Solar Float Design and Simulation Using LDPE Material

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Abstract - Floating PV installations are frequently constructed on inland huge bodies of water, whether natural or man-made. The proposals include a floating mounting mechanism that supports PV modules over water with a framing structure comparable to a standard ground-mounted PV system. The two most prevalent types of solar trackers on the market are single-axis and dual-axis. Single-axis solar trackers follow the sun from east to west while rotating around a single point, moving in unison, by panel row, or by section. Dual-axis trackers allow panels to monitor the sun directly by rotating on both the X and Y axes. Because they travel east-west, single axis trackers are the most often used sun trackers in India. When compared to a fixed solar tracker mount panel, single-axis trackers are approximately 32.17 percent efficient. These trackers follow the Sun from East to West, ensuring continuous power generation throughout the day. Trackers provide 15-16% more annual power than a static plant with the same installed capacity. This is a seasonal tilt structure that is designed to meet the design criteria for tilt angles ranging from 5 to 15 degrees. During the season, manual tilting is performed. Based on the principle of buoyancy efficient and light weight design, build and simulate the model using light weight and low-cost materials that can sustain a variety of external loads. Consider the Anchoring Mooring Efficient Design based on the wind and wave loads. The LDPE material design will be subjected to Finite Element Analysis [FEA], as well as a fatigue analysis. The solar floats should be constructed in a modular structure to facilitate easy construction and disassembly as well as transportation from one area to another.

Key Words: Floating Solar PV Plant, LDPE (Low Density Polyethylene), FEA analysis, CFD Simulation.

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1. INTRODUCTION

Floating Solar is also known as Floating Photovoltaics (FPV) it is a system having Solar Panels on a floating system. It is made out of solar panels that are installed on a pontoon or floats [1]. Floating Solar is installed at the reservoirs, hydro power stations, lakes, canals, Irrigation, Water Treatment, Quarry and Mining etc. The Project site is Located in theRiva River in the state of Madhya Pradesh, India. The Coordinates of the site are 24°31'45.9"N 81°16'49.4"E. From the coordinates the Longitude of the site can be determined as 24° and the latitude of the site as 81°.Downwind (DW), Upwind (UW), Live load (LL) and Dead load (DL) these are the different loading conditions applied on the structure.

1.1 Materials Used

HDPE is used to make the Solar Floats utilized in the floating solar business. LDPE, Polypropylene, and other materials can be used as HDPE substitutes. In lower temperatures, HDPE has a reduced impact strength, whereas LDPE has an advantage in this regard. In the realm of Solar Floats, switching from HDPE to LDPE becomes more cost effective. For maintenance needs, the Solar Floats' modular structure made of LDPE material is critical. Table 1 shows properties of LDPE.

Table 1: Properties of LDPE

Density	917 Kg/m^3
Youngs Modulus	172000 KN/m^2
Yield Strength	18 MPa
Poisson's Ratio	0.439
Allowable Stress	12MPa
Specific Heat	1842 J/(Kg*k)
Tensile Strength	13270 KN/m^2

1.2 Objectives

The Solar Floating model must be designed and tested in the presence of high waves and fatigue strains. The design and implementation of a brand-new float concept that combines the walkway float and the main float will be carried out. This is a seasonal tilt structure that complies with the design specifications for the necessary tilt angles. Development and simulation of a model using lightweight, inexpensive materials that can endure a range of external loads and adhere to the buoyancy-efficient design principle. Finite Element Analysis will be used to design the LDPE material and fatigue analysis. Considering the Anchoring Mooring Efficient Design based on the wind load and the dead load.

2. Design and Analysis

It is more cost-effective and efficient than Traditional land/rooftop installations [2]. The IS 875 Code addresses the wind loads that must be taken into account while designing buildings, structures, and their individual parts [3]. Requirements for the Code: Wind Loads on Buildings and Structures (IS: 875(Part3)). High Load Capacity Capability as well as Resistant to the ultraviolet rays. Material selection is carried out at a low cost.

The Design Parameters required for the installing conditions are as shown in the Table 2.

Table 2: Design Parameters

Wind Speed	Tilt Angle	Power Output	Solar Panel
47 m/s	24^0	500KWp	520W

The Solar Panel and Float Assembly, as well as the parts necessary for the mounting structure, are depicted in Figure 1 and 3 respectively.

