PERFORMANCE OF SPENT BLEACHING EARTH AS CEMENT REPLACEMENT IN CONCRETE

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ABSTRACT

Spent bleaching earth (SBE) is an industrial waste, mainly generated from the edible oil processing. SBE is obtained by ultrasonic extraction where hexane act as solvent. By replacing cement with SBE, waste disposal problem of SBE can be reduced and economical concrete can be produced. This study is to investigate the engineering properties of concrete with 50% and 60% of spent bleaching earth (SBE) as replacement of cement. The field of studies also covers important parameters including compressive strength, flexural strength, and drying shrinkage in determining the engineering properties. Total of 54 cubes (150 x 150 x150 mm) and 54 prisms (100 x 100 x 500 mm) were prepared in three different percentage of cement. These entire samples were cured under air curing and water curing. Through the observation, the spent bleaching earth showed lower early strength gain. However, 60% SBE concrete show lower result than 50% SBE, which mean that the percentage of SBE need to reduce to ensure the concrete achieved its specific strength. This study offered that the SBE as the new material implementation of lightweight composite design and construction utilizes existing technologies which lead to another choice in the current markets for greener environment.

ABSTRAK

Spent bleaching earth (SBE) merupakan salah satu daripada bahan buangan industri. SBE boleh didapati daripada penurasan minyak kelapa sawit melalui kaedah ultrasonic extraction, di mana hexane bertindak sebagai solvent. Dengan menggantikan simen dengan SBE, masalah pembuangan sisa industri dapat dikurangkan. Di samping itu, konkrit yang lebih ekonomi juga dapat dihasilkan. Kajian ini bertujuan untuk mengkaji sifat kejuruteraan konkrit dengan menggantikan simen kepada 50% dan 60% SBE. Kajian ini juga merangkumi kekuatan mampatan, kekuatan flexural dan drying shrinkage konkrit. Sejumlah 54 cubes (150 x 150 x150 mm) and 54 prisms (100 x 100 x 500 mm) disediakan untuk tiga jenis campuran, iaitu 50% SBE, 60% SBE dan 100% konkrit biasa. Kesemua campuran ini akan diawet dalam air dan udara. Berdasarkan kajian ini, SBE menunjukkan peningkatan kekuatan konkrit yang rendah daripada konkrit biasa. 60% SBE menunjukkan peningkatan kekuatan yang rendah jika dibandingkan dengan 50% SBE. Oleh itu, peratusan SBE harus dikurangkan untuk mendapat kekuatan yang diinginkan. SBE boleh dijadikan bahan baru dalam campuran konkrit untuk struktur ringan dalam aspek bahan pembinaan. Ia juga membuka pasaran baru dalam pasaran semasa.

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LIST OF ABBREVIATION

%	-	percent
°C	-	degree Celcius
>	-	more than
<	-	less than
BS	-	British Standard
SBE	-	Spent Bleaching Earth
UMP	-	Universiti Malaysia Pahang
FKASA	-	Fakulti Kejuruteraan Awam & Sumber Alam
FKKSA	-	Fakulti Kejuruteraan Kimia & Sumber Alam
cm^2/g	-	centimeter square per gram
mL/m^2	-	mililiter per meter square
SRPC	-	Sulphate Resisting Portland Cement
$MgSO_4$	-	Magnesium Sulphate
$Ca(OH)_2$	-	Calcium Hydroxide
ASTM	-	American Society for Testing and Materials
MS	-	Malaysia Standard
mm	-	millimeter
kg	-	kilogram
OPC	-	Ordinary Portland Cement
MPa	-	Mega Pascal
W/C	-	water per cement

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

At the beginning of 2010, property markets went down dramatically, especially the construction industry. However, research and development in worldwide continue and not be affected. Construction project getting more stable, easier and faster. Implementation of Lightweight Composite design and construction utilizes existing technology which led to another choice in the current markets.

In Malaysia, the Cement & Concrete Association of Malaysia (C&CA) is stepping up efforts to expand the concrete business. It aims to boost up the demand of cement and open up opportunities to develop in variety of industry in Malaysia. Local university and Research Company start to invest more in cement and concrete industry to improve current used concrete. Nowadays, there are many types of new invented mix concrete, such as concrete with oil palm shell, egg shell, rubber, and more to be invented.

1.2 Problem Statement

According John August (1997), common density range of normal concrete is around 150 pounds per cubic foot (pcf) or 2402.769 kg/m^3 in SI unit. Yet regular concrete has some drawbacks. It is heavy, hard to work with, and after it sets, one cannot cut or nail into it without some difficulty or use of special tools. Some complaints about it include the perception that it is cold and damp.

