RESEARCH ARTICLE OPEN ACCESS

Mechanical Behavior of Areca Fiber and Maize Powder Hybrid Composites

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ABSTRACT
Natural fibers are gaining the interest in packaging, domestic, low cost housing and other general applications. In this work the mechanical properties of randomly distributed areca fiber and maize powder reinforced phenol formaldehyde were studied. From the results Youngs modulus is maximum found in 300 ml of resin. The maximum tensile strength is for 300B composite plate. The maximum Young's modulus for 300B is 135MPa, for bending strength of various composite plates, the composite plate with 400 ml PF resin shows the maximum bending load compared to other composite plates. The composite plate of 400C shows the maximum bending load compared to other composite plates. The maximum bending load for 400C composite plate is 0.854 kN. The adhesive tensile strength increases with decrease in Areca fiber and increase in maize powder up to 700 gms of Areca and 300 gms of maize powder. Later the adhesive tensile strength decreases with decrease in Areca fiber and increase in maize powder. Maximum adhesive tensile stress is 0.137 MPa for 400B composite plate compared to remaining composite plates.
***Keywords* -** Areca fiber, Maize powder, composites, Phenol formaldehyde.

I. INTRODUCTION

Manmade fibers using glass, carbon, boron etc. are being used as reinforcing materials in the fiber reinforced plastics (FRP) which have been widely accepted as materials for structural and non-structural applications. The main reason for the interest in FRP is due to their specific modulus, high stiffness and strength to weight ratio compared to other conventional materials. However, these materials are prohibitively expensive in their use for other general purpose and applications. Nowadays natural fibers like banana, cotton, coir, sisal jute have attracted the attention of scientist and technologists for applications in packaging, low-cost housing and other structures. [1] It has been found that these natural fiber composites possess better electrical resistance, good thermal and acoustic insulating properties and high resistance to fracture.

The increasing interest in introducing degradable, renewable, and inexpensive reinforcement materials, which have been environment friendly, has stimulated the use of hard cellulose fibers. The low cost, less weight and abundant availability make the natural fibers an attractive alternative. The current major uses of hard cellulose fibers like flax, jute, banana, sisal, pineapple leaf fiber are in textile, packaging and paper manufacturing. These fibers are considered as hard cellulosic fibers because of their high tensile modulus and low elongation at break.

Many attempts were made by scientists and technologists to utilize natural fibers in the fabrication of composites. Natural fibers have attracted the attention of scientists & technologists because of the following advantages. [2] These fibers, despite their low strength can lead to composites with specific strengths because of their low density.

- Natural fibers are abundantly available renewable resources.
- Natural fibers are nontoxic and Eco-friendly and biodegradable and are quite cheep.
- Scientific data of the structure and properties of the fibers are readily available.

Among all the natural fiber reinforcing materials, Areca appears to be a promising material because it is inexpensive, availability is abundant and a very high potential perennial crop. It belongs to the species Areca catechu L., under the family palmecea and originated in the Malaya peninsular, East India. [3] Major industrial cultivation is in East India and other countries in Asia. In India, Areca nut cultivation is coming up on a large scale basis with a view to attaining self sufficiency in medicine, paint, chocolate, Gutka, etc.

II. MATERIALS

The samples are prepared as per ISO standards. The husks are taken directly from the areca nut fields, containing lot of dirt and dust. The dirt and dust the individual fibers and coarse fibers are removed by washing them with water. The coarse fiber cluster is again fed into the machine and the process is repeated to get individual fibers. Thus fibers are extracted. The fibers were chemically treated in a solution of KOH (Potassium Hydroxide) [3,4,6]. A mould made of aluminum sheet dimension of 300x300 mm was used to prepare the board [2]. In order to get required dimension of 300x300x10 mm of board, two frames of same dimension were placed adjacently on the mould. Thoroughly mixed mixture of areca fibers, maize powder, 5% of hardener and phenol formaldehyde resin was taken and placed in the mould uniformly. A layer of aluminum foil was placed both at the top and bottom of the board so that board can be easily taken out from the mould. For preparation of 200A Composite plate, an Areca fiber of 800 gms and Maize powder of 200 gms along with 200 ml Phenol formaldehyde resin are mixed uniformly and used for preparation of boards. For preparation of 200B Composite plate, 700gms of Areca fiber and 300 gms of Maize powder along with 200 ml of Phenol formaldehyde resin are uniformly mixed and used for preparation of boards. Similarly for the 200C and 200D composite plates was prepared. Same procedure was followed for preparation of 300 and 400 composite plates. The surface of the specimens shall be essentially flat. Test specimens were cut into 10 cm by 10 cm squares.

