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STABILITY AND STRESS ANALYSIS OF SOLAR ARRAY STRUCTURE

Raghuvendra Singh Som[1], Rishabh Sharma[2], Harshit Tripathi[3]

[1,2,3]*Student, Manufacturing Technology, J.S.S. Academy of Technical Education, Noida (India)*

ABSTRACT

Solar energy is one of the best forms of alternative energy sources. It can cater for various power supply requirements up to a great extent and it is the need of the hour. Solar panel which is the basic building block for obtaining power supply through solar cells has a wide range of applications.Several design approaches of the supporting structures have been presented in order to achieve the maximum overall efficiency. They are loaded mainly by aerodynamic forces. International regulations as well as the competition between industries define that they must withstand the enormous loads that result from air velocities over 120 km/h. Furthermore, they must have a life expectancy of more than 20 years.In this paper the analysis of load calculation, which includes the creation of a simple CFD model using ANSA as preprocessor and ANSYS-CFX as solver to determine the pressure distribution on the solar panel area.

Keywords: Stress Analysis of solar array, stability of solar array, Analysis, Stability

I. INTRODUCTION

Nowadays the demand for clean, renewable energy sources is increasing. In order to collect solar power effectively, it is necessary to use large areas of solar panels properly aligned to the sun. A wide variety of design solutions is suggested so as to achieve maximum efficiency. The fact that these structures have to support a large area of solar panels, makes them vulnerable to wind action. Laws and regulations prescribe that such structures must withstand air velocities over 120 km/h. Competition among industries raises this limit to 140 km/h.The main load of the support structures is caused by the wind action. On the other side, a CFD model results in the pressure distribution that enables one to determine easily the required node loads. It should be noted that the solid model used in the analysis was still in a somewhat conceptualized state at the time this analysis was done, and did not include certain small connecting structures such as angled iron brackets and connecting hardware that are included in the finished structure. Furthermore, the solid model did not include wiring and electrical conduits used to electrically connect the solar panels to the charging station. Since the high stress areas are in the base of the support column and the round support plate, the lack of fidelity in the upper structure is of minor consequence. The solar panel weight is manufacturer supplied data, and includes the aluminum mounting frame.

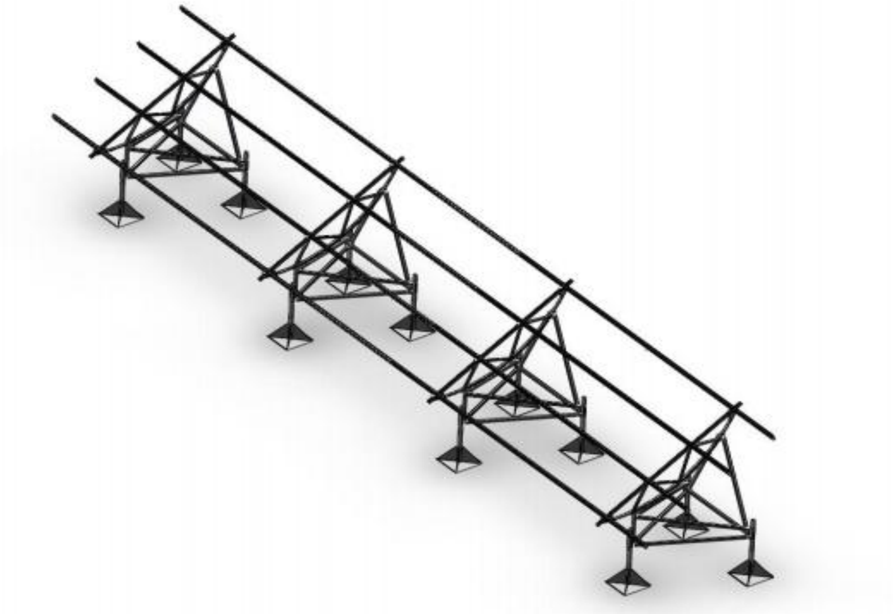

Fig 2.0 (external 3d structure for mounting of solar array)

