PROGRAM BOOK

2nd Composite Materials and Manufacturing Symposium
(CMMS 2016)

13th – 14th November 2016
Universiti Teknologi Malaysia

CONTENTS

FOREWORD

On behalf of the organizing committee, it is a great honour to extend our warmest welcome to all participants and visitors to Universiti Teknologi Malaysia, specifically to the 2nd Composite Materials and Manufacturing Symposium 2016 (CMMS 2016).

Dear participants, CMM Symposium 2016 is intended to be a platform for sharing ideas, improving knowledge, awareness and skills as well as dissemination of information among researchers, academia, postgraduate and undergraduate students, or professionals within the field of Composite Materials and Manufacturing Engineering. This international event is also intended for networking opportunities and gathering for the composite community.

My gratitude and appreciation go to the Keynote Speaker, Prof. Hitoshi Takagi from Tokushima University, Japan and Invited Speaker, Dr. Kheng-Lim Goh from Newcastle University, Singapore for their cooperation and willingness to contribute to this event. I would also like to thank all the participants for coming to this event. I do hope that all the participants will gain benefits from this event that can lead to further enhanced research in composite materials and manufacturing.

My sincere appreciation also goes to all members of the organizing committee for their efforts in making the symposium a success. I hope that there will be many more similar events for all of us to get together and share our common passion for the future of composite materials.

We are looking forward to seeing you in our next events.

ASSOC. PROF. DR. MOHD YAZID BIN YAHYA
Chairman
2nd Composite Materials and Manufacturing Symposium
Centre for Composites (C*f*C)
Universiti Teknologi Malaysia (UTM)

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TENTATIVE PROGRAM

13th NOVEMBER 2016 (SUNDAY) BILIK ILMUAN 2, ANJUNG RAZAK, UTM KL		
8.00	**Registration**	
8.45 - 9.00	**Welcoming speech** Prof. Dr. Mohd Nasir Tamin Deputy Dean (Research and Innovation) Faculty of Mechanical Engineering Universiti Teknologi Malaysia	
9.00 - 9.30	**Keynote speaker** *"Cellulose nanofibre-reinforced green composites: Fabrication and characterization"* **Prof. Dr.Hitoshi Takagi** Department of Mechanical Science, Graduate School of Science and Technology, Tokushima University	
9.30 - 10.00	**Invited speaker** *"Fibre reinforced composite damage and repair: prospects and challenges"* **Dr Kheng-Lim Goh** Senior Lecturer School of Mechanical and System Engineering Newcastle University, Singapore	
10.00 - 10.15	**Morning Break**	

PRESENTATION SESSION 1 (CHAIRMAN: ASSOC. PROF. DR. AMRAN AYOB)			
	Presenter	**Tittle**	**Remarks**
10.15 – 10.30	Prof. Ir. Dr. Mariatti Jaafar	Flexural Properties of Hybrid Carbon Fibre/Epoxy Composites Via Electrophoretic Deposition Process: Effect of Applied Voltage and Deposition Time	
10.30 – 10.45	Zahidah Bt Ansari	Compression and Tensile Properties of Pineapple Leaf Fibre Reinforced Polylactic Acid Composites	
10.45 – 11.00	Mohd Ridzuan bin Mohd Jamir	Effect of Elevated Temperature on The Tensile Strength of Napier/Glass-Epoxy Hybrid Reinforced Composites	Change to session 2 14.30-14.45
11.00 – 11.15	Umar Abdul Hanan	Mechanical Properties of Recycled CFRP Powder Reinforced Epoxy Composites	
11.15 – 11.30	Azisyahirah Azizan	Effect of Fibre Misalignment on Tensile Response of Unidirectional FRP Composite Lamina	
11.30 – 11.45	Dr. Wong King Jye	Mode I Delamination of Chopped Strand Mat E-Glass Reinforced Vinyl Ester Composites	
11.45 – 12.00	Damira Muhalim	Mechanical Properties of Ultrasonic Assisted Compression of Polyvinyl Chloride (PVC) Foam	
12.00 - 12.15	Syed Mohd Saiful Azwan Syed Hamzah	Low-Velocity Impact of Through Thickness Polymer Pins-Foam Core Sandwich Panel	Change to session 3 16.45-17.00
12.15 – 12.30	Dr. Denni Kurniawan	Mechanical properties of polylactic acid/zein/lyocell composite	
12.30 – 12.45	Noraina Alia Mat Noor	Synergistic Effects of MWCNTs Nanofiller Inclusions into Epoxy/Kenaf Hybrid Composites	
12.45 – 13.00	Ogunbode Ezekiel Babatunde	Interfacial Bond Strength Analysis between Kenaf Fibrous Concrete Composite and Plain Concrete	
13.00 – 14.00	**Lunch Break**		

PRESENTATION SESSION 2 (CHAIRMAN: ASSOC. PROF. DR ASTUTY AMRIN)			
	Presenter	**Title**	**Remarks**
14.00 - 14.15	Siti Amni Husna binti Roslan	A Review on Chemical Treatments of Natural Fibre In Reinforced Polymer Composites	
14.15 – 14.30	Siti Khalijah Jamal	Effect of Tropical Weathering on Interlaminar Shear Behavior of Hybrid Woven Kenaf/Recycled GFRP Reinforced Polyester Composite	
14.30 - 14.45	Revati Radakisnin	A Novel Biodegradable Napier/PLA Composite	Change to session 1 10.45-11.00
14.45 – 15.00	Nur Khaleeda binti Romli	The Effect of Variant Unit Cell and Thickness of Trapezoidal Carbon/Epoxy Composite Sandwich Panel	
15.00 – 15.15	Ogunbode Ezekiel Babatunde	The durability Performance of Kenaf Fibre reinforced polymer composites (KFRP)	
15.15 – 15.30	Dr. Fahmi Fariq Muhammad	Implementation of Nano-composite organics for solar energy harvesting- A ternary composite system	
15.30 - 15.45	**Tea Break**		
PRESENTATION SESSION 3 (CHAIRMAN: DR WONG KING JYE)			
15.45 – 16.00	Dr. Irza Sukmana	A Review on Magnesium-based Materials for Bone Applications	
16.00 – 16.15	Mahzan Johar	Non-Fickian Moisture Absorption Characteristics of Adhesive Joints – Capillary Effect and Residual Properties	
16.15 – 16.30	Mohamad Airul Amin Md Dani	Ballistics Impact Performance of Carbon Fibre Reinforced Polymer (CFRP)/Aluminium Composites	
16.30 – 16.45	Aiman Akmal Abdul Nasir	Influence of Machining Parameters and Fibre Orientations on Residual Tensile Strength and Delamination of Drilled Flax Fibre Reinforced Polymer Composites	
16.45 – 17.00	Ang Jia Yi	System Identification Modelling of Glass/Epoxy Composite Pipes under Multi-Axial Loadings	Change to session 1 12.00 – 12.15
17.00 – 17.15	Dr. Fauzan Ahmad	Multiwalled Carbon Nanotubes Polymer Composites with Low Threshold Input Pump Power for Q-Switched Pulse Laser Generation	
17.15 – 17.30	**Closing Ceremony and Best Presenter Award** Assoc. Prof. Dr. Mohd Yazid bin Yahya Director Centre for Composites Institute for Vehicle System & Engineering (IVeSE) Universiti Teknologi Malaysia		

LIST OF PRESENTATION PAPER

MANUFACTURING, MODELING AND APPLICATIONS

KEYNOTE SPEAKER

Biography and Abstract

KEYNOTE SPEAKER

PROF. DR. HITOSHI TAKAGI

Tokushima University, Japan

Professor Hitoshi Takagi is a Head of Department of Mechanical Science, Graduate School of Science and Technology, Tokushima University, Japan Obtaining his PhD of Engineering from Hiroshima University, Japan. Prof Dr Hitoshi was awarded with his Masters and Bachelor of Engineering degrees from Tokushima University, Japan. He was Visiting Scientist at Cornell University, USA and National Taiwan University of Science and Technology, Taiwan. His research background were Mechanics of green composite materials, interface/interphase characterization in natural fibre-reinforced composites, functionality of natural fibre composites, and fibre surface modification for controlled adhesion. He was an author of over 110 manuscripts, 22 books, and over 420 conference abstracts and papers with some were awarded as best paper and best poster. He is member and committee of some professional societies, including Japan Society of Mechanical Engineers, Japan Society of Materials Science, Japan Society of Polymer Processing and Japan Society for Composite Materials.

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Cellulose Nanofibre-reinforced Green Composites: Fabrication and Characterization

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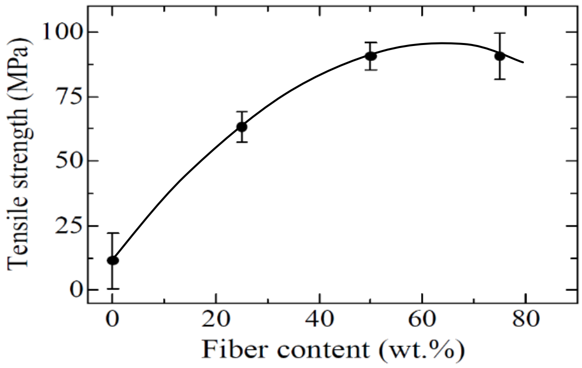
Keywords: Green nanocomposites; cellulose nanofibre; biodegradable resin.

Abstract:

Recently the research and development of bio-based engineering materials have been widely done in North America, Europe, Asia and elsewhere [1-3], because public attention has been focused on various environmental issues such as global warming, waste problems, etc. Hence, many researches have tried to make high-performance materials by using various bio-based resources, such as starch, soy protein and plant fibre, in order to establish a resource-circulating society [4].

Cellulose nanofibre has been successfully extracted from various cellulosic materials, such as wood pulp and grass [5]. The cellulose nanofibre has attracted researchers' attention because its estimated mechanical performance are excellent; for example, tensile strength is 2-3 GPa and Young's modulus is 140 GPa [6, 7]. In this paper, we deal with fabrication of cellulose nanofibre-reinforced green composites that have fully-biodegradable function and their static mechanical properties including tensile strength, flexural strength, and modulus. The effects of processing parameters on the mechanical performance of the green nanocomposites were discussed. Finally the influence of fibre orientation control on the mechanical performance is also explored by applying the mechanical extension treatment to the green nanocomposites.

