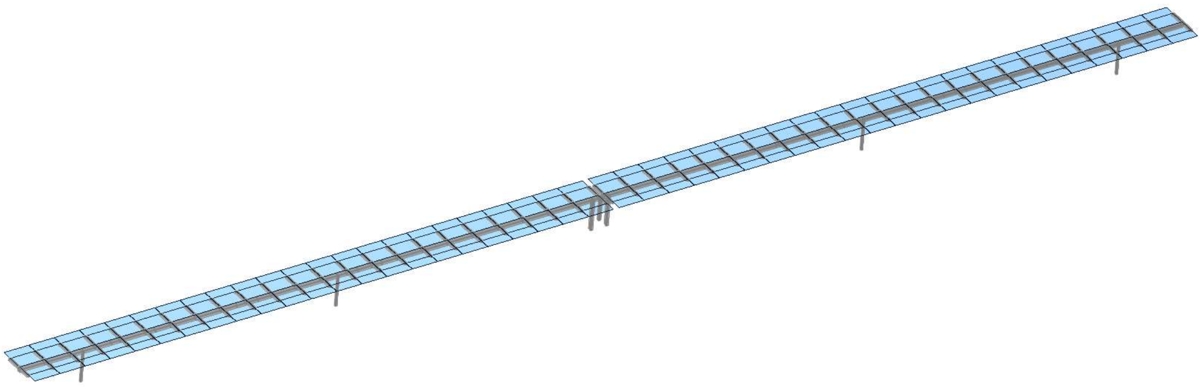
STRUCTURAL ANALYSIS OF SOLAR ARRAY

GEOGRAPHIC SITUATION: MARRUECOS

AXONE 4.0 Single-Axis Tracker 46x1



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1. OBJECT

1.1 Introduction

The object of this document is to justify that the solar array complies with the strength requirements specified in this report, which are based in the norms, see reference section (4.1), under the specifications defined in the following chapters.

The solar array layout consists of 18 rows, in which two different configurations are placed taking into account if the row is located in the front part (more exposed) or in the interior ones. These two structures are defined in following chapters. Additionally, a third configuration is located next to the Motor as it is shown in Figure 2. The analysis of this structure it is not carried out because it is covered by results from Zone I and Zone II.

Each row is composed by 46 solar panel in a portrait configuration, 23 per side, in one row, reaching a total length of around 47m.

Each solar panel has dimensions of 1966 mm x 1000 mm, and they are mounted on a beam supported by posts with an approximate height of 1186.5 mm.

The solar plant is composed by blocks of 18 rows, all those rows are moved from -55º to +55, by the same motor, located in the centre of the block.

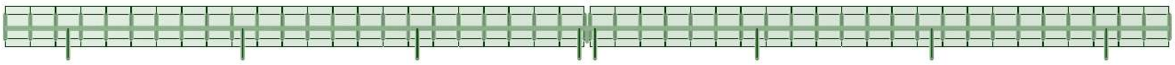

Figure 1. ***Indicative Drawing of a row***

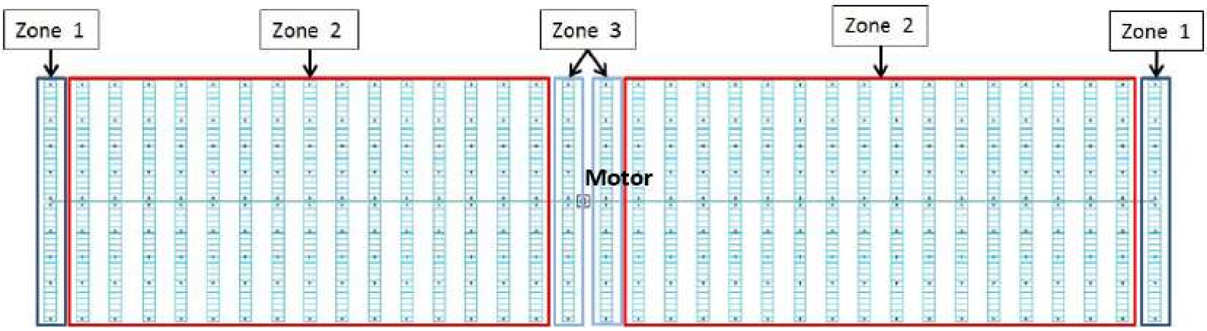

Figure 2. ***Disposition of the block***

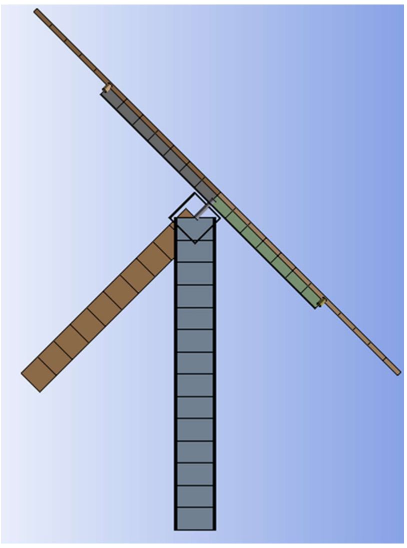

Figure 3. ***Lateral View of One Row in working position***

2. SCOPE

The scope of this report is that the multiple solar arrays analysed, complies the specified strength requirements based in norms, section (4.1), under the next specifications:

- The wind load considered in this analysis corresponds to a wind velocity equal to **25 m/s (56 mph)** in work position and a 3s wind gust of **35 m/s (67 mph)** at 10m high in the stow one. The loads for the work position have been obtained from reference [IV] according with the customer specifications while for the stow one the reference [III] has been followed.
- The wind and the weight loads have been increased using the corresponded factor obtained from reference [II]. They have been chosen considering that the structure is not a "slender structure that exhibits significant cross-wind response". Besides, the solar array structure has a reduced height in comparison with its length.
- The strength justification of the structure is based on Linear-elastic static finite element analysis to validate structure.

3. ASSUMPTIONS

In order to carry out the analysis of the structure and its components, the following assumptions have been taking into account:

a) Two different models have been developed, one for zone 1 and other for the rows of the zone 2. As it was mentioned above, structure in Zone III is covered by analysis of Zone I and II.

b) To simplify, only one row has been modelled applying the corresponding loads and boundary conditions to each row. The reactions obtained from them have been used to calculate the joint members between rows.

4. REFERENCES

4.1 Applicable Standards

The solar array shall be designed to the normal and expected base set of requirements established by:

[I] AISC 360 Specifications for Structural Steel Buildings.

[II] ASCE 7-10: Chapter 2: Combinations of Loads

[III] ASCE 7-10: Chapter 26: Wind Loads

[IV] "Aerodynamic performance of a single axis row solar array". ATOS Origin S.A.

