MECHANICAL BEHAVIOR OF PALM KERNAL SHELL CONCRETE

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ABSTRACT

Palm kernel shell is a waste which is abundantly generated and disposed at the landfill by Malaysian palm oil industry. As a result, it contributes toward pollution problem. Using palm kernel shell as partial course aggregate replacement with different in concrete making would be able to reduce the amount of this waste ending up at landfill. This thesis presents an experimental study on the workability, compressive strength and flexural strength. Two types of mixes are prepared. One consists of a control mix and another one consist various sizes of crushed palm kernel shell with fixed percentages replacement. The sizes of palm kernel shell are 2.36mm-5mm,5mm-10mm and 10mm-15mm.The influenced of with palm kernel shell several sizes on the properties of concrete have been investigated. The workability decrease with an increase in the size of palm kernel shell used and compressive strength at size 5mm-10mm has a good strength. Flexural test increase with increase the size of palm kernel shell.

ABSTRAK

Tempurung kelapa sawit adalah satu pembaziran yang banyaknya dihasilkan dan dilupuskan di tapak pelupusan oleh industri minyak sawit Malaysia. Hasilnya, ia menyumbang ke arah masalah pencemaran. Menggunakan tempurung kelapa sawit sebagai sebahagian penggantian batu dengan saiz yang berbeza dalam pembuatan konkrit akan dapat mengurangkan jumlah sisa yang akan dilupusan. Tesis ini membentangkan kajian eksperimen pada kebolehkerjaan, kekuatan mampatan dan kekuatan lenturan. Dua jenis campuran disediakan di dalam penyelidikan ini. Campuran pertama terdiri daripada campuran kawalan dan campuran kedua lagi terdiri pelbagai saiz tempurung kelapa sawit dengan penggantian peratusan tetap. Saiz tempurung kelapa sawit adalah 2.36mm-5mm, 5mm-10mm dan 10mm-15mm. Penurunan kebolehkerjaan dengan kadar peningkatan saiz tempurung kelapa sawit yang digunakan. Bagi kekuatan mampatan untuk campuran konkrit dengan saiz 5mm-10mm tempuruing kelapa sawit, iamya mempunyai kekuatan yang baik berbanding campuran yang lain. Kekuatan lenturan pula meningkat dengan peningkatkan saiz tempurung kelapa sawit.

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kN	kiloNewton
MPa	MegaPascal
N/mm^2	Newton per milimeter square
mm	Milimeter
cm	Centimeter

CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

Nowadays, the construction industry use concrete as the main construction material. There are few types of concrete such as high strength concrete, dense concrete, lightweight concrete and others. The use of high strength concrete is also being more utilized in the construction industry due its high durability and strength compared to those of normal strength thus offering many more application in the future. High strength concrete can be used to produce lighter, longer precast members and small size columns. Commonly in buildings, high strength concrete is used in beams but it also can be used as a vertical members and it will reduce their cross section. High density or heavyweight concrete is concrete with a density greater than 2600kg/m^3. It's primary use is in radiation shielding, either in nuclear power plants or in radiation therapy units. It can also be used as ballast in offshore locations such as pipelines. While lightweight concrete is type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as nailbility and lessened the dead weight. It is lighter than the conventional concrete. The main specialties of lightweight concrete are its low density and thermal conductivity. The advantages are reduction of dead load, and lower haulage and handling costs.

High strength concrete is made possible by reducing porosity, inhomogeneity and microcracks which can be achieved by using supplementary coarse aggregates such as palm kernel shell and coconut shell.

