UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A STUDY ON NEW MATERIAL OF BUILDING PARTITION WALL FABRICATED FROM BIOCOMPOSITE COCONUT FIBER-BASED

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours. The member of the supervisory is as follow:

……

(MOHD AFDHAL BIN SHAMSUDIN)

ABSTRACT

The purpose of this research is to develop new material of building partition wall and to determine the material properties of the new material. The new material is consist of coconut fiber as the reinforcement and mixture of epoxy resin and cornstarch as the binder. The mass scale use of synthetic fibers and synthetic binders in industry have a negative impact towards environment. Moreover, it also can impact human health and animal health. The use of natural binder and natural fiber can reduce the dependency on the synthetic binder and synthetic fiber as well as reduce the negative impact towards the environment, humans and animals health. Coconut fibers are extracted from the outer shell of a coconut. Coconut trees or its scientific name, *Cocos nucifera* are commonly found planted non-commercially in Malaysia especially in rural areas. The epoxy resin is a thermosetting matrix or resin that have more than one of epoxide groups that consist in the molecule. Epoxy resin is widely used as a versatile adhesive that can be used with several materials including wood, fabric, glass or metal. Cornstarch is a biodegradable polymers that can be used in many application including cooking ingredients, used as thickening agent and adhesive purpose. The specimen samples are prepared by mixing the coconut fiber and the mixture of epoxy resin and cornstarch by using hand lay-up technique. The prepared specimen samples are tested for tensile test and flexural test using Instron 5969 Series Universal Testing Machine (UTM). All the test was adhered to ASTM D3039 and ASTM D790 respectively. Based on the obtained results, it was found out that the specimen samples of 20% coconut fiber + 80% epoxy resin and cornstarch showed the best result for the tensile test and flexural test. By using the 20% coconut fiber + 80 epoxy resin and cornstarch composition, the building partition wall was fabricated. Lastly, all the objectives of this research have been met where the new material of building partition wall has been developed and the material properties of the new material have been determined.

ABSTRAK

Tujuan penyelidikan ini adalah untuk membangunkan bahan baru untuk dinding pembahagi bangunan dan menentukan sifat material bahan baru tersebut. Bahan baru ini terdiri daripada serat kelapa sebagai penguat dan campuran resin epoksi dan jagung sebagai pengikat. Penggunaan skala besar serat sintetik dan pengikat sintetik dalam industri mempunyai kesan negatif terhadap alam sekitar. Selain itu, ia juga boleh memberi kesan kepada kesihatan manusia dan kesihatan haiwan. Penggunaan pengikat semulajadi dan serat semulajadi boleh mengurangkan kebergantungan pada pengikat sintetik dan serat sintetik serta mengurangkan kesan negatif terhadap alam sekitar, kesihatan manusia dan haiwan. Serat kelapa diekstrak dari kulit kelapa bahagian luar. Pokok kelapa atau nama saintifiknya, Cocos nucifera biasanya ditanam secara bukan komersial di Malaysia terutama di kawasan luar bandar. Resin epoksi adalah matriks termoset atau resin yang mempunyai lebih daripada satu kumpulan epoksida yang terdiri daripada molekul. Resin epoksi digunakan secara meluas sebagai pelekat serba boleh yang boleh digunakan dengan beberapa bahan termasuk kayu, kain, kaca atau logam. Kanji jagung ialah polimer bio-terurai yang boleh digunakan dalam banyak aplikasi termasuk bahan masakan, digunakan sebagai agen penebalan dan tujuan pelekat. Sampel spesimen disediakan dengan mencampurkan serat kelapa dan campuran resin epoksi dan tepung jagung dengan menggunakan teknik “hand lay-up”. Sampel spesimen yang disediakan diuji untuk ujian tegangan dan ujian lentur menggunakan Instron 5969 Series Universal Testing Machine (UTM). Semua ujian telah mematuhi ASTM D3039 dan ASTM D790. Berdasarkan keputusan yang diperoleh, didapati sampel spesimen 20% kelapa serat + 80% epoksi resin dan kanji jagung menunjukkan hasil terbaik untuk ujian tegangan dan ujian lenturan. Dengan menggunakan 20% serat kelapa + 80 epoksi resin dan komposisi jagung, dinding pembahagi bangunan dibuat. Akhir sekali, semua objektif kajian ini telah dipenuhi di mana bahan baru dinding pembahagi bangunan telah dibangunkan dan sifat material bahan baru telah ditentukan.

DEDICATION

To my beloved mother, my beloved father, my family, my friends and my supervisor, Mr Afdhal Bin Shamsudin.

ACKNOWLEDGEMENT

Alhamdulillah, praise to Allah SWT the Almighty for his blessing in giving me chance, strength, ideas, determination and patience in completing this final year project research which is a compulsory graduation requirement of my Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours.

