# A POTENTIAL O[illegible]STE BY-PRODUCT (PALM OIL C[illegible]L) AS PARTIAL AGGREGATE REPLACEMENT.

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# ABSTRACT

Palm oil clinker (POC) and oil palm shell (OPS) which is relatively low cost and abundantly available has the potential as a replacement for aggregates in the production of concrete. This study investigates the effects of substitution of palm oil clinker and oil palm shell aggregates towards the mechanical properties of porous concrete which consist of density and compressive strength. The most suitable water cement ratio for the mixture of porous concrete was obtained through mix design and yielded a constant of 0.57. Four types of samples were prepared with the constant w/c of 0.57 and POC content of 5% for all mixture and OPS content of 0%, 5%, 10% and 15% by the weight of crushed granite aggregates respectively. The result of this study indicates that the substitution of POC and OPS aggregates in concrete reduces the density of concrete. The higher porosity achieved through the addition of POC aggregates contributes to the reduction in density. However, the replacement of crushed granite aggregates with POC and OPS aggregates resulted in a drop in strength development. The result shows that the compressive strength of concrete reduced significantly. This study indicates that concrete with POC and OPS content can be utilized as lightweight concrete but cannot be used for load bearing purposes due to low strength.

# ABSTRAK

Klinker kelapa sawit (POC) dan tempurung kelapa sawit (OPS) yang berkos agak rendah dan boleh diperoleh dengan banyak, mempunyai potensi sebagai pengganti batu kelikir dalam penyediaan konkrit. Kajian ini membincangkan kesan penggantian klinker kelapa sawit dan tempurung kelapa sawit terhadap sifat-sifat mekanikal konkrit yang terdiri daripada ketumpatan dan kekuatan mampatan. Nisbah air simen yang paling sesuai untuk campuran konkrit telah diperolehi melalui reka bentuk campuran dan menghasilkan pemalar 0.57. Empat jenis sampel telah disediakan dengan pemalar w/ c 0.57 dan kandungan POC sebanyak 5% untuk semua campuran dan kandungan OPS sebanyak 0%, 5%, 10% dan 15% berdasarkan berat batu kelikir untuk setiap jenis sampel. Hasil kajian ini menunjukkan bahawa penggantian POC dan OPS agregat dalam konkrit mengurangkan ketumpatan konkrit. Keliangan yang lebih tinggi dicapai melalui penambahan agregat POC menyumbang kepada pengurangan ketumpatan konkrit. Walau bagaimanapun, penggantian batu kelikir granit dengan batu klinker dan tempurung kelapa sawit menyebabkan pengurangan dalam kekuatan konkrit. Hasilnya menunjukkan bahawa kekuatan mampatan konkrit berkurangan dengan ketara. Kajian ini menunjukkan bahawa konkrit dengan kandungan POC dan OPS boleh digunakan sebagai konkrit ringan tetapi tidak boleh digunakan untuk menampung beban yang tinggi kerana kekuatan konkrit jenis ini rendah.

# TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF SYMBOLS

| | | |
|---|---|---|
| P | - | Maximum load at failure/ Breaking load |
| A | - | Cross area of concrete cube |

# LIST OF ABBREVIATIONS

| | |
|---|---|
| ACV | Aggregate Crushing Value |
| AIV | Aggregate Impact Value |
| ASTM | American Society for Testing and Materials |
| BS | British Standard |
| FFB | Fresh Fruit Bunch |
| HMA | Hot Mix Asphalt |
| LWA | Light Weight Aggregate |
| OPC | Ordinary Portland Cement |
| OPS | Oil Palm Shell |
| POC | Palm Oil Clinker |
| RAC | Recycle Aggregate Concrete |
| w/c | Water-cement |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Much research has been carried out in the area of concrete materials that resulted in the introduction of various types of materials to be introduced and added to the production of concrete. The research also carried out in order to produce a strong and durable concrete with the use of waste material from industries as a material in concrete production. Mainly, the selection of new materials in today's construction is due to resource constraint and cost-cutting measures thus, resulting in the selection of materials that do not have any value in the current market. By using these waste materials, concrete production costs can be reduced.

At the same time, industrial sector in Malaysia that has been growing time to time has resulted in many studies done in order to reduce pollution. This includes the recycling of waste materials as a material in concrete production. Besides that, Malaysia is one of the country's largest palm oil producers in the world, a lot of waste from the process that includes palm oil clinker and oil palm shell that is likely to be used in concrete mixtures.

