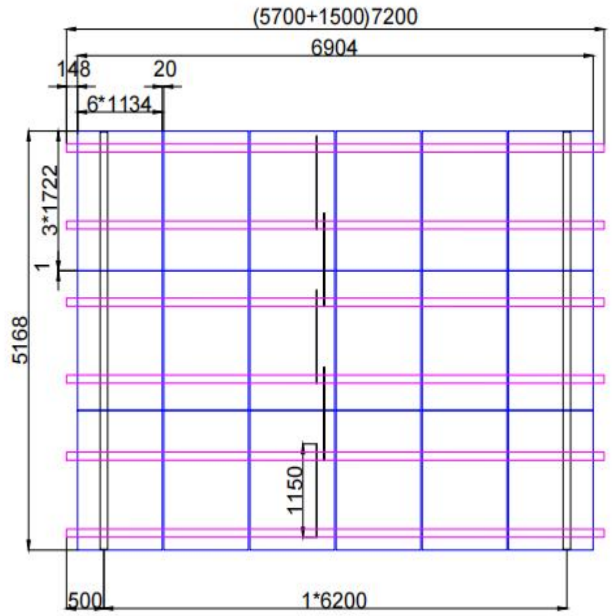
- Solar Panel：L1722*W1134*H30/35　400W　20.8Kg
- Layout：3x6
- Installation angle：5°
- Span：3437*6200 mm
- Calculation ground clearance：2826 mm
- Exposure category：B
- Wind speed in design：V=58.1 m/s　（provided by the client）
- Load of snow accumulation on the ground：So=1.44 KN/m²
- Design working life of structure：25years
- Design Software :sap2000

