QUASI-STATIC AND DYNAMIC COMPRESSION BEHAVIOURS OF BIOCOMPOSITES

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DECLARATION

I declare that this project report entitled "Quasi-static and dynamic compression behaviours of biocomposites" is the result of my own work except as cited in the references.

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Date : 27 JUN 2016

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 the degree of Bachelor of Mechanical Engineering (Structure & Materials).

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DEDICATION

To my beloved family and friends

ABSTRACT

The focus of this research is to study the effect of strain rates on the mechanical behaviour of PALF reinforced PLA biocomposite. This research investigates the effect of test speed on the mechanical behaviour of the biocomposite when subjected to both quasi-static and dynamic loading. The specimen used in this project is PALF reinforced PLA biocomposite and three type of testing were carried out including Quasi-static indentation testing, drop weight impact testing and surface morphological analysis using SEM. In this study, quasi-static indentation test are carried out at two different velocities which are 1 mm/min and 2 mm/min. Drop weight impact test are carried out at velocities 1 m/s, 1.5 m/s, 2 m/s, 2.5 m/s, 3 m/s and 3.5 m/s. From the result velocity 1mm/min for quasi-static indentation test had maximum peak force which value 2480. 56 ± 88.55 N. In drop weight impact test the maximum peak force at speed 2.5 m/s which value 825.2 ± 86.89 N and total energy absorbed is 5.79 ± 0.67 J. From the results, maximum force and energy against time are directly proportional. The load and energy increased with in increasing time. Several type of damages were absorbed under both impact test and this include upper skin failure, skin core debonding and core crushing.

ABSTRAK

Fokus kajian ini adalah untuk mengkaji kesan kadar halaju rendah pada tingkah laku mekanikal komposit polimer PLA diperkuat serat daun nanas. Kajian ini menyiasat kerosakan kesan daripada biokomposit pada kelajuan rendah. Spesimen yang digunakan dalam projek ini adalah komposit polimer PLA diperkuat serat daun nanas dan tiga jenis ujian akan dijalankan termasuk ujian lekukan Quasi-statik, ujian hentaman dan analisa permukaan morfologi menggunakan mesin imbasan mikroskop elektron . Dalam kajian ini, ujian lekukan Quasi-statik dijalankan dengan dua halaju yang berbeza iaitu 1mm/min dan 2 mm/min. Untuk ujian hentaman dijalankan pada kadar kelajuan adalah 1 m/s, 1.5 m/ s, 2 m/s, 2.5 m/s, 3 m/s dan 3.5 m/s. Keputusan ujian pada 1mm/min untuk ujian lekukan quasi-statik mempunyai nilai daya yang tinggi iaitu pada 2480.56 ± 88.55 N. Dalam ujian hentaman, daya maksimum terhasil pada kelajuan 2.5 m/s iaitu 825.2 ± 86.89 N dan jumlah tenaga diserap adalah 5.79 ± 0.67 J. Dari kuasa keputusan dan tenaga terhadap masa adalah berkadar terus, daya dan tenaga meningkat jika masa dinaikkan. Beberapa jenis kerosakan telah diserap di bawah kedua-dua ujian kesan dan ini termasuklah kerosakan skin, teras bercantum dan kerosakan teras.

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Secondly, I would like to thank a senior named Siti Nur Rabiatuladawiyah Binti Ramli for spending her time to guide me. She has shared knowledge in the field of composite with me and guide me to do experiment. Also, I would like to thank laboratory staff of Faculty Mechanical Engineering (UTeM) and En. Faizol (UiTM) for they kindness in suggesting me the suitable time to use laboratory equipment for his action saved me a lot of time.

I would like to thank my course mates for giving me their support, patience and encouragement. Finally, I would like to thank my family for their support.

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PALF	Pineapple Leaf Fibre
PLA	Polylactic acid
SEM	Scanning Electron Microscope
ASTM	American Standard of Testing and Material

LIST OF SYMBOL

σ_f	=	Fracture stress
E_b	=	Modulus of elasticity for flexural testing
P	=	Load at a given point on the load deflection curve in flexural test
L	=	Support span, mm
b	=	Width of the beam tested, mm
d	=	Depth of the beam tested, mm

CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

The combination of various synthetic reinforcing fillers with many polymer composites has been initiated during the past decades. The improvement in mechanical properties and to meet the demand characteristics in actual applications has become the main purposes in modification of composites. The result from this has brought the academic and industrial people of polymer composite towards the biodegradable polymers from renewable resources for many kind of application [1]. As a result of growing awareness of global environment, the green products which have criteria such as the sustainability, eco-efficiency, industrial ecology, green chemistry and engineering is integrated into the development of new products. Hence, numerous studies are proceeded to find ways in utilizing the natural fillers as the replacement of synthetic fibers as reinforcing fillers. Example of natural fibre include pineapple leaf (PALF), kenaf, sisal, jute and rice straw.

Natural fiber as reinforcement in comparison to those of synthetic features many advantages such as flexibility, lightness, easier and safer in handling and working condition, easy to fabricate on intricate required shape with economic savings. They are broadly known and utilized in many areas such as building industry, transportation and consumer goods [2].

