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# Design and analysis of solar panel support structure – A review Paper

**GadhaviAkash G.[1],Dipesh D. Kundaliya[2],**

[1] PG Scholar, CAD/CAM, V.V.P Engineering Collage, gadhaviakash@gmail.com

[2] Assistant Professor, Guide, V.V.P. Engineering College, ddkundakiya@gmail.com

***ABSRACT***

*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 review 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]

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. [1]

Solar panels convert the suns energy into usable forms. Solar panels can be a certain kind of device that attracts the sun to use the sun to power machinery that can transfer the heat from the sun into whatever they need. Solar panels can be different shapes and sizes but their main purpose is to convert the light in order to make electricity. Solar panels can be found in all different shapes and sizes including round, square, and rectangle.Since things have changed and newer material has surfaced and since we know more about the solar panels the cost is not as high, although it is still higher than using man made methods of producing heat and electricity. As long as the sun shines solar panel will provide power.

1]Reducing the Financial Costs of Electricity.
3] Generating Energy Independence.
4] Solar Power Reduces Air Pollution from Coal Power Plants.
5] Conservation of Resources.

Photovoltaic solar panels are the major components of the systems providing power generation. Electrical power generation through photovoltaic conversion provides clean, safe and efficient way of supplying energy. [2] The technology of solar arrays includes the optimization of structural platforms, lightweight array frames, innovative deployment systems and higher efficiency photovoltaic components.The existing types of technology, methods of installation, and mounting locations (ground, roof, or integrated with the building envelope) vary significantly, and are consequently affected by wind loads differently.

## 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.

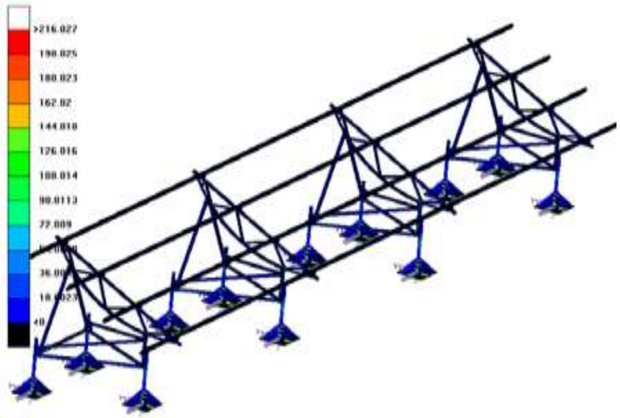


**Figure [1]:- Stress in fixed design [1]**

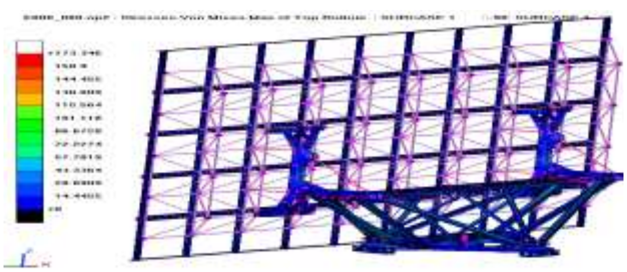


**Figure [2]:- Stresses in adjustable design [1].**

**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. They also find effect of mean module force co-efficient on design parameter of solar panel. They found effect of mean module force co-efficient on design parameters (tilt angle, height) of solar panel. The results show module force co-efficient for single array cases is larger than multi array cases.

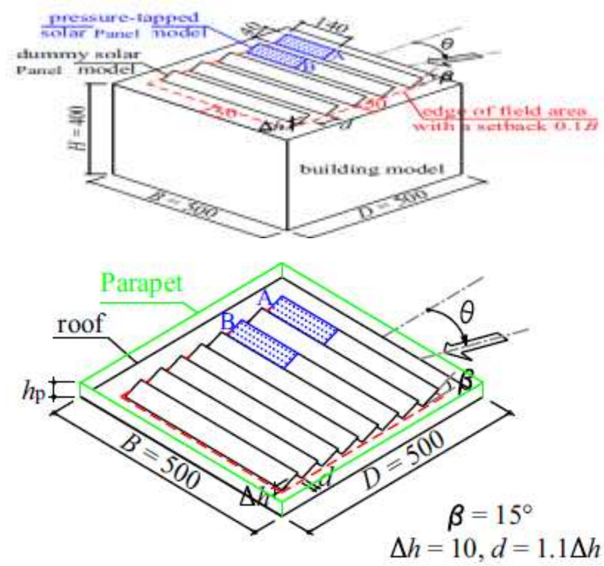



**Fig [3]. Solar panels without parapet [2] solar panels with parapet [2]**

**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 $7ms^{-1}$ and 12 $ms^{-1}$ with various blowing directions including gravity. The result shows that this CAE technique is applicable for designing a reliable and efficient tracking photovoltaic system. Highly stressed regions are located at bushing and ball bearing & according to von-mises criterion there is no structural failure for given photovoltaic system. The result also indicate displacement and angular displacement increase with an elevation angle for wind directions at $0^0$ ,$30^0$, and $60^0$ but it will started decrease with wind direction of $120^0, 150^0,$ and $180^0$

