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Design and analysis of solar panel support structure

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Abstract

Nowadays the demand for clean, renewable energy sources is increasing. The use of renewable energy resources is increasing rapidly. Following this trend, the implementation of large area solar prepared is considered to be a necessity. Several design approaches of the supporting structures have been presented in order to achieve the maximum overall efficiency. They are loaded mainly by wind forces. Furthermore, they must have a life expectancy of more than 20 years. In this research paper, there is consideration about design and analysis of solar panel support structure by considering environmental effect like wind load, structural load and height of structure. The analysis can be done by using load calculation with creating model in software and followed by analysis using different software to determine pressure distribution on the solar panel area and structure. Identification of the structure critical points it can be further extend up to different material, design modification and analysis of solar panel support structure.

Keywords: *Solar panel, types of structures, literature review, wind load, structural deformation*

I. INTRODUCTION

Sun is the ultimate source of energy, almost all forms of energy is either directly or indirectly related to it. It has been saying that the energy released from sun in one second is more than that what mankind had used since the dawn of civilization. The current impetus for alternative energy sources is increasing the demand for solar energy. Solar energy is a promising type sustainable energy which is inexhaustible and abundant. Till now, we were not able to tap the full potential of this "green energy." [5]

II. LITERATURE REVIEW

A. Mihailidis et al. [1] represented the analysis of two different design approaches of solar panel support structures.

- Fixed support structure design.
- Adjustable support structure design.

They did analysis according to the following steps. 1) Load calculation, 2) Analysis of the structure, which includes the creation of a Finite element model using ANSA as preprocessor. Loads calculated in the first step are applied to the model. As solver MSC Nastran is used.3) Identification of the structure critical points. According to the results weak points are redesigned in order to increase the end. **Jinxin Cao et al.** [2] performed a wind tunnel experiment to evaluate wind loads on solar panels mounted on flat roofs. In order to find module force characteristics at different locations on the roof they use solar array which were fabricated with pressure taps. They consider two different cases 1] single array, 2] multi-array and find mean and peak module force co-efficient. **Chih-Kuang Lin et al.** [3] use FEA approach to find the effects of self weight and wind loads on structural deformation and misalignment of solar radiation. They consider distribution of stress and deformation with wind speed 7 and 12 with various blowing directions including gravity. **AlyMousaadAly et al.** [4] built testing models of large civil engineering structures at geometric scale 1:500 to 1:100. **Alex Mathew et. al**. [5] Worked on design and stability analysis of solar panel support structure made out from mild steel. The result shows that the solar panel support structure can able to sustain a wind load with velocity 55 . **Georgeta Vasies et al**. [6] presented Numerical simulations for analysis of wind action on solar panels located on flat roofs with and without parapets. Numerical simulations are performed in ANSYS CFX, Presence of the parapet help mitigate the wind loads, and average pressure is up to 18.6% lower that for solar panels placed on flat roof without parapet. **Girma T. Bitsuamlaka et al.** [7] presented the aerodynamic features of ground-mounted solar panels under atmospheric boundary layer **Vijay B. Sarode et.al.** [8] represented the design and optimization of solar panel support structure which is made up form steel. They proposed to introduce latest FEA knowledge and concepts to work on this sector to provide a detail optimized design.So they had created the model in PRO-E software.

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III. LOAD CALCULATION

Vb= Basic wind speed= 180 km/hr=50 m/s;

Design wind speed, Vb= 57.8908 m/s

Design wind pressure, Pz = 2114.8781 N/m^ (2)

Wind load on plate of structure,

Wind load on plate, F = 40,167 N.

