THE EFFECT OF MIX ... VE STREGTH AND DENSITY OF OIL PALM SHELL LIGHTWEIGHT AGGREGATES CONCRETE CONTAINING PALM OIL FUEL ASH AS A PARTIAL CEMENT REPLACEMENT

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Thesis submitted in fulfilment of the requirements for the award of degree of

B.ENG (HONs) CIVIL ENGINEERING

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

2014

ABSTRACT

Oil palm shell (OPS) and oil palm fuel ash (POFA) is the one of the popular waste material from agro industries that can use to replace the aggregates content and cement content. This study will present some of the experimental result toward the effect of mix ingredient on compressive strength of oil palm shell lightweight aggregates concrete containing oil palm fuel ash as a partial cement replacement. Two types of mixes that its oil palm shell lightweight aggregates containing 20% of POFA and 0% POFA of oil palm shell as a control specimen was casting. The effect of superplasticizer, water cement ratio, sand content and cement content to the compressive strength and density of oil palm shell lightweight aggregates containing POFA was investigated in this study. All specimen (100x100) mm cubes was cast and subjected to water curing until the testing date. Compressive strength test was conducted following procedures in Reference standard: BS 1881: PART 116:1983 at 7 and 28days.

ABSTRAK

Tempurung kelapa sawit (OPS) dan abu bahan api kelapa sawit (POFA) adalah salah satu daripada bahan buangan yang popular daripada industri yang boleh menggunakan untuk menggantikan kandungan agregat dan kandungan simen. Kajian ini akan membentangkan beberapa keputusan eksperimen ke arah kesan bahan campuran kepada kekuatan mampatan tempurung kelapa sawit agregat ringan konkrit yang mengandungi abu bahan api kelapa sawit sebagai pengganti simen separa. Dua jenis campuran yang agregat ringan tempurung kelapa sawit yang mengandungi 20% daripada POFA dan 0% POFA daripada tempurung kelapa sawit sebagai spesimen kawalan telah pemutus. Kesan superplasticizer, nisbah simen air, kandungan pasir dan kandungan simen untuk kekuatan mampatan dan ketumpatan tempurung kelapa sawit agregat ringan yang mengandungi POFA telah disiasat dalam kajian ini. Semua spesimen (100x100) kiub mm telah dibuang dan tertakluk kepada pengawetan air sehingga tarikh ujian. Ujian kekuatan mampatan dijalankan prosedur berikut dalam standard Rujukan: BS 1881: BAHAGIAN 116:1983 pada 28hari.

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°C	Degree calcius
%	Percentage
μm	Micrometer
kg/m^3	Kilogram per metre cube
N/mm^2	Newton per milimeter square
Mpa	Megapascal

LIST OF ABBREVIATIONS

OPS	Oil palm shell
LWAC	Lightweight aggregate concrete
POFA	Palm oil fuel ash
OPC	Ordinary Portland cement
MPOB	Malaysian Palm Oil Berhad
BS	British standard
ASTM	American society for testing and material

CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

Concrete is one of the oldest manufactured construction material and it has been used extensively in the construction of various structures since ancient day. The continuous research and development of concrete has resulted in the production of many types of concrete.

Each of the concrete possesses their own unique characteristic to meet and suit the demand of industry. One of the concrete that it popularity increase drastically in recent year is lightweight concrete from integration of palm oil shell waste product into concrete mix.

Malaysia is well known for the palm oil industries and is the one of the largest palm oil producers and exporter in the world (mannan, 2008). In 2008, Malaysia already produced 17.7millions tons of palm oil on 4.5 million hectares of land, (Malaysian palm oil statistics, 2008). As a result, these industries generate a lot of abundant waste product annually from 200 palm oil mills in Malaysia during palm oil processing and these waste products are simply disposed without any commercial return (Mannan and Ganapathy, 2004) .

The large amount of waste product from palm oil industries is the one of the main contributors to the environment pollution when it is not reused. Its accumulating disposal on landfill is becoming a prime environmental issue to country, (Mannan, 2006). So, the study to utilize the waste material from palm oil industry should be conducted.

1.2 PROBLEM STATEMENTS

The abundant production of waste material from palm oil plantation will give an impact to the environment with the pollutions and harmful the ecosystem if there a no proper action taken to reduce it. This waste product is normally disposed through incineration is hard to disposed easily. Consequently, the government has to assign more hectares of land for the huge waste disposal, leading to further financial loses incurring from necessary transportation and maintenance. While, the cement and course aggregates is one of the natural resources and price of cement and course aggregates so expensive and will be depleted over the time.