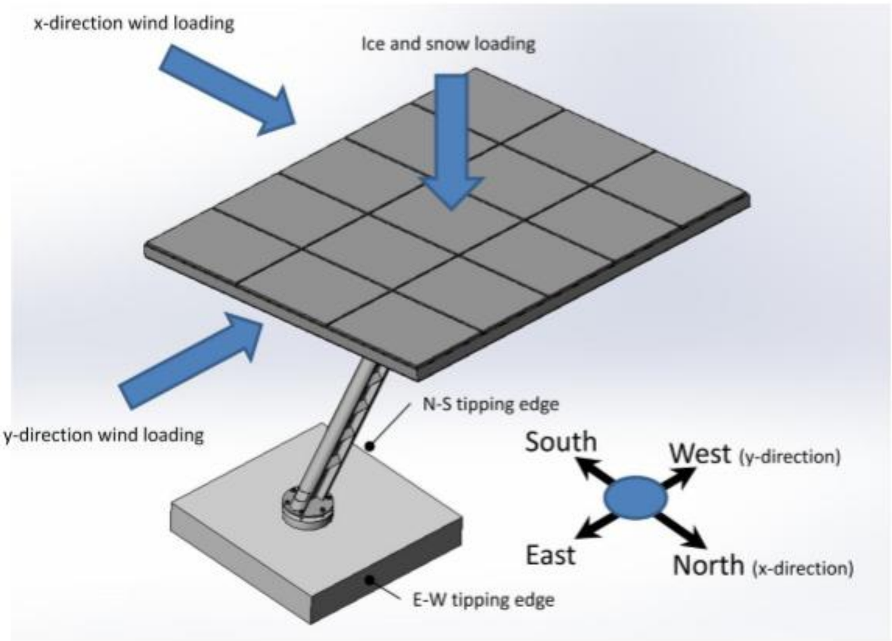

Fig 2.1(external 3d structure for a solar panel mounting)

II. STABILITY AND STRESS ANALYSIS

Wind direction is stochastic and therefore it is necessary to compute the pressure distribution for a variety of wind directions, because it is usually very difficult to estimate which one is the most critical.Wind loading acting on the solar panel mounting structure is given by equation 1:

$$F = C_d A(1/2\dot{\rho}v^2) \quad \text{…….. (1)}$$

Where:

C_d = drag coefficient of the structure.

A= frontal area acted on by the wind.

ρ̇= mass density of air.

v= wind velocity.

In this analysis, a conservative value of 2 was used for the drag coefficient, and air density was assumed to be 1.21x10-7 lb-sec2/in4, which corresponds to the air density at a temperature of 0 C. Note that the density used is the mass density and not the weight density.

Wind pressure and wind loads for the east and south directions are presented in figure 8 as a function of wind speed.

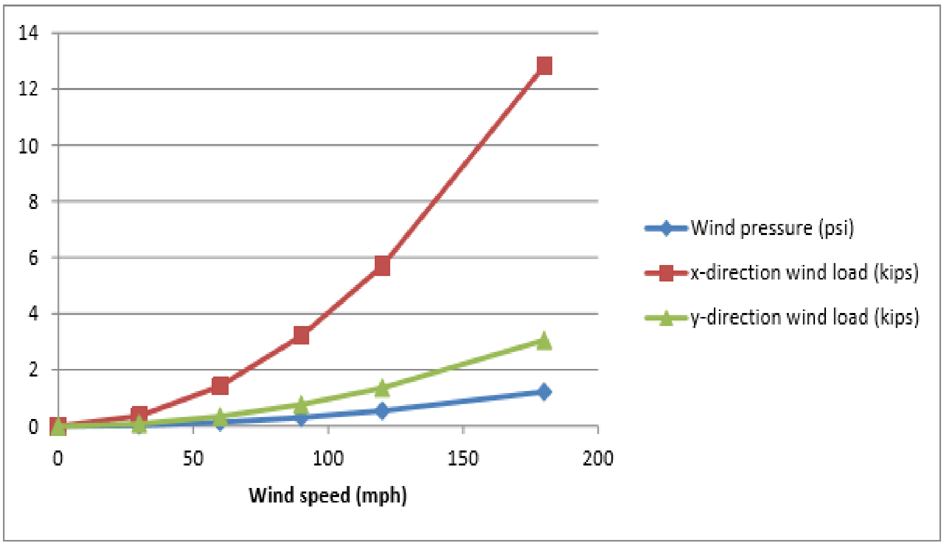

Fig. 3.1 (Wind loads vs. wind speed. The x direction corresponds to a south wind, and the y direction corresponds to an east wind)

