

Comparative Study of Composite Made from Ensete False Banana Fibres and Polyethylene with Block Board

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Abstract
This paper is an effort to utilize abundant availability of natural fibres and waste plastics for the development of composite materials based on polymer and particles of natural fibres for conservation of natural resources such as forests. Ensete false banana (EFB) fibres were used as reinforcement to obtain composites with melted waste polyethylene bottled as matrix phase. The composites were prepared by means of compression moulding, and then the effects of fibres loading on mechanical properties such as impact strength, flexural strength, and wear resistance were investigated. Water uptake was also studied. It was observed that the flexural modulus, compressive strength and flexural strength of treated EBF reinforced PE increased linearly with increment of fibres loadings. This trend was similar for impact strength where it exhibited a slight reduction at the initial stage but increased later as the fibres loading increased. It was also observed the water absorption increased with increase in fibres loading. Machining operations such as grinding, milling, drilling and cutting can be performed on the composite. The study has demonstrated that the optimum fibres loading for the best performance of the composite achieved was 30 wt%. The composite produced has a high potential as alternative block board materials.
Keywords: Ensete false banana, Block board, fibres, plastics waste, composites

INTRODUCTION

With the current forest cover of 1.7% in Kenya and annual population growth rate of 2.7%, the demand for block board from wood is expected increase (Matiru, 2007). Construction industry has over the years been heavily dependent on wood as a construction of materials. Wood has been the major raw material in making of construction products such as ceiling board, particle board, block board, and floor tiles among others (Chaudhary et al, 2013*)*. Therefore, there is need to develop alternative materials which would be used to replace wood. In addition to the development of alternative building materials, there is need for proper disposal of the plastic waste. In Kenya alone, over 24 million plastic bags are used monthly, half of which end up in the solid waste mainstream. These plastics bags now constitute the biggest challenge to solid waste management in Kenya (Odhiambo et al, 2014*,* Devendra and Kaustubh, 2014, Kimutai et al, 2014*)*.

Most of the reinforcement materials which have been used to develop alternative materials for use in the building and construction industry are agro fibres such as bagasse, cereal straw, coconut coir, corn stalks, jute, kenaf, rice stalks, hazelnut husk, peanut hull, pine cone, almond shell and bamboo (Matoke et al, *2012,* Verma et al, *2012,* Abba et al, *2013).* Little information exists on characteristics of biocomposite from Ensete false banana plants.

EFB plants also called *Ensete ventricosum is* known by a multitude of names depending on where it is being cultivated and it is an important food crop in many parts of Africa. It is found in Kenya, Ethiopia, Malawi, South Africa and Zimbabwe. Ensete false banana plants look just like their namesakes, only larger (12 meters high), with leaves that are more erect and inedible fruit. The large leaves are lance shaped, arrayed in a spiral and are bright green struck with a red midrib. This traditional staple crop is highly drought resistant and, in fact, can live up to 7 years without water. The Ensete false banana plants provide not only food, but fibre for making ropes and mats. These fibres are strong and can be used to make biocomposite.

The aim of this study was to investigate the suitability of *Ensete ventricosum* banana fibres in production of block board as alternative and to reduce the shortage of raw material in forest industry.

MATERIALS AND METHOD

Waste plastics collected at Moi University shopping center were first cleaned using warm water and soap to remove dirt, paper labels, oils, fats etc. The Polyethylene plastics were sorted and cut into small square pieces of approximately 20 mm x 20 mm. This was done at the Mechanical Engineering Labs, Moi University. After washing plastics were then left to dry in the open air.

EFB fibres which are contained in the pseudo stem of Ensete false banana plant were obtained from Moi University staff quarters and others from Ndubeneti village in Nandi County. These pseudo stem were first tapped to make them weak. Fibres were then extracted manually from semi-dried leaves by a blunt knife. The fibres were then taken through cleaning steps where they were washed thoroughly in distilled water. Basically, this removed most of the foreign objects and impurities inside the fibres.

The fibres were cut into small pieces of approximately 10 mm length after being air dried, Since EFB fibres were susceptible to water content, drying and storing in a dry condition were crucial ready to serve as reinforcing agents in matrix.