By integrating the waste material from palm oil industries such as palm oil fuel ash as a partial cement replacement and oil palm shell as a course aggregates replacement into concrete mix design that problem can be reduced. The research and study to integrating waste material into concrete production is already done but no one knows what is the effect of others mix ingredients of lightweight aggregates concrete that containing palm oil fuel ash as a partial cement replacement namely water cement ratio, superplasticizer, sand content, and cement content toward the compressive strength and density of lightweight aggregates concrete therefore the research is conducted.

1.3 OBJECTIVES OF STUDY

Objectives of this study are as follow:

i. To determine the effect of water cement ratio on compressive strength and density of Oil Palm Shell (OPS) Lightweight aggregate concrete containing palm oil fuel ash (POFA)
ii. To determine the effect of superplasticizer content on compressive strength and density of Oil Palm Shell (OPS) Lightweight aggregate concrete containing palm oil fuel ash (POFA)

iii. To determine the effect of sand content on compressive strength and density of Oil Palm Shell (OPS) Lightweight aggregate concrete containing palm oil fuel ash (POFA)

iv. To determine the effect of cement content on compressive strength and density of Oil Palm Shell (OPS) Lightweight aggregate concrete containing palm oil fuel ash (POFA)

1.4 SCOPE OF STUDY

The scope of study will be focusing on the effect of mixing ingredient towards workability, density and compressive strength of oil palm shell (OPS) lightweight aggregates concrete that containing the palm oil fuel ash as a partial cement replacement in concrete mix design. In this study there are two types of mixes has been use that its concrete containing 20% of POFA of oil palm shell lightweight aggregates concrete and 0% of lightweight aggregates concrete as a control specimen and subjected to water curing for 28days before testing.

1.5 SIGNIFICANCE OF STUDY

By integrating oil palm shell (OPS) as a course aggregates replacement and palm oil fuel ash (POFA) as partial cement replacement ,since it is waste product from the oil palm industries and contribute to environmental pollution used the oil palm shell and palm oil fuel ash will reduce or solved the environmental problem. Besides that the lowest price of waste product from palm oil industries can reduce the construction material cost of concrete production to produce cheaper concrete in price without affecting the strength of concrete.

As we know course aggregates such as granite and stone will be depleted someday because it is a natural material that cannot be reuse and very expensive. By use oil palm shell as a course aggregates replacement it can solved that problem. Palm oil fuel ash (POFA) can be used as partial cement replacement to enhance the strength and durability of lightweight concrete by reduce the uses of cement amount. While used oil palm shell as course aggregate replacement will decrease or replace the course aggregates use in concrete without affecting the strength of concrete that comparable with the normal concrete. Overall, the use of oil palm shell and palm oil fuel ash in concrete making could make the concrete become more lighter, cheap in price and can reduce the pollution from palm oil mills.

1.6 LAYOUT OF THESIS

This report is consisting of 5 chapters. Chapter 1 discuss about the introduction to palm oil fuel ash concrete and the problem statement of research. The objective of study also discuss in this chapter together with the the scope of study and the significance of the research.

In chapter 2, the review of palm oil shell concrete as a lightweight concrete was study according to available previous journal and thesis that contributed to information that need in this research.

In Chapter 3, the laboratory work of study was discusses in the methodology part. The material preparation, method to get the mix proportion and mixing procedure are discussed in this chapter. Besides that, the testing methods used in testing the specimens are also discussed in this chapter.

Chapter 4 mainly presents and discusses about the laboratory results of lightweight concrete incorporated with POFA and OPS in term of compressive strength and density of concrete on the effect of water cement ratio, superplasticzer, sand content and cement content.

Chapter 5 concludes the whole study. Few conclusions and were drawn with respective objectives listed based on the results obtained from this study. Besides that, there are few recommendations was suggested in this chapter for future studies of the current research

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

2.1.1 Conventional concrete

Generally conventional concrete is the widely construction material use in site and produced by following the mixing instructions that are commonly consist of cement, sand or other common material as the aggregate, and often mixed with admixtures. Generally conventional concrete have a high self-weight due to aggregates normal aggregates weight use and the cost to produce conventional concrete is high.