[V] AISI -S100-2007: North American Specification for the Design of Cold-Formed Steel Structural Members

4.2 Computational Analysis

- Ansys V17

5. UNITS

All parameters are expressed as SI basic units and units derived from SI basic units:

Fundamentals:

Length	Millimeter	[mm]
Time	Second	[sec]
Force	Newton	[N]

Derivatives:

Mass	Ton	[Ton]
Pressure	Mega Pascal	[MPa]
Density	---	[Ton/mm3]
Acceleration of gravity	g = 9810 mm/s2	
Stress	MPa = N/mm2	

The use of these units is consistent with Newton's Law F= m x a

6. AXIS SYSTEM

The following coordinate systems are used throughout this document (all geometric, FEM and results are stated in terms consistent with them).

The global axis system is defined as follows:

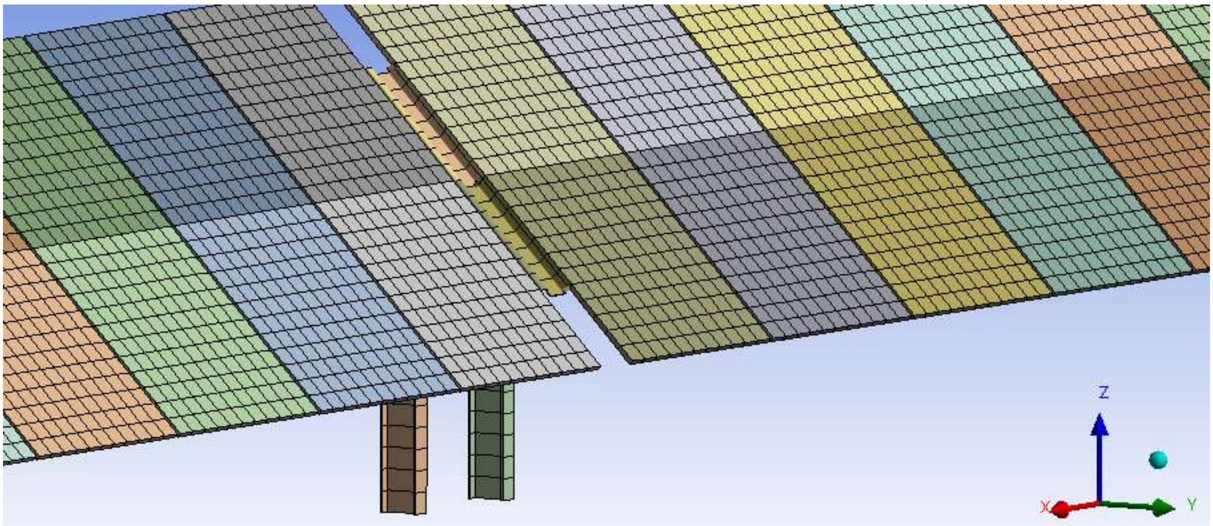

Figure 4. ***Solar Array. Global Axis***

7. DEFINITION OF THE STRUCTURE

As it has been mentioned previously, two structures have been analyzed, depending on the location where the row is situated.

- The exterior row (Zone I) has a configuration with 8 posts.

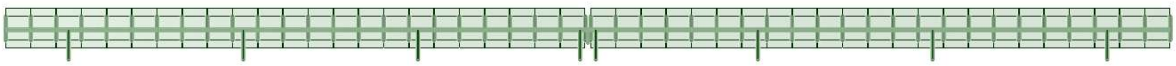

Figure 5.***Structure in Zone I: Axone 46x1. 8 Posts***

- The rest of rows (Zone II and 3) has a configuration with 6 posts.

Figure 6.***Structure in Zone II and III: Axone 46x1. 6 Posts.***

In both structures, the solar panels are established in portrait orientation, as it is shown in the following picture:

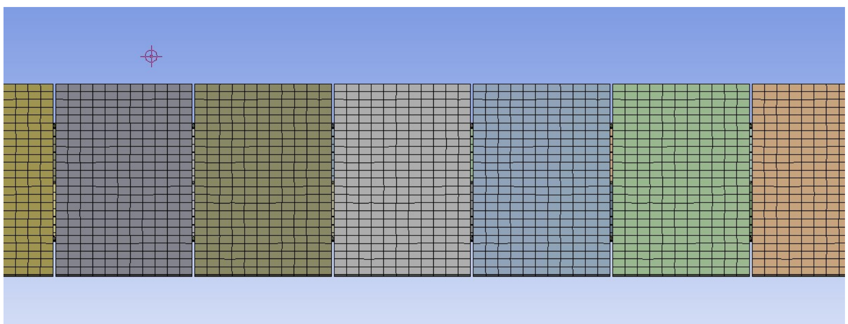

Figure 7.***One Panel per Columns (2000mmx1000mm)***

7.1 Structure of a Row

Each row is composed by a rotation beam, about 47m of length, supported by 8 posts in Zone I, by a rotation beam, about 47m of length supported by 6 posts in Zone II and III. The solar modules are fixed over this horizontal beam, using omega profiles. In the middle of the block it is located a motor to allow the rotation in order to maximize the area of absorption and to situate the structure in a stow position in case of high wind.

Zone Location	Total Length (mm)	Gap Between Posts (mm)	Number of Posts
I	47000	6500/7000/7000 Cantilever 2909.5	8
II	47000	10233.5/10233.5 Cantilever 2909.5	6
III	47000	10233.5/10233.5 Cantilever 2909.5	6

Table 1. ***Structure of a Row depending on the Zone***

The central posts have different section than the rest of posts.

7.2 Main Components

In general, each structure of 1 axis solar array is composed by the following components: Posts, Rotation Beam, Panel Rail (Omega profile) and Solar Modules. The distribution and its location in the structure are shown in the next figure:

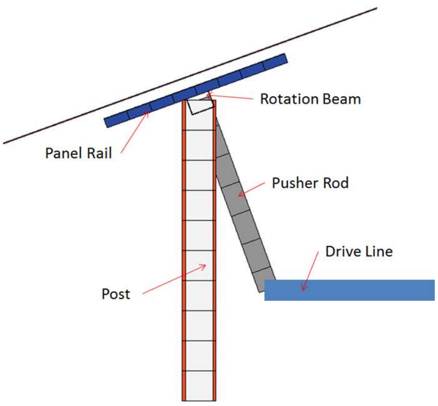

Figure 8.***Main Components in a Row.***

7.2.1 Central Posts and Lateral Post

- Central Posts: IPE and Cp Section

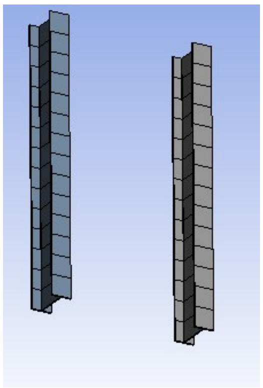

Figure 9. ***Central Posts***

Length: 1186.5 mm

Section: IPE 160

Quantity: 2 per row

Material: Carbon steel S-355-JR

- Lateral Posts: IPE and Cp Section.