Fig. 1: Cut pseudo stem of EFB plant

Fig. 2: EFB Fibres

The required amount of PE plastic were weighed and put in a crucible. The crucible was then placed in the oven which had been pre heated to a temperature of 350^{o}C. Plastic was then left in the oven to melt for a period of 30 minutes after which it was removed and the fibres were added to it and mixed thoroughly. The percentage of fibres were varied between 0 to 40% .The mixture was poured into the mould where it was compressed using a hydraulic press. The mould was designed to produce the composite panel with length of 150 mm, width of 80 mm. After the composite was formed, it was left to cool for 72 hours so as to harden

Fig. 3: Crucible for melting PE

Fig. 4: Composite samples

Finally bending test, impact strength, compression test, flexural strength, water absorption test and machining test were investigated. Bending and compression tests were done using universal testing machine (UTM).

Fig. 5: Bending test using a UTM

Fig. 6: Compression test using a UTM

RESULTS AND DISCUSSION

Compression strength

The Compression strength of the EFB fibres with PE were determined by 100 KN manually controlled universal testing machine found at Eldoret Polytechnic as show in Fig. 6. It was found that the compressive strength kept increasing with increase in fibre content from 0% fibre content to 30% fibre content. At 40% fibre content, the compressive strength decreased because the interfacial adhesion between fibre and PE was not good therefore reducing the compression force applied on it. It was also seen that composite with 30% fibre has the best compressive strength than specimen M (Block board) in the market.

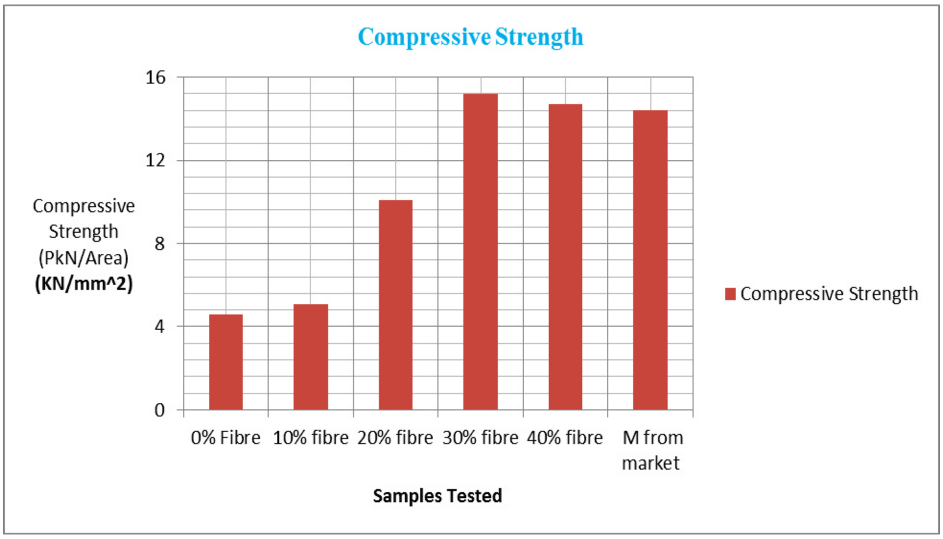

Fig. 7: Comparison of compressive strength of EFP reinforced composite and block board

Bending Test

Flexural strength and flexural modulus for EBF reinforced with PE and sample M from market are shown in Fig.8. It is observed that the Flexural strength increased from 16.67Mpa to 32.86Mpa and flexural modulus increased from 1018Mpa to 2153Mpa respectively for pure PE to 40% wt fibre. The addition of fibre increased the flexural strength and flexural modulus of unreinforced PE as much as 97% and 112% respectively. The flexural strength and flexural modulus of specimen M were 23.53MPa and 1458MPa respectively. These show that the composite material with fibre content above 20% has high resistance to bending force than the specimen M from the market. Materials that withstand more bending loads are resistant to cracks and hence they do not fracture easily and hence increased work life. It is also noted that the flexural strength of the composite increased linearly with fibre composition.