The stability analysis assumes a wind speed of 185 kmph, resulting in a wind pressure of approximately 4.13 $kg/m^2$and a total south wind loading of 2376.82 kg and a total east wind loading of 567 kg.

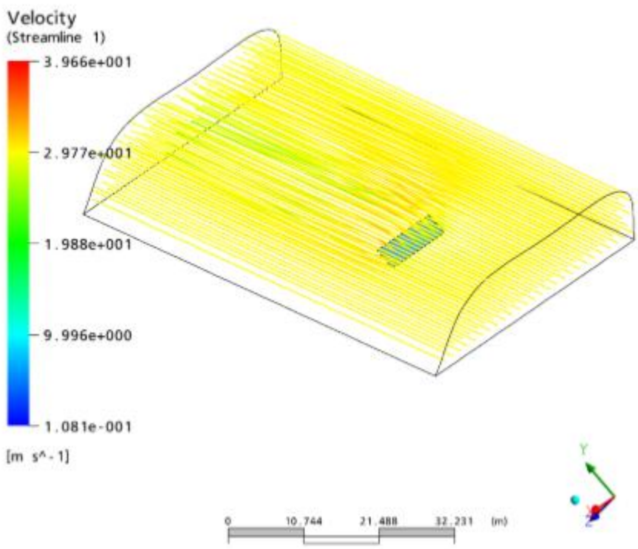

Fig. 3.2 (CFX results: Air streamlines)

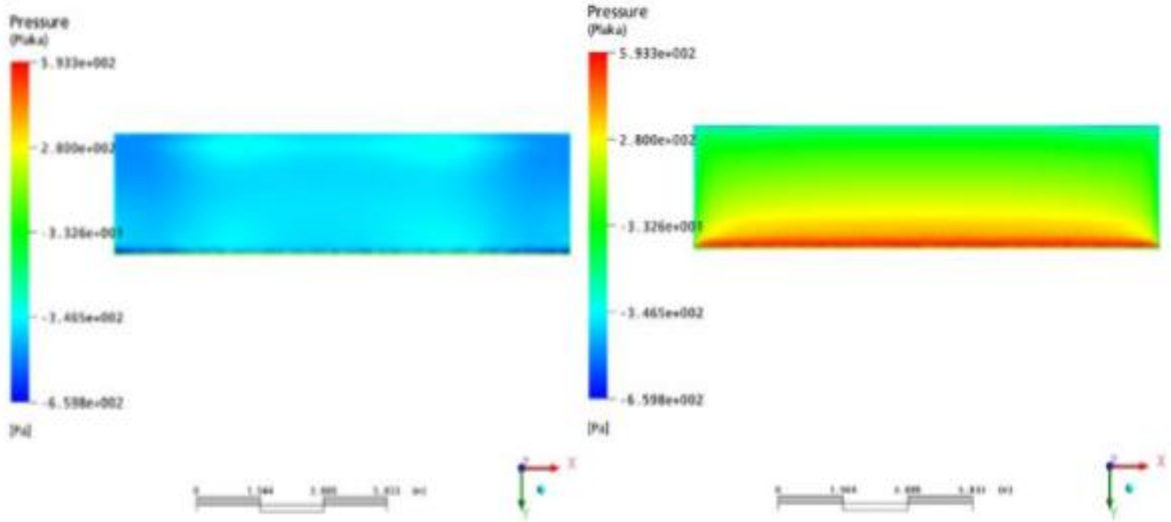

Fig. 3.3 (CFX Results: Pressure distribution on the front and the back of the plate)