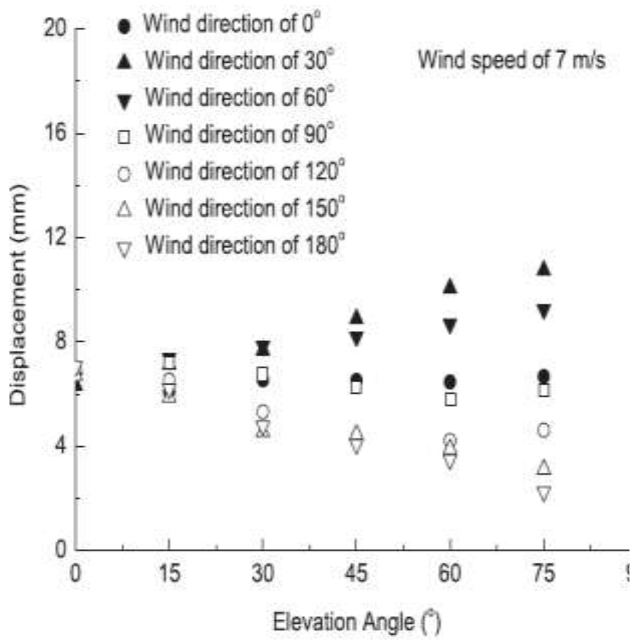



**Fig [4]: Displacement Vs elevation angle (wind speed= $7ms^{-1}$)[3]**

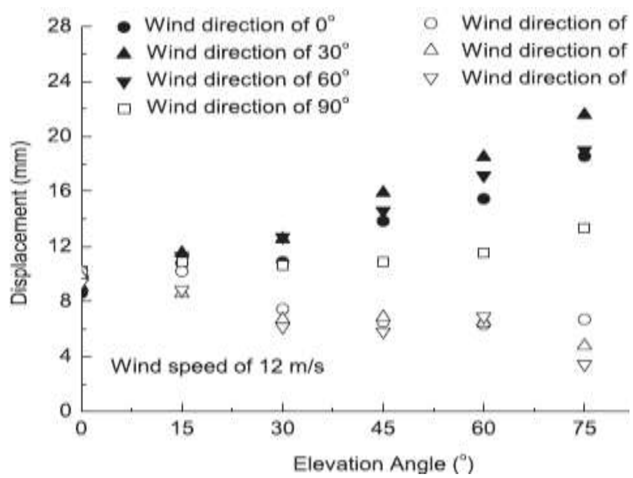



**Fig [5]:Displacement Vs elevation angle (wind speed= $12ms^{-1}$)[3]**

**AlyMousaadAly et al.** [4] built testing models of large civil engineering structures at geometric scale 1:500 to 1:100. They were producing an aerodynamic model of solar panel subjected to wind load and mounted on ground. Testing can be carried out experimentally (in boundary layer wind tunnel) and numerically (by computational fluid dynamics) at different geometric scale. The result shows that for very small size solar panels are having different mean loads as they are located very close to ground.

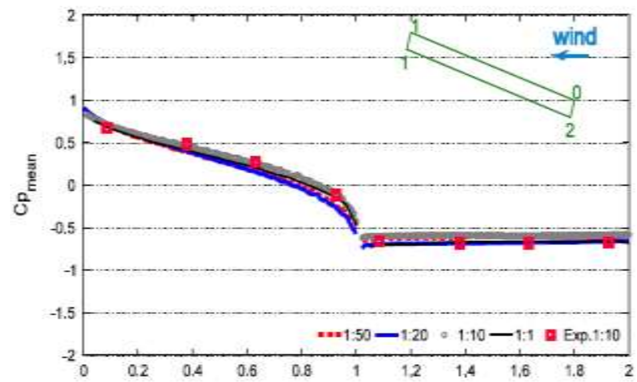



**Fig [6]: CFD mean pressure coefficients on a center line going over upper and lower surfaces for scales1:50, 1:20, 1:10 and 1:1 along with data from a physical BLWT experiment carried out on a 1:10 scaled model.[4**