2.Load calculation

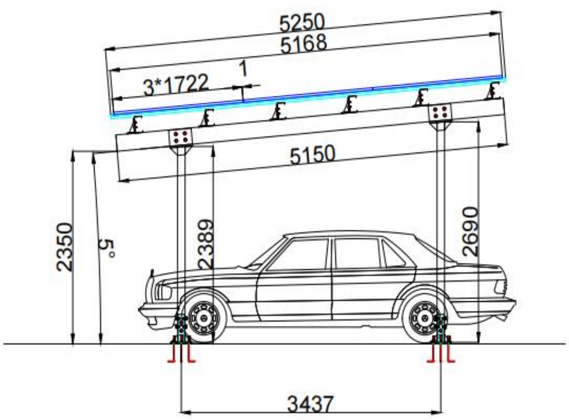
2.1 Design structural

2.1.1 Sketch of bracket

- Layout

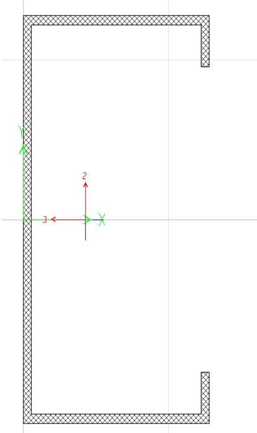


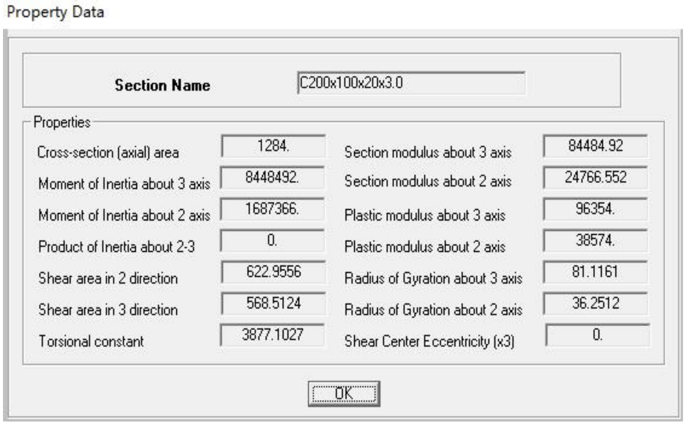
- Side view



2.1.2 Structure properties

a.Mount rail C200x100x20x3.0 Q235B

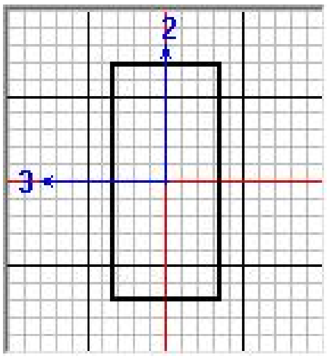


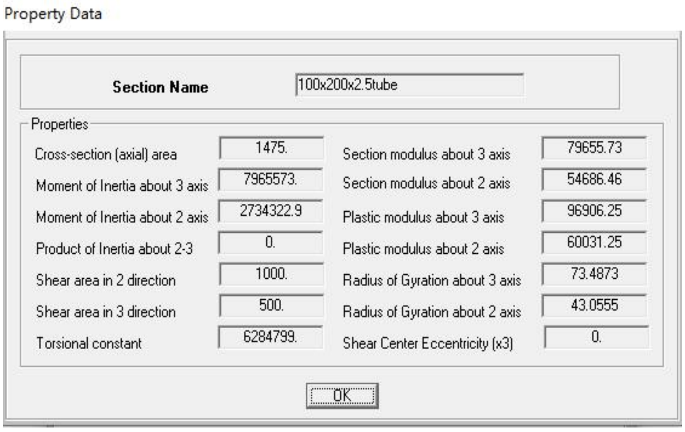


Property Data

Section Name	C200x100x20x3.0		
Cross-section (axial) area	1284.	Section modulus about 3 axis	84484.92
Moment of Inertia about 3 axis	8448492.	Section modulus about 2 axis	24766.552
Moment of Inertia about 2 axis	1687366.	Plastic modulus about 3 axis	96354.
Product of Inertia about 2-3	0.	Plastic modulus about 2 axis	38574.
Shear area in 2 direction	622.9556	Radius of Gyration about 3 axis	81.1161
Shear area in 3 direction	568.5124	Radius of Gyration about 2 axis	36.2512
Torsional constant	3877.1027	Shear Center Eccentricity (x3)	0.

b.Welded beam 100*200*2.5 Q235B

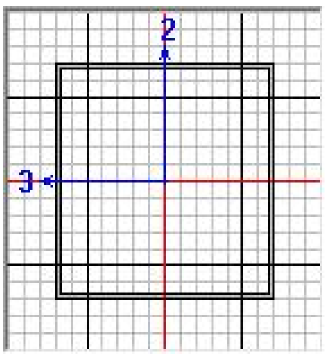


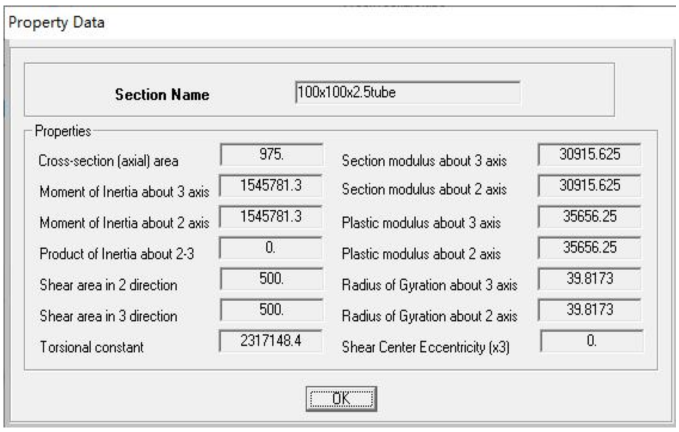


Property Data

Section Name	100x200x2.5tube		
Cross-section (axial) area	1475.	Section modulus about 3 axis	79655.73
Moment of Inertia about 3 axis	7965573.	Section modulus about 2 axis	54686.46
Moment of Inertia about 2 axis	2734322.9	Plastic modulus about 3 axis	96906.25
Product of Inertia about 2-3	0.	Plastic modulus about 2 axis	60031.25
Shear area in 2 direction	1000.	Radius of Gyration about 3 axis	73.4873
Shear area in 3 direction	500.	Radius of Gyration about 2 axis	43.0555
Torsional constant	6284799.	Shear Center Eccentricity (x3)	0.

