PHYSICAL PROPERTIES OF CONCRETE WITH 5.0 AND 10.0 PERCENT PALM OIL BOILER STONE (POBS) AS FINE AGGREGATE REPLACEMENT

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ABSTRACT

It has been more than a decade since the understanding and use of waste material was developed. The behavior and promising desired characteristic led to many studies and research work to reveal the potential of this material as suitable, safe and economical building material. One of the many challenges of research work in engineering material is to improve the material in different ways to obtain a better product. The palm oil boiler stone (POBS) is a new waste material and abundantly available has the potential as a replacement for fine aggregates in the production of concrete. This study investigates the effects of substitution of POBS aggregates towards the physical properties of concrete which consist of workability and compressive strength as a primary physical property. Three types of samples were prepared with the constant water/cement ratio (w/c) of 0.57 and POBS content of 0%, 5% and 10% in concrete. A total of 27 concrete cube specimens 150 mm x 150 mm x 150 mm were prepared for standard testing. The tests that were conducted are slump test, compacting factor test and concrete compression test at curing age of 7, 14 and 28 days. The result of this study indicates that the substitution of POBS aggregates in concrete increases the workability and strength of concrete. This study indicates that concrete with POBS content can be used for load bearing purposes due to high strength.

ABSTRAK

Pengetahuan dan penggunaan bahan buangan dalam aspek pembinaan telah lama dipraktikkan sejak beratus tahun yang lalu di merata dunia. Keupayaan dan sifat-sifat bahan buangan ini yang mencirikan sifat kejuruteraan telah menarik minat pelbagai golongan masyarakat terutamanya penyelidik, ilmuan dan para saintis untuk mengkaji dengan lebih mendalam lagi potensi bahan buangan ini yang dapat menyumbang kepada aspek-aspek kesesuaian, selamat dan bahan kejuruteraan yang murah serta mudah didapati. Salah satu cabaran yang dihadapi dalam kerja-kerja penyelidikan bahan kejuruteraan adalah bagaimana bahan buangan ini dapat dipertingkatkan sifatnya supaya produk yang berkualiti dapat dihasilkan. Bahan bakar kelapa sawit (POBS) adalah bahan buangan yang baru dan boleh diperolehi dengan banyak, mempunyai potensi sebagai pengganti batu kelikir dalam penyediaan konkrit. Kajian ini membincangkan kesan penggantian bahan bakar kelapa sawit terhadap sifat-sifat fizikal konkrit yang terdiri daripada kebolehkerjaan dan kekuatan mampatan sebagai sifat-sifat fizikal primer. Tiga jenis sampel disediakan dengan pemalar nisbah air simen (w/c) 0.57 dan peratusan kandungan bahan bakar kelapa sawit iaitu 0%, 5% dan 10% untuk setiap jenis sampel. Sebanyak 27 spesimen kiub konkrit bersaiz 150 mm x 150 mm x 150 mm telah disediakan untuk ujian mampatan. Ujian yang dilakukan adalah uji kemerosotan, uji faktor pemadatan dan uji mampatan konkrit pada umur rawatan 7, 14 dan 28 hari. Keputusan kajian ini menunjukkan bahawa kandungan bahan bakar kelapa sawit dalam konkrit menyebabkan peningkatan kebolehkerjaan dan kekuatan mampatan konkrit. Kajian ini menunjukkan bahawa konkrit dengan kandungan bahan bakar kelapa sawit dapat digunakan untuk menampung beban yang tinggi kerana kekuatan konkrit adalah tinggi.

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LIST OF ABBREVIATIONS

ACI	-	American Concrete Institution
ASTM	-	American Society for Testing and Materials
BS	-	British Standard
DOE	-	Department of Environment
EFB	-	Empty Fruit Brunches
MS	-	Malaysian Standard
OPC	-	Ordinary Portland Cement
OPS	-	Oil Palm Shells
PKS	-	Palm Kernel Shells
POBS	-	Palm Oil Boiler Stone
POC	-	Palm Oil Clinker
POME	-	Palm Oil Mill Effluent
RCC	-	Roller Compacted Concretes
SRM	-	Sand Replacement Material
w/c	-	Water/Cement

LIST OF SYMBOLS

M_p	-	Mass of the partially compacted concrete
M_f	-	Mass of the fully compacted concrete
P	-	Ultimate compressive load of concrete
A	-	Surface area in contact with the platens

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CHAPTER 1

INTRODUCTION

1.1 General

Concrete is a widely used structural material. It was first adopted as a structural material during the nineteenth century. Good or bad concrete is made from the same discrete materials such as cement, fine aggregate or coarse aggregate, water and admixture. The usual primary requirement of good concrete is a satisfactory compressive strength in its hardened state. Besides that, good concrete having fluidity suitable to works is homogenous and unlikely to segregate. Concrete can be divided into normal concrete, lightweight concrete and high strength concrete. Furthermore, concrete also can be classified into winter concreting, hot-weather concreting, pre-cast concrete, mass concrete, water-tight concrete, underwater concrete and recycled concrete based on materials used, construction condition and the required efficiency.