Fully biodegradable green nanocomposites were fabricated by combining dispersion-type biodegradable resins and cellulose nanofibres. The diameter of the cellulose nanofibres is 10-100 nm and they have a web-like network microstructure. The mixture of dispersion type biodegradable resin and cellulose nanofibres were mixed well by using a stirrer, and then dried in an air-circulating oven. Nanocomposite samples were prepared by a conventional hot pressing method. Their mechanical properties were evaluated by tensile tests. Higher tensile strength and Young's modulus and lower fracture elongation were obtained by the use of PLA-based resin and highly homogenized cellulose nanofibres. Their tensile strength reaches the peak value of approximately 100 MPa at fibre weight content of about 60% by weight (Fig. 1). The PLA-based composite has high strength and high modulus comparable to glass fibre reinforced plastics. This composite system has a large number of possibilities for structural application.



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Acknowledgements:

This work was financially supported by Japan Society for the Promotion of Science (JSPS) KAKENHI Grant Number 15K14148 and by the Ministry of Education, Culture, Sports, Science and Technology, Japan, the project S1311036. We wish to thank the timely help given by Mr. Matsumoto, Mr. Sakaguchi, Mr. Nishimura, and Mr. Matsui in analyzing the large number of samples.

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INVITED SPEAKER

Biography and Abstract

INVITED SPEAKER

DR. KHENG-LIM GOH

Newcastle University, Singapore

Kheng Lim Goh is a Senior Lecturer at School of Mechanical and System Engineering, Newcastle University Singapore. Obtaining his PhD from Aberdeen University, UK. Dr. Goh was awarded with Masters and Bachelor's degree in Physics from National University of Singapore; and Masters in Medical Physics from University of Aberdeen. He was also the Director of Operations (Singapore Program) at Newcastle University of Singapore from 2011 until 2016. His research interests include synthesis and characterisation of polymer- and biopolymer-based composites reinforced by nanoparticles; extracellular matrix; cell-matrix interaction; fibril biomechanics; age-related changes; and functionalization of the fibre-matrix interface. He is author of over 30 journal and manuscript. He is a member of some professional bodies, which are Institution of Mechanical Engineers (MIMechE) and Institution of Physics (MInstP); and also awarded with the title Chartered Engineer (CEng) and Chartered Physicist (CPhys).

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Fibre Reinforced Composite Damage and Repair: Prospects and Challenges

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Keywords: Fibre composites; stress transfer; fracture; repair

Abstract:

The purpose of this talk is to present recent attempts consolidate the theories of discontinuous-fibre reinforced composites within a framework for understanding what really happened when damage has occurred in the composite and when repair is carried out. For further details concerning the framework underpinning the theories of discontinuous-fibre reinforced composites see a recent book authored by Goh [1].

In principle, when a fibre-reinforced composite structure is loaded (e.g. tensile, compression, torsion, impact), the structure takes up load because the matrix, which usually forms the bulk of the composite, deforms in shear and stress is transferred from the matrix to the fibre via the adhesion at the fibre-matrix interface. However, several things can go wrong as the load increases. For instance, initiation of debonding, matrix crack, or localised plasticity within the matrix or fibre (Fig 1) [2]–[4]. Thereafter these failure sites could propagate in size and eventually the composite ruptures into two.

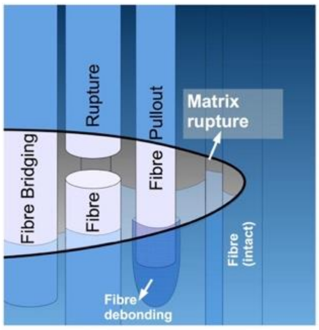

Fig.1. A mode 1 crack in a fibre reinforced composite showing the microscopic failures. Adapted from a monograph by Goh [1]

Of significant interest is when the failures occurred at a barely visible stage. Several repairs (namely exogenous-driven) techniques such as patch/structural flush (Fig 2A), resin injection (Fig 2B), and structural mechanically–fastened doubler, have been developed to repair damages in composite. In principle, any repair, whether temporary or permanent, should lead to a final state that is comparable to the undamaged state. From the mechanical integrity perspective, this addresses a comprehensive range of the response of the composite across elastic, plastic and rupture loading regimes.

This talk will survey how some of these repair techniques attempts to mitigate the failure and to ensure that the mechanical integrity is restored. As the composite science and technology landscape continue to evolve, many novel fibre reinforced composites have been developed, but many new and important discoveries concerning the composite mechanical response have also been found. The contemporary composite designer and engineer have to keep abreast of these new developments.

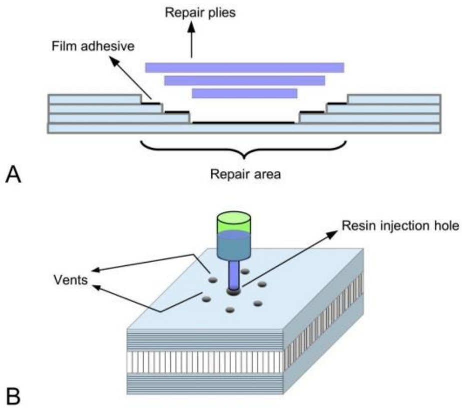

Fig.2. Repair of fibre reinforced composites. (A) Structural flush method. (B) Resin injection method.

References

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TECHNICAL PAPERS

Abstract of Technical Papers

1ST SESSION

PAPER ID : 05

Flexural Properties of Hybrid Carbon Fibre/Epoxy Composites via Electrophoretic Deposition Process: Effect of Deposition Time

Ervina Junaidi[1,2], Mariatti Jaafar[1*] and Sinin Hamdan[2]

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Keywords: Electrophoretic deposition; multi-walled carbon nanotubes; carbon fibre; composite materials; flexural properties.

Abstract:

In this study, multi-walled carbon nanotube (MWCNT) have been deposited onto carbon fibre (CF) fabric via electrophoretic deposition (EPD) (Fig. 1) followed by the vacuum bagging technique for the fabrication of carbon fibre reinforced epoxy composites.

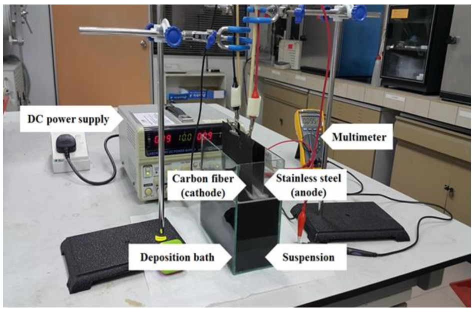

Fig.1 EPD apparatus for filler deposition

The effect of parameter related to the EPD technique such as deposition times (5-30 min) on flexural properties of hybrid CF/epoxy composites were investigated and compared. Based on the zeta potential measurements of pristine MWCNT (P-MWCNT), P-MWCNT have a small and positive surface charge (positive zeta potential) [1]. Under electric field, positively charged P-MWCNT in aqueous suspensions migrate onto negatively charged CF cathode [2]. Deposition of MWCNT onto CF fabric were observed and confirmed by SEM analysis, which reveal that the as-received CF fabric demonstrates smooth surface with parallel apparent grooves distributed along the CF axis, while the pristine MWCNT-coated CF represents a rougher surface that covered randomly by pristine MWCNT [3].

The evolution of the current profile versus time demonstrated that the current is proportional to the applied electric field strength, which leads to the increase in yield of the deposited MWCNT [2, 4]. However, deposition rate decreases and attains a plateau at high deposition times (30 min). It has been revealed that deposition of MWCNT at fixed voltage (40V) and shorter deposition time (5min) demonstrated significant flexural properties of the carbon fibre reinforced epoxy composites. In conclusion, deposition time is one of the significant parameters to determine the morphology and the amount of deposited MWCNT. Longer deposition time caused excessive coating and leads to agglomeration of MWCNT and subsequently dropped the flexural properties (Fig.2).

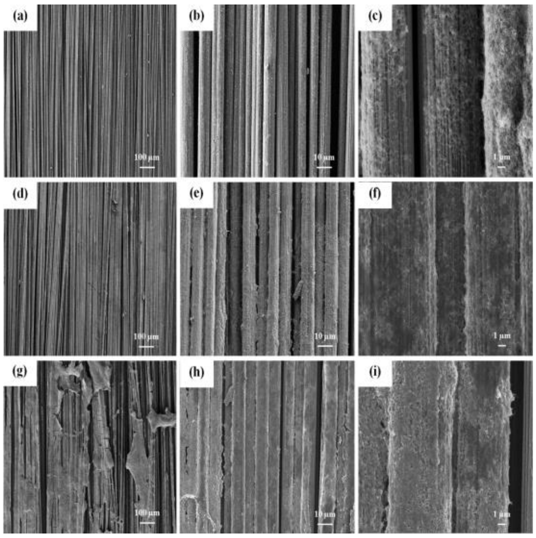
Fig.2 SEM images of pristine MWCNT-coated CF fabric at various deposition time (a)-(c) 5 min, (d)-(f) 15 min and (g)-(i) 30 min (magnification of 100x for (a), (d), (g), 1000x for (b), (e), (h) and 5000x for (c), (f) and (i)).

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PAPER ID : 04

Compression and Tensile Properties of Pineapple Leaf Fibre Reinforced Polylactic Acid Composites

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Keywords: Finite element analysis, numerical modelling, pineapple leaf fibre, PLA, ABAQUS 6.13.

Abstract:

This paper presented the study on tensile and compression properties of pineapple leaf fibre (PLF) reinforced with polylactic acid (PLA). The PLF used in this experiment were crush into short fibre form and then later on mix with PLA by using a bra-blender set at 165°C and 50 rpm consecutively [1]. The ratio between fibres to matrix fabricated in this experiment were 30% fibre and 70% PLA as it had optimum mechanical properties [2]. The mixtures of PLF and PLA from the bra-blender were then crush into powder form before being hot-compressed at 165°C for 15 minutes into several 3mm sheets. Later on, the sheets were cut into slots to further be assemble into a square honeycomb structure [3][4]. The sandwich honeycomb structure then undergo a compression test whereby a single dog-bone shape of the same PLF/PLA composite undergo a tensile test. A similar simulation using ABAQUS 6.13 was conducted based on Poisson's ratio and Young's modulus from the tensile result to validate the significant compatibility between the result of the experiment and the simulation [5][6][7][8].

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PAPER ID : 07

Effect of Elevated Temperature on the Tensile Strength of Napier/Glass-Epoxy Hybrid Reinforced Composites

M.J.M. Ridzuan[1*], M.S. Abdul Majid[1], M. Afendi[1], AZ Ahmad Firdaus[1] and K. Azduwin[2]

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[2] Faculty of Engineering Technology, Universiti Malaysia Perlis, Unicity Alam Campus, 02100 Padang Besar, Perlis, Malaysia.