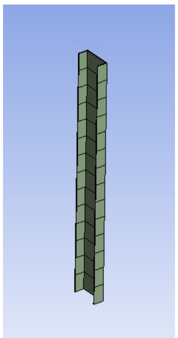

Figure 10. ***Lateral Posts***

Length: 1186.5 mm

Section: Zone 1: IPE140 and 2 and 3: Cp140x50x20x4

Quantity: Zone 1: 4 and Zone 2 and 3: 2

Material: Zone 1: Carbon Steel S-275-JR and Zone 2 and 3: Carbon steel S-355-JR

7.2.2 Rotation Beam

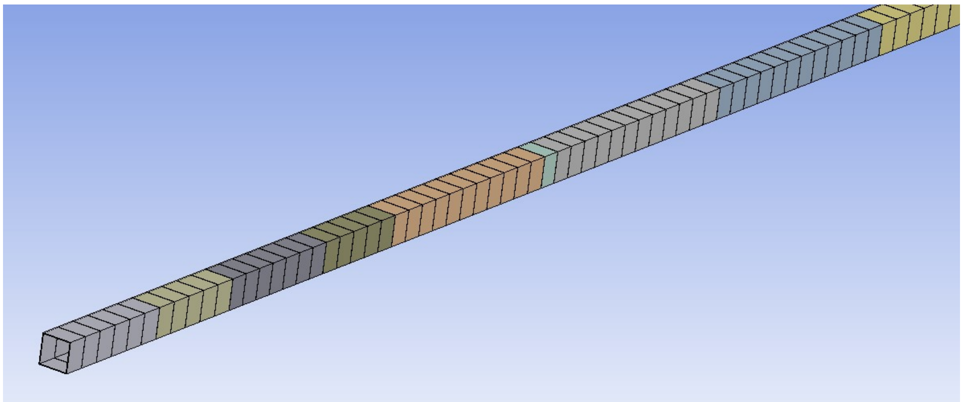

Figure 11. ***Rotation Beam***

Length: Zone 1, Zone2 and 3: 46670 mm

Central Section: Zone 1: 120x120x4 and Zone 2 and Zone 3: 120x120x3

External Section: Zone 1, Zone 2 and Zone 3: 120x120x3

Material: Zone 1, 2 and 3: Carbon steel S-355-JR

7.2.3 Panel Rail

The Panel Rail has been made according to an Zeta Profile, it is connected to the Torque tube and provides support for the Module. The Module is through-bolted to the Panel Rail.

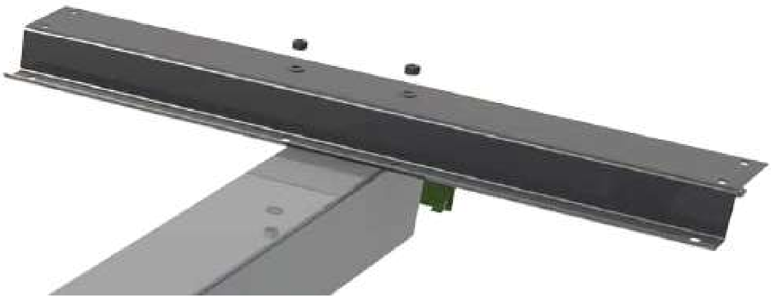

Figure 12. ***Z Panel Rail***

Length: 1118 mm

Section: Zone 1: 3mm and Zone 2 and 3: 2mm

Material: Zone 1, Zone 2 and Zone 3, Carbon steel S-355-JR

7.2.4 Solar Module

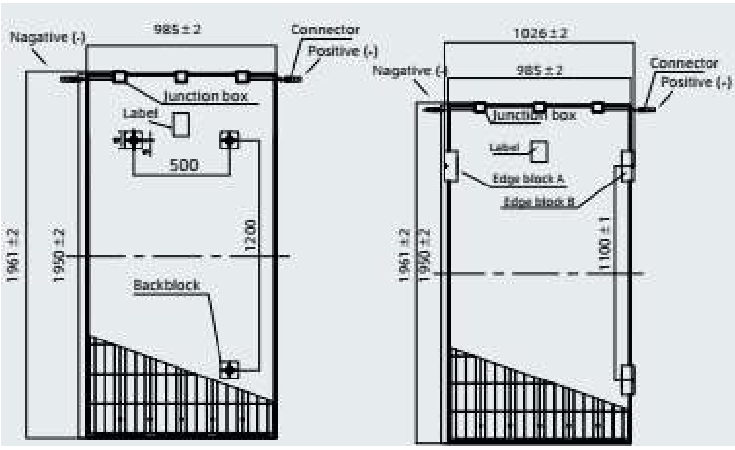

Figure 13. ***Glass-Glass Solar Module***

Length: 1968 mm

Width: 992 mm

Weight: 26.4 kg

7.2.5 Pusher Rod

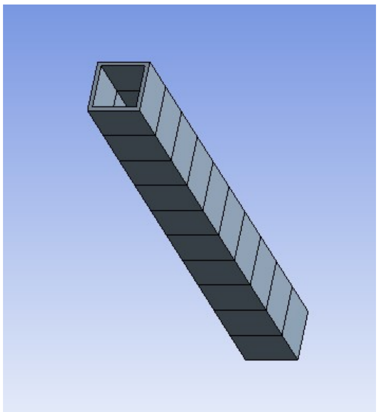

Figure 14. ***Pusher Rod***

Length: 805 mm

Section: Zone 1 and Zone 3: 100x100x10 and Zone 2: 100x100x6

Material: Zone 1 and 3: Carbon steel S-355-JR and Zone 2: S-275-JR

7.2.6 Summary of Main Elements

In the next table a summary of the main elements of the structure is done as well as the material.

ELEMENT	SECTION	MATERIAL	AMOUNT
Central Posts	IPE-160	S355	2
Lateral Posts	IPE-140	S275	6
Central Rotation Beam	120x120x4	S355	1
Lateral Rotation Beam	120x120x3	S355	4
Pusher Rod	100x100x10	S355	1
Panel Rail	Z 3 mm	S355	48

Table 2. ***Summary of Principal Elements Zone I***

ELEMENT	SECTION	MATERIAL	AMOUNT
Central Posts	IPE-160	S355	2
Lateral Posts	CP 140	S355	4
Central Rotation Beam	120x120x3	S355	1
Lateral Rotation Beam	120x120x3	S355	4
Pusher Rod	100x100x6	S275	1
Panel Rail	Z 2 mm	S355	48

Table 3. ***Summary of Principal Elements Zone II***

ELEMENT	SECTION	MATERIAL	AMOUNT
Central Posts	IPE-160	S355	2
Lateral Posts	CP 140	S355	4
Central Rotation Beam	120x120x4	S355	1
Lateral Rotation Beam	120x120x3	S355	4
Pusher Rod	100x100x10	S355	1
Panel Rail	Z 2 mm	S355	48

Table 4. ***Summary of Principal Elements Zone III***

8. FINITE MODEL DESCRIPTION

8.1 General

As it was mentioned above, depending on the studied Zone, two different models have been carried out.

