RESEARCH AND DEVELOPMENT OF ROOF TILE USING KENAF CORE AND CLAY

MUHAMMAD FIKRI BIN ZULKIFLI
B091810102

BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY (PROCESS AND TECHNOLOGY) WITH HONOURS

2021

Faculty of Mechanical and Manufacturing Engineering Technology

RESEARCH AND DEVELOPMENT OF ROOF TILE USING KENAF CORE AND CLAY

Muhammad Fikri Bin Zulkifli

Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours

2021

RESEARCH AND DEVELOPMENT OF ROOF TILE USING KENAF CORE AND CLAY

MUHAMMAD FIKRI BIN ZULKIFLI

A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this thesis entitled “Research and Development of Roof Tile Using Kenaf Core and Clay” is the result of my own research except as cited in the references. This thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : MUHAMMAD FIKRI BIN ZULKIFLI

Date : 18 JANUARY 2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours.

Signature : .....

Supervisor Name : PROF. MADYA IR. TS. DR. MOHD YUHAZRI BIN YAAKOB

Date : 18 January 2022

DEDICATION

Dedicated to

My honourable father, Zulkifli Bin Abd. Rahman

My lovely mother, Rohana Binti Mohamed Nor

My supportive brothers, Muhammad Hafiz Zulkifli and Muhammad Asyraaf Bin Zulkifli,

My sweet sisters, Intan Najiha Binti Zulkifli and Intan Maisarah Binti Zulkifli

Thank you so much

ABSTRACT

In the recent decades, the natural fibre (NF) has been one of the major interesting research subjects due to low cost, environmentally friendly, sustainability and available in abundance. This study will explore the kenaf core (KC) reinforced clay composite for roof tile application. In this research, there are varieties of size for KC will be used such as 20 mm, 10 mm, 20 mesh and 40 mesh. This KC will be integrated with clay using the conventional method in fabricating a roof tile which includes process such as pressing, drying and firing. The samples are made in various ratios ranging from 10% to 40%. Additionally, it will have a dimensions of 300 mm × 280 mm × 7 mm, and will be compressed with a force of 14.95 kN by a hydraulic machine. The samples were dried for 14 days before going through the fire process at 100°C for roughly 5 hours, where they will be heated until stiff and solidified. Compression, flexural and thermal testing are used to investigate the sample's mechanical and physical properties. Thorough examination is performed with the information obtained by scanning electron microscopy (SEM). From the result, it was found that 20 mesh has only a slight difference of flexural strength performance than pure clay of 3.78%. It was also found that 30% KC of 40 mesh can withstand a force of 408.17 N. In addition, 40% KC of 10 mm has the highest value for heat resistance at 3.37°C. It can be concluded, integrating KC with clay enhance the heat resistance performance for the matrix material.

ABSTRAK

Dalam dekad kebelakangan ini, gentian semula jadi (NF) telah menjadi salah satu subjek penyelidikan yang menarik kerana kos yang rendah, mesra alam, kemampanan dan tersedia dengan banyak. Kajian ini akan meneroka komposit tanah liat bertetulang teras kenaf (KC) untuk aplikasi jubin bumbung. Dalam penyelidikan ini, terdapat jenis saiz untuk KC yang akan digunakan seperti 20 mm, 10 mm, 20 mesh dan 40 mesh. KC ini akan disepadukan dengan tanah liat menggunakan kaedah konvensional dalam fabrikasi jubin bumbung yang merangkumi proses seperti menekan, mengering dan membakar. Sampel dibuat dalam pelbagai nisbah antara 10% hingga 40%. Selain itu, ia akan mempunyai dimensi 300 mm × 280 mm × 7 mm, dan akan dimampatkan dengan daya 14.95 kN oleh mesin hidraulik. Sampel telah dikeringkan selama 14 hari sebelum melalui proses kebakaran pada suhu 100°C selama kira-kira 5 jam, di mana ia akan dipanaskan sehingga kaku dan pepejal. Ujian mampatan, lentur dan terma digunakan untuk menyiasat sifat mekanikal dan fizikal sampel. Pemeriksaan menyeluruh dilakukan dengan maklumat yang diperolehi dengan mengimbas mikroskop elektron (SEM). Daripada keputusan tersebut, didapati 20 mesh hanya mempunyai sedikit perbezaan prestasi kekuatan lentur berbanding tanah liat tulen sebanyak 3.78%. Didapati juga bahawa 30% KC daripada 40 mesh boleh menahan daya 408.17 N. Selain itu, 40% KC sebanyak 10 mm mempunyai nilai rintangan haba tertinggi pada 3.37°C. Ia boleh disimpulkan, menyepadukan KC dengan tanah liat meningkatkan prestasi rintangan haba untuk bahan matriks.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I would like to thank and praise Allah the Almighty, my Creator, my Sustainer, for everything I received since the beginning of my life. I would like to extend my appreciation to the Universiti Teknikal Malaysia Melaka (UTeM) for providing the research platform and gave permission to use machinery in the laboratory.