Spent bleaching earth (SBE) is the extraction of residual oil from palm oil refining industry. However, the disposal of SBE to landfill may be limited by strict environment regulations in the near future. SBE also present fire hazard in spontaneous combustion because it possesses the pyrogenic nature due to the unsaturation of the fatty acids in the retained oils. The waste is commonly disposed to landfill without any pretreatment.

1.3 Objective

The objectives of this study are;

i. To determine the compressive strength and flexural strength of OPC concrete with 50% and 60% SBE as cement replacement

ii. To study the effects of air curing and water curing condition to the properties of OPC concrete mixture containing 50% and 60% of SBE.

1.4 Scope of Work

In the laboratory works, the OPC concrete mixture was added with 50% and 60% of SBE to replace cement. Three types of samples were tested; Sample A will be OPC concrete mix with 50% of SBE and sample B with 60% of SBE, and sample C as control sample containing 100% of OPC concrete. Cube with 150 mm x 150 mm x 150mm and prism with 100 mm x 100 mm x 500 mm dimension will be use in this test to test its compressive strength and flexural strength.

Tests will be conducted at FKASA Concrete Lab, UMP. Code of practice for this test will base on BS EN 12390-3 Testing hardened concrete: Compressive Strength of test specimens. BS EN 12390-4 Testing hardened concrete: Compressive Strength: Specification of testing machine. BS EN 12390-5 Testing hardened concrete: Flexural Strength of test specimens. The specimens will be cast using mix ratio of Mix ratio 1:0.6:2.1:3.1 (cement:water:sand:aggregate). 50% and 60% of SBE will be added to the concrete mixture to replace cement. The basic material is spent bleaching earth, aggregate, sand, cement, and plywood (formwork). Flow chart of the experiment is shown in Figure 1.0.

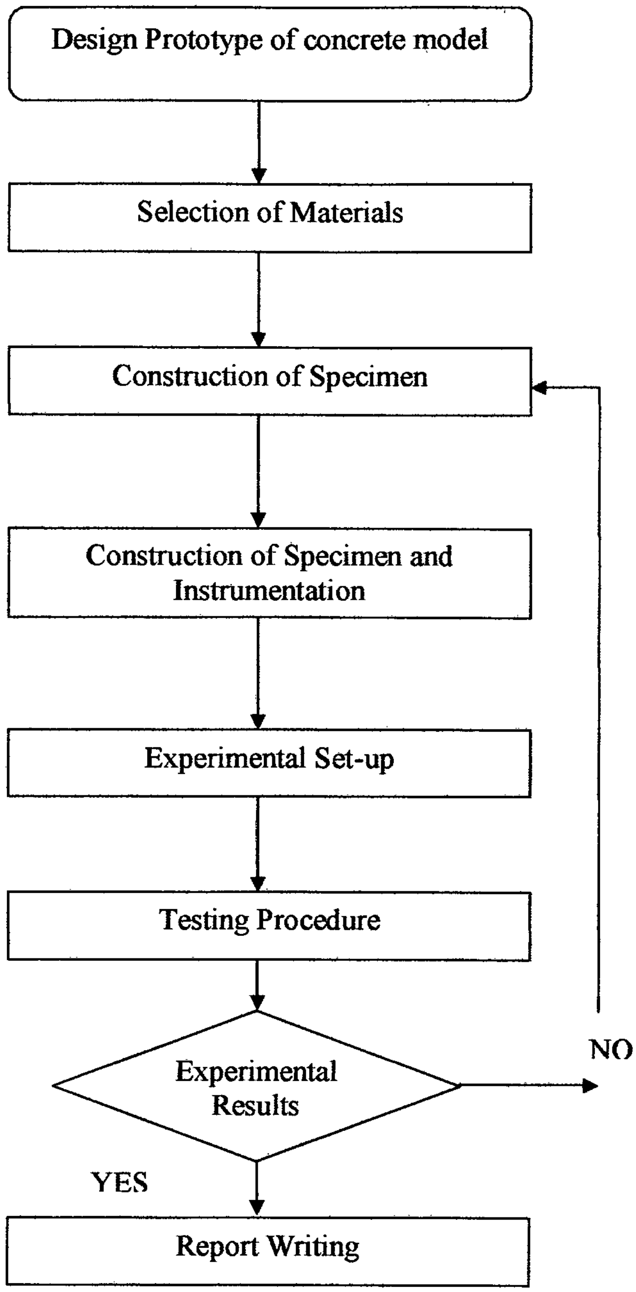

Figure 1.0: Flow Chart of Study

1.5 Significance of Study

Most researches on SBE reclamation focused on the oil left in the spent clay or the clay reused in other fields; that is, the clay itself is not regenerated to its adsorption capacity. In recent years, the rising costs of landfill and associated utilization methods have shifted the emphasis from oil reclamation to added-on values of SBE waste in the environmental applications.