Keywords: Napier fibre, Hybrid composites, Tensile Strength and Temperature

Abstract:

The effects of elevated temperature on the tensile strength of Napier/glass-epoxy hybrid reinforced composites and its morphology of fractured surfaces are discussed. Napier/glass-epoxy hybrid reinforced composites were fabricated by using vacuum infusion method by arranging Napier fibres in between sheets of woven glass fibres. Napier and glass fibres were laminated with estimated volume ratios were 24 and 6 vol. %, respectively. The epoxy resin was used as matrix estimated to 70 vol. %. Specimens were tested to failure under tension at a cross-head speed of 1 mm/min using Universal Testing Machine (Instron) with a load cell 100 kN at four different temperatures of RT, 40°C, 60°C and 80°C.

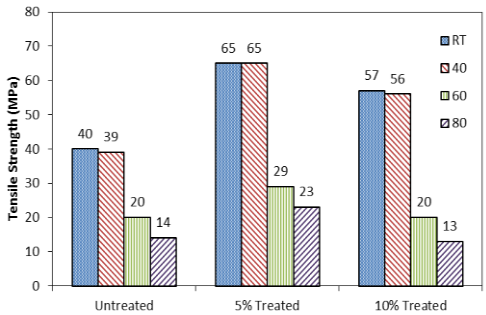

Fig.1 Tensile strength of Napier/glass-epoxy hybrid reinforced composites

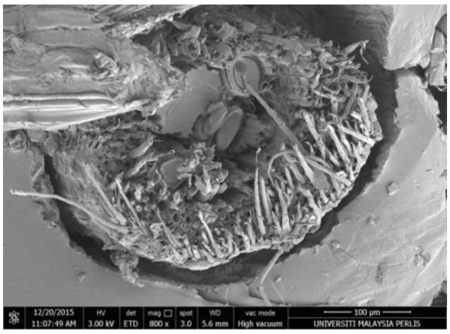

Fig.2 Field emission scanning electron microscope images of Napier/glass-epoxy hybrid reinforced composite

The morphology of fractured surface of hybrid composites was investigated by field emission scanning electron microscopy. The result shows reduction in tensile strength at elevated temperatures. The increase in the temperature activates the process of diffusion, and generates critical stresses which cause the damage at first-ply or at the centre of the hybrid plate, as a result lower the tensile strength. The observation of FESEM images indicates that the fracture mode is of evolution of localized damage, from fibre/matrix debonding, matric cracking, delamination and fibre breakage.

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PAPER ID : 11

Mechanical Properties of Recycled CFRP Powder Reinforced Epoxy Composites

Umar Abdul Hanan[1], Shukur Abu Hassan[1,2*], Mat Uzir Wahit[2], Ahmad Raizal Md Rozali[1,3], Kamarul Bahrin Mohamad[3], Azmi Adam[1,4], Siti Khalijah Jamal[1,2]
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Keywords: Composite recycling, CFRP powder, tensile, flexural, epoxy matrix

Abstract:

Carbon fibre reinforced polymers (CFRP) are by nature strong, durable and non-homogeneous, which makes them inherently difficult and challenging to recycle [1-2]. As an effort to reduce CFRP waste, CFRP powder (rCF) from machining process (milling and drilling) of CFRP aerospace products were collected and incorporated into epoxy resin as a new composite material as shown in Fig.1. In this study, rCF/epoxy composites plate was fabricated using an open mould at different weight percentage of 0%, 20% (20rCF), 40% (40rCF) and 60% (60rCF). Regarding mechanical performance, the material was tested for tensile and flexural properties. The tensile strength and modulus of pure epoxy was 58 MPa and 5.6 GPa, respectively. However, a decreased in tensile strength was recorded with the increased of CFRP powder. The tensile strength drops by 17% for 20rCF, 27% for 40rCF and 31% for 60rCF. For Young's Modulus, 20rCF and 40rCF has higher value than epoxy which were 6.0 GPa and 6.6 GPa, respectively. However, the modulus of 60rCF (5.5 GPa) was slightly lower than epoxy. Regarding flexural strength, the epoxy was found to be 109 MPa and the increased of rCF have decreases the bending performance. For instance, the flexural strength of 20rCF, 40rCF and 60rCF was 94 MPa, 92 MPa and 91 MPa, respectively.

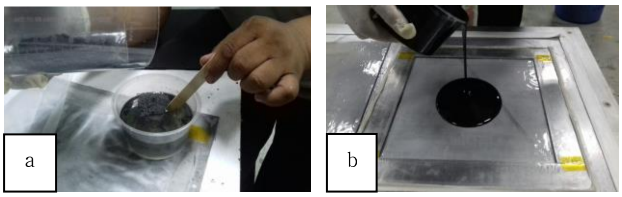

Fig.1 (a) Mixing of rGF into epoxy resin (b) rCF/epoxy compound poured into the mould

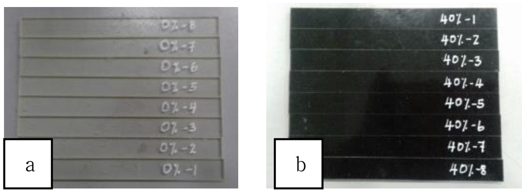

Fig.2 Tensile specimens of (a) epoxy and (b) 40rCF

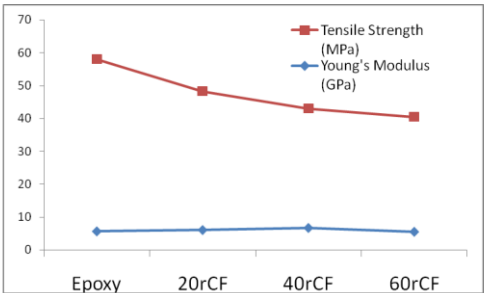

Fig.3 Tensile properties of rCF/epoxy

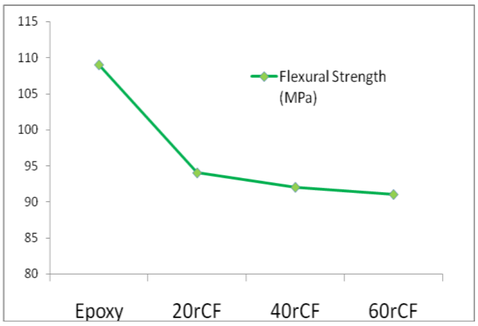

Fig.4 Flexural strength of rCF/epoxy

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PAPER ID : 14

Effect of Fibre Misalignment on Tensile Response of Unidirectional FRP Composite Lamina

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Keywords: carbon fibre, unidirectional lamina, fibre misalignment, tension test

Abstract:

Composite structures present high strength, low weight and design flexibility in terms of fibre orientation and number of plies. Among the most fundamental properties of fibre-reinforced polymer (FRP) composite are those obtained from tensile testing of a unidirectional (UD) composite in the fibre direction [0-2]. These properties include modulus of elasticity, Poisson’s ratio, tensile strength, and ultimate tensile strain. The tensile test that measures these properties is straight forward; A thin strip of a UD composite is placed into the wedge grips of a mechanical testing machine and loaded slowly in tension. Loading continues to ultimate failure, the point at which tensile strength and ultimate tensile strain are determined [3]. Mechanical responses and failure of FRP composite laminates could be predicted using the validated finite element (FE) simulation. The material constitutive and damage models employed in the simulation are developed based on the properties of the unidirectional lamina, including those obtained through tension tests. Such computational model assumes perfectly aligned fibres in the lamina. So far, very little attention has been paid to investigate the effect of misalignment of the fibre in the lamina itself. On the other hand, there are concerns about the performance of a component when errors may be resulted from fibre misalignment which has been studied in the literature [4-6]. In this respect, this paper examined the effect of fabrication-inherited fibre misalignment on the tensile response of the unidirectional lamina. For this purpose, a series of tension tests are performed on unidirectional carbon fibre-reinforced polymer (CFRP) composite lamina specimens with different gage lengths ranging from 20 to 120 mm. Fibre misalignment is quantified to be $\alpha = 7^o$ and represents the nominal deviation of the fibres from the reference long axis direction, as shown in Figure 1.

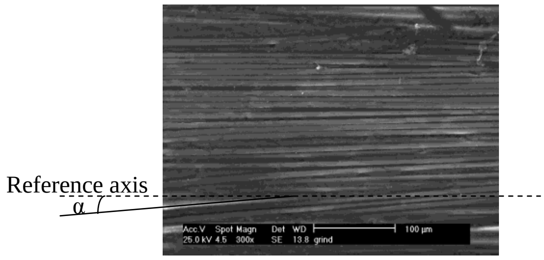

Fig.1.Microscopy image of UD lamina illustrating the extent of fibre misalignment.

Load-displacement responses of the specimens are compared. Results show that the nominal tensile strength of the lamina is 1089±33 MPa. The elastic modulus, however, increases from 36.96 to 55.93 GPa as the gage lengths vary from 20 to 120 mm, respectively. This is due to the induced bending effects on the reinforcing fibres that is greater for longer gage lengths. Multiple fibre fracture events, each is depicted in a noticeable load drop, are recorded throughout the tensile loading of long lamina specimens. Although the load at fracture is accurately reproduced by the FE simulation using the damage-based mesoscale model, the effect of fibre misalignment could not be captured.

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PAPER ID : 15

Mode I Delamination of Chopped Strand Mat E-glass Reinforced Vinyl Ester Composites

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Keywords: Chopped strand mat E-glass, vinyl ester, delamination, double cantilever beam, mode I fracture toughness.

Abstract:

The objective of the present work is to investigate mode I delamination behaviour of chopped strand mat (CSM) E-glass reinforced vinyl ester (VE) composite. CSM E-glass has the advantages of lower cost compared to plain weave, even strength, good flexibility, excellent wetting, dispersion, strand integrity and coating performance [1–2]. Meanwhile, VE is popular its good corrosion and water absorption resistance [3–4]. The opening mode delamination was characterised using double cantilever beam (DCB) test. A 16-ply CSM E-glass/VE composite plate with pre-crack at the mid-thickness was fabricated using hand lay-up technique and cured by vacuum bagging method. The composite plate with average thickness of 12 mm were then cut into specimens at 20 mm width and 190 mm length. After that, the specimens were tested at five initial crack lengths, a_o, which were 60, 65, 70, 75 and 80 mm. All tests were carried out at crosshead speed of 1 mm/min at ambient conditions. Results showed that all force-displacement curves increased linearly at the initial stage, followed by a slight drop. Subsequently, load increased in a non-linear manner and decreased after the maximum load was attained. From the strain gauge data, the slight drop in the force has been identified as the crack initiation point. Mode I fracture toughness, G_{IC} was then calculated using Berry's model and experimental calibration method (ECM). From the compliance plots, the coefficients of the compliance equations for Berry's model were $k = 2.78\times10^{-6}$, $n = 2.5$. As for ECM, the coefficients obtained were $C_1 = 1.74\times10^{-2}$ and $C_2 = 2.75\times10^{-7}$. In addition, the average G_{IC} was 183 N/m and 185 N/m calculated using Berry's model and ECM, respectively. Both data reduction methods provided similar G_{IC} value. Finally, through scanning electron micrographs, the dominant failure mechanisms were found to be matrix cracking, fibre debonding and fibre breakage.