My utmost appreciation goes to my main supervisor, Professor Madya Ir. Ts. Dr. Mohd Yuhazri Bin Yaakob, Deputy Dean (Research and Industrial Network), Universiti Teknikal Malaysia Melaka (UTeM), for all his support, advice and inspiration. His constant patience for guiding and providing priceless insights throughout the semester will forever be remembered and appreciated. Not to mention, life and work advice for future concern. I am also grateful to my co-supervisor, Dr. Mohd Amirhafizan Bin Husin who constantly teaches and guides me in this journey.

Last but not least, from the bottom of my heart a gratitude to my teammates Nur Hazirah Iffah Binti Hashim, Meryl Anyie Tomy and Melanie Lye Chuok Xin for the great supports and friendship. Finally, thank you to all the individual(s) who had provided me the assistance, support and inspiration to embark on my study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

cm	-	Centimetre
mm	-	Millimetre
kg	-	Kilogram
N	-	Newton
kN	-	Kilo newton
kPa	-	Kilo Pascal
MPa	-	Mega Pascal
V	-	Volt
°C	-	Celsius
W/mK	-	Watt per meter-Kelvin
mm/min	-	Millimetre/minute
KC	-	Kenaf core
RPM	-	Revolutions per minutes
SEM	-	Scanning electron microscopy
LKTN	-	Lembaga Kenaf dan Tembakau Negara
ASTM	-	American Society for Testing and Materials

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

This chapter will explain and elaborate the background of the study, characteristics and behaviour of the composite material and clay-based roof tiles. This study will be based on essential theories and concepts gathered from primary sources such as previous research, books, and journals. All of the data and issues are gathered in order to identify ways to enhance this research.

1.1 Background

A composite material is made up of one or more components with varying physical and chemical characteristics (Weber et al., 1987). This material's output would be considerably improved if it were merged with other materials. The material will become more durable, lightweight, heat and electricity resistant (Rajak et al., 2019). It can also strengthen and stiffen the material. In addition, it can improve its stiffness and strength (Puttegowda et al., 2018). Nowadays, it can be seen its uses in all kinds of industry such as construction (Quintana et al., 2018), automotive (Araújo et al., 2017), aerospace (Barile et al., 2019) and transportation (Ma et al., 2019). Currently, there are a lot of studies showing the improvement the composite material. In Fehri et al. (2017) research, the combination exhibit the increase in performance in term of mechanical properties where the young's modulus of the material increase substantially. This indicate that the material have better ultimate tensile strength which mean it can withstand a large amount of force.

There are two types of composite material which are matrix and reinforcement (Priyanka et al., 2017). Metal, polymer, or ceramics are commonly used as the major matrices material (Ibrahim et al., 2015). The weight on these materials is generally rather heavy. Furthermore, it can be used as a binding and holding medium for solidifying reinforcement (Guggilla and Batra, 2011). Renewable and biodegradable fibres are commonly used in reinforcement composites, making them environmentally friendly. Aside from that, the mechanical qualities it has make it a viable replacement for polymer-based composites (Jha et al., 2019). This fibre may be obtained from a variety of natural sources, including minerals, animals, and plants. It also comes in a variety of forms, including roving, yarn, mats, and fabrics (Sanjay et al., 2018). Interface composite is the area where the matrix and reinforcing component interact or coincide to produce an applicable material (Kaya, 2018). There is a lot of past research that the result shows a significant enhancement of the combination between the matrix and reinforcement material (Sun et al., 2018; Nikolenko et al., 2021; Patterson et al., 2018; Wang et al., 2019). While the matrix has a strong property on its own, its performance can still be improved when reinforcing material is incorporated. Nowadays, there are several studies that aim to incorporate the composite material into construction industry and the purpose for the integration it to enhance the current material performances.

Clay is also one of the matrix materials that are commonly used in construction and other industry. It main applications in construction are roof and brick whereas there are also studies that use it for other purposes (Yong-Feng et al., 2017). Clay are always been used in residential houses because of its practicality. It is durable, fireproof and provides a good insulation that comes with great appearance (Thovichit, 2007) and because of this, there are huge demands for the material but it is expensive and has lower flexural strength

which means it is easily cracked. Currently there a several studies to reinforced clay using composite to further improve the performance of the material.

