Fatigue analysis of glass fiber reinforced composites

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ABSTRACT

Some structure materials can match the flexibility and effectiveness of glass fiber Reinforced plastic, commonly called GFRP for short or simply fiberglass. Even it is very high strength, light weight, strong, and completely waterproof, it can be molded into free form shapes such as aerospace structures, and then also it has its endurance limits. Endurance limit means loss of strength and stiffness. This article describes about the fatigue life material properties of GFRP composites are studied based on an extensive experimental study. Then the loss of stiffness was used as a damage parameter and related to raise the temperature. The objective of this project is to analyze the damage and ageing effects in composites and find the change in physical and mechanical properties. The work discusses the experimental investigations carried out on Glass Fiber reinforced plastic (GFRP) composite specimens in which the acquire result is analyzed. Mainly this article explains about the fatigue analysis of glass fiber reinforced composites with varying loads and shown the number of cycles with stand.

Keywords: *Composite materials, GFRP composites, Mechanical properties, Flexural strength, fatigue, cyclic impact.*

1. INTRODUCTION

FRP composites are defined as the materials that contain fibers embedded in a resin matrix. The aim of combining fibers and resins that are different in character is to take advantage of the unique material features of either component to result in an engineered material with desired overall composite action for particular applications. Continuous fiber-reinforced composites contain reinforcements contain lengths much more than their cross-sectional dimensions. Such a composite is considered to be a irregular fiber or short fiber composite if its properties differ with fiber length. On the other hand, when the length of the fiber is such that any additional increase in length does not, for example, additional increase the elastic modulus or strength of the composite, the composite is considered to be continuous fiber reinforced. Most continuous fiber composites, in fact, contain fibers that are similar in length to the overall dimensions of the composite part. Engineering properties of FRP composites for structural applications, in most cases, are subject by fiber reinforcements. Additional fibers usually give rise to high strength and stiffness. Excessively high fiber/matrix ratios may, however lead to strength decrease or premature failure due to internal fracture. Fiber lengths and orientation also affect the properties.

Glass fibers: The most common reinforcement for the polymer matrix composites be a glass fiber. Most of the fibers are based on silica (SiO_2), with addition of oxides of Ca, Na, B, Al, and Fe. The glass fibers are classified into three classes-

- E-glass
- S-glass
- C-glass

The E-glass is chosen for electrical use and the S-glass for high strength. The C-glass is for high corrosion resistance, and it is special for civil engineering application. Of the three fibers, the E-glass is the most common reinforcement material used in civil engineering structures. It is created from lime-alumina borosilicate which can be easily obtained from plenty of raw materials like sand. The glass fiber strength and modulus can degrade with increasing temperature. Even if the glass material creeps under a sustained load, it can be designed to perform satisfactorily. The fiber itself is regarded as an isotropic material and has a poorer thermal expansion coefficient than the steel.

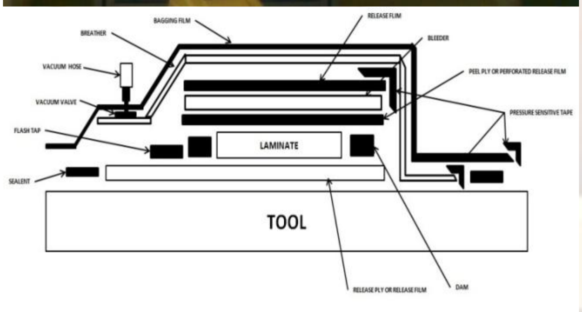
E-glass (electrical) Family of glassed with a calcium aluminum borosilicate composition and a maximum alkali composition of 3%. These are used when strength and high electrical resistivity are essential.

S-glass (tensile strength) Fibers have a magnesium alumina-silicate composition, which demonstrates high strength and used in use where the very high tensile strength is required.

