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Research article

Production of banana / glass fiber bio–composite profile and its bending strength

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Abstract

In this study, biocomposite profiles, in the dimensions of 40x40x1100 mm, were produced. Biocomposites consisting of polyester resin glue and banana fibers as a filling material and glass ropes binding were prepared by compression moulding technique under 400 bar pressure and at 70 °C temperature using a hydraulic pres. In order to gain higher strength on the outer surfaces of the produced profiles, glass fiber and polyester binding were used. One and two fold glass fibers were laid down in two different orientations. One of them was laid by hand lay-up method which was used to increase strength of the outer surfaces. The bending test was applied to the produced specimens in the dimension of 40x40x550 mm. The flexural strength values were calculated according to TS EN 310 using the obtained Fmax values. The test results showed that the highest and lowest bending strengths for a single layer specimen were 13.085 N/mm^2 and 8.957 N/mm^2, respectively. While, the highest and lowest bending strengths for the double layers specimens were 18.196 N/mm^2 and 16.834 N/mm^2, respectively. From these results it can be concluded that these composites can be used in various structural components for the greenhouse industry and stair handrails, fencing and decoration for garden furniture.

Keywords: *Banana fibers, glass fibers, biocomposite.*

1. Introduction

Material types and applications of new materials technologies have been developed day by day. Composites or hybrid designs which constitute the basis of these materials consist of at least two different materials. Composite materials offer superior properties and formed by joining at least two different materials at the macro level [1].

Increasing the world's population is leading to large amounts of waste of natural or synthetic material. These waste materials result in environmental problems. The environmental problems are caused by waste plastics, metals and some other lignocellulosic materials. Parallel to the increase in population, the demand for the forest products needed by the people grows, and the necessity of finding new sources appears. For a better environment, there is a need to reduce environmental pollution through effective waste recycling and finding new ways. Plastic waste, and agricultural wastes are leading environmental problems. If we evaluate the production of composite materials, a new alternative source of raw materials consist. So that wood materials need will be reduced and this is thought to be important for the forest products industry [2]. Sugarcane, bamboo, jute, kenaf, cotton, rice straw, rice husks, banana, wheat, tobacco,

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pineapple, sunflower stalk, corn stalk, hemp, oat straw, cotton straw, hay, rye, barley, flax and so on over fifty vegetable-based, research has been done to produce composite materials from hundreds of lignocellulosic material in the laboratory [3].

In their study, Samal and colleagues produced a mixture of short banana and glass fiber reinforced polypropylene (PP) hybrid composites through compression molding technique using a twin screw extruder. The composites were produced with and without maleic anhydride (MAPP). For the both composition, an increase as seen in the tensile, bending and impact strengths up to 30 % by increasing weight of banana fibers [4].

Mukhopadhyay and colleagues examined the behavior of banana fibers and their fracture behaviour. They characterised banana fibers depending on the diameter variation, mechanical properties and the influences of the stresses acting on the fracture morphology. Stress-strain curves for different strain rates were obtained and fractured surfaces were examined by SEM [5]. Altinisik and Yilmaz carried out a study in order to examine post-harvest waste from the banana plant, natural fibers used as the reinforcement in plastic-based composites. Banana fibers, felt making, hand made moulding process method, tensile test and Charpy impact strength tests were made and samples obtained. Tensile and impact strength increased with the increase in volume recorded the banana fibers [6].

In their study, Maleque and colleagues produced pseudo-woven fabric-reinforced epoxy composite samples from the roots of banana. Tensile, flexural and impact tests were applied to samples produced. In addition, fracture surfaces were examined by SEM. When compared to the pure epoxy, the banana-fiber-reinforced epoxy showed improvement in flexural strength, impact resistance and plastic deformation properties [7]. Herrera-Estrada et al made a study on the banana fiber-reinforced composites for automotive and transportation applications. They reported that improvements were seen in bending strength, bending modulus and fiber matrix interface of the banana / ecopolyester composites [8]. Large number of studies on natural fibers, especially, the natural fiber reinforced composite materials was conducted [9-15]. In addition, many researchers have investigated the physical and mechanical properties of natural fiber reinforced composites [16-20].

