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Investigation of Mechanical Properties of Composite Material Reinforced by Aluminum-Fibers

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ABSTRACT

A composite material is made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons. More recently, researchers have also begun to actively include sensing, actuation, computation and communication.

In this work the mechanical properties of aluminum, glass fiber and synthetic fiber and their composite with aluminum were evaluated with reference to ASTM D638-02 a. During the tensile load, the maximum strain was obtained in synthetic fiber whereas maximum stress was obtained in glass fiber- synthetic fiber composite. Composite material has shown an improvement of mechanical properties when compared with individual materials.

Keywords: *Aluminum; Glass Fibre; Synthetic Fibre; Stress; Strain.*

1.0 Introduction

The composites are compound materials which differ from alloys by the fact that the individual components retain their characteristics but are so incorporated into the composite as to take advantage only of their attributes and not of their short comings in order to obtain improved materials. Composite materials are heterogeneous materials consisting of two or more solid phases, which are in intimate contact with each other on a microscopic scale. They can be also considered as homogeneous materials on a microscopic scale in the sense that any portion of it will have the same physical property.

The damage tolerance of polymeric materials can be enhanced by improving the inter-laminar properties of the polymer composites [1]. A new finite element model for laminated composite beams includes sufficient degrees of freedom to allow the cross-sections of each lamina to deform into a shape which includes up through cubic terms in thickness co-ordinate. The element consequently admits shear deformation up through quadratic terms for each lamina but not interfacial slip or delaminating [2].

The free vibration analysis of a cross-ply laminated composite beam on Pasternak Foundation. The model is designed in such a way that it can be used for single-stepped cross section. For the first time to-date, the same analysis was conducted for a single-stepped LCB on Pasternak foundation. Stiffness and mass matrices of a cross-ply LCB on Pasternak foundation using the energy method are computed [3].

The cracks can be present in structures due to their limited fatigue strengths or due to the manufacturing processes. These cracks open for a part of the cycle and close when the vibration reverses its direction. These cracks will grow over time, as the load reversals continue, and may reach a point where they pose a threat to the integrity of the structure. As a result, all such structures must be carefully maintained and more generally, SHM denotes a reliable system with the ability to detect and interpret adverse change in a structure due to damage or normal operation. [4]. the finite beam element was

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formulated using the composite element method with a one-member–one-element configuration with cracks where the interaction effect between cracks in the same element was automatically included. The accuracy and convergence speed of the proposed model in computation were compared with existing models and experimental results [5]. The effects of crack depth and location, fiber orientation, and fiber volume fraction on the flexibility and consequently on natural frequency and mode shapes for cracked fiber-reinforced composite beams are investigated [6].

The mechanical properties of aluminum, nylon, GFRP, aluminum-GFRP composite & aluminum-nylon composite were found by using experimental method. One layer of GFRP is sandwiched between two layers of aluminum to form GFRP composite. Similarly, nylon composite is formed [7, 8].

Many technologies require materials with unusual combination of properties that cannot be met by the conventional materials [9]. Many composite materials are composed of just two phases one is termed the matrix, which is continuously surrounded by the other phase, often called the dispersed phase [10]. Recently an increasing use of composites reinforced with different types of fibers has occurred, owing the following advantages: they are strong enough, light in weight, abundant, non-abrasive and cheap [11].The damage tolerance of polymeric materials can be enhanced by improving the inter-laminar properties of the polymer composites [12]. Fiber is known as material which strengthens the composites. For decades, fiber has been used to increase toughness and tensile ductility. Some innovations have been applied such as Fiber Reinforced Concrete (FRC) High Performance Fiber Reinforced Cementations Composites (HPRFCC) which is known as Engineered Cementations Composites (ECC). It is important to conduct study to know the performance of fiber in cementations matrix. The properties of interfaces between fiber and cementations matrices and their stress transfer takes an important role in determining the whole composites properties, selecting the main ingredients of composites, and predicting the failure of composite. The majority of engineering composites materials in demanding applications consists of continuous fibers of glass or carbon reinforcement in thermosetting epoxy polymer. There has been a tremendous advancement in recent days. Compared to metals, the polymeric composites have many advantages as higher fatigue strength, higher corrosion resistance and lower weight [13,14] polymeric composites are susceptible to mechanical damages when they are subjected to efforts of tension, flexural, compression which can lead to material failure. Therefore it is necessary to use materials with higher damage tolerance & carryout an adequate mechanical evaluation. Damage tolerance of epoxy polymeric composites can be enhanced by improving the inter laminar properties by toughening matrix, reinforcement with bidirectional woven fabrics [15,16]. Scanning electron micrographs obtained from fracture surfaces were used for a qualitative evaluation of the interfacial properties of coir /epoxy and compared with glass fibers [17] were analyzed. Length of the fibers was in the range between 8 and 337 mm. The fibers amount with the length range of 15~145 mm was 81.95% of all measured fibers. Weight of fibers with the length range of 35~225 mm accounted for 88.34% of all measurement. The average fineness of the coir fibers was 27.94 tex. Longer fibers usually had higher diameters. Composite boards were fabricated by using a heat press machine with the coir fiber as the reinforcement and the rubber as matrix.