This research work focuses on the mechanical behaviour of the PALF reinforced PLA biocomposites o when subjected to both quasi static and dynamic loading via quasi static compression and drop weight impact testing.

Quasi-static load means the load is applied so slowly that the structure deforms also very slowly (very low strain rate) and therefore the inertia force is very small and can be ignored. Example of low velocity impact such as tool drop, runaway stones and tire blow out debris [3]. Although the visual examination of the impacted surface may reveal very little damage but significant damages might exist between the surface and the core of material. This type of damages will leads to reduction of the compressive and bending strength of biocomposites.

1.2 OBJECTIVES.

The objectives of this project as listed below :

1. To study the strain rate effects on the mechanical behaviour of biocomposites.
2. To study the effect of different speed on the mechanical properties of biocomposites.

1.3 SCOPES.

The scopes of this project are listed as below :

1. Characterization of the raw material.
2. Fabrication of the biocomposites.
3. Mechanical testing via quasi-static compression and drop weight testing.
4. Surface morphology via scanning electron microscope (SEM).

1.4 PROBLEM STATEMENT.

Numerous studies on biocomposites have been reported, particularly focusing on the quasi static response. Meanwhile, there is limited findings on the dynamic response of the biocomposites, i.e when subjected to low velocity impact. Hence this project aims to investigate further into this area with focus on PALF reinforced PLA biocomposites.

1.5 PLANNIG AND EXECUTION.

Table 1.1 shows the all research activities against the time frame needed to complete the final year project 1 (PSM 1). The project is started in week 1 which is selection a suitable topic. Following this experimental work includes design of experiment are set out. Fabrication of test panels will be do around week 5 to week 10. The test panels are then subjected to several testing includes mechanical, physical and thermal characteristic.. After all the test is finish, the data collected will be analysis and report will be writing. The seminar will be conducting in week 14. In addition, literature reviewed will be do while all process is conduct. For this PSM 1 , preliminary experimental work are done to assess the of the biocomposites and to characterize the raw material. Several mechanical test were also conducted including tensile,flexural, and charpy impact test,as well as thermal analysis via DSC. Further work wiil be conducted in PSM II.

Table 1.1 : Grant Chart For Final Year Project 1 (PSM I).

WEEK / ACTIVITIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Research Title Selection	■	■												
Literature Review	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Experiment Design	■	■	■	■	■									
Fabrication • PLA • Composites (Short Fibre)					■	■	■	■	■	■				
Characterization Testing • Physical • Thermal • Mechanical									■	■	■	■		
Data Analysis											■	■		
Report Writing												■	■	
Report Submission													■	
PSM 1 Seminar														■

Table 1.2 : Grant Chart For Final Year Project II (PSM II).

WEEK / ACTIVITIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Material Review	■	■												
Experiment Design		■	■											
Experimental Work			■	■	■									
Fabrication Sample					■	■	■	■	■	■				
Mechanical Testing • Compression • Drop Weight							■	■	■	■	■	■		
Morphological Studies											■	■		
Analysis & Discussion on Result											■	■	■	
Report Writing												■	■	
Report Submission													■	
PSM II Seminar														■

CHAPTER II

LITERATURE REVIEW

2.1 COMPOSITES

Composites is a combination of two or more materials where it consist of the reinforcing elements, fillers and composites matrix binder in which the new material are different in composition on macro-scale [4]. Normally the matrix material found in the composite materials is the constituent that is consistent and is frequently present in the big amount in the composite. In addition, the reinforcement is the second constituent in a composite material and it is typically alluded to as the strengthening stage since it improves the mechanical properties of the matrix. As a result, it will make it harder, more grounded and stiffer than the matrix.

One of the reasons why composites are used because of homogeneous structural material that be found has all of needed characteristics for a given application [5]. By strengthening the materials its become more harder and lower density if the fabrication and designing is done correctly. The essence of the concept of composites is that the load is applied over a large surface area of the matrix. Matrix then transfers the load to the reinforcement, which being stiffer, increases the strength of the composite.

Some of simple example of composites that we can see in daily life is concrete. Concrete is made by mixing the cement, sand and aggregate. By combine this three material, it produce a good compression strength that can resist squashing. In addition, to make its more stronger, studies have found to combine the compound with the rods or wire to increase its tensile strength. This called reinforced concrete [6].

Composites offers many advantages to the industry. Some of these advantages are [7] :

i) Reinforcement of the resin resulting in increased tensile strength, flexural strength, compression strength, impact strength, rigidity and combination of these properties.
ii) Increased size stability.
iii) Improved fire retardancy.
iv) Corrosion protection.
v) Improved electrical properties; reduction of dielectric constant.
vi) Coloring.
vii) Improved processibility, controlled viscosities, good mixing, controlled orientation of fibres.

