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A Study about the Protection of an Array of Solar Panels from the Wind Load Action

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***Abstract*—This work deals with the effect of wind load on solar fields. A set of simulations have been performed to evaluate this effect at different positions in an array of solar panels. The effect of a protection baffle can reduce the wind loads by an order of magnitude.**

***Index Terms*— CFD, maintenance cost, Photovoltaic power plant**

I. Introduction

In the last years, a number of studies focused on the wind action on solar trackers, due to the fast growth of the number of photovoltaic power plants. Some works studied the effect of wind experimentally, in wind tunnels [1], [2] (Mohapatra, 2011; Pfahl et al., 2011). Other works, dealt with CFD simulations on the same topic [3], [4] (Hernandez et al., 2009; Wang et al., 2011). In most cases, the study was limited to the effect of the wind in a single solar tracker. Nevertheless real devices consist on arrays of several panels. The effect of wind in such arrays has not yet been so well studied [5] (Shademan and Hangan, 2010).

This work deals with the effect of wind on an array of solar trackers. A panel of protection is proposed to skip the wind upon the array and reduce the load to be supported. The study was carried on through a set of simulations, as a kind of virtual experimentation.

II. Model of Solar Field

The model of solar field studied is compounded by a 5 x 5 array of solar panels, upon a planar ground. Solar panels are 7 x 4.5 m, with an inclination of 45º (corresponding to the latitude of south of Europe). From the ground, the height of the center of the panels is 2 m (Fig. 1). The protection of photovoltaic devices consists on a shell of 40 m length, with an inclination of 45º. It covers completely the central lines of solar panels, but partially the lines at the end of the array.

The calculations were performed with Solid Works Flow Simulation™. The computational domain studied is 200 x 70 x 15 m. The meshing delivers 1.2 million cells, with an automatic refinement for narrow channels. The velocity of the wind computed is 5 m/s, which means a gentle breeze (3 Beaufort). Although this is far of a critical loads situation, it allows comparing the effect of protection.

III. Effect of Protection Panel for Several Positions within the Array

The parameters that have been taken in account are the position of the solar panel in the array, the height of the panel of protection and the distance between the protection and the first row of the array. Four different positions of the panels within the array were studied, as marked in Fig. 2. The first one is located in a position not well covered by the protection baffle. The position 2 is at the first row, closest to the baffle, at the middle of the array. The position 3 is a central position, at the third row of panels. Finally, the position 4 is at the last corner of the array, not well covered by the baffle but sheltered by the solar panels that are before it.

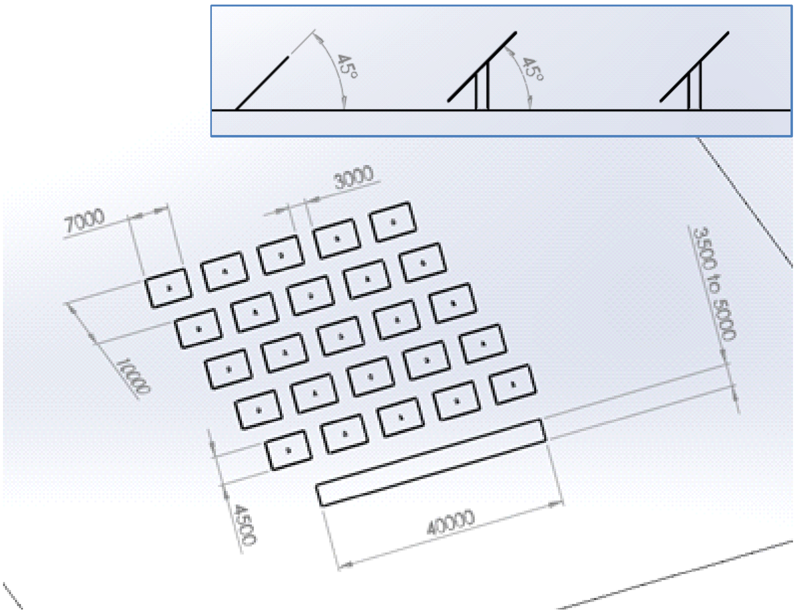

Fig. 1: The array of solar panels: dimensions (mm). On top: lateral view.