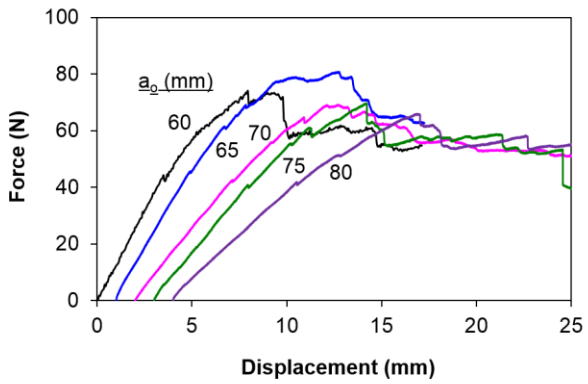

Fig.1. Force-displacement curves of CSM glass/vinyl ester composite.

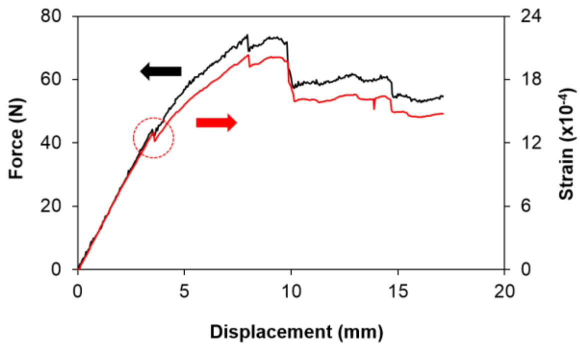

Fig. 2. Load cell and strain gauge responses of the specimen.

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PAPER ID : 18

Mechanical Properties of Ultrasonic Assisted Compression of Polyvinyl Chloride (Pvc) Foam

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Keywords: Polyvinyl chloride foam; ultrasonic vibration; compression test.

Abstract:

Polyvinyl chloride (PVC) closed-cell foam is a multifunctional material that are lightweight, strong, stiff and tough which has received attention since 1970s until today. It provides superior strength to weight ratio which is widely used as core materials in sandwich structures for all composite applications which require damage tolerance and weight saving [1, 2]. The application of PVC closed-cell foam could be extended to the high frequency cyclic force such as in aircraft structure, high speed machine and gas turbine components. Therefore, this is a requirement to identify the response of this material to this condition. There are several studies have been conducted to investigate the properties of PVC closed-cell foam. They were interested in finding the quasi-static property and dynamic property such as response of this material to impact and flexural vibration [2, 3]. The compressive property at low and high strain rate and its capability to absorb energy also have been investigated [4, 5].

The present study aims to investigate the physical and mechanical response of ultrasonic assisted compression of PVC closed-cell foam. A series of static and ultrasonic compression test of PVC closed-cell foam (see Fig. 1) was conducted at a constant cross head speed of 30 mm/min on dry surface conditions. For the static compression test, specimen was statically compressed between two platen and for the ultrasonic compression test, specimens were compressed between two platens of which the upper platen was connected to the cross head of a Shimadzu Universal Testing Machine and the lower platen is the double-slotted block horn that is tuned to a longitudinal mode at 20 kHz, providing an average nominal vibration peak amplitude of 10 µm on the platen surface.

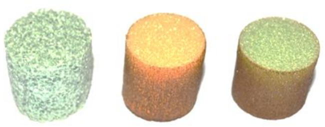

Fig. 1. Cylindrical specimens of PVC closed foam.

The ultrasonic excitation was applied continuously from the onset of plastic deformation to the completion of the test. Both static and ultrasonic compression test were compressed until it reduced more than 50% of its original length.

Fig. 2 shows the results of both static and ultrasonic compression test. In the static compression test, linear elasticity at low stresses followed by an almost constant stress and continues by a regime of densification in which the stress rises steeply. The densification region shown a rapid rise in stress starting from the end of the steady-state region. For the ultrasonic compression test, the load drop drastically immediately after yield when the ultrasonic vibration is applied and start to regain repetitively at a lower stress than the yield stress. The ultrasonic vibration has reduced the stress to approximately 0.5 MPa and at an almost constant stress until it reach more than 50% of its height reduction. It is suggested that the high frequency lower platen excitation has effectively reduced the stress and extend its densification strain.

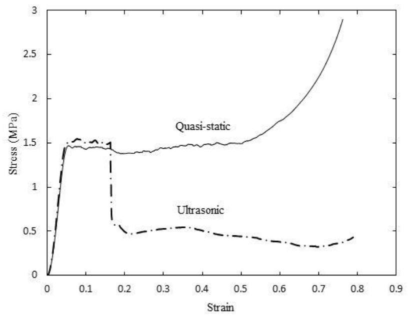

Fig. 2. Comparison of static and ultrasonic compression test on PVC closed foam (density; 80 kg/m^3).

It is expected that through in-depth understanding of material response under high cyclic stress provides useful information for PVC closed-cell foam design, fabrication and application.

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PAPER ID : 22

Low-Velocity Impact of Through Thickness Polymer Pins-Foam Core Sandwich Panel

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Keywords: *low-velocity impact; polymer pins; foam core; through-thickness; sandwich panel;*

Abstract:

Z-pin reinforced foam core has been developed and proved that the reinforcement brings significant improvements in out-of-plane shear, compression and bending rigidity and strength of sandwich structures. The Z-pin network and soft foam provide a combination that has high structural efficiency. The penetration of Z-pin through the foam core to provide a superior bonding between facesheet and core, which in turn improves sandwich damage tolerance [1]. High impact response of Z-pin reinforced foam core sandwich composites was carried out. The experimental results revealed that Z-pin reinforcement can suppress core crushing under the high impact loading [2]. O'Brien and Paris [3] investigated the failure mechanisms in transition regions between solid laminates and Z-pinned truss sandwich. The failure process was documented for various loadings using digital video and high-resolution cameras. Andrea et al. [4] investigated the out of- plane properties, including shear, compression, and tension. The Z-pinned foam core sandwich was found to exhibit higher specific stiffness, it lower ultimate strength compared to conventional honeycomb sandwich. Under dynamic compression, it was revealed that there was interaction between Z-pins and polymer foam. It was concluded that the micro-inertia of the pin increased through-thickness compression collapse load in the dynamic experiments [5].

Fig.1 Low-velocity impact test conducted in this study.

Foam core sandwich panel (FCS) and 1mm diameter polymer pins-foam core sandwich panel (PPFCS) made of chopped strand mat glass fibre skins with thickness of 0.5 mm and polyurethane foam core with thickness of 11.3 mm were used in this study. The sandwich structure was fabricated using bubble-free resin vacuum infusion process. As shown in Fig 1, low-velocity impact tests were prepared using the Dynatup 8250Falling Weight Impact Testing Machine with a rigid 16 mm hemispherical nose shape indentor at different velocity of 2 m/s, 2.4 m/s and 2.8 m/s. The average result from load-deflection and energy absorption are compared. The result for 2 m/s velocity of both types of sandwich panel were compared and reported in Fig 2. The differences of load-deflection behavior for both types of sandwich panel were shown in (a). By reinforcing the foam core sandwich panel with polymer pins, the load and the deflection were increased significantly. The ultimate load was increased up to 30.8% and the deflection was increased up to 34.1%. It is proved that the concept of the polymer pins inside the sandwich panel enhanced the stiffness and the strength of the sandwich panel. Besides that, (b) revealed that the energy absorption of the sandwich panel was increased significantly by the proved of 80.9%.

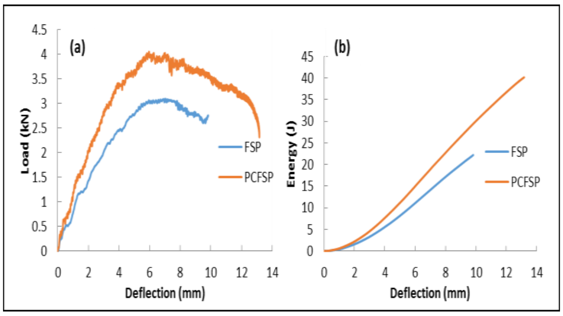

Fig.2. Comparison of Load-Deflection (a) and Enrgy Absorption (b).

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PAPER ID : 23

Mechanical Properties of Polylactic Acid/zein/lyocell Composite

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Keywords: Lyocell; zein; polylactic acid; mechanical properties.

Abstract:

Combination of biodegradable plastic as the matrix and cellulose fibre as the reinforcement offers potentials as green composite. Polylactid acid (PLA) which is originated from plants has the ecofriendly image and good physical properties to be the biodegradable thermoplastic matrix. For the reinforcement, regenerated cellulose fibre (lyocell) is of interest since it has uniform morphological, mechanical, and physical properties like synthetic fibres as well as low density, environmental friendliness, and biodegradability of natural fibres. It also was reported to give reinforcement to thermoplastic polymers [1].

However, incompatibility between PLA and lyocell might restrict the potentials of the green composites. This study intends to explore the use of zein as coupling agent for this compatibilizing purpose. Zein is a prolamine protein from corn, which is amphiphilic for having affinity to both polar and non-polar groups. Previously it was used as coupling agent for thermoplastic matrix/natural fibre composite and gave improved mechanical properties [2] which indicate the composite's constituents are better compatiblized.

For this study, PLA films used were procured from Green Chemical Co., Ltd., Korea, lyocell fabric (acetate taffeta) was from Yu Kwang Co., Ltd., Korea, while zein was supplied in the form of yellowish powder by Sigma Aldrich, Korea.

For the fibre treatment, zein of 10wt% of the lyocell fibre was diluted in ethanol, stirred until homogenous. The lyocell fibre was then immersed in the solution for 30 minutes. Afterwards, the zein treated lyocell fabric was dried in convection oven (at 60^{o}C). PLA films and treated lyocell fibre were hot pressed to produce composites with 20wt% lyocell content, set at 170^{o}C and 1000 kgf for 15 minutes. For comparisons, neat PLA and PLA/untreated lyocell were also fabricated. Tensile tests were conducted according to ASTM D3039 using Instron 5882 at cross head speed of 5 mm/min.

The mechanical properties of the composite are shown in Table 1. Strength of PLA/untreated lyocell composite was lower than that of neat PLA, indicating compatibility issue between constituents. With addition of zein, the resulting composite's strength got even lower. In term of tensile modulus, untreated PLA/lyocell composite showed increased stiffness compared to neat PLA, with zein treatment caused little effect. Elongation at break of untreated PLA/lyocell composite was lower than neat PLA's, and drop further for zein treated composite.