It is important to pointed out that roof is one of the fundamental in house or building constructions because it is an important part of the construction because it gives the users cover that can protect its user from bad weather such as rain, storm, hail and others (Alkali et al., 2018). Not only that, it can gives a user a comfortable place to rest. There are several types of material that are being used to make a roof such as clay (Akhtar et al., 2017), concrete (Kreiger et al., 2019), asphalt (Sahito et al., 2020), metal (Saini and Shafei, 2019) and wood (Hoq and Judd, 2020). Each of these materials has their own application. For instance, metal is used on high and tall building because of its properties and safety reason. Clay, concrete and asphalt are commonly installed on a residential home while wood can be found used on traditional houses.

To summarize, currently the researcher are solely focuses on the capability and the application of kenaf fibre in construction material. There is no denying the advantage and benefit of the long fibre but it is rather expensive compared to the core fibre. Additionally, this resulted in lack of study on the core fibre. Thus, the purpose of this research is to investigate the benefit and the capability of KC fibre in the construction industry and how it would affect the properties of the construction matrix material. Aside from that, develop the material to create a commercially viable product.

1.2 Problem Statement

Since past few decades, the researchers are mainly study in researching and developing the roof tile by combine the matrix material of roof tiles with natural fibre such as asbestos fibre (Oberta et al., 2018), sisal fibre (Zaryoun and Hosseini, 2019), bamboo fibre (Amin et al., 2021). The current study only developing the roof tiles with fibre only

thus resulted in the lack of knowledge in other by-product of the plant which is the core. The core also has the capability of mechanical properties to enhance the matrix material. Therefore this study is carried out to investigate the core ability in enhancing the performance of clay-based tiles. The core will be mixed together with the clay before going through the manufacturing process of the roof tiles.

While long fibre delivers excellent results, it is more costly than the bast or plant's core. The clay-based roof tile alone has expensive price tag (Nurhasanah et al., 2020). It is not practical to combine an already expensive matrix with another expensive material. Moreover, while the researches are focusing to reinforce the roof tiles with natural fibre, it is a waste to ignore a component which made up the majority of the plant. It is more practical to spend less but gaining more. KC yield are harvested more than the fibre making it easier to obtain. While there is less study on researching the capability of the core, the current study shows the potential that the KC can give according to its application. Therefore this study is carried out, to investigate the capability of KC reinforced clay for roof application.

Furthermore, the current clay based roof tiles have unsatisfactory flexural strength. It cracked easily when someone step onto the tiles (De Silva and Mallwattha, 2018). It is a concern for the house owner because there will be time when there are a need to go onto the roof to installed an antenna or other devices. On top of that, the potential it breaks during a hail is high. Roof need to be strong and tough to protect the home from catastrophe. It is an important part of the house that can make the home owner feel safe and live in comfort. By conducting testing on the material, it must be determine that the roof tile is strong and can be used for a long time. Thus, increases the cost to maintain the tiles. Lastly, there is no scientific study has that has been found developing KC to be

integrated with clay to use as roof tiles. Hence, the purpose of this study is to go in-depth investigating the potential of KC reinforced clay for roof application.

1.3 Objective

The objectives of the research are as follows:

a) To fabricate KC reinforced clay composite using different ratio between the materials for roof tiles application.

b) To investigate the mechanical and physical properties of KC reinforced clay composite with different ratio.

c) To propose the best optimum ratio of KC reinforced clay composite for roof tile application.

1.4 Scope of Research

The scopes of the study are as follows:

a) The study will be conducted to observe the potential of KC.

b) To fabricate clay roof tile using conventional method reinforced with KC with size of 3 mm, 0.84 mm and 0.40 mm.

c) To determine the improvement of the roof tiles when it is mixed with composite component.

d) To determine the usage reduction of clay in the combination of composite.

e) To study which of the suitable value of composition that can produce the best roof tiles.

f) To investigate the flexural strength of KC reinforced clay composite for roof application.

g) To investigate thermal performance of KC reinforced clay composite for roof application.

h) To investigate KC reinforced clay composite capability of water absorption for roof application.

1.5 Rational of Research

The rational of the research are as follows:

a) There is a shortage in the uses of KC in construction industry. Hence, the purpose of this study is to explore the benefits of the KC to be mixed with clay as a roof tiles.

b) Expose the potential of the KC by developing more information about the KC because currently the main focus of the by-product of the kenaf plant is its fibre.

c) To understand the behaviour of KC and its ability to absorb water.

d) KC is type of plant can be easily grown in tropical climate and when the demand is high the villager can grow the plant which can directly boost social economy.

1.6 Thesis Arrangement

The first chapter of the thesis lays the groundwork for the rest of the thesis. The background of the study, problem statement, objective study, scope of research, and rationale of study are all introduced in Chapter 1 to establish the core understanding of the title. The second chapter delves into specifics and details. The literature study in this chapter demonstrates the theory or foundation of various issues. Not only that, but a full evaluation is conducted in which historical or current research on KC, its qualities, and