The popularity and wide use of concrete as a construction material derives from its advantages over other construction materials. Some of these advantages is concrete has the ability to be cast to any desired shape since it is in a plastic condition when the materials are mixed and hardens as time passes. Concrete is durable because it does not easily lose its quality as does steel, which corrodes, and as does timber, which decays with time with satisfactorily high compressive strength and has fairly high fire resistance as compared to that of metals and timbers.

2.1.2 Waste material as replacement concrete

According to Ahmad (2008) one of the potential recycles material from palm oil industry is palm oil fuel ash which contains siliceous compositions and reacted as pozzolans to produce a stronger and denser concrete. There are many experimental works conducted by introducing recycled material likes palm oil fuel ash (POFA) as a replacement of the cement with different percentages to improve the properties of concrete and use oil palm shell (OPS) as a coarse aggregates replacement based on suitable size.

2.2 LIGHTWEIGHT AGGREGATES CONCRETE

2.2.1 Introduction

Lightweight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities. In concrete construction, structural lightweight concrete is an important and give solves weight and durability problems in building. It many item around the characteristic of lightweight aggregate for housing and the effect of material regarding the durability. The compressive strength, water absorption and workability are significant for the structural lightweight aggregate concrete. One of the ways to reduce the weight of structure is the use of lightweight aggregate concrete (LWAC). The benefit of LWAC as structural material was recognized as far back as Roman days. Lightweight aggregate concrete is usually defined as a concrete having an air-dry density of below 1850 kg/m^3 (115 kg/m^3) as opposed to a normal concrete having a density of about 2300 kg/m^3 (145 lb/ft^3) but a finite limit is undesirable. The lightweight concrete has its obvious advantages of high strength/weight ratio, good tensile strength, low coefficient of thermal expansion, and superior heat and sound insulation characteristic due to air voids in lightweight aggregates (Mouli, 2008).

2.2.2 Characteristic of lightweight aggregates concrete

Porous lightweight aggregate of low specific gravity is used in this lightweight concrete instead of ordinary concrete. The lightweight aggregate can be natural aggregate such as pumice, scoria and all of those of volcanic origin and the artificial aggregate such as expanded blast-furnace slag, vermiculite and clinker aggregate. The main characteristic of this lightweight aggregate is its high porosity which results in a low specific gravity (Mouli, 2008). Lightweight aggregate concrete have the good bond between the aggregate and the surrounding hydrated cement paste. This is the consequence of several factors. First, the rough surface texture of many lightweight aggregates is conducive to a good mechanical interlocking between the two materials. In fact, there is often some penetration of cement paste into the open surface pores in the coarse aggregate particles. Second, the module of elasticity of the lightweightaggregate particles and of the hardened cement paste does not differ much from one another (Neville, 1995).

2.3 POZZOLANIC MATERIAL

A material that, when used in conjunction with Portland cement, contributes to the properties of the hardened concrete through hydraulic or pozzolanic activity, or both. Basically Pozzolanic materials is a siliceous and aluminous material which in itself possesses little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties (ASTM, 2008).

2.3.1 Pozzolanic Reaction

POFA contained high amount of silicon dioxide in amorphous form that can react with calcium hydroxide generated from the hydration process to produce more calcium silicate hydrate, C-S-H gel compound (Karim, 2011)

$$2S + 3CH \rightarrow C_3S_2H_3 \quad (2.1)$$

The products of the pozzolanic reaction cannot be distinguished from those of the primary cement hydration and therefore make their own contribution to the strength and other properties of the hardened cement paste and concrete (Eldagal, O.E.A, 2008)

2.3.2 Effect of Fineness of POFA on Concrete Strength

The fineness of POFA influenced the strength of concrete, the finer POFA will lead to the strength development than the. The strength of concrete is influenced by the fineness of POFA. For same replacement of POFA in concrete, finer POFA would lead to greater strength development than the coarser one due to higher total surface area of POFA particle that increase the pozzolanic activity and hence increase the concrete strength. (Awal, 1998). This is due to higher total surface area of POFA particle that increase the pozzolanic activity and hence increase the concrete strength.

2.4 CONCRETE MIXTURE REPLACEMENT

2.4.1 Oil Palm Shell (OPS)

Oil palm shell is a one of type waste material that produce from palm oil industries, Malaysia provide a large of amount oil palm shell every years. Oil palm shell has a characteristic that can be study to replace the aggregates in concrete mixture (mannan & kurian , 2006). OPS is available in various shapes, such as curved, flaky, elongated, roughly parabolic, and other irregular shapes same as aggregates but its more light than aggregates and this characteristic of OPS will produce lightweight structure when use as a replacement to aggregates which more cheap and easy to get from any palm oil factory. The thickness varies and depends on the species of palm tree from which the palm nut is obtained and ranges from 0.15 - 8 mm (Basri, 1999)

The low bulk density of the palm oil shells can produce lightweight hardened concrete. These lightweight concretes are very useful in construction industry since the lightweight concrete can reduce the self-weight of structural members. Thus, it can reduce the dead load of the structure and reduce the use of reinforcement steel (mannan & kurian, 2006).