The surface treatment of the coir fiber and its mechanical properties, Fiber surface modification by ethylene di-methyl-acrylate (EMA) and cured under UV radiation. Pretreatment with UV radiation and mercerization were done before grafting with a view to improve the physic mechanical performance of coir fibers. The effects of mercerization on shrinkage and fiber weight losses were monitored at different temperature and alkali concentration.

They observed that, fiber shrinkage is higher at low temperature and 20% alkali treated coir fibers yielded maximum shrinkage and weight losses. It was found that higher shrinkage of the polymer grafted fiber showed enhanced physical mechanical properties. The grafting of alkali treated fiber shows an increase of polymer loading (about 56% higher) and tensile strength (about

27%) than 50% EMA grafted fiber. The fiber surface topology and the tensile fracture surfaces were characterized by scanning electron microscopy and were found improved interfacial bonding to the modified fiber–matrix interface [18].

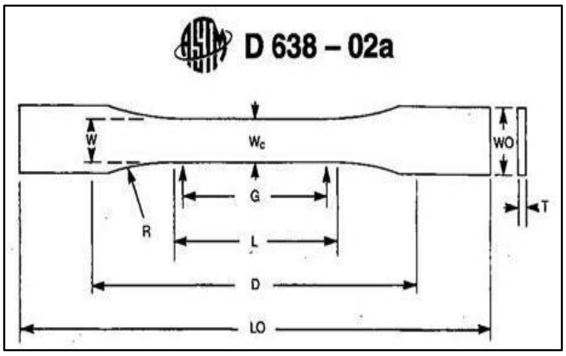
2.0 Experimental Procedure

The procedure for conducting the tensile test in a UTM as follows:

- The ASTM D638 composite tensile test specimen was checked for dimension.
- The specimens were clamped in the fixture of the UTM.
- The strain gage which is connected in the UTM, measured the displacement value.
- The specimen was break in two piece, after critical load applied on the specimen as shown in figure.
- The stress and strain values were noted from the computer which is coupled with the UTM.

Fig 1: Fracture Specimens

Fig 2: Drawing of Test Specimen



3.0 Specification of Specimen

All the specimens 1, 2 and 3are made with the help of ASTM code D638-02 a [19] and have the characteristics.

Specimen 1: Aluminum (Type-I)

Specimen 2: Aluminum (Type-II)

Specimen 3: Aluminum (Type-III)

Similarly all the three specimens are made by Type-I, Type-II and Type-III for composite and their individual materials.

4.0 Results and Discussion

4.1 Tensile test

Figure 3 shows the engineering stress-strain curve for Aluminum specimens with an enlarged scale, from zero to specimen fracture. Here it appears that the rate of strain hardening diminishes up to UTS (Ultimate Tensile Strength).Beyond that point, the material appears to strain soften, so that each increment of additional strain requires a smaller stress.

Table 1: Dimensions of Test Specimen

Specimen Dimension (mm)			
Dimension	Thickness 7mm or less		over 7 to 14 mm
Type-I	Type-II		Type-III
W- Width	13	6	19
L-Length	57	57	57
WO-Width over all	19	19	29
LO Length over all	165	183	246
G-Gage length	50	50	50
D- grips Distance	115	135	115

Table 2: Tensile Properties of Aluminum and Their Composites

Material	Ultimate Strength (MPa) Specimen-I	Ultimate Strength (MPa) Specimen-II	Mean Ultimate Strength (MPa)	Strain Specimen-I	Strain Specimen-II	Mean Strain
Aluminum	173.88	164.21	169.045	0.5423	0.5571	0.5497
Glass fiber	222.5838	220.014	220.29	0.2624	0.2784	0.2704
Synthetic fiber	206	201	203.5	0.5908	0.5798	0.5853
Aluminum-Synthetic fiber-Aluminum	215.24	210.01	212.625	0.57043	0.5801	0.5752
Aluminum - Glass fiber-Aluminum	273.136	268.325	270.73	0.4414	0.4423	0.4418
Glass fiber-Synthetic fiber-lass fiber	290.704	293.214	291.95	0.4646	0.4712	0.4679