III. EXPERIMENTATION

Tests were performed according to the following standards: tensile strength (IS 2380 (part 3)-1977), flexural strength (IS: 2380 (part4)-1977), and adhesive tensile strength (IS: 2380 (part 5) – 1977).

IV. RESULTS AND DISCUSSION

A. Tensile strength

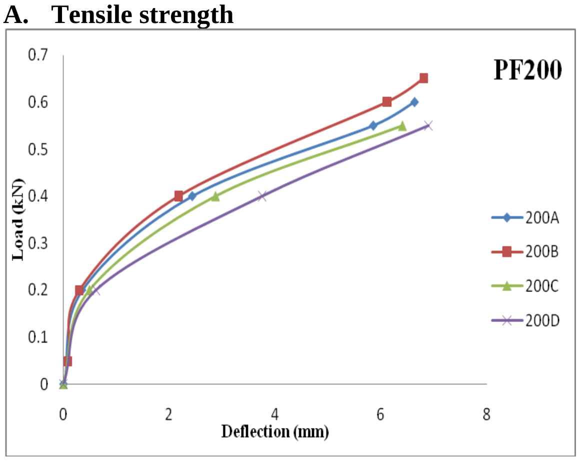

Figure 1: Load-Deflection curves for tensile strength of 200ml PF composite plates

Fig.1 shows the load-deflection curves for areca fiber and maize powder reinforced PF composite plates. From the result it is reveal that tensile strength increases with decrease in Areca fiber and increase in maize powder upto 700 gms of Areca and 300 gms of maize powder. Later the tensile strength decreases with decrease in Areca fiber and increase in maize powder. The tensile strength is maximum in 200B composite plate and its Young's modulus is 77.72 MPa compared to remaining composite plates.

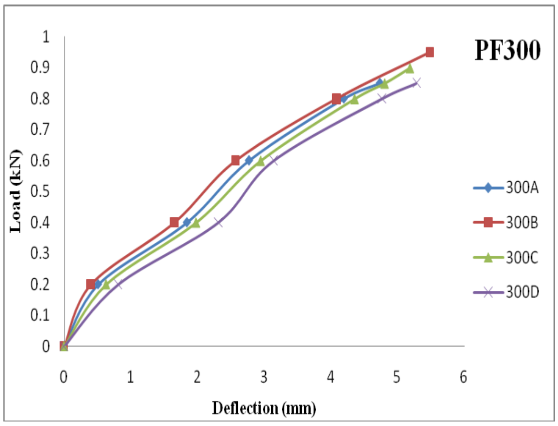

Figure 2: Load-Deflection curves for tensile strength of 300ml PF composite plates

Fig.2 shows the load-deflection curves for areca fiber and maize powder reinforced PF composite plates. These curves are linear in elastic region. The tensile strength increases with decrease in Areca fiber and increase in maize powder upto 700 gms of Areca and 300 gms of maize powder. Later the tensile strength decreases with decrease in Areca fiber and increase in maize powder. The tensile strength is maximum in 300B composite plate and its Young's modulus is 135MPa compared to remaining composite plates.

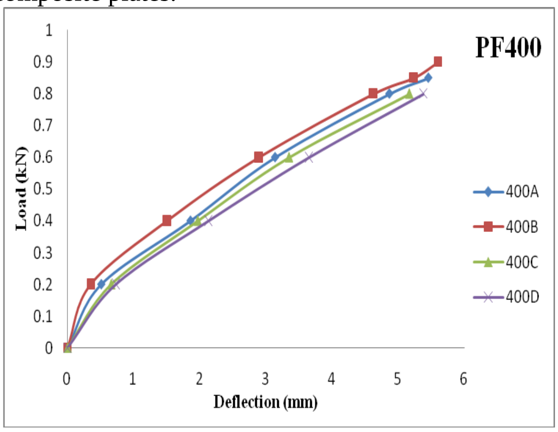

Figure3: Load-Deflection curves for tensile strength of 400ml PF composite plates

Fig. 3 shows the load-deflection curves for areca fiber and maize powder reinforced PF composite plates. The tensile strength increases with decrease in Areca fiber and increase in maize powder upto 700 gms of Areca and 300 gms of maize powder. Later the tensile strength decreases with decrease in Areca fiber and increase in maize powder. The tensile strength is maximum in 400B composite plate and its Young's modulus is 125.2 MPa compared to remaining composite plates. Mukhopadhyay describes the tensile properties of unidirectional composites depend more on the tensile properties of the fibers with a high fiber volume fraction. The strength and the modulus values of the fresh fibers were superior than the aged fibers. S. Jain et al. [8,9] showed the tensile, bending and static strength of the composite reinforced by bamboo orthogonal strip mats. A.V. Rajulu et al. [10] investigated the effect of fiber length on the tensile properties of short bamboo fiber epoxy composites.

