# WORKABILITY AND MECHANICAL PROPERTIES OF OIL PALM SHELL LIGHTWEIGHT AGGREGATE CONCRETE CONTAINING FLY ASH AS PARTIAL CEMENT REPLACEMENT

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## STUDENT'S DECLARATION

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

Pengeluaran konkrit menggunakan sejumlah besar sumber semula jadi. Tempurung kelapa sawit (OPS) merupakan salah satu bahan sisa pengeluar utama dari industri kelapa sawit dan abu terbang (FA) dari pembakaran. Sisa-sisa ini menyebabkan banyak masalah alam sekitar. Bagi menyelesaikan masalah ini, OPS digunakan untuk menggantikan agregat kasar dan FA sebagai pengganti simen separa. Kajian ini bertujuan untuk mengkaji kebolehkerjaan, kekuatan mampatan, kekuatan lenturan, pemisahan kekuatan tegangan dan modulus keanjalan OPS konkrit agreget ringan (LWAC) yang mengandungi FA. 10, 20, 30, dan 40% FA ditambah dalam konkrit sebagai pengganti simen separa. Sebanyak 180 spesimen telah disediakan dan tertakluk kepada kaedah pengawetan udara untuk dikaji. Hasilnya menunjukkan pengurangan kekuatan apabila semakin meningkatnya FA dalam spesimen. OPS LWAC yang mengandungi 20% FA masih boleh digunakan untuk aplikasi struktur.

## ABSTRACT

The production of concrete consumes a larger number of natural resources. The oil palm shell (OPS) was one of the major producer waste material from the oil palm industry and fly ash (FA) wastes from combustion. These wastes have caused many environmental problems. In order to solve this problem, the OPS was used to replace coarse aggregate and FA as a partial cement replacement. This research is to investigate workability, compressive strength, flexural strength, splitting tensile strength and modulus of elasticity of OPS lightweight aggregate concrete (LWAC) containing FA. 10, 20, 30, and 40% of FA added in the concrete as partial cement replacement. A total of 180 specimens were subjected to air curing for testing. The result demonstrates the reduction of strength when the increasing level of FA in the specimen. The OPS LWAC containing 20% of FA still can be used for structural application.

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## LIST OF SYMBOLS

| | |
|---|---|
| % | Percentage |
| GPa | Giga Pascal |
| Kg | Kilograms |
| $Kg/m^3$ | Kilograms per meter cubes |
| m | Metre |
| $m^3$ | Meter cubes |
| mm | Millimetre |
| MPa | Mega Pascal |
| w/c | Water content |

## LIST OF ABBREVIATIONS

| | |
|---|---|
| $Al_2O_3$ | Aluminium |
| ASTM | American Society for Testing and Materials |
| BS | British Standard |
| BS EN | British Standard European Norm |
| CaO | Calcium |
| CI | Chloride |
| $CO_2$ | Carbon dioxide |
| C-S-H gel | Calcium Silicate Hydrate gel |
| FA | Fly Ash |
| $Fe_2O_3$ | Iron |
| $K_2O$ | Potassium |
| LWAC | Lightweight Aggregate Concrete |
| MgO | Magnesium |
| Mil ha | Million hectares |
| MOE | Modulus of Elasticity |
| N | Nitrogen |
| $Na_2O$ | Sodium |
| OPC | Ordinary Portland Cement |
| OPS | Oil Palm Shell |
| S | Sulphur |
| $SiO_2$ | Silica |
| $SO_2$ | Sulphur dioxide |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Concrete was a composite material made from cement, aggregate, sand, and water. This was a versatile material that easily mixed and flexible to be molded into multiple shapes. However, there was a negative impact using concrete for the environment that needed a great number of natural resources (Alengaram et al. 2013). The negative impact of concrete on the environment can be reduced by using recycled or waste material. For instance, oil palm shell (OPS) was one of the recycled materials produced in oil palm industries. Malaysia was the second largest exporter of palm oil that was reported in 2011 that 5 mil ha area of land was used for oil palm plantation (Lim et al. 2013). This resulted in the annual production of about 61.1 miles of solid waste such as empty fruit branches, fibers and kernels in the country (Islam et al. 2016). The used of OPS in concrete to replace aggregate produced environmentally friendly concrete.

