A STUDY ON QUASI STATIC INDENTATION BEHAVIOUR OF KENAF BAST FIBRE REINFORCED METAL LAMINATE SYSTEM

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DECLARATION

I declare that this project report entitled "A Study on Quasi Static Indentation Behaviour of Kenaf Bast Fibre Reinforced Metal Laminate System" is the result of my own work except as cited in the references.

Signature	: ....
Name	: Nisallini A/P Pilvamangalam
Date	: ....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of Bachelor of Mechanical Engineering (Structure & Materials).

Signature : ....

Name : Dr. Sivakumar A/L Dhar Malingam

Date : ....

DEDICATION

To my parents.

ABSTRACT

The growing concerns in reducing the usage of non-renewable sources in production of engineering materials have called for the development of FML. Fibre Metal Laminate (FML) is hybrid material that has the combined advantages of metallic materials and fibre reinforced matrix systems. It had been widely used in aircraft and automotive industry for impact prone applications due to its excellent mechanical properties. This study investigates the quasi static indentation behaviour of fibre metal laminates (FML) based on kenaf/Poypropylene. The effects of fibre length (3, 6 and 9cm) and fibre loading (50, 60 and 70 wt%) were studied. Aluminium 5052-0 has been used in this research. The specimens were prepared and tested using Instron Universal Mechanical Tester 5585H in accordance to ASTM D6264 to assess their performance. The results reveal that FML 60 wt% treated 9cm kenaf fibre exhibited the highest energy absorbing properties at 30.82J compared to other configuration tested. It also proves that FMLs with treated kenaf fibre absorbs an average of 19% more energy compared to FMLs with untreated kenaf fibre.

ABSTRAK

Kajian ini dijalankan untuk menyiasat kesan rawatan kimia, muatan serat dan penjang serat terhadap kelakuan lamina logam gentian (FML) apabila dikenakan beban quasi statik. lamina logam gentian berdasarkan serat kenaf yang dirawat dan tidak dirawat dengan muatan serat 50 wt%, 60% berat dan 70 wt% berat dan panjang serat 3cm, 6cm dan 9 cm telah disediakan untuk menjalankan kajian ini. Aluminium 5052-0 juga telah digunakan dalam kajian ini. Spesimen telah disediakan dan diuji menggunakan mesin Instron Universal Mechanical Tester 5585H berdasarkan piawai ASTM D6264 untuk menilai prestasi specimen. Hasil eksperimen menunjukkan bahawa FML T-60(9) mempunyai sifat penyerapan tenaga dan rintangan penembusan yang tertinggi berbanding dengan konfigurasi lain yang diuji. Ia juga menunjukkan bahawa FMLs dengan serat kenaf dirawat mampu menyerap lebih banyak tenaga berbanding FMLs dengan serat kenaf yang tidak dirawat.

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I wish to express my sincere gratitude to my supervisor Dr. Sivakumar A/L Dhar Malingam for his continuous guidance and encouragement to successfully complete my final year project.

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FML	Fibre Metal Laminate
SEM	Scanning Electron Microscope
PP	Polyproplene
PLA	Poly(lactic acid)
NaOH	Sodium Hydroxide

CHAPTER 1

INTRODUCTION

1.1 Background

Recently, researches have shown an increased interest in replacing synthetic fibres with natural fibres as an eco-friendly and cost effective move in the production of engineering materials. Due to the potential of petroleum shortage in future, there is a growing interest in maximizing the use of renewable materials in order to reduce the dependence on petroleum based products (Ramesh, 2016). This eventually led to the development of eco-friendly natural fibre thermoplastic composites.

Kenaf is the common name for hibiscus cannabinus which is a member of the Malvaecae family (Tajeddin, Rahman & Abdulah, 2009). Although kenaf originated from Africa, it is now grown commercially in the United States of America, India, Indonesia, Bangladesh, Malaysia, South Africa, Thailand, Vietnam, and several parts of Africa. Like most natural fibres, kenaf has low density, high specific mechanical properties and is environment friendly (Avella et al. 2008). It was found that tensile modulus, impact strength and the ultimate tensile stress of kenaf reinforced polypropylene composites increases with the fibre content with a moderate increase between 30 and 40% fibre weight fraction and a sharp increase from 40 to 50% fibre weight fraction (Wambua, Ivens & Verpoest, 2003).