To simulate the Axone Single-Axis Tracker, only one row has been modelled for each zone, in order to simplify the analysis, applying the corresponding boundary conditions. So each row has been analyzed isolated using their properties and loads.

The finite element model consists of mid-surfaces.

Nominal dimensions are considered.

Ansys V17 has been used to generate the finite element model.

Mesh is mainly based on “**Beam elements**” except the solar modules, which are defined with “**Shell elements”** using quadrilaterals.

In case of bolted joints, “**Rigid**” elements are used to simulate the bolt and to join locally the different parts (Zone I and Zone II respectively).

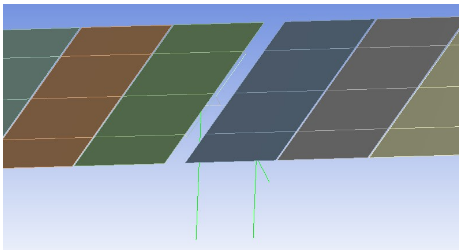

Figure 15. ***Solar Array Finite Model Zone I and II***

8.2 Elements

The following types of elements have been used in the finite element model:

• **Shell element**: has both bending and membrane capabilities. Both in-plane and normal loads are permitted. The element has six degrees of freedom at each node: translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z-axes. As it was mentioned above, two different components were modelled with Shell. On the one hand, the solar panels have an average size of mesh of 83 mm.

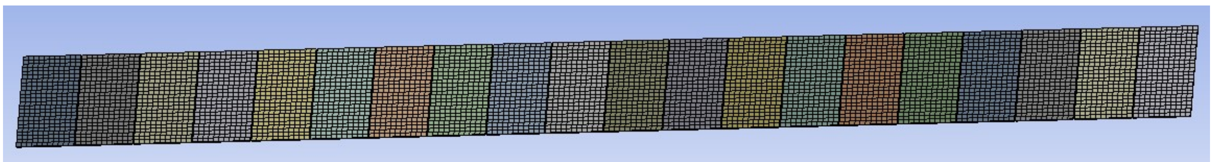

Figure 16. ***Shell Elements at Solar Module***

- **Beam element**: is a uniaxial element with tension-compression, torsion, and bending capabilities. The element has six degrees of freedom at two nodes: translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z axes. This element includes stress stiffening; large deflection capabilities and simplifications due to its symmetry and standard pipe geometry are included. Depending on the element represented, different profiles has been utilized.

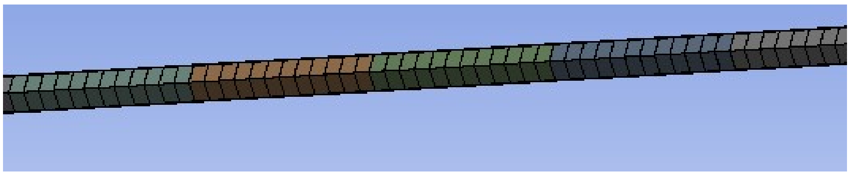

Figure 17. ***Beam Elements at Horizontal Rotation Beam***

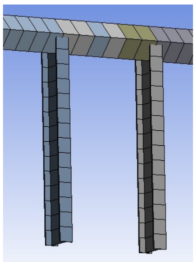

Figure 18. ***Central Post Beams***

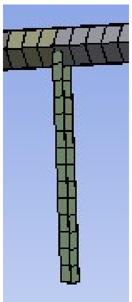

Figure 19. ***Lateral Post Beams***

• **Rigid element**: is suitable for analyzing bolted joints. It is a scalar spring element according to the following equation F=k*x. Six degrees of freedom occur at each node. These include translations in the x, y, and z directions and rotations about the x, y, and z directions.

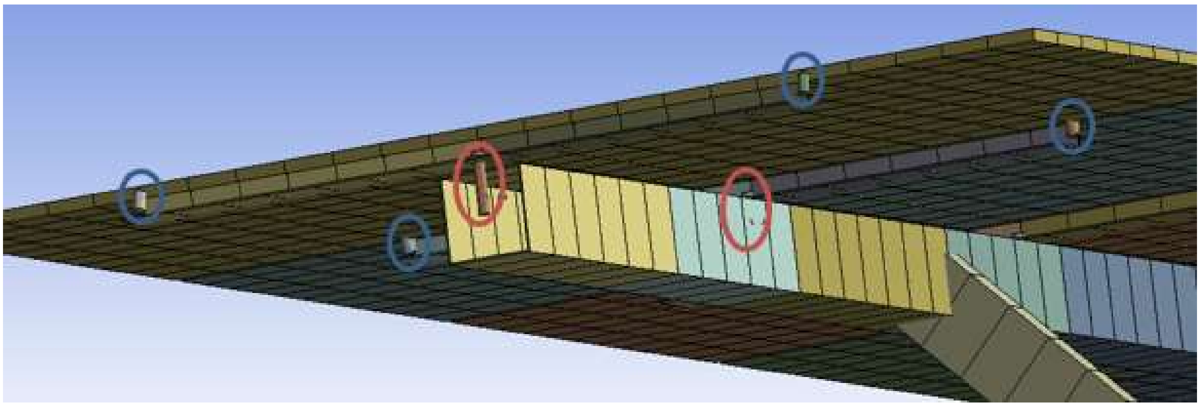

Figure 20. ***Rigid Elements***

In blue circles, are shown the bolts which joint the solar module with the panel rail.

In red circles, are presented the bolts which joint the panel rail with the rotation beam.

• **Rotation joint**: to simulate the bearing joint between the rotation beam and the posts a special connector which only allow the rotation in the X global axis has been defined.

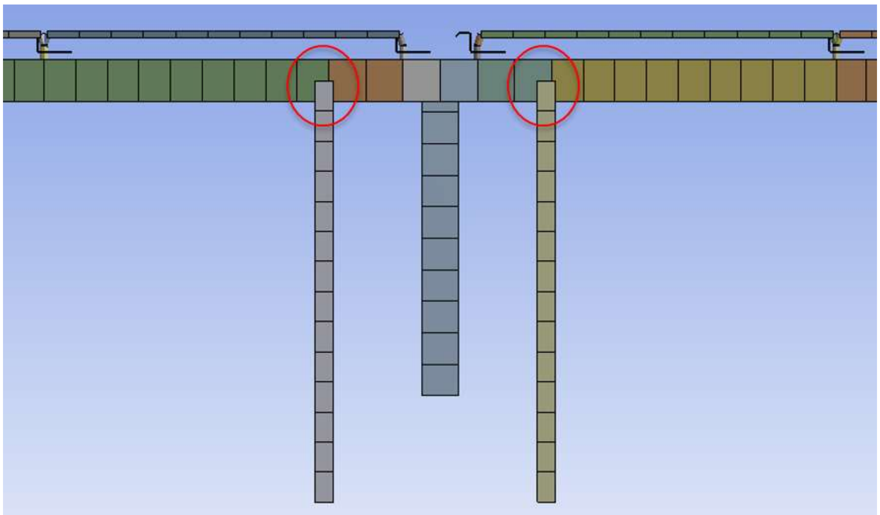

Figure 21. ***Bearing joint***

8.3 Materials

All the solar array structure is made of S275JR and S355JR steel; the next tables show physical and mechanical properties.

