POZZOLANIC ACTIVITY EVALUATION OF SPENT BLEACHING EARTH ASH STRENGTH ACTIVITY INDEX, FRATTINI TEST AND SATURATED LIME TEST

SHARIFAH BINTI RASUL

FACULTY OF ENGINEERING

UNIVERSITI MALAYSIA SABAH

2022

POZZOLANIC ACTIVITY EVALUATION OF SPENT BLEACHING EARTH ASH STRENGTH ACTIVITY INDEX, FRATTINI TEST AND SATURATED LIME TEST

SHARIFAH BINTI RASUL

THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF BACHELOR OF CIVIL ENGINEERING

FACULTY OF ENGINEERING
UNIVERSITI MALAYSIA SABAH
2022

UNIVERSITI MALAYSIA SABAH

BORANG PENGESAHAN STATUS TESIS

JUDUL :

IJAZAH:

BIDANG:

SAYA **SHARIFAH BINTI RASUL**, Sesi **2018-2022**, mengaku membenarkan tesis Sarjana Muda ini disimpan di Perpustakaan Universiti Malaysia Sabah dengan syarat-syarat kegunaan seperti berikut:

1. Tesis ini adalah hak milik Universiti Malaysia Sabah.
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (/):

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	TIDAK TERHAD	

Disahkan oleh:

ANITA BINTI ARSAD
PUSTAKAWAN KANAN
UNIVERSITI MALAYSIA SABAH

SHARIFAH BINTI RASUL
BK18160282

(TANDATANGAN PUSTAKAWAN)

(DR. ANDREW LIM CHUNG HAN)
PENYELIA

TARIKH : 1 JULY 2022

Catatan:
*Potong yang tidak berkenaan.
*Jika tesis ini SULIT dan TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT dan TERHAD.
*Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana Secara Penyelidikan atau disertai bagi pengajian secara kerja kursus dan Laporan Projek Sarjana Muda (LPSM).

DECLARATION

I hereby declare that this thesis was submitted to University Malaysia Sabah as partial fulfilment of the requirements for the degree of Bachelor of Civil Engineering. This thesis has not been submitted to any other university for any degree. I also certify that the work described herein is entirely my own, except for quotations and summaries sources of which have been duly acknowledged.

1 July 2022

BK18160282

Sharifah binti Rasul

CERTIFICATION

NAME	:	SHARIFAH BINTI RASUL
MATRIC NO.	:	BK18160282
TITLE	:	POZZOLANIC ACTIVITY EVALUATION OF SPENT BLEACHING EARTH ASH BY STRENGTH ACTIVITY INDEX, FRATTINI TEST AND SATURATED LIME TEST
DEGREE	:	BACHELOR OF ENGINEERING
FIELD	:	CIVIL
VIVA DATE	:	21 JULY 2022

CERTIFIED BY;

Signature

SINGLE SUPERVISION

SUPERVISOR
Dr. Andrew Lim Chung Han

ACKNOWLEDGEMENT

First and foremost, I'd like to express my gratitude to Allah Almighty for His guidance and blessings throughout my entire thesis writing. In addition, it gives me great pleasure to give special thanks to everyone who helped me prepare my research from start to finish. My heartfelt gratitude goes to Dr. Andrew Lim Chung Han, my Final Year Project Supervisor for his greatest guidance and encouragement. He graciously shared his experience with me and discussed the wide range of engineering knowledge and technical suggestions with me.

Not to mention my family and loved ones for their encouragement, morale, and patience throughout this endeavour. I would not have been able to finish my thesis without their tireless efforts and guidance.

In addition, I also want to express my sincere gratitude to my absolutely incredible friends who are always prepared to help me improve my thesis writing by sharing ideas or criticisms. The thesis would not be able to be completed without them.

Finally, I would want to express my gratitude to everyone who, whether directly or indirectly, offered me assistance and shared their knowledge and information throughout the writing of my project.

Sharifah Binti Rasul
1 June 2022

ABSTRACT

The process of palm oil refining produces spent bleaching earth (SBE) as a waste by-product. In Malaysia, this waste usually ends up in landfills. Recycled from SBE, spent bleaching earth ash (SBEA) is a sustainable product that is increasingly integrated as a blended cement in construction applications. It has the potential to be used as supplementary cementitious material and partially substitute cement that contributes to carbon dioxide emission. This research seeks to determine the pozzolanic reactivity of untreated and calcined SBEA. Strength Activity Index (SAI) according to the British Standards, Frattini test, and saturated lime test used to measure the pozzolanic reactivity. Results indicated that both the untreated and calcined SBEA have pozzolanic reactivity. Based on Frattini and saturated lime results, both samples show high pozzolanic activity. However, in all tests, untreated SBEA shows higher pozzolanic activity compared to calcined SBEA.