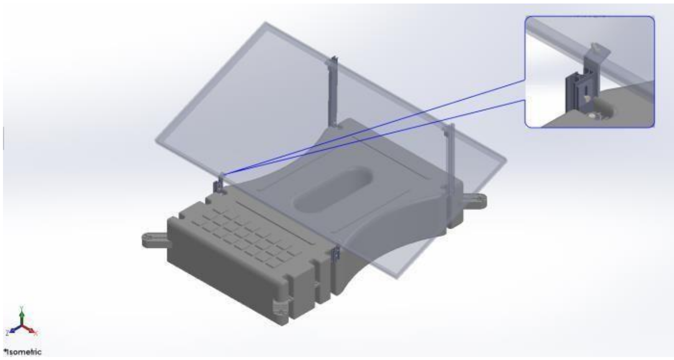
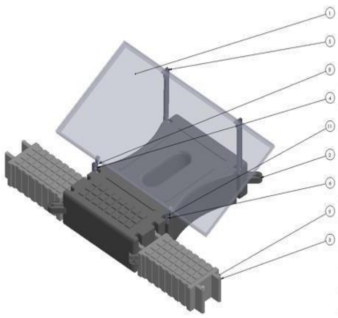


Fig 1: Solar Floats Assembly

The Floating Solar Assembly consists of the various parts as well as hardware components such as Solar Float made up of LDPE material, Solar Panel of 144 Cells MONO PERC configuration. The 3D assembly illustrates the unit of components for single panel float configuration as shown in Figure 2.



Sr.No	Part Name	Quantity
1	Solar Panel	1
2	Solar Float	1
3	Joining Float	2
4	Railing 585 mm	2
5	Railing 100 mm	2
6	L Cleat	4
7	Angle Bracket 114deg	2
8	Angle Bracket 66deg	2
9	Connection Pin	8
10	Connection Nut	8
11	M8 Bolt	16
12	M8 Nut	16
13	M8 Washer	32

Fig 2: Component List

Such twenty-panel float assembly will form a pontoon together generating 10KWp Power, such 50 pontoons will together generate 500KWp power.

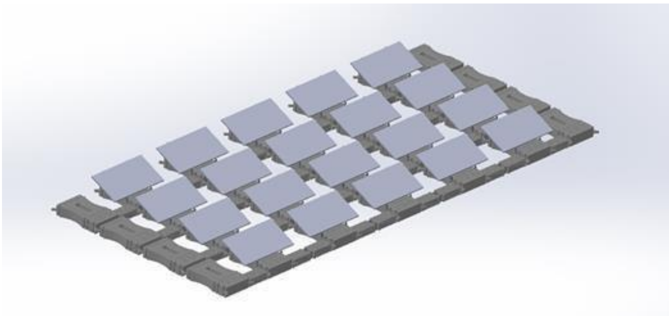


Fig 3: Pontoon Configuration

The Computational Fluid Dynamics (CFD) at a given initial boundary condition as basic wind speed at the location of installation gives the output values as the maximum pressure values acting upon the structure due to the flow of the wind as well as different types of loadings as dead load, Upwind and Downwind loads due to the surrounding conditions and gravity effect.

The Meshing is performed on the structure in the given computational domain as shown in Figure 4. Mesh size is of 10 mm number of elements is 361706 and the number of nodes is 478541.

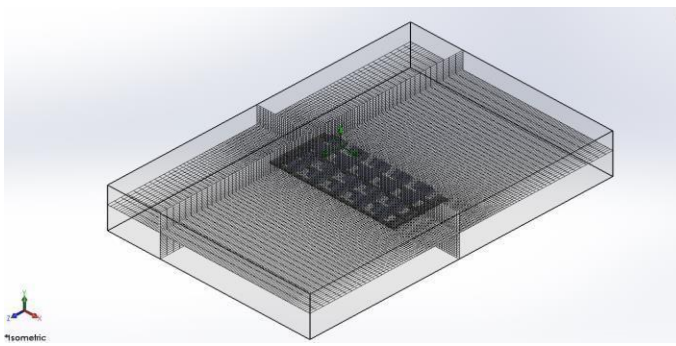


Fig 4: Meshing

The result obtained from the computational fluid dynamics (CFD) are as shown in Figure 5. It can be studied that velocity values at the surface are as the minimum value of 0m/s and the maximum value is 67.791 m/s.