MATERIAL (en 1993-1-1:2005)	ELASTIC MODULUS (MPa)	POISSON RATION	DENSITY (Kg/m³)
S275JR	210000	0.3	7850
S355JR			

Table 5. ***Material Physical Properties***

MATERIAL (EN 1993-1-1:2005)	THICKNESS [mm]	MECHANICAL PROPERTIES	
		YIELD STRESS [MPa]	ULTIMATE STRENGTH [MPa]
S275JR	T≤16	275	410
	16<T≤40	265	
S355JR	T≤16	355	470
	16<T≤40	345	

Table 6. ***Material Mechanical Properties***

The material properties are considered to be linear elastic for the global model.

8.4 Boundary Conditions

• The lower nodes of every post constraint the translations and the rotations in all directions.

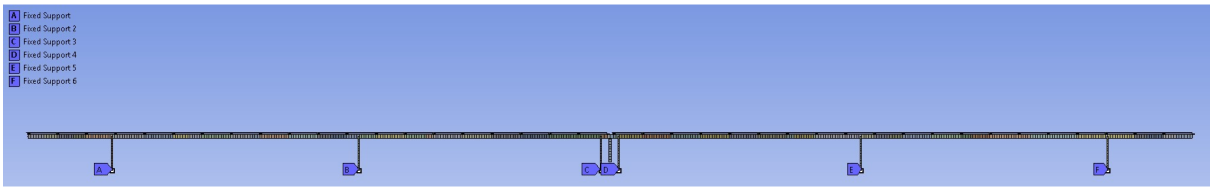

Figure 22. ***Posts Boundary Conditions***

• The lower node of the pusher Rod has is translation in “y direction” restricted, as it is presented in the following picture:

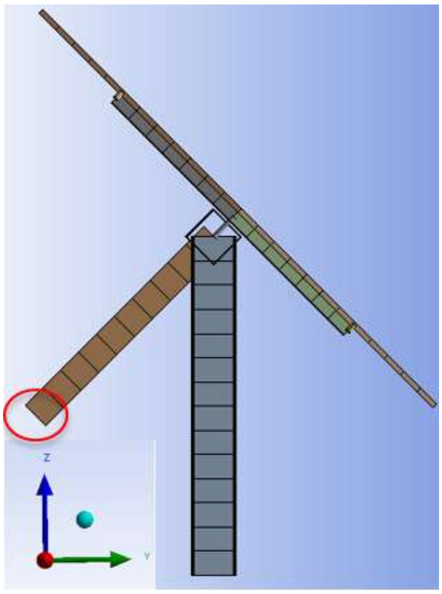

Figure 23. ***Pusher rod Boundary Condition***

9. STRENGH REQUIREMENTS

According to reference [I] a safety coefficient has been applied to the yield stress of each material. There are two design criteria defined in the ASCE code: Load and Resistance factor design (LRFD) and Allowable stress design (ASD).

$$\sigma_{final} = \frac{\sigma_y}{SC}$$

Strength requirements are function to design criteria used. In this case, the structure has been calculated according to ASD design criteria, for reasons of optimization. The next table shows the safety coefficient values for each material.

MATERIAL	YIELD STRESS (MPa)	SAFETY COEFICIENTΦ (-)	ALLOWABLE STRESS (MPa)
S275JR	275	1.67	164.6
S355JR	355	1.67	212.6

Table 7. ***Allowable Stress Value according to ASD Method***

10. LOAD CASES

10.1 Wind Load

10.1.1 Wind load in Working position

In order to determinate the wind load of this structure an aerodynamic study for the Axone Single-Axis Tracker has been carried out. This study has been done supposing a maximum wind velocity of 25m/s (~56 mph).

According to this study, the loads for each row are reflected in the table below.

The table below has been built according to reference [III].

ROW	ROW INCLINATION CRITICAL (º)	PRESSURE DISTRIBUTION	MAXIMUM PEAK VALUE (Pa)
Row 1	55º	A	1085
Internal Rows	20º	A	460
Row 18	55º	F	1100

Table 8. ***Results of the Aerodynamic Study: critical Wind values in each Row***

These loads are applied perpendicularly to the surface of the solar module. The shape of the load is a triangular distribution from 0 Pa to each maximum value of the table above. The shaded values are the called "suction" cases, where the wind affects the lower surface of the solar modules.

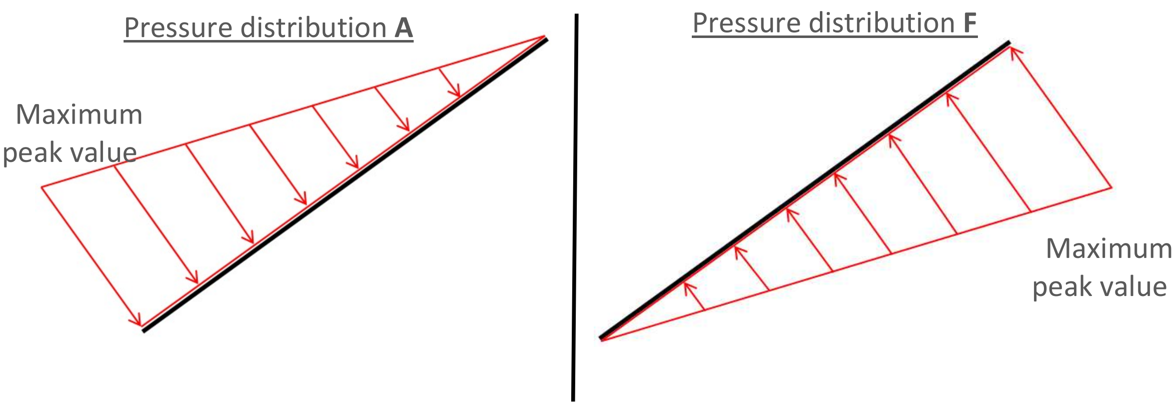

Figure 24. ***Distribution of the Wind Load***

10.1.2 Wind load in Stow position

According to the situations of the structure, the design wind loads are the following:

Basic Wind Speed: 35 m/s (~78 mph).

Importance factor: I=1

Wind exposure: C

Gust Effect factor: G=0.85

According to reference [III]., the loads for each row are the following.

ROW	ROW INCLINATION CRITICAL (º)	PRESSURE DISTRIBUTION	MAXIMUM VALUE (Pa)	MAXIMUM VALUE (Pa)
All Rows	0º	A2	481	120
All Rows	0º	F2	441	40

Table 9. ***Results of the wind load in Stow Position: critical Wind values in each Row***

These loads are applied perpendicularly to the surface of the solar module. The shape of the load is a rectangular distribution for haft length of the panel. There is one rectangle for maximum value of the table above and another one for the minimum value. The shaded values are the called "suction" cases, where the wind affects the lower surface of the solar modules.