Table 1. Mechanical properties of neat PLA and the composites.

Specimen	Tensile Strength (MPa)	Young's Modulus (GPa)	Elongation (%)
PLA	40 ± 4	2.8 ± 0.1	1.6 ± 0.3
PLA/lyocell	32 ± 1	2.9 ± 0.2	1.4 ± 0.1
PLA/zein/lyocell	20 ± 1	2.9 ± 0.1	0.8 ± 0.1

Previous works reported that PLA/lyocell composites showed significantly higher strength, modulus, and elongation compared to neat PLA [3-4]. This different trend in this study was likely contributed by the fabric's sizing. During manufacture, the lyocell yarns were sized by waxy substance made of starch for friction reduction [5]. Being the fibre's outermost layer, the sizing seems not compatible with the PLA matrix. Regarding the less performing zein as coupling agent, some possible reasons include brittleness of the zein, denaturation of the structure that occurred during hot pressing, or because it could not compound well with the lyocell fibre.

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PAPER ID : 01

Synergistic Effects of MWCNTs Nanofiller Inclusions into Epoxy/Kenaf Hybrid Composites

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Keywords: MWCNTs-kenaf/epoxy composites; synergistic effects; matrix-filler interaction.

Abstract:

The ideas of combining the intriguing behavior of nanomaterial with the promising attributes of natural fibre are brilliant in order to introduce new candidates of advanced materials for many important engineering applications. Fortified with the government regulation and public concern about the decreases of current landfill, high processing cost of synthetic fillers and related environmental issues, the attention on utilizing natural fibre in many potential applications are getting under spotlight [1]. Manufacturing of high performance composite can be achieved by combining synthetic filler [2], [3] and/or natural filler [4] in polymer matrices.

This research put an initiative to explore the potential of enhanced reinforcement effects for Epoxy/Kenaf composites system with MWCNTs nanofiller inclusions. Preliminary study on the effects of various MWCNTs loadings (0, 0.25, 0.50, 0.75, 1.00 and 3.00 wt. %) to the epoxy based matrix has been conducted. It was found that, addition of only 0.50 wt. % of MWCNTs possessed higher tensile strength and thermal performances among others. Hence, the content of MWCNTs at 0.50 wt% was kept constant for hybrid Epoxy/Kenaf-MWCNTs composites preparation by varying the kenaf loadings into 5.00, 10.00, 15.00, 20.00 and 30.00 wt% additions. Later, the evaluations on mechanical, physical and thermal performances for hybrid epoxy/kenaf/MWCNTs systems were performed and compared with epoxy/kenaf composites at similar content of kenaf addition. The synergistic effects between MWCNTs and kenaf are pronounced through the impact strength analysis, whereby the toughness of hybrid composites of epoxy/30 wt. % kenaf/0.50 wt. % MWCNTs had improved about 35.89% as compared than unfilled epoxy system. However, the synergism effects does not really intense for other mechanical and physical attributes but are noticeable for improving the thermal stability of produced hybrid composites. Observation onto their tensile fractured surfaces via scanning electron microscopy has been conducted to further support the reinforcement characteristic of Epoxy/Kenaf hybrid composites due to MWCNTs nanofiller inclusion and possible matrix-filler interaction mechanism involved.

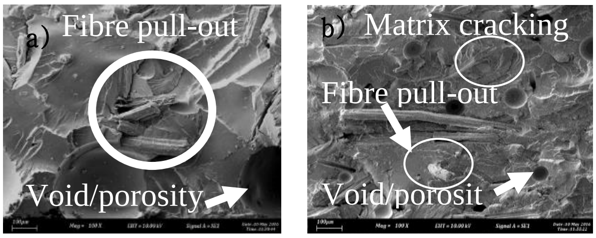

Fig 1. (a-b) SEM micrograph of the fractured surfaces of (a) Epoxy/Kenaf composite and (b) Epoxy/MWCNTs/Kenaf hybrid nanocomposite at 5 wt % of kenaf loading.

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PAPER ID : 19

Interfacial Bond Strength Analysis between Kenaf Fibrous Concrete Composite and Plain Concrete

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Keywords: Composite, interfacial bond strength, kenaf fibre.

Abstract:

The deterioration of concrete structures is a matter of critical concern as it threatens the durability and strength of concrete structures. Generally, infrastructures in developed and developing countries such as United States and Malaysia are suffering damages from increasing and unpredictable loads which they are exposed to [1]. In response to infrastructure damaged by repairing and enhancing its structural capacity, new construction materials are used in constructing overlay and/or patching the damaged or deteriorating part of the structure. Such potential material is natural fibrous concrete (NFC). The exclusivity of NFC is its light weight, improved durability, ductility, sustainability and relatively low cost of production [2]. Other addition pluses of NFC are it low environmental impact and bio-degradability [2]. This attributes made NFC potentially suitable for repair, retrofitting and rehabilitation of reinforced concrete structures (RCS) or for use as a new construction material.

Also the improved durability and low density of NFC related with its flexural and tensile properties make the main idea to use it in rehabilitating and strengthening the regions where the structure is exposed to high mechanical loading and severe environmental stress worthwhile. Usually, there always exist a weak connexion between the bond strength of the old and new concrete structures during strengthening and rehabilitation of concrete structures [3]. Research carried out by Gorst [4] showed that rehabilitation or repair of concrete structures is deem successful when good bond is achieved between the old and the new concrete. This is the goal of engaging in any structure repair. The fibre used in this research is a bio fibre from Kenaf plant (Fig. 1).

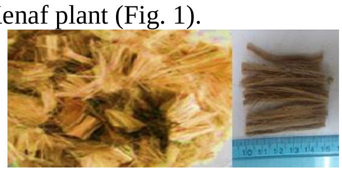

Fig.1. Treated Kenaf fibre chopped to 50mm length

The fibres were subjected to surface treatment by sodium hydroxide reagents (NaOH) to improve the bond characteristics of the interfacial zone between the fibres and the cement matrix and also to reduce it hydrophilic properties [5]. Kenaf fibrous concrete composite (KFCC) can be used with advantage in new structures such as precast elements, as well as the strengthening, repair and rehabilitation of old structures so as to improve their durability properties. These structures are composite components, with parts as Plain concrete (PC) and others as KFC. This study therefore, investigated the interfacial bonding behaviour between KFC and PC. Shear, tensile and compressive tests were carried out to measure the bond strength in shear, direct tension and compression respectively for PC to PC, PC to KFC and KFC to KFC interface (Fig 2a, b & c).

Fig.2. Interface failure mode of (a) compressive (b) tensile and (c) shear test specimen.

Three different types of concrete grade (25, 35, and 45 MPa) were produced for the KFC, and one type of concrete grade (35 MPa) for the substrate PC. The outcome of the test showed that KFC had excellent interlock with the surface of the PC substrate, and thus, gives bond strength greater than the strength of PC. New concrete with the highest concrete grade of 45 MPa ensued in high compressive, tensile and shear bond strength.

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TECHNICAL PAPERS

Abstract of Technical Papers

2ND SESSION

PAPER ID : 08

A Review on Chemical Treatments of Natural Fibre in Reinforced Polymer Composite

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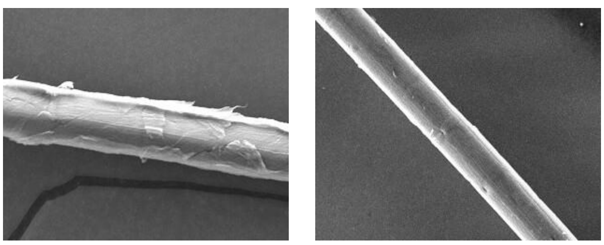
Keywords: Natural fibre; chemical treatment; fibre reinforced polymer.

Abstract:

In the composite industry, synthetic fibres like carbon and glass can be replaced with natural fibres due to their low cost and environmentally friendly properties of being biodegradable and sustainable [1-4]. Studies proved that mechanical properties of natural fibres reinforced polymer composites are excellent and competent to be utilized in high-tech applications. However, the presence of chemical constituents such as cellulose, lignin, hemicellulose and wax substances in natural fibres have formed into polar groups which absorb moisture [2]. Thus, resulted in poor bonding with non-polar polymer matrix and degrade the true capabilities of natural fibre composites. To overcome this defect, chemical treatment is introduced in order to modify and enhance the surface of natural fibres for better adhesion with polymer matrix. In this paper, the different types of chemical treatment that being used in treating natural fibres are reviewed. The modifying works done by chemical treatments such as alkaline, acetylation, benzoylation, silane and others are discussed and supported with the latest outputs from researches that carried out the treatment works on natural fibres. Fig.1 shows the SEM images on untreated and alkali treated of bamboo fibre by using 4 % of NaOH solution [3]. From the images, the rough surface of bamboo fibre turned smoother after the treatment indicates that chemical reacted with bamboo fibre by removing chemical components like hemicellulose, wax substances and some impurities that accumulated at the surface of fibre. Thus, improve the bonding between natural fibre and polymer matrix.



(a) (b)

Fig.1 Surface morphology images of (a) untreated and (b) 4 % of alkali treated bamboo fibre via SEM [4].

In addition, the treatment also improve the fibre strength, which resulted into composite with excellent mechanical properties. Fig.2 shows the effect of concentration of alkali solution on the tensile strength of sugar palm fibre reinforced epoxy composites [4].

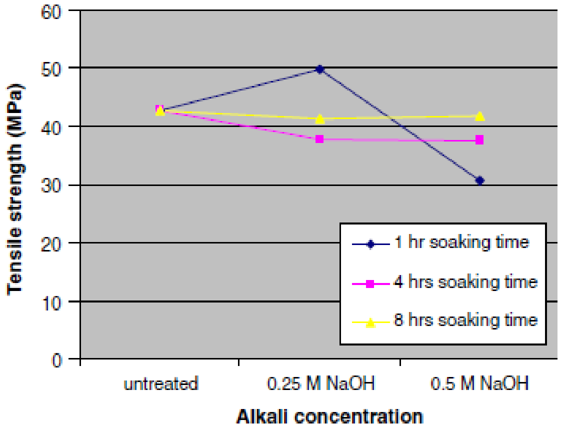


Fig.2 Tensile strength of sugar palm fibre reinforced epoxy with difference concentration of alkali solution [5].

Based on the literatures, chemical treatments not only improve the surface of natural fibre for better adhesion, but also improve the fibre strength which contribute to their outstanding composites mechanical properties.

