EFFECT OF GLAZED ROOF TILE WASTE WEIGHT FRACTION ON THE MECHANICAL PROPERTIES OF ECO-FRIENDLY CONCRETE

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

by

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Sesi Pengajian: **2021/2022 Semester 2**

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Sekian dimaklumkan. Terima kasih.

Yang benar,

(PROFESOR MADYA DR. JARIAH BINTI MOHAMAD JUOI)

DECLARATION

I hereby, declared this report entitled "Effect of Glazed Roof Tile Waste Weight Fraction on The Mechanical Properties of Eco-Friendly Concrete" is the result of my own research except as cited in references.

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Date : 29 June 2022

APPROVAL

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

(PROFESOR MADYA DR. JARIAH BINTI MOHAMAD JUOI)

ABSTRAK

Pembekal konkrit mengutamakan pengeluaran produk berasaskan konkrit yang dapat dikekalkan dan mesra kepada alam kerana konkrit merupakan bahan binaan yang paling banyak digunakan di dunia. Menghalang sisa dan bahan tercemar daripada mencemarkan udara, tanah dan air, penyelesaian praktikal lebih baik untuk alam sekitar, manusia dan masa depan. Dalam kajian ini, penggantian agregat halus dalam campuran simen dengan sisa bumbung kitar semula bersalut (GRTW) telah disiasat. Penciptaan konkrit hijau sedang dilakukan dengan cara yang baru. Objektif projek ini adalah untuk mencirikan sifat fizikal sisa bumbung kitar semula bagi menggantikan agregat halus dalam konkrit hijau, untuk menganalisis sifat fizikal dan mekanikal konkrit hijau yang dihasilkan menggunakan sisa bumbung kitar semula sebagai agregat halus dan untuk mencirikan struktur mikro hijau hasil konkrit menggunakan sisa bumbung. 12 kiub sampel konkrit berukuran 100 mm x 100 mm x 100 mm setiap satu telah . 9 spesimen konkrit yang mengandungi GRTW sebagai agregat halus didalam pecahan berat yang berbeza (10%, 20% dan 50%), manakala 3 spesimen konkrit pula mengandungi campuran biasa sebagai spesimen kawalan. Semua spesimen diperiksa untuk menilai kebolehkerjaan dengan menggunakan ujian mampatan termasuk ujian kemerosotan, ujian ketumpatan, ujian penyerapan air dan ujian kekuatan mampatan. Keputusan daripada ujian yang dijalankan mendapati bahawa kekuatan berkurangan secara beransur-ansur dengan 10% penggantian GRTW dan meningkat pada 20% dan 50% penggantian GRTW jika dibandingkan dengan rujukan iaitu British Standard. Kalsium silikat hidrat (C-S-H), kalsium aluminosilikat hidrat (C-A-S-H), portlandit (P), dan ettringit (E) ialah komposisi mineral yang terdapat dalam campuran konkrit. Dalam campuran 20% GRTW, proses penghidratan adalah sama seperti campuran konkrit biasa tetapi, perkembangan gel C-S-H dalam campuran adalah lebih rendah berbanding dengan campuran konkrit biasa. Untuk menggantikan pasir sebagai agregat halus dalam konkrit, penggantian 20% GRTW telah metunjukkan prestasi mekanikal yang lebih baik daripada spesimen kawalan dari segi ujian kemerosatan, ujian penyerapan air dan ujian mampatan.