B. Flexural Strength

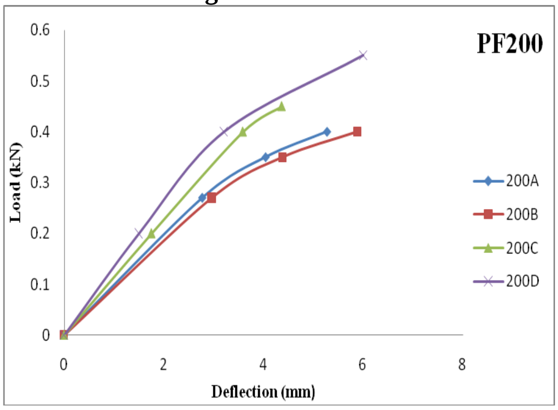

Fig.4 Load-Deflection curves for bending strength of 200ml PF composite plates

Fig.4 shows the load deflection curve for bending strength of Areca fiber and maize powder reinforced PF composite plate. This curve shows that the bending load for composite plate increases with decrease in Areca fiber and increase in maize powder. The composite plate of 200D shows the maximum bending load compared to other composite plates. The maximum bending load is 0.753 kN for 200D composite plate.

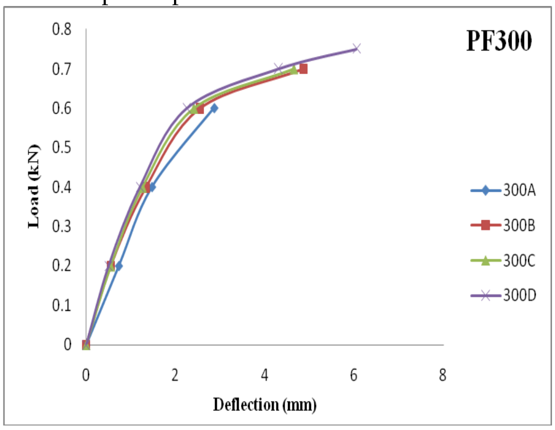

Figure.5: Load-Deflection curves for bending strength of 300ml PF composite plates

Fig.5 shows the load deflection curve for bending strength of Areca fiber and maize powder reinforced PF composite plate. This curve shows that the bending load for composite plate increases with decrease in Areca fiber and increase in maize powder. The composite plate of 300D shows the maximum bending load compared to other composite plates. The maximum bending load is 0.951 kN for 300D composite plate.

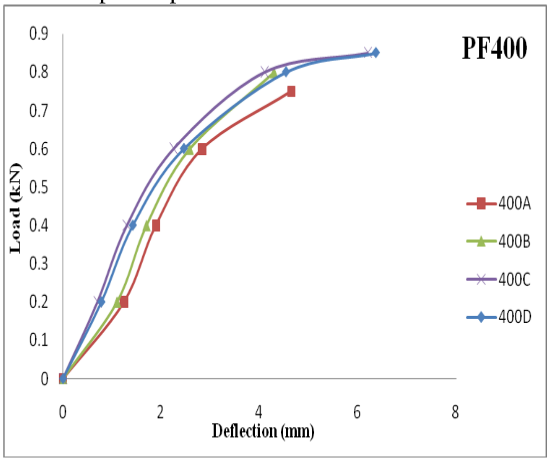

Figure 6: Load-Deflection curves for bending strength of 400ml PF composite plates

Fig.6 shows the load deflection curve for bending strength of Areca fiber and maize powder reinforced PF composite plate. This curve shows that the bending load for composite plate increases with decrease in Areca fiber and increase in maize powder. The composite plate of 400C shows the maximum bending load compared to other composite plates. The maximum bending load for 400C composite plate is 1.054 kN.