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PAPER ID : 12

Effect of Tropical Weathering on Interlaminar Shear Behavior of Hybrid Woven Kenaf/Recycled GFRP Reinforced Polyester Composite

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Keywords: Recycled GFRP, Woven Kenaf, Tropical weathering, Interlaminar shear, Durability

Abstract:
Interlaminar shear behavior of hybrid woven kenaf/recycled GFRP (rGFRP) exposed in tropical weathering of Malaysia were investigated in this study. Malaysia's climate is categorized as tropical weathering, classified as hot and humid throughout the year. The average rainfall is 250 centimeters a year and the average temperature is 27 °C, hot and wet tropical weather reported to affect natural fibre polymer composites severely [1]. Synthetic fibre reinforcement is one of the solution to improved natural fibre mechanical properties and durability [2]. Interlaminar shear strength (ILSS) is one of importance mechanical properties in laminate composite related to delamination behavior. Delamination known as the failure at the interface between different layers the ILSS defined as the resistance against delamination upon shear stress at break. Hybrid synthetic fibre reported to improved ILSS natural fibre composite mechanical properties [3]. However, composite recycling especially glass fibre reinforced polymer (GFRP) has been a major problem to the environment due to it market domination, cheap, non-degradable and difficulty in recycling.

(a) (b)

Fig.1 Hybrid woven kenaf/rGFRP composites (a) Expose to tropical weathering (b) Interlaminar shear test

Fibre from rGFRP is potential as a reinforcement instead of using virgin glass fibre. In the present study, glass fibres were segregated from other constituents of GFRP waste through mechanical grinding, sieved, washed and dried before used as interleaf reinforcement between two layers of woven kenaf. Sieved rGFRP segregated into three different fibre size, powder, fine and course. A same amount of rGFRP fibre weight to virgin glass mat areal density as a references. Polyester resin selected as a matrix binder in the composites. Compression molding used as a fabrication method with average fibre weight percentage ratios are constant at 37% for all samples. Two parameter conditions for comparison, without weathering exposure and 3 months tropical weathering disclosure. The effect of weathering on the ILSS of hybrid woven kenaf/rGFRP composites shows comparable value in kenaf composite, hybrid fine rGFRP and hybrid powder rGFRP with 2.94 MPa, 2.7 MPa and 2.62 MPa respectively. Hybrid fine rGFRP shows higher ILSS before weathering exposure reach up to 3.7 MPa, coarse rGFRP shows lower value 2.88 MPa. In general, weathering reduce the ILS composite strength, however hybridization approach helps reduced the percentage drop compared to neat kenaf composite.

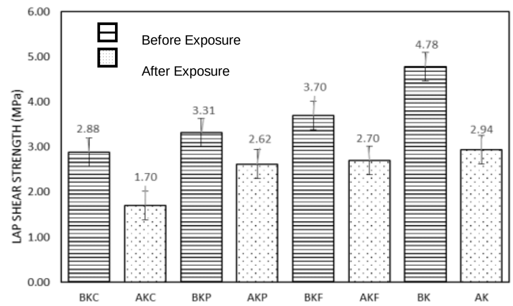

Fig.2. Effect of weathering on ILSS

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PAPER ID : 16

Biodegradable Napier/Pla Composite for Tissue Engineering

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***Keywords*:** *Polylactic acid; Napier fibre; scaffold; microstructure; mechanical properties*

Abstract:

Generally, scaffolds are required to have suitable degradation rate and ample mechanical support to sustain loadings and stresses caused during in vitro and in vivo regeneration and degradation, possessing characteristics of high porosity, appropriate size of pore, biocompatibility, biodegradability and appropriate degradation rate [1]. Thus, there is an often need for enhancement in scaffold mechanical properties [2]. Such improvement is achievable by the incorporation of natural fibres. Polylactic acid (PLA), or simply polylactide, is a biodegradable synthetic polymer widely used to construct scaffolds [3]. It is biocompatible and has the ability to customize mechanical properties and degradation kinetics suitable for many applications [4]. Biomedical application using natural fibre and bio-composite is only recently discovered. Thus, new plant fibres can be incorporated into the composite combination. Napier grass or Elephant grass (*Pennisetum purpureum*) has yet to be done research on their applications in the biomedical field. Its fibre can be potentially used as one of the biomaterial for scaffolding to form a bio-composite since it is also biodegradable, biocompatible and possesses good mechanical properties.

The inspection of the scaffold morphology shows that the pores diameter ranges from 80 to 200 μm, similar to the size of NaCl porogens. The porous structure of the composite scaffolds exhibits high interconnectivity and open network with abundant and well-developed porosity. The pore size of the scaffold should be at least 100 μm to allow proliferation of cells [5]. 100 to 350 μm pore size is commonly accepted for osteogenesis and bone growth [6].

Fig 1 shows the effect of increasing Napier contents from 0 wt% to 30 wt% on the mechanical properties. Briefly, the mechanical properties are shown to have significantly increased since Napier fibre acts as the reinforcing filler for the PLA matrix.

The scaffolds developed have the compressive strength comparative to the strength value of trabecular bone (2 to 12 MPa). Thus, the scaffolds will be mechanically suitable for osteogenesis.

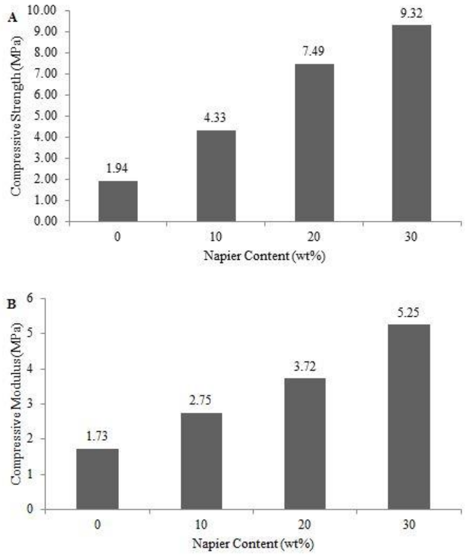

Fig.1 .Compressive strength (A) and compressive modulus (B) of Napier/PLA composite scaffolds.

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PAPER ID : 03

The Effect of Variant Unit Cell and Thickness of Trapezoidal Carbon/Epoxy Composite Sandwich Panel

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Keywords: Sandwich structure, Carbon fibre, Finite Element Analysis, Strength

Abstract:

As industry in development and rise, steady demand of improving properties for available material has generated. Throughout a few researches and knowledge, it can lead to material improvement of mechanical properties such as improvement by new generation in composite material. Applications of composite materials are widely used in many industries such in automobiles, airplanes, marine and off-shore industries. The composite material that have high strength and energy absorption are good in consolidation, vibration, and good corrosion resistance [1]. The distribution of stress and energy dissipation is affected by microscopic structure and adhesion of fibres and matrix [2]. The strength of the sandwich structures are depended on number of unit cell and thickness of cell wall. Debonding between skin and core caused from continuous loading of the experiment. Thickness of cell wall acted as important role which to avoid buckling effect during compression force loaded on the structure surface [3]. The strength of corrugated core also depended on the material used, density ad types of loading [4]. There are many types of sandwich structures such as honeycomb core, foam core and corrugated core. Honeycomb core structures have excellent combination of strength and efficiency to reduce weight of components [5]. In this experiment, the response of sandwich panels with trapezoidal corrugated cores to quasi-static loading is investigated by employing experimental and computational approaches. The sandwich panel consists of top and bottom face sheets, adhesive layer and core. A series of experimental investigation and numerical analysis on Carbon Fibre Reinforced Plastic (CFRP) sandwich panels under tensile and compression testing were conducted. The trapezoidal cores were fabricated by using a compression moulding technique. The face sheets were fabricated based on the same material and then bonded with the core using high shear strength adhesive material. The objectives of this experiment are to determine ultimate stress and strain for tensile and compression and, the role of the number unit cell and thickness of cell wall determined local failure behaviours of the panels. The experimental results were compared with Abaqus/Standard 6.13 software. The deformation modes observed in this study include core buckling, debonding and fibre breakage. The experimental data shows the compressive strength of 3U5P is 3.27 MPa and higher than 3U3P and 3U4P specimens. It is found that core arrangement is key factor governing the quasi-static response of sandwich panels with corrugated cores.

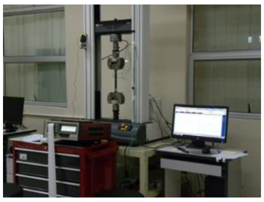
Fig 3.experiment setup for tensile testing

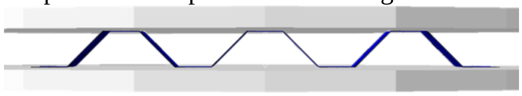
Fig 2.FEA model of 3U5P


Fig 3.3U5P specimen failed under compression test.

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PAPER ID : 20

The Durability Performance of Kenaf Fibre Reinforced Polymer Composites (KFRP)

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Keywords: Composite, kenaf fibre reinforced polymer composites, kenaf fibre, environment.

Abstract:

As a result of polymer composites increased use in today's society, an extensive investigation was carried out in this report to condense what's been, thus far, discovered as to the effects of aging on polymer composites.

Several studies have been initiated in the past few years on the use of natural fibres as reinforcements in polymer matrices for making various building products and dough-moulding compounds [1-3]. In view of the severity of environmental agents, a systematic programme on the performance evaluation of Kenaf Fibre Reinforced Polymer (KFRP) was undertaken in order to generate confidence amongst users as substitute materials in buildings. In the present study, we report the performance of KFRP composites under various exposure conditions during 2 years.

KFRP is a composite material, which consists of epoxy, polyester and vinylester as matrixes and Kenaf fibres as reinforcement. Kenaf has been widely cultivated in Malaysia and its fibres can be used to produce composite products for structural applications. Therefore, this study was conducted experimentally to investigate the engineering properties of the composites materials and its performance to the local tropical climate. The effects of quantity of kenaf fibres in the composites and exposure under different environmental conditions were investigated. The tests were conducted in accordance with the requirements of the American Standard of Testing and Materials (ASTM).

A total of 2260 samples of kenaf fibre reinforced polymer composites containing 10%, 30% and 40% of fibre volume fractions with 6 mm nominal thickness were produced. The samples were exposed to outdoor environment, laboratory environment and immersed in water and acidic liquid with 5% of H_2SO_4 . The control samples were kept in the room with dark and normal conditions. The samples were tested for to understand the physical properties and performance. The tests were carried out at 0, 12 and 24 months periods of exposure. Results from the physical observation showed that surface degradation occurred significantly after 12 and 24 months and fungal attack developed on the surface of samples exposed to outdoor conditions. Furthermore, surface roughness and discoloration occurred on the top surface of the samples. The unexposed samples had the highest tensile and compressive properties as compared to all other exposed samples.

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PAPER ID : 02

Implementation of Nano-composite Organics for Solar Energy Harvesting- A Ternary Composite System

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Keywords: Organic composite; ternary organic solar cells; photovoltaic performance.

