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AN EVALUATION ON THE EFFECT OF NATURAL FIBRES ON THE MECHANICAL PROPERTIES OF KENAF-COIR HYBRID COMPOSITE

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ABSTRACT: *Over the past few decades, we find that polymers have replaced many of the conventional metals/materials in various applications. This is possible because of the advantages polymers offer over conventional materials. The most important advantages of using polymers are the ease of processing, productivity, and cost reduction. In most of these applications, the properties of polymers are modified using fillers and fibres to suit the high strength/high modulus requirements. Fibre-reinforced polymers offer advantages over other conventional materials when specific properties are compared. These composites are finding applications in diverse fields from appliances to space crafts.*

KEYWORDS: Reinforcement, Compressive Strength, Environmentally Friendly, Hybrid Composite.

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INTRODUCTION

Composites are combinations of two materials in which one of the materials, called the reinforcing phase, is in the form of fibres, sheets, or particles, and are embedded in the other materials called the matrix phase (Haneefa, Bindu, Aravind & Thomas, 2008; Chabba, Matthews & Netravali, 2005). The reinforcing material and the matrix material can be metal, ceramic or polymer. Composites are used because overall properties of the composites are superior to those of the individual components. For example, polymer/ceramic composites have a greater modulus than the polymer component, but are not as brittle as ceramics (Mirbagheri, Tajvidi, Hermanson & Ghasemi, 2007; John & Venkata, 2004). Typically, reinforcing materials are strong with low densities while the matrix is usually a ductile, or tough, material. If the composite is designed and fabricated correctly, it combines the strength of the reinforcement with the ductility or toughness of the matrix to achieve a combination of desirable properties not available in any single conventional material (Gul hameed, Khalid & Ehsan, 2010; Osswald & Menges, 2003). The downside is that such composites are often more expensive than conventional materials. Examples of some current application of composites include the diesel piston, brake-shoes and pads, tires among many others.

LITERATURE/THEORETICAL UNDERPINNING

The strength of the composite depends primarily on the amount, arrangement and type of fibre (or particle) reinforcement in the resin. Typically, the higher the reinforcement contents, the greater the strength (Mouritz, Leong & Herszberg, 1997; Mohd, Harizan & Zainal, 2007). In some cases, glass fibres are combined with other fibres, such as carbon or aramid (Kevlar29 and Kevlar49), to create a "hybrid" composite that combines the properties of more than one reinforcing material. In addition, the composite is often formulated with fillers and additives that change processing or performance parameters (Chabba, Matthews & Netravali, 2005; John & Venkata, 2004; Robson, 1993).

Natural fibres have recently attracted the attention of scientists and technologists because of the advantages that these fibres provide over conventional reinforcement materials, and the development of natural fibre composites has been a subject of interest for the past few years (Osswald, & Menges, 2003; Yousif, Wong & El-Tayeb, 2007). These natural fibres are low-cost fibres with low density and high specific properties. These are biodegradable and non abrasive, unlike other reinforcing fibres. Also, they are readily available and their specific properties are comparable to those of other fibres used for reinforcements.

The need to use natural materials in composite development is necessary as it will save cost in importing synthetic ones and at the same time be a source of revenue generation (Karnani, Krishnan, & Narayan, 1997; Yousif, Wong & El-Tayeb, 2007). Before now, little research made on natural fibres only centred on their production and curing characterization instead of their mechanical properties. Major research works in composite development have been focused on the use of synthetic fibres. Different kinds of synthetic fibres used include glass and carbon fibres. Today, natural fibres such as sisal, jute, banana, coir and kenaf are capable of subduing the traditional synthetic fibres in use. This is due to the fact that apart from their availability and affordability, they have the desired properties needed or available in the

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conventional synthetic fibres (John, Venkata, & Naidu, 2004; Gul hameed, Khalid & Ehsan, 2010; Osswald & Menges, 2003).

Coir is a natural fibre extracted from the husk of coconut and used in products such as floor mats, doormats, brushes, mattresses, among others. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut (Yousif, Wong & El-Tayeb, 2007; Sharifah & Martin, 2004). As industries attempt to lessen the dependence on petroleum-based fuels and products due to high cost, scarcity and the uncertainty of it remaining forever, there is an increasing need to investigate more environmentally friendly, sustainable materials to replace the existing glass and carbon fibre reinforced materials. Therefore, attention has recently shifted to the properties and fabrication of natural fibre reinforced materials.

METHODOLOGY

Materials

Some of the materials used in this work are kenaf fibre, coir fibre, unsaturated polyester as the matrix, cobalt naphthalate (as the accelerator), Methyl Ethyl Ketone Peroxide: MEKP (as the Catalyst), cellophane leather (used to seal the mould for easy removal of the casting), roller, scissors, water, container and mould.

Methods

Fibre Extraction and Treatment

Both kenaf and coir fibres were obtained from the known kenaf and coconut plants respectively. They were extracted through pilling from the kenaf stick and coconut shell. Their physical properties differ where kenaf fibre were found to be long while the coir were short.

Specimen Fabrication

The specimen was fabricated using a Hand Lay-Up method or technique, which involves pouring the calculated amount of resin with thoroughly mixed Promoters; Accelerator & Catalyst at 4% and 1% respectively to the mould and allowing for ten minutes so that it starts pre-hardening. A cellophane leather sheet was put on to it, followed by the mould cover and a pressure was applied by placing a concrete block over the setup for 24 hours to cure the laminate completely. The laminate was then taken for machining according to ASTM standard for testing after curing. A roller was used at every fibre-matrix layer to compress the mixture so as to remove air trapped from the fabricated specimen.