ABSTRACT

Concrete suppliers are prioritising the production of sustainable and ecologically friendly concrete products because concrete is the most widely used building material in the world. By preventing waste and pollutants from contaminating our air, land, and water, these practical solutions are better for the environment, human and for the future. In this study, the replacement of fine aggregates in a cement mixture with glazed recycled roof tile waste (GRTW) is investigated. The creation of green concrete is being done in a novel way. The objectives of this project are to characterize the physical properties of recycle roof tile waste for replacing fine aggregates in green concrete, to analyze the physical and mechanical properties of green concrete produced using recycled roof tile waste as fine aggregate and to characterize the microstructure of green concrete produce using roof tiles waste. 12 concrete samples measuring 100 mm x 100 mm x 100 mm each were evaluated. 9 concrete specimens contained GRTW as fine aggregate in different weight fraction (10%, 20% and 50%), whereas 3 concrete specimens were preserved as control specimens. All specimens were ultimately examined for workability utilising compression testing, which includes the slump test, density test, water absorption test, and compressive strength test. According to the test results, when compared to the reference, or British Standard, the strength steadily declined with a 10% GRTW replacement and increased at 20% and 50% GRTW replacement. Mineral compositions such as portlandite (P), ettringite (E), calcium silicate hydrate (C-S-H), and calcium aluminosilicate hydrate (C-A-S-H) can be found in concrete mixtures. The hydration process in a 20% GRTW mix is the same as in a regular concrete mix, but the amount of C-S-H gel that forms in the mix is less than in a regular concrete mix. In order to substitute sand as the fine aggregate in concrete, a substitution of 20% GRTW had been shown to have better mechanical performance than the control specimen in terms of the slump test, water absorption test, and compression test.

DEDICATION

I would like to thank my supervisor, Associate Professor Madya Dr. Jariah Binti Mohamad Juoi of Universiti Teknikal Malaysia Melaka (UTeM), for providing me with so much guidance for this Final Year Project 2 throughout multiple consultations. I am very grateful to the final year students of last semester which is Farihah, Elsee and Ika made samples for me to use this semester. Most importantly, I would like to express my heartfelt thanks to my family for their unwavering support, as well as my friends, who will share and assist me in understanding if I run into any difficulties during this study. Thank you all so much for your continued support in allowing me to do this research. I would also like to express my gratitude to all of the panels who participated in the question and answer portion of my Final Year Project 2 presentation and helped me understand how to know more. I would also like to express my gratitude to all of the panels that participated in the question and answer portion of my Final Year Project2 presentation and helped me understand how to choose important keywords for research.

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LIST OF ABBREVIATIONS

GRTW	-	Glazed roof tile waste
RTW	-	Roof tile waste
RCC	-	Recycle ceramic concrete
RCCS	-	Recycle ceramic coarse sand
PCCA	-	Pavement continuously concrete armed
RCA	-	Recycle concrete aggregate
SCC	-	Self-consolidating concrete
NA	-	Natural aggregate
NAC	-	Natural aggregate concrete
SEM	-	Scanning electron microscope
XRD	-	X-ray diffraction
XRF	-	X-ray fluorescence
ITZ	-	Interfacial Transition Zone
CSH	-	Calcium Silicate Hydrate
SH	-	Silicate Hydrate
CW	-	Ceramic waste
EDX	-	Energy Dispersive X-Ray
BSE	-	Backscattered electron
FTWA	-	Floor tile waste aggregate
REF	-	Reference concrete mix
PSA	-	Particle Size Distribution
BET	-	Brunauer-Emmett-Teller
BJH	-	Barrett-Joyner-Halenda

LIST OF SYMBOLS

cm	-	Centimetre
m	-	Metre
%	-	Percent
g/cm^3	-	Grams per centimetre cube
wt. %	-	Weight percent
mm	-	Millimetre
MPa	-	Mega Pascal
GPa	-	Giga Pascal
°C	-	Degree Celsius
TPa	-	Tera Pascal
W/mK	-	Watt per metre per Kelvin
K	-	Kelvin
nm	-	Nanometre
kg.cm3	-	Kilogram centimetre cube
phr	-	Part per hundred resin
τ_{ISS}	-	Interfacial shear strength
P	-	Peak force
r_f	-	Fibre radius
l_e	-	Embedded fibre length
kg	-	Kilograms
mm/min.	-	Millimetre per minute
rpm	-	Revolution per minute
kN	-	Kilo newton
W	-	Sample width
y	-	Geometry correction factor
S	-	Span length
a	-	Notch length
B	-	Sample thickness
K_{IC}	-	Fracture toughness

