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Investigation on Flexural and Impact Properties of Abaca and Manila Hybrid Composite

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Abstract. Bio-fibre composites are increasingly replacing conventional and synthetic composite materials for the past two decades. This is due to their abundant availability, high strength to weight ratio and bio-degradability. Suitable properties of natural fibres can be imparted by changing the orientation of the fibres during manufacturing process. This paper proposes a hybrid property of natural fibre composite made up of Manila and abaca fibres as reinforcing agents with epoxy resin as matrix .Hand lay-up process is used for manufacturing this composite laminate. Then the treated fibres with increased strength are used with epoxy LY556 resin with HY951 hardener under room temperature. Three different samples are prepared and their mechanical properties like impact and flexural strength are found. This hybrid composite is effectively developed for automobile and electrical applications.

Introduction

Natural fibre composite accelerating their application with an asset of being eco friendly and high performance in the engineering society. Natural fibres can be acquired from natural resources such as plants, animals or mineral. In a hunt for a high performance fibres among various natural fibres available, various fibres are experimented for the best results [1,2,3]. Natural fibers such as hemp, flax and sisal have been identified as attractive candidates for this. Manila hemp has a good potential for application purposes and its tensile and flexural strength are highly convincing for mechanical applications [4]. The cellulosic content of the natural fiber can significantly alter the mechanical and chemical properties of the composite [5,6]. It was found that as the Manila fiber content in the composite increased up to 70%, there is a proportional increase in the tensile and flexural properties [6]. Abaca fibers have better bonding with the matrix when compared to cellulose fibers and this is attributed to their rough surface [7,8].

The abaca fibers treated with fungamix and natural enzyme showed better chemical resistance in acid and base medium[9,10]. The moisture absorption was also reduced by 40% and the tensile and flexural strengths showed a significant increase of 5–45% and 10–35% respectively [11]. Abaca fibers increase the flexural strength of the composite, when compared to the non-reinforced composite with the same matrix [12]

The Glass fiber reinforced composite with plain laminate exhibits better strength than a laminate with circular hole or rectangular hole, hence various orientations are being experimented in order to arrive with a best performance composite material which can be incorporated in engineering applications[13] .Fibre matrix interface with the polymer used plays a significant role in the properties of the composites. In this paper hybrid Manila laminate is fabricated and their properties are evaluated. Mechanical properties of abaca and banana fibre with jute and kenaf were evaluated and it was concluded that hybrid composite have better strength [14,15]

Experimental Details

Materials

Natural Fibres

Natural fibres are a class of continuous and hair like filaments. Its classification includes plant and animal fibres. Plant fibres namely cotton, flax, hemp, abaca, sisal, jute, kenaf, bamboo and coconut are widely used. They are preferredmostly since they are eco-friendly, and also available in less cost.

Manila and Abaca Fibre. Manila is a type of fiber obtained from abaca (Musa textilis) which is buff-colored. The fibers are usually long and have very good strength and durability. They exhibit strongresistance to saltwater and hence can be used in saline environments. Abaca is a cellulosic fibre which is obtained from the pseudo-stem of banana plant (Musa sepientum). Abaca fibres are strong, light weight and long fibres Some of its valued characteristics include, non-slipping and anti-static qualities, fire resistance, abrasion resistance, rodent resistance.

Glass Fiber

Woven roved glass fiber composites are now widely used due to their high strength to weight ratio. Thewoven roving improves the mechanical properties. They are used to improve the surface finish of thecomposite.

Resin and Hardener

Epoxy resin (LY 556) and hardener (HY 951) is utilized for the fabrication of the composite. The resinandhardener are mixed in the ratio of 10:1 to provide adequate interfacial bonding.

Experimental Setup

There are many methods available for manufacturing of composites namely Pultrusion, Resin transfer molding and Hand layup method. But, hand layup process is the most widelyused and economical process in the manufacturing of composites. Initially, the mold is prepared with a release agent to ensure that the manufactured part can be easily removed from the mold. Then, the GFRP mat is laid over the surface and the Epoxy Resin is applied along with the hardener using a brush. Hardener increases the strength of the composite. A roller is used to remove the entrapped air and also to spread the resin hardener mixture uniformly and reduce porosity. A curing time of 6-7 hours is given after preparing the required base structure for composite. Then, the required layerof fiber combination is stacked up over the base, applying resin-hardener for getting better mixture simultaneously for each layer. Fibre are arranged in different orientation may be vertical, horizontal or inclined .After forming the required combination. it is loaded (8-10Kilograms) for a time period of 10 hours to obtain the optimum composite matrix.