2.1.1 Thermoplastics.

Thermoplastic, is a material that is plastic or deformable, melts to a liquid when heated and freezes to a brittle, glassy state when cooled sufficiently. A thermoplastic material will flow at elevated temperatures (above the glass transition temperature or crystalline melting point), and the solidified polymer can be reheated as many times as desired and it will do the same thing. These include polyethylene, polypropylene, polystyrene and polyvinyl chloride [7].

2.1.2 Thermoset.

Thermosetting plastics (thermosets) are polymer materials that cure, through the addition of energy, to a stronger form. Thermoset, once their shape has been made by casting or by plastic flow at elevated temperature, will not longer melt or flow on reheating. Principle thermosets are epoxies, polyesters and formaldehyde-based resins. When the molecular weight has increased to a point so that the melting point is higher than the surrounding ambient temperature, the material will forms into a solid material during the reaction. After it is cured, a thermoset material cannot be melted and re-shaped. They do not lend themselves to recycling like thermoplastics, which can be melted and re-molded [7].

2.2 BIOCOMPOSITES.

Nowadays, many studies have been done in studying the behaviour of biocomposites. It's due to the environmental awareness of an non-renewable synthetic. The outcome from utilizing the reused polymers as a part of the configuration of biocomposites product with the enhancing of that reused polymer material properties by the consolidation of renewable support such normal fiber getting from the waste of farming product is the conceivable approach to let down the environment impact. Furthermore, biocomposites has many advantages such as lower manufacturing costs and lower weight. Biocomposites means the combination of natural fibres with bio based matrices. Figure 2.1 shows the development of biocomposites from renewable resources and then the stage separates to two combination to formed the biocomposites [8].

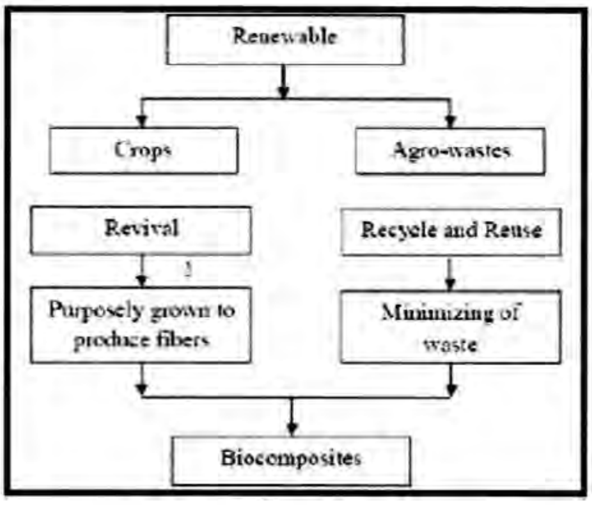

Figure 2.1 : Development of biocomposites from renewable resources [8].

As far as the fortification, this may include plant strands, for example, cotton, flax, hemp, pineapple leaf fibre, kenaf, and others. Matrices may be polymers, preferably got from renewable assets, for example, vegetable oils or starches. On the other hand, and all the more usually at the present time, manufactured, fossil-determined polymers preponderate and may be either "virgin" or reused thermoplastics, for example, polyethylene, polypropylene, polystyrene and polyvinyl chloride, or virgin thermosets, for example, unsaturated polyesters, phenol formaldehyde, isocyanates and epoxies [9].

2.3 POLYMER MATRIX MATERIAL.

In this research, polylactic acid (PLA) is chosen to be study as a biodegradable polymer to make as a matrix material in this research. Polylactic acid (PLA) is a starch-based polymer where the lactic acid is the essential monomer for the generation of PLA. PLA is biocompatible and biodegradable semi-crystalline polyester. High-atomic weight PLA I for the most part arranged by ring opening polymerization of the cyclic lactide dimer which thus, is gotten by the microbial aging of yearly renewable sugar-based materials, for example, starch or cellulose.

PLA has good mechanical properties which comparable to the petroleum based synthetic polymers. It is well-known with high elasticity modulus and high stiffness, and biocompatibility. These characteristic made PLA the important polymers utilized in the surgical-implant materials and drug-delivery systems nowadays [10]. Figure 2.2 shows the molecular structure of PLA .

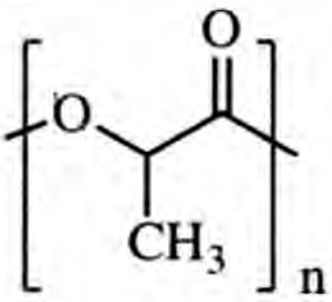

Figure 2.2 : The molecular structure of Polylactic Acid (PLA) [10].

2.4 NATURAL FIBRE REINFORCEMENT

Natural fibres have recently attracted the attention of scientist and technologist because of the advantages that these fibres provide over the conventional reinforcement materials. Biocomposites means the combination of natural fibre with bio based matrices. Example of natural fibre that can easily get in this country can be seen in Figure 2.3. Advantages of using natural fibers are low cost, low density, acceptable specific properties, ease of separation, enhanced energy recovery and biodegradability [11]. In addition, the natural fibre reduce wear on processing machinery and its no dangerous to human health and environment. Furthermore, natural fibre likes kenaf, or pineapple leaf fibre (PLAF) can