COMPARISON OF SOME NATURAL FIBRES WITH GLASS FIBRES IN COMPOSITE DEVELOPMENT

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ABSTRACT

The comparison of some natural fibres with glass fibres in composite development is a work that involves the collection of glass fibers and natural fibres and using them in the development of fibre-reinforced plastic composites. Five different fibres were collected- the natural and synthetic fibres. The synthetic fibres were the glass fibres (woven roving), while the natural fibres were the dried palm fruits, coconut, palm sponge and ukam plant fibres. Five specimens from each fibre-reinforced composite produced were tested in tension and compression and their average results determined. The analysis of the mechanical properties obtained showed that natural fibres possess mechanical properties such as strength, modulus of elasticity, total energy absorption capacity per unit volume and the total energy absorption capacity per unit weight in appreciable magnitude. For example the tensile strengths of natural fibres like Ukam plant fibres (160 MPa) and that of coconut fibres (144 MPa) are very close to that of E-glass fibres (189 MPa). Similarly, their compressive strengths (74 MPa and 68 MPa respectively) showed that they can withstand compressive stresses like the synthetic fibres with compressive strength 89 MPa. The Ukam plant fibres, therefore proved to be the best in terms of mechanical properties compared to others. However, the low performance of dried palm fruits fibres in tensile strength (131.4 MPa) and compressive strength (62 MPa) makes them unsuitable for engineering applications that require the use of fibres.

KEYWORDS: fibres, mechanical properties, composite and matrix.

1.0 INTRODUCTION

Fibre reinforced plastics (FRP) are the most widely used group of materials which fibres act as reinforcements to give the combination its strength and toughness. The combination has the advantage as structural material over both unreinforced plastics and fibres used by themselves. Unreinforced plastics have a low density, are relative easy to process, resistant to weathering and do not require a surface finish (Wood, 1980). However, factors which greatly limit their application as structural materials are their low stiffness, low strength and their tendency to "creep" under load conditions. On the other hand, fibres are very stiff and strong but are so brittle that these qualities cannot be utilized commercially. Therefore, by combining fibres with plastics, it is possible to obtain the advantageous properties of these materials in a single composite (Nick and Mark, 2004)

The result of this combination is a material, which is light, strong with weather resistance surface and which by the nature of its constituents, can be fabricated into large and if required, complex shapes. In natural fibre reinforced plastics, the fibres improve the otherwise low stiffness of the plastics, increase its strength and reduce "creep". The resin transmits load onto the fibers and the whole being a matrix, the resin protects them from damage. Depending on the selection of the matrix materials and the method of reinforcing, the processor can produce a range of materials to suit the application (Sebe et al, 2000). A unique feature of fibre-reinforced plastics is that the final material can usually be formed during the moulding process.

There are very many situations in engineering where no single material will be suitable to meet a particular design requirement. However, two materials in combination may possess the required properties and provide a feasible solution to the materials selection problem. The principle of composite materials is not new. The use of straw in the manufacture of dried mud bricks, and the use of hair and other fibres to strengthen plasters date back to ancient civilizations (Enetanya, 2000). A typical composite material is a system of materials consisting of two or more materials (mixed and bonded) on a microscopic scale(Hill 2004).

There has been a wide range of activities on FRP composites (Richardson, 2007). The characteristics and mechanical properties of reinforcing fibres are provided in order to give insight into the kind of structures they could be formed into, and what the effects on environmental factors on such composites would be.

The aim of this study is to promote the use of local materials, reduce the cost of importation and at the same time conserve scarce foreign exchange.

2.0 EXPERIMENTAL PRODEDURE

In the development of FRP composite specimens, four sets of fibers were obtained: one set being synthetic fibers while the rest were natural fibres. The synthetic fibres were the glass fibres (0.01mm diameter) while the natural ones were coconut(0.04mm diameter), dried palm fruit and ukam plant fibers(0.04mm and 0.03mm diameters respectively). The natural fibers were prepared in a woven roving by orientation.

