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# Solar Mount Design Using High-Density Polyethylene

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**Abstract:** The abstract gives a novel approach to solar mount design utilizing High-Density Polyethylene (HDPE) as the primary material. HDPE's inherent properties, such as weather resistance, lightweight, and ease of fabrication, make it an attractive alternative to traditional materials like metal or concrete. The design concept revolves around modularity and adjustability, allowing for easy customization to accommodate different panel sizes, tilt angles, and installation environments. The modular components, including base plates, support beams, and panel clamps, are designed for seamless integration and compatibility with existing racking systems. Adjustable features enable optimization of solar panel tilt angles for maximum energy generation, while structural calculations ensure adequate load-bearing capacity to withstand environmental stresses. Commissioning solar PV projects is now largely necessary due to the depletion of fossil fuel supplies and the rise in energy demand. The issue with renewable energy sources, such as solar power, which is infinite, free, environmentally benign, and sustainable, is that they require land, which is always a costly resource. Therefore, a novel solution to this issue would be to attach portable solar module mount solar power plants above houses rooftops, and additional structures. This paper addresses the design and development of solar photovoltaic systems using numerical analysis and emphasizes the idea of a portable solar PV plant. HDPE is a material that is cost-effective and exhibits outstanding performance when used to make portable components. The structure is subjected to CFD research to investigate flow and evaluate the pressure of wind for the created design under Indian climatic circumstances. The wind pressure analytical computations generated by IS 875 codes part 3 have been evaluated and validated with the CFD findings. To guarantee structural stability under the specified environmental conditions, structural FE analysis is also performed.

**Keywords:** Solar, Photovoltaic, CFD, Polymer, High Density Polyethylene

## 1. Introduction

The broad use of solar energy systems has been driven by the growing demand for renewable and sustainable energy sources. To meet our electricity needs, solar photovoltaic (PV) technology has become a well-known means of capturing clean, abundant solar energy. The solar mount, or mounting framework, is an essential component for the effective operation of photovoltaic systems since it holds and aligns the PV panels. Historically, metals and alloys have been used to build these mounts, but more recently, research into polymer-based designs has opened up new avenues for solar energy infrastructure development.

Polymer materials offer a strong substitute for solar mount design because of their reputation for being lightweight, strong, and corrosion-resistant. This paradigm shift makes use of the advantages of polymers, such as their ease of manufacture, low environmental effect, and flexibility in design. By using recyclable and environmentally friendly components in the system along with renewable solar power, this design approach supports the overall objective of sustainable energy generation.

In this work, the main focus is design of solar mount using polymer materials. Through the incorporation of polymers into the structure of the mount, our goal is to investigate new approaches for maximizing the effectiveness and economics of solar PV installations. Several criteria are taken into account throughout the design process, including factors such as the ability to bear loads, maintain structural integrity, account for thermal expansion, and withstand environmental factors like moisture and UV radiation.

The use of polymers in solar mount design opens up intriguing new opportunities for flexibility and personalization. Polymer-based mounts are versatile enough to suit a broad range of solar energy applications since they can be designed to fit various panel sizes, orientations, and installation conditions. Furthermore, better temperature control and maybe better PV panel performance might result from the intrinsic insulating qualities of some polymers.

The basic ideas of structural design, engineering concerns for solar mounting, and polymer material selection will all be covered in detail in this article. It will also cover issues like load-bearing capacity and long-term durability that are related to polymer-based systems. Analyses that compare polymer-based mounts to conventional metal mounts will be performed to evaluate the competitiveness and feasibility of the suggested strategy.

