CHARACTERIZATION ON THE NEW FIRED UNGLAZED ROOF TILES WASTE PRODUCTS AS FINE AGGREGATE IN CONCRETE

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Faculty of Mechanical and Manufacturing Engineering Technology

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DECLARATION

I declare that this thesis entitled “Characterization on The New Fired Unglazed Roof Tiles Waste Products As Fine Aggregate In Concrete” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Ika Eliyana Binti Abdul Rahim

Date : 18/01/2022

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 & Technology) with Honours.

Signature :

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Date : 14/1/2021

DEDICATION

Alhamdulillah

Praise to Allah for the strength, guidance and knowledge that was given by Allah for me to complete this study

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To my beloved parents, families and my friends, for every support that was given to me.

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To my supervisor. Prof. Madya Ts. Dr. Zulkifli Bin Mohd Rosli for his guidance and advice in completing this research.

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To all people who support me through my journey

ABSTRACT

The use of recycled fired unglazed roof tile waste (URTW) to replace current aggregates (sand) in a concrete mixture is investigated in this study. This study is a good approach to the environment to make green concrete. This project studies and analyses the characteristics of fired URTW and studies the mechanical properties of green concrete made from fired URTW. In this project, the preparation of raw materials, which crushing the fired URTW with a machine crusher, is part of the research. The crushed fired URTW will then be subjected to specific sieve analysis, particle size distribution, surface area, pore size, and pore volume using Brunauer-Emmett-Teller analysis (BET). The analysis then continued with X-Ray Diffraction (XRD), X-Ray Fluorescence (XRF) and Scanning Electron Microscopy (SEM). Slump test, water absorption, compressive test and Scanning Electron Microscopy (SEM), and Energy-dispersive X-ray Spectroscopy (EDX) are all part of the analysis for producing green concrete. The composition of a material, sieve analysis, and water absorption of crushed URTW are expected to be suitable as fine aggregate in the fabrication of green concrete. These can be demonstrated by comparing the mechanical properties and workability of the green concrete used in construction. The findings of this study will be used to determine whether this material can be used to replace sand in the green concrete mixture.

ABSTRAK

Kajian ini menyiasat penggunaan jubin bumbung tanpa kaca (URTW) yang dikitar semula untuk menggantikan agregat (pasir) sedia ada dalam campuran konkrit. Penyelidikan ini adalah cara terbaik untuk membuat konkrit hijau untuk alam sekitar. Projek ini mengkaji dan menganalisis sifat URTW yang dinyalakan, dan mengkaji sifat mekanikal konkrit hijau yang diperbuat daripada URTW yang dibakar. Dalam projek ini, penyediaan bahan mentah, penghancuran URTW yang dibakar dengan penghancur mekanikal, adalah sebahagian daripada penyelidikan. URTW yang telah dihancurkan kemudiannya tertakluk kepada analisis penapisan khusus, taburan saiz zarah, luas permukaan, saiz liang dan isipadu liang menggunakan analisis Brunauer-Emmett-Teller (BET). Analisis kemudiannya diteruskan menggunakan Difraksi sinar-X (XRD), Pendarfluor sinar-X (XRF) dan Mikroskopi Elektron Pengimbasan (SEM). Ujian slump, penyerapan air, ujian mampatan dan Scanning Electron Microscopy (SEM) dan Energy Dispersive X-ray Spectroscopy (EDX) adalah sebahagian daripada analisis untuk menghasilkan konkrit hijau.. Komposisi bahan, analisis penapisan dan penyerapan air URTW yang dihancurkan dijangka sesuai sebagai agregat halus untuk pembuatan konkrit hijau. Ini boleh ditunjukkan dengan membandingkan sifat mekanikal dan kebolehkerjaan konkrit hijau yang digunakan dalam pembinaan. Hasil kajian ini akan digunakan untuk menentukan sama ada bahan ini boleh digunakan untuk menggantikan pasir dalam campuran konkrit hijau

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INTRODUCTION

1.0 Background

Environmental degradation has captivated the world's attention and is one of the most widely debated topics locally, nationally, and globally. According to Kamar & Hamid (2012), the building industry exploits 30 to 40 percent of natural resources, 50% of energy is used for heating and cooling in buildings, nearly 40% of global material consumption is transformed to the built environment, and 30% of energy use is due to housing. It will bring the built environment and the construction industry into the spotlight, as their activities have a significant environmental impact.