In this study, a suitable volume fraction of 30% was adopted. This is because, beyond this value (over reinforcement), noticeable cracks appear on the composite while at a value below 30% (under reinforcement) the composite becomes weak in tension. Gel-coat thickness was also restricted to 0.4 mm to prevent the formulation of star crazing on the composite. Before the fibers were used in composite development, they were treated with some chemicals for different purposes. The first treatment was by soaking and washing them with alkali, saline (brine) and diluted sulphuric acid (H_2SO_4) solution. This was to ensure: an effective fiber-resin interaction; a good interfacial bond capable of creating room for effective stress transfer from the matrix to the fibers; and improved resistance to moisture-induced degradation of the interface and the composite properties.

The second treatment was by soaking the fibers in a solution of copperchromacinate in order to protect them against biodegradation (Prescolt et al, 2005)

A 3 x 80 x 300 mm wooden mould was made. The next step was the dusting of the mould followed by the application of polyvinylchloride as the release agent. Then a catalyzed gel-coat was applied to a thickness of about 0.4 mm. This was very necessary in order to establish the visual appearance and the ductility of the specimen and prevent the fibres from showing in the laminate. It also provides the laminate the appropriate protection against weathering and corrosion. Care was taken to ensure that the thickness of the gel-coat was uniform in the mould. When the gel-coat was partially solidified, a layer of catalyzed polyester resin was brushed on the gel-coat and the first layer of fibers placed on it, pressed carefully and consolidated with a roller. More resin was brushed uniformly in the already placed fibre layer. The coverage of the fibres was formulated from a fiber volume fraction of 30%.

When the laminate has gelled, excess reinforcements around the edge of the mould were trimmed off with a pair of scissors. As the specimen solidified, it was demoulded and set aside to cure. Curing occurred at room temperature within two hours after moulding. This happened when all the heat of reaction had been given off (exothermic reaction), a situation initiated by the presence of catalyst. The fibers reinforced plastic specimen so formed was smoothened with a sand paper and subsequently cut into 3 x 20 x 300 mm for testing.

2.1 TEST METHODS

The HSMIC Hounsfield Monsanto material testing machine and equipment were used for the strength test. The test specimens were cut approximately to the length: width: thickness ratio of 300:20:3 (plate 1). Tensile and compressive forces were gradually applied (for tensile and compressive tests respectively) to failure along the specimen axis for each sample composition; the applied force being parallel to the fibre orientation. Five identical test specimens were prepared and tested for each sample composition at laboratory temperatures (about 27°C) in dry conditions. Average data for the five specimens were then computed for each point in figures 2 and 3.

It should be noted in table 1 that glass fibers have higher values of mechanical properties such as strength, elastic modulus, toughness and modulus of resilience than the natural fibers. According to Hyer (2008), these properties were determined as follows:

$$E = \frac{\delta ut.c}{\varepsilon}$$

$$U_{VT.C} = \frac{\delta^2_{ut.c}}{2E_{T.C}}$$

$$U_{wt.c} = \frac{U_{vt.c}}{\delta}$$

Where δ_{utc} = Ultimate stress in tension or compression

$P_{t,c}$ = tensile or compressive load

A = Area of the specimen

$E_{t,c}$ = modulus of elasticity in tension or compression

$U_{vt,c}$ = energy absorption capacity per weight in tension or compression

$U_{Wt,c}$ = energy absorption capacity per weight in tension or compression

Γ = specific unit weight

$E_{ut,c}$ = ultimate strain in tension and compression

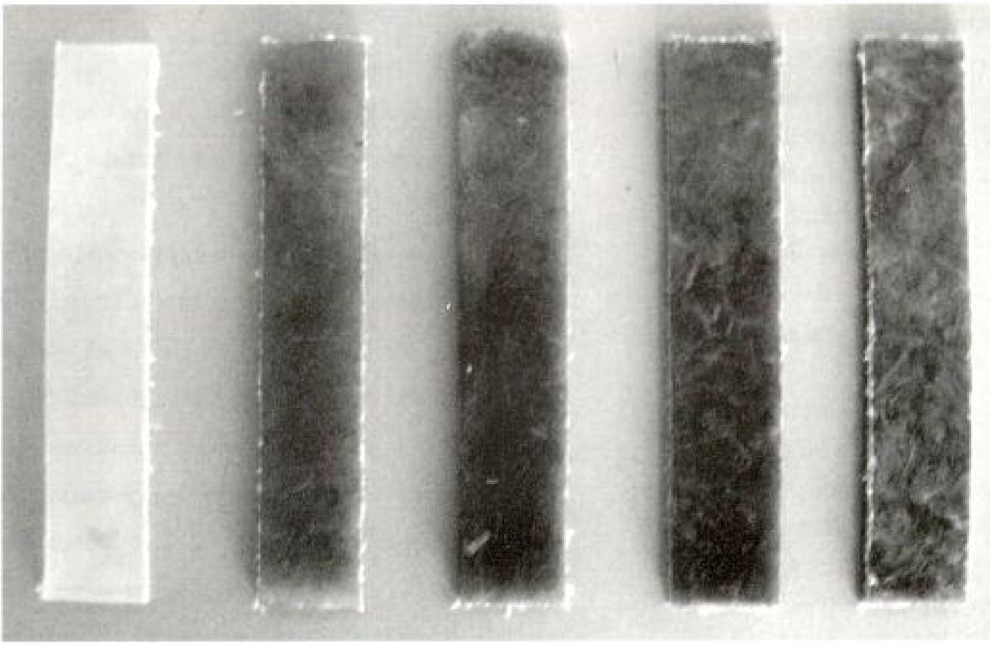


plate 1: Test specimens of fibre reinforced plastic composites

3.0 RESULTS AND DISCUSSIONS

The specimens so far produced were tested to failure in tension and compression. The failure mode of the specimens in tension occurred by spitting which is an indication of delamination. On the other hand, the failure mode of the specimens in compression occurred by crushing at the limits of compression resistance. FRP composite materials being brittle in nature have no boundary between the elastic limit and failure point (Kroschwittz, 2005). Curves of tensile and compressive strength test for the four different specimens are shown in figures 2 and 3 and the resulting mechanical properties presented in Table 1.

From the results obtained, it should be observed that natural fibers possess mechanical properties like the synthetic ones. For example, the tensile strengths of natural fibers like Ukam plant fibers (160 MPa) and that of coconut fibers (144 MPa) are very close to that of E-glass fibers (189 MPa). Their compressive strength (74 MPa and68 MPa, respectively) showed that they can withstand compressive stresses like the synthetic fibers with compressive strength 89 MPa.

A closer look at figure 3 reveals that at failure, some of test specimens were observed to have kinked. This behavior indicates failure by buckling. Comparison between figures 2 and 3 show that the compressive strengths of fibre reinforced composites are lower than their tensile strengths. Failure modes of the composites in tension, however, indicate that they are brittle in nature.

