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Solar Roof Top System Structure Analysis and Its Cost Optimization

Aditya Gulalkari[1], Prajwal Kalmegh[2], Chinmay Bokey[3], Anurodh Patil[4], Tushar Mohod[5]
[1,2,3,4]*Student, Dept. of Mechanical Engineering, H.V.P.M. College of Engineering and Technology, Amravati, India*
[5]*Professor, Department of Mechanical Engineering, H.V.P.M. College of Engineering and Technology, Amravati, India*

Abstract: ***Nowadays the demand for clean, renewable energy sources is increasing. The use of renewable energy resource increasing rapidly. The structure plays an important role in stability of an entire solar mounting structure. The solar structure decide the life period of hole solar panel mounting system solar structure has to withstand different types of loading conditions and bear the weight of photo-voltaic panels. In this review paper, there is consideration about design and analysis and cost optimization of solar panel support structure by considering environmental effect like wind load, structural load and height of structure , material selection and also their properties . The analysis can be done by creating model in software and followed by analysis using different software to determine pressure distribution on the solar panel area and structure, then it can break and will be affect the power generation and also affect the life cycle of the hole solar panel mounting system.***
Keyword:-Solar panel, types of structures, wind load, structural Analysis, Cost Optimization.

I. INTRODUCTION

Sun is the ultimate source of energy, almost all forms of energy is either directly or indirectly related 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. 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 .In so 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. One of the main components of solar system plants is the structure. If the structure fails, then the entire plant will shut down. Thus structures designed to withstand different loading parameters. Such as height of structure wind load, structure load .Mounting structures are the backbone of a solar power plant as they provide support to modules. These support structures raise solar panels at appropriate angles to ensure that they receive maximum solar irradiation .Solar PV rooftop system is basically a small power plant at your rooftop. Solar PV modules form an array and it requires a mounting structure to hold PV modules at the required angle for maximized generation. The solar panels convert solar energy in the form of light into electricity in DC form Direct Current .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 all loading condition differently Also the structure should withstand the loads until the service life span of plant . There are different types of solar mounting structure. They are either mounted on ground, on roofs or on poles. There are five basic types of mounting structures of which four are fixed- angle types and one variable-angle type: Roof Mounted Racks. Ground Mounted Racks are used in solar structure mounting system.

II. SOLAR MOUNTING SYSTEM

Mounting structures need to be durable to be able to bear the weight of solar panels, high wind speeds and a range of temperatures. In order to adapt to topographical features and weather conditions at site, module mounting structures require customisation. These structures can be set up for rooftop plants, ground-mounted solar, carport and sun tracker solutions. Mounting structures have evolved over the years in terms of weight, material, adaptability and cost. Solar panels are not directly attached to the ground or rooftops; rather, they need to be mounted on supporting structures that can align them perfectly for optimised energy production. The primary purpose of mounting structures is to position the solar panel at an angle that can maximise the amount of sunlight it receives. These structures also protect the modules from natural calamities and prevent dust, water and other elements from accumulating on their surface. In addition, mounting structures allow for easy maintenance and repairs of solar panels. Mounting structures are the backbone of a solar power plant as they provide support to modules. These support structures raise solar panels at appropriate angles to ensure that they receive maximum solar irradiation.

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Fig. 1: Solar mounting structure.

III. TYPES OF ROOFTOP STRUCTURES

A. Standard Rooftop Mounting Structure

Standard Rooftop Mounting Structure is the most common choice of many households. These are the most basic mounting structures that come in three different types.

1.Railed Mounting Structure: In a railed mounting structure, solar panels are fixed on several rails through a set of clamps. The rails are made of aluminium and attach to your roof by using a drill and nut-bolts.

2.Rail less/Ballasted Mounting System: Rail less mounting structure is also known as ballasted mounting structure. In this structure, solar panels are directly fixed with the roof by using hardware. This is a cost effective and easy way to install solar panels on roofs.

3.Shared Rail Mounting System: Shared rail mounting system is very similar to railed system. In the railed mounting system, 4 rails are used to fix 2 rows of solar panel. While in the shared rail system only 3 rails will be used to mount 2 rows. The middle rail will be shared by both the rows.