Kalam and Joshi indicated that SBE was regenerated with the pretreatment of hexane extraction, and then reclaimed by an autoclave with the methods of wet oxidation or of heating in aqueous medium. The purpose of the present work is to study the effects of OPC concrete with SBE as partial replacement materials for Portland cement on the properties of the most widely manufactured concrete. This will provide additional type of choices for materials in construction. Besides that, it also will reduce the waste of SBE and commercialize it in another sector.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Revolution of industry has brought a lot of improvement to research and development related to materials of concrete. These developments have been facilitated by increased knowledge of the atomic and molecular structure of materials; the development of more powerful instrumentation and monitoring techniques; studies of long-term failures; decreases in the cost-effectiveness of traditional materials; and the need for stronger and better performing materials suitable for larger structures and longer spans, as well as for increased ductility. Nawy state that in 21st century will see the emergence of high-strength, high-performance concrete, particularly in the world's infrastructure of roads, buildings, and bridges (Nawy 1996).

2.2 Introduction to Spent Bleaching Earth

Spent bleaching earth (SBE) is an industrial waste, mainly generated from the edible oil processing (Z. Werner 1994). It is noted that SBE can present a fire hazard (i.e. spontaneous combustion), because it usually contains 20–40 wt.% oil by weight (D.R. Taylor et.al. 1990). These oils retained and not removed by filter pressing may possess the pyrogenic nature due to the instauration. Currently, world production of edible oil and fat industries amounts to more than 65 million tons and production of SBE is estimated at 650,000 tons worldwide (Lee et al., 2000). Mohd Azri bin Sukiran mentioned that the disposal of SBE to landfill may be limited by strict environment regulations in the near future (Mohd Azri bin Sukiran 2008).

2.3 Properties of Spent Bleaching Earth

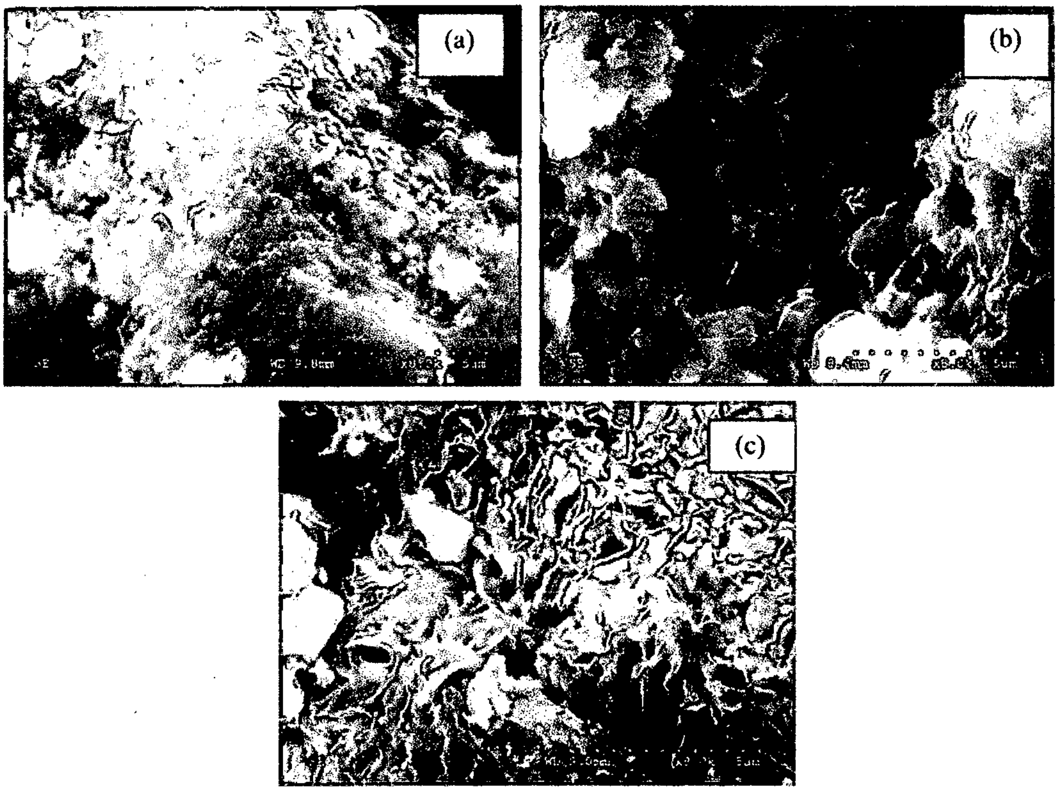

Figure 2.1 SEM photographs of (a) VBE, (b) SBE and (c) TSBE.

