STUDY OF NEW GREEN CONCRETE PRODUCT BASED ON UNGLAZED FIRED ROOF TILE WASTE

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in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this project entitled "Study Of New Green Concrete Product Based On Unglazed Fired Roolftile Waste" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Elsee Layu

Date : 18th 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.

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DEDICATION

My genuine gratefulness and warmest regard to dedicating this work to my family and friends, especially to my respected parent, Marten Labo and Kuab Baru, constantly encourage and support me. Many thanks to my caring friends whose advice worked for this thesis paper, and who care about my well-being at the same time. I also dedicate this dissertation to my siblings, lecturers, and coursemates, who kindly shared their knowledge and word of advice to work on this thesis.

ABSTRACT

The unglazed roof tile waste (URTW) potentially replaces fine aggregate concrete to produce new green concrete at 40, 50, and 60%. This research focuses on investigating the mechanical behaviour of URTW as fine aggregate in the concrete mix design. Both fresh and hardened concrete's physical and mechanical properties will be determined. The concrete’s mechanical behaviour contained URTW compared to the control mix in terms of its workability during slump test and its percentage of water absorption and compressive strength in a hardened state. The current experiment result of the compressive strength test for new green concrete is improved at an increasing percentage of URTW replacement. The result of the mechanical behaviour as to its compressive strength, workability, and water absorption of new green concrete shall be parallel with the standard value of BS. Specifically, the compressive strength of new green concrete achieved the targeted mean strength of M25 grade concrete at every percentage of replacing river sand with URTW.

ABSTRAK

Sisa jubin bumbung tanpa kaca atau unglazed roof tile waste (URTW) berpotensi menggantikan konkrit agregat halus untuk menghasilkan konkrit hijau yang baru pada kandungan 40, 50, dan 60%. Kajian ini bertujuan untuk mengkaji tingkah laku mekanikal URTW sebagai agregat halus dalam reka bentuk campuran konkrit. Sifat fizikal dan mekanikal konkrit segar dan konkrit keras akan ditentukan. Sifat mekanikal konkrit mengandungi URTW akan dibandingkan dengan konkrit campuran kawalan dari segi kebolehkerjaannya semasa ujian kemerosotan atau slump test dan peratusan penyerapan air dan kekuatan mampatan dalam keadaan mengeras. Hasil eksperimen semasa ujian kekuatan mampatan untuk konkrit hijau yang baru telah bertambahbaik pada seiring peningkatan peratusan gantian URTW. Hasil kajian sifat mekanikal mengenai kekuatan mampatannya, kebolehkerjaan, dan penyerapan air konkrit hijau yang baru hendaklah selari dengan nilai standard BS. Khususnya, kekuatan mampatan konkrit hijau yang baru mencapai kekuatan min yang disasarkan pada konkrit gred M25 pada setiap peratusan penggantian pasir sungai dengan URTW

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LIST OF SYMBOLS AND ABBREVIATIONS

URTW	Unglazed Roof Tile Waste
PCC	Portland Composite Cement
µm	Micrometer
mm	millimeter
AS	American Standard
BS	British Standard
PBM	Planatery Ball Milling
RAWA	Real-time Assesment of Water Absorption
M	Margin
k	Permitted Percentage Defective Value
s	Standard Deviation
Fm	Mean Strength Target
fc	Characteristic Strength
Wf	Appropiate Free-Water Content For Fine Aggregate
Wc	Appropiate Free-Water Content For Coarse Aggregate
w/c	Water-Cement Ratio

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CHAPTER 1

INTRODUCTION

1.1 Background

Presently, the growth of building construction has increased yearly over time. Klee (2004) stated that the estimated concrete manufactured each year is roughly 25 billion tons of concrete worldwide. According to Doye (2017), concrete is the ultimate significant contributor to the emission of the greenhouse. At the same time, concrete has unique properties where the recovery often falls between the standard definition of reuse and recycling. (Klee, 2004).