ABSTRAK

Proses penapisan minyak sawit menghasilkan debu peluntur terpakai (SBE) sebagai bahan sisa. Di Malaysia, sisa ini biasanya berakhir di tapak pelupusan sampah. Dikitar semula daripada SBE, abu debu peluntur terpakai (SBEA) adalah produk mampan yang semakin disepadukan sebagai simen campuran dalam aplikasi pembinaan. Ia berpotensi untuk digunakan sebagai bahan tambahan simen dan menggantikan sebahagian simen yang menyumbang kepada pelepasan karbon dioksida. Penyelidikan ini bertujuan untuk menentukan kereaktifan pozzolanik SBEA yang tidak dirawat dan dikalsin. Indeks Aktiviti Kekuatan (SAI) mengikut Piawaian British, ujian Frattini, dan ujian kapur tepu digunakan untuk mengukur kereaktifan pozzolanik. Keputusan menunjukkan bahawa kedua-dua SBEA yang tidak dirawat dan dikalsinkan mempunyai kereaktifan pozzolanik. Berdasarkan keputusan Frattini dan kapur tepu, kedua-dua sampel menunjukkan aktiviti pozzolanik yang tinggi. Walau bagaimanapun, dalam semua ujian, SBEA yang tidak dirawat menunjukkan aktiviti pozzolanik yang lebih tinggi berbanding dengan SBEA yang dikalsin.

LIST OF TABLES

LIST OF FIGURES/PHOTOGRAPHS

LIST OF FORMULA

LIST OF ABBREVIATIONS/SYMBOLS

SL – saturated lime

SBEA – Spent Bleaching Earth Ash

SAI – Strength Activity Index

CKD – cement kiln dust

CH – calcium hydroxide

SBE – Spent Bleaching Earth

GHG – greenhouse gas

SCM – supplementary cementitious material

FA – fly ash

OPC – Ordinary Portland Cement

EC – expanded clay

RHA – rice husk

BFA – biomass ashes

EBA – eucalyptus bark ashes

G – glass waste powder

EBA – Enhanced Biomass Ash

CFA – Coal fly ash

SF – Silica Fume

MK – Metakaolin

CFA – Coal Fly Ash

ISSA – Incinerated Sewage Sludge Ash

MSWI BA – municipal solid waste incinerator bottom ashes

C&DW – construction and demolition waste

EAFS – electric arc furnace slag

HPC – high performance concrete

CWP – ceramic waste powder

CCK – coal-series kaolin

RCK – raw coal-series kaolin

SCBA – sugar cane bagasse ash

BA – bamboo ash

NP – natural pozzolan

BFS – blast furnace slag

FRCB – Fired Rejected Clay Bricks

CAH – calcium aluminate hydrate

OD – oven dry

SSD – saturated-surface-dry

EDTA – ethylenediaminetetraacetic acid

LIST OF APPENDICES

LIST OF CONTENT

CHAPTER 1

INTRODUCTION

1.1 Introduction

The demand for new structures and infrastructure grows as the world expands and develops, necessitating a vast amount of construction material. New environmentally friendly materials that are also cost-effective are being developed as demand increases (Ababneh & Matalkah, 2018; Malhotra & Mehta, 2004; Safiuddin & M.F.M. Zain, 2016).

The manufacture of Portland cement contributes for around 5% percent of carbon dioxide emissions into the atmosphere. (Gartner, 2004). CO_2 emissions are roughly one tonne per tonne of clinker generated when fossil fuels are employed (Hendriks et al., 1999; Malhotra, 2006; v. M. Malhotra, 2002). CO_2 is released into the atmosphere in two ways: first, when calcium carbonate is thermally destroyed, and second when fossil fuels are burned in a rotary furnace to create a high temperature environment (Benhelal et al., 2013). Furthermore, cement production consumes a substantial amount of energy; the cement industry is projected to utilise around 2% of global energy. Global cement output is around 1.89 billion tonnes per year. (Huntzinger & Eatmon, 2009; Suhendro, 2014).