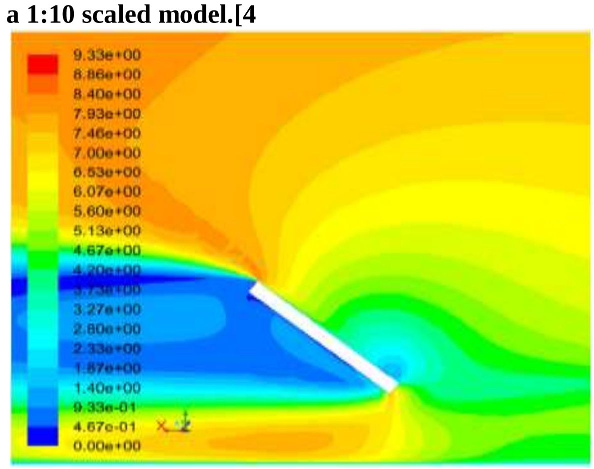


**Fig [7]:Contour plot of CFD mean velocity (m/s) around a model scaled 1:50.[4]**

**Alex Mathew et. al**. [5] Worked on design and stability analysis of solar panel support structure made out from mild steel. They conducted this work as a part of project of Mahindra Reva Ltd. Named as "solar 2 car". The result shows that the solar panel support structure can able to sustain a wind load with velocity $55ms^{-1}$. They calculated required amount of weight to withstand wind load for different wind zones without any holding arrangements and then after optimization can be done for easy assembly, dismantle and transportation

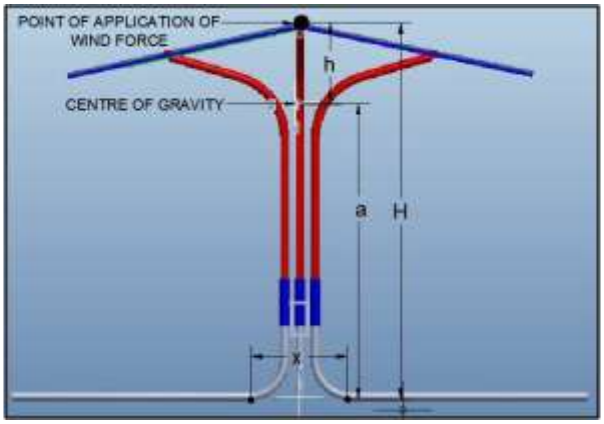
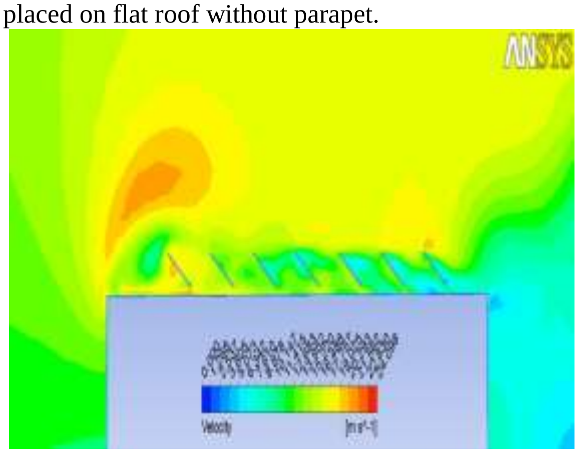



**Fig [8]: CAD Model of solar panel supporting structure with parameters in CREO software. [5]**

**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, for an incidence wind angle of 45°.they are watching that Oblique direction of wind generating high intensity of uplift forces in the corner areas of the flat roof, forces which bring an additional load on support systems of solar panels. 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.




**Fig[9]: central zone of solar panels rows, for building without parapet.[6]**

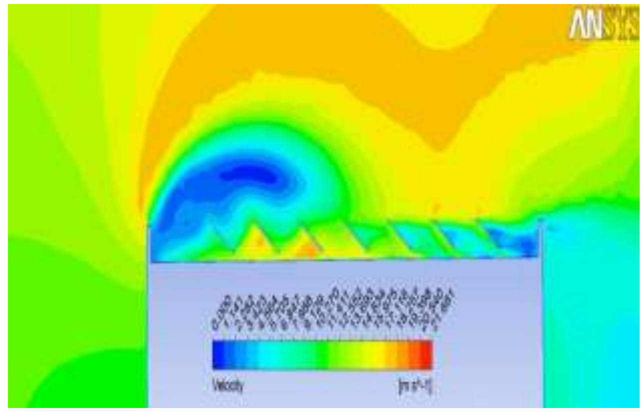



**Fig [10]: Central zone of solar panels rows, for building with parapet [6]**

**Girma T. Bitsuamlaka et al.** [7] presented the aerodynamic features of ground-mounted solar panels under atmospheric boundary layer. They did four different test cases to determine the wind effects on stand-alone ground mounted solar panels differing from one another by wind angle of attack and number of panels. They verified that there is reduction in wind loads on the adjacent solar panel when they are arranged in tandem. After that they were conclude that 'the solar panels experienced the highest overall wind loads for 180° wind angle of attack'

