MECHANICAL TESTING OF NATURAL FIBRE REINFORCED POLYESTER RESIN COMPOSITES AND MODE 1 FRACTURE TOUGHNESS TESTING OF RESIN BLOCKS

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INTRODUCTION

Recent European Parliament directive requires companies to achieve materials recycling greater than 80% in particular in the automotive sector [1]. The research on natural fibre based composite materials fits well into this ecological image. The advantages of natural fibres over synthetic materials include, low density, relative cheapness, availability and biodegradability. In this paper we explore the fabrication and mechanical testing of natural fibre composites and this is part of an on going study at Strathclyde University and describes the fabrication of composites using natural fibre and styrene polyester resin. The properties of the synthetic resin can be varied by changing the catalysts concentration and flexural (three point bending) and single-edged notched bending (SENB) properties are reported at different concentrations of the catalyst.

TEST SPECIMENS

In this study the fibre volume fraction (*fvf)* of the composite is approximately 36%, determined by mass measurement and the use of fibre and resin densities. Van de Weyenberg et al [2] has reported data on 40% *fvf*, while Wambua, P et al [4] have studied 30% *fvf*. Aluminium tabs were bonded to the ends of the composite strips with araldite. The samples for fracture toughness test were prepared from blocks of resin manufactured by vacuum infusion and used to produce the standard 'Single Edge Notched Bend, (SENB)' specimens. As the properties of natural fibres are variable, it is expected that there will be variability in the data and four fibre reinforced composites were tested for each type of fibre (eg Sisal). Two fracture toughness tests were performed for each catalyst concentration.

TEST RESULTS AND DISCUSSION

Fig. 1 is a representative plot of the stress – strain graph obtained from the tensile testing data of the bio-composites. The relationships between the stresses and strains are almost linear up to the peak stresses, when the materials fail. As seen there is little or no plastic deformation. Hence the constitutive model can be represented by the linear elastic model instead of the relatively robust Ramberg-Osgood strain hardening model. A summary of the properties of the natural fibre composites, showing the mean values from four sets of tests and standard deviation are shown in *Table 1*. The strength of Kenaf and Flax were relatively close to each other, but Kenaf was higher and Abaca was the least strong. The morphology of the fracture path is unpredictable taking cognizance of the varied characteristics of the structure. Two fracture toughness tests were performed for each percentage of catalyst concentration and the results were relatively close to each other. This test has been performed by considering a procedure set by the European Structural Integrity Society – E399 [3]. The rate of loading used was 1mm/min, as too high cross head speeds will introduce dynamic effects into the results. A representative plot showing the fracture load and toughness represented as the crack opening displacement is presented in *Fig. 2* and *Table 2* is the summary of the results. In general, increase in catalyst concentration resulted in increase in the fracture load and toughness.

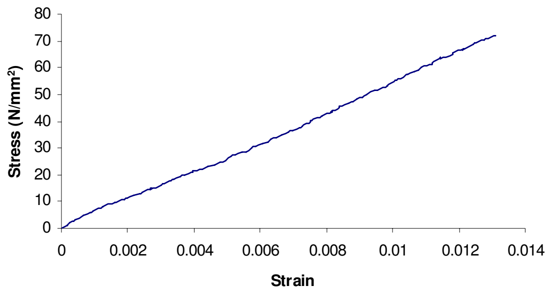

Fig. 1 A representative stress – strain graph of abaca fibre bio-composite

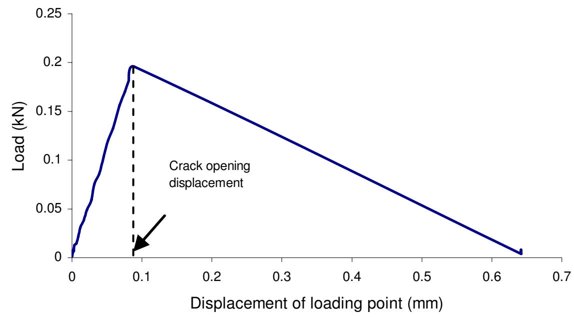

Fig. 2 Representative load – displacement plot obtained from single-edge notched bending test

Table 1 Composite properties from tensile tests

	Abaca	Flax	Kenaf	Sisal
Strength (MPa)	74 ± 3	85 ± 10	91 ± 3	79 ± 6
Stiffness (GPa)	5.90 ± 0.3	9.42 ± 0.6	10.36 ± 0.5	7.30 ± 0.6
Energy to failure (J)	1.40 ± 0.16	1.18 ± 0.28	1.25 ± 0.11	1.40 ± 0.22

Table 2 Summary of fracture toughness tests

Percentage of catalyst	Fracture load (kN)	Crack opening displacement (mm)
1% catalyst	0.176 ± 0.004	0.077 ± 0.003
1.3% catalyst	0.183 ± 0.003	0.083 ± 0.002
1.5% catalyst	0.198 ± 0.002	0.090 ± 0.001
1.8% catalyst	0.313 ± 0.003	0.150 ± 0.002
2% catalyst	0.227 ± 0.004	0.133 ± 0.003

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