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Experimental Investigation on Shear and Hardness of Abaca based Hybrid Composites

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ABSTRACT. Present technology development in the area of materials replaces the conventional materials used in automobile and aerospace sector by composite materials due their less weight and bio degradability. This paper aims to fabricate and investigate the mechanical properties of abaca-raffia hybrid composite fabricated by hand layup process. Since, abaca fiber has more strength than other fibers like kenaf, banana and sisal, the composite with this fiber can be suitable replacement material for automotive applications.The properties like double shear and hardnessare evaluated andthe result shows that the double shear properties and hardness of the hybrid composites [GFRP +Abaca+Raffia] is higher than other two combinations. The internal microstructure of the hybrid composites were analysed using Scanning electron microscope (SEM).

1. INTRODUCTION

Nowadays, natural fibre composites are replacing conventional materials due to increase in environmental awareness. Beckermann and Pickering[1] studied the properties of the hemp reinforced withMaleic Anhydride-Grafted Polypropylene (MAPP) by injection moulding process and concluded that injection moulded hemp reinforced with MAPP has more tensile strength and Young's modulus compared to the hemp without reinforcement.Hautala et al[2] found a new method of making mats from hemp fiber and found that method for making mats from spring harvesting is more suitable for industrial purposes and it is also a cost efficient method. Pickering et al[3] studied the properties of alkali treated fibers and concluded that alkali treated fiber has higher crystallinity index than the untreated fiber and further concluded that by alkali treatment, the fiber strength is improved. Marianne Le Troedec et al [4]studied the treatment of the hemp fiber with Sodium Hydroxide[NaOH] and found that treatment with 6% of NaOH clean fibers by removing the amorphous compounds and it also increases the crystallinity index of the fiber . Vincent Placet [5] studied the thermal-mechanical behaviour of the hemp fiber and concluded that the rigidity of the fibers increasesduring the initial stresses and also found that the rigidity and endurance decreases due to the thermal degradation.Le [6] investigated the mechanical properties of hemp and starch composites and found that agro-composite material is used as a filling material in construction and is deformable and cannot be crushed under loading which will fail due to great displacement.Kabir [7] investigated the tensile properties of chemically treated hemp reinforced composites and concluded that chemically-treated fibres possess high tensile strength than that of untreated fibres.Adel RamezaniKakroodi et al[8] investigated the mechanical, morphological and water absorption properties of maleated polyethylene/hemp composites and concluded that tensile and flexural properties of themaleic anhydride polyethylene[MAPE] matrix,water absorption and impact strength (up to 50%)increases with hemp content. Yan et al [9] studied the reinforcement of hemp with polypropylene (PP), and concluded that the tensile, flexural and impact strengths of PP/NHF(Noil hemp fibre) and PP/SHF(scotched hemp fibre) increases with increasing amount of maleic anhydride polypropylene(MAPP).Enrico Sassoni [10] studied the application of novel sustainable hemp-based composites in the building industry. The panels exhibited promising physical, thermal and mechanical properties while the low density panels exhibited a good thermal conductivity and the medium density panels exhibited a higher thermal conductivity.Shinji Ochi [11] studied the cultivation of kenaf and its application to biodegradable composite materials and it was concluded that the highest temperature that does not affect the fibre strength is 160° C. Yousif et al[12] investigated the flexural properties of the treated and untreated kenaf fibre reinforced epoxy (KFRE) composites and their result revealed that flexural strength of the treated kenaf composite was superior when compared to the untreated composites. Vijaya Ramnath et al [13,14,15] investigated mechanical properties of hybrid composites made up of Jute with Abaca, banana fibers and concluded that hybrid composites has high strength than mono fiber composites. Ghani et al [16] studied the mechanical properties of Kenaf/Fiber glass polyester hybrid composite and concluded that, as the moisture penetration into the

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composites increase, the mechanical properties of the kenaf fiber deteriorated. Nor Amalina Nordin et al [17] studied the wear rate of kenaf fiber composites. Long kenaf fibers were used as the raw material and it was concluded that sliding distance plays an important role in specific wear rate between the composites. Vijaya Ramnath et al. [18, 19, 21 ,22] evaluated the mechanical properties of Abaca and pineapple hybrid composite and concluded that natural fiber composites are found to have good mechanical properties and suitable for electrical and automotive applications. They also found mechanical properties of twisted kenaf fibers and concluded that fiber twisting has effect on mechanical strength of composites. Anuar al [20]studied the mechanical properties of reinforced thermoplastic elastomer composite with kenaf bast fibre and concluded that kenaf fibre played an important role in increasing the impact strength of the composites.

