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Different types of loads acting on Solar Structure – A review paper

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Abstract – *Solar structure plays an important role in stability of a solar power plant. The solar structure has to withstand different types of loading conditions and bear the weight of photo-voltaic panels. This study reviews few papers and standards that a structure should be designed. If the structure is not designed considering all loading factors, then it can lead to breakage of structure which intern will affect the power generated. Also the structure should withstand the loads until the service life span of plant.*

1. INTRODUCTION

Many countries are now moving towards renewable source of energy for power generation. Solar energy is emerging as one of the prominent source of energy.

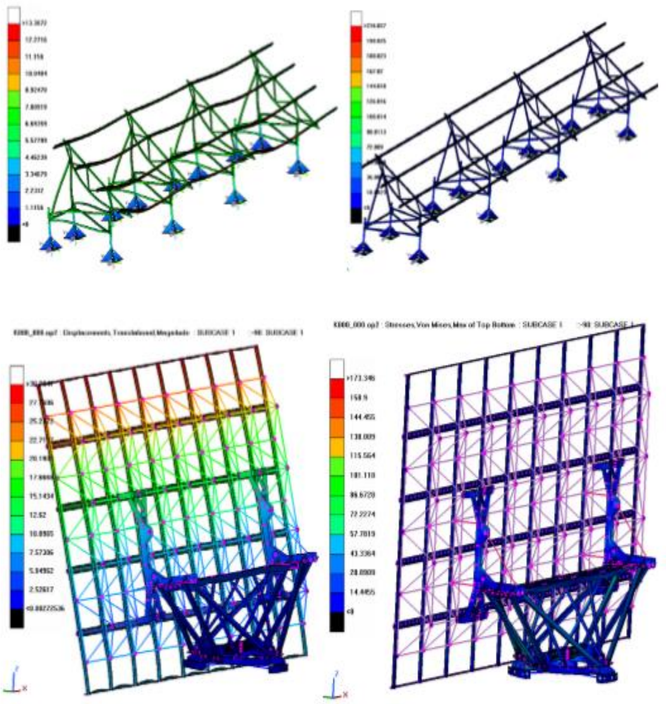

Fig -1: Shows stress and deflection due to self & wind load on solar structure [1]

One of the main component of such plants is the structure. If the structure fails, then the entire plant will shut down. Thus structure is designed to withstand different loading parameters. The wind speed during cluster areas is 30-40 km/hr, but it can reach to about 180 km/hr during cyclone condition. These winds induced forces on the panels thereby increasing the load on the structure. The structure should be designed for a life span of 20 years. In certain cases, the panel is tilted as per the position of the sun for attaining maximum efficiency. For such application different mechanisms are to be used in a structure to facilitate the motion and the torque induced. [1]

2. LITERATURE REVIEW

Mihailidis et al. Analysis of solar panel supporting structure is studied in this paper. Finnie Element Method (FEM) is used to calculate the stresses acting on the supporting structure. The two main types of solar structure, fixed and adjustable are studied in this paper. In this paper, the fluid dynamics of air acting on the structure are studied. A resultant force acting on the panel is calculated. The FEA analysis is performed in NASTRAN solver. The stresses on different members of the structure are studied in this paper. In addition, a comparison of a fixed and adjustable structure is studied. [1]