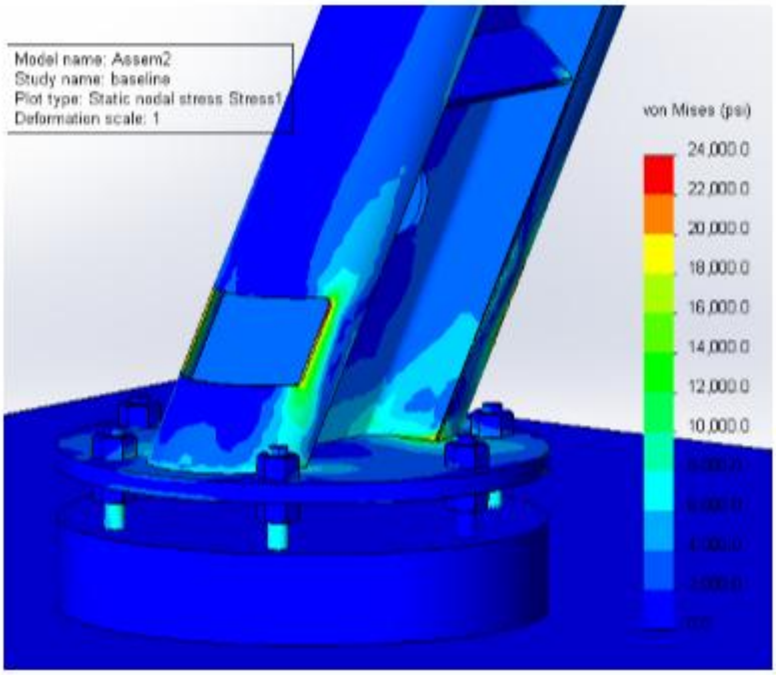

Fig. 3.4 (Von Misses stress for the baseline case)

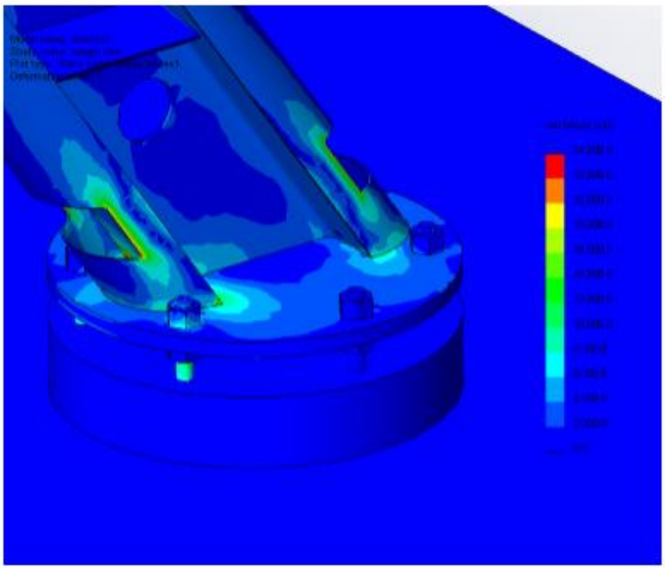

Fig. 3.5(Von Misses stress for the baseline case)

2.1 Material Properties

Material	Modulus	Poisonratio
AISI 1045 steel	206.82 GPa	0.3
Concrete	24.12 GPa	0.3
Solar panel	68.94 GPa	0.3

III. CONCLUSION

The purpose of this project was to aid Advanced Modular Power & Lighting in developing a mount for a solar panel and after much deliberation. In the aspects of design and performanceit must be have angle adjusting capabilities ranging from 0˚ to 90˚. The solar panel support structure is design optimized using computer based Finite element software ANSYS. Initial wind load calculations are carried out based on the given wind speed. Initial calculations are carried out to find critical position of loading. Calculations are done for structural members based on allowable stresses of the structure. The result shows that design could withstand in the wind speed of 185 kmph.

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