*Research Journal of Material Sciences* ISSN 2320–6055
Vol. **8(1),** 24-28, February **(2020)** *Res. J. Material Sci.*

# Ductility and stiffness property evaluation for coconut fibre reinforced composite

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**Available online at: www.isca.in, www.isca.me**
Received 1st October 2019, revised 20th December 2019, accepted 20th January 2020

## Abstract

*The ductility and stiffness properties of the coconut coir with reinforced epoxy resin were carried out. Specimen containing fibre lengths of 5mm, 10mm and 15mm were moulded and treated with alkali (NAOH) and also not treating the fibre with alkali. The samples were prepared in accordance with ASTM standard D3039. An Instron machine was used to do the tensile tests of the samples. The tensile test machine has an electro-mechanical sensor used for purpose of controlling the strain in the test pieces. The results show that the deflection of the composite coir is associated with the ductility of the material. the ductility of the composite is significantly influence by the increasing length of the fibre content. The material deflection ratio is more in the treated fibre compared with the untreated fibre. This is however not well pronounced in the 5 mm fibre content. The study provides the understanding the relationship between the deflection of the material and the load applied during application for purpose of deducing the ductility properties of such material.*

**Keywords**: Coir, polyester composite, ductility, fibre, stiffness, damping.

## Introduction

Coconut Coir is one of the natural fibre obtained from the husk of coconut. The coir is found between the hard internal shell of the coconut and its outer coat and had been successfully used for the development of floor mats, brushes, insulations, packages and had served as reinforcement materials in thermo-set and thermoplastic production among some other application[1-4]. The use of natural fibres such as the coconut fibre as reinforced composite in recent time is a focus of discuss in replacing the inorganic reinforcement[5,6]. Shaik et al.[7] investigated the mechanical and dynamical characteristic of coir fibre reinforced composite for possible engineering application.

Ali[8] discussed extensively the properties of composites such as cement paste and concrete. Coconut fibres were used as reinforcement for the composite. The study of these properties as were investigated was also presented.

Reinforced coconut fibres have been successfully used for the manufacture of non-structural elements found to be cheap and durable. Its usage in the automotive industry for the production of seat cushion cannot be over emphasized. Zulkifli et al.[9] studied the potential use of coconut coir for sound absorbing material.

Shiney and Premlet[10] reveals that coir mats shows good absorption coefficient at high frequencies and also the coir mats with latex backing improves the absorption capability of such composite.

In view of this, coating the mats with fire resistant material makes it suitable for building acoustics and automobiles. The study shows that the effective combination of the coconut coir with porous layer backing could serve as an effective sound absorbing medium.

Yahya et al.[11] found that at higher frequency, the fibre of coconut have good sound absorption property but poor sound absorption property at lower frequency. This acoustic characteristic of the coconut coir give an insight into the possibility of its use for vibration absorbing medium. In view of this it is important to investigate the likely properties of the coconut coir that could be responsible for its possible use as a vibration absorbing medium.

Coir fibers as natural fibers offer comparable properties with other mineral fillers. Jayavani et al.[12] reviews different methods of coir fibre modification which include sodium hypochlorite and other alkali treatment among others. It also reviews composites of coir fibre with thermoplastic, rubber and thermoset plastics.

Coconut fibre reinforced composite is employed in industries for the manufacture of seat cushion for automobile. The dimensional instability and flammability characteristic often limits its use for high temperature applications. Studies have however shown that the length of the coconut fibre and its orientation contributes to the emerging mechanical properties of the coir[13].

Other factors as enumerated include the stress–strain relationship of the fibre and matrix phases, the volume fraction of the phases and the manner at which the fibre is distributed and orientated relative to one another[14]. Natural fibre however demonstrates a linear behaviour and sharp fracture.

The strength of the composite is found to be influenced extensively by the fraction of the natural fibre in the volume of the composite. The increase in the volume fraction tends to proportionally influence the increase in the strength. The need for composite material development engineering application using coir could be a subtle opportunity for weight saving materials with quality durability, toughness and cost effectiveness[15].

Gelfuso[16] has established the possibility of the use of coconut fibre for vibration damping. Specimen of coconut fibre polypropylene was prepared on which dynamic test was carried out. The loss factor, storage factor and the composite loss modulus were found to reduce considerably with increasing fibre contents. This behaviour was attributed to lower elastic modulus of the fibre.