Many research has been made to studied the potential of waste from the oil palm shell such as the high strength of OPS lightweight aggregates concrete (mannan &ganapathy, 2001) and the effect of steel fibre to OPS lightweight concrete (shafigh.et.al,2011)

2.4.2 Palm Oil Fuel Ash (POFA)

In 2010, the Malaysian Palm Oil Board (MPOB, 2010) estimated that the total oil palm planted area in Malaysia is 4.85 million hectares. The total amount of fresh fruit bunches processes by over four hundred palm oil mills are approximately 87.5 million tonnes. Approximated 61.1 million tonnes of solid waste by-products in the form of fibres, kernels and empty fruit bunches are produced, which is about 70 % of fresh fruit bunches processed (MPOB, 2010).

Palm oil fuel ash is a by-product produced in palm oil mill and varies in tone of colour from whitish grey to darker shade based on the carbon content in it and generally has a pozzolan characteristic. The combustion of palm oil husk and palm kernel shell in the steam boiler produces POFA, which is approximately 5 % of solid waste by-product, equivalent to 3.1million tonnes in Malaysia in 2010 (Tangchirapat, 2007). Palm oil fuel ash is the product of burning oil palm husk and palm kernel shell in the palm oil mill boiler and POFA was utilized as a pozzolan in concrete (YUAN, 2012)

2.4.3 Replacement of oil palm shell as aggregates to concretes in concrete

Oil palm shell has a characteristic that suitable and comparable to use as aggregates base on their characteristic in mixtures of production concrete (awal, 2011). The palm oil shells obtained can be crushed type or uncrushed type. The crushed palm oil shells have irregular shapes and different sizes of shells, different thickness of the shell and having low density compared with the conventional aggregate. Whereas for the uncrushed palm oil shell, the shapes are spherical and it can be smooth or rough depend on the extraction process.

The low bulk density of the palm oil shells can produce lightweight hardened concrete. These lightweight concretes are very useful in construction industry since the lightweight concrete can reduce the self-weight of structural members (sata, 2010). Thus, it can reduce the dead load of the structure and reduce the use of reinforcement steel. This results the overall cost reduction in construction industries (Jorge de Brito, 2012).

2.4.4 Addition of palm oil fuel ash (POFA) in concrete

Utilization of POFA in cement as an addition in cementation gives an advantages to concrete production. By adding of POFA in concrete mix will produce new concrete product that more beneficial and advantages compared with conventional concrete. In present study, several experiment is conducted in determine the properties of concrete with present of POFA with a different percentages of POFA from 0%-50% is adding for testing (Awal, 2011). POFA that use in concrete mix need to dried in an oven at least for 24 hours and sieved through 600-μm sieve as to remove any foreign material and use only the suitable size that pass sieve 600-μm. (YUAN, 2012)

2.5 RHEOLOGICAL PROPERTIES

2.5.1 Chemical properties of OPS lightweight aggregate concrete containing palm oil fuel ash (POFA).

Generally palm oil fuel ash have a pozzolan characteristic that can exchange the properties of concrete when use it. Pozzolan as an amorphous or glassy silicate material that reacts with calcium hydroxide formed during the hydration of Portland cement in concrete. The substance that contributes to the strength of the concrete is called calcium silicate hydrate (C-S-H). Calcium hydroxide will reduce the strength of the concrete. Pozzolans contains silica that react with calcium hydroxide in concrete to form extra calcium silicate hydrate compound and diminish calcium hydroxide, further strengthening the concrete due to increase of C-S-H compound and making it stronger, denser, and durable during its service life (Neville, 1987). Pozzolans also serve to reduce the permeability of the concrete, which helps to make it more resistant to deterioration and swelling associated with various exposure conditions (Mohd Hilton Ahmad, 2011)

$$C_2S + H_2O \rightarrow C - S - H + Ca(OH)_2 \qquad (2.2)$$

Dicalcium silicate water calcium silicate hydrate calcium hydroxide

$$Ca(OH)_2 + SiO_2 \rightarrow C - S - H + H_2O \qquad (2.3)$$

Calcium hydroxide silica oxide calcium silicate hydrate water

In current research, 5%, 10% and 15% of cement replacement of POFA is use to study the effect of different percentage on concrete mixture. The results obtained were compared to Ordinary Portland cement (OPC) as control concrete.