Malaysia is a country that produces oil palm and the largest producer and exporter of oil palm in world. Oil palm industry in Malaysia has produce 17.60 million tons of oil palm in 2009 comparing to the production in 2008 is 17.56 million tones.
From the mills, roughly over 4 million tons of palm kernel shell solid waste was produced annually. Thus the large amount of waste produced has caused the nation's pollution problem occurs (Teo et al, 2006). One of the ways to minimize the pollution, these wastes would be utilization of some of these into constructive building materials. Palm Kernel Shell (PKS) are light weight and having a similar sized, so it is suitable to be replacement as an aggregates in concrete. These waste materials that do not produce toxic when they are mixed with wet concrete. Therefore PKS able to prevent the damage of natural resources and also able to control or maintain the ecological balance.
According to Basri.H.B, Mannan.M.A. & Zain .M.F.M, (1998), replacement aggregates with PKS can produce lightweight concrete with a moderate strength and it is able to applicant in flooring and walls. There are some product of PKS concrete that had been studied, for instances University Malaysia Sabah (UMS) has constructed a 2 meter span footbridge in the years 2001 and an effective cost house with the area of about 59m² in the years 2003 (Teo et al, 2006). Therefore, the demand of the PKS concrete in construction development will be increasing and able to become an alternative approaches in construction.

Thus, the studies of performances may be carried out to show that PKS concrete is applicable and able to have the same or similarly properties with normal concrete nowadays. Since the PKS considered lightweight, cost-effective and environmental friendly, it can be the alternative way to produce a lightweight concrete.

1.1 PROBLEM STATEMENT

The high demand for conventional construction materials such as concrete, bricks, hollow blocks, solid blocks, pavement blocks and tiles in construction industry has led towards a rapid decrease in natural sources such as gravel, granite and river sand, thus causing ecological imbalance. In the case of granite, the extensive use of concrete has lead high consumption of this course aggregates. Continuous usage of this

nonrenewable resource would cause the depletion of this natural aggregate for the use of future generation.

At the same time, oil palm industries in Malaysia have continued to increase due to the high demands of human needs such as vegetable oil. Oil palm shell is one of byproducts produce at oil palm mills. In Malaysia, over 4 million tons of oil palm shell has been generated annually. This shell has been dump and stockpiled at landfill, thus causes storage problem in the vicinity of the factories since large quantities of these wastes are produced every day. Hence, these wastes are harmful to the ecosystem.
In addition, with the global economic recession coupled with the market inflationary trends, the constituent materials used for these structures had led to a very high cost of construction. Using PKS waste in the production concrete material would reduce only reduced the environmental problem.

1.2 OBJECTIVES OF STUDY

I. To determine the strength of flexural strength when added with 3 different range size of PKS(2.36mm-5mm, 5mm-10mm and 10mm-15mm).
II. To determine the compressive strength of concrete when added with 3 different range size of PKS (2.36mm-5mm, 5mm-10mm and 10mm-15mm).
III. To determine the workability of concrete when added with 3 different range size of PKS (2.36m-5mm, 5mm-10mm and 10mm-15mm).

1.3 SCOPE OF STUDY

This study was conducted to determine the strength of concrete added with palm kernel shell. In addition, palm kernel shell has an excellent potential to improve the performance of concrete. The scope of work mainly focuses on:

i. In this study, grade concrete 15 MPa with 0.55 w/c ratio. The mixture contains fine aggregates, coarse aggregates, cement and water.

ii. The sample will be added with 3 different range size of palm kernel shell which are 2.36mm-5mm, 5mm-10mm and 10mm-15mm.

iii. . The slump test will be carried out to determine the workability of concrete according British Standard (BS EN 1350: Part 2(2009)).

iv. . This study will compare the strength of concrete between palm kernel shell concrete and normal concrete.

v. The compression test will be carried out to determine the compressive strength of concrete follow British Standard Institution (BS 1881: Part 116:1983 and ASTM C 39-03). The size of cube that will be cast is 150mm x 150mm x 150mm for 27 cubes.

vi. The flexural test will be carried out to determine the flexural strength of concrete follow British Standard Institution (BS 1881: Part 118 and ASTM C 78-02). The size of concrete prism is 100mm x 100mm x 500mm for 27 beams

vii. The concretes will undergo curing process for 7, 14 and 28 days and the concretes will be tested at the same days.

1.4 SIGNIFICANT OF PURPOSE STUDY

This research will give further understanding of the palm kernel shell (PKS) concrete towards physical properties. By replacing the coarse aggregates in concrete with PKS , good concrete with lower cost and higher sustainability may be produced while preserving the characteristics and advantages of concrete.