Many waste or by-products in sizes larger than cement particles may be used as aggregates in mortar or concrete. Industrial wastes have continued to increase due to the continued demands of resource use by humans. For these wastes to be incorporated into concrete, they can either be used as part of the cement mixture or as aggregate in concrete in order to maintain the sustainability of this construction material (Pincha, 2010). Various types of by-product materials such as fly ash, silica fume, rice husk ash, and others have been widely used as pozzolanic materials in concrete. Their utilization not only improves concrete properties, but also preserves the environment. Fly ash or another popular pozzolan can improve concrete properties such as workability, durability, and ultimate strength in hardened concrete (Vanchai, 2007). Concrete prepared with such materials showed improvement in workability and durability compared to normal concrete and has been used in the construction of power and chemical plants and under-water structures. Use of some waste materials has been well documented in design specifications. New by-products and waste materials are being generated by various industries, dumping or disposal of these materials causes environmental and health problems. Therefore, recycling of waste materials are great potential in concrete industry (Khalifa, 2010).

Large quantities of waste materials and by-products are generated from manufacturing processes, service industries and municipal solid wastes. As a result, solid waste management has become one of the major environmental concerns in the world. With the increasing awareness about the environment, scarcity of land-fill space and due to its ever increasing cost, waste materials and by-products utilization has become an attractive alternative to disposal. High consumption of natural sources, high amount production of industrial wastes and environmental pollution require obtaining new solutions for a sustainable development. Utilization of waste materials and by-products is a partial solution to environmental and ecological problems. Use of these materials not only helps in getting them utilized in cement, concrete, and other construction materials, it helps in reducing the cost of cement and concrete manufacturing, but also has numerous indirect benefits such as reduction in land-fill cost, saving in energy, and protecting the environment form possible pollution effects. Further, their utilization may improve the microstructure,

mechanical and durability properties of mortar and concrete, which are difficult to achieve by the use of only ordinary Portland cement.

1.2 Problem Statement

Concrete is a widely used material in the world. Based on global usage, it is placed at second position after water. Fine aggregate is an essential component of concrete. The most commonly used fine aggregate is natural river or pit sand. The global consumption of natural sand is very high due to the extensive use of concrete. In particular, the demand of natural sand is quite high in developing countries owing to rapid infrastructural growth. In this situation, some developing countries like Malaysia and Thailand are facing a shortage in the supply of natural sand. Therefore, the construction industries of developing countries are in stress to identify alternative materials to lessen or replace the demand for natural sand (Safiuddin, 2007).

Natural resources are depleting world wide while at the same time the generated wastes from the industry are increasing substantially. The sustainable development for construction involves the use of non-conventional and innovative materials, and recycling of waste materials in order to compensate the lack of natural resources and to find alternative ways for conserving the environment (Khalifa, 2009). Some alternative materials have already been used as a part of natural sand. For example, fly ash, slag, and limestone and siliceous stone powder were used in concrete mixtures as a partial replacement of natural sand. Also, the rock dust was used as an alternative to natural sand and its effects on the strength and workability of the concretes were investigated. Very recently, several researchers (Khalifa, 2010, Evangelista and Brito, 2007 and Rafat, 2003) have used manufactured fine aggregate

as a partial replacement of natural sand, and investigated its effect on major concrete properties (Safiuddin, 2007).

Similarly, quarry waste fine aggregate could be an alternative to natural sand. It is a by-product generated from quarrying activities involved in the production of crushed coarse aggregates. Quarry waste fine aggregate, which is generally considered as a waste material, causes an environmental load due to disposal problem. Hence, the use of quarry waste fine aggregate in concrete mixtures will reduce not only the demand for natural sand but also the environmental burden. Moreover, the incorporation of quarry waste fine aggregate will offset the production cost of concrete. In brief, the successful utilization of quarry waste fine aggregate will turn this waste material into a valuable resource (Safiuddin, 2007).

The current study has used palm oil boiler stone (POBS) in concrete mixtures as a partial replacement of natural sand. This study is to investigate the effects of POBS on slump test and compacting factor test of the fresh concretes. In addition, this study is to examine the effect of POBS on compressive strength.