B. Elevated Solar Panel Structure

In elevated solar panel structure, solar panels are installed at a height of 10 to 15 ft. There will be a little room type space beneath the mounting structure. It is also the most common types of mounting structure.

IV. MATERIAL USED IN SOLAR MOUNTING STRUCTURE

Stainless steel, aluminium and galvalume are the primary materials used in solar mounting structures in India. While steel and aluminium have been in use for a long time, galvalume is a more recent addition. The type of material used for mounting structures is dependent on the location and the life cycle of the plant. Earlier, wood and polymer were used as mounting structure materials. However, they have been replaced with more durable materials and are no longer actively used.

1) *Stainless Steel:* Durability and stability are the inherent properties of stainless steel, which makes it ideal for manufacturing mounting structures. This helps hold solar panels in place in harsh weather conditions. Most Indian projects use stainless steel for mounting structures. For components that are exposed directly to damaging weather conditions, hot-dip galvanisation (HDG) is done to prevent corrosion and improve the life of the structure. Typically, a 70 micron coating thickness is sufficient for parts that are not subject to mechanical wear and tear such as mounting structures. However, HDG has its own limitations in terms of quality control as it is largely a semi-automated process. Meanwhile, pre-galvanised steel is used for solar mounting structures. It is typically used for parts that are not highly exposed to corrosive elements and water. Cold formed steel (CFS) or light gauge steel has been found to be highly suitable for solar mounting structures.CFS has high tensile strength despite being lightweight. This allows the framing of mounting structures to be done on-site as well. The frames can be manufactured and assembled in a factory, or can be assembled at the plant location so as to allow minor adjustments to ensure a well-fitting mounting structure. The material is highly flexible in terms of thickness, design and length. Moreover, it is cost-effective, and can be manufactured and installed with greater precision. CFS is also resistant to corrosion and can withstand high winds and rust with the help of HDG core and a layer of zinc, as used by many manufacturers.

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2) *Aluminium:* Aluminium extrusions have been widely used as solar mounting structures in India. The extrusion process provides flexibility to the design, and gives it the optimum rigidity and strength. The material is lightweight, has low density and can be easily transported to far-flung areas. Moreover, aluminium so used is highly durable, almost maintenance-free and recyclable. Some of the key properties of aluminium used in solar mounting structures are high strength, formability, electrical and thermal conduction, resistance to corrosion, and high heat and light reflection. Moreover, it is easy to fabricate and recycle. Aluminium mounting structures are also ideal for rooftop solar plants given the rooftop weight restrictions. It is suitable for the installation of solar panels on carports and other platforms. Aluminium extrusions can be customised on-site, and require less installation time. They do not entail high labour costs. The low weight of aluminium eases its transportation. It also keeps the transport costs low. Aluminium is naturally resistant to oxidation and other environmentally corrosive effects. These parts can be designed for quick snap-together installation with tight joints.

3) *Galvanized Iron:* Galvanized iron is essentially iron that's been coated with a protective zinc layer on the outside. Iron itself is susceptible to weather-related degradation. When exposed to moisture and oxygen, for example, iron will rust and corrode. ln galvanizing zinc coating is applied to iron or steel to prevent it from rusting. There are several methods of galvanising. The most common method employed in module mounting structure is the hot dip galvanization. In hot dip galvanization, the material to be galvanized is submerged in molten zinc at a temperature of around 449 °C. The galvanized material when exposed to atmosphere, the pure zinc reacts with the oxygen forming zinc oxide which further reacts with the carbon do oxide in the atmosphere to form Zinc Carbonate. The zinc carbonate is dull grey coloured and strong material. It gives protection to the material beneath the coating from any corrosion. In solar PV module mounting structure, iron is used for galvanizing process. Galvanized iron is manufactured and used for wide variety of purposes but its primary use is for sheet metal roofing and other building materials, such as metal framing studs, metal roof shingles and fencing. The various property of Galvanized iron are corrosion resistance Association, galvanized steel resists corrosion up to 100 times better than uncoated steel Surface Appearance. All galvanized steel has a matte-grey appearance. Formability, Durability, Recyclable, due to this property galvanized iron are mostly used in solar mounting structure. The real benefits of Galvanized iron are. Lowest first cost. Galvanizing is lower in first cost than many other commonly specified protective coatings for steel. Less maintenance, Lowest long term cost, long life , reliability ,Reliability Toughest coating ,Automatic protection for damaged areas , Complete protection. Ease of inspection. Because of this benefits galvanized iron are mostly used in mounting of solar mounting structure.