C. Adhesive tensile strength

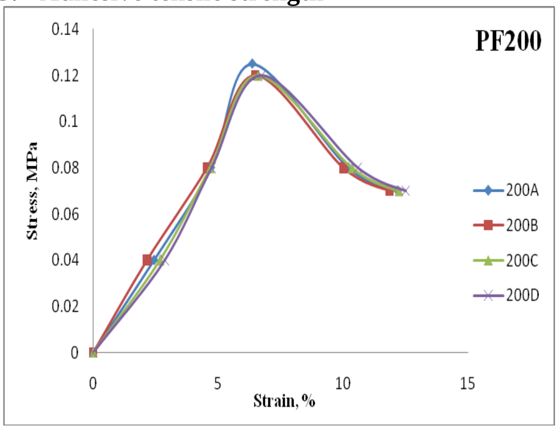

Figure 7 Adhesive Tenslie stress – strain curves for 200ml PF composite plate

Fig. 7 shows the stress-strain curves for areca fiber and maize powder reinforced 200ml PF composite plates. The adhesive tensile strength decreases with decrease in Areca fiber and increase in maize powder. Maximum adhesive tensile stress is 0.225 MPa for 200A composite plate compared to remaining composite plates.

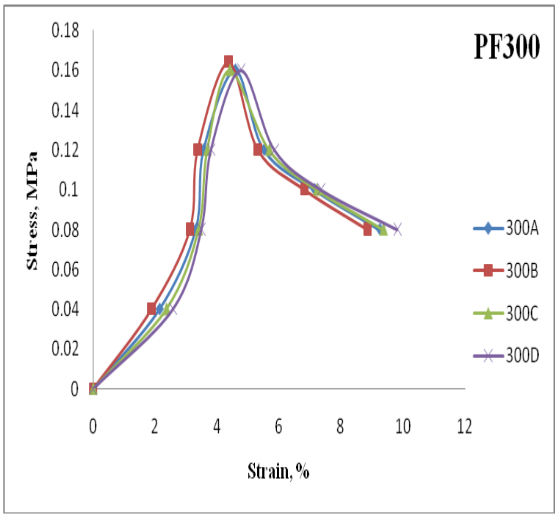

Figure 8 Adhesive Tenslie stress – strain curves for 300ml PF composite plate

Fig. 8 shows the stress-strain curves for areca fiber and maize powder reinforced 300ml PF composite plates. The adhesive tensile strength increases with decrease in Areca fiber and increase in maize powder upto 350 gms of Areca and 150 gms of maize powder. Later the adhesive tensile strength decreases with decrease in Areca fiber and increase in maize powder. Maximum adhesive tensile stress is 0.264 MPa for 300B composite plate compared to remaining composite plates.

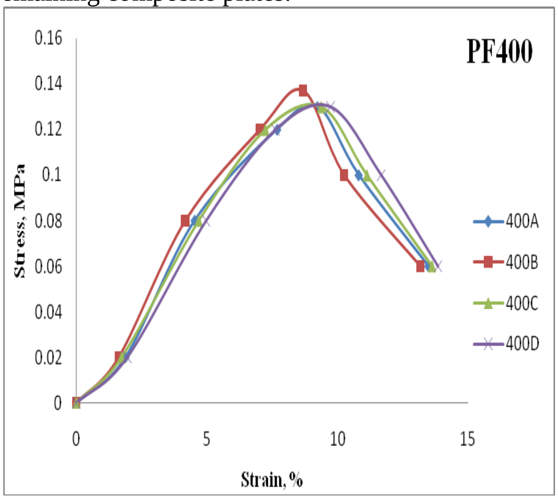

Figure 9 Adhesive Tenslie stress – strain curves for 400ml PF composite plate

Fig. 9 shows the stress-strain curves for areca fiber and maize powder reinforced 400ml PF composite plates. The adhesive tensile strength increases with decrease in Areca fiber and increase in maize powder upto 700 gms of Areca and 300 gms of maize powder. Later the adhesive tensile strength decreases with decrease in Areca fiber and increase in maize powder. Maximum adhesive tensile stress is 0.237 MPa for 400B composite plate compared to remaining composite plates. Mukhopadhyay explains the Adhesion by interdiffusion is a mechanical interlocking on a molecular scale. This mechanism of adhesion is applicable to materials whose molecules possess a high degree of mobility as well as affinity toward the opposing molecules. In the presence of moisture, the molten matrix cannot properly diffuse into the fiber and results in lack of adequate fiber–matrix adhesion

V. CONCLUSION

- The overall results demonstrated for fiber composites shows good mechanical properties.
- The tensile strength obtained is 135MPa in 300b Composite which a maximum.
- The flexural strength is 1.054KN for 400C.
- The adhesive tensile strength is 0.264KN obtained for 300B

Based on the results, the composite materials can be used in packing industries, low cost housing, domestic purposes and can be used as commutative material for plywood.

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