INFLUENCE OF ELEVATED TEMPERATURE ON PROPERTIES OF LIGHTWEIGHT CONCRETE CONTAINING PALM OIL FUEL ASH (POFA) SUBJECTED TO WATER COOLING

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SUPERVISOR'S DECLARATION

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 degree of Bachelor of Civil Engineering and Earth Resources

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Konkrit ringan telah banyak digunakan sebagai bahan pembinaan untuk pembangunan. Pengeluaran simen menghasilkan gas karbon dioksida yang membahayakan alam sekitar. Pada masa yang sama, Malaysia merupakan salah satu pengeluar dan pengeksport terbesar yang telah menghasilkan abu bahan bakar kelapa sawit yang akan dibuang sebagai sisa. Oleh itu, penyelidikan ini menyiasat suhu-suhu tinggi pada sifat konkrit ringan yang mengandungi abu bahan bakar kelapa sawit sebagai pengganti simen separa. Konkrit ringan dibuat dengan simen digantikan dengan peratusan yang berbeza daripada abu bahan bakar kelapa sawit (10%, 20%, 30% dan 40%). Ujian kekuatan mampatan dilakukan terhadap spesimen selepas kaedah penyejukan.Kemudian, spesimen tersebut tertumpu kepada suhu tinggi (200 °C, 400 °C, 600 °C dan 800 °C) dalam relau elektrik selama tempoh 1 jam. Selepas itu, spesimen konkrit akan tertakluk kepada penyejukan air sehingga tiada stim. Seterusnya, spesimen akan diuji untuk sifat fizikalnya seperti warna, berat, retak dan kekuatan mampatan. Penemuan ini akan menunjukkan prestasi konkrit ringan yang mengandungi abu bahan api kelapa sawit apabila tertakluk kepada suhu tinggi. Pada 40% konkrit daripada abu bahan kelapa sawit, penurunan berat badan adalah yang tertinggi pada semua suhu kerana kawalan kandungan kelembapan yang lebih tinggi oleh jumlah yang tinggi abu bahan kelapa sawit. Seterusnya, kekuatan mampatan sisa pada 10% abu bahan kelapa sawit menunjukkan nilai tertinggi kerana konkrit menjalani dua jenis proses penghidratan nama proses dan tindak balas pozolanik yang dihasilkan lebih banyak kalsium silicate hydrate (C-S-H) gel. Di samping itu, keretakan garis rambut diperhatikan pada 400 °C dan lebih banyak keretakan boleh dilihat pada suhu 600 °C-800 °C.

ABSTRACT

Lightweight concrete has been largely used as construction material for development. The cement production produce carbon dioxide gas which harmful to the environment. At the same time, Malaysia being one of the largest producer and exporter palm oil produces POFA which disposed as waste. Thus, this research investigate the influence of elevated temperature on properties of lightweight concrete containing palm oil fuel ash (POFA) as partial cement replacement. Lightweight concrete was partially replaced by different percentages of POFA (10%, 20%, 30% and 40%). Compressive strength test was conducted on control specimens as well as the specimens after cooling method. Then, the specimens were subjected to high temperature beginning from 200°C, 400°C, 600°C until 800°C in electric furnace for 1 hour period. After that, the concrete specimens subjected to water cooling until there is no steam out. Next, the specimens were observed for its physical changes namely color, weight loss and cracks. The residual compressive strength also been tested. At 40% of POFA, the weight loss is the highest at all temperatures due to the greater moisture content control by the high volume of POFA. Next, the residual compressive strength at 10% of POFA show the highest value because of the concrete undergo two types of process name hydration process and pozzolanic reaction which more calcium silicate hydrate (C-S-H) gel produced. In addition, the hairline cracks were observed at 400°C and more cracks can be seen at 600°C-800°C.

