PENCIRIAN SIFAT KOMPOSIT POLIMER BERGENTIAN SEMULA JADI UNTUK APPLIKASI STRUKTUR

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CHARACTERIZATION OF NATURAL FIBRE POLYMER COMPOSITES FOR STRUCTURAL APPLICATION

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Specially dedicated to my beloved mother Wendy Lee Wai Yong, beloved father Liew Moon Fah, sister, brother, lecturers, and friends.

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ABSTRACT

Oil palm fibre which is relatively low cost and abundantly available has the potential as polymer reinforcement in structural applications. This study initially investigated the tensile behaviour of single oil palm fibre and physical properties like diameter, moisture content, moisture absorption and density. Then, the tensile behaviour of natural fibre reinforced polymer composites as a function of fibre volume ratio, fibre length and fibre surface modification was investigated. Lastly, flexural behaviour of reinforced concrete beam strengthened with unidirectional oil palm fibre composite was tested and was compared with reinforced concrete beam strengthened with woven glass fibre composite and ordinary reinforced concrete beam. Oil palm fibre is light but high moisture content, high moisture absorption and large variance of cross section area. The fibre tensile properties are relatively low compare to the literature which may due to degradation problems. The stiffness of the composite is significantly improved when the fibre volume ratio increased. At 10% of fibre volume ratio, the modulus of elasticity is increased up to 150 % compare to neat resin. Higher aspect ratio yield higher tensile strength and modulus of elasticity of the composite. The effect of alkali treatment increases 10% of the tensile strength of the fibres. Oil palm fibre composite could be used as strengthening material for reinforced concrete beam by increasing the flexural strength and stiffness of the reinforced concrete beam while maintaining the ductility of the beams.

ABSTRAK

Gentian minyak kelapa sawit yang kos rendah dan berlambak-lambak di negara ini merupakan bahan gentian yang bepontensi digunakan dalam aplikasi struktur. Kajian ini mengkaji sifat ketengangan gentian minyak kelapa sawit dan sifat fizikal gentian minyak kelapa sawit seperti diameter, kandungan kelembapan, sifat penyerapan kelembapan dan ketumpatan. Kemudian, sifat ketegangan composit polimer bergentian semula jadi dikaji. Antara parameter yang telah dikaji terhadap composit ialah kadaran isipadu gentian, panjang gentian dan modikasi permukaan gentian. Akhirnya, sifat lenturan rasuk konkrit bertulang besi yang diperkuatkan dengan komposit dikaji. Komposit yang terlibat dalam kajian lenturan rasuk termasuk bahan komposit polimer bertulang gentian sintesis – gentian kaca, dan bahan komposit polimer bertulang gentian semula jadi – gentian kelapa sawit. Daripada kajian ini, gentian minyak kelapa sawit adalah bahan yang ringan tetapi kandungan kelembapan yang tinggi, penyerapan kelembapan yang tinggi dan diameter yang perbezaan besar. Sifat ketegangan gentian kelapa sawit adalah rendah berbanding dengan gentian lain seperti gentian kaca mungkin disebabkan masalah pereputan. Keanjalan komposit bergentian kelapa sawit gentian diperbaiki apabila kadaran isipadu gentian bertambah. Gentian kelapa sawit yang lebih panjang menghasilkan composit yang lebih baik dalam sifat ketegangan komposit. Modifikasi permukaan gentian kelapa sawit dengan menggunakan rawatan akali hanya menambahkan daya ketegangan komposit. Komposit polimer bergentian kelapa sawit boleh digunakan bahan penguatan untuk rasuk konkrit bertulang besi dengan menambahkan kekuatan kelenturan dan kekerasan rasuk konkrit bertulang besi pada masa yang sama mengekalkan kemuluran rasuk.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF EQUATIONS

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 General

Natural fibres can be defined as slender threads created by nature. Comparatively, synthetic fibres are created by humans from minerals. Synthetic fibres are extensively used in advanced composites like airplanes, sports gadgets, automotive and infrastructure due to high strength and high performance when combine with plastic material. However, synthetic fibres like glass fibre are usually high cost compare to conventional materials like wood, steel and concrete which limit the use of synthetic fibres in advance applications only. Unlike the synthetic fibres, natural fibres are cheap and available in large quantity and yet environmental friendly[1].

In the past, natural fibres are used in early human civilization in fabric applications. High strength natural fibres like jute, cotton, silk and kenaf are used extensively and directly in one-dimensional products like lines, ropes and cloths. Others natural fibres like oil palm fibres, banana leaf fibres, and rice stalks fibres are residual agriculture product. They are usually disposed into land fill or disposed by open burning.

Environmental issues arise when these materials are in large quantities. Landfill method becomes not economical whilst open burning results air pollution and global warming.