This paper therefore tends to evaluate associated properties of the coconut fibre towards establishing a possible damping property inherent in the material. The article will focus on the experimental evaluation using the tensile test. The study aim at understanding the relationship between the deflection of the material and the load applied during application for purpose of deducing the ductility properties of such material. It is desired to understand how the constitution of the coconut fibre composite influences the load- extension relationship of the material.

## Materials and methods

The ASTM standard (D3039) is commonly used for fibre tensile test and thus it is suitable for the fabricated test specimen made of coconut fibre and epoxy resin.

**Specimen:** The materials used for the experiment include coconut husk were collected from a primary source at the Lagos beach. The coconut husk was soaked in water for easy separation of the fibres. 30g of the fibres were soaked in 100g of alkali solution and washed with distilled water after which allowed to dry for 24 hours to ascertain total removal of the moisture contents. A total of thirty (30) numbers of specimens were produced with 5, 10 and 15mm length of fibre contents. The materials were prepared in composite of epoxy resin hardened with araldite and moulded. Specimen sizes of 250 x 25 x 3 mm were prepared by the D 3039 standard of the ASTM. The prepared untreated and treated specimens are as shown respectively in Figures-1 and 2.

**Tensile test:** The Instron® 3369 was used to do the tensile tests of the samples. The load range of the machine is 50kN. The electro-mechanical sensor installed on the machine enables the control of the sample strain within the test region of the samples.

Strips of material with defined dimensions prepared for the tests were anchored one after the other at one end and subjected to gradual increase in axial load. The gradual increment of the load results in the axial deflection of the loaded end which increases with respect to the load value and eventually with continuous loading, the test specimen fracture as shown in Figure-3.


a b c

**Figure-1:** Untreated specimens containing (a) 5mm, (b) 10mm and (c) 15mm lengths of fibre contents (Control specimen).


a b c

**Figure-2:** Treated specimens containing (a) 5mm, (b) 10mm and (c) 15mm lengths of fibre contents.


a. Untreated fibre b. Treated fibre

**Figure-3:** Fractured specimen after tensile test.

The stiffness of the material is obtained by normalizing the load by the original length of the specimen using the equation-1.

$$\varepsilon = \frac{\delta}{l} \quad (1)$$

Where: $\varepsilon$ is the material strain which measures the stiffness of the material, $\delta$ is the material deformation and $l$ is the length of the specimen.

## Results and discussion

Figures-4 to 6 shows the relationship between the load and the deflection of the fibre composites. Figure-7 is a measure of the material stiffness as a response to the deflections due to the applied load.

**Influence of the length of fibre on ductility:** The composite deflection is associated with the ductility of the material as is observed in other materials. The figures shows that the ductility of the composite is significantly influence by the increasing length of the fibre content. The material deflection ratio is more in the treated fibre compared with the untreated fibre. This is however not well pronounced in the 5mm fibre content. The 10 mm fibre content shows a significant improvement in its ductility and more is observed for the 15mm fibre content as explicitly shown in Figure-5. However, increasing length of the material encourages strength reducing flaws which could be associated with its ductility thus making the material more likely to be a good for vibration absorbing. There is however the likelihood that the material becomes weaker due to the flaws.

**Influence of service load on the stiffness of the material:** The stiffness of the material describes its fracture related failure. In could be infered in Figure-7 that the stiffness of the material improves with increasing service load for the three categories of the material fibre contentss, however at higher fibre content, there is no significant difference in the material stiffness. This could be due to the likely misorientation of the fibre structure due to increasing strain. The trail is likely to place an optimum fibre content on such developed material, which means that further increase in the fibre length content of the material will not influence the material stiffness.

