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Comparative Investigation of the Mechanical Properties of Coconut Coir Fibre and Synthetic Fibre Reinforced Plaster of Paris (POP) Based Composites for Celling Applications

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Authors' contributions

This work was carried out in collaboration among all authors. Author AKA designed the study, wrote the protocol and wrote the first draft of the manuscript. Author OMO performed the statistical analysis. Authors OMO and SKO managed the analyses of the study. Author SKO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Coconut coir fibre and synthetic string fibre were used as reinforcements in plaster of Paris (POP) for ceiling application in this research. Coconut coir fibre, being fairly strong and stiff as well as cheap and plentiful with low energy demand during manufacture was used alongside synthetic fibre in view that both can serve as material for ceiling board. The fibres, whose mass fraction were the variables in this work, were cut down into smaller sizes and mixed with cement and water. The resulting slurry was then poured into rectangular moulds and allowed to cure. Flexural, Impact and Hardness tests were carried out on the various samples. From the analysis of results for the mechanical properties of coconut coir and synthetic fibres reinforced POP based composites, it was discovered that both Coconut coir and synthetic fibre show promising performances with respect to the properties considered.

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1. 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 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.

Making of roof tiles, pipes, silos and tanks by Coconut coir and sisal-fibre reinforced concrete have been reached great achievements [1]. Coconut husk as example of agricultural waste products, in which Coconut coir fibre is obtained in the processing of coconut oil, is available in large quantities in the tropical regions, most especially in Africa, Asia and southern America. However, the durability has not yet been solved, it has also been noticed that the degree of enhancement of concrete by coconut fibres depends on the type of coconut species.

Natural or synthetic fibres usage has provided great development of composite materials which has shown significant uses in variety of fields [2]. In construction industries 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 girders, bridge decks, and slab-on-girder bridge structures. When compared to reinforced concrete (RC) decks, hybrid FRP concrete decks reveals more resilience with less toughness weakening under design truckloads [3].

The decision of natural reinforcement materials in the manufacture of polymeric based composites has possessed significant attention from researchers [4,5]. 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.

A fibre are classes of hair-like materials that are continuous filaments or in discrete elongated pieces, similar to pieces of thread, has contributed significantly in improving a nation's economic base, industrialization and comfort of its teeming population [6].

In the last three decades, the global need for affordable housing has stimulated extensive research on cementitious matrix composite [7,8]. Different entities in tropical regions have conducted an important effort on the study of cementitious composites materials reinforced with fibres [9]. Indeed, fibres offer a cheap and reliable approach that can be used to reduce the cost of construction materials. The goal for developing such alternative technology is to promote sustainable building material [10].

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 [11]. 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 [12]. Cement bonded particles and coconut fibre based panels which are more dimensionally stable under varying relative humidity change are good construction materials which are of great importance to mankind and possess unique qualities over other panel products [13]. This made cement bonded materials more acceptable with resistance to decay, and their perceived performance during natural disasters [14]. The properties of cement bonded particle made it a versatile material for roofing, ceiling board, flooring, partitioning, cladding and shuttering [15,7,8]. It is widely advised that more frequently, the comparison of two types of fibres should be performed in order to analyze the flexural performance of the obtained material. The mechanical properties of

synthetic fibre concrete change widely in relation to the strength, type, and dosage of the fibre [16]. Therefore, these changes are also reflected on the observed test specimens especially on the direction perpendicular to the applied stress. For concrete test specimens, it is known that the dimensions of the specimen affect the test results depending on the size of the concretes ingredients. Even though, the test standards allow the use of different geometries, development of hybrid composite like coconut coir to satisfy the good needs as investigated by this research.

2. MATERIALS AND METHODS

The raw materials used for this work were sourced locally. The major materials are; coconut coir fibre, synthetic fibre and white cement. The composites were developed by mixing the constituents in predetermined proportions of 10, 20, 30 and 40%. About 10 litres of water were poured inside a cleaned large wash basin and 0.5 kg of white cement was added continuously to the water with thorough mixing until semi-solid mixture was achieved. The respective fibre weights were added and further stirred properly until homogenous mix was obtained. The mixture was poured into the mould and allowed to cure. The cured samples were removed from the mould and allowed to cure further for about 28 days at ambient temperature. Figs. 1 and 2 show samples of the synthetic and sponge fibres, respectively.

2.1 Determination of Mechanical Properties

The boards produced are trimmed and cut into specimen sizes and subject to tests in accordance with the procedures stipulated, the ratio of the fibre's length over its diameter affects the bonding between the fibres and the concrete under mechanical behavior [17]. Figs. 3 and 4 show flexural specimen and impact specimen of the synthetic and coconut coir fibres, respectively.

2.2 Flexural Test

Flexural strength is defined as a material`s ability to resist deformation under load. Flexural test is conducted and guided by ASTM D790 standard, using universal Testing Machine UNITEK 94100. For the testing, the cross head rate is kept at 2 mm/min and a span of 75 mm is kept up.

2.3 Impact Test

A pendulum type impact testing machine is used for conducting notched bar impacts test. The impact tests are carried out following ASTM D256 standard, using an impact tester. This is a kinetic energy needed to initiate fracture and continue the fracture until the specimen is broken.

Fig. 1. Synthetic string fibre

2.4 Micro 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 the use of micro hardness tester. The hardness values were summed to get an average for each specimen.

Fig. 2.Sponge fibre

3. RESULTS AND DISCUSSION

Fig. 3, show the flexural strength at peak for the coconut coir and synthetic fibres reinforced POP based composites. From the results, it is observed that the strength of the coconut coir based composites and synthetic based composites increase at amount within 10-40%. Thus, varying the volume fraction of the fibres has effect on the strength of the POP based composites.