Abstract:

Heterostructure composites based on organic materials have been receiving considerable attention for their application as active layers in organic solar cell devices [1-3]. Realization of solution-processed organic solar cells for solar energy harvesting is of great importance because of the minimal materials usage, cost effective, light weight and flexibility. In this research work, a solution-processed organic solar cell based on a ternary heterostructure is presented by means of incorporating small molecules of tris(8-hydroxyquinoline) gallium (Gaq3) or Alq3 as secondary electron acceptors. The donor material is α,ω-dihexyl-sexithiophene (DH6T), while the primary acceptor is methano-fullerene ($PC_{61}BM$). The results showed that short circuit current (I_{Sc}), open circuit voltage (V_{oc}), and fill factor (FF) of the devices were pronouncedly enhanced by the inclusion of Gaq3 or Alq3. The maximum output power and conversion efficiency of the ternary devices were increased by an order of 5.8 times compared to that of the control devices, as shown in Figure 1.

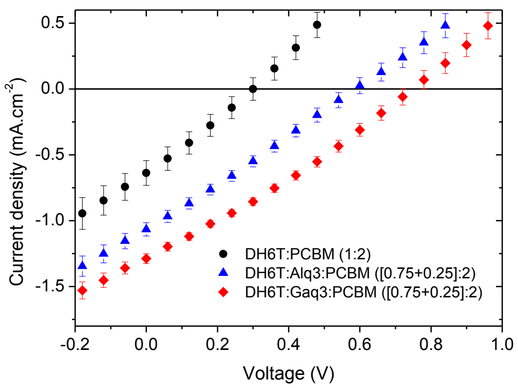

Fig.1. The *J-V* characteristics of organic solar cells based on ternary composite system of DH6T:Mq3:PCBM

These improvements were ascribed to the broadened light absorption, better energy level alignment between the donor-acceptor components, a balanced charge transfer, and increased crystallinity of the active layers, as shown in Figure 2 and 3. It is concluded that ternary nano-composite structure can be a promising candidate to be utilized for efficient solar energy harvesting.

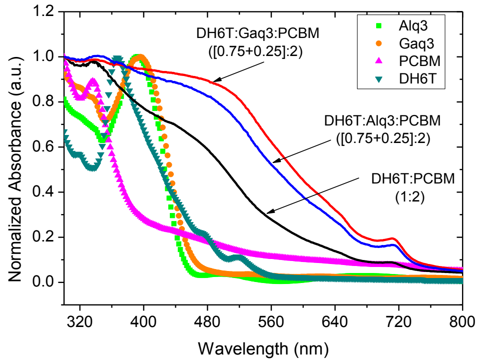

Fig.2. Absorption spectra for the ternary composite system of DH6T:Mq3:PCBM and their components.

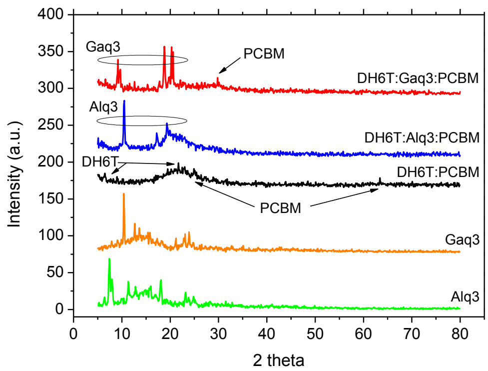

Fig.3. XRD patterns for the ternary composite system of DH6T:Mq3:PCBM and its Mq3 component.

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TECHNICAL PAPERS

Abstract of Technical Papers

3RD SESSION

PAPER ID : 06

A Review on Magnesium-based Materials for Bone Applications

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Keywords: Magnesium, bone implant, manufacturing process, porous, biocompatibility.

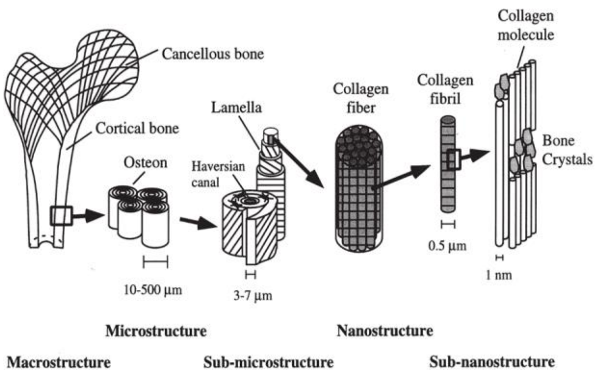
Abstract:

The use of biodegradable metallic-based material for bone applications as an implant as well for scaffolding purposes have been increasing significantly. The interest on biodegradable bone implant materials are driven from the increasing knowledge on biomedical materials and tissue engineering field to some positive clinical findings. Various biodegradable polymeric- and metallic-based materials have been used for bone screw, for instant. Biodegradable materials also desirable feature for bone scaffold application since the goal is that it uses as a temporary structure holding a growing bone tissues until the bone defect healed. Magnesium has a potential chance to serve as biodegradable bone implant material, as it has mechanical properties similar to natural bone, lightweight, and biocompatible approved. This article aims to report current development and future potential use of magnesium-based metal for bone implant application. Techniques on manufacturing process, mechanical performance, and biocompatibility assessment of magnesium and its alloys will also highlight.

Human bone structured as an open cell composite material composed of a complex vascular system and a significant fraction of protein-related materials. Bone also like other connective tissues, which has cells, fibers and a matrix. In bone, the extracellular matrix is calcified and the fibers, which are collagen, are very highly ordered. At the architectural level, bone is made up of two types of different tissues tightly packed together. The outer shell is of dense compact or cortical bone, while the inner core is comprised of porous cellular, cancellous or trabecular bone. Although both bone types comprise the same composition, each one contains different proportions of the organic and inorganic materials, degree of porosity and organization. The porosity of cortical bone is 5-10%, while in cancellous bones the porosity ranges between 75% and 90% [2]. The cells of the bone are developed into one of three main structures, osteoblasts, osteoclasts or osteocytes [3].

Cortical bone is highly dense and contains cylindrically organized osteons, also known as Haversian system, ranges between 10 to 500 μm. It is notable that the Haversian canal is composed of blood vessels in parallel to the long axis of the bone. These blood vessels are interconnected with vessels on the surface of the bone through perforating canals [4,5]. Contrary to cortical bone, cancellous bone is highly porous, consisting of an interconnected network of trabeculae which is about 50-300 μm in diameter. Figure 1illustrates the basic architecture of the bone [4].

Fig.1 four-cable ballistic pendulum system



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Non-Fickian Absorption Characteristics of Adhesive Joints -Capillary effect and residual properties

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Keywords: Adhesive joint, moisture absorption, non-fickian, residual property model, cohesive failure, mixed failure, adhesive failure.

Abstract:

Adhesive joints are employed in advanced structures due to requirement of lightweigt materials, espcially in automotive and aerospace industries [1]. The increasing use of adhesive joints is derived from the ability to distribute uniform stress distribution on the surface bonded area, good vibration and damping properties. However, mechanical performance of polymer-based adhesive joint is susceptible to moisture absorption [2]. This study quantifies the effect of absorbed moisture on the strength, stiffness, and energy properties of the joint. For this purpose, moisture absorption characteristics of structural adhesive joints (Araldite2015) with different thickness (0.5, 1.0, and 1.5mm) are established under accelerated aging conditions (deionized water at 60°C). A thickness-dependent two-phase moisture absorption model is used to characterize moisture absorption of the adhesive joints. Fig. 1 compares the moisture absorption behavior of adhesive joints with different thicknesses. Results show that the moisture absorption of the adhesive joints at 0.5mm thickness is governed by the capillary action. Meanwhile, the 1.5mm thickness is governed by classical diffusion. The glass transition temperature for the moisture-absorbed adhesive is decreased to 68°C when compared to 83°C for the as-received adhesive sample.

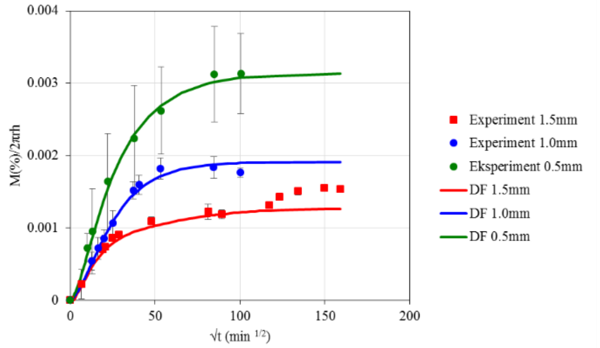
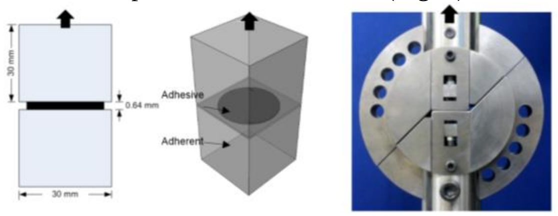


Fig. 1 Moisture absorption behaviour of adhesive joint with diferent thickness

Adhesive joint specimens with aluminum 6061 adherents and 0.5mm-thick Araldite 2015 adhesive compound are subjected to dry, 0.1, 0.15, 0.18, and 0.2 pct moisture contents. The specimens are tested in shear and tension under quasi-static loading condition of 1mm/min. Schematic of the adhesively bonded specimen and experimental setup are shown in Fig. 2. The variations in the properties are fitted using a residual property model. The degradation parameter, ζ does not to exhibit particular trend with the loading configuration. In addition, due to fluctuation of data in shear, the normalized strength is less well fitted compared to the tensile one (Fig. 3).



(a) (b)

Fig 2. (a) Adhesively bonded specimens geometry and (b) modified Arcan jig setup for tension test of the specimen

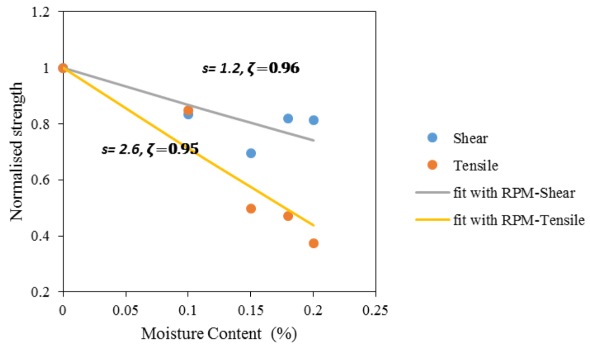


Fig.3: Normalized properties fitted using residual property model.