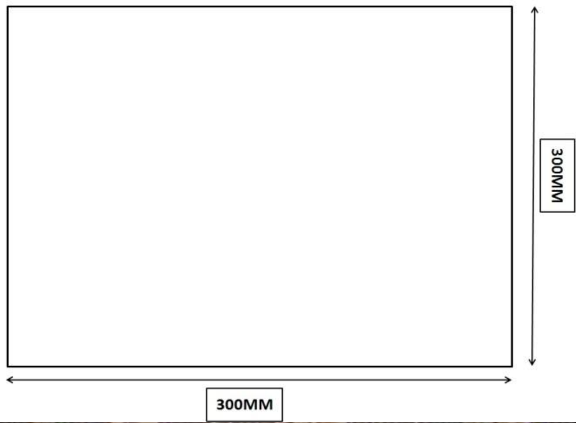
C-glass (chemical) It contains a soda lime borosilicate composition that are mainly used for its chemical stability in corrosive environment. It is frequently used on composites that contain acidic materials.

Structure of glass fiber: Glass fibers have high tensile strength, impact strengths and high chemical resistance. Then they have relatively low modulus, low fatigue resistance, self-abrasiveness and very low adhesion to matrix composites. Then the three dimensional network of structure of glass results in isotropic properties of glass fibers, in contrast to those of carbon and Kevlar aramid fibers which are anisotropic. The elastic modulus of glass fibers measured along the fiber axis is the same as that measured in the transverse direction, a characteristic unique to glass fibers.

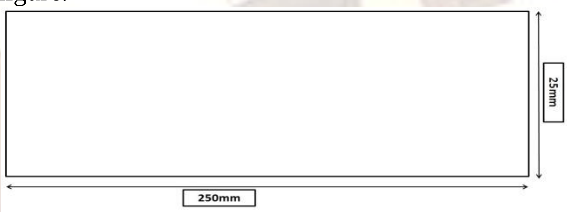
Material Preparation: If bidirectional (0°/90°) glass fiber reinforced epoxy laminate will be study in this project. Here the composite laminate is made up of seven layers of glass fibers with epoxy resin were fabricated. The plain weave fabric of E glass E420 fibers and LY 556 Epoxy Resin with XY 951 Hardener were used. The constant thickness of 3.4mm will be maintained throughout the experiment. Fiber-volume fraction of the composites was 65%. Vacuum bagging technique was used for the manufacturing of composite laminate. Resin and hardener were mixed in the ratio of 10:1. Alternate layer of resin-hardener mixture and carbon fibers were applied at room temperature. Curing at room temperature was done for 24 hours and post- curing at 100°C was done for 2 hours.



LAYUP SEQUENCE FOR BAGGING OPERATION



Material Cutting: Test coupons will be cut according to the ASTM E 466-01 for Fatigue testing by using water jet cutting technique. The test coupon will have dimension of length 250mm and width 25 mm and thickness 3mm as shown in figure.



Test Coupons Preparation: After cutting the material it's should be cleaned then gripping surface to attach the coupons as per the ASTM E 466-01 standard. If the gripping material should be rough in nature so will place the 1mm aluminum plate on both sites. By using the araldite nature so will place the 1mm aluminum plate on both sites. By using the araldite resin and hardener to paste the plates. Then it's should de

rough by using the fillet. And the test test coupons are as shown in figure
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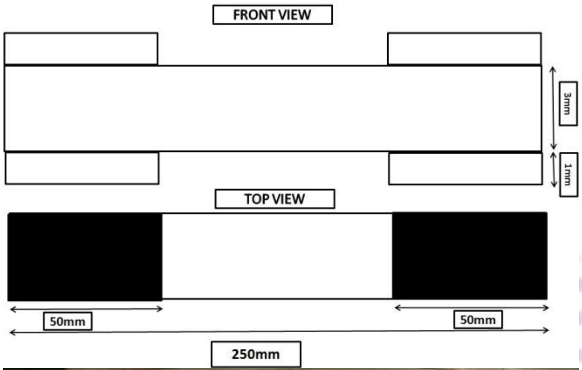
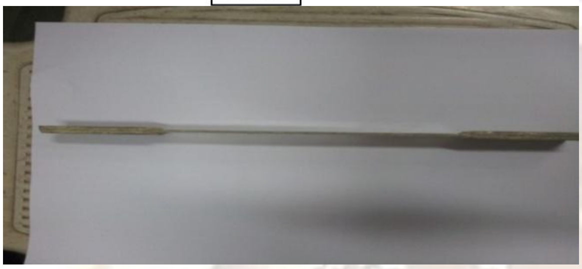