One of the major drawbacks of natural fibre reinforced material is the poor adhesion between the filler surface and the matrices in the composite material which affects its mechanical properties (Edeerozey et al., 2007). This issue can be handled by using coupling agents and fibre surface treatment using alkaline solution in order to strengthen the adhesion between the natural fibre and the matrix. Previous researches on kenaf natural fibre reinforced polypropylene composites have provided insights of its tensile and flexural strength when compared with other compression moulded fibre composites reinforced with coir, sisal, hemp and jute fibre (Zampaloni et al., 2007). Thus, kenaf bast reinforced composite fibre could be useful in several industries such as automotive and aerospace industry.

Fibre metal laminate (FML) can be defined as a hybrid material consisting of metal sheets sandwiching a fibre reinforced plastic layer (Alderliesten et al., 2009). Figure 1.1 shows the layup of a FML. In a fatigue test conducted by Fokker Aero on Fokker-27 centre wings showed that laminated structures have higher resistance to fatigue crack growth. It was observed that the fibres in composite layer reduce the crack growth by acting as a barrier against crack propagation while the metal layers contributes in terms of ductility and impact resistance (Cortés & Cantwell, 2004). Several experiments performed on FML with larger fatigue cracks in aluminium have proved the enhanced fatigue performance of this material (Vlot & Gunnink, 2001).

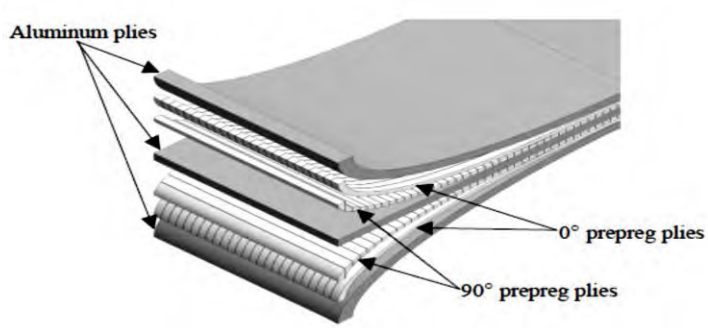

Figure 1.1: A sample of FML layup (Source: Rodi, 2012)

1.2 Problem statement

New regulations on environment and the growing concerns in reducing the usage of non-renewable sources in production of engineering materials have called for the development of FML. FML is a hybrid material consisting of alternating layers of metallic sheet and fibre reinforced composite stacked together. The FML has combined advantages of metallic materials and fibre reinforced matrix systems. Recently FML have been used widely in aircraft and automotive industry for impact prone applications due to its excellent mechanical properties. This research will study the FML under quasi static impact. FML made of Aluminium alloy 5052-0 with kenaf bast fibre reinforced polypropylene (PP) is manufactured for the test.

1.3 Objectives

The objectives of this study are:

1. To investigate the effect of fibre length of treated and untreated kenaf bast fibre – polypropylene on quasi static indentation of FML.

2. To investigate the effect of loading of treated and untreated kenaf bast fibre – polypropylene on quasi static indentation of FML.

1.4 Scope of project

The scopes of this study are:

1. To fabricate FML.
2. To conduct quasi static indentation test on FML according to ASTM D6264.

CHAPTER 2

LITERATURE REVIEW

2.1 Kenaf fibre

Originated from Africa 4000 years ago, kenaf is now actively cultivated around the globe for its fibre (Zhang, 2004). The kenaf stem consist of two types of fibres; the outer bark, known as bast and the inner core with a makeup of about 40% and 60%, respectively. Figure 2.1 shows the kenaf bast fibre used for this research.

