



UNIVERSITI PUTRA MALAYSIA

***TENSILE AND FATIGUE PROPERTIES OF UNIDIRECTIONAL KENAF
FIBRE REINFORCED EPOXY COMPOSITES***

ABDUL HAKIM BIN ABDULLAH

FK 2011 41

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The logo of Universiti Putra Malaysia (UPM) is a shield-shaped emblem. At the top left, the letters 'UPM' are written in white on a red rectangular background. The central part of the shield features a stylized white and red design, possibly representing a book or a traditional symbol. The shield is set against a light grey background.

ABDUL HAKIM BIN ABDULLAH

MASTER OF SCIENCE

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**TENSILE AND FATIGUE PROPERTIES OF UNIDIRECTIONAL KENAF
FIBRE REINFORCED EPOXY COMPOSITES**

By

ABDUL HAKIM BIN ABDULLAH

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirement for the Degree of Master of Science**

March 2011

DEDICATION

*Thanks to my beloved father and mother, Abdullah B. Kassim and Rusizah Bt. Md. Taib
and also my siblings, Nurhidayah, Mohd Hakimi, Ahmad Suhaimi, Nurnadiah,
Nurdiyanah and my wife Nor' Izzati Hamdan for their patience and support during the
long preparation of this thesis*

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master Science

TENSILE AND FATIGUE PROPERTIES OF UNIDIRECTIONAL KENAF FIBRE REINFORCED EPOXY COMPOSITES

By

ABDUL HAKIM ABDULLAH

March 2011

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Faculty : Engineering

This research work is concerned with the tensile and fatigue properties of unidirectional kenaf fibre reinforced epoxy composites at three different fibre volume fractions; 0%, 15% and 45%. Two types of composites material, namely kenaf/epoxy A composites and kenaf/epoxy B composites were used. The chemical functions of epoxy A and epoxy B were examined by using Fourier transform infrared technique from 500-4000 cm^{-1} frequency band. The composites were prepared using hand lay-up technique. The tensile tests were performed in accordance to ASTM D-3039 while fatigue tests in accordance to ASTM D-3479. All fatigue tests were conducted at constant stress amplitude, frequency of 5 Hz and the maximum stress applied was between 90-40% of ultimate tensile stress. The analysis of surface morphology was done by using scanning electron microscope.

The results showed that the tensile properties improved as the fibre volume fraction increased. Although the stress-strain curves of 15% and 45% fibre volume fraction

composites did not exhibit any yield points, the bi-linear expression that transition region behaviour was observed. On the other hand, the elastic modulus decreased drastically after passing over this region but the composites remained as brittle material. Using T-test, the transition point had been statistically proven different for 15% and 45% kenaf/epoxy composites. The Fourier transforms infrared spectra showed that similar chemical functional group present in epoxy A and B which indicated the bi-linear expression was contributed by matrix.

Similar to those tensile properties, the effect of fibre volume fraction in composites resulted better fatigue life and fatigue resistance. However, there was no indication of endurance limit characteristic had been shown by composites in S-N curves. The survived 1 million cycle specimens was apparently within or below the transition region and the damages received in this region were ultimately greater. Statistical analysis using Weibull distributions confirmed the failure was caused by fatigue failure. The beginning of damages was matrix cracking and eventually, the reason of the transition region behaviour in stress-strain curves.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**SIFAT TEGANGAN DAN KELESUAN KOMPOSIT EKAARAH GENTIAN
KENAF BERTETULANG EPOKSI**

Oleh

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Penyelidikan ini adalah bertujuan untuk menentukan sifat tegangan dan kelesuan gentian ekaarah kenaf bertetulang epoksi terhadap tiga jenis pecahan ispadu gentian; 0%, 15% dan 45%. Dua jenis komposit, iaitu komposit kenaf/epoksi A dan komposit kenaf/epoksi B telah digunakan di dalam penyelidikan. Ikatan fungsi kimia pada epoksi A dan epoksi B telah diperiksa menggunakan kaedah infra merah perubahan Fourier diukur dari julat frekuensi $500-4000\text{ cm}^{-1}$. Ujian tegangan yang telah dilakukan adalah berdasarkan kepada ASTM D-3039 manakala ujian kelesuan adalah berdasarkan ASTM D-3479. Ujian kelesuan dijalankan berdasarkan tekanan sekata, frekuensi 5 Hz dan had maksimum tekanan dikenakan adalah daripada 90-40% tegangan utama. Analisis permukaan yang dijalankan adalah dengan menggunakan alat pengimbas elektron mikroskop.

Keputusan akhir daripada ujian tegangan menunjukkan sifat tegangan juga meningkat apabila pecahan ispadu gentian meningkat. Walaupun graf tegangan-terikan 15% dan 45% pecahan ispadu gentian tidak menunjukkan sebarang titik hasil, ekspresi dua garis

lurus yang menyebabkan peralihan bahagian telah dilihat. Yang lebih tepat lagi, perubahan terhadap modulus elastik telah dapat dilihat selepas melepasi bahagian ini dan komposit masih bersifat rapuh. Dengan menggunakan ujian-T, titik perubahan telah dibuktikan berbeza secara statistik untuk komposit 15% dan 45% kenaf/epoksi. Spektrum infra merah perubahan Fourier menunjukkan kandungan fungsi kimia adalah sama untuk epoksi A dan epoksi B di mana ia menunjukkan ekspresi dua garis lurus adalah berpunca daripada matriks.

Sama seperti sifat tegangan, kesan pecahan ispadu gentian juga telah menyebabkan keputusan hayat kelesuan dan rintangan kelesuan bertambah baik. Walau bagaimanapun, tidak terdapat ciri-ciri daya tahan telah dicapai pada graf S-N. Bahan ujian yang tidak pecah pada kitaran satu juta adalah berada di dalam atau di bawah peralihan bahagian dan kerosakan yang diterimanya adalah lebih besar. Statistik taburan Weibull telah mengesahkan bahawa kegagalan adalah berpunca daripada kegagalan kelesuan. Permulaan kerosakan adalah keretakan pada bahagian matriks dan menjadi punca kepada tabiat peralihan bahagian.

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I certify that an Examination Committee has **met** on (4 March 2011) to conduct the final examination of Abdul Hakim Abdullah on his Master of Science thesis entitled “**Tensile and Fatigue Properties of Unidirectional Kenaf Fibre Reinforced Epoxy Composites**” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the candidate be awarded the relevant degree.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

ABDUL HAKIM ABDULLAH

Date: 4 March 2011

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