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Ballistic Impact Performances of Carbon Fibre Reinforced Polymer (CFRP)/Aluminium Composites

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Keywords: Energy absorption, Ballistic limit, Tensile failure, Elastic deformation, High-speed photography.

Abstract:

This study report on the ballistic performances of carbon fibre reinforced polymer (CFRP)/aluminium composites upon ballistic impact based on energy absorption. Two parameters were considered influencing the energy absorption performance, namely aluminium thickness and adhesive type. Although there are many studies reported on the effect of these two parameters upon ballistic impact [1], only a few literatures could be found focusing on composite systems. The development of a model for calculating the energy absorbed by composites upon ballistic impact was based on the previous related researches. Three major components were identified by the model, contributed to the energy lost by the projectile during ballistic impact, namely tensile failure, elastic deformation, and the kinetic energy of the moving portion of the composites [2]. These three components are combined in the model to determine the total energy absorbed by the composites and also its ballistic limit value. The model thus evaluate the experimental values of the composite systems: CFRP/aluminium sandwich composites with different aluminium thickness (1mm, 2.5mm, and 4mm) and also different adhesive (Sikadur 330 and Sikadur 30). Using a series of ballistic tests with strike velocity ranging between 200 m/s to 250 m/s, all parameters needed such as strike and residual velocity, velocity of moving portion, and also size of cone formed has been measured using sensors and high-speed camera (Fig. 1).

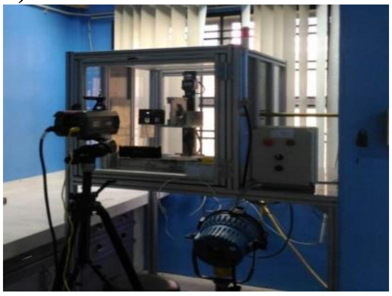
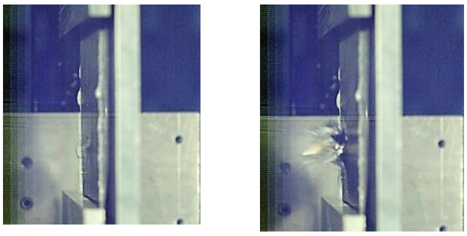


Fig. 1 high speed camera final setup

The experimental results show the ballistic limit increase upon the increment of aluminium thickness for both Sikadur 30 (174.82 m/s, 178.50 m/s, 228.43 m/s) and Sikadur 300 (132.77 m/s, 170.23 m/s, 225.68 m/s) samples. High speed photography analysis shows how transverse wave propagate through the samples and different size of deformed region formed on each sample during penetration process (Fig. 2). In terms of total energy absorption, Sikadur 30 samples give a bigger value. However, Sikadur 330 samples have better increment percentage in total energy absorbed with average of 70% rather than 27% of Sikadur 30 samples. As a conclusion, tensile failure becomes more dominant upon the increment of aluminium thickness until elastic deformation becomes the only mechanism worked when the ballistics limit reach the strike velocity of the projectile.



(a) (b)

Fig. 2 high speed camera photography (a) t_1 – initial stage (b) t_2 – fracture stage

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PAPER ID : 13

Influence of Machining Parameters and Fibre Orientations on Residual Tensile Strength and Delamination of Drilled Flax Fibre Reinforced Polymer Composites

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Keywords: Flax fibre reinforced polymer composites; drilling; residual tensile strength; Taguchi method; ANOVA.

Abstract:

Due to the environmental awareness, the utilization of natural fibre as a potential substitute for the man-made (synthetic) fibre in composite materials has attracted interest among researchers [1, 2]. Since natural resources gain more attention for their comparable mechanical properties, they are extensively used in varieties of applications [3]. In assembling the parts for the final product, drilling; as the mostly used secondary machining of the fibre reinforced composite laminates; is unavoidable [4]. However, drilling-induced damage such as delamination and matrix cracking around the hole often drastically affect the mechanical strength of the composites. Saleem et. al. [5] highlighted that this damage is mainly influenced by the choice of machining parameters, the geometry of the cutting tool and the nature of composite materials This study investigates the effects of drilling parameters, namely; cutting speed, feed rate, and also fibre orientation on the residual tensile strength and the delamination factor of the drilled flax fibre reinforced epoxy composite. Fig.1 shows the three-type of fibre orientations that used for the experiments.

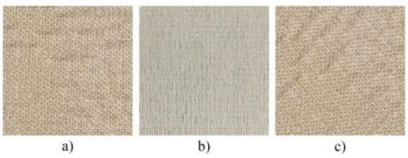

Fig.1 Type of fibre orientations: (a) Woven, (b) Unidirectional, and (c) Bi-axial.

In this work, the Taguchi Design of Experiment based on the three levels; namely; spindle speed: 3000, 6000 and 9000 rpm, feed rate: 0.16, 0.24 and 0.32 mm/rev and fibre orientation: woven, unidirectional and bi-axial has been employed. Subsequently, static loading tests (according to the ASTM Standard D3039) were performed on the open-hole specimens to determine the tensile residual strength. Whereas, the extent of delamination damage was quantitatively evaluated based on delamination factor.

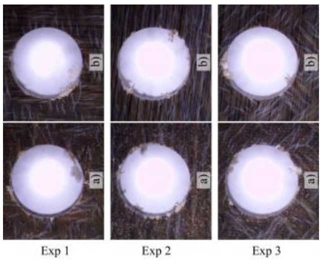

Fig.2 shows several optical microscopic images of delamination damage for the flax fibre composite under the state drilling conditions.

Photographs of the delaminated area of specimens drilled according to experiment 1, 2 and 3 at the (a) entrance side and the (b) exit side.

Experimental and statistical analyses imply that fibre orientation is the factor that has the strongest influences (97.63%) on residual tensile strength of drilled composites. Maximum residual tensile strength of 124.29 MPa is achieved prior using unidirectional orientation-type of flax fibre specimens. In particular, feed rate should be kept at lowest level as possible while spindle speed can be set at the highest level, even though this may not be desirable for machining productivity and tool sharpness. The combination of low speed and feed gives lowest delamination damage at the hole entrance and exit. Nevertheless, woven type of fibre orientation is recommended in improving delamination damage.

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PAPER ID : 17

Modelling using System Identification on the Behaviors of Multiaxial Glass/Epoxy Composite Pipes

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Keyword: *System identification, modelling, glass fibre reinforced epoxy, composite pipes, multiaxial loadings*

Abstract :

Normally, the qualification of glass-reinforced epoxy(GRE) pipes are governed by the international standard OSP 14692-1:2002, through ASTM D2992[1]. The paper aims is to model the performance of the Glass Fibre Reinforced Epoxy (GRE) composite pipe under multiaxial loading by via system identification approach. System identification modelling depends on the input and output of the experimental result. System identification can be achieved by several methods. Those methods consist of least square method, gradient correction method, maximum like hood method and so on[2]. But for this paper, the general model of the estimator has been listed in table 1.

The experimental data used is obtained from the developed pressurise test rig at figure 1. The model is based on the pure hydrostatic (2H: 1A) loading by using GRE pipes of three different winding angles (±45 °, ±55 °, ±63 °).

A different method of system identifications approach is applied for comparison to obtain the best modelling accuracy which then used to evaluate the performance of the pipe. The result shows that the transfer function method could model and has the highest efficiency compare with the experimental result.

Table 1. Equation representation for the estimator

ARX MODEL	A(z)y(t)=B(z)u(t−nk)+e(t)
ARMAX MODEL	A(z)y(t)=B(z)u(t−nk)+C(z)e(t)
PROCESS MODEL	$P(s) = K.e^{-T_{d*s}} \times \frac{1+T_z s}{(1+T_p s)}$
TRANSFER FUNCTION	$Y(s) = \frac{num(s)}{den(s)} u(s) + E(s)$

Fig.1. Automated pressure test rig

References

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PAPER ID : 21

Multiwalled Carbon Nanotubes Polymer Composites With Low Threshold Input Pump Power For Q-Switched Pulse Laser Generation

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Keywords: Multi-walled carbon nanotubes, polymer composite,Q-switcher

Abstract:

The application of nano material as filler had been successfully demonstrated in improving the mechanical properties of materials or to improve flame retardancy[1]. Apart of mechanical properties of nanomaterials, optical properties is one of the interesting properties to explore[2]. In this works, we exploit optical properties of Mutli-walled carbon nanotubes(MWCNTs) polymer composites as passive saturable absorber for pulse laser generation. Pulse laser had found a wide application in material processing, telecommunication and medical surgery[3]. We demonstrate a pulse laser generation in Q-switched regime at telecommunication wavelength region by integrating a MWCNTs embed in Polyethylene oxide (PEO) based film as passive saturable absorber. The MWCNTs was embed in PEO by solution casting approach and then dried at ambient temperature to develop a MWCNTs-PEO film. The integration of the MWCNTs-PEO film as passive Q-switcher is by attaching a small portion of the developed film at the end of fibre ferrule in the laser cavity with ring configuration to generate pulse laser as shown in Fig. 1.

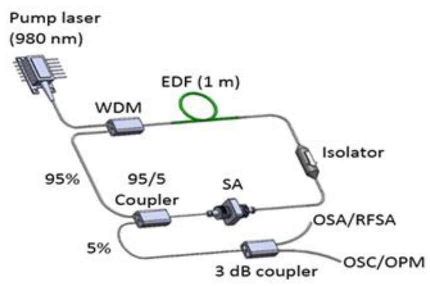

Fig.1 experimental setup

The experimental works reveal a low threshold incident input pump power of 8.54 mW for pulse laser generation. The proposed Q–switcher operates at input pump power ranges from 8.54 mW to 13.8 mW with central wavelength of 1560.34 nm. We observe the tunable repetition rate from 9.9 kHz to 20.8 kHz and the pulse width narrowed from 36 µs to 17.8 µs. The laser produces maximum instantaneous output peak power and pulse energy of 1.55mW and 29 nJ, respectively. Fig. 2 shows the repetition rate and peak power versus pump power.The low threshold input power for pulse laser generation is attractive and could find an application especially in material processing.

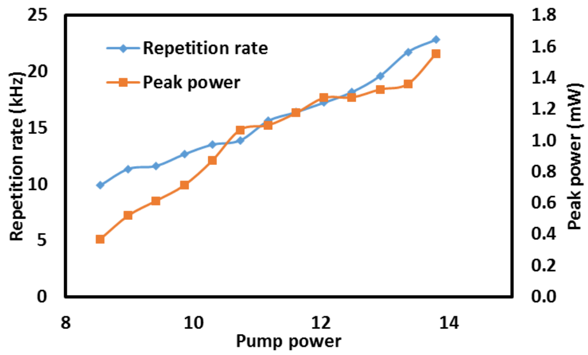

Fig. 2 repetition rate and peak power versus pump power

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