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AGEING ANALYSIS OF GFRP AND CFRP COMPOSITES

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Abstract— The marine sector is only one of several modern-day major industries that makes use of composite materials due to its adaptability and versatility. A larger portion of a marine device's lifespan must be spent submerged. A maritime propeller made of GFRP composite material has recently been the subject of research. The characteristics of composite materials, on the other hand, changed when they were exposed to water. Here, we use a hand-layup process to create GFRP composite materials. The samples were exposed to salt water for 15, 30, and 45 days, and their water absorption pattern was measured according to ASTM D570. In accordance with ASTM D638, both the exposed and aged GFRP samples underwent testing.

Keywords— Composite Material, Water Ageing , ASTM

I. INTRODUCTION

Historically, significant investments in the research and development of sophisticated composite materials were being made by the aircraft and shipbuilding sectors. Synthesised from two or more materials with very differing chemical or physical characteristics, a "composite" is a man-made substance. In order to construct longer-lasting and more economically viable boats and aeroplanes, they had to choose materials that were both lighter and stronger. The general public was able to more easily get this technology as it gained popularity. To create a boat that would last longer, be stronger, and weigh less, boat builders began to experiment with these new materials. It only took a few years for the ribs to reveal themselves as the boat's weakest point; eventually, the junction between the rib and the outer shell would begin to disintegrate, threatening the boat's structural integrity. Composites, which are both lighter and stronger than traditional materials, allowed designers to try out new ideas at last.

In an effort to lessen the frequency of working-condition failures, a number of researchers have been working on a supplement material for marine propellers for some time. The hulls of most boats and yachts, with the exception of very large vessels, are constructed from composite materials. Composite materials have recently become the centre of attention in research on maritime propellers [1]. Contrarily, studies have shown that composite materials age differently in water. There are a lot of industrial uses for fibre glass reinforced bidirectional polymer composites because of their numerous benefits, including their low weight, processing simplicity, price suspension, and noise. [2][3].There is a significant decrease in tensile strength as the ageing time of seawater increases [4]. It is the composite's ability to absorb water that is as time goes on, the fickian diffusion model predicts a decline in both strength and stiffness [5]. Ageing in salt water decreases the fatigue strength and lifespan of GFRP composites [6]. Vinyl ester/glass composites lost 20% of their flexural strength as a result of water ageing [7]. Fracture toughness, which leads to failure at early stresses, is significantly affected by water absorption as well.[8] The purpose of this study is to examine the effects of salt water ageing on marine propellers constructed of GFRP composite material, after a literature assessment. The composite material was made and then aged in salt water for 15, 30, and 45 days.

II. MATERIALS AND METHODOLOGY

To prepare the composite materials the combination of materials are used as shown in table 1. The materials are obtained from sree industrial composite, Hyderabad.

A. *Manufacturing*

Hand Layup Technique is used to make the composites. Combining 90 parts epoxy (LY 556) with 10 parts hardener (HY 951), the two were thoroughly mixed using a mechanical stirrer. After a portion of the mixture has been put into a 200 Sq.mm precast form with a thickness of 3 mm, the fibres are positioned, and the remaining mixture is poured into the mould. It took 24 hours for composite materials to cure while under strain. After composite lamination, use Mould Release Spray to quickly remove material from the mold[9]. Samples were produced according to ASTM D638 [10].

TABLE I. *MATERIALS USED FOR SPECIMEN PREPARATION*

S.No	Specimen	Fiber	Matrix	Saline water Ageing
1	C1	Woven Glass	Epoxy (LY 556) + Hardener (HY 951)	-
2	C2			15 days
3	C3			30 Days
4	C4			45 Days

B. *Testing*

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Aged composite materials are subjected to tensile testing in accordance with ASTM standards, and the outcomes are contrasted with the characteristics of plain GFRP. The samples are immersed in water with a salinity of 3.5% for 15, 30, and 45 days, respectively, to simulate seawater. The test is conducted using an Instron-supplied Universal Testing Machine (UTM) with a 50 KN load cell and a crosshead speed of 2 mm/min.RESULTS AND DISCUSSION

A. Water uptake

Ageing is carried according to ASTM D570. Samples are initially dried in the oven for 24hours at 50 degrees. Immersed samples are weighted for every 24 hours by removing from water and wiping with tissue paper. The weight of the samples recorded and the percentage of increase in weight is calculated by using the following relation. The average value of 3 specimens were plotted in following image.

$$water\ uptake\ \% = \frac{w_1 - w_0}{w_0} X100$$

Where:
W_1= weight of the sample after immersion (Grams)
W_0= Initial weight of the samples (Grams)