2.5.2 Workability characteristics of OPS lightweight aggregates containing palm oil fuel ash (POFA).

According to the slump values, normal weight concrete produced medium workability while the OPS had high workability. It has been found that the silica fume that was added in OPS increased the cohesiveness of the concrete. Thus, to produce the desired workability the addition of SP was mandatory. The spherical particles of fly ash generally contribute to workability. Generally, for lightweight concretes, the slump measurements underestimate the workability of concrete and hence flow table test is recommended for concrete in which the cohesion is improved (Clarke, 1993).

2.6 MECHANICAL PROPERTIES

2.6.1 Compressive strength

Generally, the development of compressive strength of concrete will increase with the age. In current study, the different amount of OPS and POFA is added to see the effects on the strength of the concrete. The rate of strength gained was substantial as the curing day's increases, from day 1 to 28 days. Basically the strength of the concrete decreases as the percentage of OPS increases. The compressive strength of the concrete specimens is reciprocal to the percentage of OPS added. As the percentage of OPS increases, the compressive strength of the concrete decreases and vice versa (Payam Shafigh, 2010).

While Concrete incorporated with POFA tend to have slow strength gain at early age as compared with OPC concrete, but at later ages, the compressive strength is found to be higher than of OPC concrete (Sata, 2010). This is due to the pozzolanic characteristic possessed by POFA, which extended the hydration process and consequently, the compressive strength of concrete incorporated with POFA is improved.

2.6.2 Workability

Workability of concrete reduces as the amount percentage of OPS increases, as the percentage of OPS increases, the workability of the concrete reduces. This can be attributed to the fact that since the control aggregate is denser than the OPS aggregate, and the replacement is by weight, the specific surface increases as the OPS content increases. This implies that more cement paste is required for the lubrication of the aggregate, hence reducing the entire fluidity of the mix, thereby reducing the height of the slump (Saman, 2011)

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In this chapter describes the materials used, the mixing procedures and the test methods followed in conducting experimental. The compressive strength and workability of lightweight concrete incorporated with POFA and OPS are the two major areas of study in determining the optimum mix proportions for the lightweight concrete specimens that contain POFA and OPS.

3.2 PREPARATION OF MATERIAL

3.2.1 Ordinary Portland cement

Ordinary Portland Cement (OPC) is the most common cement used in general concrete construction when there is no exposure to sulphates in the soil or groundwater. OPC is a grey coloured powder. It is capable of bonding mineral fragments into a compact whole when mixed with water. This hydration process results in a progressive stiffening, hardening and strength development. The raw materials required for the manufacture of OPC are calcareous material such as limestone or chalk and argillaceous materials such as shale or clay. A mixture of these materials is burnt at a high temperature of approximately 1400 0C in a rotary kiln to form clinker. The clinker is then cooled and grounded with a requisite amount of gypsum into fine powder known as Portland cement. Ordinary Portland cement (OPC) of "ORANG KUAT" branded from YTL Cement Sdn. Bhd. was used throughout the study.

From the laboratory test that conducted, the compound of cement that used show as picture below :

RESULTS:

Sample 1) Cement

No	Parameter	Results	Unit	Test Method
1.	Calcium Oxide (CaO)	62.28	%	Quantexpress (Best Detection)
2.	Silicon Dioxide (SiO2)	16.05	%	Quantexpress (Best Detection)
3.	Sulphur Trioxide (SO3)	4.10	%	Quantexpress (Best Detection)
4.	Aluminium Oxide (Al2O3)	3.67	%	Quantexpress (Best Detection)
5.	Iron Oxide (Fe2O3)	3.41	%	Quantexpress (Best Detection)
6.	Potassium Oxide (K2O)	0.82	%	Quantexpress (Best Detection)
7.	Magnesium Oxide (MgO)	0.56	%	Quantexpress (Best Detection)
8.	Titanium Oxide (TiO2)	0.25	%	Quantexpress (Best Detection)
9.	Manganese Oxide (MnO)	0.14	%	Quantexpress (Best Detection)
10.	Zinc Oxide (ZnO)	-0.08	%	Quantexpress (Best Detection)

Figure 3.1: cement conpound

3.2.2 Palm Oil Fuel Ash

For this study, the POFA was obtained from Lepar Hilir Oil Palm Factory. The POFA obtained was dried in an oven at temperature of 105 °C ± 5 °C to remove the moisture content in it. The dried POFA was then sieved through a 600μm sieve in order to remove bigger size particles and any other foreign materials before grinding into grind machine before it can use in casting process.