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LIST OF SYMBOLS

°C	Degree
Mpa	Mega Pascal
Mm	Millimetre
%	Percent
Kg/m^3	Kilogram per metre cube
µm	Micrometre
µmm	Micro millimetre
N/mm^2	Newton millimetre square

LIST OF ABBREVIATIONS

OPC	Ordinary Portland Cement
POFA	Palm oil fuel ash
POBS	Palm oil boiler stone
POC	Palm oil clinker
LWAC	Lightweight aggregate concrete
LOI	Loss of ignition
BS	British standard
C-S-H	Calcium silicate hydrate

CHAPTER 1

INTRODUCTION

1.1 Introduction

With the growing demand for supplementary cementing materials, smart and efficacious conservation of construction materials comprising several by-product wastes have received more attention for the sustainability of green construction (Sua-iam & Makul, 2013). As Malaysia is one of the largest exporter and producer, it produces more waste such as palm oil fuel ash and palm oil boiler stone through an incineration process. To reduce the usage of cement, waste products from palm oil mill can be utilize towards to sustainability of green construction. The issue of natural resources depletion has been mentioned by (Bjork, 1999). Thus, concern towards environmental degradation such as global warming, atmosphere pollutions and waste disposal lead to the usage of waste product in lightweight concrete.

Fire represents one of the most severe potential risks to which structures may be subjected. The performance of all load bearing structural members in buildings under elevated temperature is the foremost concern that must be addressed to allow their safe use (Jumaat, Alengaram, Ahmmad, Bahri, & Islam, 2015). Therefore, the present research seeks to explore the performance of lightweight concrete containing palm oil fuel ash in response towards elevated temperature. The determination of elevated temperature resistance of lightweight concrete during fire is complicated due to the constituent materials with different thermal characteristics of this composite material and it is also dependent on moisture content and porosity (Shah & Ahmad, 1994).

This study focused on the properties of lightweight concrete containing palm oil fuel ash (POFA) after subjected to elevated temperatures. The behaviour of the lightweight concrete with POFA at elevated temperatures was investigated in comparison with the behaviour of normal concrete. A comparative analysis was conducted in terms of physical changes of the lightweight concrete. It is projected that the results of this study can deepen the understanding of lightweight concrete POFA leading to safer design and application of this technology. An assessment of the impact of water cooling was also included in this research.

1.2 Problem Statement

Since Malaysia is one of the largest exporter and producer in the world, the waste products, palm oil fuel ash (POFA) were disposed in the landfills which cause environmental pollution. Plus, due to high demand of cement for development, the price of the cement increasing over the time and thus make the construction cost higher. Concern towards preserving natural resources for future generation has lead towards approaches of using palm oil fuel ash (POFA) as partial cement replacement in lightweight concrete. Although it can be used to produce lightweight concrete but the fire resistance of this palm oil fuel ash (POFA) lightweight concrete yet to be studied. Since, the determination of elevated temperature resistance of lightweight concrete during fire is very complicated due to constituent's materials with different thermal characteristics of this composite (Shah & Ahmad, 1994). Therefore, the present research investigates fire resistance containing palm oil fuel ash (POFA) in lightweight concrete.

1.3 Objectives

This study was conducted to achieve the following objectives:

i. To investigate the impact of elevated temperature on colour and weight loss of lightweight concrete containing palm oil fuel ash as partial cement replacement subjected to water cooling.

ii. To determine the effect of elevated temperature on compressive strength of lightweight concrete containing palm oil fuel ash as partial cement replacement subjected to water cooling.

1.4 Significance of Research

This study provides knowledge on the properties of lightweight concrete containing palm oil fuel ash (POFA) when it is subjected to high temperature. From the research, we can discover the effect of palm oil fuel ash as partial cement replacement on the behaviour of lightweight concrete. By using palm oil fuel ash (POFA) as partial replacement in the concrete, we can reduce the usage of landfill to dispose the by-products of palm oil. Furthermore, we can reduce the production and usage of cement in concrete so that the emission of carbon dioxide gas is decrease. From that, we can reduce the effect of the greenhouse gases which lead to global warming.

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