Fly ash (FA) had become a waste material that allotted from coal power plants to make primary coal combustion (Xu & Shi, 2018). This caused an environmental issue such as emission of carbon dioxide ($CO_2$), air pollutants and waste. The environment issue can be reduced by using FA as a cement replacement on concrete. FA can be applied in concrete production, cement clinkers, waste stabilization, road basement and geopolymer concrete (Hemalatha et al. 2017). The abundant benefit of using FA as a cement replacement, that improved workability, improve mechanical of concrete, reduce heat hydration and thermal cracking in concrete (Sahmaran et al. 2009). Utilization of FA in OPS concrete would expand the use of FA in the concrete industry.

## 1.2 Problem Statement

Oil palm shell (OPS) was one of the major producer waste material from the oil palm industry. It can be estimating the production of OPS over 6.89 million tons that generated annually in Malaysia (Chong et al. 2013). OPS can cause pollution when it just left to rot in a huge mound. This waste material took a long time to dispose of and create less environment-friendly. However, when using OPS as an aggregate replacement reduced the use of natural stone such as gravel and granite. This because the source of gravel and granite reduce from time to time due to abundant amount use in the construction industry.

Fly ash (FA) that came from coal combustion also a waste that can give impact to the environment if it is discarded with improper circumstances and can cause environmental problems. It has been stated by Nordin et al. (2016), the FA from power plant had produced hundreds of millions of tons of FA every year. Besides that, the cement production industry contributes to the higher emission of carbon dioxide, $CO_2$. This is because the production of Ordinary Portland Cement (OPC) consume the energy of raw material and external heat.

## 1.3 Objective of Study

The objectives of the research are as follow;

a) To investigate the workability and compressive strength concrete of oil palm shell lightweight aggregate concrete (OPS LWAC) containing fly ash (FA) as partial cement replacement.
b) To investigate the splitting tensile strength and flexural strength concrete of oil palm shell lightweight aggregate concrete (OPS LWAC) containing fly ash (FA) as a partial cement replacement.
c) To investigate the modulus of elasticity concrete of oil palm shell lightweight aggregate concrete (OPS LWAC) containing fly ash (FA) as a partial cement replacement.

## 1.4 Scope of Research

This study was conducted to determine the workability and mechanical properties of oil palm shell OPS LWAC containing FA as partial cement replacement. OPS used in this research was obtained from Kilang Sawit Panching, Kuantan, Pahang. The concrete had been replaced aggregate entirely with oil palm shell. OPC will partially replace by FA with different percentages of 0, 10, 20, 30, and 40 percent. There were a few testing of concretes to determine workability and mechanical properties of concrete. The test is a compressive, flexural, splitting tensile strength test and modulus of elasticity (MOE) test. The concrete was subjected to air curing. The testing was conducted in 7, 28 and 60 days.

## 1.5 Significance of Research

The use of OPS as a replacement of gravel and granite in LWAC can save a lot of natural aggregates. The use of FA as partial cement replacement can save and less usage of cement in concrete industries. Besides that, it can lessen the waste of FA in Malaysia and create a cleaner environment. Furthermore, the usage of OPS and FA can reduce building cost and optimization the usage of plant agricultural waste in the production of green construction material.

## 1.6 Layout of Thesis

Chapter one discusses the introduction part that consists of a problem statement, the objective of the study, the scope of research, the significance of research and layout of the thesis. Chapter two describes the summary of a literature review of oil palm shell OPS LWAC and FA. This includes the review of the material used such as OPS, FA, cement, sand, water, and superplasticizer. It provides a context for the research, to justify the research and illustrate how the concrete contains OPS and FA have been studies previously.

Chapter three discusses the methodologies parts that consist of the detailed apparatus, material preparation, method of preparation sample and laboratory test are discussed in this chapter. All test will be elaborated in this chapter according to the procedure outlined in the existing standard. Chapter four discuss and elaborated the

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