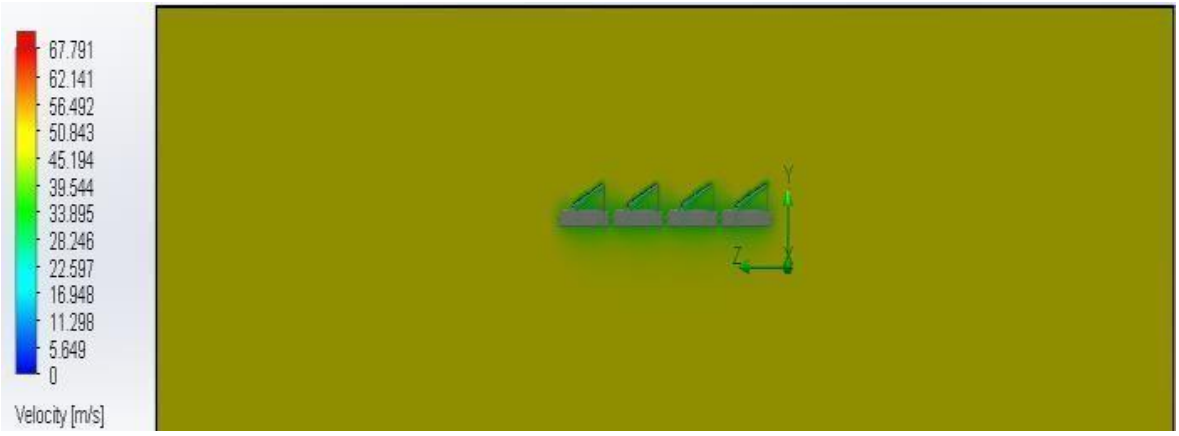


Fig 5: CFD Velocity Output

The pressure values as shown in Table 3 on the surface of the assembly gives the different values and the maximum values obtained from it are used as the Input values for the Finite Element Analysis of the Structure where theeffects on each component can be analyzed and the structure can be determined for the fluttering effects as well as the possible failures occurred due to the different loading conditions.

Table 3: Pressure Values

DOWNWIND PRESSURE (Pa)	UPWIND PRESSURE (Pa)
-446.48	-153.93
-425.9	-175.24
-396.94	-180.52
-393.85	-185.34
-613.38	-319.95
-393.13	-186.52
-399.29	-180.73
-429.42	-174.92
-445.44	-154.16
-217.84	-215.14
-167.72	-331.8
-143.83	-218.43
-128.23	-181.59
-122.73	-205.72
-130.95	-196.91
-145.39	-221.92
-163.72	-230.41
-226.08	-213.57
MAX=613.38	MAX=331.8

Finite Element Analysis (FEA) is performed input pressure values from the (CFD), the maximum value of 613.38 Pa is taken for downwind pressure and maximum value 331.8 Pa is taken for upwind pressure condition, self-weight due to gravity is taken into consideration as the Dead Load acting on the assembly. The FEA is performed for the different condition as due to Down Wind load, Upwind Load and the Live load acting on the Assembly.

3D Representation of the Assembly for FEA is shown in Figure 6.

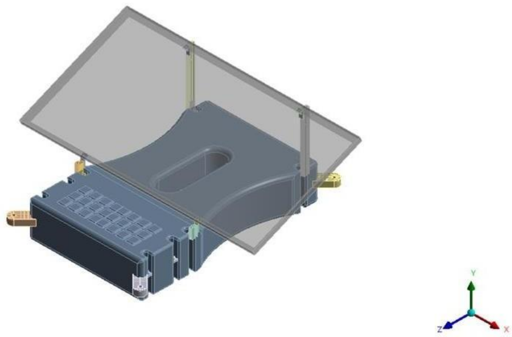


Fig 6: FEA 3D Assembly

Mesh size of 10mm is taken for meshing of the Assembly as shown in Figure 7 for accurate results to be obtained from Analysis.