c.Welded pile 100*100*2.5 Q235B

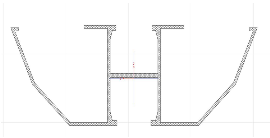


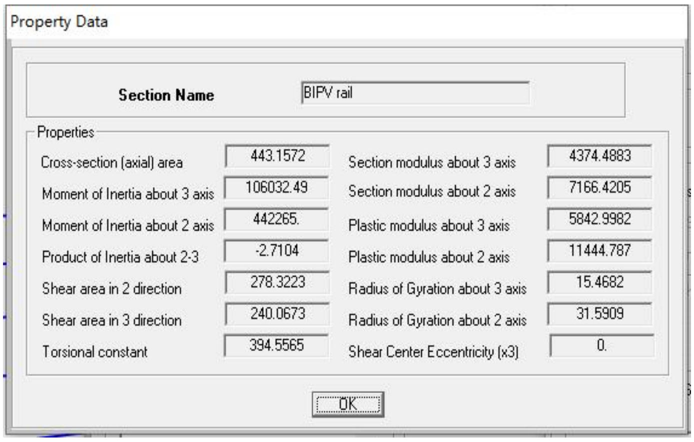


Property Data

Section Name	100x100x2.5tube		
Cross-section (axial) area	975.	Section modulus about 3 axis	30915.625
Moment of Inertia about 3 axis	1545781.3	Section modulus about 2 axis	30915.625
Moment of Inertia about 2 axis	1545781.3	Plastic modulus about 3 axis	35656.25
Product of Inertia about 2-3	0.	Plastic modulus about 2 axis	35656.25
Shear area in 2 direction	500.	Radius of Gyration about 3 axis	39.8173
Shear area in 3 direction	500.	Radius of Gyration about 2 axis	39.8173
Torsional constant	2317148.4	Shear Center Eccentricity (x3)	0.

d.BIPV rail AL6005-T5



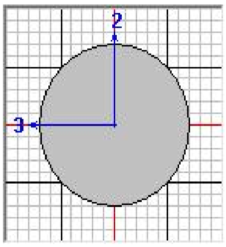


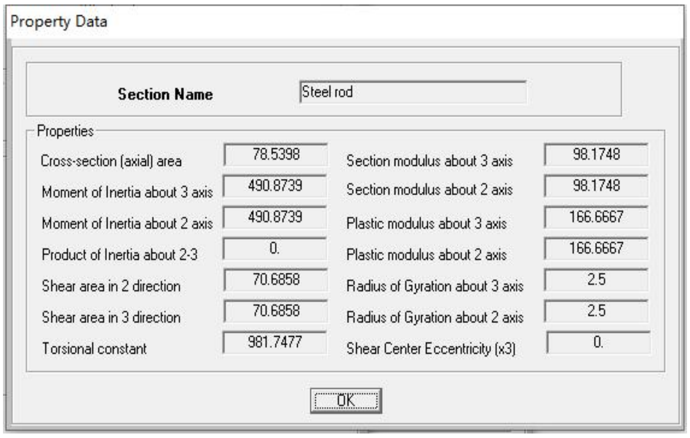
Property Data

Section Name	BIPV rail		
Cross-section (axial) area	443.1572	Section modulus about 3 axis	4374.4883
Moment of Inertia about 3 axis	106032.49	Section modulus about 2 axis	7166.4205
Moment of Inertia about 2 axis	442265.	Plastic modulus about 3 axis	5842.9982
Product of Inertia about 2-3	-2.7104	Plastic modulus about 2 axis	11444.787
Shear area in 2 direction	278.3223	Radius of Gyration about 3 axis	15.4682
Shear area in 3 direction	240.0673	Radius of Gyration about 2 axis	31.5909
Torsional constant	394.5565	Shear Center Eccentricity (x3)	0.

OK

e.Steel rod φ10 Q235B





Property Data

Section Name	Steel rod		
Cross-section (axial) area	78.5398	Section modulus about 3 axis	98.1748
Moment of Inertia about 3 axis	490.8739	Section modulus about 2 axis	98.1748
Moment of Inertia about 2 axis	490.8739	Plastic modulus about 3 axis	166.6667
Product of Inertia about 2-3	0.	Plastic modulus about 2 axis	166.6667
Shear area in 2 direction	70.6858	Radius of Gyration about 3 axis	2.5
Shear area in 3 direction	70.6858	Radius of Gyration about 2 axis	2.5
Torsional constant	981.7477	Shear Center Eccentricity (x3)	0.

OK

2.2 Load calculation

2.2.1 Dead load

●Solar Panel：

Dead-weight of panel G1=20.8kg ≈ 0.204 KN

Standard load of panel：G1/m2 = 0.204KN/（1.722*1.134）= 104 N/m²

2.2.2 Snow load

（1）Flat Roof Snow Loads, pf

a. Ground snow load, Pg

Pg= 1440 N/m2

b. Exposure Factor, Ce 0.9

The value for Ce shall be determined from Table 7-

Table 7-2 Exposure Factor, C_e

Terrain Category	Exposure of Roof[a] Fully Exposed	Partially Exposed	Sheltered
B (see Section 26.7)	0.9	1.0	1.2
C (see Section 26.7)	0.9	1.0	1.1
D (see Section 26.7)	0.8	0.9	1.0
Above the treeline in windswept mountainous areas.	0.7	0.8	N/A
In Alaska, in areas where trees do not exist within a 2-mile (3-km) radius of the site.	0.7	0.8	N/A