Figure 2.1: Kenaf bast fibre

2.1.1 Kenaf bast fibre morphology

Several studies on the structure and properties of kenaf bast fibre have been conducted in the past in order to understand the pros and cons of the natural fibre by analysing its morphology and characteristics. Analysis on kenaf fibres was carried out using Scanning Electron Microscope (SEM) by several researches as shown in Figure 2.2. Figure 2.2 (a) shows the longitudinal view of kenaf fibre that highlights its longitudinal ridges and non-porous surface. Figure 2.2 (b) shows the SEM images across the cross section of kenaf fibre.

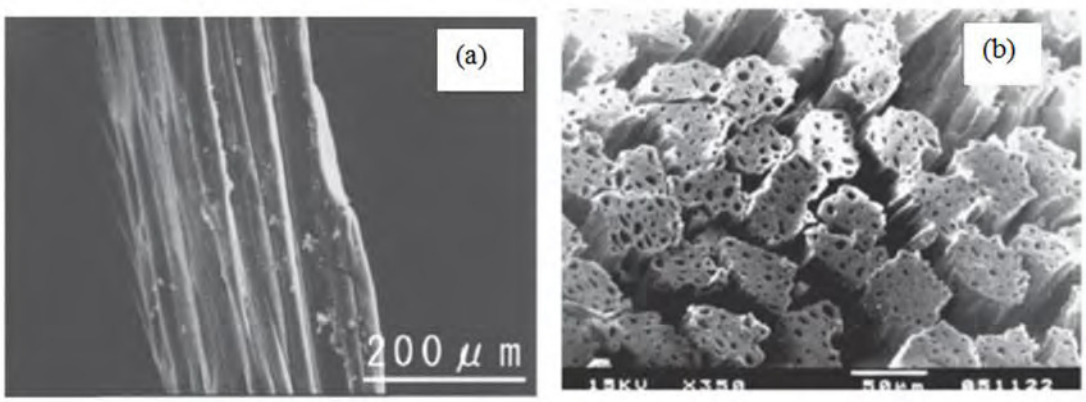

Figure 2.2: (a) Longitudinal view of the untreated kenaf fibres (Source: Shibata et al., 2008), (b) SEM images across the cross section of kenaf fibre (Source: Sharifah & Ansell, 2004)

Kenaf fibres are lignocellulose material mainly composed of cellulose, whose elementary unit, anhydro d-glucose, contains three hydroxyl (–OH) groups. These hydroxyl groups are the reasons for its hydrophilic characteristics. The hydrophilic nature of kenaf and the nonpolar characteristics of most thermoplastics result in compounding difficulties leading to non-uniform dispersion of fibres within the matrix, which weakens the properties of the resultant composite (John et al., 2010).

Previous researches show that chemical treatments can be used to improve the mechanical performance of the natural fiber. Based on a study regarding chemical modification of kenaf fibers conducted by Edeerozey et al. (2007), it was observed that the kenaf fibre that have been treated with alkali had better mechanical properties compared to untreated kenaf fiber. The study has compared various concentrations of NaOH in order to find the optimum concentration of NaOH to alkalize kenaf fibers.