Concrete is the most widely used synthetic material made up of cement, water, coarse aggregate, and fine aggregate. Since aggregate typically being used as natural sand, the available source of natural sand is getting exhausted due to rapid growth in construction activity stated by (Doye, 2017). To overcome this, it has conclusively been shown that recycled aggregates from construction and demolition waste is an alternative to primary (natural) aggregates. Several studies investigating by replacing sand with different industrial waste such as bottom ash, copper slag, furnace slag, ceramic waste limestone, marble dust, and quarry dust.

There is a local company in Johor that have pile up of Fired Unglazed Roof Tile Waste (URTW). Therefore, to eliminate pile up of fired URTW, it is considered to replace of natural fine aggregates in concrete and serve as an internal concrete curing material. This is related to its porosity which necessitates the regular supply of internal water to the cement paste (Ceesay & Miyazawa, 2019). Several studies have been proposed that the ability of fired URTW as fine aggregate to enhance hydrated cement leads to an increase in compressive strength and a reduction in autogenous shrinkage of the concrete formed, the overall result is still uncertain. Hence, this is referring to the different properties and characteristics of the fired URTW itself.

This project studies and analyze the characteristics of fired URTW aggregate and studies the mechanical properties of green concrete made from fired URTW. The preparation of raw materials, which crushing the fired URTW with a machine crusher, is part of the research. The crushed fired URTW will then be subjected to specific sieve analysis, particle size distribution, surface area, pore size, and pore volume using Brunauer-Emmett-Teller analysis (BET). The analysis then continued with X-Ray Diffraction (XRD), X-Ray Fluorescence (XRF) and Scanning Electron Microscopy (SEM). Slump test, water absorption, compressive test, and Scanning Electron Microscopy (SEM), and Energy-dispersive X-ray Spectroscopy (EDX) are all part of the analysis for producing green concrete.

1.1 Problem Statement

Concrete is a combination of cement, water, and aggregate. Aggregate, which makes up 60 to 80 percent of the volume and 70 to 85 percent of concrete weight, is commonly referred to as an inert filler (Ozioko, 2020). River sand is the one of the raw resources needed to make a concrete. However, it has become increasingly expensive and limited due to demand of construction materials in construction industries. Thus, (Kaish et al., 2021) have proven that the industrial waste is a good filler material as a fine aggregate by filling the concrete internal void and increasing the strength properties of a normal strength concrete.

To replace sand using URTW, the particle size of URTW should be proportional to the particle size of sand. Hence, several steps are required to set the parameter within the standard used. URTW is next tested using sieve analysis to determine the particle size distribution in the concrete mixture. The physical properties and characteristic of the URTW as a fine aggregate in green concrete are then analyze through composition and structural analysis. To investigate the impact of replacing fine aggregate in concrete with varying amounts of URTW. Also, to analyze the impact of URTW into concrete on mechanical properties and microstructure.

1.3 Objectives

The objectives of this study are:

1. To recycle the Fired Unglazed Roof Tiles Waste (URTW) into a green concrete as fine aggregate.
2. To analyze the characteristic and physical properties of the URTW as a fine aggregate in green concrete.
3. To compare strength of Fired URTW as fine green concrete aggregate with the fine natural aggregate (sand).

1.4 Scopes of Study

In this study, the primary raw materials used are Fired Unglazed Roof Tiles Waste (URTW) as a fine aggregate to substitute in concrete. To get a fine aggregate of URTW is by using Grinder Machine and Planetary Milling Ball Machine. Then, Sieve Analysis (Gradation Test) determines the fine aggregate particle size distribution whether it is suitable to use in concrete mixing. The characterization of URTW will be carried out by Scanning Electroscopy Microscope (SEM), particle size distribution, X-Ray Fluorescence (XRF), and X-Ray Diffraction (XRD).

1.5 Research Methodology

This thesis is organized in the format provided by Universiti Teknikal Malaysia Melaka (UTeM), which is based on the study’s publication. Introduction, literature review, methodology, results, discussion, and conclusion are the six sections in this report. The structure’s details are as follows:

Chapter 1

This chapter explains the study’s goal and identifies the problem that triggered the study. This chapter elaborated on the significance and scope of the study and work.

