RESEARCH ARTICLE OPEN ACCESS

Experimental Investigation of Flexural Properties of Wood Polymer Composites

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ABSTRACT
The development of alternative wood composites based on the use of waste wood powder can be beneficial due to over exploitation of natural resources. This paper presents the mechanical properties of the waste wood powder filled epoxy composites prepared for research work. The results of various characterization tests are reported here. This includes evaluation of tensile strength, and Flexural strength. The experimented was conducted with five specimens for the properties repeatability. The interpretation of the results and the comparison among various composite samples are also presented.
Keywords - Waste wood powder, Epoxy composites, Tensile Strength, Flexural Strength

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Date of Submission: 24-06-2023 Date of acceptance: 05-07-2023

I. INTRODUCTION

The real polymer revolution had its beginnings in the early Twentieth century with the development of Bakelite a phenolic in 1909 and of synthetic butyl rubber in 1922. Almost all the polymers we use so widely today were developed in a twenty years span from 1940 to 1960 among them the bulk commodity polymers polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC) and polyurethane (PU). The combined annual tonnage of these commodities has now approached as that of steel. Designers seized on these new materials into cheap, brightly colored and easily molded to complex shapes to produce a wide spectrum of optimistic products. Design with polymers has since matured, they are now as important as metals in household products, automobile engineering and most recently in aerospace.

Though wood does not shrink and swell much with temperature, it readily absorbs moisture, which alters its properties and dimensions and can lead to bio-degradation if not protected. Flaws are also inherence in wood. But modern designs demands for the materials that are reliable from batch to batch but wood properties vary from batch to batch. By bearing in mind of all the above factors consistent efforts have been made to find a substitute material for wood, which would also be effectively useful in engineering applications. One such replacement would be wood polymer composites. In wood Composites, wood fibers used as reinforcement in the material. There have been various wood-based composites in use for a long time in different applications. Wood can be used in many different forms as reinforcement e.g. in the form of wood sheets, wood flours or fibre. The quality of the material can vary greatly and the strength will vary with the quality of the wood. Some of the mechanical properties values are presented in Table.1.

Table 1 Mechanical property of softwood and hardwood

Properties	Types of wood	
	Soft wood	**Hard wood**
Density (kg/m^3)	450-900	490-750
Tensile strength (MPa)	90-110	60-140
Compression Strength (MPa)	40-50	40-60
Bending Strength (MPa)	65-90	60-125
Shear Strength (MPa)	7.5-10.0	8.0-12.0
Young's –Modulus (GPa)	110-120	100-170

II. PREPARATION OF WOOD POLYMER COMPOSITES

The concept of wood polymer composites (WPC) generating interest as new methods of combining the materials are developed. They combine the best features of wood and polymer. Processing of WPCs is an expert task but the results can meet the most demanding customer requirements. WPCs are made using a variety of raw materials. The basic are wood and polymer mix must be modified with hardener to improve the final properties of the WPC. One of the major concerns with wood plastic composites in the past has been the difficulty in combining thermoplastics intimately with the wood flour.

The term "wood flour" for which no clear-cut definition has been adopted, is applied somewhat loosely to wood reduced to finely divided particles approximating those of cereal flours in size, appearance and texture. A specific method of production is not involved in the name "wood flour." Wood flour in general is neither a uniform nor a standardized product. Fig 1. shows the wood flour and fibers used for the fabrication process.

Fig 1. Wood flour and wood fibers

III. Wood Epoxy Composites

Wood epoxy is particular type composite, which comprises of epoxy resin, hardener and graded wood floor as ingredients. In this work the following epoxy resin is employed Waste Wood composites.

- Epoxy resin : Araldite LY- 554
- Hardener : Hardener HY951
- Reinforcement : Waste wood flour

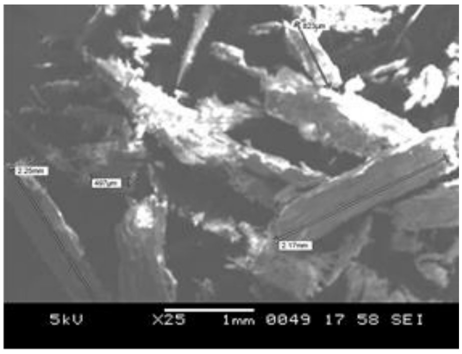

Fig 2. Dimensions of wood fibers

Wood epoxy is particular type composite, which comprises of epoxy resin, hardener and graded wood floor as ingredients. The wood residues are collected and refined for fabrication of polymer composites. The length of the fiber varies from 0.497mm to 2.25 mm and the average diameter of the fiber is 410µm. Fig. 2 reveals that they are randomly oriented, with the wood flour content

MOULD DESIGN

The dimension of the waste wood fibers composite was 300mm (L) x 300 mm (W) and the boards had 10 mm thickness. Fig. 3 shows the mould for casting. The required equipments for the mould that was used to lay the material down into mats were including glass, transparency plastic for the bottom layer and spacer frame.

Fig 3. Mould for casting the composite

IV. RESULTS AND DISCUSSION

The composite material becomes stiffer with the addition of epoxy matrix. As the epoxy content increases so do the yield stress, tensile modulus and tensile strength, but in opposing trend, the ductility of the material falls. In case of 30 wt% wood reinforced composites, lack of intimate bonding between wood flour and epoxy matrix has led to numerous irregularly shaped micro-voids or micro-flaws, which make the transfer of stress from the matrix to the fibers, poor and the mechanical properties of the fibers and matrix were not fully utilized. However the 30 wt% of wood reinforcement is capable of baring max. Peak load of 6.06 kN., compared to 40 wt% and 50 wt% of wood reinforcement. The breaking load increases with decrease in the wood content filled in the composite. Fig. 4 shows the average tensile strength of wood epoxy composite. The maximum tensile strength of 44 MPa was observed for composites containing 30 wt % of wood reinforcement and the minimum tensile strength of 37 MPa for those with 50 wt% of wood flour composition. The 40 wt% of wood reinforcement exhibits tensile strength of 43 MPa. The observed decrease in the tensile strength and stiffness is attributed to the poor interfacial bonding between the wood flour and the epoxy matrix with increase in wood reinforcement. The tensile modulus increases with decreases in wood reinforcement. The 30 wt% of wood reinforcement shows the max. tensile modulus of 2450 MPa as shown in Fig. 5. The 50 wt % of wood reinforcement exhibits the min. tensile modulus of 1859 MPa.