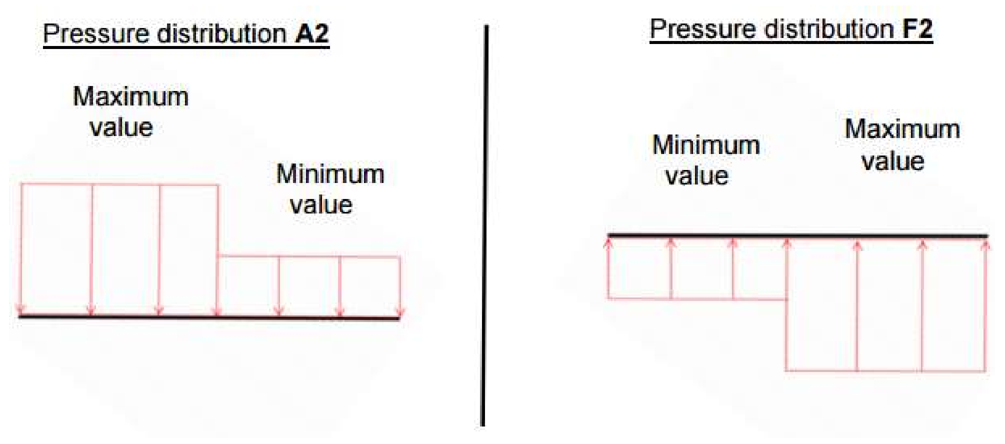

Figure 25. ***Distribution of the wind load***

10.2 Load Cases

Following the specifications in reference [II], the load combinations are also function to design criteria used. There are two possible load combinations: Load Combinations using strength design or load and resistance factor (LRFD) and Load Combinations using allowable stress design (ASD)

A pre-analysis was carried out taking into account both design criteria: "Load combination using resistance factor design (LRFD)" and "Load combination using allowable stress design (ASD)". Results showed that LRFD criterion is less conservative than ASD criterion.

For this reason, the final structural analysis and the optimization of the structure only have been carried out following the specifications of ASD design criterion.

Load combinations following ASD criterion is described below, taking into account that in reference [II],, there are defined four different Load Cases.

CASE		WHEIGHT	EARTHQUAKE X	EARTHQUAKE Y	WIND PRESSURE LOAD A	WIND PRESSURE LOAD B
0º	**Wind Direction 0 Case A W1**	1.0	0.0	0.0	0.6	0.0
	Wind Direction 0 Case A W0.6	0.6	0.0	0.0	0.0	0.6
20º	**Wind Direction 0 Case A W1**	1.0	0.0	0.0	1.0	0.0
	Wind Direction 0 Case A W0.6	0.6	0.0	0.0	0.0	1.0
55º	**Wind Direction 0 Case A W1**	1.0	0.0	0.0	1.0	0.0
	Wind Direction 0 Case A W0.6	0.6	0.0	0.0	0.0	1.0

Table 10. ***Coefficients of each Load Case***

The coefficients applied to the weight, wind load and to the earthquake load have been obtained from referenced [II].

11. STATIC ANALYSIS RESULTS

Results plots for the static critical load cases are presented in order to provide the security of the structure.

Generally, in the following pictures the Von Mises stresses are presented. The Von Mises theory is acceptable for the strength of the base material.

Maximum nodal stresses of the structural and several main components can be seen below. It shows also, the magnitude displacement of the whole structure and the solar modules.

11.1 Summary Results

Having done a study of the critical load cases, in the next table the stress values are shown by components, it is marked the critical component for each zone.

The stresses values shown in the next table and plots have been calculated taking into account the load factors defined in Table 10. The stress values correspond to the results of critical cases.

ZONE	ALLOWABLE STRESS (MPa)	PANEL RAIL		CENTRAL POST		LATERAL POST		CENTRAL ROTATION BEAM		PUSHER ROD	
		Stress (MPa)	SF	Stress (MPa)	SF	Stress (MPa)	SF	Stress (MPa)	SF	Stress (MPa)	SF
I	164.6	-	-	-	-			-	-	-	-
	212.6	2.05	103.34	**187.7**	**1.13**	128.04	1.66	177	1.2	139.6	1.52
II	164.6	-	-	-	-	-	-	-	-	**95**	**1.77**
	212.6	59.3	3.58	70.63	3.0	**200.6**	**1.06**	167	1.27	-	-

Table 11*. **Summary Results for each Component***

SF: Safety factor defined as: SF= Yield allowable stress / Component stress

The envelope of worst loads transmitted to the ground regarding to the foundations, are shown in the next table. These values are per post.

ZONE	LOCATION	SECTION	LATERAL POST			
			Forces (N)			Moments (Nm)
			Y	Z Traction	Z Compression	X
I	**Central**	**IPE-160**	16442	1542	4085.2	19500
I	**Lateral**	**IPE-140**	7595	3583	8187	9010
II	**Central**	**IPE-160**	3577	340	4540	4240
II	**Lateral**	**CP140**	1586	1016	8912	1880

Table 12. ***Ground Load Summary Results***

The axis system used is shown in Figure 4.