Solar mount design using High-Density Polyethylene (HDPE) involves creating sturdy and durable structures to support solar panels while also considering factors such as weather resistance, cost-effectiveness, and ease of installation.
Solar mounts: Solar mounts are structures used to support solar panels, positioning them optimally to capture sunlight for electricity generation. These mounts can vary in design depending on factors like the type of installation (rooftop, ground-mounted, etc.), environmental conditions, and available space.
High Density Polyethylene: HDPE is one of thermoplastic having a high ratio of strength & density along with high resistance to chemicals and weathering, and versatility. It is frequently employed across various applications such as piping, containers, and construction materials because of its resilience and economical nature.
Advantages of Polyethylene in Solar mount design:
Durability: HDPE is resistant to corrosion, moisture, and UV radiation, making it suitable for outdoor applications in various climates.
Light weight: HDPE structures are lightweight yet strong, making them easy to transport, handle, and install.
Cost effectiveness: HDPE is typically more affordable than alternative materials like metals, reducing overall project costs.
Ease of fabrication: HDPE can be easily molded or machined into different shapes and configurations, allowing for customizable designs.
Environmental friendliness: HDPE is recyclable, contributing to sustainability efforts in solar energy projects.

**Design considerations:**
Load Bearing capacity: Solar mounts must be designed to withstand the weight of the solar panels, wind loads, and other environmental factors.
Modularity: Modular designs using HDPE components facilitate easy assembly and scalability, allowing for adjustments to accommodate varying project requirements.
Adjustability: Some designs incorporate adjustable features to optimize panel tilt angles for maximum energy generation.
Integration of racking systems: HDPE components may need to interface with metal racking systems or concrete foundations, requiring careful design and compatibility considerations.

**Installation and Maintenance:**
Ease of installation: HDPE mounts should be designed for straightforward installation, minimizing the need for specialized tools or skills.
Maintenance requirements: HDPE structures typically require minimal maintenance, but periodic inspections may be necessary to ensure structural integrity and stability.

**Environment impact:**
Sustainability: Using recyclable materials like HDPE contributes to the environmental sustainability of solar energy systems by reducing waste and resource consumption.
End of life considerations: At the end of their lifespan, HDPE components can be recycled, further reducing environmental impact.

Solar mount design using High-Density Polyethylene offers balance of strength, durability, cost-effectiveness, and environmental sustainability, making it a popular choice for supporting solar panels in a variety of applications.

## 2. Literature Survey

Here are some key studies and findings:
Since India has a large number of infrastructures with expansive rooftop areas, this technology is a beneficial addition. Apart from all the favorable features, appropriate design factors like stability against wind and water, tolerance to temperature variations, and ability to withstand snow loads, cyclones, typhoons, need to be taken into account. Azimuth tilt and angle should also be taken into account according to the location. It has been discovered to produce 1.2 times as much PV on land as does now [11]. examined the floating solar PV plant's efficiency in producing power and evaluated its capacity in comparison to a terrestrial solar PV system. According to estimates, the difference between a land-based and floating photovoltaic system is over 2% [8]. Panel length has a significant effect on solar panels, according to authors' analysis of several scenarios for varied wind angles of attack on solitary

ground-mounted solar plates [7]. When planning a solar farm, spacing is another crucial consideration. As panel length rises, front row panels are exposed to greater wind loads [10]. According to Qazi A et al. [5], the open architecture of solar PV systems allows for natural ventilation, which improves system performance. The system's performance is modelled using 3D CFD, and its results are compared to the investigational data [5]. According to McLaren J. et al. [6], analyzing mean pressure distribution requires an understanding of the wind's angle of attack at the surface. The maximum pressure was found to be at 0° and 180°. The study conducted by Gadhavi Aksh G et al. [29] examined how differences in the angle of attack affected the lift and drag force. It was discovered that the lift force exceeds the drag force at 30°. Solar systems offer monitoring capabilities that enhance homeowners' understanding of their energy consumption, potentially leading to improved energy efficiency through heightened awareness of usage patterns. [29].