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Malaysia is the second largest producer of palm oil and in the process produces a waste by-product, known as palm oil clinker (POC). The aggregates produced from clinker are lightweight, porous and irregular in shape, and thus having low values of bulk density and specific gravity. Clinker was found to be suitable to replace normal gravel aggregate in concrete mixture (Kamarudin, 1991). In Malaysia, the development of using palm oil clinker as lightweight aggregate in construction industry especially in structural application started about 30 years ago. Prior to that, palm oil clinker is only known as industrial waste material and if no attempts made to recycle these materials, they are dumped together with the ash and other burning waste. Since palm oil clinker are abundant and have small commercial value in Malaysia, attempts have been made to utilize these materials as lightweight aggregate in concrete construction industry (Noor Mohamed, 2001).

Beside POC, palm oil also produces a waste by-product, known as oil palm shell (OPS). OPS is a suitable raw material for recycling because it is produced in large quantities in localized areas. In the past, it was often used as fuel to generate steam at the mills (Ma et al. 1993). Since burning is now prohibited by regulations to prevent air pollution it has come to a solution which gives advantage to reduce pollution by adding both POC and OPS into concrete mixture. In this present research, an investigation on effectiveness of POC and OPS by adding it into concrete mixture.

## 1.2 Significant of Study

Concrete is most widely used construction material in the world after water. A basic mix of concrete may consist of cement, aggregates and water in a required proportion. In some cases an admixture is added into the mix to modify the properties and characteristics of either fresh or harden concrete. For this study, the aggregates will be replace by palm oil clinker and add with oil palm shell. This study have been made to investigate and propose another way as an alternative to revealed

that the replacement of palm oil clinker and shell for aggregate in concrete mixture can make concrete be more efficient and cost-effective material for construction.

Nowadays, the uses of recycled materials as concrete material become popular because of environmental laws are stricter and this gives an advantage to this study as well as to maximize the uses of recycled materials. In addition, by using waste material also can reduce the concrete production cost and environmental pollution. Besides that, this can greatly affect the industry by reducing the number of quarries and landfills required.

## 1.3 Problem Statement

Generally, some industrial by products and waste materials are available in large quantity. Nowadays, the most popular agro-industrial in Malaysia is palm oil industries. This agro-industries increasable develop have led to numerous production and disposal of industrial waste. In the other word, this industrial waste should be managed properly or re-use the waste to produce another product.

It revealed that, natural raw materials that become more limited such as aggregate. It can be outlined that, the need for other alternative materials from the waste industrial product as an alternative material to replace natural materials. To face this problem, it is opportunity to study the effectiveness of these waste industrial products as aggregate replacement within the suitable percent of palm oil clinker and shell. The important constraints on the use of these waste materials, it must fulfill the engineering requirement in term of physical properties and strength of concrete.

Besides that, natural raw materials that become more limited had caused the need for other alternative materials to replace natural materials. However, studies need to be made prior to relate materials can be used as a substitute alternative. Tests should be done on the concrete to ensure that the concrete beyond the prescribed specifications in terms of strength and durability.

## 1.4 Objective of Study

The objectives of study are:

a) To determine the workability of fresh concrete containing palm oil clinker and oil palm oil shell with different percentage.

b) To determine the compressive strength of concrete with different percentage of palm oil clinkers crushed add with oil palm shell as aggregate replacement.

## 1.5 Scope of Study

In conducting research, the scope boundary needs to be defined and a few limitation factors to be drawn to avoid a very wide scope of research and unfocused study. The scope of this study will focused on laboratory tests for determine the physical properties and compressive strength of concrete using POC and OPS as aggregate replacement in terms of fresh concrete test and hardened concrete test.

The POC and OPS collected from Ladang Sungai Jernih, Pekan will be grind to 20mm in size by using grinder at Concrete Laboratory, University Malaysia Pahang. Conventional materials that will be use which include Portland cement, aggregate, sand, palm oil clinker and fruit bunch and also water.

Testing for compressive strength of concrete specimen conducted with concrete cube size 150 x 150 x 150mm. The concrete grade for each series of concrete cube is grade 30 and the ratio of mix proportion design is 1: 2: 3. A water cement ratio (w/c) of 0.57 will be considered. Aggregate replacement using POC as constant 5% and OPS by 5%, 10% and 15% from the total weight of the aggregate.