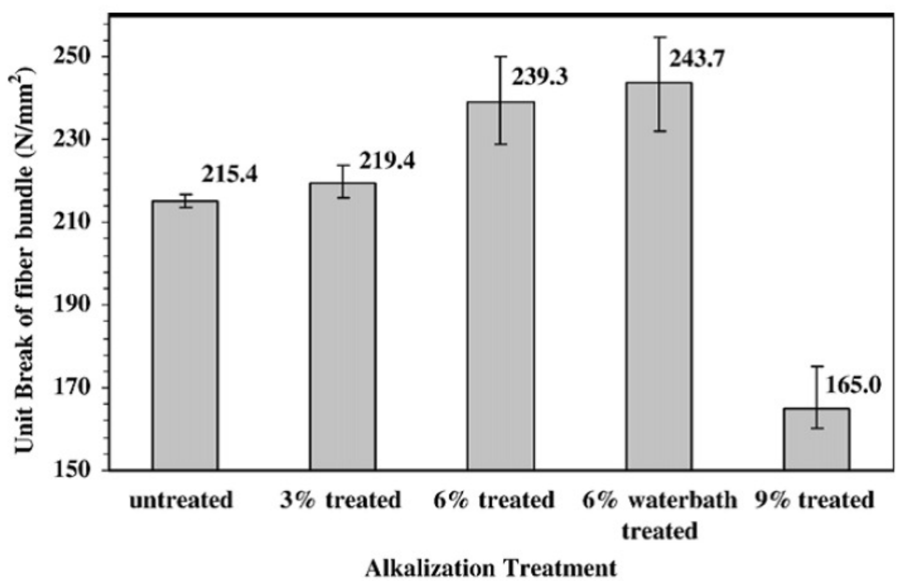

Figure 2.3: Fiber bundle tensile strength of differently treated kenaf fiber (Source: Edeerozey et al., 2007)

Figure 2.3 shows the fiber bundle tensile strength of differently treated kenaf fiber. Based on the results, fiber treated with 6% NaOH in water bath (at 95 °C) recorded the highest value of unit break (UB). However, when the NaOH concentration is increased to 9%, the average unit break decreased significantly. This may be due to the fibre damage caused by the high concentration of NaOH, thus resulting in lower tensile strength.

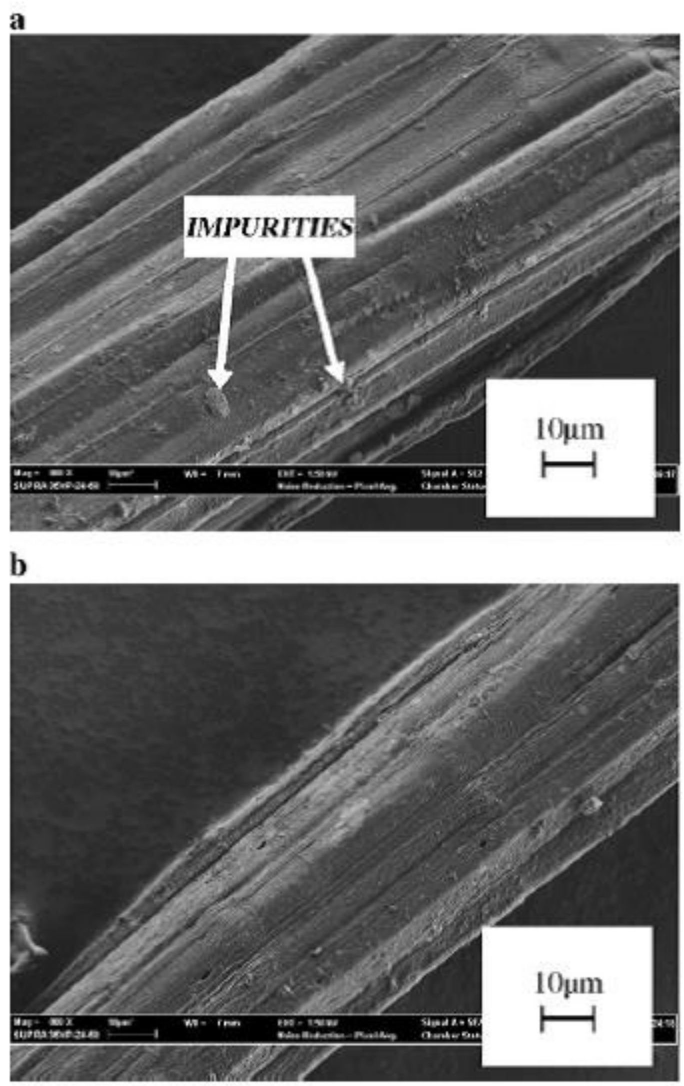

Figure 2.4: SEM micrograph of (a) an untreated kenaf fiber and (b) 3% NaOH treated kenaf fiber (Source: Edeerozey et al., 2007)

In Figure 2.4, it can be observed that the chemical surface treatment causes a clean and rough surface on the fibre which is important for interfacial bonding of polymer and kenaf fibre because it provides a better interlocking between the polymer and fibre (Mahjoub et al., 2014)

2.1.2 Mechanical properties of kenaf bast fibres

Ochi (2008) conducted a research to investigate the effect of environmental temperature on the growth of the kenaf fibre on the tensile and elastic properties of the kenaf fibre and emulsion-type PLA resin composite. The study was conducted by comparing the tensile strength of kenaf fibres grown at 22°C and 30°C. Kenaf fibre bundles with a diameter of 50–150 µm and length of 500 mm were used for this study.

