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Some Investigations on Glass-Reinforced Aluminium Laminate (GLARE) for Marine Applications

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ABSTRACT

Fiber metal laminates (FMLs) have been used as one the best materials suited for shipbuilding, aeronautical and aerospace applications because of their superior mechanical properties over traditional materials. In this work, the glass fiber aluminum laminates were prepared in the laboratory. The degradation in tensile strength of Glass Laminate Aluminum Reinforced Epoxy (GLARE) due to aqueous environments has been investigated for marine applications. A Universal Tensile testing machine has been used for the testing of the GLARE specimen for its tensile strength. The tensile strength was decreased by approximately 20% after the 15 days of immersion.

Keywords: GLARE, Glass fiber, Aluminum, Tensile strength, Composite

I. INTRODUCTION

During the past decades, increasing demand in the aircraft industry for high-performance, lightweight structures has stimulated a strong trend towards the development of refined models for fiber-metal laminates (FMLs). Fiber-metal laminates are hybrid composites built up from interlacing layers of thin metal and fiber-reinforced adhesives. They are mostly used in the aerospace and marine industry due to their good strength and lightweight. There are several different materials constituents used in manufacturing FML to study and improve its characteristics [1-3].

In 1980, Vogelesang and Schijve made the first FML using aluminium (Al) alloy and aramid fibre reinforcement. It is known as Aramid-Reinforced Aluminium Laminate (ARALL). It was found that it has fatigue properties better than in a monolithic single metal due to the resistance of fibre to the fatigue crack growth (fibre bridging). In 1987, AKZO established another type of FML called Glass laminate aluminium reinforced epoxy (GLARE) that started to be produced and commercialized in four grades in 1991. All these grades use unidirectional fiberglass, but of different orientation directions. Also, they use different types of aluminium alloy. It was found that GLARE 1 and GLARE 2 of unidirectional (0°) fiberglass can withstand much higher loads in the direction of the fiberglass orientation than in the other directions, GLARE 3 which uses an equal amount of fiberglass in the perpendicular directions can withstand equal loads in both directions, while

GLARE 4 which uses twice the amount of fiberglass in one direction than in the perpendicular direction can withstand twice the load in one direction than in the other direction. The fatigue properties of all GLARE grades are excellent [4-5].

Another type of FML which consists of carbon fibre had been investigated at Delft University of technology, which is much stiffer than ARALL called carbon-reinforced aluminium laminates (CARALL). CARALL is produced in three unidirectional different fibre orientations; 0°, 90°, and 45°. Carbon fibre provides stiffness higher than aramid fibre and glass fibre. The application of carbon fibre in FMLs has excellent resistance to crack growth which was the driver behind the investigation of carbon fibre in FMLs. But there is a problem in using carbon fibre with aluminium in a moisture environment which is the galvanic corrosion between the materials, so aluminium has to be isolated from the carbon fibre through using thermoplastic polyetherimide coatings.

II. METHODS AND MATERIAL

Unidirectional E-glass fibre and Epoxy (Resin & Hardener) is purchased from Carbon Black Composites, Mumbai. Aluminium sheet of grade 5052 is purchased from Nextgen Steel & Alloys, Mumbai. Commercially available glass fibre mat and aluminium has been used for making specimen. For the experimentation unidirectional roll of glass fibre was purchased having 50 cm width having 0^{O} fibre orientation woven with polymer fibres. The fibre was initially cut from roll in lengths of 550 mm and width of 300 mm. The GLARE was prepared shown in the figure 1.

Figure 1: Glass fiber metal laminate Sheet

The specimen had been cut and prepared as per the ASTM standards D3037/3039 for tensile test as shown in Figure 2.

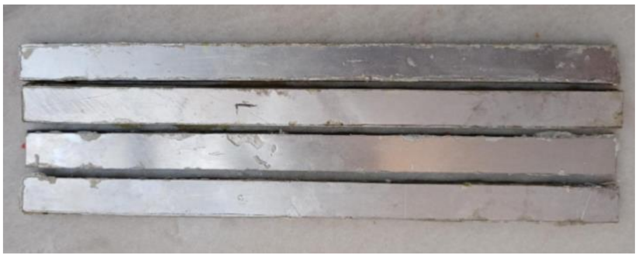

Figure 2: Tensile specimen cut from GLARE

The specimen were dipped into a water bath of 15 days. The water absorption were recoeded after 3 days for total 15 days. The tensile strength was evaluated after 15 days of water emmersion.