Fig 7: Meshing

The input parameter for the computations is the loading condition for Downwind and Dead load operating on the assembly as shown in Figure 8.

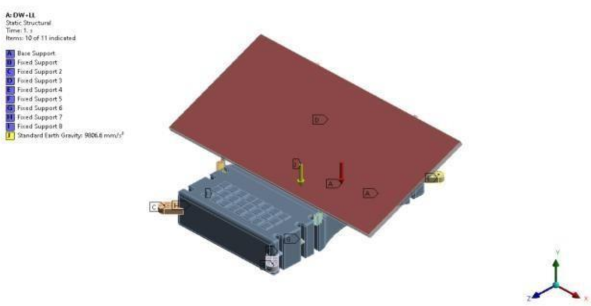


Fig 8: Loading Conditions For DW+DL

As shown in Figure 9, Stress Value obtained as 8.6644 MPa at the very small part of the Float as the Allowable Stress value for LDPE Material is 12 MPa. The conclusion is that the structure is reliable for supporting load.

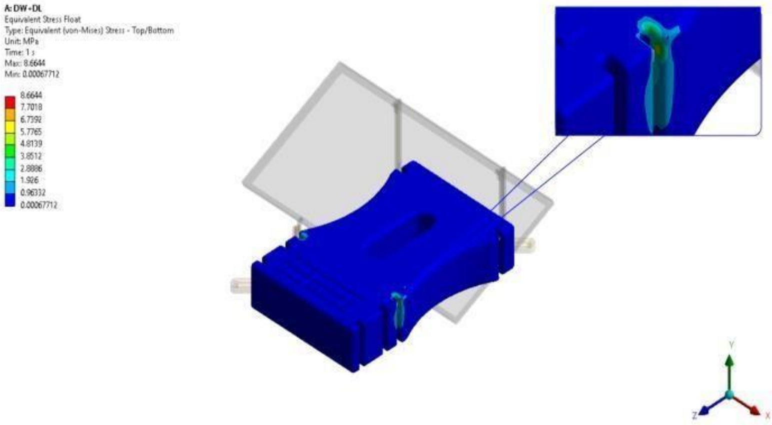


Fig 9: Stress on Float DW

Total Deformation Value obtained in Figure 10 as 6.9046 mm at the minute section of the Float as the Allowable Deformation value for LDPE Material is 10 mm. The structure is trustworthy for supporting deformation, according to the analysis.

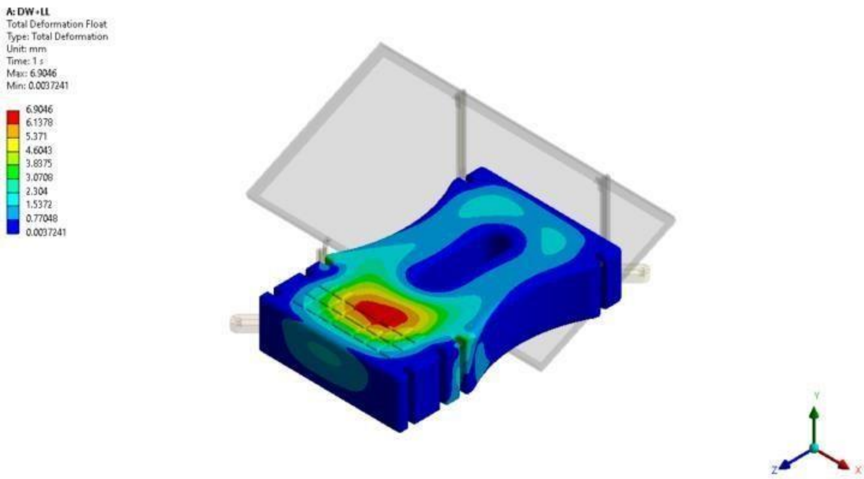


Fig 10: Total Deformation on Float DW

3. Buoyancy Calculations

An object's buoyancy is its capacity to float. This occurs when a buoyant force acting upward acts on an object submerged in a fluid. A buoyant object in a fluid will experience an upward force from the fluid equal to its downward force from gravity. Table 4 shows Buoyancy Calculations.