Wind load on front column, F= 366.042 N

Wind load on rear column, F= 797.305 N

IV.MODELLING OF STRUCTURE

Name of dimension	Value
Height of structure	3000 mm
Width of structure	6736 mm
Depth of structure	2000 mm
Tilt angle	30˚
No. of solar panel contained	16 panels
Diameter of column	200 mm

Table [1]: Dimensions of solar panel support structure

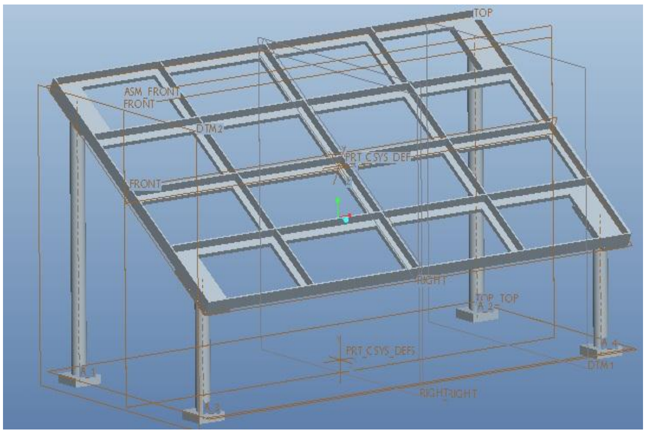

Fig [1]: 3-D Model of support structure in Pro-E software

V. ANALYSIS

Steps of analysis is given

Mesh generation:

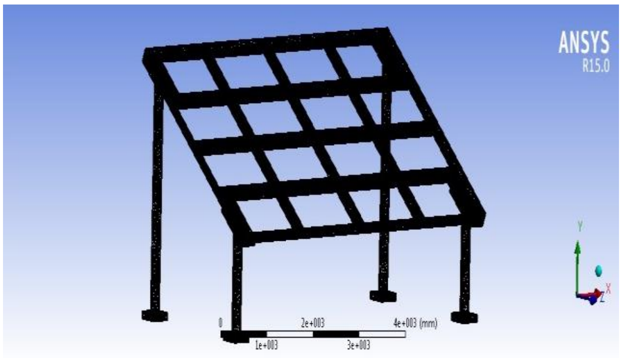

Fig [2]: Meshing in ANSYS

Mesh type	Medium
Node	351261
Elements	185660

Table [2]: Meshing information of structure

After meshing the next step is giving values of forces which are imposed on structure by wind and applying boundary condition. According to the objective of project I consider wind load for two directions.

- For normal direction
- For opposite direction.

- **For normal direction of wind:**

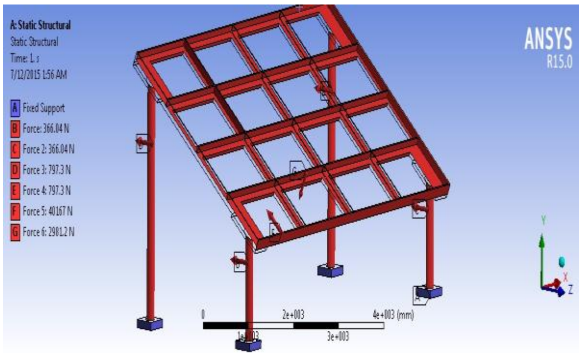

Fig [3]: Boundary condition of structure (wind direction= normal)

- **For opposite direction of wind:**

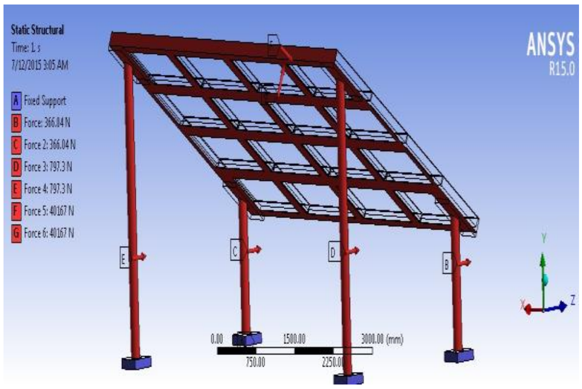

Fig [4]: Boundary condition of structure (wind direction=opposite)

