Analysis for the Soalr Mounting System

1. Introduction

1.1 Project description

The following sections contain the determination of the forces and the structural design calculations of the ground mounted photovoltaic system.

1.2 Technical codes

- ASCE7-05 Chapter 6: wind loads
- ASCE7-05 Chapter 7: snow loads
- ASCE7-05 Chapter 2: combinations of Loads
- International Building Code. IBC, 2006
- Aluminum Design Manual, Eighth Edition, 2005
- ANSI/AISC 360-16 An American National Standard
- ANSI/AISC 360-16 An American National Standard

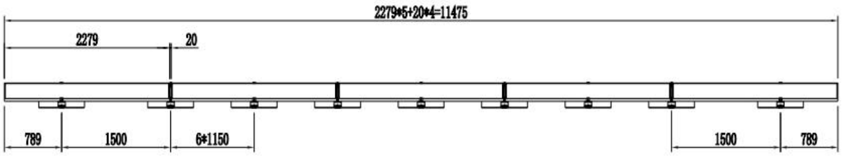
1.3 Project Information

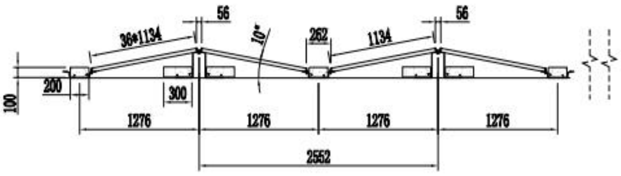
The modules have the following dimensions:	2278		x	1134	x	35	mm
Area of Module	2.58	m^2					
maximum power	560	Wp					
Weight of Module	27.80	kg					
Unit Array :	36	rows	x	5	column		
the quantity of solar panel	180	pcs					
Array tilt angle (Deg)	10	°					
exposure category [B, C, D]	C						
Occupancy Category =	III						
basic wind speed	25.6	M/S	=	####	kN/m2		
basic snow load	1.00	kN/m2					

1.4 construction

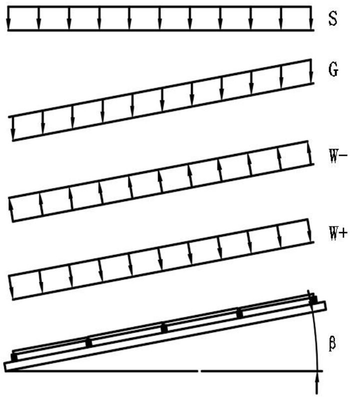
Unit Array :	36	rows x	5	column
Total area of module=			464.99	m^2
tit of modules with horizontal plain			10	°

total dimensions of a solar mounting unint：





2 Load actions



with：

β ° inclination

G based on International Building Code, IBC, 2006 according to manufacturers certificate

W+ ASCE7-05 Chapter 6: wind loads

W- ASCE7-05 Chapter 6: wind loads

S ASCE7-05 Chapter 7: snow loads

2.1 permanent loads D

selfweight of solar modules	272.44	N
Total weight of solar panel	######	N

2.2 snow loads S

zone of snow loads p_g 1 KN/m^2 (ASCE7-05 Eq. 7-1, 7-2

sloped roof snow loads ps

ps= $C_s*p_f=0.7C_s*C_e*C_t*I_s*p_g$ = 0.6048 KN/m^2

Importance Factor,I_s = 0.8

Exposure Factor, C_e = 0.9

Thermal Factor, C_t = 1.2

the roof slope factor,C_s = 1.00

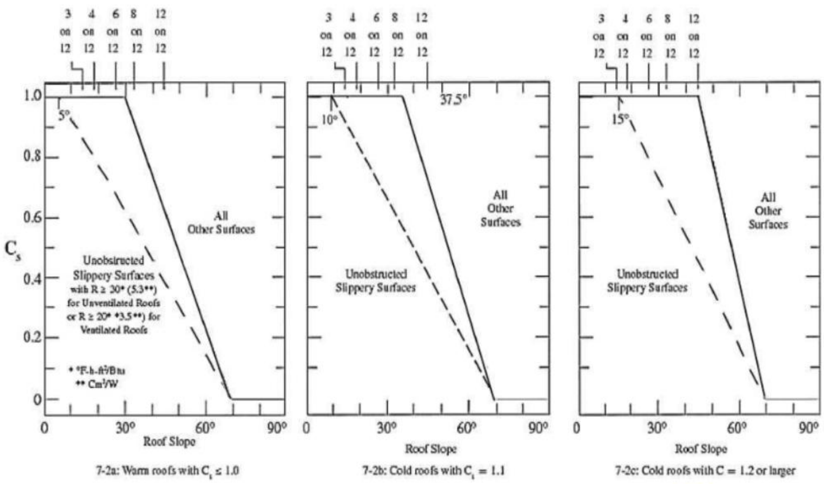


FIGURE 7.4-1 Graphs for Determining Roof Slope Factor, C_s, for Warm and Cold Roofs (See Table 7.3-2 for C_t Definitions)