11.2 Critical Load Case

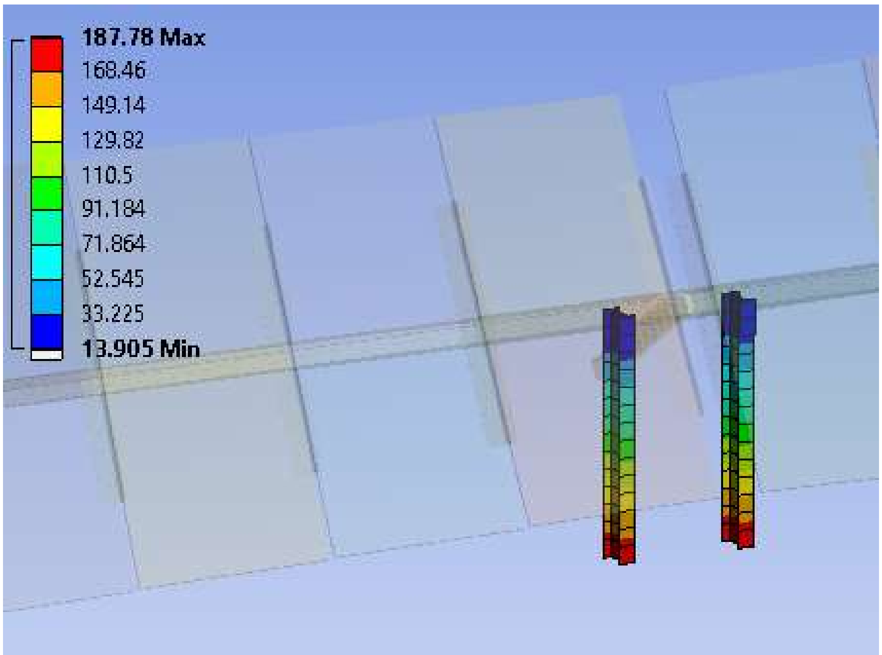

Figure 26. ***Central Posts Result (MPa) in Zone I***

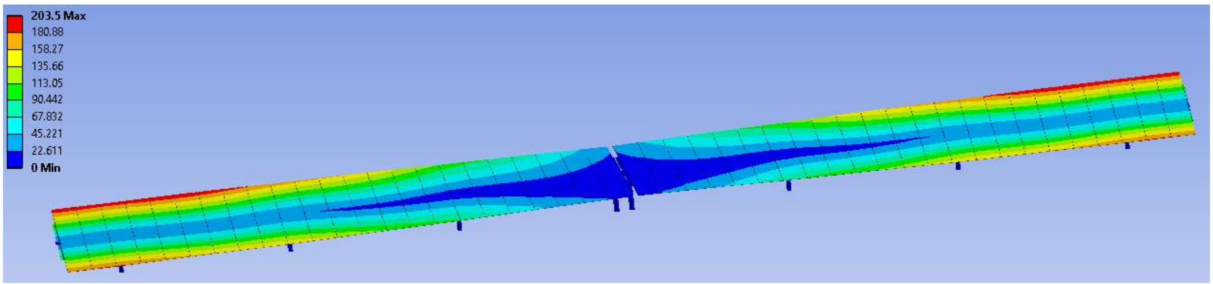

Figure 27. ***Magnitude Displacement of the Structure (mm) in Zone I***

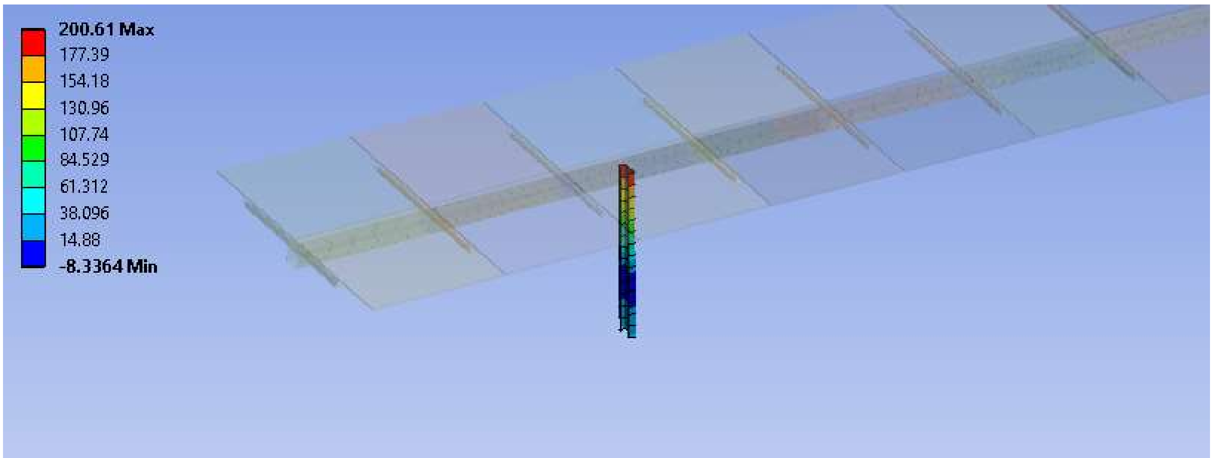

Figure 28. ***Central Posts and Pusher Rod Stress Result (MPa) in Zone II***

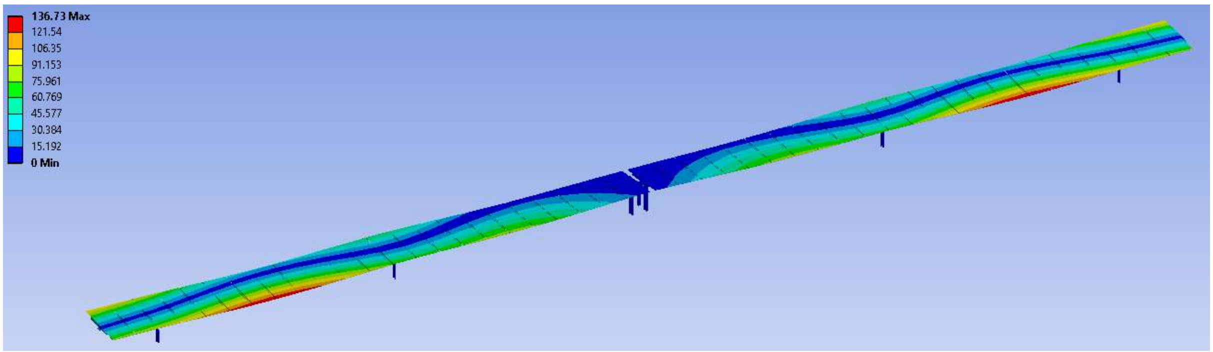

Figure 29. ***Magnitude Displacement of the Structure (mm) in Zone II***

12. BUCKLING RESISTANCE OF DRIVE LINE

12.1 DRIVE LINE DESCRIPTION

The buckling is a geometrical fail due to the compression or loads, this fail can appear before the structures reach to the yield stress, so a specific analysis has to be done to check them.

The part of the structure that is susceptible to suffer a buckling fail in these load cases is the Drive Line, due to its length and high compression loads.

The assembly of the Drive Line is made by 17 beams (one between pair of rows) which will be studied separately.

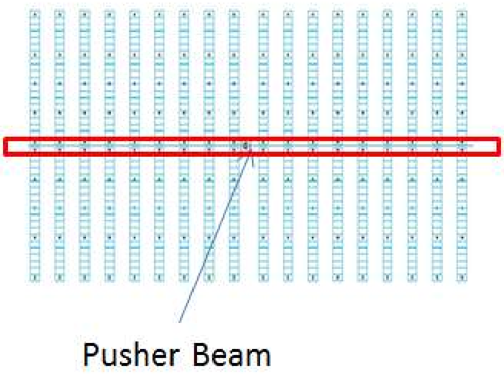

Figure 30. ***Solar Array Layout***

The separation between the rows studied will be 5770 mm in general members.

At the centre of the structure, specifically between rows 9 and 10, it is located the motor that moves the Drive Line. This movement is transmitted to the pusher rod which allow the rotation of the rotation beam thereby the solar modules can reach 55º of inclination.