2. MATERIALS USED

In this work Abaca fiber which is also known as Manila hemp and Raffia which is a palm of Madagascar are used to fabricate the composites. Epoxy resin (Araldite LY 556) along with hardener is used to fabricate the composite. Glass fiber laminates are used as top and bottom most layer while the natural fibres are used as reinforcements between them.

3. FABRICATION PROCEDURE

The composites are fabricated by hand layup process. The GFRP is kept as top and bottom most layer of the composite. The first type composite is fabricated using GFRP with Abaca (composite I),while the second type composite is fabricated using GFRP and Raffia(composite II) and the third typecontains Abaca, Raffia and GFRP(composite III).Epoxy resin is used and the entrapped air is removed from the surface of the fiber by the use of roller.A load of 10-12kgs is applied for the curing time of15 hours to get required composite laminate.

4. TESTING OF MATERIALS

4.1DOUBLE SHEAR TEST

The shear test attachment is placed on the lower table, which contains a cutter. Now, the Load is applied such that the specimen breaks in two or three pieces. If the specimen breaks in two pieces it is single shear and if it breaks in three pieces then it is double shear.During test at a particular stage, straight fracture occurs, breaking the test piece into three pieces. Maximum load recorded by the pointer is noted down.Fig 1 shows double shear test specimen as per ASTM.

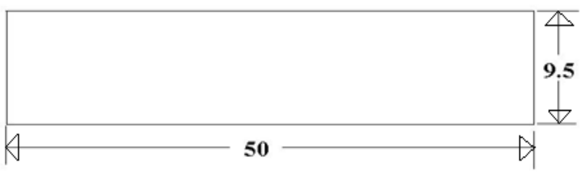

Figure 1: Double shear test specimen [ASTM: D5379]

4.2 HARDNESS TEST

Hardness is a measure of resistance offered by a material for indentation in compressive load. In this work, Rockwell hardness test was conducted by applying 60Kgf load with hardened steel ball indenter.

5. RESULTS AND DISCUSSIONS

5.1 DOUBLE SHEAR TEST

The result of double shear test of composite is shown in table 1.Double shear test was conducted on the composite specimens namely composite I, composite II and composite III and the load Vs. displacement graphs are plotted as shown in fig 2, 3, 4.

Table 1: Results of double shear test

Composites	Break Load (KN)	Displacement at F_{MAX} (mm)	Maximum Displacement (mm)	Ultimate Stress (kN/mm^2)
GFRP + Abaca	1.935	1.600	3.900	0.037
GFRP + Raffia	0.425	1.500	1.700	0.019
GFRP + Abaca + Raffia	2.290	2.100	4.700	0.044

Figure 2. Double Shear Test Graph- (Composite I)

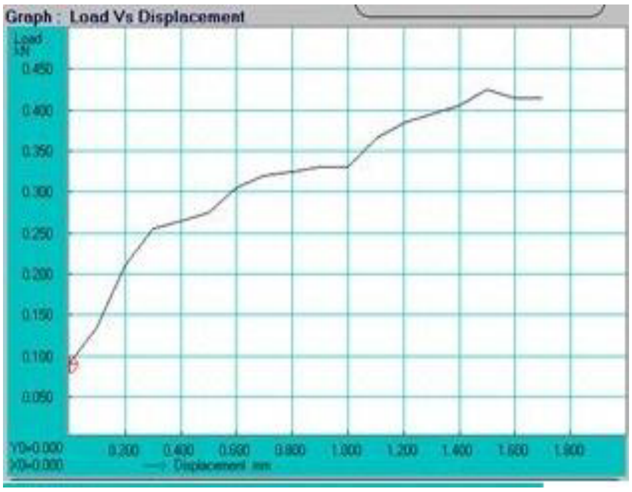

Figure 3. Double Shear Test Graph – (Composite II)