- **Analysis for normal direction:**

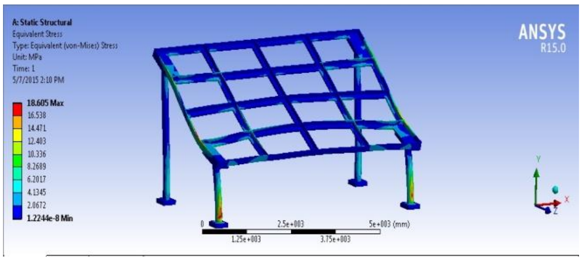

Fig [5]: Stress in structure

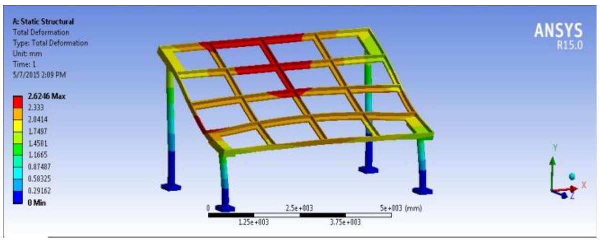

Fig [6]: Total deformation in structure

	SS400		A6000 T5		GRP	
	Normal		Normal		Normal	
	Max.	Min.	Max.	Min.	Max	Min.
Stress (MPa)	18.605	1.2244*10^(-8)	18.605	1.2244*10^(-8)	19.892	3.732*10^(-8)
Deformation (mm)	2.6246	0	2.6246	0	2.9835	0

Table [3]: comparison of software result

	SS400		A6000 T5		GRP	
	Opposite		Opposite		Opposite	
	Max.	Min.	Max.	Min.	Max	Min.
Stress (MPa)	37.943	2.2852*10^(-8)	37.92	2.4884*10^(-8)	39.583	3.921*10^(-8)
Deformation (mm)	1.9797	0	5.5584	0	5.9852	0

Table [4]: comparison of software result for opposite wind direction

➢ <u>3-D model of support structure:</u>

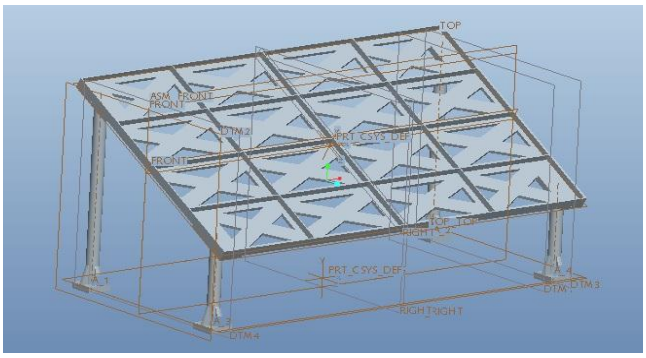

Fig [7] : Modified structure

<u>Analysis:</u>

➢ Analysis of modified solar panel support structure is given below,

- ➢ Analysis of structure made out from,
  - ➢ SS400 (Structural steel)
  - ➢ A6000 T5 (Aluminum alloy)
  - ➢ Glass reinforced plastic (GRP)

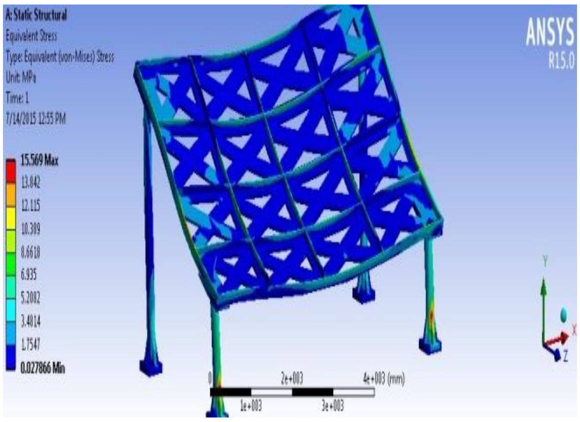

Fig [8]: Stress in modified structure made up from SS400 (Wind direction= normal)