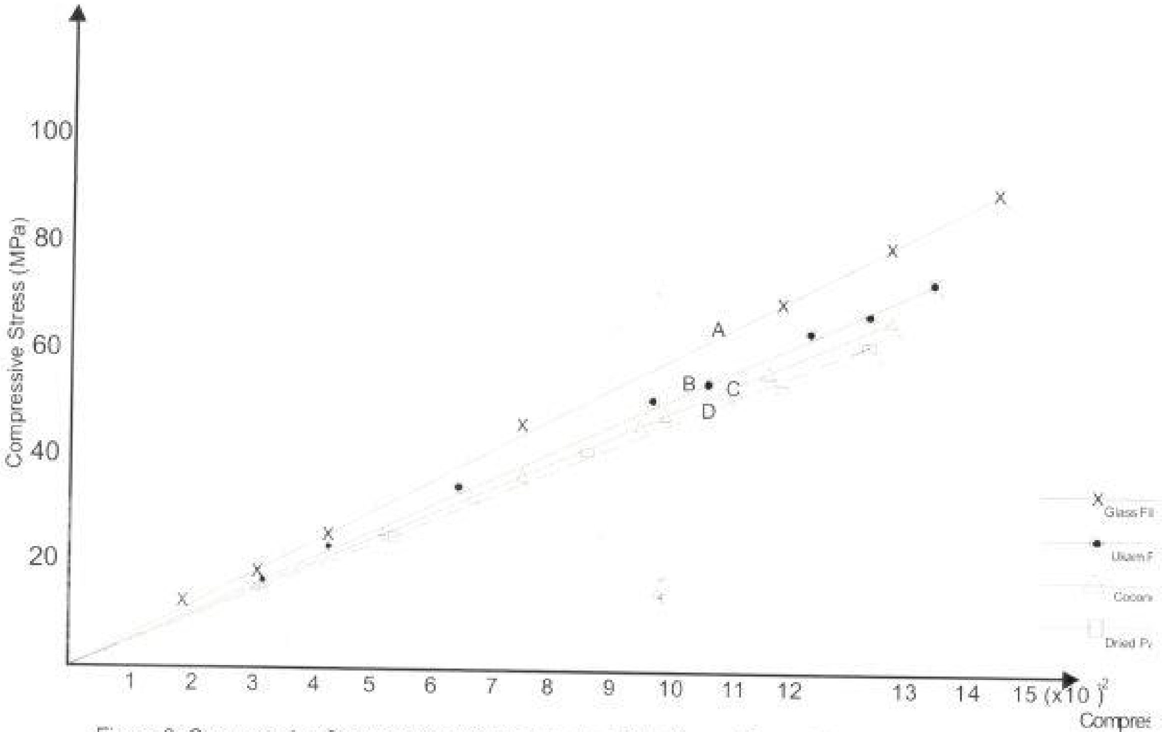
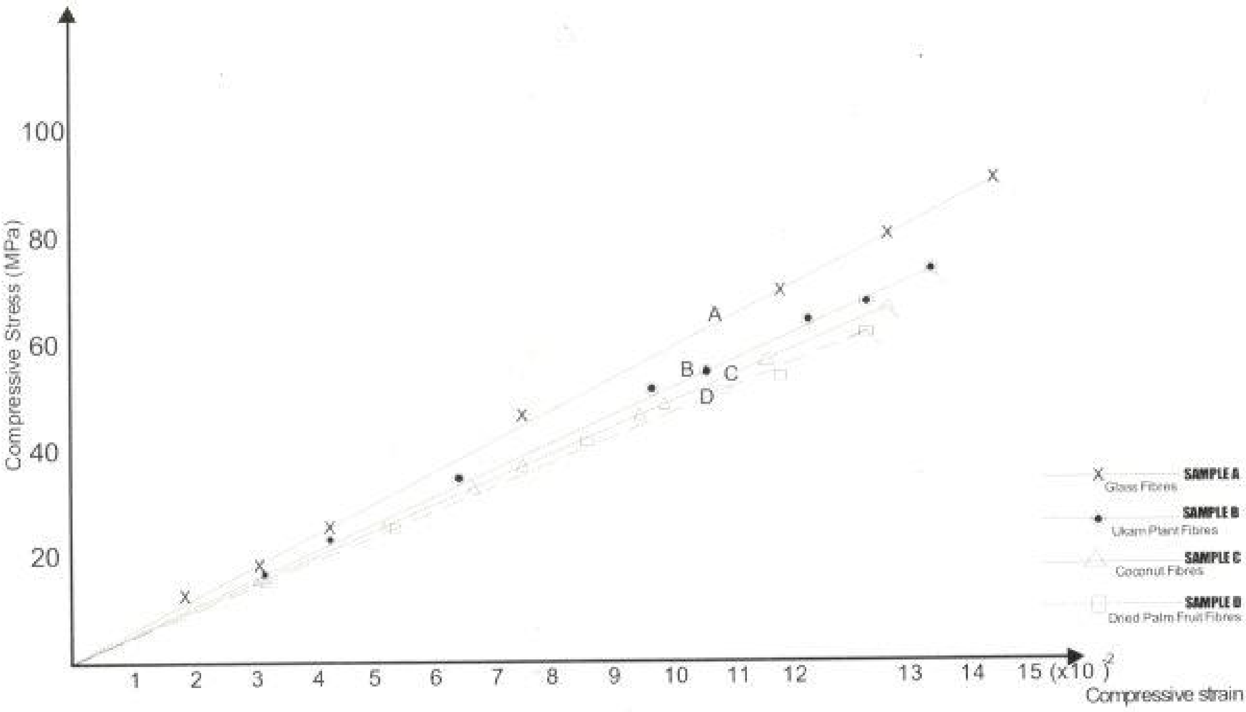


Figure 3: Compressive Stress against Strain graphs of the fibre reinforced plastic composites