In addition, the project would not be completed without the guidance, assistance and encouragement from peoples around me especially my supervisor, Mr Mohd Afdhal Bin Shamsudin and assistant engineer, Mr Azizul Ikhwan Bin Mohd. I want to express my deepest thanks and gratitude to my supervisor for his guidance, comments, advices and suggestions in helping me completing this research.

Not to mention my friends who supported me and helping me in completing this research. Last but not least, I want to express my deepest gratitude and thanks to my family that had been very supportive, understanding and praying for my health and sanity in completing this research.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ASTM	-	American Society for Testing and Material
°C	-	Degree Celsius
PAH	-	Polycyclic Aromatic Hydrocarbon
OPEC	-	Organization of the Petroleum Exporting Countries
OH	-	Hydroxyl group
CO_2	-	Carbon Dioxide
cm	-	Centimeter
mm	-	Milimeter
m	-	Meter
μm	-	Micrometer
MPa	-	Mega Pascal
GPa	-	Giga Pascal
N	-	Newton
CAD	-	Computer Aided Design
FEA	-	Finite Element Analysis
UTM	-	Universal Testing Machine

CHAPTER 1

INTRODUCTION

1.1 Background

Composite is considered as one of the solution to the lack of required properties of a material for a specific application. According to W. D. Callister (2007), composite is made up of two or more individual materials, which taken from the basic material types like metals, ceramics and polymers that intended to achieve a combination of properties that is not displayed by any single materials. Furthermore, composite is intended to exhibit the best characteristics from the basic materials that is not suitable for specific application that require more demanding characteristics. Bio-composite is made up of two or more naturally derived materials.

Bio-composite consists of fiber and binder or matrix that naturally derived. D. Geentanjali et. al., (2016) stated that the natural fibers have been gaining popularity in the construction industry compared to synthetic fibers because of their renewable nature, high availability at low cost, high stiffness, and the encouraging use in different applications. Natural fibers can be found from natural resources like plants and animals. Natural binder or matrix also can be found from natural resources especially from plants.

According to B. Nystrom (2007), construction and automotive industries increasing the use of natural fibers from coconut, flax, jute, hemp, pineapple, sisal and many more. Automotive company like Mercedes Benz, DaimlerChrysler and Toyota are applying composite from natural fiber for their interior and exterior parts and components. Industries are interested to use natural fibers as it relatively cheaper than synthetic fibers that will cost more.

The natural fiber that will be used is derived from coconut coir. Coconut fiber can be derived from its coir or bunch. Coconut coir is the outer shell of a coconut. Coconut fiber can be found at any areas that coconut trees are planted. In Malaysia, coconut trees are commercially planted in Johore, Selangor and Perak (Hakim. 2011). M. Ali et, al. (2012) stated that coconut advantages are moth-proof, fungi and rot resistant, good temperature and sound insulator, flame retardant, unaffected by moisture and dampness, tough and durable and it can back to its original shape even after constant use.

The natural binder or matrix that will be used is derived from corn. The corn starch is derived from corn grain. The corn starch is very multipurpose as it can be used in many application. Corn starch found to be perfect for adhesive purposes. The corn starch can be found retailed anywhere in big supermarket or even small retail store. The use of corn starch as binder is very suitable in South Asia especially in Malaysia as corns are widely available in Malaysia. Malaysia's climate is very suitable for corn farming. The suitable temperature for corn farming is between 30°C to 35°C and can ready to harvest in 68 days to 72 days according to Norkaspi et. al., (2010).

Building partition wall is a solid structure that is used to divide a large space into a smaller space. Building partition wall is widely used in commercial building, office building, hotels building, and housing. It is considered as an alternative rather than building a concrete wall that will consume more money, time and effort. Building partition wall is easy to install and will save a lot of cost, time and effort. There are variety of choice for material that used for building partition wall.

According to Qian Wang and Cong Zhang (2018), the building partition wall can be divided into three types which are masonry partition, skeleton partition and plate partition. Masonry partition build with clay brick. Skeleton partition consists of panel and stud. Usually the material that used for are steel, gypsum and wood. The plate partition uses same height plate partition. Typical plate partition materials are plywood, plasterboard and particle board. The building partition wall for this research is plate partition type. The end product is a scale model of building partition wall fabricated from the corn starch based bio-composite reinforced with coconut fiber.

