RECYCLED GLASS AND CARBON FIBER BY MECHANICAL PROCESS FOR CONCRETE COMPOSITE

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

B051710191 BACHELOR OF MANUFACTURING ENGINEERING (Hons.) 2021 UTeM

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This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Hons.)

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2020/2021

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: **RECYCLED GLASS AND CARBON FIBER BY MECHANICAL PROCESS FOR CONCRETE COMPOSITE**

Sesi Pengajian: **2020/2021 Semester 2**

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I hereby, declared this report entitled "Recycled Glass and Carbon Fiber by Mechanical Process for Concrete Composite" is the result of my own research except as cited in references.

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Date : 16 July 2021

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for the Degree of Bachelor Manufacturing Engineering (Hons). The member of the supervisory committee are as follow:

………………………………………………

(DR. SYAHRIZA BINTI ISMAIL)

ABSTRAK

Sisa polimer menghasilkan dan memakan banyak polimer bertetulang gentian karbon (CFRP) dan polimer bertetulang gentian kaca (GFRP) kerana ia digunakan dalam pelbagai bidang seperti industri pembinaan, penerbangan, minyak dan gas, sukan dan angin. Bahan-bahan ini sangat digunakan dalam pengeluaran di seluruh dunia. Selanjutnya, orang akhirnya membuang bahan komposit ini ke sungai, dan lain-lain, dan bahan komposit tidak hancur cukup cepat. Di samping itu, kos penghantaran sampah yang tinggi ke tempat pembuangan sampah dan caj kualiti semula jadi per kilogram, iaitu RM10/kg. Tujuan kajian ini adalah pertama, untuk mengkaji ukuran serat yang sesuai untuk pembuatan konkrit dari kaca kitar semula dan gentian karbon dengan menggunakan kaedah kitar semula mekanikal. Kedua, untuk menilai sifat mekanikal konkrit yang disediakan menggunakan gentian kaca dan karbon kitar semula. Ketiga, untuk melakukan analisis morfologi pada permukaan konkrit yang retak menggunakan mikroskopi elektron imbasan (SEM) dan struktur kristal menggunakan Difraksi Sinar-X (XRD). Ukuran gentian pada 50μm untuk pembuatan konkrit dilihat sesuai dengan kaedah kitar semula mekanikal ini. Kekuatan tegangan utama dan modulus konkrit Young dengan gentian kaca kitar semula adalah yang tertinggi di antara konkrit biasa dan konkrit dengan serat karbon kitar semula masing-masing adalah 9.06 MPa dan 6.92 MPa. Oleh itu, konkrit dengan kemasukan gentian kaca kitar semula telah menghasilkan peningkatan luar biasa sekitar 10.49% pada kekuatan tegangan dan 53.78% modulus Young berbanding dengan konkrit biasa. Terakhir, lakukan analisis morfologi pada permukaan konkrit yang retak menggunakan mikroskopi elektron imbasan (SEM) dan Difraksi Sinar-X (XRD). Dari mikrograf SEM, ini menunjukkan dengan jelas bahawa gentian kaca kitar semula mempunyai ikatan kuat dengan konkrit. Selain daripada itu, penyebaran gentian kaca kitar semula yang baik dalam konkrit dijumpai yang cenderung memberikan kekuatan tinggi dan ikatan yang baik. Dari analisis XRD, konkrit dengan

konkrit gentian kaca, ia menghasilkan banyak puncak. Ini membuktikan bahawa adanya $Ca_3Si_2O_7$ dalam konkrit dengan gentian kaca kitar semula. Dengan cara demikian, ikatan antara $Ca_3Si_2O_7$ dalam konkrit dan SiO_2 dalam gentian kaca kitar semula adalah kekuatan yang kuat. Kajian ini menunjukkan dengan jelas pilihan yang layak untuk pengurusan sisa untuk gentian kaca kitar semula dan bahan serat karbon kitar semula melalui pengembangan aplikasi kitar semula akhir yang ekonomik yang akan menyumbang kepada industri komposit polimer yang diperkuat dengan gentian yang lebih lestari.