Angel θ	0	15	70	90
C_S	1	1	0	0

Area of Module	464.99	m^2
Solar panels bear snow pressure	281223.15	N

2.3 wind loads:

Calculation of the wind pressure code comply with the ASCE 7-10

Based Wind Speed =	25.6	M/S
Exposre is	C	
Building is Category	III	

Wind Loads

Main Building System (MWFRS):

Building is classified as an **Building, Low-Rise**

h = mean roof height =	65.61	ft< 60ft	20.00	meter
Z = height being evaluated=	65.61	ft< 60ft	20.00	meter

Analytical Procedures

Building is regular shaped

Building has simple response characteristics

Design Procedure

Basic Wind Speed, V and Kd

V=	25.6	M/S	Basic Wind Speed

Speci Check with local building officials

Wind Directionality Factor for use with equations in sections 2.3 &2.4

Kd=	0.85	MWFRS
Is=	0.8	Importance factor

Exposure

Surface Roughness

Exposure Category C

Velocity Pressure Exposure Coefficient: **Kz & Kh** shall be from Table 6-3

Find Kz: Exp C, h=15ft

zg= 900 α= 9.50

Z roof=	65.61	Roof ht
Z min=	65.61	min Roof ht
Kz= 2.01*(z/zg)^(2/a)=	0.85	by formula for Exp C, h=15 ft
Kzmin= 2.01*(zmin/zg)^(2/a)=	0.85	

Topographic Effects

Determine applicability of Kzt Factors:

Topographic Feature is isolated for 100*ht of feature, or 2mi, whichever is l	FALSE	no
Feature protudes above terrain within 2 mile quadrant by a factor of 2 or mo	FALSE	no
Sructure is located in half of hill/ ridge or at crest of escarpment:	FALSE	no
H/Lh > .2	FALSE	no

Bldg Ht Check : if in Exp C or D, min ht= 15ft, or

If in Exp B, min ht =60ft Does Bldg meet min ht?

Exp B check :	B	no
Exp C check :	C	no
Exp D check :	D	no

if 26.8.1.1 thru 26.8.1.5.5 are all yes, Kzt is per formula, otherwise, Kzt=1.0

Kzt Criteria is met? FALSE

Kzt= 1.00

Gust Effect Factor

Rigid Structures G= 0.85

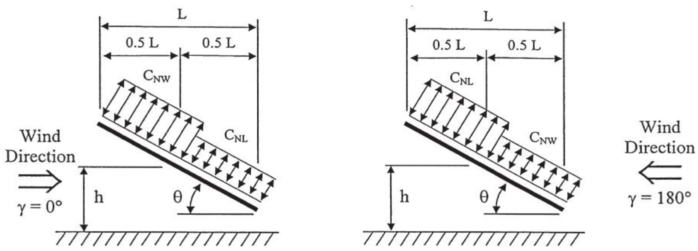
Note: Code equaion allows this factor to be calculated more accurately, using equations 6-4 thru 6-

Flexible Structures G= Applies only to structures with natural frequency less than 1 hz

Design Wind Loads on Enclosed and Partially Enclosed Rigid Buildings

MWFRS

P=q*G*Cp



Roof Angle θ	Load Case	Wind Direction, $\gamma = 0°$				Wind Direction, $\gamma = 180°$			
		Clear Wind Flow		Obstructed Wind Flow		Clear Wind Flow		Obstructed Wind Flow	
		C_{NW}	C_{NL}	C_{NW}	C_{NL}	C_{NW}	C_{NL}	C_{NW}	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

Array tilt angle (Deg)= 10

γ = 0 Cp(-)= -1.57 (max)

γ = 180 Cp(+)= 1.67 (max)

Desig

P=0.613 *Kz *Kzt *Kd *V^2*G*CP

max Wind pressure W_A = 410.01 N/m^2 Pd

W_B = -385.41 N/m^2 Pu

Solar panels bear wind pressure F_A = 95325.28 N

F_B = -89605.76 N

2.5 Basic load combinations

Where strength design or load and resistance factor design is used, structures and portions thereof shall resist the most critical effects from the following combinations of factored loads:

1.4 D

1.2D+ 1.6L+0.5（L_r or S or R)

1.2D+1.6（L_r or S or R)+(1.0L or 0.5W)

1.2D+ 1.0W+1.0L+0.5(L_r or S or R)