The POBS is a waste material produced from the burning of fiber and shell as a fuel to heat the steam for the generation of electricity and palm oil extraction process. Since the POBS is disposed in landfills, these results are increase every year and now becoming a problem to be disposed of. Since it doesn't have any value, researchers should find the way to utilize this waste material to be incorporated in the production of concrete. In order to completely evaluate the potential of POBS for new applications, further studies are vital.

1.3 Research Objective

The objectives of this research are:

i) To investigate the physical properties of concrete added with 5.0% and 10.0% POBS as fine aggregate replacement in the concrete.

ii) To compare the compressive strength of conventional concrete and POBS concrete at different age of curing days.

iii) To determine the effect of concrete properties using various percentage of POBS.

1.4 Scope of Study

This study will be conducted by adding 5% and 10% of POBS as the fine aggregate replacement. The desired characteristic strength of 30 N/mm^2 at 28 days was used in this study. The materials used are conventional concrete and POBS concrete. Another mix is done using Ordinary Portland Cement (OPC) as a control mix. Workability was tested on fresh concrete using slump test and compacting factor test. For hardened concrete, only compressive strength was tested. Cubes will be tested at the age of 7, 14 and 28 days. The test result will be getting after doing the experiment in concrete laboratory. The method of mix design applied here was in accordance to the method published by the Department of Environment (DOE) UK (1998). The size of cube sample was 150 x 150 x 150 mm each. Cubes are cured in water in curing tank for 7, 14 and 28 days.

1.5 Significance of Research

This research will give a further understanding of the POBS substitution towards the physical properties of the concrete. By substituting the fine aggregates in concrete with waste material, a better material with lower cost and higher sustainability can be produced while preserving the characteristics and advantages of concrete.

Other than that, positive findings from this study also help to promote the use of POBS as construction materials and therefore we will be able to reuse the agricultural waste in the country such as oil palm fiber as a natural source of construction materials.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Concrete is one of the major construction materials being used worldwide. Besides cement and water, aggregate forms one of the main constituent materials for concrete since it occupies nearly 60%–80% of concrete volume. The aggregate types utilized are both coarse aggregates (with particle size more than 4.75 mm) and fine aggregates (with particle size less than 4.75 mm). Aggregates which are used in concrete are obtained either from natural sources or by manufactured. Coarse aggregates are bound with cement paste during the hydration process to form concrete mass whereas fine aggregates are utilized to fill the gaps between the coarse aggregate particles. The rapid increase in the natural aggregates consumption every year due to the increase in the construction industry worldwide means that the aggregate reserves are being depleted rapidly, particularly in some desert regions such as Arabian Gulf region. It has

been reported that, without proper alternative aggregates being utilized in the near future, the concrete industry globally will consume 8–12 billion tons annually of natural aggregates after the year 2010. Such large consumption of natural aggregates will cause destruction to the environment. Therefore there is an urgent need to find and supply alternative substitutes for natural aggregates by exploring the possibility of utilization of industrial by-products and waste materials in making concrete. This will lead to sustainable concrete design and greener environment (Khalifa, 2009).

2.2 Concrete

Concrete is obtained by mixing cement, water and aggregates and sometimes admixtures in required proportions. These mixtures then placed in forms and allowed to cure and become hard like stone. The hardening is caused by chemical reaction between water and cement and it continues for a long time, and consequently the concrete grows stronger with age. The strength, durability and other characteristic of concrete depend upon the properties of its ingredients, the proportions of the mix, the method of compaction and other controls during placing, compaction and curing.

2.2.1 Conventional Concrete

Concrete has been called pourable stone. Extremely durable, it was used 3,600 years ago by the Egyptians to build columns that are still standing. It is the most frequently used structural building material in the United States today, the main component in buildings, bridges, pavement, dams, breakwaters and docks. Even barges and ships are made of it. It would be hard to imagine modern life today without concrete. Conventional concrete combines sand, gravel and water with Portland cement to make a building material that is strong, inexpensive, and long lasting. Since concrete is used in such large quantities, the building industry has developed alternatives to regular concrete that are more sustainable and environmentally friendly.

2.2.2 Palm Oil Boiler Stone (POBS) Concrete

2.2.2.1 Palm Oil Boiler Stone (POBS)

In this region, a lot of emphasis has been given towards using agricultural waste as building materials. Research has been carried out for studying the utilization of agricultural wastes such as rise husk, palm oil fibres and palm oil shells to be used in structural lightweight concrete (Noor Mohamed, 2001).

Malaysia is the second largest palm oil producing country in the world and it produces more than half of world's palm oil. The production of palm oil result in by-products such as empty fruit brunches (EFB), palm kernel shells (PKS) or oil palm shells (OPS), pericap, palm oil mill effluent (POME) and palm oil clinker (POC). One of the ways of disposing these wastes would be utilization of some of these into constructive building materials. This will also help to prevent the depletion of natural resources and to maintain ecological balance (Alengaram et al., 2008).