The workability test of fresh concrete will be examine through slump test, vebe test and compacting factor test accordance to BS 1881:Part102, Part103, Part104:1983. The physical properties of POC and OPS as aggregate replacement in term of compressive strength will be tested as accordance to BS 1881:Part116:1983. Hence the workability of fresh concrete with different percentage of POC and OPS will be examined.

36 of cube with size of 150 mm x 150 mm x 150 mm will be prepared. All samples are water cured and will be tested at age 7, 14 and 28 days.

# CHAPTER 2

# LITERITURE REVIEW

## 2.1 Introduction

Concrete is made of the basic ingredients of hydraulic cement that usually Portland cement, course aggregates, fine aggregates and water. Besides that, there have many material can be add in concrete mix to improve quality or the microstructure and consequently the durability properties of concrete. These materials are consisting of admixtures and replacement material.

In recent years, there are various studies on of concrete in diversifying sources of the material involved. Among the materials involved in the study of which is the aggregate. Among the resulting aggregate consists of crushed glass, materials industrial waste, the construction waste such as concrete, crushed brick and more.

Through the observation of several studies, see that the material used in this study consists of waste materials. The evidence can be seen with the aggregate income by disposal of industrial waste material such as palm oil clinker and oil palm shell that is likely to be use in concrete mixture.

Malaysia is the second largest producer of palm oil and in the process produces a waste by-product, known as clinker. The aggregates produced from clinker are lightweight, porous and irregular in shape, and thus having low values of bulk density and specific gravity. Clinker was found to be suitable to replace normal gravel aggregate in concrete mixture (Kamarudin, 1991). In Malaysia, the development of using palm oil clinker as lightweight aggregate in construction industry especially in structural application started about 30 years ago. Prior to that, palm oil clinker is only known as industrial waste material and if no attempts made to recycle these materials, they are dumped together with the ash and other burning waste. Since palm oil clinker are abundant and have small commercial value in Malaysia, attempts have been made to utilize these materials as lightweight aggregate in concrete construction industry (Noor Mohamed, 2001).

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## 2.2 Ordinary Portland Cement

### 2.2.1 General

According to BS12:1996, cement is hydraulic binder. It is finely ground inorganic material which, when mixed with water will form a paste which set and hardens by mean of hydration reaction and process and which after hardening will retains its strength and stability even under water.

Portland cement type I (BS 12:1978), is the most used in construction up until now a day. It also calls ordinary Portland cement. This OPC only can be used in normal construction that does not have any sulphate attack or groundwater.

### 2.2.2 Chemical Composition of Portland cement

Portland cement mostly contained limestone or chalk, alumina, and silica found as clay or shale. Generally, chemical contain of Portland cement is showed in Table 2.1, which give interval limitation of oxide in Portland cement.

**Table 2.1:** Estimate interval limitation of Portland cement

| Oxide | Percentage (%) |
|---|---|
| CaO | 60-67 |
| $SiO_2$ | 17-25 |
| $Al_2O_3$ | 3-8 |
| $Fe_2O_3$ | 0.5-0.6 |
| MgO | 0.1-4.0 |
| $SO_3$ | 1-3 |
| Alkali | 0.2-1.3 |

Generally, high lime content in Portland cement can increase the setting time but lime can give a high early strength. Increasing of silica contain also can increase the setting time and increase the strength. In the other hand, increase alumina tends to reduce setting time but also increase strength.

## 2.3 Properties of Concrete

### 2.3.1 Workability

Workability is defined in ASTM C-125 as the property determining the effort required to manipulate a freshly mixed quantity of concrete with minimum loss of homogeneity. The term manipulate includes the early age operation of placing compacting and finishing (Metha P.K., and Monteiro, 2006). Workability can be influenced by water content, shape and size of aggregate and level of hydration but sometime can be modified by adding chemical additives. The concrete with good workability can obtain suitable level of plasticity and uniformity which will influence the quality of hardened concrete.

### 2.3.2 Strength

The strength of material is defined as the ability of material to resist stress without failure. Failure is sometimes identified with appearance of cracks. While in concrete, strength related to the stress required causing failure and it is defined as the maximum stress the concrete sample can withstand (Metha P.k., and Monteiro, 2006).