Fig. 4, show the impact energy results for the samples from where it is seen that all the samples from coconut coir based POP composites are enhanced more than that of synthetic based composites but not with significant difference. It is observed that the impact energy is reducing as the reinforcement content increases for both reinforcements; hence, the optimum impact energy is obtained at 10% for both reinforcement.

Micro hardness values for the samples are shown in Fig. 5, with a trend that is similar to what is obtained in Fig. 4. However, contrary to Fig. 4, the hardness values are the same at all reinforcement contents for both fibres. Also, there is a significant difference between the hardness within 20-40% where the decrease is noticed to be marginal as the reinforcement contents increases.

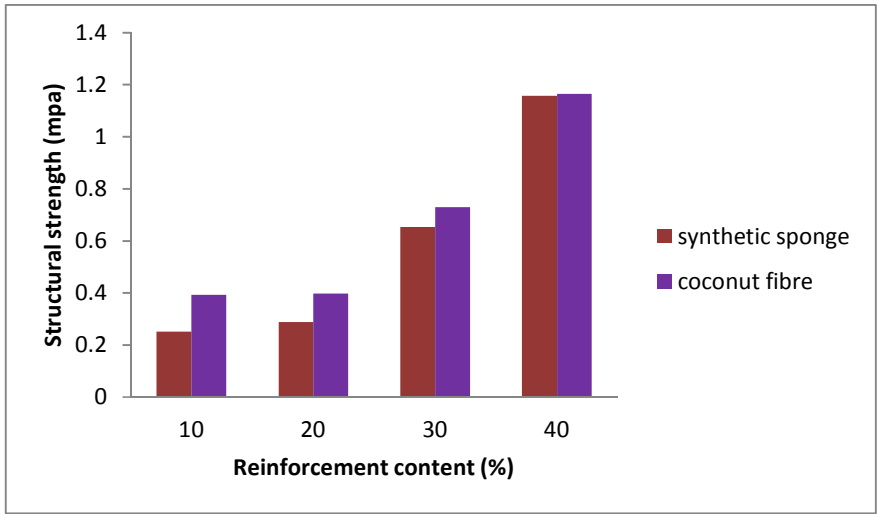

Fig. 3. Variation of flexural strength with reinforcement content

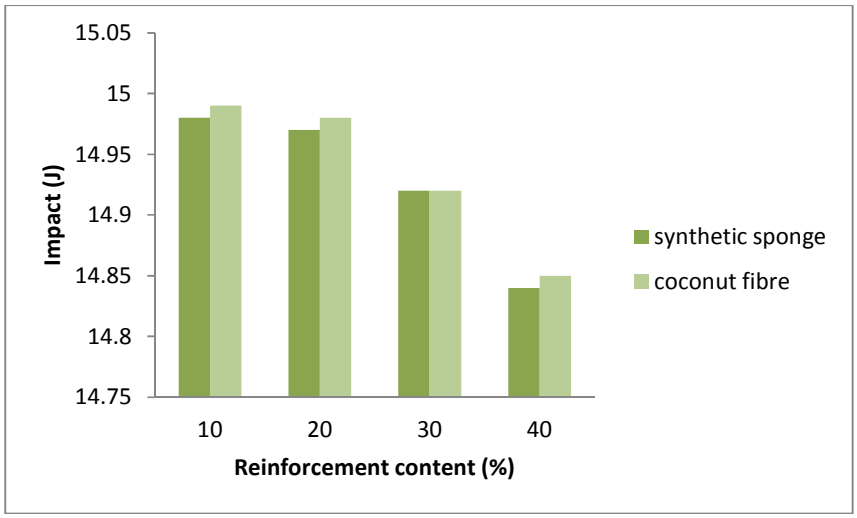

Fig. 4. Variation of impact energy with reinforcement content

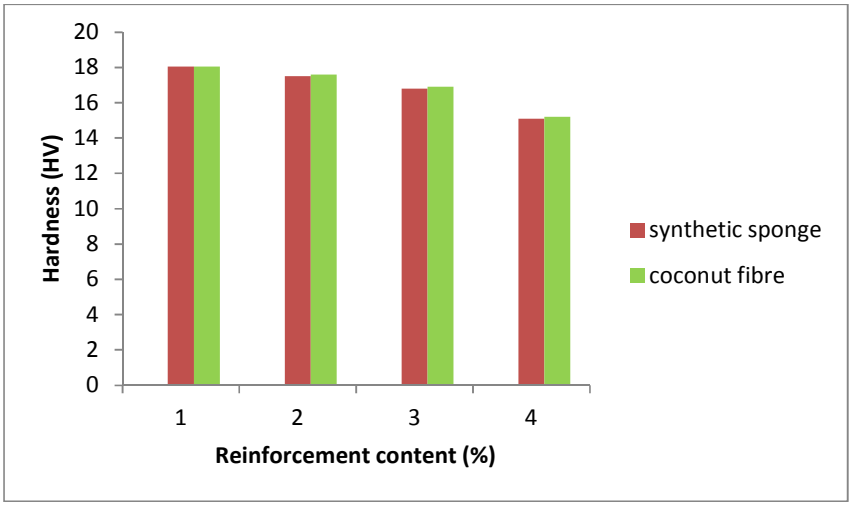

Fig. 5. Variation of hardness with reinforcement content

4. CONCLUSION

In the results from the analysis of the mechanical properties of coconut coir and synthetic fibres reinforced POP based composites greatly influenced by the fiber percentages, with the observed strength from the flexural, hardness and the impact of both synthetic and coconut fibres, either will be a great POP based constituents.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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