2. Material and Method

2.1. Materials

The banana fibers used for biocomposite profiles production were obtained from the agricultural lands in in Zonguldak province, the top side of the banana plant was cut from the soil. General purpose polyester resin (CE 92 N8) and 300 g/m^2 multi-faceted glass fibers (MAT8) were supplied by Glass Fiber Inc. Methyl ethyl ketone peroxide was used as the hardener (MEK) while the cobalt naftanat as a catalyst. As the mould, the mould having cavity volume of 40x40x1100 mm was used. For pressing, 15 ton capacity hydraulic press, and as mold release agents, liquid PVA and pure vaseline were used.

2.2. Preparation of Fibers

Parts of the bananas tree bodies were separated and then dried by spreading. The dried fibers were kept in water for two days in order to separate the outer membrane of them. Then, the fibers removed from the water, leaving the outer surface of lignin and pectin membranes with the help of a spatula, was laid to dry again. Crumbled dry fibers were separated from the remaining parts of the outer membrane. Fig. 1 shows the banana fibers cut and sifted. The dried fibers were brought into bundles, so that the size of 6-10 mm, was cut with garden scissor, then the dust and small pieces of 6 mm, the removal was eliminated.

Fig. 1 Banana fiber

2.3. Banana / Glass fiber Bio-composite Production

The mould release agent was applied to the mating surfaces of the mould and then a layer of fibers was hand lay-up by wetting with polyester. The cut banana fibers were weighed and mixed with resin and glass fibers. Polyester resin and glass ropes joined and blended into the banana fibers. As a filling material (Table 1), a mixture was prepared in homogeneous as possible so that the mold was filled, and the mold is closed and placed to the press. The mould on the press was heated for two hours with the help of heating elements in order to accelerate curing period. The composites were removed from the mould and then were left on the floor for two days. Finally, onto the profile, single layer (SL) and double layers (DL) were applied including multi-glass fiber with a hand lay-up method. Table 2 shows the constituents of the composite and their weights.

Table 1
The filling material components

Material name	Weight (g)
Banana fiber	375
Polyester resin	40
Glass rope	25
Glass fiber	50
Polyester for wetting	75
Total	565

Table 2
Constituents of banana / glass fiber bio-composite

Material name	Weight (g)	
	SL	**DL**
Glass fiber	64	128
Polyester resin	128	256
Total	192	384

3. Bending Strength

The bending tests were carried out on a SHIMADZU AG-IS unit with a capacity of 50 kN. This unit was in the laboratories of furniture and decoration department in Karabuk

University Safranbolu Vocational College. Fig. 2 shows the unit and the bending test setup.

Fig. 2 SHIMADZU bending test machine and test setup

For bending tests, a total of six samples were used. Three of them were coated with single layer of fibers while the remaining three were coated with double layers of fibers. The Fmax force at which the specimens break were determining by entering the cross-section, length and speed data into the unit. The single layer coated specimens (SL) were in the dimensions of 43x43x550 mm while double layers coated specimens (DL) were in the dimensions of 45x45x550 mm. The bending speed was selected as 10 mm/min. The distance between the support was 350 mm. Schematic diagram of the bending setup is shown in Fig. 3.

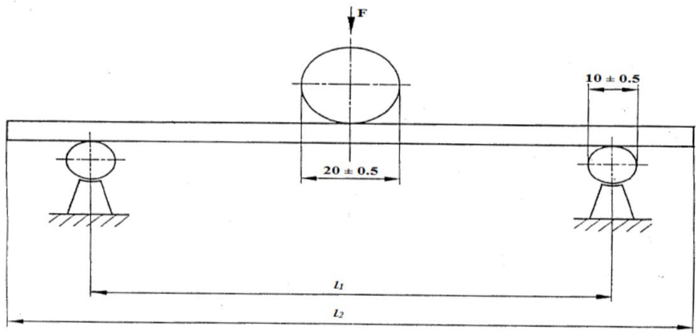

Fig. 3 Schematic diagram of the bending setup

Bending strength of the specimens was calculated using the obtained Fmax force from the bending tests according to the EN 310 standard. Bending strength equation;

$$f_m = \frac{3 \times F_{max} \times l}{2 \times b \times t^2} \quad (1)$$

here ;

f_m is bending strength (N/mm^2),
F_{max} is the sample broken force (N),
l is the distance between supports (mm),
b, t are the sections of the sample (mm).