Virgin bleaching earth (VBE),
spent bleaching earth (SBE),
and treated spent bleaching earth (TSBE).

According to Xinyuan Technology, SBE shows selectively absorbing, high de-coloring rate, fast filtering speed, and low residual oil. It can remove soap contents, traces of heavy metals in vegetable oils, and function as natural antioxidant. SBE can also adsorb the toxins, such as aflatoxing from vegetable oil and fat, pesticide remains, and bad smell. The de-colored oils are clear and transparent, and stable in quality. The de-colored oils' acid value also won't rise again and its color won't get heavier again (XinyuanTechnology Co. Ltd 2010)

Table 2.1: Chemical Composition of SBE

Characteristic	**Solvent Extraction**		**SC-CO_2 Extraction**	
	WAC (acid-activated) oil	**NC (neutral) oil**	**WAC (acid-activated) oil**	**NC (neutral) oil**
FFA (%)	11.5	12.6	11.5	12.6
PV (meq kg^{-1})	3.1	3.4	2.8	2.2
Phosphorus (ppm)	19.3	18.7	18.1	15.8
Fe (ppm)	0.22	1.24	N.D.	N.D.
Cu (ppm)	0.32	0.38	N.D.	N.D.
Carotene content (ppm)	3	6	7	7
Total vitamin E (ppm)	0	0	0	38.8
Fatty acid composition, (FAC) (wt% as methyl esters)				
C14:0	1.1	1.0	1.2	1.3
C16:0	45.2	44.4	44.5	43.6
C18:0	4.9	4.7	5.1	4.9
C18:1	37.9	39.4	38.6	39.7
C18:2	10.9	10.5	10.6	10.5
Oil recovery (%)	30	21	27	20

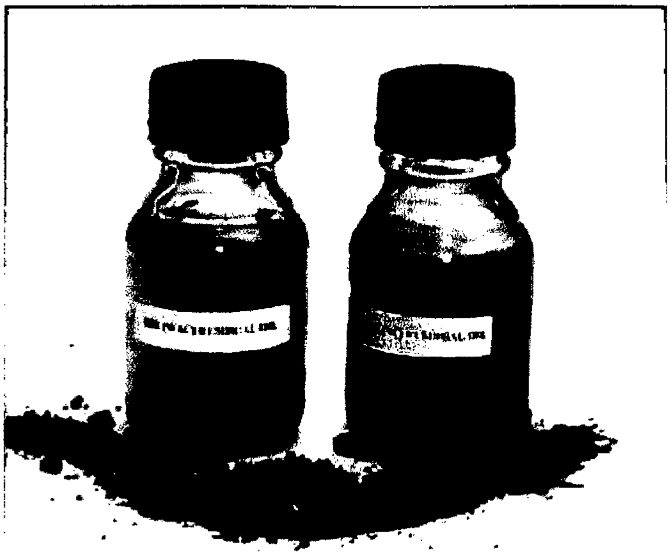

Figure 2.2 Residual oil from SBE (WAC and NC).

2.4 Methods to recover residual oil from SBE

There are two types of spent bleaching earth (SBE), which is acid-activated, WAC and neutral, NC. In this study, SBE was obtained by solvent extraction of residual oil from SBE (reflux condition). The SBE (WAC) (800 g) was packed in a thimber inside a soxhlet extractor. Hexane (3 L) was poured into a 5 L round bottom flask as extracting medium. The extraction was continued for 2 days until the extracted hexane was colorless. Removal of hexane under reduced pressure left a yellow residual oil (30%), which was then subjected to esterification process. The residual oil of SBE (NC) was obtained in a similar manner to give 21% of yellow residual oil. Loh Soh Kheang proved that the percentage yield of residual oil recovered from SBE (WAC & NC) was based on the weight of SBE used for the extraction process (Loh Soh Kheang, et al. 2007). This test was conducted in Chemical Engineering and Earth Resources (FKKSA) lab in University Malaysia Pahang (UMP).