Chapter 2

This chapter justifies the overall literature review conducted by previous studies in the field of this thesis. In addition, the research gap identified through a review of prior studies is discussed in this chapter.

Chapter 3

This chapter described the methodology used in this study for materials preparation, testing procedure, and data collection.

Chapter 4

The result and discussion of the testing on the characterization of the New Fired Unglazed Roof Tile Waste (URTW) as fine aggregate in concrete were presented in this chapter. The chapter contains a detailed discussion of the outcome.

Chapter 5

This chapter presents the study's overall conclusion with recommendations and improvements for future research according to the New Fired Unglazed Roof Tile Waste (URTW) as fine aggregate in concrete.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Many studies and developments on green concrete have been conducted recently. Researchers and scientist from all over the world have contributed to this project. This chapter summaries all of the green concrete aggregates research and theory. All research of articles and journals is based on the objectives identified in this study. The preparation of parameters and analysis on URTW samples are discussed in this chapter. Also the strength and microstucture of the concrete using URTW.

2.2 Materials

2.2.1 Concrete

Concrete is a composite material made up of a hard particulate substance called aggregate (usually sand and gravel) bonded together with cement and water (Monteiro., n.d.). In the construction industry, it can be mixed to meet the needs and shape into almost any shape especially for industrial, commercial, and residential floor slab construction, post-tensioned slabs are the preferred method. Since concrete has different requirements and properties, it makes sense to classify concrete uses based on where and how it is produced and the method of application (Al-neshawy, 2018). (VDT, 2015) proposed that the aggregate concrete should be made up of particles with adequate strength and weather resistance and should not contain any harmful materials.