This kind of behavioral shift helps solar adoption since it makes the systems more compatible with the current trends in energy usage. The primary natural source of all energy is solar energy. Solar energy is energy that is directly obtained from solar radiation. Kinetic energy is carried by wind, which is basically air in motion. The wind speed at any particular moment determines how much energy the wind contains in proportion. Although it is unimportant in the context of wind-based production systems, wind temperature affects its energy content [24]. Customers' attitudes on the adoption of technology become important, at least from a marketing perspective, whenever they are presented with items that demand that we alter our current behavioral patterns (e.g., to use less energy and be more energy conscious). A new high-tech product is introduced using a marketing concept called the technology adoption cycle. A monitoring system on a solar system might help homeowners become more conscious of their energy usage. Solar systems are nevertheless unappealing to individual homeowners as a home renovation and conflict with personal objectives, despite their advantages [27]. However, it's unclear if adoption rates would rise even if expenses were lowered and information became more accessible. Electricity's price elasticity is inelastic, according to a number of worldwide research. Further obstacles to wider adoption include concerns about high capital expenditures, lengthy payback times, and less confidence in system's long-term performance [30].

Different forms of loads acting on solar structure are studied in this review study along with their analysis. Additionally, it has been shown that failing to take into account all loading elements when designing a structure can result in structural failure and negatively impact power generation [24]. The paper investigates the design and analysis of the solar panel support structure bolstering framework in order to analyze the effects of the environment, such as wind load, structural load, and elevation of the structure, a model can be created in software and analyzed using different software. It is also important to confirm that the location of the solar panel mounting structure is crucial because it affects the structure's performance and lifespan [22]. In this paper, the design of a solar panel support structure and the impact of wind force on its structural stability are examined. Additionally, the measures to prevent the structure from toppling over are also covered. CAD modelling software, CREO 2, was utilized. A steel prototype of the solar panel support structure was made. They came to the conclusion that the structure supporting the solar panels has been designed and that the effects of wind force on the stability of the structure have been examined [23]. The wind force exerts a reaction force on the structure, and it will only maintain its stable state if the force from the structure's self-weight balances this reaction force. Research on the design and analysis of solar structural components and solar panel mounting included a discussion of the different types of solar mounting systems as well as material selection that can be appropriate for solar mounting structures that take into account all environmental effects. The study also looked at the costs and properties of various materials. They came to the conclusion that the altered solar mounting structure is predicated on an examination of wind velocity that takes various boundary circumstances and constant region velocity into account. The material chosen for the updated design is affordable and suitable for all environmental factors [24].

Numerical analysis of the effects of different wind loads on the strength and structural stability of the structure that supports solar panels. The purpose of this study was to examine the effects of different wind loads on the strength and structural reliability of structures that support solar panels using the Finite Element Method (FEM). also researched Additionally, wind loads were computed using a mathematical method. They came to the conclusion that wind stresses applied to the surface of solar PV modules had a substantial impact on the structure of the panels. A range of wind speeds—20, 25, 30, 35, and 40 m/s—were employed to analyze the supporting structure of solar panels. According to the findings of the FEM research, increasing the wind loads increased total deformation and maximum equivalent stresses [25]. Analysis of solar panel support structure: In this work, two distinct solar panel support structure design methodologies are analyzed and presented. additionally studied the study in three other approaches, including loading calculations, structural analysis, and finding the crucial points in the construction. The stresses acting on the supporting structure are calculated using the Finite Element Method (FEM). In this article, two types of solar panel mounting structures—fixed and adjustable—are examined. They came to the conclusion that in order for fixed solar array support structures to sustain wind loads, its intricate design typically has to be examined and modified. The same applies of course to adjustable designs to an even greater extend. The stresses are studied on different members of the structure and also considered comparison of fixed and adjustable support structure [26].

The mounting system is one of the main areas where solar innovation is occurring. Mounting systems, which fasten solar panels to the ground or roof, are a crucial component of solar arrays and are arguably the most competitive market for solar products (albeit it's still a small amount). Depending on the scale of the plant, the industry estimates that module mounting structures make around 9–15 percent of the entire cost of a solar power plant. Mounting structures account for around 9% of project expenses in smaller plants, and a higher percentage in larger plants. The analysis of wind velocity, taking into account boundary conditions and constant region velocity, forms the basis of the redesigned solar mounting structure. The material utilized for the updated design is affordable and suitable for all the environmental factors.