V. LITRATURE REVIEW

Nina Pande et.al. Different types of load acting on solar structure in this review paper studies different types of load acting on solar structure and their analysis. Also studied if the structure is not designed considering all loading factor then it can lead to breakage of structure which intern will affect the power generation.

Gadhavi Akash G et.al. Design and analysis of solar panel support structure in the paper studies Support structure by considering environmental effects like wind load , height of structure , structural load the analysis can be done by creating the model in software and then analysis in different software . Is also considered that verify that the location is important for solar panel mounting structure it also affect the performance and life span of that structure.

Alex Mathew et.al. Design and stability analysis of solar panel support structure subjected to the wind force and made in mind steel in this paper the design of solar panel support structure and the effect of wind force on its structural stability is discussed in this paper the measures for preventing the overturning of structure are also discussed they used CAD modelling software CREO 2.O test model of solar panel support structure was created steel. They concluded that the design of solar panel supporting structure is done and the effects of wind force on its structure stability are analysed. Due to the wind force, a reaction force is experienced on the structure and the structure will retain its stable state, only if this reaction force is compensated by the force due the self-weight of the structure. .

Rohit Pnjwani et.al. Studies design and analysis of solar structural and mounting for solar panel in this studies discussed the solar mounting system and their various types and also studied material selection which material can be suitable for solar mounting structure for including all environmental effects also studied material properties and cost of materials They concluded that The modified solar mounting structure is based on the analysis of wind velocity considering constants regions velocity and different boundary conditions. The material used for the modified design is appropriate for all the surrounding conditions and cost friendly.

Muhammad Waqas et. al. Numerical investigation of impact of various wind loads on the structural stability and strength of solar panel supporting structure. In this study, Finite Element Method (FEM) was established to investigate the impact of various wind loads on the structural reliability and strength of solar panel supporting structures. also studied Wind loads were also calculated by mathematical approach. They concluded that solar panel structure was significantly affected by wind loads applied on the surface of solar PV module. The wind speeds of 20 m/s, 25 m/s, 30 m/s, 35 m/s and 40 m/s were used for the analysis of solar panel supporting structure. The results obtained from the FEM analysis that total deformation and maximum equivalent stresses were increased by increasing the wind loads.

A. Mihailidis et. al. Analysis of solar panel support structure in this studies, the analysis of two different design approaches of solar panel support structures is presented. Also studied the analysis in three different ways such as Loading calculation, Analysis of the structure, identification of structure critical point also studied Finnie Element Method (FEM)is used to calculate the stresses acting on the supporting structure there are two types of solar panel mounting structure fix and adjustable are studied in this paper. They concluded that fixed solar array support structures have sophisticated design that needs to be analyzed and often improved in order to withstand the wind load. The same applies of course to adjustable designs to an even greater extend .The stresses on different members of the structure are studied and also studied comparison of fixed and adjustable support structure.

VI. ADVANTAGES OF MOUNTING STRUCTURE

1) *Increase Efficiency:* Mounting structures play an important role in determining the overall efficiency of the solar system, both rooftop and utility. They lift the PV modules at suitable angles and assure maximum energy generation by tilting the solar panels.
2) *Provide Support and Protection:* Mounting structures bear the entire weight of the solar panels. They help the solar panels to rest comfortably and work productively. Solar mounting structures protect the solar panels from being damaged.
3) *Strong and Durable:* Solar mounting structures are strong and durable to withstand extreme weather conditions. They are responsible for providing the solar system with an increased life expectancy.
4) *Available in Many Different Forms:* They are available in a variety of materialistic forms including steel, aluminium, etc. The material they are made of assures you that they are highly durable, corrosion-resistant and rust-free.
5) *Attract Technological Innovations:* Mounting structure technologies are developing rapidly. As a result, there is a reduction in the cost of the structure. Also, the installation process has become easier and faster. Besides, with technological innovations, the mounting structures are becoming more durable and productive.