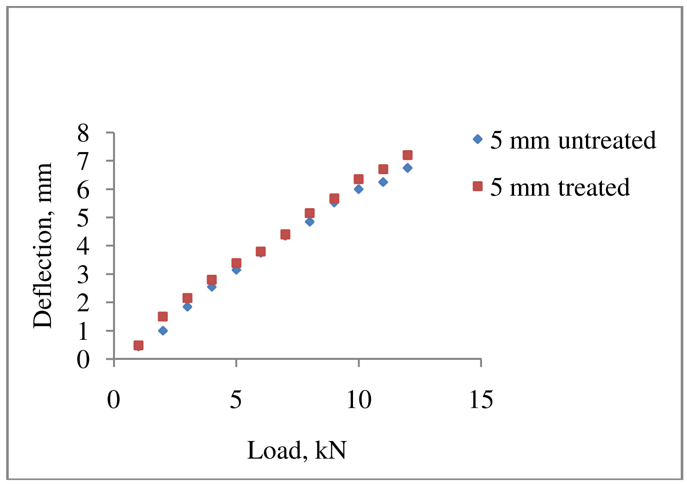


**Figure-4:** Load-extension relationship for 5mm fibre length content.

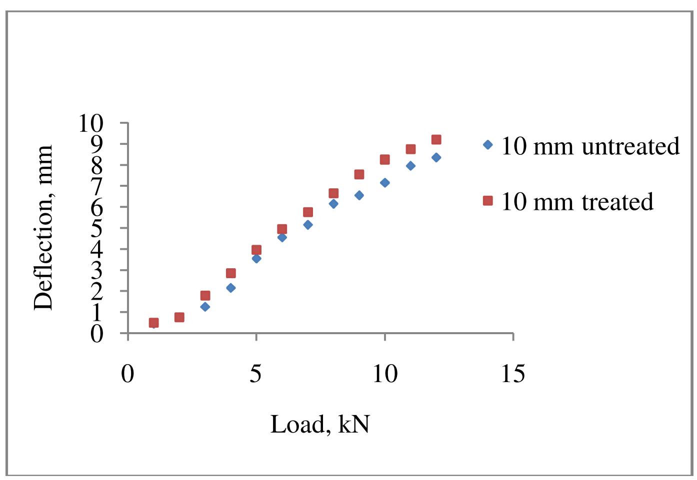


**Figure-5:** Load-extension comparison for 10mm fibre length content.

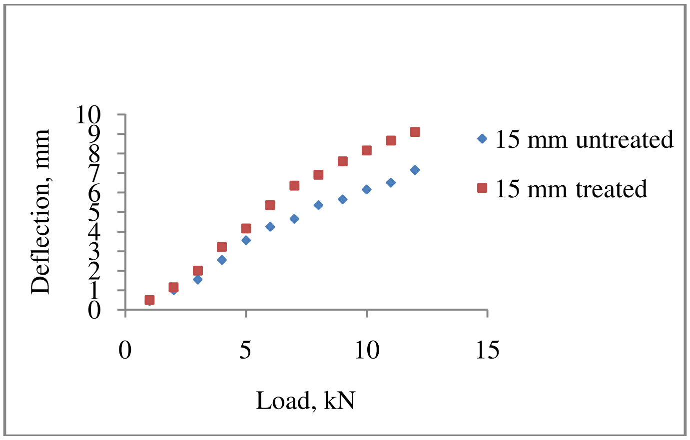


**Figure-6:** Load-extension comparison for 15mm fibre length content.

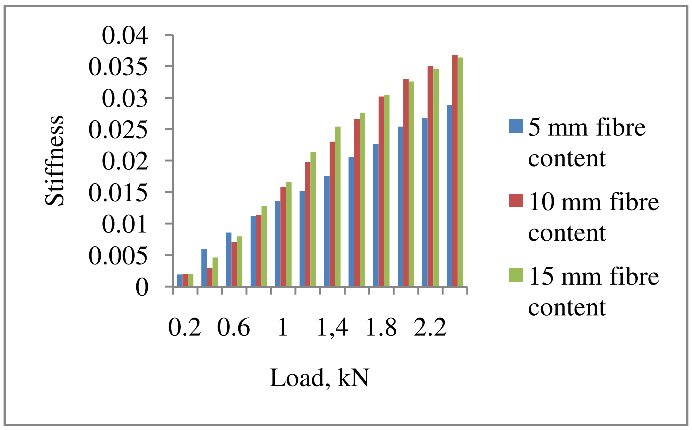


**Figure-7:** Influence of service load and fibre length on stiffness of coconut coir.

## Conclusion

The ductility and stiffness properties of the composite of polyester coconut fibre have been studied. A randomly discontinuous fibre layout in the composite was used to obtain a supposedly high composite fibre ratio. The analysis ensued that if the fibres are treated, then the extension of composite at break is more compared to the un-treated fibres and extension of composite increases as the fibre length contents increase. The study showed that increase in length of fibre improves the ductility and stiffness of the material. However a limit is approached for the stiffness as the fibre length increases beyond 10 mm in this case. The study could be applied to developing a damping material for vibration damping using coconut coir hence enhancing the beneficiation of the coir.

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