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Study of Cornfibre Hybrid Polyester Composite Mechanical Behavior for Structural Application

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Abstract

The research was focused on developing new materials using natural products, which is the valuable or suitable way to solve environmental related issues and increase the income of farmers and industries. The work was carried out using corn fibres polyester composites. The composites were produced by adding fibres at different weight fractions as FRP10, FRP20, FRP30, FRP40 and FRP50 percentages. The optimum fibre mass fraction required for flexural strength using corn fibre is 18.05(MPA) and the impact energies and Hardness of the composites were lower than that of the control which were 1.41(J/mm^2) and 2.01(BHN) respectively. In the results from the analysis of the mechanical properties of corn fibers reinforced composites greatly influenced by the fiber percentages with the observed strength from flexural and hardness. The impact of the polyester samples was improve the flexure responses of the developed composite materials. Likewise the work justifies the economic consumption of these otherwise waste materials that are detrimental as environmental pollution agent.

Keywords: Composite, hybrid polyester, Mechanical behavior, Natural fibres

1.0 Introduction

Natural reinforcing materials can be obtained at low cost and low levels of energy using local man power and technology. Natural fibre usage is of particular interest to less developed regions of the world like Nigeria, where conventional construction materials are too expensive. In making concretes with the addition of fibres, old traditional building material, has reached some new levels of performance (Aladenika *et al*., 2020; Mohammed, 2013). Fibre reinforced plastics (FRP) composites have been confirmed as a sustainable material in bridge construction. FRP or hybrid FRP–concrete is the primary construction material for bridge components such as irders, bridge decks, and slab-on-girder bridge structures (Abdelmouleh *et al*., 2007; Abdullah and Ahmend, 2012). When compared to reinforced concrete (RC) decks, hybrid FRP concrete decks reveals more resilience with less toughness weakening under design truckloads. The decision of natural reinforcement materials in the manufacture of polymeric based composites has possessed significant attention from researchers (Oladele *et al*., 2020a; Oladele *et al*., 2020b ; Tan *et al*., 2022). The properties such as good dimensional stability ease of design, good mechanical strength and lighter weight make these set of materials desirable. They have been successfully utilized in the development of composite materials with good property when compared with synthetic fibres.

In the last three decades, the global need for affordable housing has stimulated extensive research on cementitious matrix composite. Different entities in tropical regions have conducted an important effort on the study of cementitious composites materials reinforced with fibres. Indeed, fibres offer a cheap and reliable approach that can be used to reduce the cost of construction materials (Oladele *et al*., 2020, Lamberti *et al*., 2020) The goal for developing such alternative technology is to promote sustainable building material. Globally, the demand for fibre based products has been on the increase. With the goal for affordable housing system for both rural and urban population in Nigeria and other developing countries, various terms focusing on cutting down conventional building material cost have been considered. Some of such suggestions have been the sourcing, development and use of alternative and non-conventional local construction materials including the possibility of using some agricultural wastes as construction material. In many developing countries, like Nigeria, large quantities of fibres are generated on daily bases. Agricultural fibres are wasted and thrown into landfill which also contributed to environmental hazard (Hoque *et al*., 2014). Burning and burying of local fibres are now less acceptable, hence, the need to seek the economic benefit of these remains. One way through which this can be achieved is to incorporate the fibre into cement bonded particle board [CBP] production. This will not only reduce environmental hazard emanating from fibres burning but will also contribute to economic growth of the country and reduce pressure on trees from forest.

Nowadays, most developed countries are paying special attention to environmental issues, and some of the most important actions to protect the environment are focused on the optimum use of natural resource, the reduction of air pollution, loss of soil moisture, upgrading industrial and agroforestry wastes, etc.. All these are with main aim of reducing and utilizing agricultural waste, which may be profitable, pollution free and economically viable for the farmer and industries. The most suitable way is to solve environmental related issues and increase the income of farmers (Adeyeye *et al*., 2009).

Corn leaf fibre is nowadays exploited as reinforcements material owing to their low cost, fairly good mechanical properties, high specific strength, availability, eco-friendly and biodegradability characteristics Application of high-performance composites using natural fibres is increasing in various engineering fields (Xie *et al.*, 2010; Vermal *et al*., 2012; Zahan *et al.*, 2017; Zaman *et al.*, 2015) This not only reduces the cost but also saves from environmental pollution . These composites are also used in panel for partition and false ceiling, wall sheet, floor, window and door frame. The mainly fibre-reinforced composite is handled to have material properties in all directions and material properties are different in all performances with control of the fibre orientation (Kabir *et al*., 2012; Ken rosoboro *et al*., 2014).