c. Thermal Factor, Ct= 1.2

The value for Ct shall be determined from Table 7-

Table 7-3 Thermal Factor, C_t

Thermal Condition[a]	C_t
All structures except as indicated below	1.0
Structures kept just above freezing and others with cold, ventilated roofs in which the thermal resistance (R-value) between the ventilated space and the heated space exceeds 25 °F × h × ft²/Btu (4.4 K × m²/W).	1.1
Unheated and open air structures	1.2
Structures intentionally kept below freezing	1.3
Continuously heated greenhouses[b] with a roof having a thermal resistance (R-value) less than 2.0 °F × h × ft²/Btu (0.4 K × m²/W)	0.85

d. Importance Factor, Is 1

The value for Is shall be determined from Table 1.5-2 based on the Risk Category from

Risk Category from Table 1.5-1	Snow Importance Factor, I_s	Ice Importance Factor—Thickness, I_i	Ice Importance Factor—Wind, I_w	Seismic Importance Factor, I_e
I	0.80	0.80	1.00	1.00
II	1.00	1.00	1.00	1.00
III	1.10	1.25	1.00	1.25
IV	1.20	1.25	1.00	1.50

Than, The flat roof snow load, pf, shall be calculated in lb/ft2 (kN/m2) using the following formul

Pf=0.7CeCt IsPg= 1088.64 N/m2 (7.3-1)

（2）Sloped Roof Snow Loads, ps

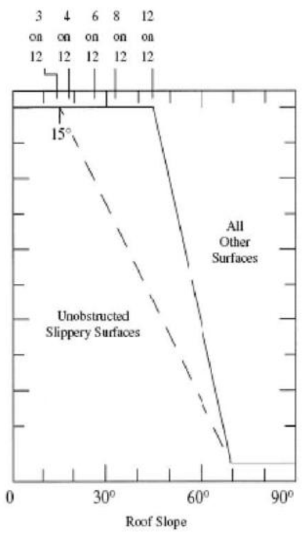
The sloped roof (balanced) snow load, ps,shall be obtained by multiplying the flat roof snow load, pf, by the roof slope fact

Ps = CsPf (7.4-1)

Cs= 1.00

Than, Ps = CsPf

= 1088.64 N/m2



7 SNOW LOADS

7-2c: Cold roofs with C = 1.2 or larger

2.2.3 Wind load

- Based Wind Speed 58.1 m/s
- Exposure category：B
- Installation angle= 5°

Design wind load for open buildings with monoslope, pitched, or troughed free module

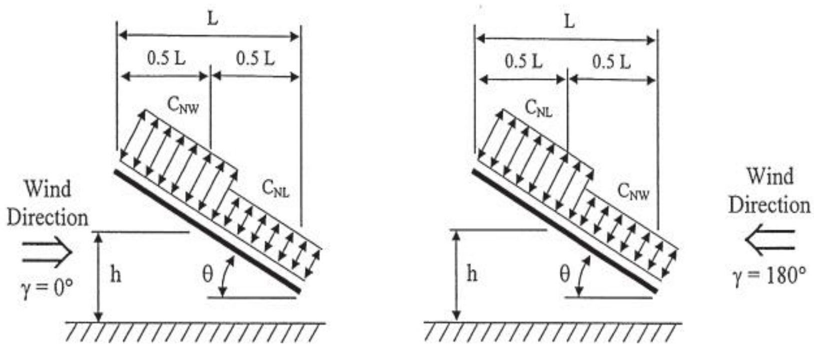
P = qhGCN(27.4-3)

Where:

qh= velocity pressure evaluated at mean roof height h using the exposure as defined inSection 26.7.3 that results in the highest wind loads for any wind direction at the site