Cutting of Laminates into Samples of Desired Sizes

The specimens produced were cut into sizes for the various tests to be carried out and the cutting was carried out using a hacksaw.

Mechanical test on the Specimens

The tests carried out are impact, flexural and compression characteristics. Each of the tests was carried out on a given laminate. All tests were conducted and carried out at the structural laboratory of the Civil Engineering Department of Abubakar Tafawa Balewa University, Bauchi State - Nigeria.

Impact Strength Test

The impact strength describes the ability of a material to absorb shock and impact energy without breaking. The impact strength test was carried out by cutting the specimens into aggregate sizes and was subjected to 15 blows from the impact machine. Impact test was done on the impact test machine. The specimen for impact test was selected in the form of cubes of roughly 10 mm square size. The specimen was placed in the test cylinder. The pounding weight was lifted and made to hit the specimen from the standard height for 15 blows. The aggregates were collected from the machine and sieved with 2.36mm SI sieve. The impact strength test of this specimen was carried out using the impact strength test machine shown below and the value was calculated using the relationship:

$$AIV = \frac{A}{B}\, X\, 100$$

Where A is the weight of the sample passing through the sieve and B is the total weight of the sample used. AIV is the aggregate impact value.

Thus, $AIV = \frac{16.7}{260}\, X\, 100 \quad = 6.423\%$

2.2.6 Flexural Strength Test

The flexural strengths of the specimens were determined for specimens using the three-point bending test as per ASTM-D790.

2.2.7 Compression Test

The compression test was carried out using an automatic compressive strength machine. The compression tests were carried out for two sets of specimens labelled at different sizes as **Z_1, Z_2, Z_3** and **Y_1, Y_2, Y_3**.

RESULTS/FINDINGS

All the tests were carried out in accordance with the ASTM standard. Table 1 shows results for flexural strength, while Table 2 and Table 3 show results for compressive strength for test 1 and test 2 respectively. Tables 4 and 5 show the flexural and compression properties of carbon, glass and kenaf-coir.

Table 1: Results of Flexural strength test

Specimen	Length (mm)	Breadth (mm)	Thickness (mm)	Breaking Load (N)	Flexural Strength (N/mm^2)
C_1	320	50	20	2.30×10^3	55.2
C_2	320	50	20	3.16×10^3	75.8
C_3	320	50	20	3.20×10^3	76.8

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Table 2: Result of compressive strength test for test 1

Specimen	Length (mm)	Depth (mm)	Area (mm^2)	Force (N)	Strength ($N/mm^{2)}$
Z_1	110	20	17400	946 X 10^3	54.36
Z_2	110	20	17400	992 X 10^3	57.01
Z_3	110	20	17400	1016 X 10^3	58.39

Table 3: Result of compressive strength test for test 2

Specimen	Length (mm)	Depth (mm)	Area (mm^2)	Force (N)	Strength ($N/mm^{2)}$
Y_1	110	10	7000	874 X 10^3	124.85
Y_2	110	10	7000	572 X 10^3	107.42
Y_3	110	10	7000	813 X 10^3	116.14

Table 4: Flexural properties of carbon, glass and kenaf-coir hybrid composite

Composite	Glass fibre	Carbon fibre	Kenaf-Coir fibre
Maximum load (N)	**921.8**	**794.2**	**2186**
Flexural Strength (N/mm)	**15.36**	**13.23**	**69.30**
Deflection (mm)	**8.225**	**4.846**	**--------**

Table 5: Compression properties of carbon, glass and kenaf-coir composite

Composite	Glass fibre	Carbon fibre	Kenaf-Coir fibre
Maximum load(N)	**4251.5**	**5700.5**	**874 X 10^3**
Compressive Strength (N/mm)	**94.47**	**126.7**	**124.85**
Deflection (mm)	**5.826**	**3.4075**	**2.85**

DISCUSSION

The flexural strength of the composite was found to be 55.2, 75.8 and 76.8 N/mm for specimens C_1, C_2, and C_3 respectively. The compression test result in the other hand has shown that the composite has strength of 54.36 N/mm^2 when a force of 2.30 KN is applied, 57.01 N/mm^2 at 992 KN and 58.39 N/mm^2 for a load of 1016 KN for test 1 and 124.85 N/mm^2, 107.42 N/mm^2, and 116.14 N/mm^2 at loads of 874 KN, 572 KN and 813 KN respectively for test 2.

The results of similar tests carried out on glass and carbon fibre reinforced composites were shown in the tables for flexural and compressive strength tests. The kenaf-coir reinforced hybrid composite even at higher loading showed better flexural and compressive strength properties.

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IMPLICATION TO RESEARCH AND PRACTICE

The use of natural fibre has improved the mechanical properties of the kenaf-coir hybrid composite. The increase in flexural and compressive strength indicates that the hybrid composite will be a good material in areas of high pressure force application.

CONCLUSION

In the above flexural and compressive test, the following conclusions are made

1. As compared to glass and carbon fibre reinforcement, the kenaf-coir fibre hybrid shows better flexural and compressive strength with more force sustained.
2. Deformation in the case of kenaf-coir fibre composite could not be measured for comparison as the machine used for testing does not possess such a facility.
3. Deformation was maximum for glass fibre and carbon fibre and minimum for kenaf-coir fibre composite.

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