III. RESULTS AND DISCUSSION

Moisture absorption: The prepared specimens were immersed in the water bath for 15 days. The weight of the specimen was observed in 3, 6, 9, 12 and 15 days respectively as shown in Table 1. The weight was recorded in specimen. It was observed that there is a significant increase in the weight of the specimen. This is due to the absorption of water into the composite matrix.

Table 1: Weight gain in specimen

No. of Days	Weight of specimen (gm)
0	30.010
3	30.121
6	30.282
9	30.410
12	30.520
15	30.643

Table 2: Tensile results

Testing day	Tensile strength (MPa)
1st day	140.78
15th day	112.22

Samples were tested on Universal testing machine for tensile strength over the period of 15 days. First test was done on 1st day to know the tensile strength.

Then second test was done on 15th day. The specimen after fracture has been shown in Figure 3.

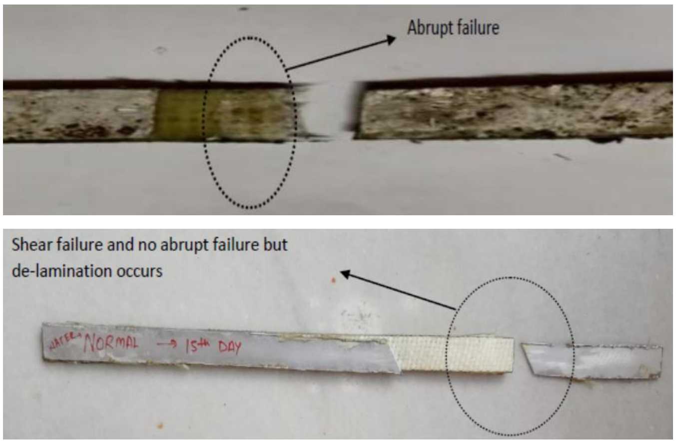

Figure 3: Tensile specimen after fracture on the 1st day and 15th day

Abrupt failure in tensile test was observed in the specimen before dipping into the water. The tensile strength of 140.78 MPa was recorded (Table 2). The specimen was taken from the water bath and again tested for tensile strength. The tensile strength of 112.22 MPa in the wet specimen. A 20.28% decrease in the tensile strength was observed. It is due to the plasticization effect of absorbed water molecules into the gaps of composite layers. The absorbed water molecules behave as a plasticizer which gives the FML structure more flexibility than before. The absorbed water molecules degrade the epoxy matrix which leads to the generation of residual stresses within the laminates and thus hinders the strength of FML. Because of the weakening and softening of matrix phase, microscopic cracks are developed in it, which leads in the reduction of tensile strength. These changes in matrix phase also degrades the interfacial bond between composite surface and metal layers of GLARE.

IV. CONCLUSION

- Glass Laminate Aluminum Reinforced Epoxy have been manufactured using Aluminum 5052 as metal and two layers of glass fabric as fiber for the production of Fiber Metal Laminate.
- The maximum moisture was absorbed by the GLARE specimens when dipped in normal water.
- GLARE specimens when tensile tested showed shear type failure and abrupt failure at 1st day of testing and at 15th day respectively. There was a 20.28% of decrement in tensile strength was observed in the specimen.

V. REFERENCES

[1]. E. C. Botelhoa, R. A. Silvac, L. C. Pardinia, M. C. Rezendea (2006): A Review on the Development and Properties of Continuous Fibre/epoxy/aluminum Hybrid Composites for Aircraft Structures. Materials Research; 9: 247-256.

[2]. S. Ebrahim, M. Torshizi, S. Dariushi, M. Sadighi, P. Safarpour (2010): A study on tensile properties of a novel fibre/metal laminates. Materials Science and Engineering A; 527: 4920–4925

[3]. T. Sinmazçelik, E. Avcua, M. Bora, O. Çoban (2011): Review on background, bonding types, and applicable test methods on fibre metal laminates. Materials and Design; 32: 3671–3685.

[4]. H.T.N. Kuan, W.J. Cantwell, Md. A. Hazizan, C. Santulli (2011): The fracture properties of environmental-friendly fibre metal laminates. Journal of Reinforced Plastics and Composites; 30(6): 499–508.

[5]. G.R. Rajkumar, M. Krishna, H.N Narasimhamurthy, J.R Nataraj, Keshavamurty Y.C (2014): Investigation of tensile and bending behavior of Aluminium based hybrid fiber metal laminates. Procedia Materials Science; 5: 60 – 68.