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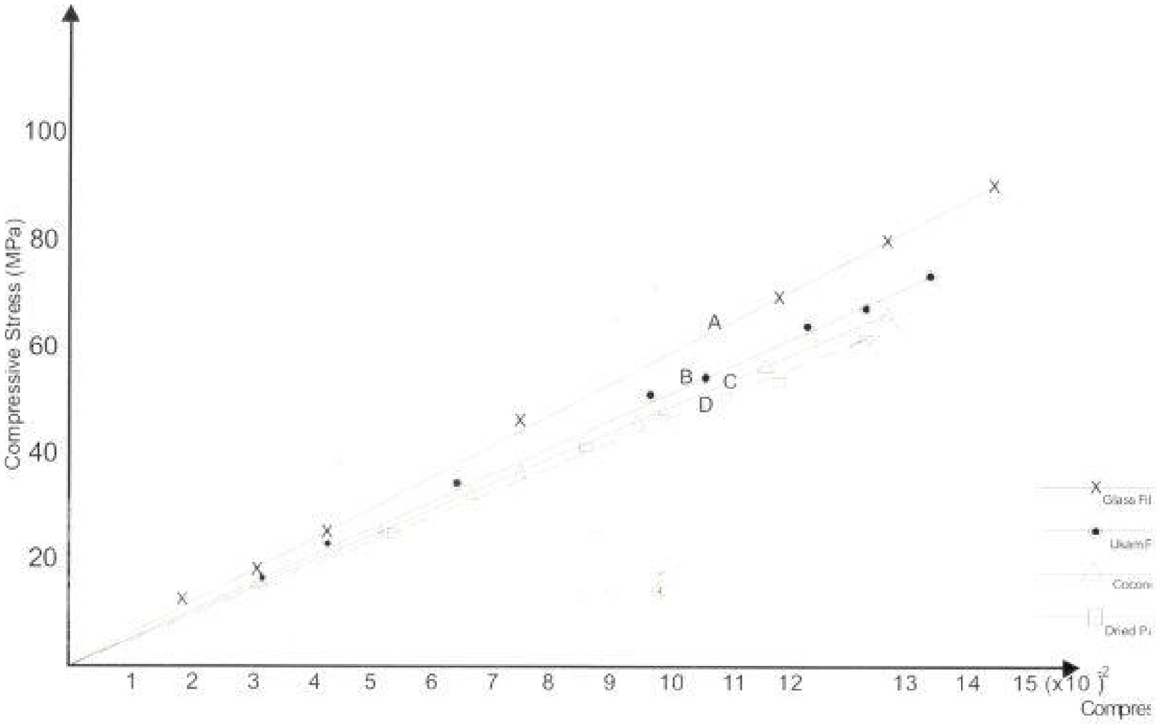

Figure 3: Compressive Stress against Strain graphs of the fibre reinforced plastic composites

Table 1: Some Mechanical Properties of the four Different Sets of Fibers

						Elastic Modulus (N/mm²)		Toughness modulus (N-mm/mm³)		Modulus Resilience (N-m/N)	
S/N	Fibre	Tensile Strength (N/mm²)	Tensile Strain	Compressive Strength (N/mm²)	Compressive Strain	Tensile	Compressive	Tensile	Compressive	Tensile	Compressive
1	Coconut	144.1	0.105	68.0	0.130	1372.38	523.08	7.57	4.42	3291.30	1921.74
2	Dried palm fruit	131.40	0.124	62.0	0.123	1059.68	1333.33	8.15	1.44	1198.53	211.76
3	Ukam	160	0.105	74.1	0.132	1529.81	561.36	8.37	4.89	1674.00	978.00
4	Glass	188.6	0.123	89.0	0.142	1533.33	626.76	11.59	6.32	1931.67	1053.33

CONCLUSION

Natural fibers were obtained readily at low cost and the production of the composites requires minimum tooling. The fibers could be used to develop FRP components in use for engineering applications. In this work, lightweight, low modulus and low strength plastics reinforced with natural fibers have been proved to possess mechanical properties capable of making them compete effectively with the synthetic ones. The most outstanding among the natural fibers (in terms of the mechanical properties) are the ukam plant fibers. These were followed closely by the coconut fibers. It could however, be predicted that in time to come natural fiber reinforced plastic components will even be preferred to steel castings in important engineering applications such as automobile bodies, boat and aircraft constructions.

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