W_m	-	Matrix mass
W_f	-	Fibre mass
T_i	-	Thickness before immersion
T_f	-	Thickness after immersion
m	-	Mass
v	-	Volume
p_f	-	Kenaf density
p_m	-	Matrix density
°C/min	-	Degree celsius per minute
N_2	-	Nitrogen gas
Hz	-	Hertz

CHAPTER 1

INTRODUCTION

1.1 Research Background

Roof tile usually made form clay which is natural resource from earth, water and fired process. During firing process, roof tiles can achieve strength and durability by using high temperature. Based on that process, it can see durability of roof tile to withstand obstacles which is rain, hot weather and so on. As a reason, it is often strung in parallel rows, with each row covering the row below it to keep out rain and conceal the nails that secure the preceding row. Roof tiles are renowned for their resistance to deterioration, corrosion, and insect damage. In general, tiled roofs are constructed to endure and are a trustworthy roofing material.

The feature of roof tiles show many advantages especially in term of raw material itself. It is achieve the concept of green product which is no harmful or endangered raw materials (Durif et al., 2010). In addition, there are no preservatives in tile roofing and waste from manufacture can be recycled back into the manufacturing process rather than being dumped. It can reduce the percentage of waste in landfill which is uncontrollable from other resource can contribute as a waste. Besides that, roof tile is long term product because of it can withstand for several years depends on condition of resistance roof tile. Roof tile also have the lowest life cycle cost of any other roofing material. Indirectly, roof tile can be suitable to be made as a raw material for new product because of has a good characteristic.

In Malaysia, the style of roofting usually used from ceramic because higher lifespan, excellent noise, heat insulation and water resistance. Ceramic, on the other hand, loses its value as it approaches the end of its useful life and is discarded Ceramic waste is rising daily, and the ceramic industries are struggling to find a viable disposal option. If these wastes are not properly removed, it will have a severe influence on the environment and building businesses are under pressure to implement an effective waste disposal solution, necessitating the urgent need for good waste management. Regrettably, this waste collecting method adds to the entire production cost.

When defined “concrete” that means it is large, sturdy and reliable. Furthermore, the majority of people spend their lives on and around concrete such as on sidewalks, highways and in buildings and structures made of beautiful materials. Due to the widespread use of concrete, it the reason aggregate need be change because of the demand from concrete industry. The search for new aggregate in concrete is the best step in finding new raw material from waste material. It is a green technique to use waste material in construction. It adds value to waste materials while also assisting in the achievement of construction sustainability goals. One of the reasons it was chosen to be an aggregate is its green nature

(Ceesay, 2019)) stated that roof tile is the new discovery for aggregate which to know it suitable to concrete. Aggregate is main component material in mixture of concrete because affecting 60% to 80% in concrete. To achieve consistent concrete strength, workability, finishing ability, and durability, aggregate must be carefully selected, blended for best efficiency, and managed. However, owing to concerns about the quality and structural performance of roof tile waste, their usage as aggregates in new concrete has often been restricted (Ceesay, 2019). While it has been argued that the potential of RTW aggregates to accelerate cement hydration results in a rise in compressive strength and a decrease in autogenous shrinkage of the resultant concrete, the overall conclusion is not compelling.

The basic mixture of concrete also consists of cement and water. The most common used for aggregate is sand, crushed stone, slag and recycled concrete. It divides in two categories which is fine and coarse aggregate. Sand and crushed stone are examples of fine aggregate which are small particles with a diameter of less than 9.55 mm. Coarse aggregate are particulates that are greater than 4.75 mm which usually range between 9.5mm and 37.5mm in diameter (VDT. Virginia Department of Transportation., 2015). If the mixture of aggregate accurate and suitable which cement and water, it can produce the good quality of concrete. A high-quality aggregate must be clean, solid, and resilient, and free of absorbed toxic substances, clay coatings, or other contaminants that might impair cement hydration or lower the consistency of the paste used to bind the aggregate value.