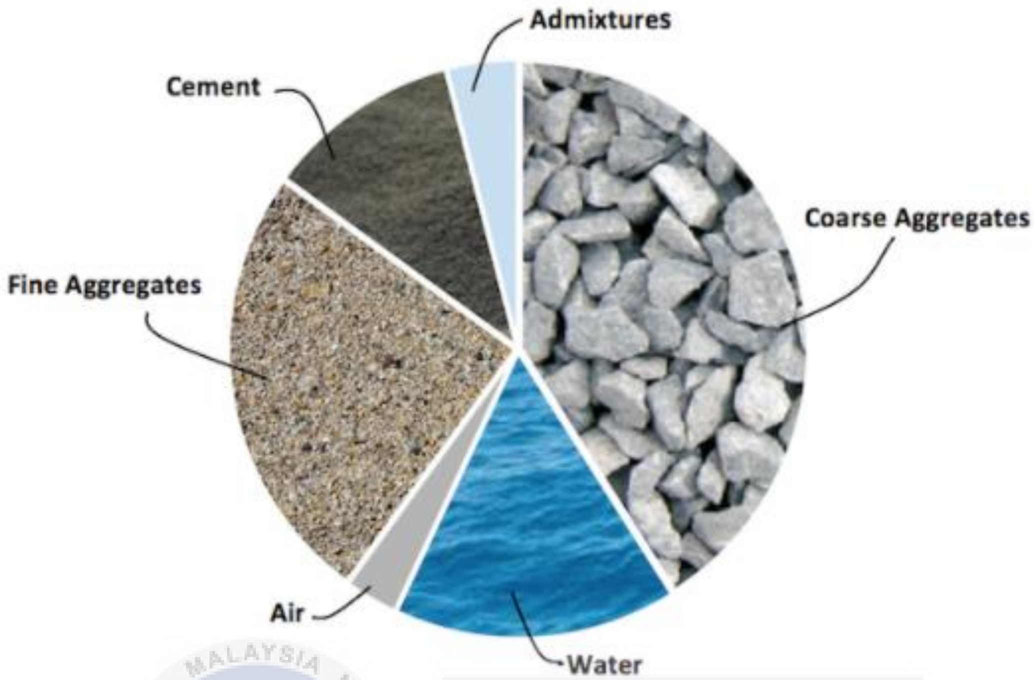

Figure 2. 1 Concrete mix design ratio

There are two types of concrete which are ordinary concrete and special concrete. Normal concrete is one of the most widely used, especially for the construction of pavements and buildings with low tensile strength requirements. Hence, it is relatively poor at withstanding stresses induced by vibrations, wind loading, and other factors. At the same time, special concrete is concrete that mixes with special ingredients or uses a special process that may be preferred for certain applications. For example, lightweight concrete, high strength concrete, heavyweight concrete, underwater concrete etc. (*Different Types of Concrete Grades and Their Uses | Base Concrete*, n.d.) research the concrete grades are determined by the concrete's strength and composition, as well as the minimum strength required after 28 days of initial construction. The strength of concrete is measured in MPa, where M denotes the mix and MPa denotes the overall strength. The strength is determined by carrying out axial compression tests on the concrete blocks or cylinders. Table 2.1 indicates code of concrete strength based on British Standard.

Table 2. 1 The British Standard of Concrete.

	Concrete Mix	Cube Strength (MPa or N/mm^2)	Mix Proportion*	Area used
Normal Grade of Concrete	M10 / C10	10	1:3:6	Non-structural works like Patio slabs and pathways
	M15 / C15	15	1:2:4	Pavement kerbs and floor blinding
	M20 / C20	20	1:1.5:3	Internal floor slabs, flooring for the workshops, garages and drive ways
Standard Concrete Grades	M25 / C25	25	1:1:2	Foundations and reinforced concrete elements
	M30 / C30	30	Design Mix	Roadways (can handle heavy traffic), reinforced concrete elements
	M35 / C35	35	Design Mix	Water tanks & septic tanks & Reinforced concrete elements
	M40 / C40	40	Design Mix	
	M45 / C45	45	Design Mix	
High Strength Concrete Grades	M50 / C50	50	Design Mix	Reinforced concrete elements where the strength requirement is higher (Eg: lower floors of a Highrise building)
	M55 / C55	55	Design Mix	
	M60 / C60	60	Design Mix	
	M65 / C65	65	Design Mix	
	M70 / C70	70	Design Mix	

*Concrete mix Proportion = Cement : fine aggregate/sand : coarse aggregate

When designing a concrete mixture, strength, durability, and workability are the must considered properties. These qualities can often be achieved without using admixtures by adequately designing the mix and using appropriate materials (except air-entraining admixtures).

2.2.2 Cement

Cement is an essential ingredient in concrete, despite making up the smallest percentage of the mixture. When cement mixed with water, it hardens and binds all of the ingredients together. Portland Cement is a common type of cement that is made up of a mixture of calcium, silicon, aluminium, iron, and small amounts of other ingredients, with gypsum added during the final grinding process to regulate the concrete's setting time analyzed by ("The Concrete Network," 2020). Table 2.2 below shows the types of cement permitted in BS EN 197-1 and BS 8500.

Table 2. 2 Types of cement permitted in BS EN 197-1 and BS 8500

Cement Designation	Main Constituents	Limitations on non clinker composition (# % by mass)
Cement types permitted in EN 197-1		
CEM I	Portland Cement	
CEM II	Blastfurnace Slag	35%
	Silica Fume	10%
	Natural Pozzolan	35%
	Pulverized-fuel Ash (siliceous and	35%
	calcareous)	35%
	Burnt Shale	35%
	Limestone	35%
	Composite (mix of above constituents)	35%
CEM III	Blastfurnace Slag Cement	95%
CEM IV	Pozzolana Cement	55%
CEM V	Composite Cement	50%
Cement types permitted in BS8500 (combinations manufactured in the cement plant)		
CEM I	Portland Cement	
CEM II	Silica Fume	10%
CEM III	Blastfurnace Slag Cement	80%
CEM IV	Pozzolanic Cement	55%
Cement types permitted in BS8500 (combinations manufactured in the mixer)		
CII	Limestone Fines combination	20%
CII	Pulverized-fuel Ash combination	35%
CIII	Blastfurnace slag combination	80%
CIV	Pulverized-fuel Ash combination	55%

2.2.3 Water

Water, when combined with cement, forms a paste that holds the aggregate together. "Concrete: Scientific Principles," (2021) stated that water plays an important role in production. In concrete, water quality is also crucial as it is free of impurities such as suspended solids, organic matter, and dissolved salts, affecting the concrete's properties such as setting, hardening, strength, and durability (Samaneh & Afshin, 2016).