G= 0.85 （gust-effect factor from Section 26.9）

CN= net pressure coefficient determined from Figs.27.4-4 through 27.4-7



Roof Angle θ	Load Case	Wind Direction, γ = 0° Clear Wind Flow C_{NW}	Clear Wind Flow C_{NL}	Obstructed Wind Flow C_{NW}	Obstructed Wind Flow C_{NL}	Wind Direction, γ = 180° Clear Wind Flow C_{NW}	Clear Wind Flow C_{NL}	Obstructed Wind Flow C_{NW}	Obstructed Wind Flow C_{NL}
0°	A	1.2	0.3	-0.5	-1.2	1.2	0.3	-0.5	-1.2
	B	-1.1	-0.1	-1.1	-0.6	-1.1	-0.1	-1.1	-0.6
7.5°	A	-0.6	-1	-1	-1.5	0.9	1.5	-0.2	-1.2
	B	-1.4	0	-1.7	-0.8	1.6	0.3	0.8	-0.3
15°	A	-0.9	-1.3	-1.1	-1.5	1.3	1.6	0.4	-1.1
	B	-1.9	0	-2.1	-0.6	1.8	0.6	1.2	-0.3
22.5°	A	-1.5	-1.6	-1.5	-1.7	1.7	1.8	0.5	-1
	B	-2.4	-0.3	-2.3	-0.9	2.2	0.7	1.3	0
30°	A	-1.8	-1.8	-1.5	-1.8	2.1	2.1	0.6	-1
	B	-2.5	-0.5	-2.3	-1.1	2.6	1	1.6	0.1
37.5°	A	-1.8	-1.8	-1.5	-1.8	2.1	2.2	0.7	-0.9
	B	-2.4	-0.6	-2.2	-1.1	2.7	1.1	1.9	0.3
45°	A	-1.6	-1.8	-1.3	-1.8	2.2	2.5	0.8	-0.9
	B	-2.3	-0.7	-1.9	-1.2	2.6	1.4	2.1	0.4

Notes:
1. C_{NW} and C_{NL} denote net pressures (contributions from top and bottom surfaces) for windward and leeward half of roof surfaces, respectively.
2. Clear wind flow denotes relatively unobstructed wind flow with blockage less than or equal to 50%. Obstructed wind flow denotes objects below roof inhibiting wind flow (>50% blockage).
3. For values of θ between 7.5° and 45°, linear interpolation is permitted. For values of θ less than 7.5°, use load coefficients for 0°.
4. Plus and minus signs signify pressures acting towards and away from the top roof surface, respectively.
5. All load cases shown for each roof angle shall be investigated.
6. Notation:
   L : horizontal dimension of roof, measured in the along wind direction, ft. (m)
   h : mean roof height, ft. (m)
   γ : direction of wind, degrees
   θ : angle of plane of roof from horizontal, degrees

Than, CN (Net pressure coefficient)

Roof Angle	Load case	Wind Direction,γ = 0° Clear Wind Flow CNW	CNL	Wind Direction, γ =180° Clear Wind Flow CNW	CNL
5	A	1.20	0.30	1.20	0.30
	B	-1.10	-0.10	-1.10	-0.10

Velocity pressure, qz, evaluated at height z shall be calculated by the following equation:

qz = 0.613KzKztKdV2 (27.3-1)

Where:

Kd= wind directionality factor, see Section 26.6

Kz= velocity pressure exposure coefficient, see Section 27.3.1

Kzt= topographic factor defined, see Section 26.8.2

V= 58.1 m/s basic wind speed, see Section 26.5

a. Wind Directionality Factor, Kd

Structure Type	Directionality Factor K_d*
Buildings Main Wind Force Resisting System Components and Cladding	 0.85 0.85
Arched Roofs	0.85
Chimneys, Tanks, and Similar Structures Square Hexagonal Round	 0.90 0.95 0.95
Solid Freestanding Walls and Solid Freestanding and Attached Signs	0.85
Open Signs and Lattice Framework	0.85
Trussed Towers Triangular, square, rectangular All other cross sections	 0.85 0.95

*Directionality Factor K_d has been calibrated with combinations of loads specified in Chapter 2. This factor shall only be applied when used in conjunction with load combinations specified in Sections 2.3 and 2.4.

Than, Kd= 0.85

b. Topographic Factor

The wind speed-up effect shall be included in the calculation of design wind loads byusing the factor Kzt:

Kzt = (1 + K1K2K3)2 (26.8-1)

where K1, K2, and K3 are given in Fig. 26.8-1.

If site conditions and locations of structures do not meet all the conditions specified in Section 26.8.1 then,

Kzt = 1

c. Velocity Pressure Exposure Coefficient

Based on the exposure category determined in Section 26.7.3, a velocity pressure exposure coefficient Kz or Kh, as applicable, shall be determined from Table 27.3-1. For a site located in a transition zone between exposure categories that is near to a change in ground surface roughness, intermediate values of Kz or Kh, between those shown in Table 27.3-1 are permitted provided that they are determined by a rational analysis method defined in the recognized literature.

Height above ground level, z		**Exposure**		
ft	**(m)**	**B**	**C**	**D**
0-15	(0-4.6)	0.57	0.85	1.03
20	(6.1)	0.62	0.90	1.08
25	(7.6)	0.66	0.94	1.12
30	(9.1)	0.70	0.98	1.16
40	(12.2)	0.76	1.04	1.22
50	(15.2)	0.81	1.09	1.27
60	(18)	0.85	1.13	1.31
70	(21.3)	0.89	1.17	1.34
80	(24.4)	0.93	1.21	1.38
90	(27.4)	0.96	1.24	1.40
100	(30.5)	0.99	1.26	1.43
120	(36.6)	1.04	1.31	1.48
140	(42.7)	1.09	1.36	1.52

Notes:

1. The velocity pressure exposure coefficient K_z may be determined from the following formula:

   For 15 ft. $\le z \le z_g$ For $z < 15$ ft.