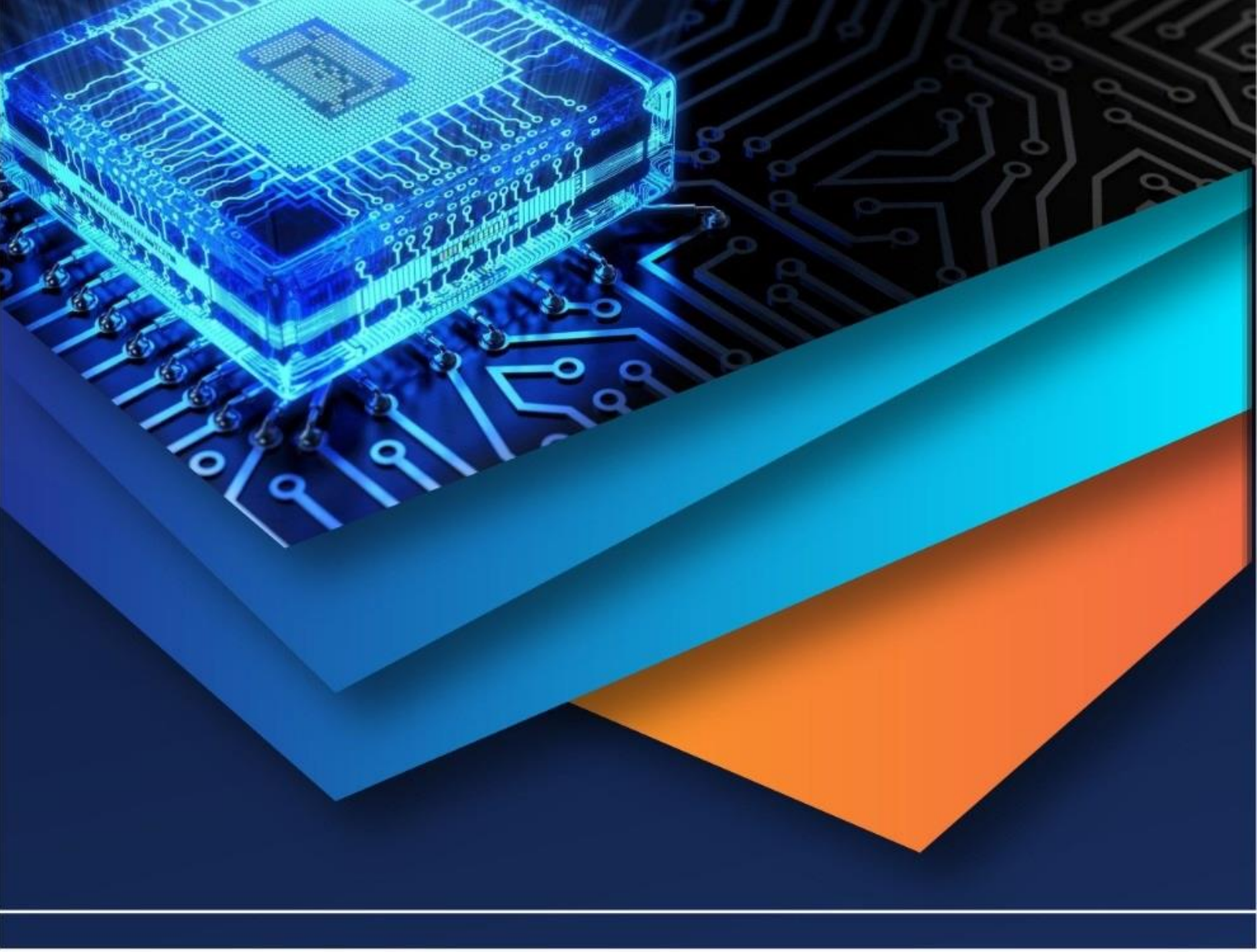
VII. CONCLUSION

We conclude that to study the various structures and design material we also observe the various types of solar mounting structure. Analysis the material and their properties and we also study advantages of solar mounting structure and their cost in our prospective to recommend the material that is galvanize iron.

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