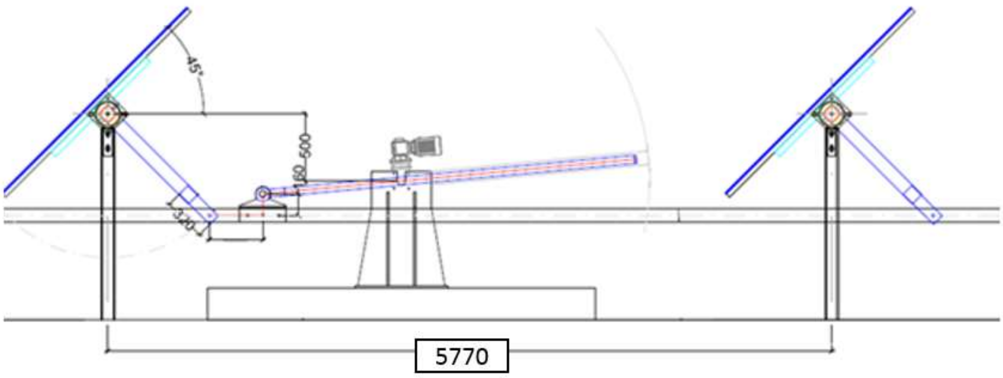

Figure 31. ***Pusher Motor Layout***

Sections of the Drive Line considered:

Location	Section	Material	Area (mm^2)	Inertia (mm^4)
Central	100x100x12	S-355-JR	4224	5.55 E+06
Rows 1 to 10	100x100x4	S-355-JR	1490	2.60 E+06
Rows 10 to 16	100x100x6	S-355-JR	1700	3.11 E+06

Table 13. ***Section of Drive Line***

12.2 RESULTS

Load distribution is assumed uniform except in the beam connecter to the actuator.

Pusher beam situated between rows 9 and 10 is susceptible to suffer a buckling-bending fail due to actuator. For this reason, it has been calculated following the next expressions according to the standard [V]:

C4 Concentrically Loaded Compression Members

The available axial strength [factored compressive resistance] shall be the smaller of the values calculated in accordance with Sections C4.1, C4.2, D1.2, D6.1.3, and D6.1.4, where applicable.

C4.1 Nominal Strength for Yielding, Flexural, Flexural-Torsional and Torsional Buckling

This section shall apply to members in which the resultant of all loads acting on the member is an axial load passing through the centroid of the effective section calculated at the *stress*, F_n, defined in this section.

(a) The nominal axial strength [compressive resistance], P_n, shall be calculated in accordance with Eq. C4.1-1. The *safety factor* and *resistance factors* in this section shall be used to determine the allowable axial strength or design axial strength [factored compressive resistance] in accordance with the applicable design method in Section A4, A5, or A6.

$$P_n = A_e F_n \qquad (Eq.\ C4.1\text{-}1)$$

Ω_c = 1.80 (*ASD*)

ϕ_c = 0.85 (*LRFD*)

= 0.80 (*LSD*)

where

A_e = *Effective area* calculated at stress F_n. For sections with circular holes, A_e is determined from the *effective width* in accordance with Section B2.2(a), subject to the limitations of that section. If the number of holes in the effective length region times the hole diameter divided by the effective length does not exceed 0.015, it is permitted to determine A_e by ignoring the holes. For closed cylindrical tubular members, A_e is provided in Section C4.1.5.

F_n shall be calculated as follows:

For $\lambda_c \leq 1.5$

$$F_n = \left(0.658^{\lambda_c^2}\right) F_y \qquad (Eq.\ C4.1\text{-}2)$$

For $\lambda_c > 1.5$

$$F_n = \left[\frac{0.877}{\lambda_c^2}\right] F_y \qquad (Eq.\ C4.1\text{-}3)$$

where

$$\lambda_c = \sqrt{\frac{F_y}{F_e}} \qquad (Eq.\ C4.1\text{-}4)$$

F_e = The least of the applicable elastic *flexural, torsional* and *flexural-torsional buckling* stress determined in accordance with Sections C4.1.1 through C4.1.5

(b) Concentrically loaded angle sections shall be designed for an additional bending moment as specified in the definitions of M_x and M_y (ASD) or $\overline{M}_x$ and $\overline{M}_y$ (LRFD or LSD) in Section C5.2.

C5 Combined Axial Load and Bending

C5.1 Combined Tensile Axial Load and Bending

C5.1.1 ASD Method

The *required strengths* T, M_x, and M_y shall satisfy the following interaction equations:

$$\frac{\Omega_b M_x}{M_{nxt}} + \frac{\Omega_b M_y}{M_{nyt}} + \frac{\Omega_t T}{T_n} \leq 1.0 \qquad (Eq.\ C5.1.1\text{-}1)$$

and

$$\frac{\Omega_b M_x}{M_{nx}} + \frac{\Omega_b M_y}{M_{ny}} - \frac{\Omega_t T}{T_n} \leq 1.0 \qquad (Eq.\ C5.1.1\text{-}2)$$

where

Ω_b = 1.67

M_x, M_y = Required flexural strengths with respect to centroidal axes of section

M_{nxt}, M_{nyt} = $S_{ft}F_y$ (Eq. C5.1.1-3)

where

S_{ft} = Section modulus of full unreduced section relative to extreme tension fiber about appropriate axis

F_y = Design *yield stress* determined in accordance with Section A7.1

Ω_t = 1.67

T = Required tensile axial strength

T_n = Nominal tensile axial strength determined in accordance with Section C2

M_{nx}, M_{ny} = Nominal flexural strengths about centroidal axes determined in accordance with Section C3.1

The other pusher beams are only subjected to compression load, so they have been checked according to the process below according to the standard [V] too:

Row separation (mm)	Section	M_{nx} (N mm)
5500	100x100x12	2.36 E+7

Table 14. ***Compression-Bending Coefficient for central pusher rod***

Row separation	Section	P_n (N)
5500	100x100x4	1.56e5
	100x100x6	2.26e5

Table 15. ***Compression Coefficient for each section***

For the central member of the drive line, which is connected to the motor, the perpendicular force generated has been taken into account, see Figure 31. This situation is more critical due to the bending generated by this load.

Finally, taking into account these loads the next safety factors for each member of the drive line have been obtained:

Location	Section	Material	Safety Factor
Central	100x100x12	S-355-JR	1.03
Rows 1 to 10	100x100x4	S-355-JR	1.16
Rows 10 to 16	100x100x6	S-355-JR	1.24

Table 16. ***Safety factor for each member of drive line.***

13. CONCLUSIONS

The Axone solar arrays analysed in this report, **complies the specified strength requirements** based in norms, section (4.1), under the next specifications:

- The wind load considered in this analysis corresponds to a wind velocity equal to 25 m/s (56 mph) in work position and a 3s wind gust of **35 m/s (78 mph)** at 10m high in the stow one. The loads for the work position have been obtained from reference [IV] according with the customer specifications while for the stow one the reference [III] has been followed.
- The wind, the earthquake and the weight loads have been increased using the corresponded factor obtained from reference [II]. They have been chosen considering that the structure is not a “slender structure that exhibits significant cross-wind response”. Besides, the solar array structure has a reduced height in comparison with its length.
- The strength justification of the structure is based on Linear-elastic static finite element analysis to validate structure.

As it is shown in the summary results, the critical zones of this structure are the central posts and the pusher rods which reaches a high stress value at the joint with the rotation beam in work position load case.