1.2 Problem Statement

Further studies on polymer composites reinforced with natural fibers have been favoured as an initiative to protect environment and to promote effective and convenient waste management (Moura, A.D.S et. al. 2019). Nowadays, the composite industry gaining some interest towards natural fibers as the petroleum sources depleted over time plus with the rising of awareness regarding the sustainable of environment for future generations (Al-Hajaj et. al., 2019). These are positive signs in order to reduce the dependency on synthetic fiber and synthetic binder. The use of natural fiber and natural binder will significantly lower the demand for synthetic fiber and binder. Over the past few years, the world production and trade in synthetic fiber showed an increasing trend. In 2012, the world synthetic fiber production was 62,213,000 metric tonne and the export total up to 30.84 billion USD (Nayak et. al., 2012). This trend shows that there is still high demand for synthetic fibers. Synthetic fibers produced from petroleum source that is limited. Sooner or later, petroleum source will depleted due to high usage. According to BP website, global oil reserves in 2017 reduce slightly about 0.03% which is 0.5 billion barrels. The global oil reserves at that time was 1696.6 billion barrels which was calculated to be sufficient for another 50.2 years according to the same consumption rate. This proved that the use of petroleum based material is not sustainable for long term. Moreover, the use of synthetic composites have negative impact towards environment. According to Mahmoud et. al., (2018), the hydrocarbons that used in the synthetic composites can combine together becoming a molecules that can cause pollution. So, the use of bio-composite coconut fiber and mixture of epoxy and cornstarch will help to solve these problems. This new material of building wall partition is made up from coconut fiber and mixture of epoxy resin. The use of natural fiber and natural binder can reduce the dependency of the synthetic fibers and synthetic binders.

1.3 Objectives

Based on the stated background and problem statement, the objectives of this project is:

1. To develop new material of building partition wall.
2. To determine the material properties of the new material.

1.4 Scope

In order to meet the objectives, two scope have been determined:

1. The new material of building partition wall developed by fabrication of biocomposite corn starch and epoxy resin based reinforced with coconut fiber.
2. The material properties of the new material determined through tensile test and flexural test using Universal Testing Machine (UTM).

CHAPTER 2

LITERATURE REVIEW

2.1 Problem of synthetic based composite

Synthetic based composite is made up from synthetic fiber and synthetic binder or matrix. Examples of synthetic fiber as stated in Figure 2.1 are nylon, polyester, acrylic, polyolefin, spandex and glass. However, the use of synthetic fiber and synthetic binder have a number of drawbacks. According to N. A. Mirza et. al., (2017), the usage of synthetic and plastic materials has soared at worrying pace forasmuch as 30 years ago. This is due to the impact of the synthetic based materials that can pollute environment in many ways. Moreover, the synthetic based composite relies to petroleum sources for its production. The petroleum source was known to be limited and are not sustainable for long term use.

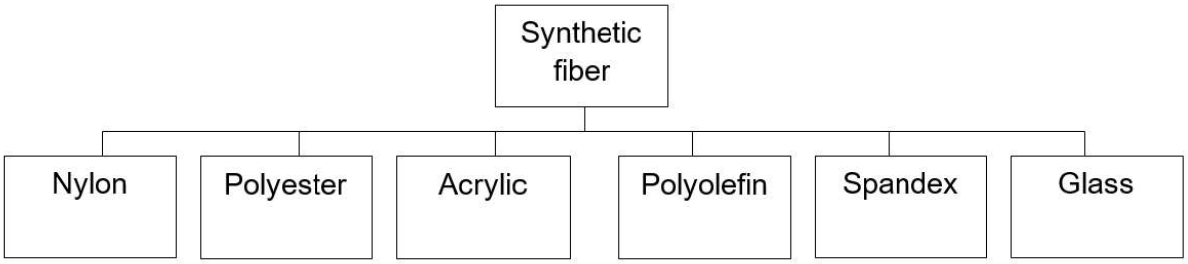

Figure 2.1: The example of synthetic fiber (Kozlowski R et. al., (2009))

According to M. Sanni (2019), petroleum can be described as an organic compounds that naturally exist in term of semisolid, liquid and gas. Examples of petroleum types are including bitumen, crude oil, and natural gas. M. Sanni (2019) stated that petroleum originates

from single celled organisms and complex organisms marine life like planktons and fishes respectively. These carbon contain organisms die and remain in ocean floor and buried under few kilometre of sediments. Kerogen, a mixture of organic chemical compound produced due to the high pressure and high temperature created by the overburden pressure developed by the layers of sediments. At the Earth's crust, kerogen releases hydrocarbons that will trapped in reservoir rock and eventually reaching the surface or escape directly to surface and loose volatile constituents to yield bitumen and tar.

The production of synthetic material requires petroleum hydrocarbons. Petroleum hydrocarbons are consist of various carbon bonds that form multi-complex structures. Examples of crude oil components are paraffin, branched paraffin, naphthene and aromatic as stated in Figure 2.2. When these petroleum hydrocarbons are bind together, it become molecules like aliphatic alkanes, alkenes and polycyclic aromatic hydrocarbons (PAH) (G. A. E. Mahmoud et. al., 2018). These molecules are known for their dangerous effect to the environment (Steliga et. al., 2012; Sarma et. al., 2004).