Other than that, positive findings from this study also help to enhance the study of PKS as construction materials. Further studies are carried to determine the durability and shrinkage characteristics of palm kernel shell concrete.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The major construction material being used worldwide is concrete. Besides cement and water, aggregate forms one of the main constituent materials for concrete since it occupies near 60% to 80% of concrete volume. The aggregate type utilized are both fines aggregates particles size less than 4.75mm and coarse aggregate with particle sizes more than 4.75mm. In concrete has aggregate that obtained either from natural source or by manufactured.

Coarse aggregate are bound with cement paste during the hydration process to dorm concrete mass while fine aggregate are utilized to fill the gaps between the coarse aggregates particles. Large the production of natural aggregates will cause affected to the environment. Therefore there an urgent to find supply alternative substitutes for natural aggregates by explored the possibility of utilization of industrial by products and waste material in make concrete. This will contribute to sustainable concrete design and greener environment (Khalifa,2009).

Attempts have been made by various researchers to reduce the cost of concrete constituents and hence total construction cost by investigating and ascertaining the usefulness of materials which could be classified as agricultural or industrial waste. Some of these wastes include sawdust, pulverized fuel ash, palm kernel shells, slag, fly ash which is produced from milling stations, thermal power station and waste treatment plants (Fernandez, 2007). In Nigeria, Okafor (1988) conducted further study on using palm kernel shell as coarse aggregate and found out that, the weight of the concrete

produced with palm kernel shells is similar to normal weight concrete. Water cement ratio affects the mechanical properties of palm kernel shell-aggregate concrete. The 28 day compressive strength of palm kernel shell concrete varied between 5 and 25 Mega Pascal (MPa) based on mix design.

Table 2.1: Type waste material concrete replacement

Type of Waste Material	
Agriculture Waste	**Industrial Waste**
Coconut	Pulverized fuel ash
Palm kernel shell	Slag
Fly ash	Sawdust

2.2 CONCRETE

Concrete formed by mixing cement, water and aggregates and sometimes admixtures in required proportions. This mixture then placed in forms and then process curing and become hard like stone. The hardening is caused by chemical reaction between water nad cement and it continues for a long time, and therefore the concrete grows stronger with age. The properties of its ingredients, the proportions of the mix, the method of compaction and other control during placed. Compaction and curing can affected the strength, durability and other characteristics.

The aggregate in this context refers to rock particles of size above 5mm. American concrete institute also sees concrete as an engineering material made from a mixture of Portland cement, water, fine and coarse aggregate and small amount of air. Handoo, 2000 defines concrete as a composite material consisting of a binding medium within which the particles are embedded. The aggregate refer to sand and gravels or crushed stones,(White,2001).

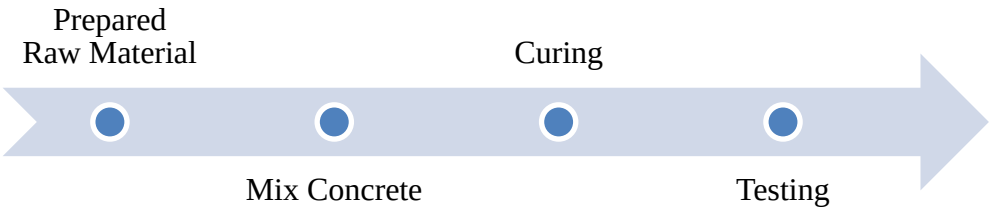

Figure 2.1: Standard Procedure of Preparing Concrete

2.2.1 Concrete Advanced Technology

Pourable stone is name of concrete that use before. Extremely durable, it was used 3600 years ago by the Egyptians to built columns that still standing. It is the most frequently used structural building in the United State today, the main pavements, dams breakwaters and component building. Combines between sand, gravel and water with Portland cement to make the conventional concrete and make a building material that strong, long lasting. Concrete widely used in the world, the building industry developed alternatives to regular concrete that are more sustainable and environment friendly. Concrete in case of unexpected fire, the concrete properties are change in the concrete properties due to extreme temperature exposures. As the concrete used for special purpose, the risk of exposing it to high temperature also increase (M.A.Pathan, 2012). Commonly conventional concrete have high self weight due to the normal aggregates weight used and cost for conventional production is really high. (Behzadet. Al, 2009).