   $K_z = 2.01\,(z/z_g)^{2/\alpha}$ $K_z = 2.01\,(15/z_g)^{2/\alpha}$

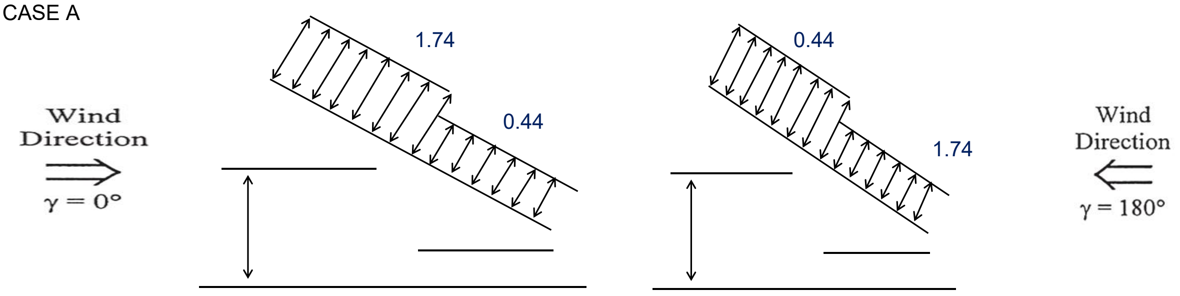
2. α and z_g are tabulated in Table 26.9.1.
3. Linear interpolation for intermediate values of height z is acceptable.
4. Exposure categories are defined in Section 26.7.

Than, Kz= 0.85
So, qz = 0.613KzKztKdV2 = 1495.03 N/m2

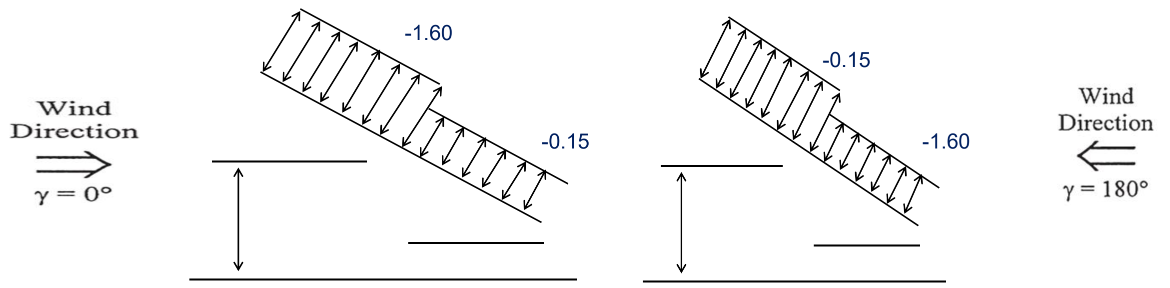
NET DESIGN PRESSURE (p)
P = qh*G*CN

Roof Angle	Load case	Wind Direction,γ = 0°		Wind Direction, γ =180°	
		Clear Wind Flow		Clear Wind Flow	
		PNW	PNL	PNW	PNL
5	A	1.74	0.44	1.74	0.44
	B	-1.60	-0.15	-1.60	-0.15

CASE A



CASE B



2.2.4 Load combination

Load and Resistance Factor Design (LRFD)

1.4D	G: Dead load
1.2D+1.6S+0.5W	S: Snow load
1.2D+1.0W+0.5S	W: Wind load
0.9D+1.0W	

2.3 Strength Calculation

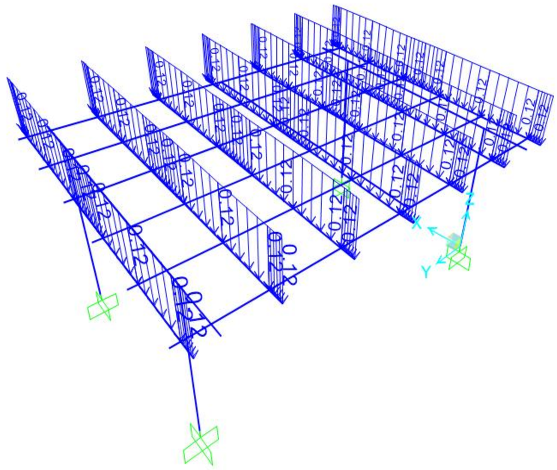
Dead load G= 0.12 N/mm
Wind load W=

Roof Angle	Load case	Wind Direction,γ = 0°		Wind Direction, γ =180°	
		Clear Wind Flow		Clear Wind Flow	
		PNW	PNL	PNW	PNL
5	A	1.74	0.44	1.74	0.44
	B	-1.60	-0.15	-1.60	-0.15