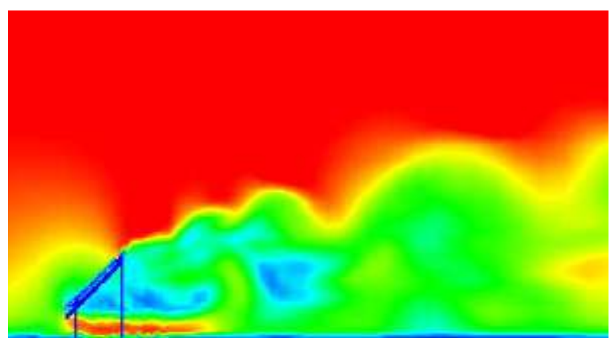


**Fig [11]: mean velocity contours for $180^0$ angle of attack [7]**

**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. They were doingAfter creating model of support structure they did analysis of structure by choosing different cross-section and they got best structural design by optimization.

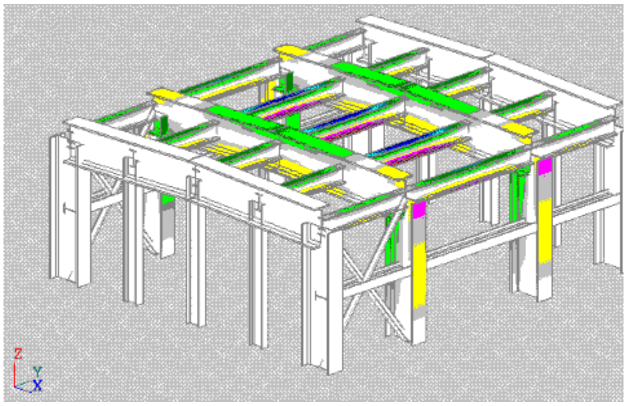


**Fig [12]: PRO-E model [8]**

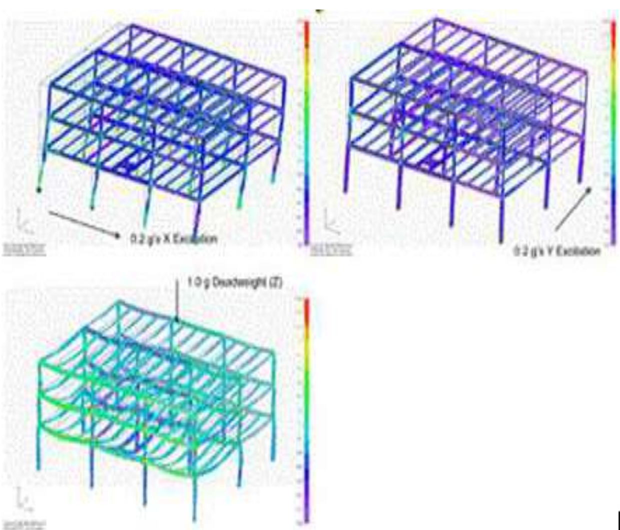


**Fig [13]: Deflection with different cross-section [8]**

## III. Procedure for finding design wind load:-

- Mainly the solar panel support structure is placed in environmental condition so they are mainly subjected to wind load.
- According to IS-875(part-3)- 1987 procedure for finding wind load is as given below**,**

1] Design wind speed,
$V_b$= Basic wind speed,
$k_1$ = Risk co-efficient (it is finding by formulae given below);

$$k_1 = \frac{A - B[\ln\left\{\left(\frac{-1}{N}\right) * \ln(1 - P_N)\right\}]}{(A + 4 * B)}$$

Where,

A, B=Co-efficient values for different basic wind speed;

N = Design life of structure in years = 50 years;

PN = Risk level in N consecutive years, Nominal value =0.63;

$k_2$ =Terrain height & structure size factor;

$k_3$ = Topography factor;

2] Design wind speed, $V_z = V_b * k_1 * k_2 * k_3$;

3] Design wind pressure, $p_z = 0.6 * V_z$;;

4] If structure having rectangular cross section then,

Design wind load,

$\mathbf{F = (C_{pe} - C_{pi}) * A * p_z}$;

Where,

$C_{pe}$ = External pressure co-efficient;

$C_{pi}$ = Internal pressure co-efficient;

A = Surface area of structure element;

$P_z$ = Design wind pressure.

5] If the structure is having component of circular cross-section then,

Design wind load**,** F = $C_f$ * Ae * Pa ;

Where,

Cf = Force co-efficient;

Ae = Frontal area of building or structure, Pa = Design wind pressure;

## IV. 4] Conclusion:-

Solar panel support structure experiences a load which is imparted by wind during its service life.Presence and absence of the parapet is also affect performance of solar panels placed on flat roof. So the location of mounting of solar panel support structure also affects its performance.

Thedeformation occurs at corners of support structure. The maximum stress appears at accessorial and jointed parts of structure FEA Results of Conformal matches with the theoretical calculation so FEA is a good tool to reduce time consuming theoretical Work and also reduce costly experimental work.

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