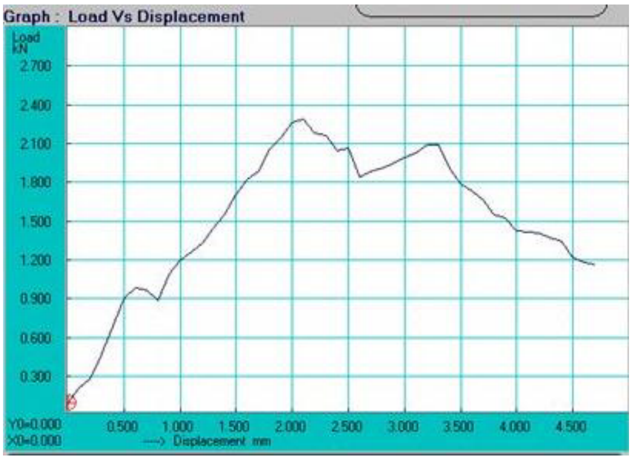

Figure 4. Double shear test graph (composite III)

From the figure 2, 3, and 4 it can be seen that the double shear properties of the hybrid composite III (GFRP+Abaca + Raffia) are higher than other two.

5.2 HARDNESS TEST

The result of hardness test of composites is shown in table 2 from which it is observed that composite III which consists of GFRP + Abaca + Raffia has more hardness than others. This is due to the presence of Raffia fiber along with Abaca which makes it harder to resist the indentation.

Table 2: Result of Hardness test

Sl.No	Composite	Hardness (HRC)
Composite I	GFRP+ Raffia	96
Composite II	GFRP+Abaca	99.5
Composite III	GFRP+Abaca+Raffia	109.5

6. MORPHOLOGICAL ANALYSIS

Morphological analysis is carried outto study the internal surface characteristics of the tested specimens.Scanning electron microscope(SEM) appliesbombardment of electrons on the fractured surface of the composite to form the image of the internal structures.

6.1SEM ANALYSIS OF COMPOSITES

Before carryingout SEM analysis, the tested samples are dried and coated with 15–20 nm thick gold layers using an Ion - Sputter coater device. The figure 5 shows the SEM image of the double shear tested specimen which indicates the fiber pullout and fiber breakage. This is due to inadequate time for curing of composite. Also, it is observed that dry surface in the inner layer of laminates which is the result of improper application of resin.

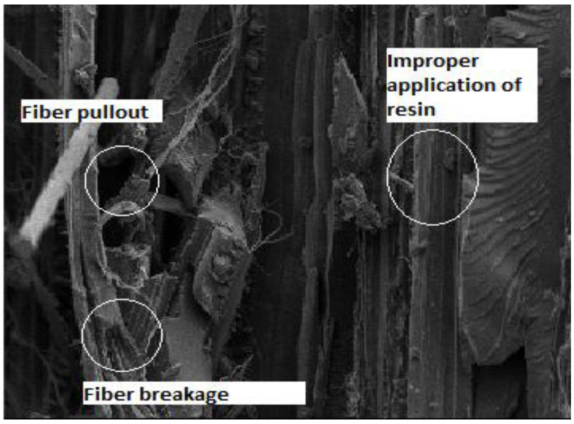

Figure 5. Double shear test SEM image

7. CONCLUSION

In this work, Abaca, Raffia based fiber composites are fabricated using hand layup method. The mechanical properties like double shear and hardness are found. The test result shows that among three composites the composite III (Abaca+Raffia+GFRP), shows better properties than others. Based on the results, following conclusions were inferred;

1.The ultimate strength in the double shear test of the composite III(GFRP + Abaca + Raffia) composite is 0.044 kN/mm^2which is higher than that of the GFRP + Abaca composite with 0.037 kN/mm^2 and GFRP + Raffia composite with a value of 0.019 kN/mm^2.

2. Also, GFRP+Abaca+Raffia composite exhibits high hardness of 109.5 HRC.

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