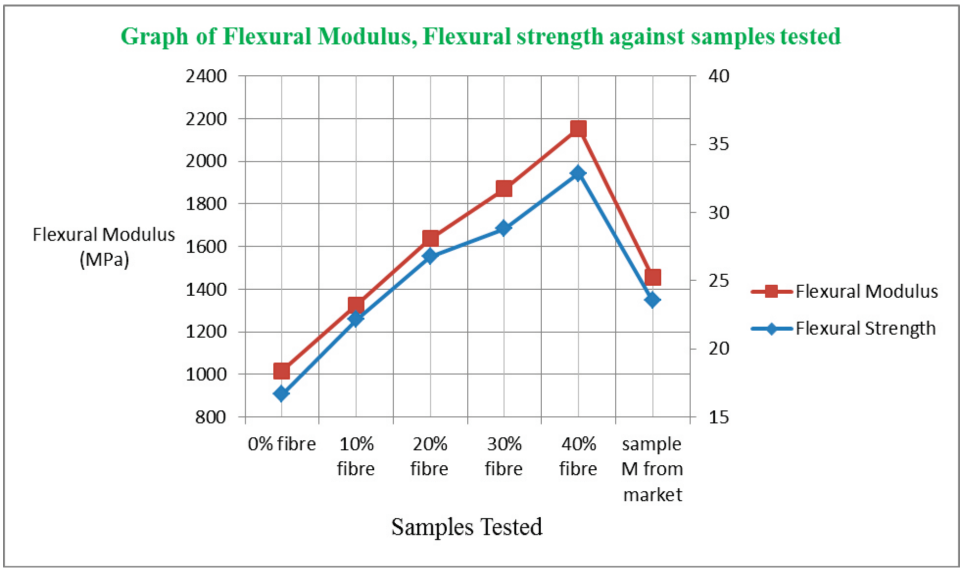

Fig. 8: Flexural Modulus and Flexural strength of EBF Reinforced PE and block board

Impact Test

The EBF reinforced PE composite has a higher value of impact strength compared to the specimen M from the market as shown in Fig 9. It is generally accepted that the toughness of a fibre composite is mainly dependent on the fibre stress-strain. However, this seems to contradict with compression properties especially compression strength. The only reason to explain this is that the composite can withstand fast impact load but if compression stress that is applied slowly, the fibre tends to slip from the matrix and leaving weak points or stress concentrated area. No doubt, this will give low toughness.

Although the impact strength was improving, there was a slight drop at the 10 wt % of EFB fibre loading (8.5Nm). Again for this case, the introduction of fibre into polyethylene acted as flaw where stresses were easily concentrated thus low energy was enough to initiate cracks and in consequently the composite failed. Devi *et al*, (1997) has reported that the energy-absorbing mechanism of fracture built in the composites includes utilization of energy required to de-bond the fibres and pull them completely out of the matrix using a weak interface between fibre and matrix. In practical interest, a significant part of energy absorption during impact takes place through the fibre pullout process.

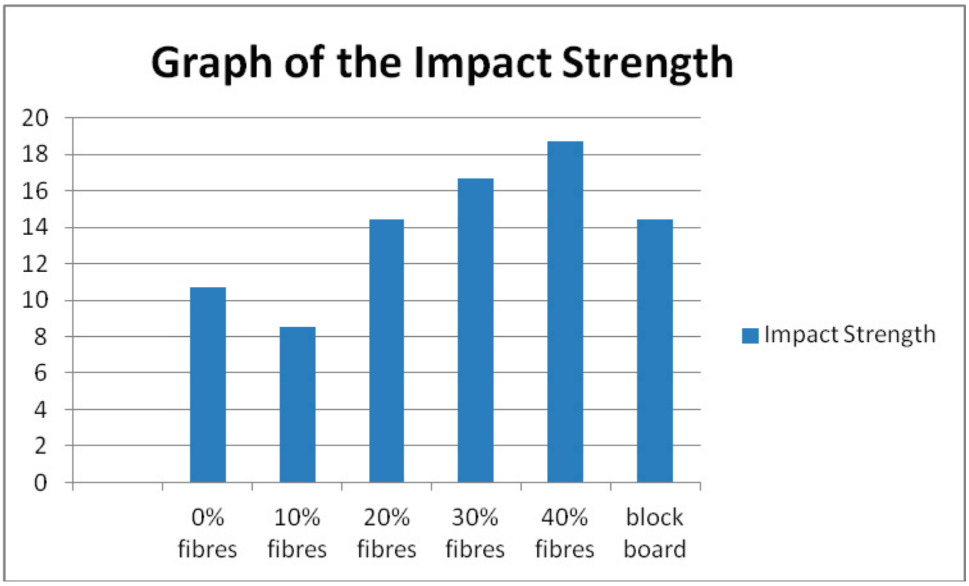

Fig. 9: *Comparison of Impact strength of composite with the block board*

Water Absorption Test

Water absorption is used to determine the amount of water absorbed by a composite
This involved determination of the following:

$$Increase\ in\ weight = \frac{W_w - D_w}{D_w} \times 100\% \qquad (1)$$

Where W_w=Weight of sample after soaking in water.
DW=Weight of sample before soaking in water

$$Density\ of\ sample(g/cm^3) = \frac{Mass\ of\ sample(g)}{volume\ of\ sample(cm^3)} \qquad (2)$$