The tensile specimen for kenaf fibre was prepared by gluing the fibre to the paperboard, which was then carefully gripped by the testing machine, and cut with a thin heated metal wire along the cutting line indicated in Figure 2.5. The JIS R 7601 method was used to determine tensile strength of kenaf fibre by performing the tensile test at a strain rate of 0.04 per min. Based on the results from Figure 2.6, it was observed that the tensile strength and elastic modulus of kenaf fibres grown under an average temperature of 30°C were greater than those grown under average temperature of 22°C.

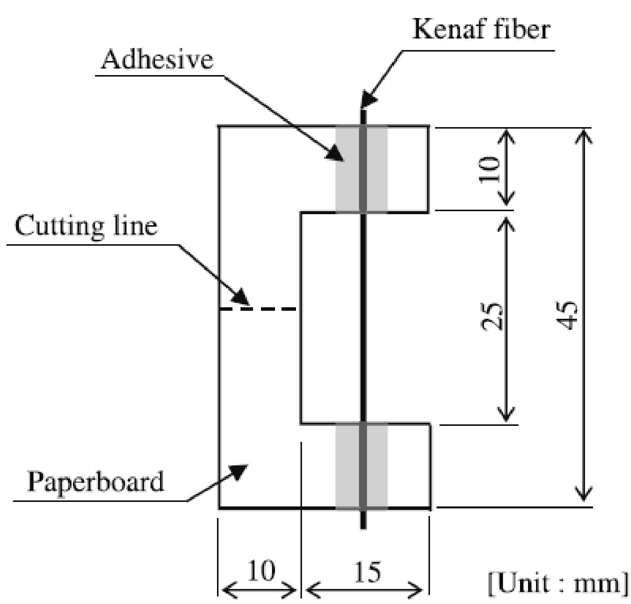

Figure 2.5: Tensile specimens for kenaf fibres (Source: Ochi, 2008)

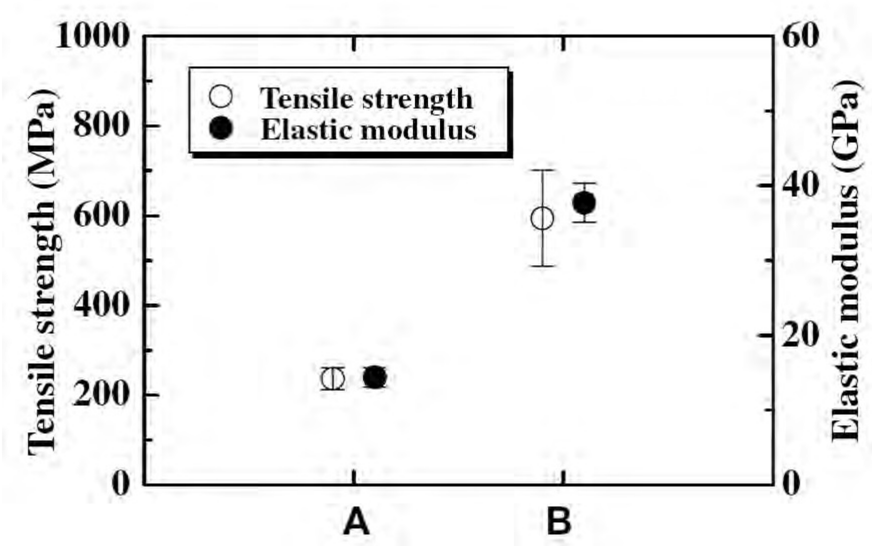

Figure 2.6: Tensile strength and elastic modulus of kenaf fibre, (A=22°C, B=30°C) (Source: Ochi, 2008)

Based on Ochi's research in 2009 regarding the tensile properties of kenaf fibre bundle, the effect of stem diameter and length on the mechanical properties of kenaf fibre of different types was investigated. The specimens for the tensile test was prepared referring to JIS R 7601: 1986 testing methods for carbon fibres and attached vertically to the testing machine. A strain rate of 0.04 per minute was applied to the fibres. At the end of the research, it was concluded that the stem diameters do not significantly affect the fibre strength based on the result shown in Figure 2.7. However, tensile strength and the elastic modulus of kenaf fibre were observed to increase with the length of the stem as shown in Figure 2.8 and 2.9.