2.2.2 Waste Material as Partially Replacement

The quest for alternative civil engineering construction material which is economical and light in weight has been major drive in carrying out this work. Palm kernel shell possess a hard characteristics as coarse aggregates and there have been attempts to use it as coarse aggregates to replace conventional coarse traditionally used for concrete production (Mohd et al.,2008).

Palm oil clinker concrete using palm oil clinker aggregates as both coarse and fine aggregates perform less resistance of shrinkage compared to palm oil clinker concrete using only palm oil clinker as coarse aggregate and conventional river sand as fine aggregates (Suraya Hani Adnan et al., 2005).

Through use of the waste material considering public concerns, the Palm Oil Fuel Ash (POFA) materials have the potential to be used as construction materials to replace conventional Ordinary Portland cement (OPC) or at least to be used together with it (Deepak T.J. et al.,2014) .

2.3 CEMENT

Cement is a fine, soft, powdery- type substance. It is made from a mixture of elements that are found in natural materials such as limestone, clay sand and shale. When cement is mixed with water, it can bind sand and gravel into hard, solid mass called concrete. Cement mixed with water, sand and gravel forms concrete. There are different types of cement, but Portland cement is the binder used most widely. Although Portland cement is named after an area in England where its use was originated, today it is manufactured all over the world. ASTM International defines Portland cement as "hydraulic cement (cement that forms a water-resistant product) produced by pulverizing clinkers consisting essentially of hydraulic calcium silicates, usually containing one or more of the forms of calcium sulfate as an inter-ground addition." Portland cement is made by fusing calcium-bearing materials with aluminum-bearing materials. The calcium may come from limestone, shells, chalk, or marl, which is a soft stone, or hard mud, sometimes called mudstone, that is rich in lime.

Concrete is a mixture of paste and aggregates or rocks. The paste composed of cement and water, coats the surface of the fine and coarse aggregates. Through a chemical reaction called hydration, the paste hardens and gains strength to form the concrete (A. Morandeau, 2012).

2.4 COARSE AGGREGATES

Aggregates are granular materials that include sand, gravel, crushed stone, river stone,and lightweight manufactured aggregates, and may occupy up to 75% of the concrete's total volume. Since aggregates are less expensive than cement paste, they are added to concrete to help reduce costs. The properties of aggregates can have a significant effect on the workability of concrete in its plastic state, as well as the durability, strength, density, and thermal properties of the hardened concrete. Coarse aggregate as the aggregate which is retained on 4.75mm sieve and contained only finer materials as permitted by specification. Uncrushed gravels or stones resulting from natural disintegration of rock (Handoo,2000). Coarse aggregates are classified according to their external characteristics such as particle shape and surface texture. Some shape of three dimensional bodies is difficult to describe but it is convenient to define certain geometric characteristics. Gravel size should be considered in relation to the thickness of the slab that is going to be poured. The size of the individual aggregates should be less than one-third of the thickness of the slab. If too much aggregate is used, the concrete may have air pockets or voids that will weaken the structure and possibly form surface imperfections (Amoakohene S.K. et al, 2005).

2.4.1 Types Of Course Aggregates

The coarse aggregate can obtained from many place such as rivers, seashores and deserts. There are more than 5 types of aggregate available and there are three common types of aggregate such as angular shape aggregate, irregular shape aggregate and rounded shape aggregate as shown in Figure 2.2, Figure 2.3 and Figure 2.4, respectively. The aggregate are round and have the minimum percentage of void ranging from 32 to 33%.They give minimum ratio of surface area. Roundness measures the relative sharpness or angularity of the edges and corners of a particle (M.A. Mannan, 2001).

Rounded course aggregates are obtained from land or dug pit. They are irregular in shape with high percentage of void ranging from 35 to 37%. It gives lesser

workability than the rounded aggregate. It is not good for high strength concretes which are subjected to tension (M.A. Mannan, 2001). Irregular course aggregates are obtained from laminated rocks. There are angular in shape with irregular shape and void percentage ranging from 38 to 45%. They are very good for high strength concretes which are subjected to tension (Payam Shafigh, 2014).