It was observed that the rate of water absorption in the composite increases as the percentages of fibres increases as shown in **Fig.10.** However, this rate of water uptake is less compared to that of specimen M (block board) which is more than 70.25%. This is explained by the fact that composite material has more tied bonding and fewer pores compared to wooden portioning boards. On the other hand, the fibre content also affect the water absorption values which shows that composites with 10% fibres has less absorption compared to composites with 20%, 30% and 40% fibres. This shows that the presence of the PE (Thermoplastic) as a filler in the matrix reduces the water absorption of the fibre portioning board.

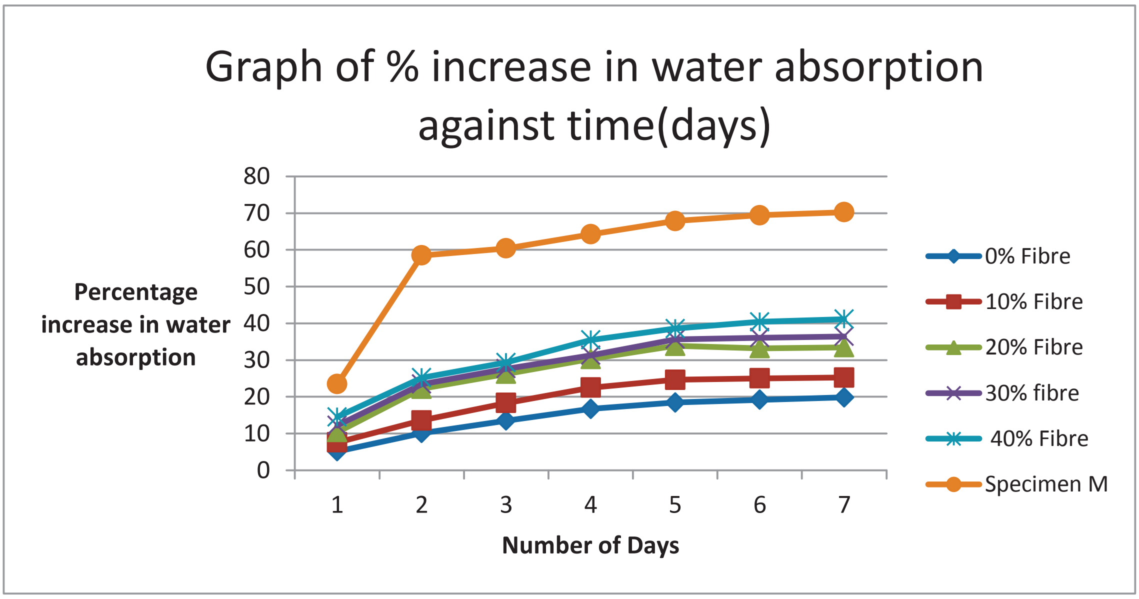

Fig.10: Graph of % increase in water absorption against time (days)

Machining Tests

Drilling - It is possible to drill the composite and the resultant surface is not as distorted as it is when drilling of a block board.

Cutting with a saw - the composite material could easily be cut, just like cutting wood. This is an important feature for a block board since it allows the user to have the desired shape.

Grinding - Grinding produced very small fine particles and a good surface finish.

CONCLUSION

Plastic waste and EFB fibres can be used to produce composites for the construction industry. EFB fibre content influences water absorption, compression strength, bending strength and impact strength of the composites. Higher fibre content resulted in high water absorption by the composite but it is significantly higher for the block board in the market. Machining operations such as grinding, milling, drilling and cutting can be performed on the composite without any difficult. Use of EBF Reinforced PE as an alternative to block board production from wood not only saves forest but also a very effective way of recycling waste plastics.

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