2.2.4 Aggregates

(Ghasemi, 2017) observed that aggregate make up 60 to 80 % of the volume of concrete. Despite the large number of aggregates used in concrete production, their importance is sometimes overlooked, and aggregates are considered fillers. There are divided into two categories fine and coarse. Research on "Aggregates for Concrete" (Brown 1998b) found that natural sand or crushed stone is the most common fine aggregates. Most particles pass through a 3/8- inch sieve while coarse aggregates are any larger particles than 0.19 inch in diameter. Still, most are between 3/8 and 1.5 inches."

2.2.4.1 Recycled aggregate

(Kaish et al., 2021) reviewed the available literature on using some of the waste materials as recycled aggregate in concrete production. Firstly is quarry dust. The author evaluated that replacing fine aggregate with quarry dust up to 50% of the time is the best way to improve the properties of concrete. A percentage increase in quarry dust content in concrete reduces workability due to the quarry dust's water demand in the mix, but a 55 percent increase in compressive strength was also observed in the concrete. Second is limestone waste. The impact of limestone powder on concrete strength is entirely determined by particle size and percentage replacement. Researchers used industrial waste materials to reduce the cost of concrete production while keeping the concrete's integrity. Another material waste is alum sludge. Alum sludge is a by-product generated during the purification of water for drinking purposes. Alum sludge has been used as a fine aggregate in the manufacture of a variety of construction materials, including low strength concrete and concrete blocks. The study also looked at the cost savings of using alum sludge as a concrete block replacement material. It has been suggested that up to 90% of the sludge could be used in the construction of new structures.

In another studies, (Mandal & Nigam, 2018) stated that recycled aggregate and silica fume used to replace natural aggregate by weight were 0, 50, and 100 percent. As the recycled aggregate's compressive and tensile strengths increase, the strength of the recycled concrete increases as it contains more silica.

2.3 Green Concrete

Green Concrete is a type of concrete that uses environmental-friendly materials. One of its advantages is that it's cheaper than traditional concrete. Although it uses less energy than traditional concrete, green concrete is not mixed with colors. Instead, its waste can be used as a combination with other materials. (Samaneh & Afshin, 2016). As (Samaneh & Afshin, 2016) stated the reason for this, is that waste products can be used as a cement or aggregate substitute and their waste disposal is inexpensive. Siroshi, Rajasthan, (2017) stated that green concrete has gone through extra steps in the mix design and placement to ensure a stable structure and low-maintenance surface—for example, energy conservation, carbon dioxide emissions, and wastewater management.

(Datta, 2020) describes the advantages of using green concrete. Green concrete has a higher chance of surviving a fire (it can withstand temperatures of up to 2400°F) and is more corrosion resistant than traditional concealed concrete. Ancient Roman structures had been discovered with similar concrete mixtures. Author also stated that fly ash already exists as a byproduct of another business manner so that you are not expending a lot more electricity to apply it to create green concrete. Green concrete is more resistant to temperature changes.

2.4 Ceramic waste

Ceramic is an inorganic, non-metallic material created by the action of heat and subsequent cooling. Ceramic materials can have a crystalline, partially crystalline, or amorphous structure (Dr. K. Ramadevi, 2017). Ceramic waste can be divided into two groups. The first is red pastes to make their goods, such as bricks, blocks, and roof tiles. The second category is white paste all fired stoneware ceramic trash, such as wall, floor, and sanitary ware (Pacheco-Torgal & Jalali, 2010).

(Zhu, 2020) stated that every year, China produces 15.5 million tonnes of construction waste, mostly concrete and bricks. In Spain, clay brick trash from demolished brick walls made up about 54 percent of building and demolition waste. The amount of waste sent to landfills would be greatly decreased if building waste was recycled. Table 2.3 listed the most common alternative aggregates among those investigated. Although the quantities and binders in the combinations studied differ, basic trends can be identified. With the exception of recycled coarse aggregate and municipal solid waste incineration (MSWI) ash-based fine aggregates, which have low density values, Table 5 displays density values that are near to reference ones.