2.5 Disposal of Spent Bleaching Earth

SBE also present fire hazard in spontaneous combustion because it possesses the pyrogenic nature due to the instauration of the fatty acids in the retained oils.The waste is commonly disposed to landfill without any pretreatment. From the environmental, safe and regulatory points of view, it is urgent to restrict the landfill practice in the future. Based to the resource conservation and recovery, the utilization of this food processing waste has increased in recent years. Kalam and Joshi indicated that SBE was regenerated with the pretreatment of hexane extraction, and then reclaimed by an autoclave with the methods of wet oxidation or of heating in aqueous medium (A. Kalam et.al 1988).

Waldmann and Eggers noted that SBE was de-oiled and thus regenerated by high-pressure extraction with supercritical CO2. Pollard et al (C. Waldmann et.al 1991). Pollard and Sollars reported that SBE was used as a precursor material for the production of clay-carbon adsorbent under chemical and physical activation methods (] S.J.T. Pollard et.al 1991. Low et al. pointed out that SBE was carbonized with the methods as reported by Pollard et al (K.S. Low et.al 1996) and then used as a sorbent. Ng et al. indicated that SBE was first de-oiled by the solvent (i.e. hexane, methanol, and supercritical CO2) extraction, and then regenerated by acid and heat treatments (K.F. Ng et.al 1997). Hou et al. investigated that SBE was thermally regenerated in a box furnace and thermo gravimetric analysis system, respectively (S.C. Hou et.al 1999). Boukerroui and Ouali reported that SBE was regenerated by thermal processing followed by washing with a solution of hydrochloric acid (A. Boukerrouiet.al 2000).

2.6 Durability of concrete

Concrete is a very durable material. To achieve the adequate durability, the selection of materials, good design and strict quality control when mixing placing and curing the concrete is essential. Careful selection of the correct type of cement, aggregate, the mix proportions and the water/cement ratio for a particular application can increase the durability of concrete structures. The design of mix should be mainly aimed at the reduction of interconnected porosity which results from the use of too high water / cement ratio.

To ensure adequate curing of concrete, curing compounds can be used to restrict the rate of water loss by evaporation from the surface of the concrete. These compounds form a continuous film over the surface of the concrete and are applied when the concrete is hardened sufficiently so that there is no damage to the surface (Chew, M.L.Y. 1988).

2.7 Drying shrinkage

Drying shrinkage is one of the major problems that affect the durability of concrete structure. The shrinkage of concrete due to moisture loss results in large local stress. With the increase of damage, concrete diffusivity increase due to an increase in the volume of pathway for the moisture to diffuse in concrete

2.8 Fire Resistance

Rapid heat rise in concrete causes evaporation of free and physically bound water and at high temperatures, moisture loss by dehydration of cement hydrates. If permeability of the concrete is insufficient to allow an adequate rate of dissipation, then the vapour pressure in the pores of the concrete will rise. A contribution to the low apparent permeability resisting vapour dissipation then the vapour pressure in the pores of the concrete will rise. When the vapour pressure rises to a critical level cracking and explosive spalling will occur.

Explosive spalling can occur after few minutes and rates are quoted up to 3 mm/min for normal weight aggregate concrete (John Brian Newman et.al). John Brian Newman state that many factors have an influence in the performance of concrete in hydrocarbon fire but those with a primary influence are:

- The rate of temperature rise in the concrete
- The moisture content of the concrete
- The permeability of the concrete

2.9 Compressive Strength

The strength of concrete originates from the strength of the hardening cement paste, originates from the hydration products. The most sought-after property of a concrete is probably strength, despite the fact that in many cases other characteristics, such as durability, maybe equally or even more important. This is understandable because concrete is a structural materials and the concrete strength appears to be a good index of a number of other technically important properties. The compressive strength of concrete is one of the most important technical properties. Concrete usually is used to resist compressive stress, thus compressive stress frequently used as a measure of the resistance because this strength is the most convenient to measure of the resistance because this strength is the most convenient to measure (Sándor Popovics)

2.10 Flexural Strength

Flexural strength is sometimes specified for structures for which the design is based on the bending strength of the concrete. Flexural strength is to be measured with beams (ASTM C 78). However, beam test sometimes provide apparently inconsistent result, the beam strength at 3 or 7 days may be higher than beam strength at 28 days (American Society of Concrete Contractors).

Flexural tests are extremely sensitive to specimen preparation, handling, and curing procedure. Beam specimens are very heavy, and allowing a beam to dry will yield lower strengths. Beams must be cured in a standard manner, and tested while wet. A short period of drying can produce a sharp drop in flexural strength.

2.11 Summary

This chapter explains about the previous research, testing method and properties of materials. SBE concrete can reduce the construction cost since it was a by-product material from oil palm manufacture that cheaper than the Portland cement. SBE concrete also can reduce the number of by-product materials thus help to save the environment.