Until recent decade, there is an increasing interest on natural fibres reinforced polymer. The potential of natural fibres replacing synthetic fibres in composite is possible[2]. In general, natural fibres offer high specific properties, low cost, non abrasive, readily available and environmental friendly where no synthetic fibres can surpass these advantages. These advantages attract scientists and technologists especially automobile industry to study on the behaviour of the natural fibres and the characteristic of the natural fibre reinforced composites. However, certain drawbacks such as incompatibility with hydrophobic polymer matrix, the tendency to form aggregates during processing, poor resistance to moisture greatly reduce the potential of natural fibres to be used as reinforcement in polymer[2]. Moreover, no literature is made on the potential of natural fibre composites in structural application. Therefore, a detail study on the characteristic of natural fibre composites is required to investigate the potential of natural fibre composites in structural use.

1.2 Background and Rationale of the Project

Natural fibre reinforced polymer consist of resin as a matrix and natural fibres as reinforcement. Natural fibres are formed in a very complex system and there is an enormous amount of variability in fibre properties, unlike synthetic fibres which is homogenous and constant in physical and mechanical properties. The variability of natural fibres depends upon the origin of the fibres, the quality of plant and location[3]. Hence, it is no doubt that the challenges of the natural fibres use as reinforcement in composite are greater than synthetic fibres.

In the past, the development of fibre reinforced polymeric materials in civil engineering increased rapidly where these materials in civil engineering applications are divided into two categories, structural and non structural. Structural applications are designed to sustain some degree of load like bridge, truss, I-beam, column, repair and rehabilitation applications. While non structural applications are non load bearing and they are designed based on quality guidelines and aesthetic considerations. In Malaysia, the utilizations of fibre reinforced polymeric materials in structural applications are still very low. One of the factors is the high cost of raw materials where mostly are imported from China, Japan, Europe and the United State of America[4]. Can local and low cost natural fibres substitute synthetic fibres in reinforced polymeric materials for structural applications?

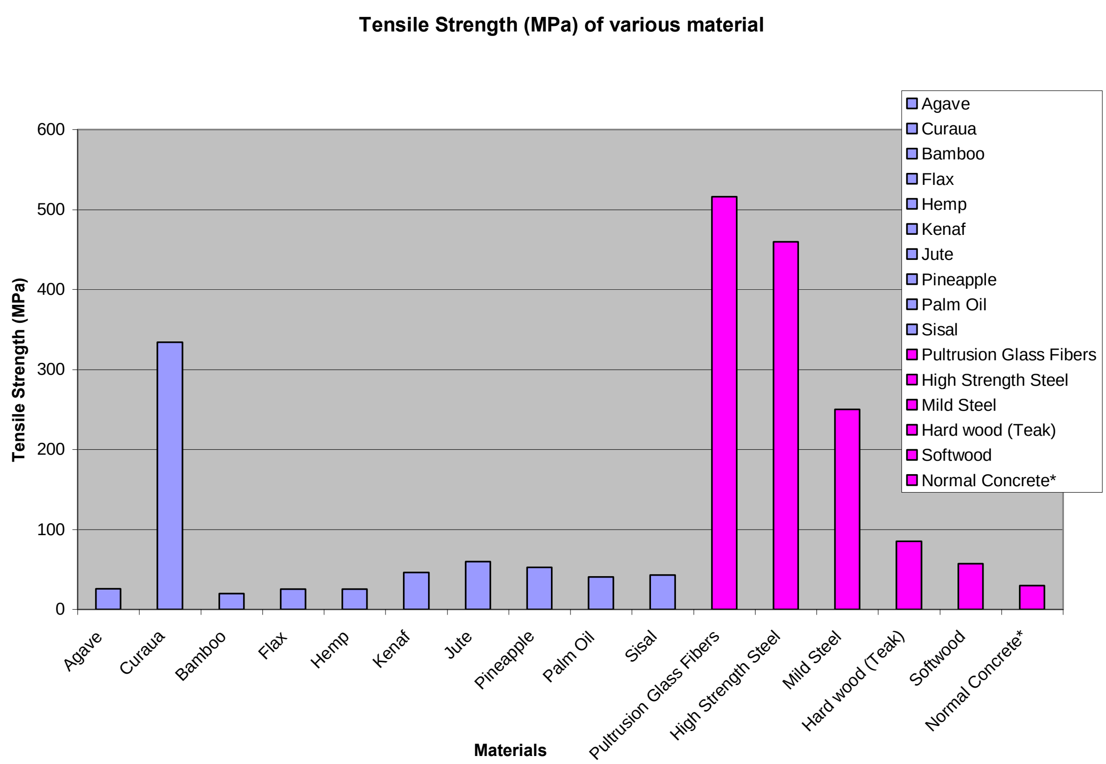
Materials in structural applications must have sufficient mechanical strength and durability to the surrounding environments. Figure 1shows the basic mechanical properties like tensile strength of the natural fibres reinforced composites are compared with the most common materials like FRP, steel, wood, and concrete. Some of the natural reinforced composites materials (like curuau fibres) are comparable to wood, steel and FRP. However, the overall average tensile strength of the natural fibre reinforced composites falls in the range of hardwood and softwood. Therefore, natural fibre reinforced composites can replaced conventional material like timber and wood in structural applications.