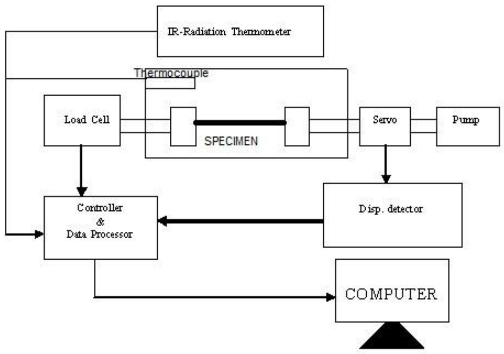
Water Jut cutting machine:
Water jet cutting machine is a device which is used for to cut the material in exact dimension and its reduces the wastage. And its specification is 58000psi/4000 bar high pressure of stream water. Its spraying value is 11 mach speeds. Then the tolerance value is +/-0.1mm to +/-0.3mm.

Fatigue Testing Machine: In this testing machine, materials are subjected to vibrating or oscillating forces. The apply the materials under such load conditions differs from the behavior under a static load. Because the material is subjected to repeated load cycles (fatigue) in actual use, designers are faced with predicting fatigue life.

ID MARKS	AH/31875-1 A	AH/31875-2 B	AH/31875-3 C
THICHNESS(mm)	2.03	2.03	2.03
BREATH(mm)	24.73	24.73	24.73
AREA(mm)2	50.20	50.20	50.20
LOAD(KN)	10.00	10.00	10.00
CYCLES	5193	5199	5180
FREQUENCY(HZ)	12	12	12
FREACTURE	YES	YES	YES

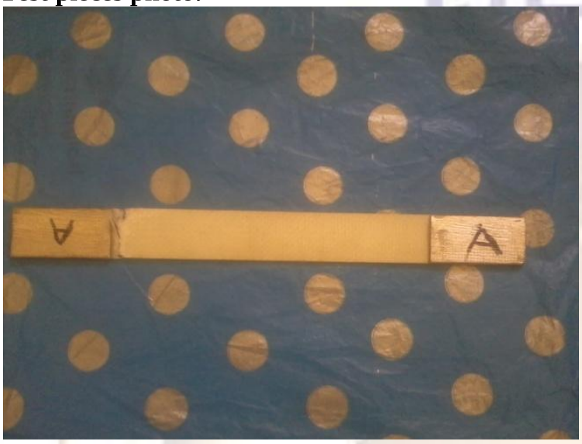
ID MARKS	AH/31874-1 A	AH/31874-2 B	AH/31874-3 C
THICHNESS (mm)	2.03	2.03	2.03
BREATH(mm)	24.73	24.73	24.73
AREA (mm)2	50.20	50.20	50.20
LOAD(KN)	5.00	5.00	5.00
CYCLES	11293	11354	11285
FREQUENCY(HZ)	12	12	12
FREACTURE	YES	YES	YES

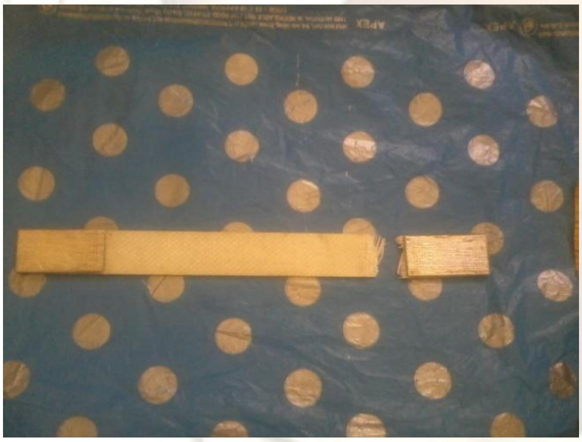
ID MARKS	AH/31876-1 A	AH/31876-2 B	AH/31876-3 C
THICHNESS(mm)	2.03	2.03	2.03
BREATH(mm)	24.73	24.73	24.73
AREA(mm)2	50.20	50.20	50.20
LOAD(KN)	15.00	15.00	15.00
CYCLES	3293	3199	3196
FREQUENCY(HZ)	12	12	12
FRECTURE	YES	YES	YES



RESULT:

Test pieces photo:





Conclusion and future work :

The fatigue test for GFRC shows that it can withstand the fatigue load efficiently compare to aluminum. In the future this work can be extended with different loading conditions to prove who the stress variation can be improved, by knowing the stress variation this can be used in airframe of the aircrafts.

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