0.9D+1.0W

1.2D+E_v+E_h+L+0.2S

0.9D-E_v+E_h

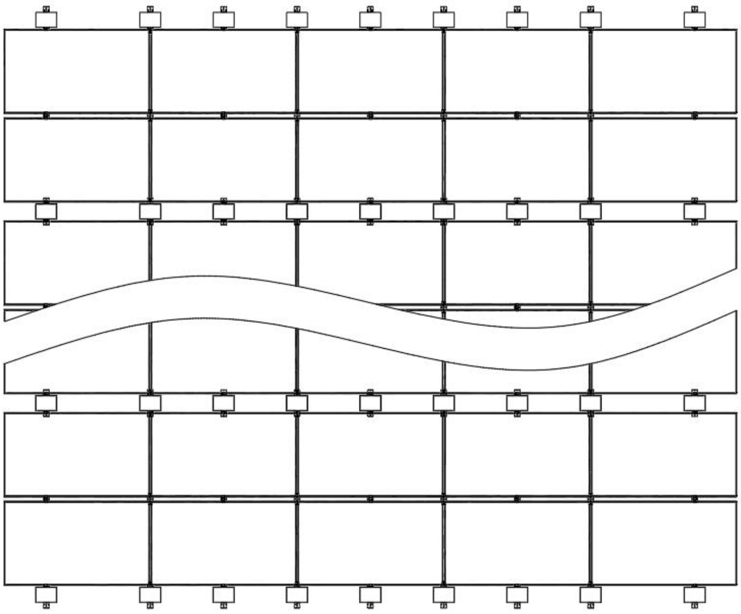
The following load combinations are considered at ultimate limit states design:

COMB1A 1.2D+ 1.6S+0.5W+ = 556466.71 N

COMB1B	1.2D+1.6S+0.5W-	=	464001.19	N
COMB2A	1.2D+1.0(W+)+0.5S	=	294783.89	N
COMB2B	1.2D+1.0(W-)+0.5S	=	109852.85	N
COMB3A	$0.9D+W_A$	=	139460.56	N
COMB3B	$0.9D+W_B$	=	-45470.48	N

Under extreme conditions, the maximum load of solar panels= 556466.71 N

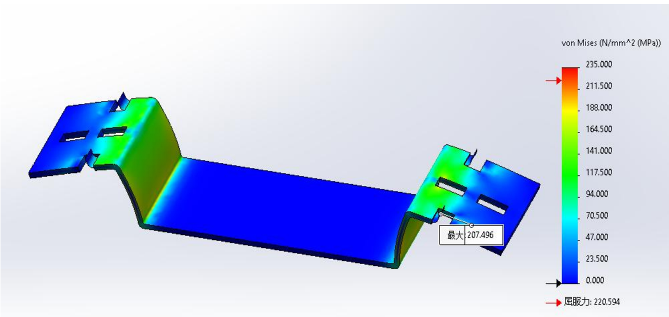
3 Design calculations



3.1 Ballast front foot str

3.1.1 Force analysis of ballasted front foot

Fy= ######* cos # ° / 648 = 846 N



It is known from the

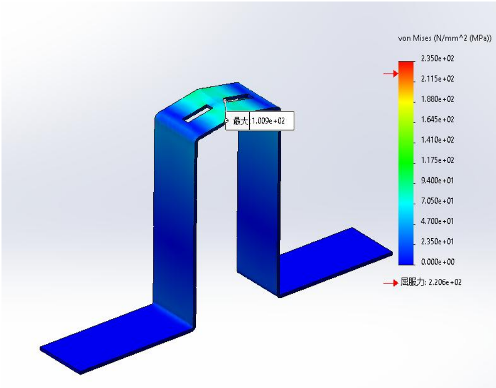
under the greatest pressure σ 207.50 Mpa < 235 Mpa

Therefore, the ballast front foot strength check is OK!

3.2 Ballast back foot strength check

3.2.1 Force analysis of the ballasted rear foot

Fy= ######* cos # ° / 648 = 846 N



It is known from the calculation results in the figure that:

under the greatest pressure	σ	100.9	Mpa	＜	235	Mpa

Therefore, the strength check of the ballasted rear foot is OK!

4 Cement pier foundation calculation

Cement piers are mainly used to carry blows away, so only the horizontal force review under negative pressure is calculated.

bracket total negative pressure F_{pu}			=	Fb*N	=	22735.24	N		
bracket vertical negative pressure F_{yu}			=	F_{pu}*cosθ	=	22389.84	N		
bracket horizontal negative pressure F_{xu}			=	F_{pu}*sinθ	=	3947.93	N		
Friction coefficient μ	=	0.5							
Cement size	=	200	*	300	*	100	mm^3		
Cement quantity	=	495	pcs						
Cement pier density	=	2350	kg/m^3						
Total weight of cement pier	=	6979.5	kg		= 68399.1 N				
Pulling resistance F	=	68399.10	N						
Pullout resistance ch 68399.1	>	22389.84			→ OK				
safety rate		68399.10	/	22390	= 3.05				
Horizontal resistance check f	=	μ * F	=	34199.55	N	>	3947.93	N	
safety rate		34199.55	/	3947.9 =	8.66				

The strength check of cement pier is OK.