On the other hand, Subhan et al. (2014) believed that most manufacturing industries, especially in developing countries like Asia, are facing with solid waste management. These issues are essential to have extra attention because they could affect the environment badly. At the same time, development of construction, these wastes are accumulated from time to time. Somehow, dumping it could risk the environment because manufactured material contains other material, making it an odd substance to the environment.

By that, many researchers try to solve these issues by doing a lot of research, studying, and improving hypotheses to develop results that could help overcome environmental threat issues. All these studies show that the concrete that 90% depending on natural resources highly impacts the environment. Even though it reduces concrete development by substituting the cementitious material with other substances, it only accepted at least 20% of aggregate content to replace recycled concrete. Klee, (2004).

Producing green concrete based on industrial waste material could benefit both parties. The reason is that environmental threats could be reduced, and solid waste management would improve. So, by the end of this study, perhaps substituting the roof-tile of industrial waste could be sustainable enough to reduce industrial waste.

1.2 Problem Statement

The constant use of natural resources has also slowly become a threat to the environment. Consequently, the culmination in the market is from time to time approximately exponential, meaning the consumption grows at a rate relative to its current value for most materials. Meanwhile, the roof tile manufacturer has difficulty managing the defective roof tiles that have become waste.

In the published paper, using recycled waste roof tiles to produce a new product like an acceptable substitute aggregate in concrete mix design could reduce consumption of natural resources simultaneously reduce environmental impact from dumping. Roof tile is made of 100% clay, and its material behaviour has its very own characteristics. The characteristic of roof tile itself is made to comply with AS 2094-2002 and is tested following AS 4064.4. Generally, all roof tiles are designed and tested to conform to the Australian Standard regarding their material properties, strength, durability, water absorption, and permeability.

Therefore, the idea of considering roof tile industrial waste to substitute fine aggregate to produce new green concrete is considered. Additionally, to substitute the sand in the concrete mix, the size of the crushed roof tile must imitate or be similar to the size of sands. To produce a fine aggregate out of the roof tile, it must go through a few processes, like crushing using Planetary Ball Milling Machine, and the sieving process using Vibrator Sieve Machine with selected parameter setting. Later, the result will be analysed to see if the aggregate meets the British Standard or the other way round.

1.3 Objective of Research

1.3.1 General Objective

i. To recycle the unglazed-fired roof tile industrial waste (URTW) into a new green concrete product.

1.3.2 Specific Objectives

i. To develop a formulation using MS Excel to calculate the proportion of URTW to substitute fine aggregate based on the BRE method.

ii. To study the physical properties of the unglazed roof tile waste as a fine aggregate in accordance with the British Standard by crushing and milling processes.

iii. To assess the mechanical behaviour of the produced green concrete based on fired unglazed roof tile industrial waste.

1.4 Scope of Research

The area of this study is an extension of parameters that should be explored and focused on. The properties of URTW to be replacing sand in the concrete mix at the maximum quantity is the aim of this research study. As a result, the work is also specified to produce fine aggregate based on URTW using a grading method that ensures the crushed URTW size is within the British Standard's range. To create the fine aggregate based on URTW, the parameter setting to get the desired aggregate size will be identified. Moreover, the new green concrete's strength will be determined at 28 days curing by compressive strength testing. Then, the result of the experiment will be collected from the compressive testing carried on each testing and procedure in this study shall comply with British Standard.

1.5 Research Rationale

This research aims to reduce the usage of natural resources (sand) to produce green concrete based on industrial roof tile waste. At the same time, maximising the composition of URTW in the concrete mix is important to ensure that at 28 days compressive strength of the green concrete imitates the conventional concrete mixture. This study's significance also focuses on the parameter of the methodology applied during the process.