The wide variety of natural fibres exhibit different types of behaviour and characteristic. To limit the scope, oil palm fibres and pineapple leaf fibres are employed in this study because it can be obtained locally.

Malaysia, the world's largest palm oil producer, produces more than 15.8 million tonnes of crude palm oil every year[5]. The oil palm fibres are usually treated as residue product and cause environmental problems when disposing them. Oil palm fibres can be extracted from empty fruit bunch and its coirs. Every single empty fruit branch of oil palm yields 400 grams of oil palm fibre and weight of every fresh fruit bunch of oil palm is around 25 kg[6]. About 8.8 million tonnes of oil palm fibres can be produced every year and yet the mesocarp oil palm fibres are not taking into account. The enormous quantity of oil palm fibres is usually disposed by two methods, open burning or land fill[6].

Currently, reports have proved that treated oil palm fibres successful act as reinforcement in composites and durable to environmental attacks[7].

Pineapple leaf fibre is another natural fibre that can be obtained locally and exhibits excellent mechanical properties. The pineapple leaf fibre consists of high cellulose material and is very often associates with excellent mechanical properties. L.Uma Devi et al. study on pineapple leaf fibre composites and the composite exhibit excellent mechanical properties in tensile strength, flexural strength and impact strength. He concluded that the pineapple leaf fibres are good in reinforcing and suitable to be structural applications.



* Compression strength is compared.

Figure 1.1: The tensile strength of natural properties of natural fibre composites and other civil engineering materials.

1.3 Overall Objectives and Scope of the Study

1.3.1 Objectives of the study:

The main objectives of the study are:

1) To characterise the physical and mechanical properties of natural fibre - oil palm fibres.
2) To characterise the tensile properties of unidirectional oil palm fibre composites as a function of fibre volume ratio, fibre length, fibre surface modification.
3) To compare the mechanical behaviour of reinforced concrete beam strengthened with unidirectional oil palm fibre composite, reinforced concrete beam strengthened with woven glass fibre composite and ordinary reinforced concrete beam.

1.3.2 Scope of the study:

The scope of study is established to achieve the objectives and this study will be mainly concentrated on experimental works. To limit the scope, only oil palm fibres and pineapple leaf fibres are employed as natural fibres. The fibres are obtained in fresh condition and require the extraction process.

Synolac 3317AW, unsaturated polyester resin purchased from Cray Valley Company is employed in this study for matrix system. All natural fibre reinforced polymeric material is fabricated using the closed mould-hand lay up system.

All testing methods and procedures are specified according to British Standard and American Society Testing Method.

Firstly, the physical and mechanical properties of oil palm fibres are determined. The physical properties tests include fibre length, fibre diameter, moisture content, moisture absorption and fibre density. Only tensile properties are interested in determining mechanical properties. The tensile properties include tensile strength, strain and modulus elasticity of oil palm fibres.

Due to high efficiency in contributing tensile properties, only unidirectional oil palm fibres composites are interested and tested. Three main factors influence the desired mechanical properties of unidirectional oil palm fibre composites, namely fibre volume fraction, fibre aspect ratio and interfacial shear strength. Fibre volume fraction influence the tensile properties directly, where more fibres are used, the tensile properties are improved. However, the tensile properties may start to decline after the optimum point. The tensile properties are also affected by fibre aspect ratio where high fibre aspect ratio composite usually improve the tensile properties of the composite. Another important factor is interfacial shear strength of oil palm fibres which can be improved by using alkali treatment.

Different fibre volume fraction, fibre aspect ratio and interfacial shear strength of oil palm fibre composites are fabricated and tested under tensile force to determine tensile properties. Comparisons are made and the desired tensile properties of oil palm fibre are used in the structural application.

In this study, the desired tensile properties are used as strengthening material in reinforced concrete beam. A total of three 2000 mm x 150 mm x 250 mm reinforced concrete beams are fabricated. The first beam maintain as control beam while the rest of the beams are strengthened with unidirectional oil palm fibre composite plate and woven glass fibre composite plate. Similar fibre volume fraction is employed for both strengthening material.. The mechanical behaviours of the beams are analysis and discussed.

1.4 Summary

The development of natural fibre composite for structural application is still at infancy stage. Due to the attractive properties like high specific strength and high specific modulus, natural fibre composite rapidly gains popularity in the use of automobile applications and structural applications. Compare to synthetic fibre composite, natural fibres are low cost and abundant in agro base country. The use of natural fibres in composites can reduce the impact of environmental issues.

This study is a preliminary stage to made natural fibre composite as structural application where only mechanical properties is focused. In fact, durability of this new material in structural application is equally important. The use of natural fibre composite in structural application is possible but requires more study and development in future.

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