4. Results and Discussions

Fmax values obtained from the tests and bending strength values (fm) are shown in Table 3. Graph of the bending strength shown in Fig. 4 banana / glass fiber bio-composite. Beginning of the bending test and the moment of application of the force of Fmax are shown in Fig. 5 for banana / glass fiber bio-composite.

Table 3
f_m and F_{max} values of banana / glass fiber bio-composite

Single layer glass fiber	F_{max} (N)	f_m (N/mm²)	Double layers glass fiber	F_{max} (N)	f_m (N/mm²)
Sample1	1926.56	13.085	Sample1	2840.63	16.834
Sample2	1318.75	8.957	Sample2	3070.68	18.196
Sample3	1812.72	12.312	Sample3	2960.43	17.543
Average value	1686.01	11.451	Average value	2957.25	17.524

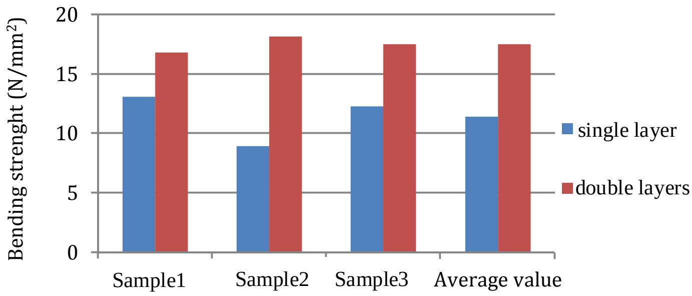

Fig.4 Bending strengths of banana / glass fiber bio-composites

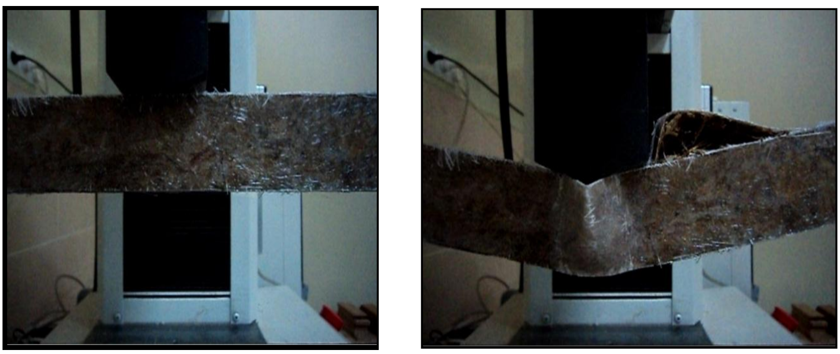

Fig. 5 Beginning of bending test and the moment of application of the force of F_{max} when testing banana / glass fiber bio-composite

5. Conclusions and Recommendations

As a result of this study, bio-composite profiles were produced using banana fibers, glass ropes and polyester resin as filling material through moulding process. The surfaces of the profiles were applied glass fibers by lay-up method. The test results showed that the highest and lowest bending strengths for a single layer specimen were found to be 13.085 N/mm² and 8.957 N/mm², respectively. While, the highest and lowest bending strengths for the double layer specimens were found to be 18.196 N/mm² and

16.834 N/mm^2, respectively. In Fig. 6, single and double layers glass fiber coated bio-composite specimens are shown. These specimens were subjected to the bending tests.

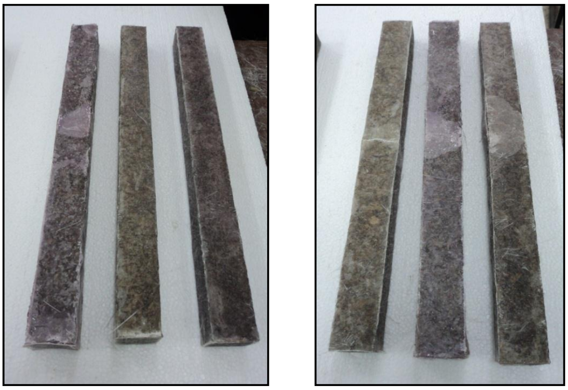

Fig. 6 Single layer and double layers of glass fiber coated banana / glass fiber bio-composite samples after bending tests

According to these results, it can be said that these produced banana / glass fiber bio-composites can be used for indoors and outdoors applications where very high strength is not required. Thus, economic benefits of the waste can be realised. In addition, no efforts and costs will be needed for disposal of this waste. Also it is considered as an alternative to wood materials and protection of forest resources can be achieved as the forest sources are rapidly disappearing.

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