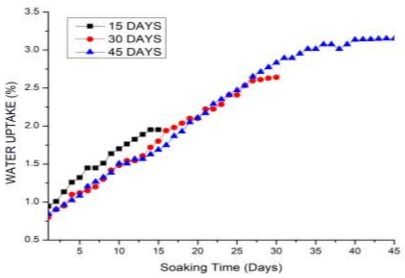

Fig. 1. *water uptake pattern of GFRP composite material*

The figure1 represents the amount of water uptake for the samples soaked in 15 days, 30 days and 45 days. The amount of water uptake increased with increase in soaking duration. The soaking duration has much influence on water uptake.The results pattern agreeing the Fick's law. The uptake pattern is found similar to the recent research on composite materials water ageing [4], [6], [7], [11]–[14]. It is known from the literature that glass fibre composites in distilled water reach the saturation usually in two or three months [15], the present study limited to1.5 months only , hence water uptake not reached to saturation stage. The change of specimen weight is apparent.

B. Mechanical characterization

The water ageing influenced the strengths and modulus of glass fibre reinforced composites in tensile and flexural loading condition, as shown in the figure 2. Initially, glass fibre has the tensile strength 84.14MPa and tensile modulus of 11.254GPa.

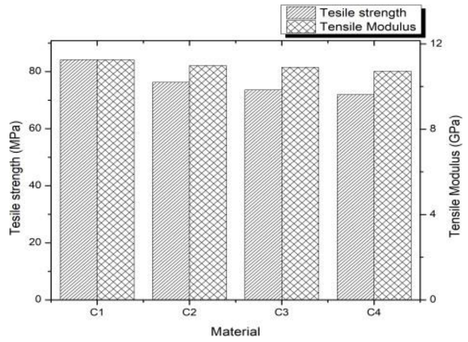

Fig. 2. *Tensile strength and modulus of GFRP composite material*

For samples aged in 3.5% salinity tensile strength decreased by 9.3%, 12.5% and 14.5%. Similarly, modulus decreed by 2.4%, 3.1% and 4.7% for 15, 30 and 45 days respectively. However, the modulus is not reduced as much as strength. The strength tensile strength of GFRP composite has found reducing with an increase in soaking time.

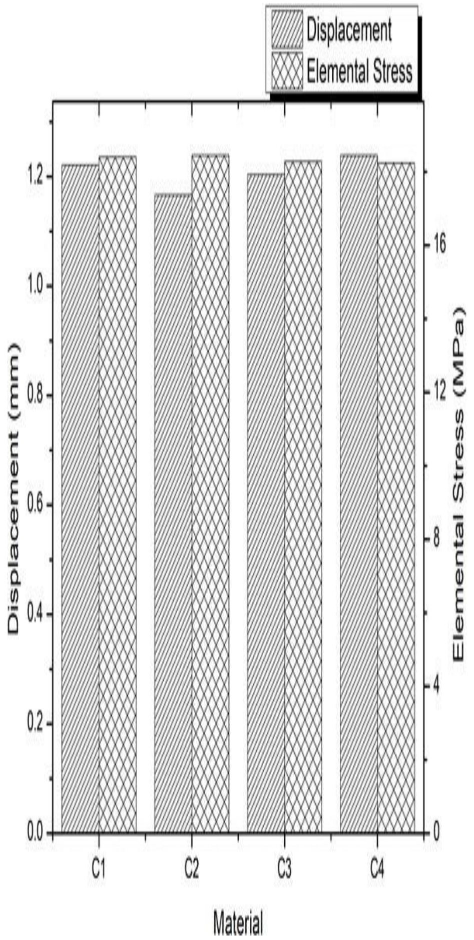

Fig. 3. *Composite marine propeller displacement and Elemental stress of aged propeller*

As the soaking period increases, the findings show that the mechanical characteristics of the GFRP composites are significantly decreased. "The interfacial damage resulting from the action of seawater could be observed in case of glass-epoxy composites," according to new study. Some kind of irreversible chemical breakdown seems to have occurred in the interfacial area of these composites. Longer fibre pull-outs and deboning between the matrix material and fibres are signs of deterioration beginning. The hydrolysis of polymeric materials, accelerated by the salty environment, and the disintegration of chemical bonds at the interface are the primary causes of these degradation symptoms. The diminished mechanical characteristics of the glass-epoxy composites are therefore readily visible.[13]. Previous research [3, 5] also shown that mechanical characteristics of glass epoxy composites degraded when submerged in water. Previous research indicated that static mechanical strength parameters are most severely affected by the migration of saltwater into composite materials when subjected to long-term soaking. There was no discernible impact on the elastic moduli, although failure strengths were found to be 20% to 40% lower. However, it would be prudent to use caution when extrapolating mechanical test findings to longer time periods [11].

III. Conclusions

These findings are based on studies that examined the structural and behavioural effects of ageing on composite maritime propellers.
• The composite material's water absorption behaviour follows Fick's law, which is induced by water ageing. Blends of polymers and glass fibres While both tensile strength and modulus declined with increasing soaking time, the former declined at a faster rate.

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