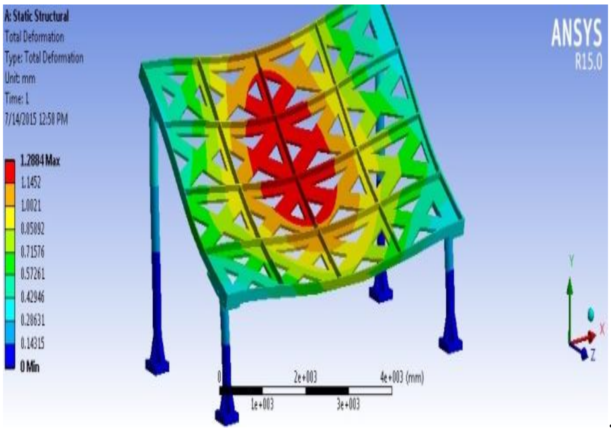

Fig [9]: Total deformation in modified structure made up from SS400 (Wind direction= normal)

	SS400		A6000 T5		GRP	
	Normal		Normal		Normal	
	Max.	Min.	Max.	Min.	Max	Min.
Stress (MPa)	15.569	0.027866	17.987	6.3792*10^(-8)	18.211	6.379*10^(-8)
Deformation (mm)	1.2889	0	2.6246	0	5.1123	0

Table [5]: Comparison of software result for normal direction

	SS400		A6000 T5		GRP	
	Opposite		Opposite		Opposite	
	Max.	Min.	Max.	Min.	Max	Min.
Stress (MPa)	17.930	6.653*10^(-14)	20.085	6.6499*10^(-14)	18.982	6.6419*10^(-14)
Deformation (mm)	1.2889	0	4.1658	0	4.9823	0

Table [6]: Comparison of software results of modified structure for opposite wind direction

CFD Analysis:

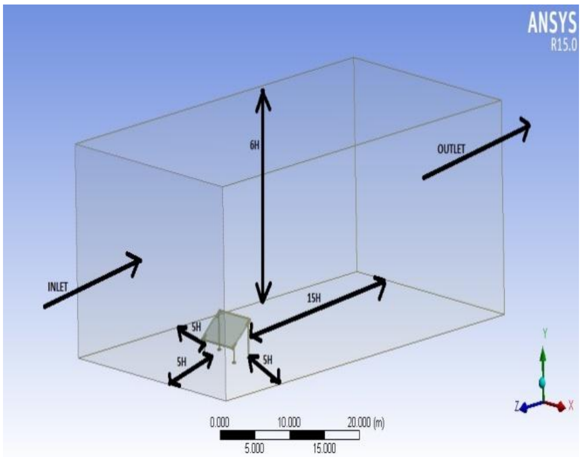

Fig [10]: Enclosure for analysis for normal wind direction

[H = Height of structure = 2500 mm]

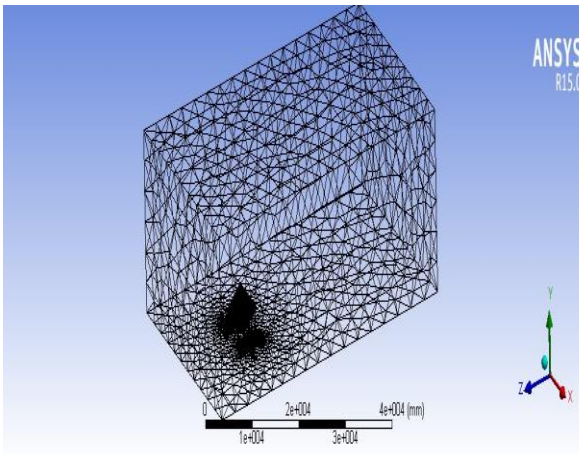

Fig [11]: Meshing in structure (wind direction= normal)