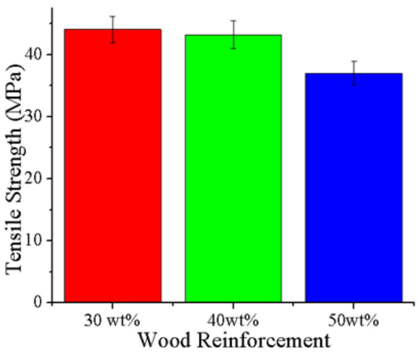

Fig 4. Effect of wood reinforcement on tensile strength

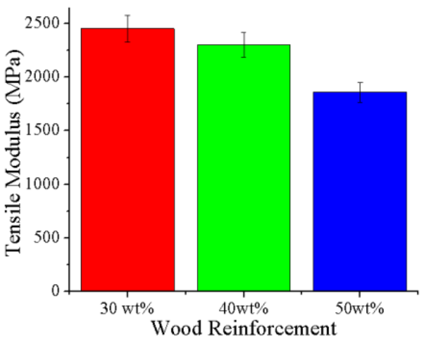

Fig 5. Effect of wood reinforcement on tensile modulus

4.1 FLEXURAL PROPERTIES

A tension test reflects the average property through the thickness, whereas a flexural test is strongly influenced by the properties of the specimen closest to the top and bottom surfaces. The stresses in a tensile test are uniform throughout the specimen cross-section, whereas the stresses in flexure vary from zero in the middle to maximum in the top and bottom surfaces.

Flexural properties have also been widely investigated. D'Almeida [1] showed that on a cost basis the composites fabricated with high flexural strength natural and wood fibers can even compete with glass Fiber-mat polyester matrix composites. Some researchers [2-3] shown that the composites made of high-density polyethylene and pinus wood flour as filler, treated with coupling agents (polypropylene maleate, 3–5 wt %), could be desirable as building materials due to their improved stability and strength properties.

A three point bending arrangement has been employed to carryout flexural testing of wood polymer composites. The test specimens of three compositions of wood polymer were fabricated. Test specimens were according to the ASTM standards (ASTM D790M). The test specimen is shown in Fig. 6. The arrangement for bending test is shown in Fig. 7 The Universal frame was used to conduct the bending test. The span length for loading the specimen was 150 mm. A dial gauge with a least count of 0.01mm was used to measure the deflection of the sample. A constant rate of loading is applied on the specimen by adding weights five samples in each composition were tested.

Fig 6. Test Specimen

Fig 7.Test Setup for flexural test

The results of the bending test show a clear distinction in the load behavior for the varied wood reinforcement. With increase in the wood reinforcement from 30 wt % to 50 wt %, the load strength is increased by 13.6%. The flexural strength 30% wood reinforced epoxy composite was found to be about 21.11 MPa. With the increase of wood fiber percentages from 30 to 40 wt%, the flexural strength increase by 10% (Fig. 8). The increase in the wood reinforcement has contributed to the increased stiffness of the composite material. The 50% wood reinforced epoxy composite has a maximum flexural strength of 28 MPa. The 50% wood reinforced specimens showed maximum flexural modulus of 2140 MPa and the 40% wood reinforcement showed flexural modulus of 1481 MPa (Fig. 9). The 30% wood reinforcement has showed the minimum flexural modulus of 1407 MPa.

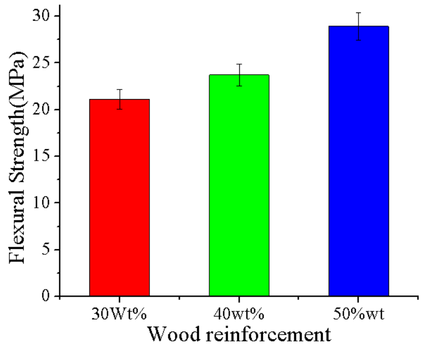

Fig. 8 Effect of wood reinforcement on flexural strength

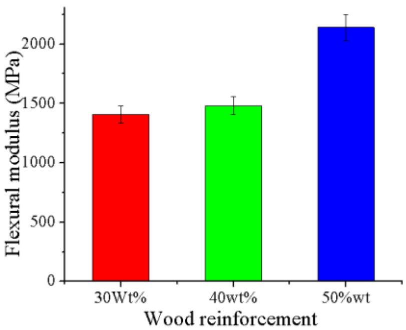

Fig. 9 Effect of wood reinforcement on flexural modulus

V. CONCLUSION

The study described, intends to investigate the mechanical properties of waste wood powder polymer composites. And also to investigate the influence of different percentage of wood content on Flexural properties of waste wood polymer composites. The conclusions of this study are as follows

It has been noticed that the mechanical properties of the composites such as tensile strength, compressive strength, flexural strength and impact strength of the wood polymer composites are also greatly influenced by the wood types.

As the percentage of epoxy content increases the tensile properties of the wood polymer composites also increases. The 30% of wood content has shown the better tensile properties.

As the wood content in the composite increase the flexural properties also increase. The 50% of wood content has shown the better Flexural properties compared with other wood polymer composites.

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