ABSTRACT

Polymer wastes produce and consume a lot of carbon fiber reinforced polymers (CFRP) and glass fiber reinforced polymers (GFRP) as they are used in various fields such as construction, aviation, oil and gas, sporting and wind industries. These materials are highly used in production throughout the world. Furthermore, people may end up throwing these composites materials into rivers, etc., and composite materials are not disintegrate fast enough. In addition, the high cost of sending waste to landfill and natural quality charge per kilogram, which is RM10/kg. The purposes of this study are firstly, to study the suitable fiber size for concrete fabrication of the recycled glass and carbon fibers by using mechanical recycling method. Secondly, to evaluate the mechanical properties of the concrete prepared using recycled glass and carbon fibers. Thirdly, to perform morphological analysis on the fractured surface of the concrete using scanning electron microscopy (SEM) and crystalline structure using X-Ray Diffraction (XRD). The fiber size at 50μm for concrete fabrication is seen to be suitable by using this mechanical recycling method. The ultimate tensile strength and Young's modulus of concrete with recycled glass fiber is the highest among normal concrete and concrete with recycled carbon fiber which is 9.06 MPa and 6.92 MPa respectively. Hence, the concrete with recycled glass fiber inclusion had yielded an extraordinary improvement of about 10.49% in the tensile strength and 53.78% of Young's modulus as compared to normal concrete. Lastly, perform morphological analysis on the fractured surface of the concrete using scanning electron microscopy (SEM) and X-Ray Diffraction (XRD). From the SEM micrograph, it shows clearly the recycled glass fiber had strong bonding with concrete. Other than that, a good dispersion of recycled glass fiber in concrete was found which tends to give high strength and good bonding. From the XRD analysis, concrete with glass fiber concrete, it produced many peaks. This proved that the present of $Ca_3Si_2O_7$ in concrete with recycled glass fiber. In such way, the bonding between $Ca_3Si_2O_7$ in concrete and the SiO_2 in recycled glass fiber were strong strength. This study

indicates clearly a viable option for waste management for recycled glass fiber and recycled carbon fiber materials through the development of an economical final recycling application that will contribute to a more sustainable fibre-reinforced polymer composite industry.

DEDICATION

Dedicated

To my beloved father, Jalaluddin Bin Muhiddin

To my beloved mother, Bousiya Begum

To my special supervisor, Dr Syahriza Binti Ismail

For giving me moral support, funding collaboration, encouragement and understanding.

Thank you so much and I love you all

ACKNOWLEDGEMENT

In the name of ALLAH, the most gracious, the most merciful, with the highest praise to Allah that I manage to complete this final year project successfully without difficulty.

First of all, I would like to express my highest gratitude to my beloved supervisor Dr. Syahriza Binti Ismail for her advice, variable information, guidance and also moral support. Her guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my Final Year Project. Without her assistance and dedicated moral support in every stage of the thesis study, this research would never be completed in time. Furthermore, I am also thankful to her for encouraging the use of correct grammar and consistent notation in my writings and for carefully reading and commenting on countless revisions of this research.

Next, I would like to show my special thanks to my co-supervisor, Mr Nor Akramin for his variable extra information, knowledge and also guidance in order to complete my Final Year Project. I am deeply grateful to him for helping me sort out the technical detail in my work.

Other than that, I would like to thank my lovely friend Muhd Shiddiq Bin Sabuddin and NurHaliana Syazwani Binti Mohd Halim who always gave me much motivation and moral support to improve my work.

Last but not least, I would like to thank my parents and to my brothers for supporting me spiritually throughout my thesis writing.

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LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
CFRP	-	Carbon Fiber reinforced Polymer
EOL	-	End of Life
GFRP	-	Glass Fiber Reinforced Polymer
MIGHT	-	Malaysian Industry-Government Group for High Technology
SEM	-	Scanning Electron Microscope
PMCs	-	Polymer Matrix Composites
PAN	-	Polyacrylonitrile
UHTC	-	Ultrahigh Temperature Ceramic
C-SiC-UHTC	-	Silicon Carbide Composites
GF	-	Glass Fiber
CF	-	Carbon Fiber
FRP	-	Fiber Reinforced Polymer
rCF	-	Recycled Carbon Fiber
vCF	-	Virgin Carbon Fiber
RAC	-	Recycled Aggregate Concrete
NAC	-	Natural Aggregate Concrete
FA	-	Fly Ash
SOP	-	Standard Operation Procedure
XRD	-	X-Ray Diffraction

LIST OF SYMBOLS

C	-	Carbon
Ca	-	Calcium
Si	-	Silicon
S	-	Sulphur
O	-	Oxygen
mm	-	millimeter
min	-	minute
%	-	percentage
°	-	degree
µm	-	micrometes
nm	-	nanaometer
N	-	Newton
kN	-	kilo Newton
g	-	gram
kV	-	kilovolts
mA	-	milliAmpere
MPa	-	Mega Pascal

CHAPTER 1

INTRODUCTION

Composite materials are simply a mixture of two or more different kinds of materials used together to incorporate the best properties or to impart new features which none of the component materials alone can achieve.

1.1 Background of Study

Recycled of carbon and glass fiber by mechanical process for concrete composite is the industrial project during my internship at G7 Aerospace. In this company, they will inspect, restore, alter, re-engineering from manufacturing, technical services and repair and revision services for parts and structures. During repair the composite material, some of the project may have fault. So that, the composite material need to throw to the dustbin. After the end of life of composite material, usually people may end up throwing to the rivers, planted or sending waste to the landfill. So that, propose that to recycling/sustainable of composite materials which require all engineering composite materials to be properly recovered and recycled, from end-of-life (EOL).