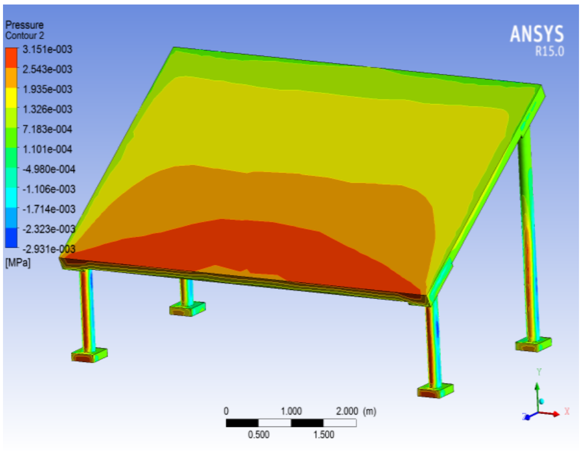

Fig [13]: Contour of pressure (wind direction= normal)

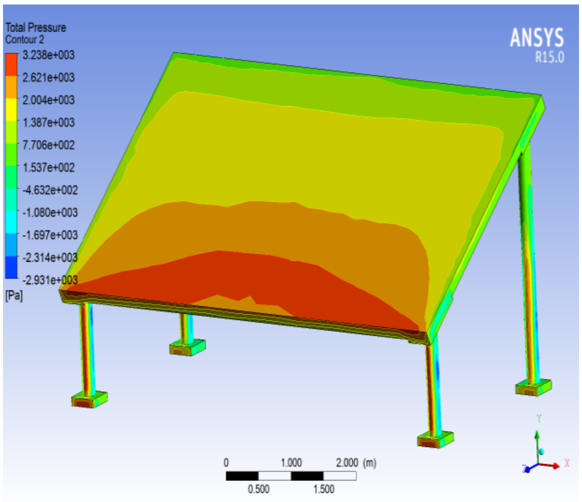

Fig [14]: Contour of total pressure (wind direction= normal)

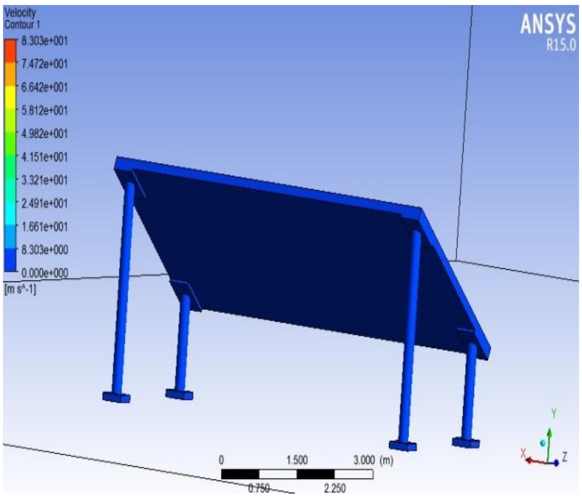

Fig [15]: Velocity contour (wind direction= normal

	Pressure (Pa)		Total pressure (Pa)		Velocity (m/s)	
	Min.	Max.	Min.	Max.	Min.	Max.
Normal	-2.931 * e+3	3.151 *e3	-2.931 * e3	3.238* e3	0	8.312 *e1
Opposite	-5.925 * e3	3.178* e2	-5.925 * e3	4.478* e2	0	8.303 *e1

Table [7]: Comparison of CFD software result for normal wind direction

VI. CONCLUSION

- For solar panel support structure the upper area of plate is the main region for failure in solar panel support structure so to overcome that problem there is a modification of structure is carried out
- After modification stress and deformation is decreased in structure and GRP is suitable material for support structure of solar panel because GRP has low price than SS400 and aluminum alloy (A6000 T5). GRP is 225 Rs/kg and it is quite less than recently used material.

VII. REFERENCES

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