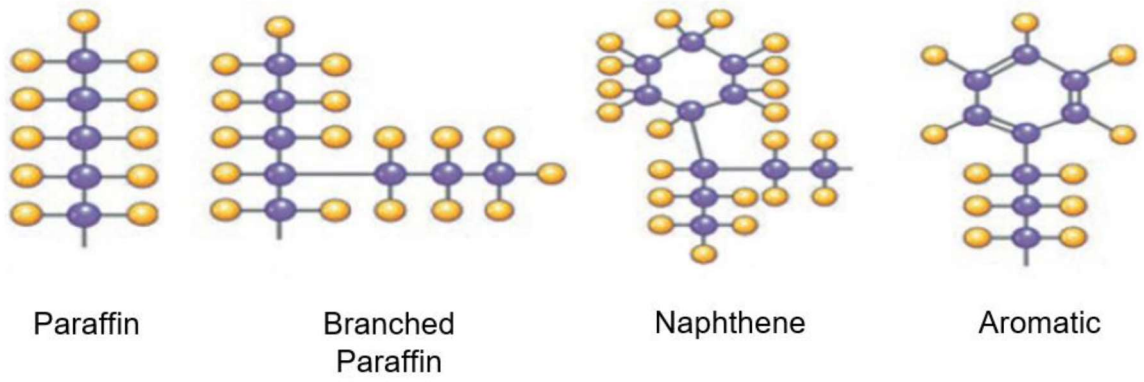

Figure 2.2: Different structures of crude oil components (G. A. E. Mahmoud et. al., 2018))

C. B. Chikere et. al., (2018) stated that hydrocarbon pollution has become a global scale environmental challenge due to the highly toxic nature of hydrocarbon chemical constituents. It is remarkable that some of hydrocarbon chemical constituents identified as mutagenic, carcinogenic and teratogenic (D. Wlóka et. al., 2017). These constituents are posing highly

pollution threat to our environment. Examples of the sources of hydrocarbons pollution are oil spills, accidents, storage, sabotage, artisanal refining and unauthorised disposal of synthetic fibers and synthetic binders as stated in Figure 2.3. Moreover, other than its highly toxic nature, it can prevent oxygen from entering the ocean during oil spill as the PAHs compounds from the petroleum hydrocarbons are poorly soluble in water (D. Wlóka et. al., 2017). It will float on the ocean then sooner will sink in the ocean and this will endangering marine life. Oil spills can cause negative impact to the environment either on land, water or even air.

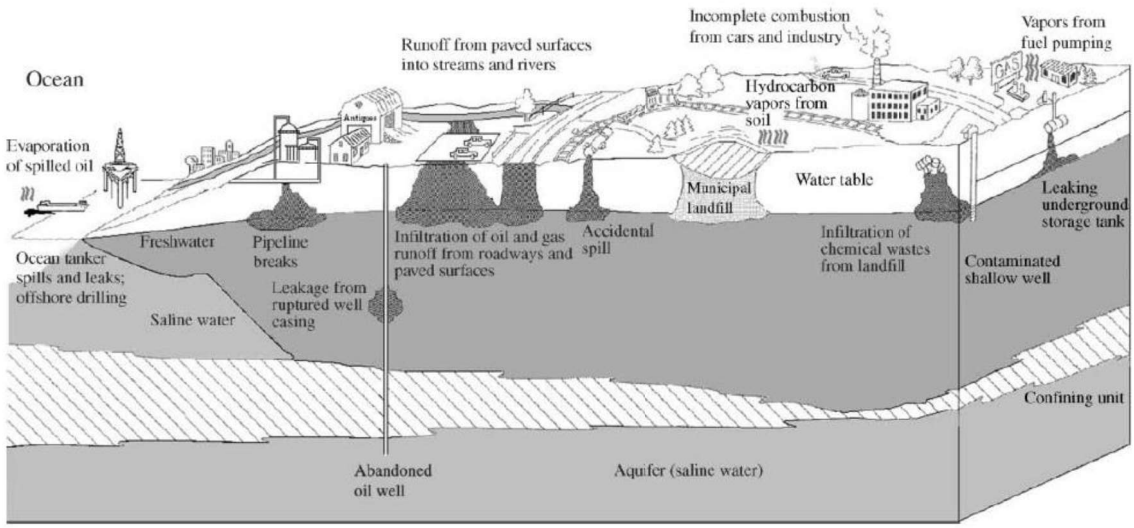

Figure 2.3: Modes of contamination by petroleum products (I. M. Cozzarelli et. al., (2003))