Material composites include strengthening components such as glass fibre, carbon fibre, kevlar and a matrix such as polyester resin, epoxy resin, etc. The most used reinforcement materials are fibre glass. They have many qualities, including high strength, high resistance to chemical conditions and low weight (Sabău, 2018).

Polymer wastes are particularly high in production and consumption of carbon fiber reinforced polymers (CFRP) and glass fiber reinforced polymers (GFRP) as they are used in various fields such as construction, aviation, oil and gas, sporting and wind industry. The materials used are very high in production and in consumption throughout the world (S.R.Naqvi, 2018). Their use as high-performance light weight strengthens recently have seen a spike in applications of high added benefit (Loris G., December 2020). Among various fiber reinforced polymer composites, GFRP composite has a market share of 95% globally (M.M. Hiremath, March 2020). According to Naqvi *et al.* (2018), the GFRP composites industry is projected to reach a compound average increase rate of 9.18% over the projected years from 2018 to 2025 (Naqvi, et al., 2018).

Although synthetic composites like fibre carbon composites and composites provide structural advantages, they have put some limitations on synthetic composites, such as high cost of raw materials, and induced an end-of-life negative environmental impact, under which synthetic composites are non-recyclable or not degradable. (M.R.Mansor, 2019).

1.2 Problem Statement

In a wide variety of uses, composite materials are used such as transportation, aerospace, renewable energies. However, because of their intrinsic variability, they were not properly recycled. In Malaysia, the composite materials are usually planted or sold.

Different surveys have measured industry needs for new composites and the number of accumulated waste over recent decades in order to mitigate the possible negative effects. The main obstacles to the spread of carbon and glass fiber use are high cost and uncertainty about whether it can be recycled when composite products reach the end of their useful life.

Besides, due to the increase in the amount of carbon and glass fiber composites use. According to the Malaysian Industry-Government Group for High Technology (MIGHT) has revealed that in terms of volume, fiber glass has largely dominated (85%) composites, despite the significant rise in the utilisation of carbon and natural fibers. The matrix material for carbon fiber composites are largely (72%) epoxy. As for the Malaysia Composite industry turnover, it was estimated to be RM3.5 billion from a total of 70 fabricators.

Currently, the largest application was construction (43%), followed by aerospace (14%) and marine (14%) sectors (Malaysia, 2016). Growing industry and increasing fuel consumption levels would result in both manufacturing scrap and end-of-life (EOL) waste.

In addition, an increase in the amount of wastes are generated from the end of life components and manufacturing waste have become a problem because the waste products are cannot biodegradable. Even though there are some polymers which are degradable and eco-friendly, but those are not good enough for engineering applications. Until now, companies have used these composite materials easily without adequate knowledge of disposal procedures. For example, people may end up throwing these composites materials into rivers, etc., and composite materials are not disintegrate fast enough. Further redo, the high cost of sending waste to landfill and natural quality charge per kilogram, which is RM10/kg (Manager G7 Aerospace, 2020).

This study is important because it is able to reduce carbon and glass fiber waste at possible landfills detrimental to human health and the environment as well as encouraging consumption recycled carbon and glass fiber in industry instead to replace virgin carbon and glass fibers. In conclusion, composites are mixing two or more parts for thin solid and robust materials, are sustainable perfection but are a recycling challenge.

1.3 Objectives

The objectives of research are as follows:

1. To study the suitable fiber size for concrete fabrication of the recycled glass and carbon fibers prepared using mechanical recycling method.

2. To evaluate the mechanical properties of the concrete prepared using recycled glass and carbon fibers.

3. To perform morphological analysis on the fractured surface of the concrete using scanning electron microscopy (SEM) and crystalline structure using X-Ray Diffraction (XRD).

1.4 Scope

The research scopes are as follow:

1. Analyse the mechanical recycling method the suitable fiber size for concrete fabrication of the recycled glass and carbon fibers that include shredding at size of 100mm and grinding at size of 50μm to form concrete composites.

2. Characterize the mechanical properties of recycled glass and carbon fibers. The properties that will be evaluated is compressive testing.

3. Analyse the morphological fractured surface of particle size of recycled glass and carbon fibers concrete composite by using SEM observation.

4. Analyse the crystalline structure and phase of recycled glass and carbon fibers concrete composite by using XRD.

1.5 Significant/Important of Study

The significant/important are detailed as follows:

1. There are some potential benefits that can be gained by composite industry after the completion of this study.

2. To gain new knowledge application of recycled of carbon and glass fiber by mechanical process for concrete composite for sustainability.