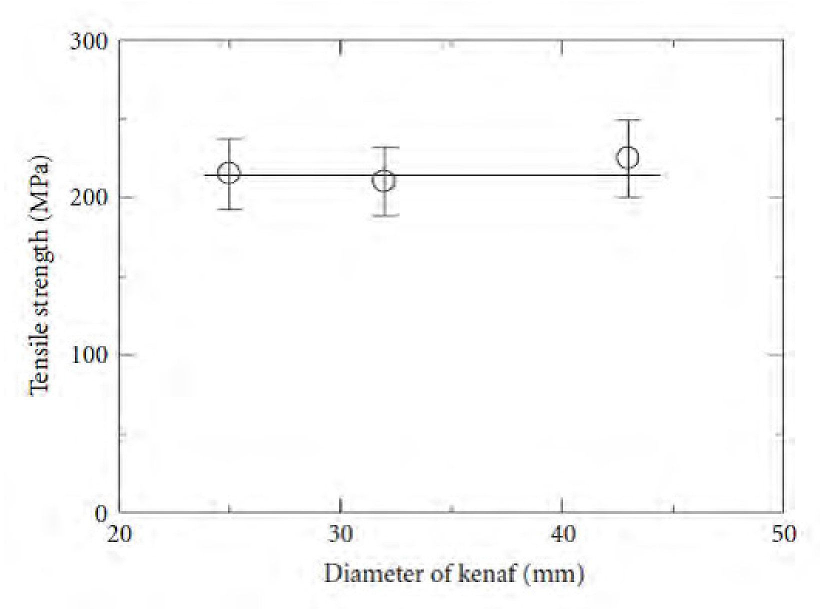

Figure 2.7: Relationship between tensile strength and diameter of kenaf (Source: Ochi, 2009)

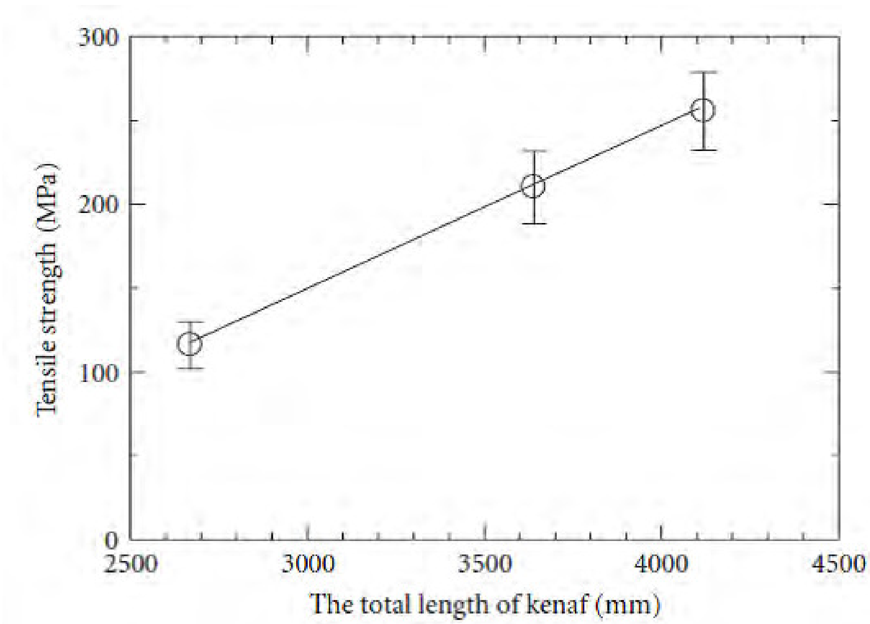

Figure 2.8: Relationship between tensile strength and length of kenaf (Source: Ochi, 2009)