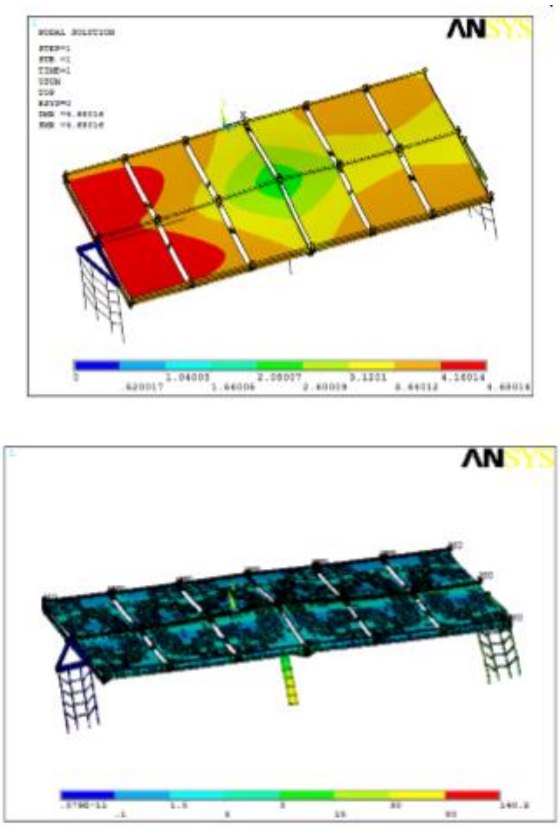

Fig -2: shows stress due to wind load [1]

Dr. N. M. Bhandari et al. has provided detailed wind load calculations on buildings and structures. The action of wind forces provides an additional live load on the building or structure. The wind speed can be determined from different wind zones mentioned in the standards. High speed winds due to cyclones or particular zones can lead to damage of a building/structure. The wind speed and its fluctuations plays an important role in designing flexible structures. Also the natural frequency plays an important role in stability of the structure. As the wind passes over the panel & structure, it creates high and low pressure bands which is responsible to produce lift and drag forces on the panels.

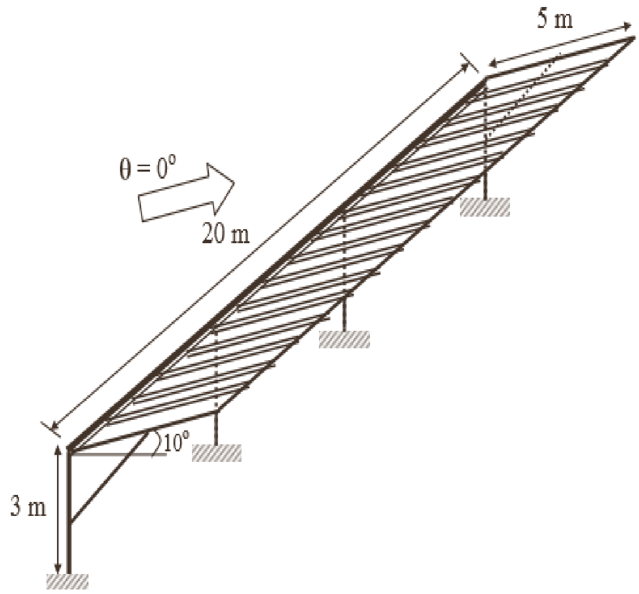

Fig -3: Wind load acting on tilted solar structure [2]

The obstructions present in the path of the structure plays a significant role in increasing or reducing the wing forces. Barrel land produces more wind speed and an obstruction reduces the wind speed. Also the location of the structure from sea level plays important role in reducing or increasing the wind force. The total height of the structure helps to determine flexibility and dynamic response of structure. With the increase in height, the flexibility of the structure reduces. The tall structures are prone to failure due to fluctuations caused due to wind forces. Such kind of structure experience random vibrations. Slenderness is an important factor considered in such tall structures to withstand vibrations.

Experimental setup is the most promising test to determine the actual wind pressure, but it is impossible to develop a practical setup in a real word scenario of such huge structure. This is where coefficient factors and computational means are applied to convert the wind speed into pressure. There are different standards depending upon the country and the wind zone locations which use various factors such as, location, height, etc. to convert the wind speed to pressure value. Also recently companies and researchers also relay of computational means for same. The engineering that focusses in such domains is called computational fluid dynamics and one can use Finnie Element Method (FEM) to calculate the pressure points. [2]

Dr. Sudhir K. Jain, et al. has provided a draft report on Indian seismic codes IS 1893 (Part 1). The earthquake analysis is called response spectrum analysis, seismic analysis or time history analysis. The vibrations are related to spectral power, hence it is called spectrum analysis. The vibrations are plotted in a particular format such as acceleration versus time or displacement versus time, called seismic data. The earthquake is generated depth below the earth's surface and the movement in the earth's crust are felt on the earth's surface. The vibrations produced are considered in three axis, one horizontal axis and two lateral axis. The mass of the structure plays an important role in determining the stability of the structure. More the mass, more stable is the structure.