The results for 15 m of distance between the baffle and the array are shown in Fig. 3. It shows the total force and the torques on solar panels, for each position. The worst position is which is not well covered by the protection

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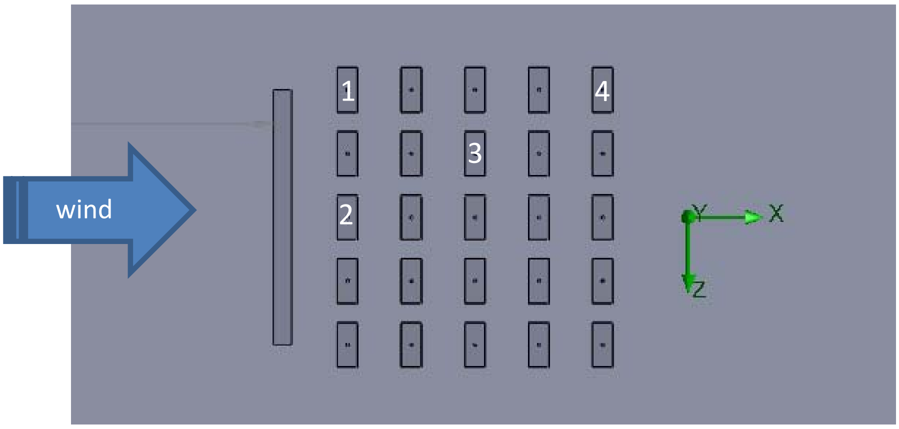

Fig. 2: The array of solar panels and the positions tested.

baffle, as it could be supposed. For every variable of interest (force, and torques) this position is clearly the worst. On the opposite, the position 2 –close to the baffle— is the best one for every type of load. The loads for the panel in position 2 are about 10% of those of the position 1. The other two positions are intermediate. The third position is better, in general: the loads are smaller. The position 4, at the end of the array, is not so good. The force and torques are closer to those of position 1.

The dependence on the height of the protection panel varies for every position. For position 1, there is an optimum value of about 4 m. For positions 2 and 4, a length of 4 m or more are the best. Finally, for position 3, the longer the baffle, the lowest the loads to be suffered.

The similarity of the values of X and Y torques is reasonable because they mean the two components of the same momentum: the one which turns on the longitudinal axis of the panels. This torque is near zero for the panels that are at the rows well covered by the protection baffle, but has a significant value for the panels at the end of the array, which are only partially protected. This partial protection gives an asymmetrical distribution of the loads on the panel which produces an XY torque.

Fig. 4 shows the same results for a distance of 10 m between the protection and the solar panels. The comparison between the different positions, gives the same qualitative conclusions than the previous test. The worst positions are 1