The chemical composition of sample of oil palm shell that has been use in this study was tested from chemical laboratory

Sample 2) POFA

No	Parameter	Results	Unit	Test Method
1.	Silicon Dioxide (SiO2)	51.55	%	Quantexpress (Best Detection)
2.	Iron Oxide (Fe2O3)	8.64	%	Quantexpress (Best Detection)
3.	Calcium Oxide (CaO)	5.91	%	Quantexpress (Best Detection)
4.	Potassium Oxide (K2O)	5.50	%	Quantexpress (Best Detection)
5.	Aluminium Oxide (Al2O3)	4.64	%	Quantexpress (Best Detection)
6.	Phosphorus Pentoxide (P2O5)	2.50	%	Quantexpress (Best Detection)
7.	Magnesium Oxide (MgO)	2.44	%	Quantexpress (Best Detection)
8.	Sulphur Trioxide (SO3)	0.61	%	Quantexpress (Best Detection)
9.	Titanium Oxide (TiO2)	0.35	%	Quantexpress (Best Detection)
10.	Chlorine (Cl)	0.25	%	Quantexpress (Best Detection)
11.	Manganese Oxide (MnO)	0.07	%	Quantexpress (Best Detection)
12.	Zirconium Dioxide (ZrO2)	0.07	%	Quantexpress (Best Detection)

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Figure 3.2 chemical composition of POFA

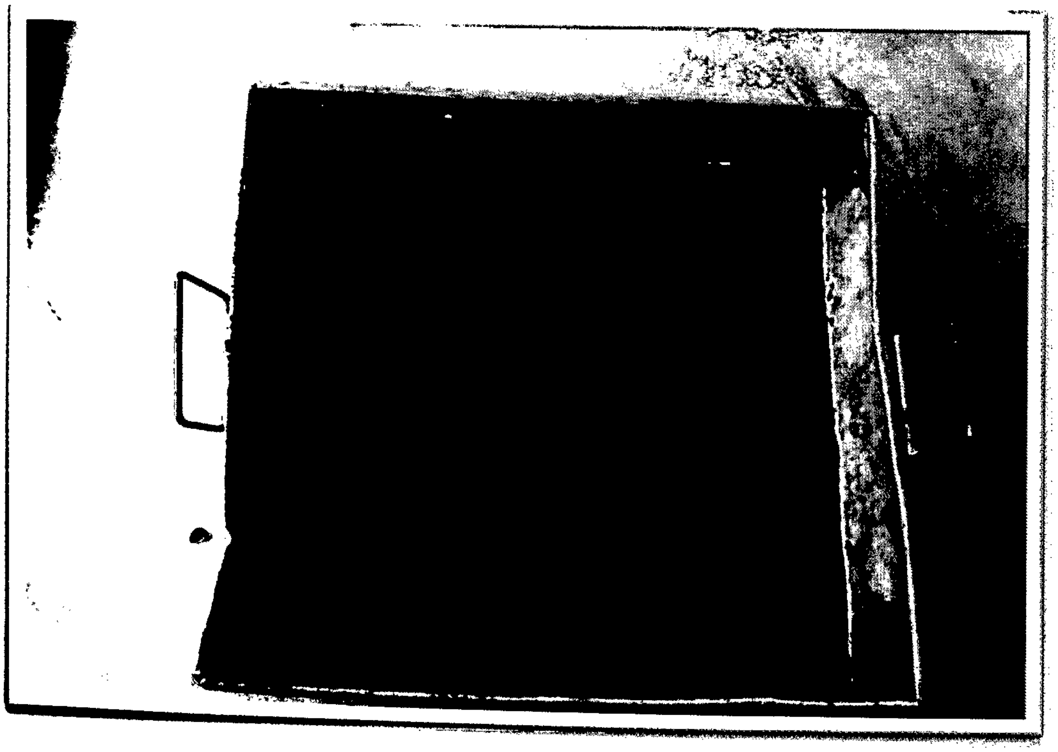

Figure 3.3: Palm Oil Fuel Ash