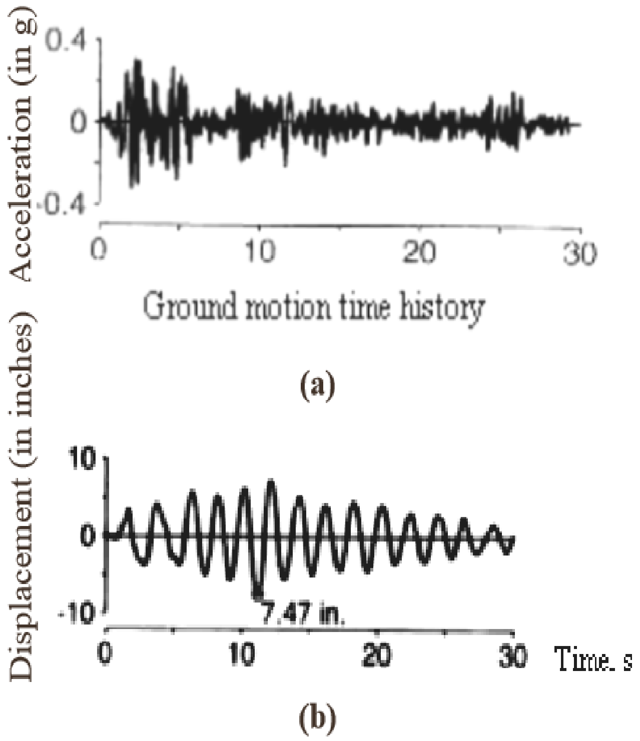

Fig -4: Shows acceleration and displacement data versus time [3]

The instrument use to record the vibrations is called accelerogram. Generally a time duration of thirty seconds is considered for accelerogram. The data can be obtained in the form of acceleration, displacement or velocity versus time in seconds. Each region is divided into particular zones with respect to the seismic activity in that particular area. Storey drift (deviation of one floor to another) is most important output parameter that is studied. The type of soil also plays an important role in in increasing and decreasing the amplitude of vibrations. A strong foundation increases the stability of the structure. [3]

Savana M. et al. Buckling analysis of solar panel supporting structure is carried out in this paper. From this paper, we can conclude that the stability of a structure depends on various factors such as sectional properties, sectional arrangements, and modelling of structure. The cross section of structure plays an important role in stability of the structure. I section is more stable but it's not economical. C section is also quite stable and economical too. The major load bearing members of a structure is the purlin. The major factor for transfer of wind loads is the inclination of panels. Five types of models are considered in this paper and static linear and buckling nonlinear analysis is performed on the structure. [4]

Ravindra Naik et al. Following are the conclusions that can be drawn from the paper. [5]

1. The force produced on the solar panels due to wind is directly proportional to the wind speed.
2. The force acting on the structure depends on the area projected. The area which comes in contact with wind plays an important role in loading of structure.
3. The different types of load that act on a solar structure are wind, self-weight and panel weight.
4. Drive torque loading due to movable solar structure is also considered in this study.
5. Two solvers are considered best for FEA analysis, they are HYPERMESH and ANSYS.
6. Optimization tool is used to reduce the total weight of structure. This helps to reduce the cost and self-weight of structure.

Louis Cattaneo et al. This documents deals with Wind, Earthquake, Snow, and Hail Loads on Solar Collectors. In this document, wind load is considered as per built of the structure. The structure of the build plays an important role in determining the amount of pressure acting on the surface. The coefficient of pressure also depends upon the location of panel. The area under influence and drag and lift forces play a major role in pressure acting on panels. During snow loading, the angle of the roof plays an important role in the accumulation of snow. The roof should be such that there is least snow accumulation. [6]

3. CONCLUSIONS

After referring the above papers, following conclusions can be drawn –

1. The first load that acts on structure is the self –weight of the structure. The general material used for structure is steel. The density of steel is 8000Kg/m3. Thus the base members experience the load of members above it. Also if the pre-stresses are higher in a component, it increases the chances of failure and reduced fatigue life

2. The second load is the live load that acts on the structure. The component that is mounted on the structure correspond to live load. The component may or may not be important but is the permanently mounted on the structure. In this reference, the weight of Photo-voltaic panel acts as a live load on the structure.