The replacement of aggregate from recycled material is the step to achieve the concept of green concrete. Green concrete is a type of regular concrete that includes recycled or environmentally friendly materials, lasts longer or performs better than traditional concrete, decreasing the need for replacement in the future. Green products are typically distinguished by two main goals which is waste reduction and resource efficiency maximisation. For example, the procedure of making green concrete is identical to that of standard concrete production. A mixing machine was used to combine 80% fly ash, some limes, water, and a small amount of cement (Solikin et al., 2013). The ultimate product is green concrete, which is made from well mixed components. Although the amount that can be added varies depending on the material, these additions frequently provide the concrete stronger or new features, such as durability and thermal insulation, while also utilising recycled materials that would otherwise wind up in a landfill.

1.2 Problem Statement

Concrete is a mixture of hard, chemically inert particle ingredients such as sand and gravel, as well as cement and water. Because sand and gravel are natural resources, engineers have tried a variety of methods to save natural resources on the planet by replacing with industrial wastes. Furthermore, it decreases industrial waste while simultaneously protecting the environment. To replace the sand with other material as fine aggregates, the characterization of raw material such as sieve analysis need to be obtaining in the mix ratio because wastes are not directly ready or prepared to replace the materials for fine aggregates. To make the replacement of fine aggregates, many steps are needed to prepare the GRTW in term of characterization, test and analysis. To perform characterization analysis such as XRD, XRF and

SEM in order to ensure that the roof tile waste is suitable to replace aggregates in existing concrete formulation.

1.3 Objectives

The objectives of this study are:

a) To characteristic the physical properties of glazed roof tile waste for replacing fine aggregates in green concrete.
b) To analyze the physical and mechanical properties of green concrete produced using several percentage weight fraction of glazed roof tile waste as fine aggregate.
c) To characterise the microstructure of green concrete produce using glazed roof tiles waste.

1.4 Scopes of the Research

The scopes of the research are as follows:

a) Study on the preparation to find the suitable characteristic for fine aggregates to replace sand. The study is focusing more on finding the best parameter for fine aggregates through crushing value determination which is sieve analysis.
b) Study on the characteristics of the crushed glazed roof tiles wastes as a fine aggregate. The study is focusing more on gaining the analysis results which are XRD, XRF, SEM and porosity.
c) Study on the mechanical and physical properties of green concrete by glazed roof tile waste. This study is focussing on the effect of percentage waste loading fine aggregate in the concrete.

CHAPTER 2

LITERATURE REVIEW

This chapter describe about classification product based on type of ceramic and consist of properties of ceramic waste that can be aggregate in concrete. In additional, preparation method of roof tile waste aggregate and preparation concrete mixture using roof tile waste aggregate can be known. Besides, the mechanical properties of concrete made using ceramic waste cover in this chapter.

2.1 Classification of ceramic waste

Ceramic waste consists of a variety of items that are critical components of the key construction materials used in almost every structure. This occurs when a significant amount of ceramic waste is created in the form of damaged or broken ceramic items. The most popular variety of pottery is distinguished by its colour, which ranges from red to white. Red ceramics are a common type of ceramic that is often made at lower temperatures, resulting in more porosity, reduced density, and poorer strength (Keshavarz & Mostofinejad, 2019). As a result of the low cost of clay processing, red ceramic is one of the most widely utilised ceramics in huge structures. White ceramic, on the other hand, is less fragile in nature and can be used in more delicate areas of a construction project to ensure that it lasts longer. Red ceramic has a better in term of properties rather than white ceramic because of durability to heat resistance.

Ceramic waste may be divided into two categories according to the source of the raw materials. It was classed according to the firing process, which is a critical step in the manufacture of ceramic items since it defines their quality. As the components progress toward the required ceramic structure, irreversible structural changes occur, which influence the final qualities of the product. The firing parameters, including temperature, pace, and time spent soaking in the kiln, vary according to the raw materials and desired result. Two forms of waste are created by structural ceramic companies that employ solely red pastes to build products such as bricks, blocks, and roof tiles. The second group contains fired ceramic wastes from stoneware ceramic applications such as flooring, walls, and sanitary ware (Ray et al., 2021). According to this research, ceramic waste may be categorised using the chart in Figure 2.1.