Corn fiber is a comparatively new innovation in the textile industry. Corn is an agricultural product with large quantities of starch, which manufacturers extract from the plant fibers and break down into sugars that are then fermented and separated into polymers. At this point in the process, the corn fibers are paste-like substances which are then extruded into delicate strands that are cut, carded, combed, and spun into yarn. Aside from the chemical processes, the rest of the process is similar to what is done with wool (Ahmed *et al*., 2002; Abe *et al.*, 2021).This work focused on the development of FRP composites for use as Agricultural waste, which reduce the menace posed by the disposal of such waste materials. Futhermore, the developed composites exhibited improved structural properties that made them suitable candidate for structural application.

2.0 Methodology

2.1 Sample Collection and Preparation of Corn Fibre.

The fibre used for this study is available in nature. The corn leaf was the agricultural wastes that we collected from Owo, a popular farm settlement in Owo land. The culms of the corn stem were collected and their bottoms of the leaves were cut, carded, combed and spin into yarn. The leaves were air dried for 2 weeks to evaporate the moisture contents. The corn leaves were later cut into 5 to 6cm length. The fibre mass fractions (Mf) were 0, 10, 20, 30, 40 and 50% used for the project.

Figure.1. Fresh corn leaf collected from Owo.

2.2. PREPARATION OF POLYESTER.

The polyester material was procured from Evro chemical ventures limited Lagos state. They involved Polyester resin, Accelerator and Catalyst. The total weight of matrix utilized was 170g. This fibre mass fraction (Mf) was defined as the ratio fitress to constituents of the matrix (polyester) by weight (Soroushian and mankunte, 1990; Alexenda *et al*., 2007).

Figure 2. Specimen for tensile, hardness and impact test

2.3. COMPOSITE DEVELOPMENT

The corn fibre-reinforced composite and the control samples were produced by 150g Polyester resin with Accelerator and Catalyst of 10g respectively were weighed using and electronic weighing balance and mixed together, Poured into the flexural and tensile test moulds made of steel. The fibre matrix fractions and 10g of catalyst were added to produced various samples according to the composition Table 1.0 the samples were extracted from the moulds when they were still warm and allowed to cure in the open laboratory air for 3days before flexural, tensile, impact and hardness tests were conducted on them.

Table 1.0: COMPOSITION OF THE CORN FIBRE REINFORCED COMPOSITES.

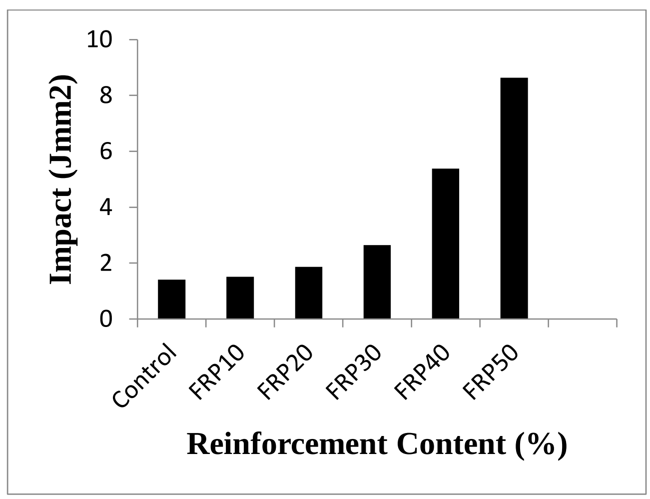
Fibre Content %	Weight of Polyester resin (g)	Weight of acceleration (g)	Weight of catalyst (g)
0	150	10	10
FRP10	150	10	10
FRP20	150	10	10
FRP30	150	10	10
FRP40	150	10	10
FRP50	150	10	10

3.0 Results and Discussion

The results obtained in this study revealed different characteristics of the formulated composite, there were significant differences between the values obtained for Tensile, Flexure, impact and Hardness tests in control and the formulated composites.

3.1 IMPACT TEST

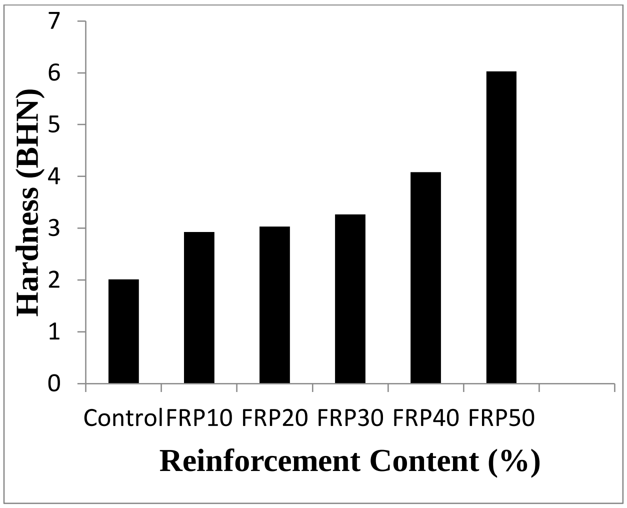
The impact energy (notched) of the FRP composite was measured on an impact tester (Housefied Balance, USA), in accordance with ASTM D-286. Fig 5.0 Shown the effect of FRP composites content on the impact energy of the samples. The test of impact test was carried out to determine the energy lost per unit cost-sectional area at the notch J/mm^2. It was observed that the Impact energies of the composites were lower than that of the control (12.10J/mm^2). However among the composites, it was 5% reinforcement content that had the highest impact energy with a value of (5.39J/mm^2). The presence of fibers resulted in reduced toughness of the matrix. It was observed that the presence of fibers resulted in reduced toughness of the matrix, since the impact energies of the composites were lower than that of the control. This submission agreed with the results presented in an earlier study on structural performance (Ahmed *et al*., 2015; Oladele *et al*., 2019).