Table 4: Buoyancy Calculations

Name	Weight (Kg)	Surface Area (m^2)
Joint Float	9.97	2.99
Main Float	21.24	12.74
Panel	33.50	-
Live Load	100	-

The Solar Float has a total height of 350 mm, of which 10 mm as shown in Figure 11, it will be submerged in water and the rest will float above it. The previous study addressed the buoyancy check of the floating structure, and it was clearly decided that the floats are buoyant enough to support the panels.

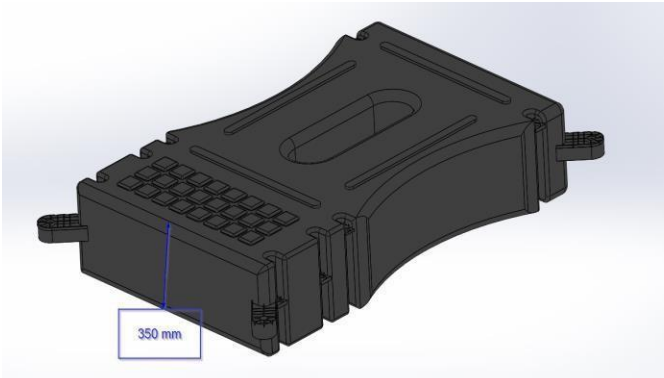


Fig 11: Dimensions of Solar Float

4. Fatigue Analysis

When a material is subjected to alternating or cyclic loads on a regular basis, the material weakens as a result of the varying loads. Fatigue is the weakening of a material, and fatigue failure is the failure caused by this type of loading. Fatigue is the leading cause of engineering failures. As a result, the number of cycles to failure for any material subjected to varying loads is a critical metric. Because the floats of a solar mounting floating system are exposed to wavy and other variable external disturbances, fatigue analysis is necessary to determine the system's actual life. Fundamental requirements must be met during the design and production phases to avoid fatigue failure. As a result, the work that follows examines the components for fatigue loading.

Fatigue tests as shown in Figure 12 are used to determine the availability of life cycles prior to fatigue failure. The obtained available life cycles before fatigue failure are 10^9 implying that 1 billion loading cycles can be applied before component failure. The number of life cycle obtained is according to the required industrial standards. As a result, the model is best suited to waves that are calm and less strong. The method works best in reservoirs, lakes, and ponds, where the water is calm and undisturbed.

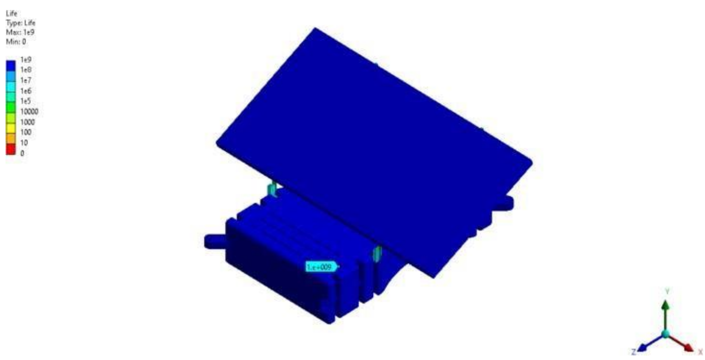


Fig 12: Fatigue Analysis of Structure

5. Conclusions

The concept of floating solar technology is discussed in this study, a design is created, along with a CFD and FEA analysis, and the key conclusions and results are examined.

The maximum wind speed and dead load were taken into account in the analysis. Wind pressure CFD study got close to analytical values. The upwind condition calculated by CFD simulation is 331.8 Pa, while the analytical analysis is 347.835 Pa. Similarly, the Downwind Condition is 613.38 Pa by CFD simulation and 626.10 Pa by analytical study. Pressure A static structural study was carried out in FEA software for the downwind, upwind, and live load scenarios. The results show that the stresses created in the required locations are within acceptable limits, proving that the float made of LDPE is suitable for the planned application of a floating solar power plant.

The system for the specified material is safe and more reliable for less intense wavy water bodies, according to fatigue testing for the number of cycles to failure as per standard float criteria. Using analytical methods, the buoyancy check of the floats for the live load was confirmed to be safe for scheduled service.

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