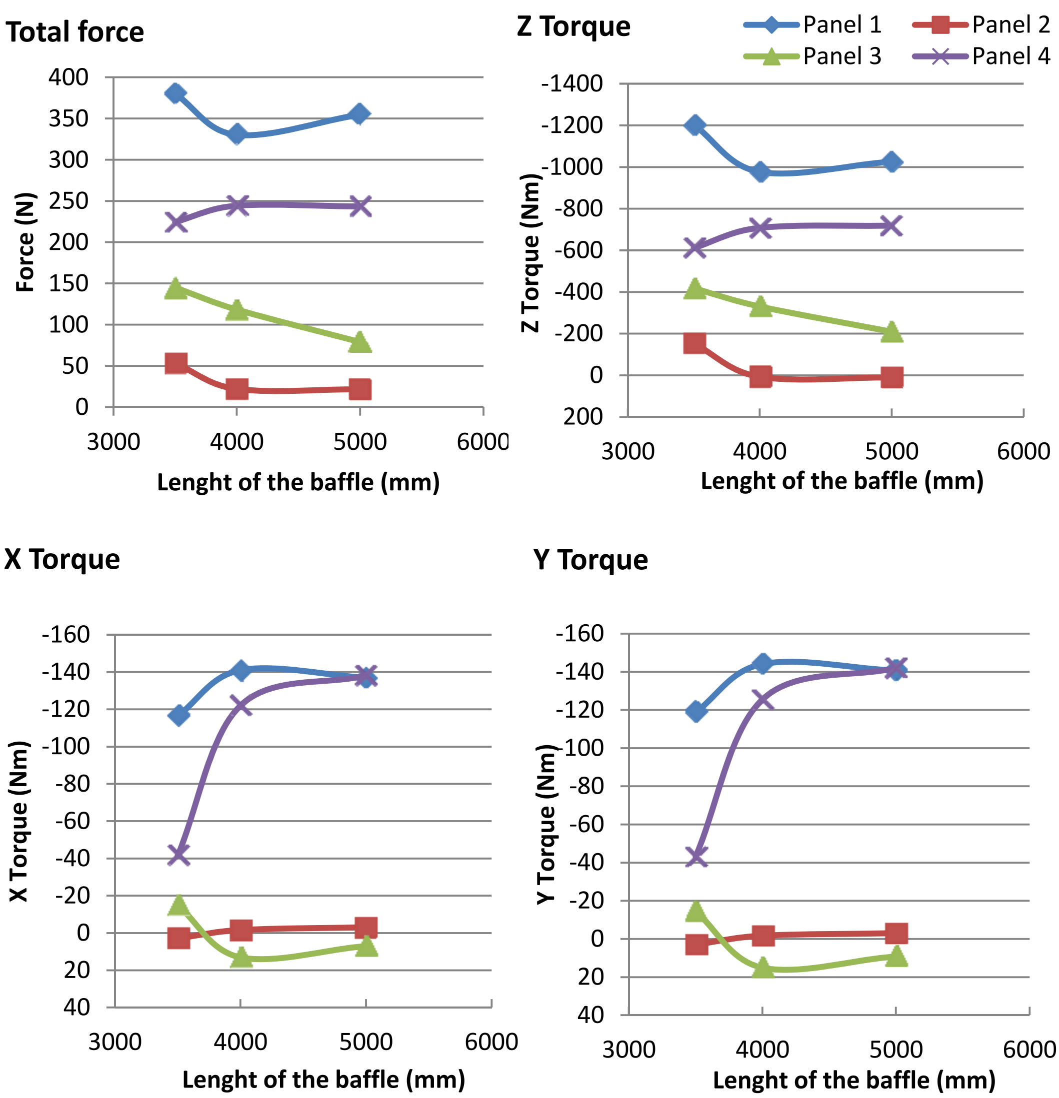

Fig. 4: Force and torque (related to the center of the solar panel) on the solar panels at the different positions. Distance between protection panel and solar field: 15 m.