Concrete has high compressive strength compare to its tensile strength. The compressive strength on concrete not depends on type of stress that applied but it also effect from the combination of various factors. The factors that can affect the compressive strength of concrete are include the properties and proportion of material, degree of compaction, and condition of curing.

Characteristic and proportion of material for example water-cement ratio, air entrainment, cement type, aggregate mixing water and admixtures. For water-cement ratio, it determines the porosity of the cement paste matrix at given degree of hydration while the air entraining can increase the porosity and decreasing the strength (Metha P.K., and Monteiro, 2006).

In addition, curing process is also an important step to build up the strength of the concrete. Cement requires a moist and controlled environment to gain strength and become fully harden. Cement paste will hardens over time. It gains strength in the days and weeks following. These indicate that the strength of concrete is directly proportional to the curing time. In about 3 weeks of curing age, over 90% of final strength is typically reached though it may continue to strength got decades. The concrete is supposed to reach target strength at the age of 28 days.

## 2.4 Application of Concrete

Concrete has been used for construction since ancient times. Modern day concrete application include dams, bridges, swimming pools, homes, streets, patios, basements, balustrades, plain cement tiles, mosaic tiles, pavement blocks, kerbs, lamp-posts, drain covers, benches and many more. Other applications of concrete include:

- Beams, drain tiles, piers, steps
- Post, Beam and Deck
- Pilasters and round column forms
- Brickledge application
- Hardscape ( Pavers )
- High Performance Admixtures
- Masonry
- Soil solidification
- Stucco ( Tilt-up )
- Insulating Concrete Form
- Motorways/roads, overpasses and parking structures
- Brick/block walls and bases for gates, fences and poles
- Building structure, fences and poles

## 2.5 Aggregates

Aggregates are defined as mineral constituents of concrete in granular or particulate form, usually comprising both coarse and fine fractions (Alexander M., Mindess S., 2005). Aggregate a granular material obtained by processing natural material (BS 882: 1992).

Aggregates is relatively inexpensive and does not enter into complex chemical reactions with water, it has been customary, therefore, to treat it as an inert filler in concrete (Mehta, 2006). Aggregates in concrete can be divided into fine and coarse aggregate. Fine aggregate is represented by sand which supply much more than coarse aggregate. Fine aggregate mainly passing a 5.0mm sieved and containing no more coarser material than is permitted for the various grading (BS 882: 1992).

Coarse aggregate is gravel which usually comes from crushed rock, like granite and basalt. Coarse aggregate mainly retained on 5.0mm sieved and containing no more finer material than is permitted for various sizes (BS 882: 1992). Aggregate characteristics that are significant for making concrete include porosity, grading or size distribution, moisture absorption, shape and surface texture, crushing strength, elastic modulus and the types of deleterious substances present.

The properties of aggregate that most important to engineers, since the performances of concrete will depend to some degree on these aggregate properties for example the parameter related to fracture, stiffness and resistance to abrasion (Alexander M., Mindess S., 2005).

### 2.5.1 Size Distribution

Generally, a series of successive crushers are used, with oversize particle being returned to the respective crusher to achieve desirable grading. The best particle distribution shape is usually achieved by primary crushing and then secondary crushing, but from an economic point of view, a single crushing process usually most effective. Primary crushing usually reduces the C&D concrete rubble to about 50mm pieces and on the way to the second crusher, electromagnet is used to remove any metal impurities in the material (Corinaldesi et al., 2002). The particle shape analysis of recycled aggregate indicates similar particle shape of natural aggregate obtained from crushed rock. The recycled aggregate generally meets all the standard requirements of aggregate used in concrete.

### 2.5.2 Strength

Though researchers have reported a reduction in strength in waste material aggregate, it should be noted that the extent of reduction is related to the parameters such as the type of concrete used for making the waste material aggregate (high, medium or low strength), replacement ration water/cement ratio and the moisture condition of the waste material aggregate (Crentsil et al., 2001). For example, Katz found that at high w/c ratio (between 0.6 and 0.75), the strength of waste material aggregate is comparable to that of reference concrete even at a replacement level of 75% (Katz, 2003). Rao found the strength of recycled aggregate and reference concrete to be comparable even at 100% replacement, provided that the water-cement ratio was higher than 0.55 (Rao, 2005). However, as the water-cement ratio is reducing to 0.40, the strength of RAC was only about 75% of the reference mix (Rao, 2005).