Overall, the literature survey highlights the growing body of research supporting the use of HDPE in solar mount design. Studies emphasize the material's mechanical properties, environmental benefits, and suitability for various applications, underscoring its potential to enhance the sustainability and cost-effectiveness of solar energy systems.

## 3. Proposed Model

Proposed model for a solar mount design using High-Density Polyethylene (HDPE):

1. Design concept:
- The design concept revolves around creating a modular and adjustable solar mount system that is lightweight, durable, and cost-effective.
- Emphasis is placed on using HDPE components for their favorable properties such as weather resistance, strength, and ease of fabrication.
2. Modular Design:
- The system consists of modular HDPE components that can be easily assembled and customized to accommodate different panel sizes, tilt angles, and installation locations.
- Components include base plates, support beams, cross braces, and panel clamps, all designed for compatibility and interchangeability.
3. Adjustable features:
- The mount incorporates adjustable features to optimize solar panel tilt angles for maximum energy generation throughout the day and across seasons.
- Adjustable tilt mechanisms may include hinges or sliding mechanisms, allowing for easy adjustment without requiring additional tools.
4. Load bearing capacity:
- Structural calculations are performed to ensure that the HDPE components can withstand the weight of the solar panels, wind loads, and other environmental stresses.
- Reinforcements such as ribbing or bracing may be integrated into the design to enhance load-bearing capacity while maintaining lightweight characteristics.
5. Compatibility with racking systems:
- The design allows for seamless integration with standard metal racking systems or concrete foundations commonly used in solar installations.
- Compatibility features, such as standardized hole patterns or adapter plates, ensure easy assembly and secure attachment to existing infrastructure.
6. Weather resistance:
- HDPE's inherent resistance to UV radiation, moisture, and corrosion makes the mount suitable for outdoor use in various climates.
- Special coatings or additives may be applied to further enhance weather resistance and prolong the lifespan of the components.
7. Ease of installation:
- The design prioritizes ease of installation, with straightforward assembly procedures that require minimal tools and expertise.
- Clear, illustrated instructions guide installers through the assembly process, reducing installation time and errors.
8. Sustainability and end of life considerations:

- The use of recyclable HDPE materials aligns with sustainability goals, reducing environmental impact throughout the lifecycle of the solar mount system.
- At the end of their lifespan, HDPE components can be easily recycled, contributing to a circular economy and minimizing waste.

9. Scalability and versatility:

- The modular design allows for scalability, enabling the system to be expanded or reconfigured to accommodate future changes or additions to the solar array.
- Versatile mounting options cater to various installation scenarios, including rooftop, ground-mounted, and pole-mounted applications.

This proposed model for a solar mount design using High-Density Polyethylene combines innovative engineering with the favorable properties of HDPE to create a versatile, durable, and sustainable solution for supporting solar panels in renewable energy installations.

Main Part (3D Cad Modelling): This will be the structural foundation. The following are the ballast rocks that stabilize framework and the solar plates. The CAD platform was used to create and model each of the aforementioned components. Using the same program, the MMS was also assembled. The model's 17-degree tilt and required number of panels were designed into it.