Fabrication Procedure

Glass Fiber
Manila Fiber (Vertical)
Manila Fiber (Horizontal)
Manila Fiber (Vertical)
Glass Fiber

Glass fibre
Abaca fibre(vertical)
Abaca fibre(horizontal)
Abaca fibre(vertical)
Glass fibre

Glass fibre
Manila fibre (vertical)
Abaca (horizontal)
Manila(vertical)
Glass fibre

Figure 1.Schematic diagram of different samples of Abaca-Manila–GFRP

The preparation of the composite samples can made by hand layup process. The composite specimen consists of five layers. GFRP layers are mounted on the top and bottom on the specimen. Intermediate layers are filled by natural fibers. Resin and hardener mixture was applied for every layer. It is mixed with a ratio of 10:1(resin : hardener). The GFRP is then completely spread with epoxy resin and rolled to remove the entrapped air and to uniformly spread the mixture. This way, the three layers of GFRP are placed one over the other to obtain top and bottom layer. A curing time of 6-7 hours is given for the top and bottom structures to obtain good strength. Then, the GFRP laminates can be easily stripped off from the mold surface. Now, the Manila layers are arranged with horizontal and vertical orientation. Finally, the fibers are closed with Woven Rovings just like the base of the laminate. Now a load of 8-10 kilograms is applied for a curing period of 8-12 hours and the mold is closed to obtain the composite laminates. Similarly two more samples are prepared. Different types of composites are shown in Table 1.

Table 1. Different composite samples

Samples	Composition
Sample 1	Manila+GFRP
Sample 2	Manila+Abaca+GFRP
Sample 3	Abaca+GFRP

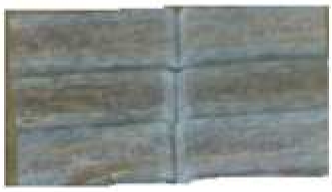

Figure 2. Specimen after impact test

Testing

Flexural Test

The composite is cut with the help of table saw as per ASTM: D790 standard. Three such samples are cut from different parts of the composite. The load is applied on the midway of the specimen until it fractures. This load is noted as breaking load and the Load vs. Displacement graphs are generated.

Impact Test

An impact testing machine with Charpy arrangement is employed to perform the test. It is done as per the ASTM: D256 standards. The specimen is subjected to an impact blow by the pendulum until it fractures and the corresponding energy absorbed by the material is noted. This test gives the maximum energy that a material can absorb which can be measured easily.

Results and Discussion

Flexural Test

Table 2. Result of flexural test for different composites

Sample	Flexural break load (kN)	Maximum displacement (mm)	Flexural strength		Flexural modulus	
			In kN/ mm^2	In MPa	In kN/mm^2	In Mpa
Sample 1	1.8	5.4	0.0059	5.9	0.602	602
Sample 2	0.98	3.86	0.0039	3.9	0.468	468
Sample 3	1.55	4.6	0.0121	12.1	1.380	1380

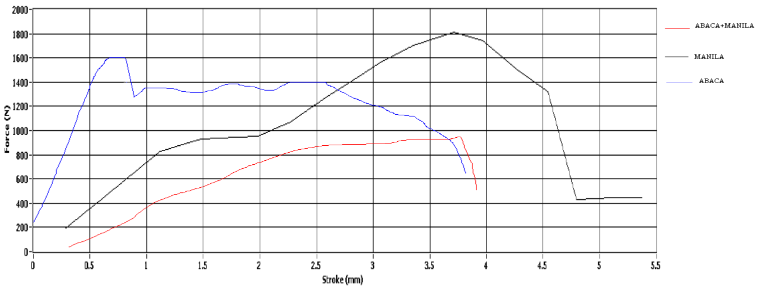

Figure 3. Comparison of flexural test results for different samples

From table 2 it is concluded that Abaca+GFRP composite (Sample 3) have better strength than hybrid composite (sample 2)

Impact Test

Table 3. Result of impact test for different composites

Sample	Energy absorbed (joules)
Sample 1	14
Sample 2	16
Sample 3	18.5

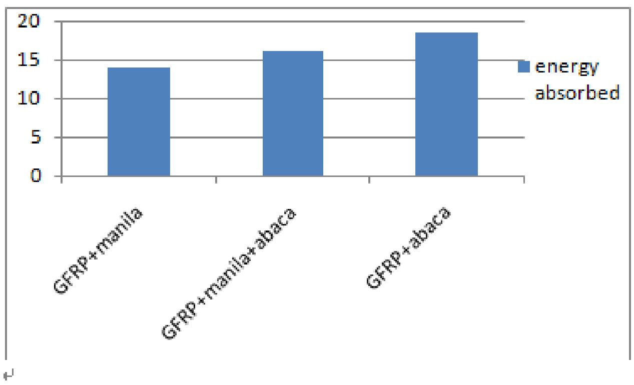

Figure 4. Comparison of impact test results for different samples

From Table 3 and Figure 4 , it is clear that sample 3 has better impact properties than hybrid composite (Sample 2). The reduction in value of hybrid composite is due to the presence of Manila fibre.

Conclusion

In this paper Manila and abaca fibres has been used as a reinforcement with GFRP and epoxy as a resin. Flexural and impact tests were carried out and result of the tests. Test results of Sample 3 exhibits the best flexural and impact properties among the three samples. On average, it is found that the average break load of the composite is 1.4 KN and the corresponding elongation is 4.62mm. The average flexural strength is 7.3 MPa.

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