Snow load S= 1.24 N/mm

2.3.1 Load diagram:

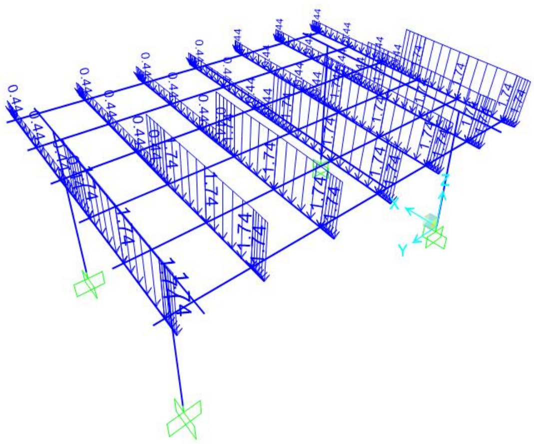
Dead load D:



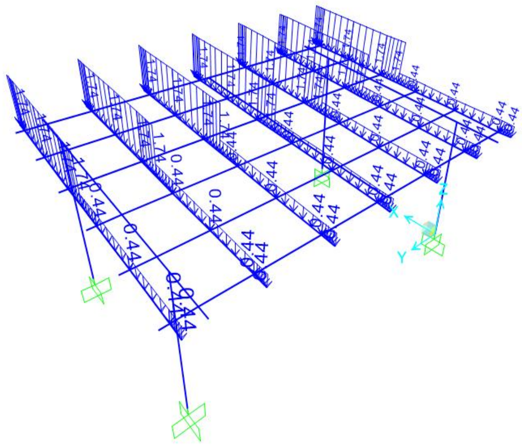
Wind load W:

CASE A

w+

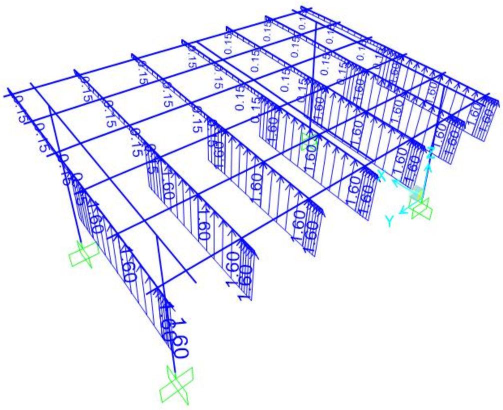


w-

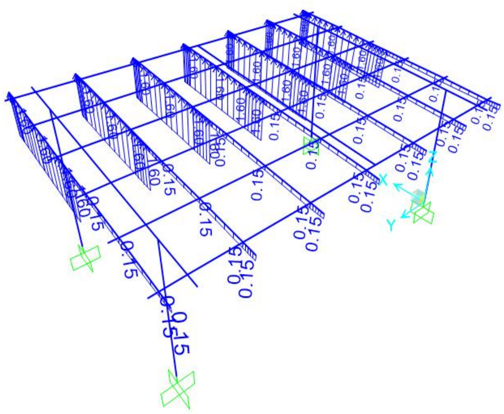


CASE B

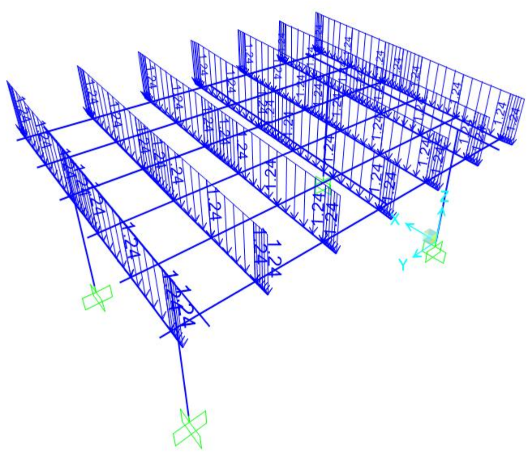
w+



w-

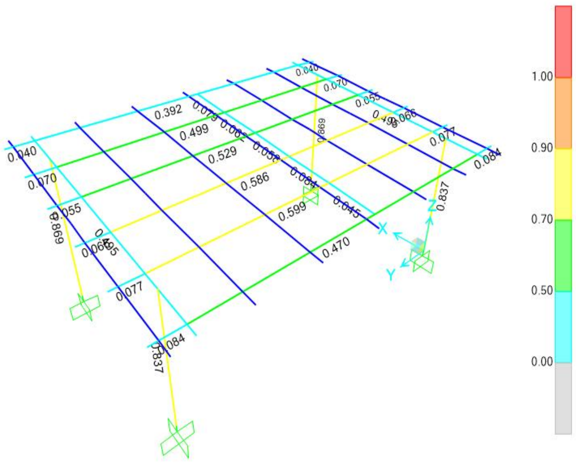


Snow load S:



2.3.2 Structural calculation

a.Design utility ratio



Items	ratio
Mount rail	0.599
Welded beam	0.495
Welded pile	0.869
Steel rod	0.084

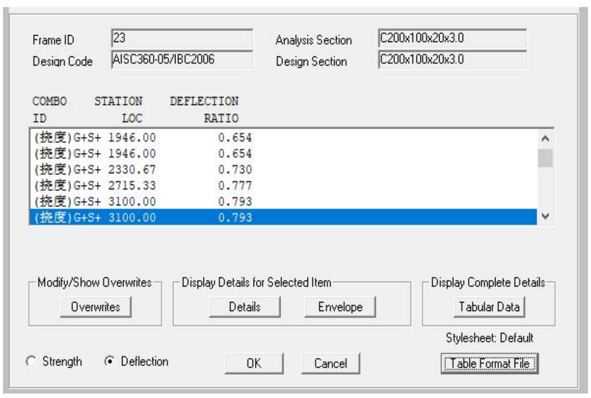
Item	BIPV rail
Axial P ,N	215.120
Moment M2,N*mm	86319.700
Moment M3,N*mm	269252.490
P σp= F/A,Mpa	0.477
M2 σy=My/WyB,Mpa	11.712
M3 σz=Mx/WxB,Mpa	63.121
[σ],Mpa	240
Ratio	0.314
	ok

Note: ratio = Actual stress/Allowable stress

------Failed ratio>1.0 ------ Passed ratio<1.0

b.Deflection ratio

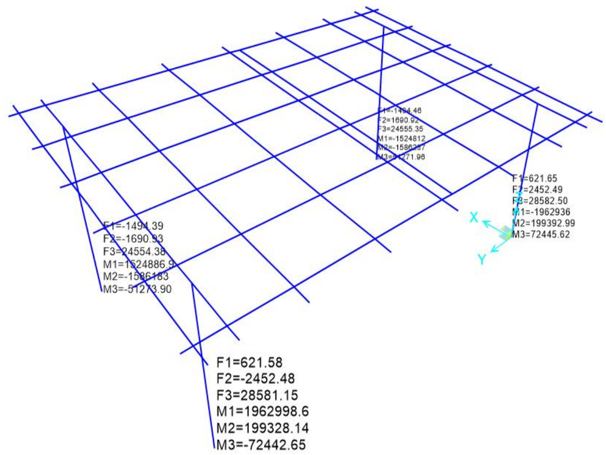
Steel Stress Check Information (AISC360-05/IBC2006)



Note: ------Failed ratio>1.0 ------ Passed ratio<1.0

c.Reaction force of foundation

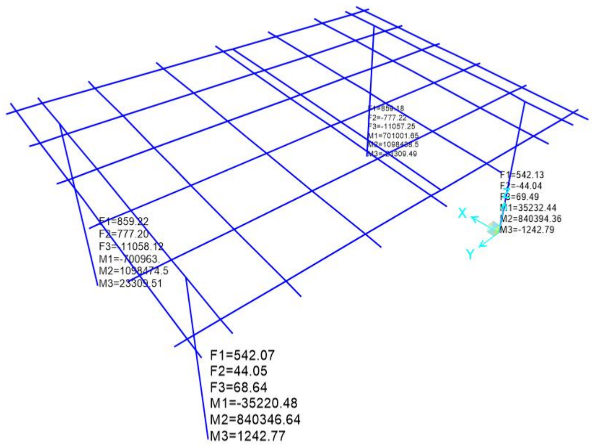
Positive Force



Maximum vertical force FV1= 28582.5 **N/1 base**

Maximum horizontal force FH1= 1494.39 **N/1 base**

Negative Force



Maximum vertical force FV1= 11058.12 **N/1 base**

Maximum horizontal force FH1= 859.22 **N/1 base**