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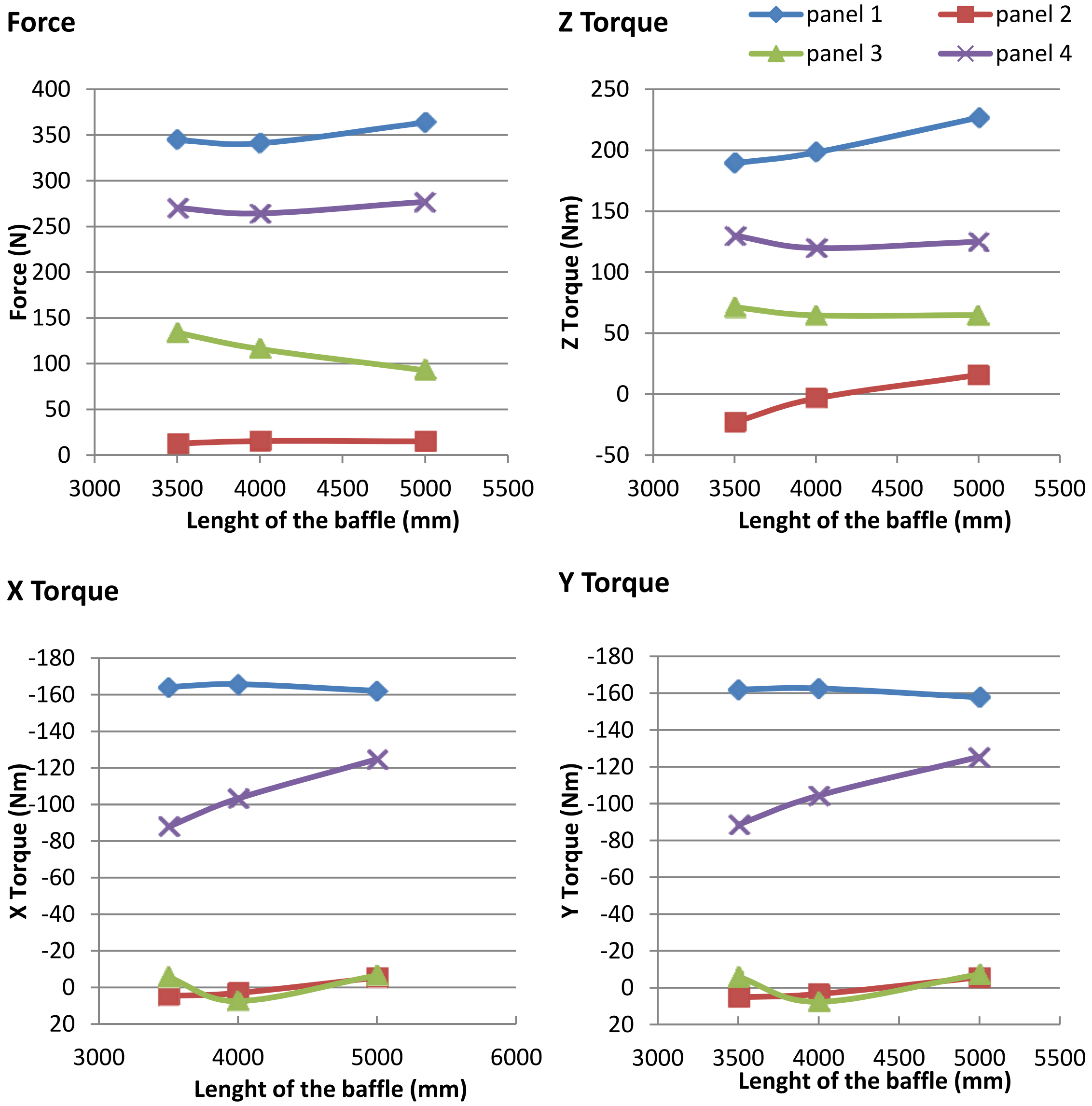

Fig. 4: Force and torque (related to the center of the panel) on the solar panels at the different positions. Distance between protection panel and solar field: 10 m.

and 4, with wind loads much higher than the other positions, better protected by the baffle.

The best position continues to be position 2 and position 3 is also well sheltered. Nevertheless, there are some differences. The first difference is that the performance of position 4 is more similar to position 1 for a distance of 10 m than for a distance of 15 m. The Z Torque is much lower for the protection closer to the solar panels array, and with opposite sense: for position 1, the torque is 200 Nm vs -1200 Nm. The opposite sense of the Z torque related to the center of the panel means a different distribution of the loads on the surfaces of the panel. For the torque related to the base of the solar panel, at the ground level, the values are negative also for the case of 10 m of distance, as expected, in the range of almost zero (position 2) to -310 Nm (for position 1). This means a 75% reduction of the torque. Thus, the position of the protection closer to the array of solar panels means a better protection for them.

IV. Conclusions and Future Work

The performed simulations show that an inclined baffle can reduce the wind loads on a solar panel array. This can be a good strategy to better the maintenance cost of photovoltaic power plants. The loads diminish one order of magnitude.

Future work should generalize these results, studying the effect of guard panel using dimensionless variables.

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