The reason for choosing URTW as a substitution for sand is that the waste from the roof tile industry is piling up. With the drawback, this research that focuses on using URTW as sand substitution could be one solution. However, the properties of the URTW shall be investigated deeply to produce the green concrete by taking this research intensely. Hence, conducting this research may provide new improvement ideas for future reference. It will also benefit the roof tile manufacturer and the environment as this research may help manage the solid waste and recycle waste into green concrete.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Plenty of research studies has been conducted to investigate the various types of waste from material and industrial waste like plastic, ash, glass, and roof tiles used in concrete as an aggregate to produce a new green concrete. It is either being used as fully or partially substitute aggregate in a concrete but depends on the material's properties. Hence, many previous studies have been performed to achieve the right proportion of concrete content without neglecting the standard requirement. Which, in a way, has no severe impact on the concrete's engineering properties. So, this chapter will review previous research findings to investigate the suitable approach as a guide to conduct the current study.

2.2 Concrete

In agreement with Somayaji (2001) statement, concrete is the most common construction material used in construction. For example, various applications are widely used, from multistory buildings, dams to railroad ties. The concrete properties are broadly in various applications, which include mechanical properties. The mechanical properties are durability, compressive strength, wear-resistance, and resistance to environmental attack. However, not all its properties are essential, but most of them are.

According to Jackson & Dhir (1996), concrete is mainly made up of several main components. The essential components of a concrete mix are cement, water, and aggregate. In some cases, admixtures will be added to the concrete mix to modify concrete properties. These traditional ingredients are mixed and moulded into the desired size and shape while the mixture is still wet. (Somayaji, 2001).

Additionally, as Domone and Illson (2010) stated, a chemical reaction would occur between water and cement after a few minutes when mixed, and this process is called hydration. This reaction will continue over time and produces a complex, strong, and durable material called hardened concrete or merely concrete. (Somayaji, 2001) . Also, the tangible property is influenced by the ingredients' composition like cement type, water, and aggregate's size or shape.

2.3 Cement

The essential component in concrete is cement. Conforming to Domone & Illston's (2010) work of studies, cement operates to bind them with aggregate the presence of water during the hydration process. Additionally, Portland cement 95% used in concrete is the most typical type of cement worldwide. However, it is vital to know the cement composition and the chemical process to produce good quality concrete. Moreover, Dvorkin et al. (2010) mentioned in their published book that selecting cement could be crucial too because the consideration should be given. For example, the required concrete properties are strength, the intensity of its growth, aggressive influence of the environment, structural features of the elements, and concrete workability.

Teychenné et al. (2010) specified that cement has different types and strength classes that produce concrete with different strength development rates. Even though the cement's different types would produce different strength ranks, it must obey the British construction standard.

2.3.1 Type of Cement

Generally, cement is divided into two categories for construction and building industry applications. The categories are hydraulic and non-hydraulic cement. Somayaji (2001) stated that hydraulic cement is any cement that, thus from powder-like to solid-state with water. In other words, cement will turn into hardened concrete because there will be a chemical reaction occurs when there is a presence of water. On the other hand, non-hydraulic cement does not require water to change its properties to solid-state.

2.4 Aggregate

In concrete mix, aggregate is one of the essential components. Moreover, aggregate often to be a substitute for recycling substances. For example, Kamaruddin *et al.*, (2017) study investigated the potential of plastic waste as construction materials. Additionally, research uses several types of plastics to substitute them as an aggregate in the concrete mix. Furthermore, Etxeberria and Vegas, (2015) reported, their research was about the effect of fine ceramic as recycled aggregate. The intention considering ceramic as a substance that can substitute a fine aggregate in concrete is because the rejected amount of ceramic from industry was tremendous.

As a result, in some cases, it's more essential to reflect about using recycled concrete, plastics, or ceramic waste as a concrete mix alternative. For instance, the influence of replacing recycled aggregate in concrete on mechanical and physical properties needs to be considered. Furthermore, the form, size, and amount of aggregate impacted the mechanical and physical qualities of the concrete. So, in line with the statement of Paultre, (2003), he concludes that aggregate affects the strength of the concrete by considering characteristics written in the Portland Cement Association (1916) study for concrete. Also, the application geometrical requirement shall be determined, just as Brown (1998) reported in his study. However, Rached, Moya and Fowler, (2009) believe that aggregate may affect other mechanical properties of the concrete. For example, the workability, permeability, wear resistance, and low modulus elasticity may affect the cement paste during the shrinkage process.