Palm oil boiler stone is a new material and most of its properties are not well known. There are no mix specifications from the manufacturers and there are no existing experimental data. Accurate determination of the properties of the aggregate such as workability and compressive strength should be done. This waste is expected to be on its increase as the country desires to produce renewable energy from biological sources (Abdullahi, 2009). The eradication of this waste is very important in order to provide decent environment for the people.

Palm oil boiler stone is a waste material which is produced from palm oil extraction industry. It is produced from the burning of fiber and shell. Figure 2.2 and Figure 2.3 shows the oil palm shell and oil palm fiber used in the boiler combustion process to produce the boiler stone. In palm oil mill, the palm oil shell together with the husk, which has been squeezed, were used as burning fires in the furnace. After burning for 4 hours at 400°C, porous lumps are formed, known as boiler stone. The flow of boiler stone process is shown in Figure 2.1.

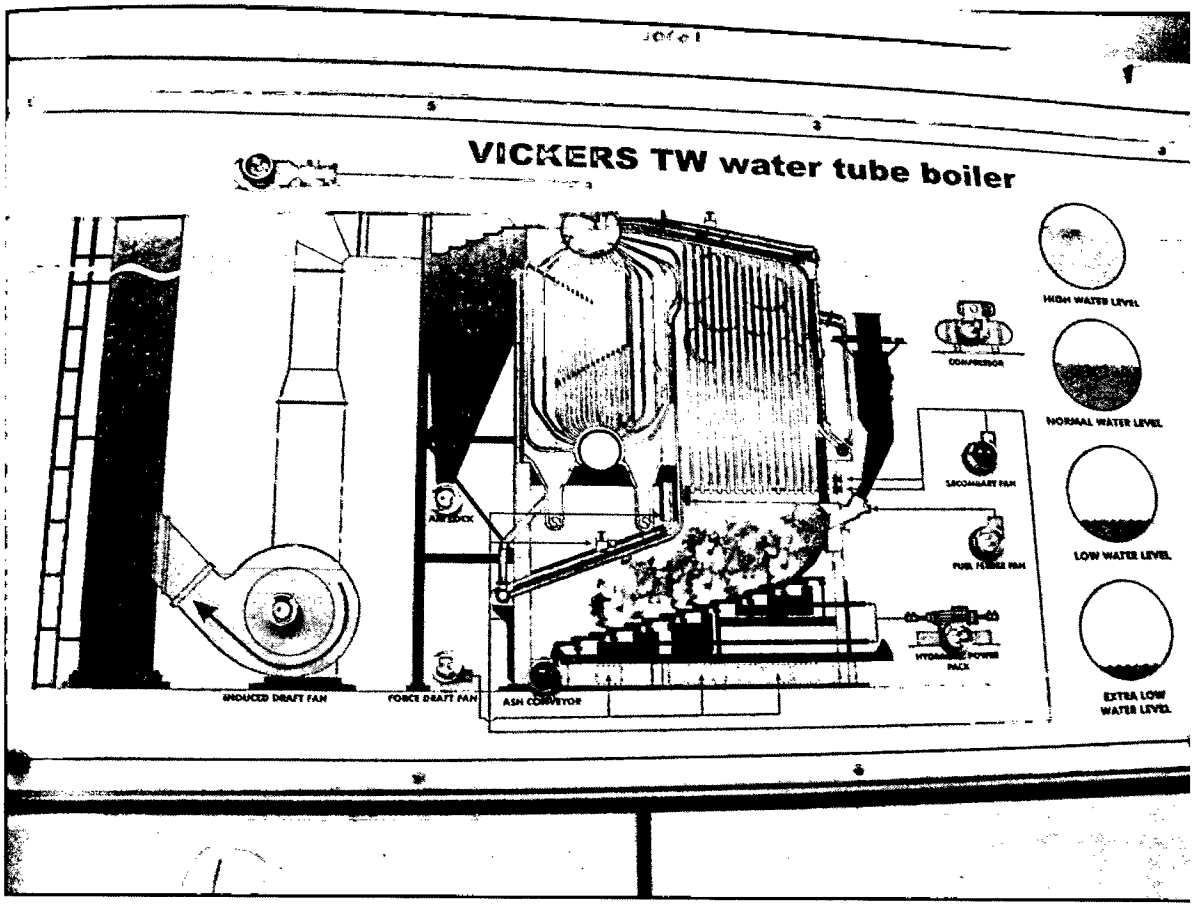

Figure 2.1: The Flow of Boiler Stone Process