The market for green concrete, which can assist in reducing greenhouse gas emissions into the environment, is increasing because of global warming. Green concrete is defined as environmentally friendly concrete that incorporates waste materials and does not necessitate a lengthy, destructive operation (Mehta, 1986, 2002). The number of additives in Portland cement (added or altered), manufacturing procedures, concrete performance, and concrete life span are the three key factors that constitute green concrete (Mehta, 2002; Suhendro, 2014). Spent Bleaching Earth Ash (SBEA) is a pozzolanic substance with cementitious qualities that can partially substitute cement in concrete production, resulting in a better environment and lower material costs (Kho, 2021a).

Cement manufacturing in Malaysia is around 20 million tonnes per year, with this industry accounting for approximately 12% of overall energy consumption in Malaysia (Bakhtyar et al., 2017). Malaysia produced 2,992 thousand metric tonnes of CO_2 emissions from cement in 2014. CO_2 emissions from Malaysian cement manufacturing climbed at a 4.28% yearly rate from 1,457 thousand metric tonnes in 1995 to 2,992 thousand metric tonnes in 2014 (Ministry of Natural Resources and Environment, 2016).

Apart from CO_2, cement production generates millions of tonnes of cement kiln dust, or CKD, a waste product that causes health problems, the most common of which are respiratory problems (Rahmani et al., 2018).

Partially replacing cement with an alternate material is one option for reducing CO_2 emissions and mitigating other adverse effects of cement production (Abdollahi & Zarei, 2018; Antiohos et al., 2013; Ghrici et al., 2018; Malhotra, 2006). Utilizing supplementary cementitious materials rather of cement can minimise carbon dioxide emissions. In the construction sector, substituting 15-40% of cement with mineral additions like fly ash and blast furnace slag can cut CO_2 emissions by 60–70%. Other substitute materials, such as volcanic ash, crushed limestone, and broken glass can reduce CO_2 emissions by 50% while simultaneously lowering energy consumption. The physical and chemical qualities of these materials, as well as the source from which they are obtained, impact their effectiveness as cement alternatives (Miller et al., 2016; National Ready Mixed Concrete Association, 2008).

As a result, researchers are studying an increasing range of natural and synthetic pozzolans for usage in concrete. Since at least the 1970s, additional cementitious material has been used in concrete in North America. These materials are employed in modern concrete not only because they are cost-effective and environmentally friendly but also because they improve the strength and endurance of the concrete (Mehta, 1981, 1990). As a result of a rising focus on lowering the effects of generated carbon dioxide on the environment, several alternative materials are now being included in Portland cement concrete. Adding additional cementitious ingredients to concrete or mortar lowers the material's cost and reduces the amount of energy consumed in the manufacturing of Portland cement, according to Juenger and Siddique (2015) and Khan 10 et al. (2017). Alternative cementing materials have been the focus of a substantial and ongoing investigation. Because it is time-consuming to measure the strength development characteristics of each of these extra cementitious materials separately, a broad understanding of the mechanisms underlying their performance is necessary (Owaid et al. 2012l; AL-Jumaily et al. 2015).

Previous studies have found that numerous industries, agricultural, and thermoelectric plant residues, including mineral additives like fly ash, silica fume, rice husk, granulated blast furnace slag, sugarcane bagasse, and palm oil ash, can replace Portland cement in amounts varying from 5% to 30% or even higher percentages (Cheerarot & Jaturapitakkul, 2004; Owaid et al., 2012; Uzal & Turanli, 2003). As partial cement alternatives, fly ash, silica fume, metakaolin, rice husk, powdered, granulated blast furnace slag, and volcanic tuff (natural pozzolans) are now widely employed (Ghrici et al., 2018; Khan & Alhozaimy, 2011; Zhang et al., 2002). These compounds improve alkali-silica reaction resistance, durability, long-term strength, freeze-thaw resistance, and prevent thermal cracking produced by hydration heat in concrete (Ababneh & Matalkah, 2018; al-Swaidani & Aliyan, 2015; Kaid et al., 2009; Labbaci et al., 2017).

1.2 Problem Statement

A crude palm oil refinery facility produces roughly 2 million tonnes of wasted bleaching earth (SBE) each year around the world (Beshara & Cheeseman, 2014). Malaysia is well-known for producing a large quantity of palm oil fruits. In order to make refined palm oil, bleaching earth is added at the degumming and bleaching stage of processing crude palm oil. SBE is a by-product of the refining of crude palm oil. These waste products typically find their way into landfills in Malaysia (Loh et al., 2013). Due to spontaneous anaerobic degradation, SBE disposal in landfills may have an impact on greenhouse gas (GHG) emissions.