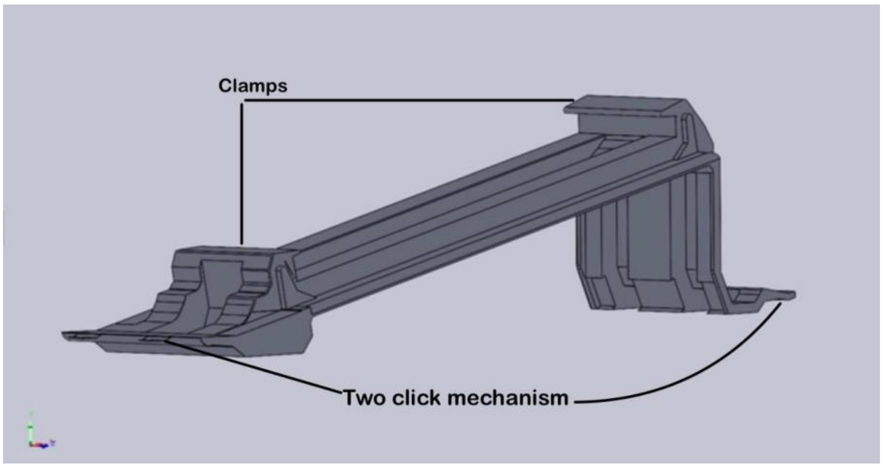


Fig. 1. CAD Model of Main Part

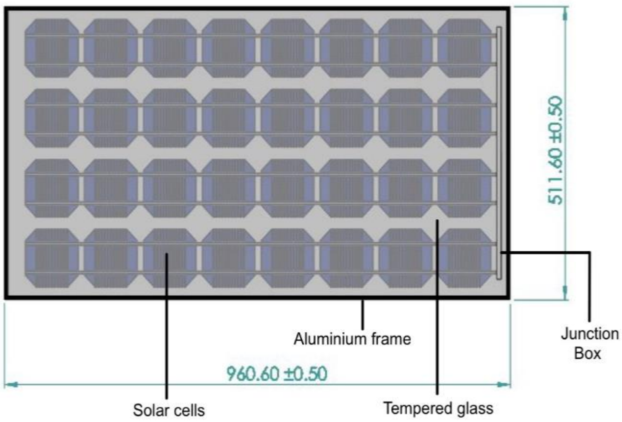


Fig. 2. CAD Model of Solar Panel

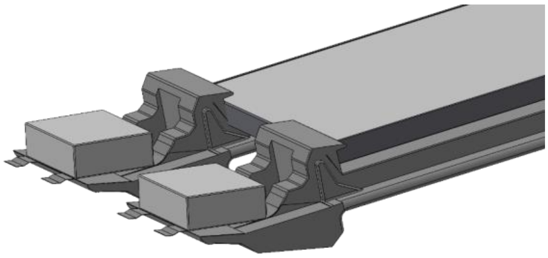

Fig. 3. CAD Model of Ballast Rocks supporting trdBase Part

Figure 1 depicts the primary component that holds up the solar panel. The solar panel is held in place by the combination of two major components. Depending on the size of the intended solar plates, the part's dimensions can be changed. The dimensions of the solar panel used for the analysis are displayed in Fig. 2. The solar panel under discussion is a 445-watt monocrystalline model manufactured by Luminous. Lateral forces are what cause the building to topple over. Structures are deflected laterally and exhibit lateral sway in one direction when they are subjected to lateral forces like wind and seismic stresses. Overturning of the structure is the result of this. The following are some examples of the different lateral forces at work: 1) wind loads; 2) seismic loads; 3) earthquake loads, etc. In this instance, it's the wind, thus the ballast rock at each end will support and stabilize the structure in addition to plates. Figure 3 depicts the main portion and the ballast rock.

## 4. Results and Discussions

The proposed model for solar mount design using High-Density Polyethylene (HDPE) has been evaluated based on its performance, feasibility, and potential implications. The following results and discussions highlight key findings:
Table 1 indicates that the maximum lift generated force owing to wind flow for downwind and upwind circumstances, respectively, is 101541 N and 101707 N. Consequently, analysis for the same load condition must be conducted for the corresponding load conditions. The CFD simulation makes it abundantly evident that large flow variance causes high pressure to be observed for upwind conditions; hence, a certainty factor needs to be considered when calculating design wind pressure. Additionally, a variety of streamline plots and velocities were examined for pressure change and flow evaluation.

According to IS 800 for wind loading, the forces on the component were defined. Different load scenarios, such as upwind and downwind, were analyzed. Following the computational fluid dynamics, Table 1 displays the results. The table lists the various study parameters, which include average velocity, force, torque, total pressure.