Fig 3(a): Stress-Strain Diagram for Aluminum (a) Specimen-I

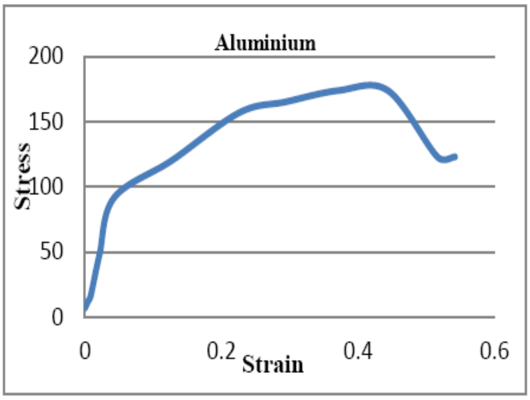


Fig 4(a): Stress-Strain Diagram for Glass Fiber-Specimen-I

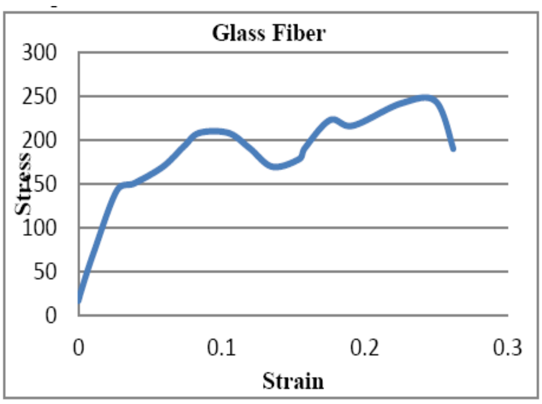


Fig 4(b): Stress-Strain Diagram for Aluminum (b) Specimen-II

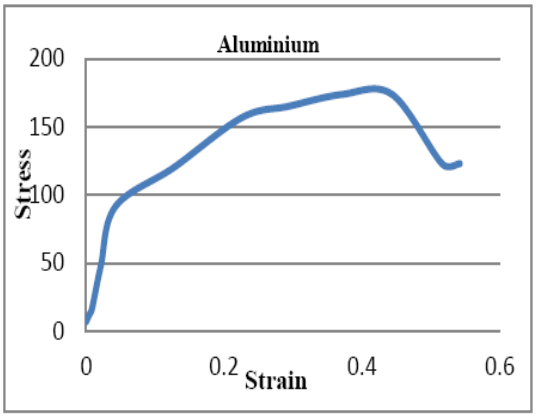


Fig 4(b): Stress-Strain Diagram for Glass Fiber - Specimen-II

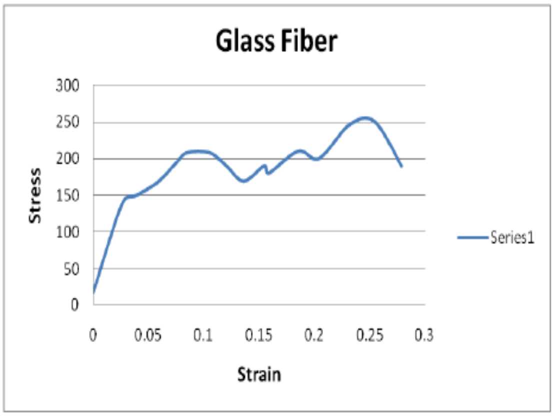


Fig 5 (a):- Stress-Strain Diagram for Synthetic Fiber -Specimen-I

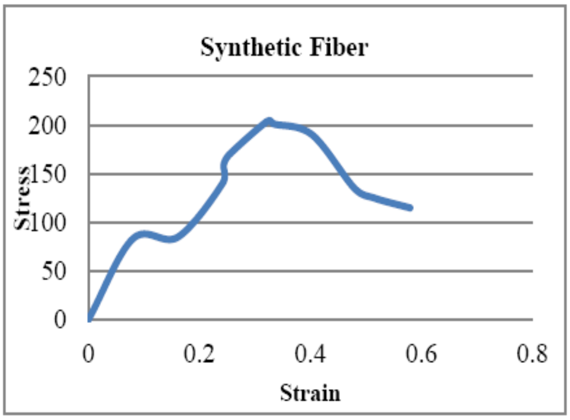


Fig 6 (b):- Stress-Strain Diagram for Synthetic Fiber Al-Glass Fiber-Al

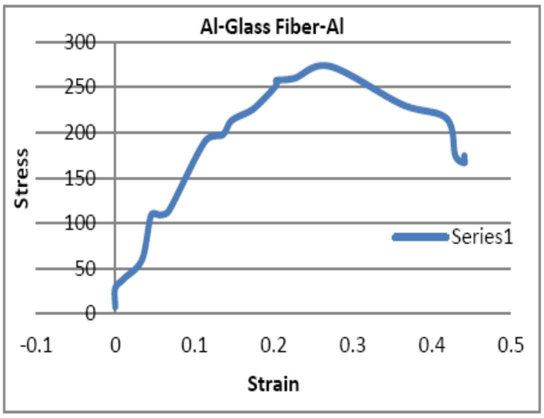


Fig.6 (a): Stress-Strain Diagram for Synthetic Fiber-Al-Synthetic Fiber

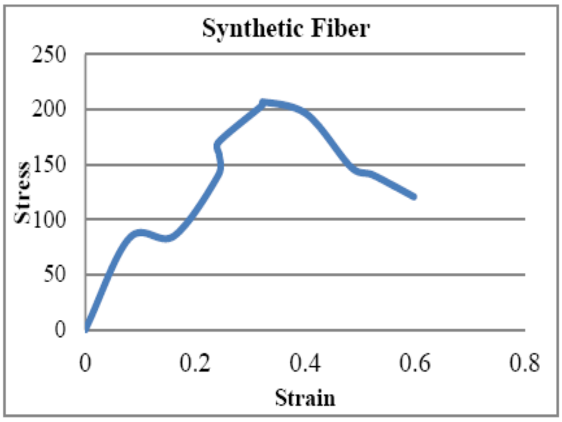


Fig 7 (a) Ultimate Stress Distrbution of Different Specimen

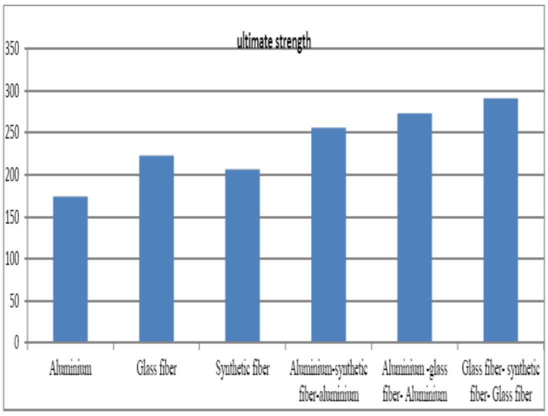


Fig 6 (b): Stress-Strain Diagram for Synthetic Fiber-Glass Fiber-Synthetic Fiber-Glass Fiber

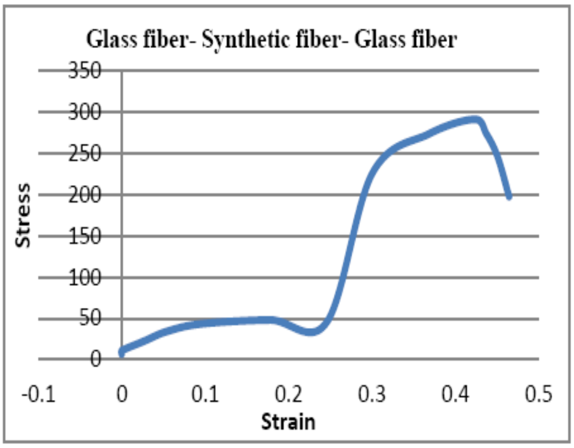
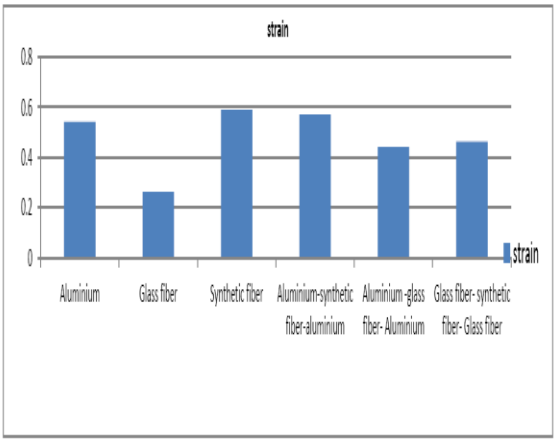


Fig 7 (B): Strain Distrbution of Different Specimen



The mechanical properties of aluminum, glass fiber, synthetic fiber and their composites were found by using experimental method. One layer of glass fiber is sandwiched between two layers of aluminum to form glass fiber composite. Similarly, other composite is formed. Acrylate is used as an adhesive material to form composites.

The tensile strength analysis for the sandwich composite structure for different specimen is presented in Figure 3-6. The figures indicate the variation of ultimate strength between 169 to 292 MPa. The maximum ultimate stress was found 292 MPa for glass fiber-synthetic fiber composite, where as minimum ultimate strength was found for pure aluminum.

5.0 Conclusions

The following conclusion may be drawn from the present work:

- The tensile strength are observed for 3 different specimen. The tensile strength increases up to certain limit, and then falls due to the variation of metal-fiber laminate.
- The Ultimate tensile strength of composite material has improved with comparison to individual material.
- The maximum ultimate stress was found 292 MPa for glass fiber-synthetic fiber composite, where as minimum ultimate strength was found for pure aluminum.
- The minimum and maximum strain was found in glass fiber and synthetic fiber respectively.

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