SBEA has recently been used in mixed cement. However, research on SBEA as a pozzolanic material has been scarce in earlier investigations. Pozzolanic waste materials are used to substitute cement in concrete, hence reducing the quantity of cement required (Chindaprasirt et al., 2007). Because the cement industry generates between 5% and 7% of worldwide CO_2 emissions, using pozzolanic material to substitute cement could reduce emissions of CO_2 (Benhelal et al., 2013).

Due to the demand for more environmentally friendly cementitious products, it is becoming more and more crucial to evaluate the pozzolanic activity of cement substitutes. The purpose of this research is to pozzolanic reactivity of untreated and calcined SBEA. It will assist in obtaining more accurate data about SBEA, which is needed to promote its use in industries.

The pozzolanic activity of the control sample (cement), the untreated SBEA, and the calcined will be evaluated using three different pozzolanic activity test methodologies, and the findings from each test are compared. The Frattini test and the saturated lime test were employed as direct tests, while the strength activity index test was utilised as an indirect test. Because they have been extensively reported on and have standard operating procedures (BS 3892, EN 196-5, and ASTM C311), the Frattini test and strength activity test were chosen. The saturated lime test technique was chosen because it yields quantitative data from a direct test procedure, is similar to but easier than the Frattini test.

1.3 Objective

The objective of this study is to:

- To determine the pozzolanic reactivity of SBEA using SAI, Frattini test and saturated lime test
- To investigate the pozzolanic reactivity of SBEA untreated and calcined SBEA.
- To study the effectiveness of calcination as means of increasing the pozzolanic activity in SBEA

1.4 Significance of Study

The evaluation of pozzolanic reactivity of SBEA can facilitate in reducing the environmental pollution. This documentation research presents the pozzolanic activity evaluation of SBEA that can be used as a valid reference for future research. The understanding of the pozzolanic reactivity of SBEA will benefit the communities and improve future approaches.

a. In particular, it reduces the environmental pollution caused by SBEA dumping.
b. Its usage as a substitute for Portland cement may help reduce carbon dioxide emissions in the building industry.

1.5 Scope of Study

This study was focused on the pozzolanic properties of untreated and calcined Spent Bleaching Earth Ash (SBEA). The SBEA used was supplied by from EcoOils Sdn Bhd (Lahad Datu, Sabah).

In this study, the calcination is done in 700°C temperature. The cement replacement for both treated and untreated SBEA are 20%.

The study is the pozzolanic activity was evaluated by Strength Activity Index (SAI), Frattini test and saturated lime test. The SAI determines the pozzolanic reactivity based on compressive strength development of blended cementitious mix concerning reference mix. It was carried out at the Concrete Lab, University of Malaysia Sabah. The Frattini and saturated lime test is used to check for the presence of $Ca(OH)_2$. Both tests are done in Environmental Lab, University of Malaysia Sabah.

CHAPTER 2

LITERATURE REVIEW

2.1 Background of Pozzolan

2.1.1 History of Pozzolan

As early as 5000 B.C., concrete has been produced with a hydraulic binder called diatomaceous earth, which is a combination of lime and natural Persian Gulf pozzolan. As early as 1500 and 1600 B.C., volcanic ash (a natural pozzolan) was used in construction in the Mediterranean region (Ramezanianpour 2014; Thomas 2013). Natural pozzolans combined with lime were utilised by the Romans in mediaeval times, and the reaction between the two produced a high-performance binder (Baronio and Binda 1997; Ababneh and Matalkah 2018). Pozzolan is derived from the Italian volcanic region of Pozzuoli, where pozzolanic volcanic ash was discovered. Later, the term was used for materials having a similar composition. There is no benefit in limiting the term to a single place because pozzolans can be found all over the world.

Pozzolans are siliceous and do not have cementitious qualities, according to Crawford (1951), but they do have cementitious capabilities when paired with lime and water in ambient conditions. Natural pozzolans were utilised in concrete as mineral admixtures for huge buildings such as dams in the nineteenth century for these reasons, according to Davis (1950). Many concrete structures have been built using Portland cement-natural pozzolan mixed concretes. This includes the Golden Gate Bridge, San Francisco-Oakland Bay Bridge, Bonneville Dam, and Friant Dam. Due to the resilience of the material to sulphate attack from seawater and its