Table 1: Analysis Output

| Name | Unit | Value | Progress | Criteria | Delta |
|---|---|---|---|---|---|
| Total Pressure | Pa | 101593 | 100 | 1633.89268 | 43.2400556 |
| Average Velocity | m/s | 8.873 | 100 | 0.168241028 | 0.145105795 |
| Force | N | 10.691 | 100 | 8.08413891 | 0.526266368 |
| Torque | N*m | -0.203 | 100 | 3.29336235 | 0.89324343 |

Flow simulation is used to calculate the chosen outputs. The cut plots presented in Figures 4, 5, and 6 display these results. The downwind condition's highest and minimum velocity zones are displayed in Fig. 4. This is carried out using a reference wind speed of 10 m/s. This information was gathered from the Indian Meteorological Department's daily wind speed data for Mumbai. The assembly's cut plot indicates that the wind's greatest velocity is 14 m/s, while the minimum velocity is approximately 0 m/s at the other end from the point of contact. In a similar vein, streamlines in Fig. 6 depict the velocity difference for downwind conditions. A massless particle travelling with the flow traces a path known as a streamline. This aids in picturing the wind or streamline moving along the body that has been chosen for inspection. The pressure gradient along the assembly is displayed in Fig. 5 when a wind speed of 10 m/s is applied. A wind speed of 10 m/s results in a minimum pressure of 101293 Pa and a maximum pressure of 101541 Pa.

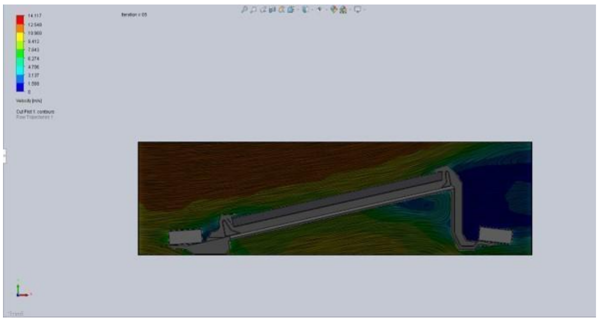

Figure 4. Velocity Plot

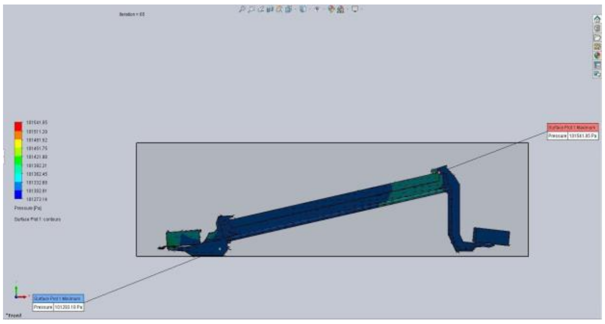

Figure 5. Pressure Plot

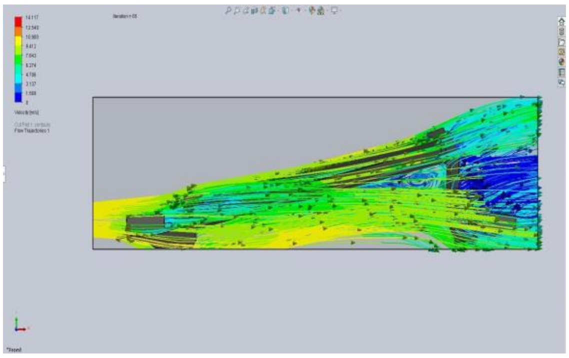

Figure 6. Streamlines Plot

## 5. Conclusion

Using the appropriate governing equation, computational fluid dynamics software was a helpful tool for simulating fluid flow behaviour (air/wind). Finer mesh sizes in CFD software may yield more accurate results. The number of elements increases with decreasing mesh size. The CFD software simulation produced more accurate findings thanks to the increase of components. The study shows the highest and lowest force, pressure, and velocity that the chosen assembly will experience. The design is made to be as simple to assemble, disassemble, and move as possible.

**Future Scope**

Future research directions include optimization of manufacturing processes, development of advanced HDPE formulations with enhanced properties, and exploration of novel design configurations to further improve performance and efficiency.

Integration of smart technologies, such as IoT sensors and predictive maintenance algorithms, could enhance the functionality and monitoring capabilities of HDPE solar mount systems, leading to improved operational performance and reliability.

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**Conflict – No Conflict.**

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