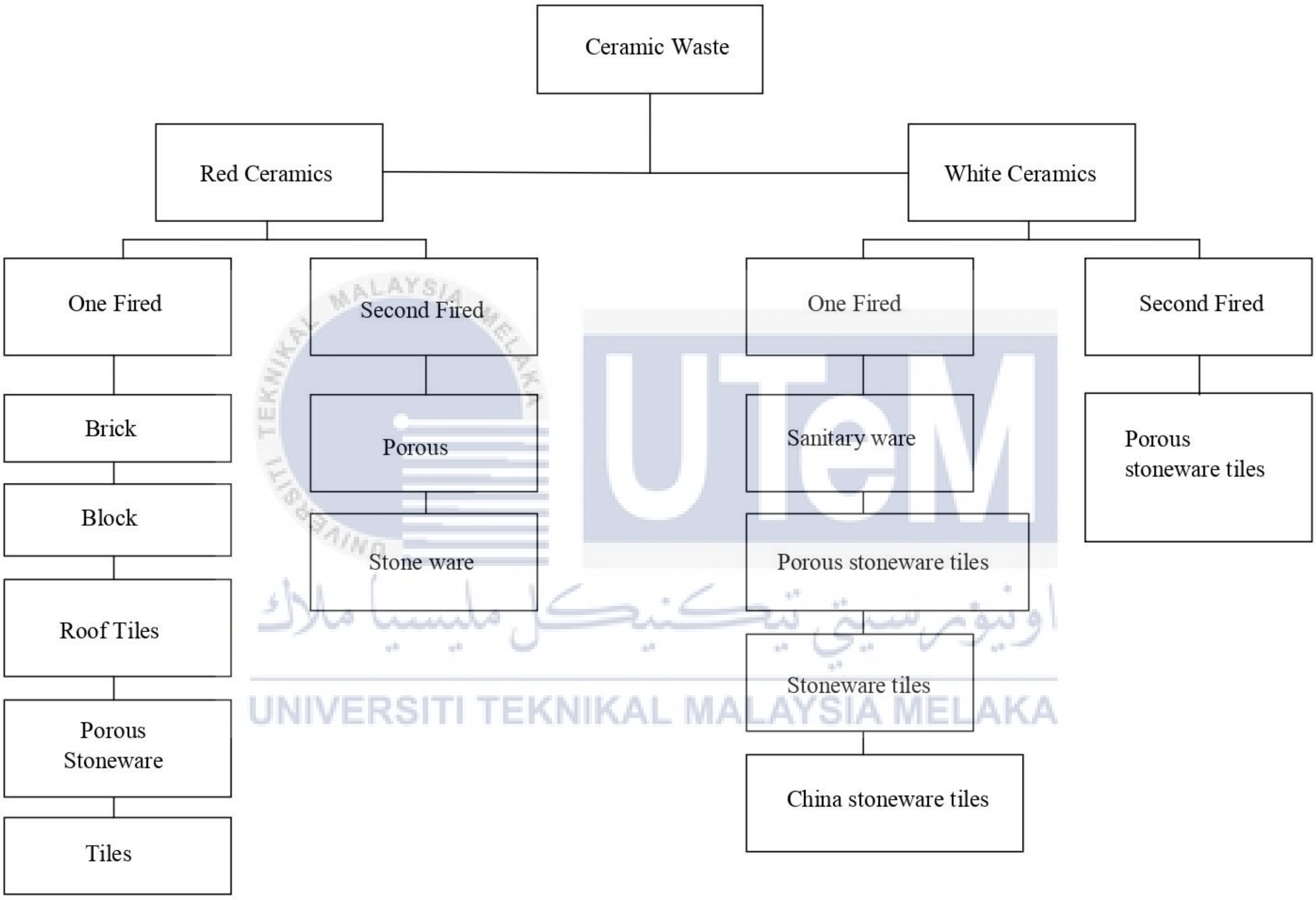

Figure 2.1: Type of ceramic waste (Ray et al., 2021)