3. Imposed wind load in upward direction – The wind produces two kinds of forces on the panels as it moves. First type produces a lift force on the panel and the other produces drag force on the panel. The upward forces tries to lift the panel and thus the members supporting the panel bear the major load. The general practice is to convert the wind speed into pressure value for small scale systems. For large systems, the pressure value is multiplied by various factors such as topology factor, obstruction factor and height of system. IS 875 part 3 provides complete guide to convert wind force to pressure value.

4. Imposed wind load in downward direction – The downward force produced by the wind is taken up by the complete structure. Usually the structure is tested for both, the upwards and the downward loads.

5. Earthquake loading – After referring the above papers we found that earthquake activity is different in different zones and thus each area has a seismic activity graph. Seismic activity graph is the movement of the earth's surface with respect to time. The device that measures it is called accelerogram. The movement of the earth's surface is converted into velocity, displacement for acceleration graph. The analysis is carried out in all three axis x, y and z and the results are summarized in to one. Earthquake analysis plays an important role as the study deals with breakage of the system.

6. Loads due to torque and moments – There are three types of solar structures. Stationary, Single axis and Dual axis. The solar panel can tilt as per the position of sun. The position of sun changes seasonally and during the day. When the panel follows any one position (with respect to sun movement), it is called single axis and when it follows both positions (with respect to sun movement), it is called Dual axis. During tilting motion of the panel, additional motors and drives are attached to the system. This increases dead weight and loads due to motion of rotating parts.

7. Snow loading – In India only a small region experiences snow and thus snow loading is applied in few northern parts of India. A specific height of snow layer such as 3-4 feet is assumed to be sitting on the panel. The weight of sitting snow is calculated and applied as dead load.

8. Miscellaneous loading – There are few loads such as load combinations, transportation loading, fatigue loading. These loads may or may not occur continuously on a structure. These loads may or may not be taken for designing structure.

REFERENCES

[1] Mihailidis, K. Panagiotidis, K. Agouridas, 'Analysis of Solar Panel Support Structures', 3rd ANSA & μETA International Conference, September 9-11, 2009 Olympic Convention Centre, Porto Carras Grand Resort Hotel, Halkidiki Greece.

[2] Dr. N.M. Bhandari, Dr. Prem Krishna, Dr, Krishen Kumar, 'An Explanatory Handbook on Proposed IS 875 (Part3) Wind Loads on Buildings and Structures', IITK-GSDMA-Wind06-V3.0.

[3] Dr. Sudhir K Jain, Dr C V R Murty, 'Proposed Draft Provision and Commentary on Indian Seismic Code IS 1893 (Part 1). IIT-GSDMA-EQ05-V4.0.-

[4] Sayana M, Megha Vijayan, 'Buckling Analysis of Solar Panel Supporting Structures', SSRG International Journal of Civil Engineering (SSRG - IJCE) – Volume 3 Issue 8 – August 2016.

[5] Ravindra Naik, Vinayakumar B. Melmari, Adarsh Adeppa, 'Analysis and Optimization Solar Panel Supporting Structures Using F.E.M, International Journal of Engineering and Innovative Technology (IJEIT), ISSN: 2277-375, Volume 2, Issue 7, January 2013

[6] Louis Cattaneo, James Robert Harris, Timothy A. Reinhold, Emil Simiu, Charles W.C. Yancey, 'Wind, Earthquake, Snow, and Hail Loads on Solar Collectors', National Engineering Laboratory, U.S. Department of Commerce, National Bureau of Standards, January 1981

[7] IS 800:2007, Indian Standard, General Construction in Steel – Code of Practice

[8] IS 875 1987, Indian Standard

[9] IS 1893 (Part 1) 2002, Indian Standard, Criteria for earthquake resistant design of structures, Part 1 General Provisions and Buildings, Fifth revision ICS 91.120.25