Fig**ure** 3.0: showing the graph of Impact against reinforcement content

3.2 HARDNESS TEST

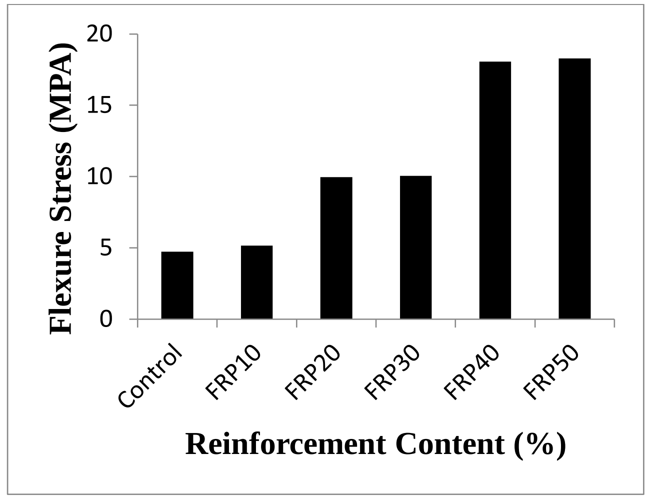
The micro hardness test was carried out by forcing a diamond cone depression into the surface of the specimen to create an impression (Indentation). The experiment was performed with use of micro hardness tester. The hardness values were summed to get an average for each specimen. Micro hardness values for the samples are shown in fig 6.0 with a trend that is similar to what obtained in impact test. However among the composites, it was observed 2% reinforcement content that had the lowest micro hardness value of 2.00BHN.



Fig**ure** 4.0: showing the graph of hardness against reinforcement content

3.3 FLEXURAL TEST

Flexural properties of the control and FRP composites samples were examined by a universal testing machine (UTMFS300-023, USA) according to ASTM D-790-03 standard. Fig 4.0 above represents the effect of the corn fibers on reinforcement content. Flexural strength had high density at control. It was observed that there are variations in flexural strength of the composites .3% was the lowest flexural strength.



Fig**ure** 5.0**:** showing the graph of maximum flexure stress against reinforcement content

3.4 TENSILE TEST

Tensile properties of the control and FRP composites samples were conducted on a universal testing machine (UTM, FS 300-1023, USA) at a crosshead speed of 5mm/min. The tensile strength result on the control sample and corn fibers composites are presented at fig 3.0. The result show that the strength of the control sample is higher than the composites strength with 12.09 MPA, it was also observed that FRP20 reinforcement contents are the lowest value.

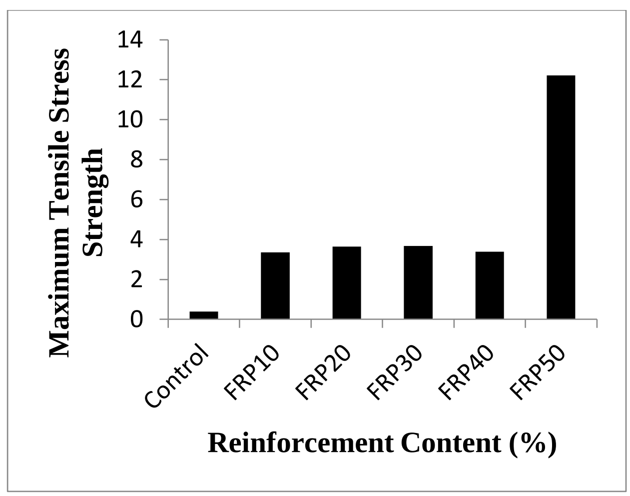


Figure 6.0: showing the graph of maximum tensile stress strength against reinforcement content.

In the results from the analysis of the mechanical properties of corn fibers reinforced composites will greatly influenced by the fiber percentages with the observed strength from flexural, hardness, the impact of the polyester Samples will improve the flexure responses of the developed composite materials.

4.0 CONCLUSION

Based on the results obtained in this study, it may be concluded that the randomly distributed corn fibers can be used to improve the flexural strength of reinforced composites sheets. Therefore the optimum fibre mass fraction required for flexural strength using corn fibre is FRP50. Likewise the work justifies the economic consumption of these otherwise waste materials that are detrimental as environmental pollution agent.

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