An aggregate is said to be flaky when it has dimension less than 3/5 of it mean dimension. Mean dimension is the average of sieve size through which the particles pass and the sieve size on which these are retained. To classify coarse aggregate based on their surface texture. The classification of the surface texture is based on the degree to which the particle surfaces are polished or dull, smooth or rough. Surface texture depends on the hardness, grain, size and pore characteristics of the parent material as well as on the degree to which forces acting on the particle surfaces (Neville, 2004).

Figure 2.2: Angular Shape Aggregate

Figure 2.3: Irregular Shape Aggregate

Figure 2.4: Rounded Shape Aggregate

2.5 WATER CEMENT RATIO

The mix water cement ratio is essential to concrete performance. Once cement and water are mixed the hydration process will begin and the concrete or mortar will begin gain strength and increase in durability with the passage time. The hydration process is driven by three elements are temperature, water and the availability of unhydrated cement. The water content is increased the ultimate strength will decreased. This is correct because as the water content is increased, the particles of unhydrated cement are pushed further apart. This reduces the ability of the cement to bond to itself and to the aggregates (Fernando Rodrigues et. Al, 2013).

2.6 PALM KERNEL SHELL

Malaysia is famous about oil that produced from palm oil kernel. Palm kernel shell have different shapes and sizes are hard endocarps that surround the kernel.(Olutoge, 1995). Large amount of untreated waste like palm kernel shell can contribute of leaching, dusting and volatilization. Improper treatment can make similar problem. Pollutions can affect the ecosystem. Concrete with Palm kernel shell as coarse aggregate can be used for construction of low cost house, pavements, blocks and paving drains (M.A.Manan,2004).

A palm kernel shell has a shell that need to flush with hot water to remove dust and other impurities that could be determined to concrete. They were sun dried and packed in plastics sheets to prevent contact with water. The compaction factor apparatus was used to assess workability of the fresh concrete (Daniel Yaw Osei, 2012). Palm kernel shell aggregates need washed with potable water mixed with detergent to remove the oil coating and dust. Because of higher water absorption capacity, palm kernel shell aggregates used in saturated surface dry condition.

2.6.1 Production of Palm Kernell Shell

Every year, palm oil industries produce large volume of palm kernel shell as waste material after the production of palm oil. Ramli (2003) stated that, nearly five million hectors of oil palm trees is expected by the year 2020 in Malaysia alone. This will increase the production of both palm oil and its wastes such as palm kernel shells. Normally, the Palm kernel shell is obtained by breaking the palm nut. They are lightweight, but hard and come in different shapes and sizes. Palm kernel shells are not fully utilized and it has contributed to environmental pollution. This kind of waste material can be utilized to substitute the conventional coarse aggregate to produce the Light Weight Concrete.

Lafarge had a breakthrough in designing an impact crusher which has an output capacity of pulverized palm kernel shells and was installed at Rawang Plant, Selangor in late2000. The second crusher was designed for throughput capacity of twenty tons per hour being the largest palm kernel shell crusher in the world to-date was installed at Kanthan Plant, Perak in mid 2001. The average monthly palm kernel shell consumption as alternative fuel for a period between 2000 and 2005 was 8000 tons per month or 8% fuel replacement for both the Plants. The production of Palm Kernel Shell is based on the six percent content by weight of the shell in relation to fresh fruit bunch received at the palm oil mills. Palm kernel shell supply comes from three major states, Johor, Pahang, and Perak while Negeri Sembilan and Terengganu support less than 10%. Johor, Pahang and Perak produce more than 77% of the total Palm Kernel Shells production.

However, most of the palm kernel shells from Selangor is for the mills' own consumption and not readily available for sale. Studies carried out at the Institute of Industrial Research on raw material resource assessment for activated carbon production, focused on wastes coconut shells, palm kernel shells and sawdust. Major producing areas of these wastes were at Akame, in the Volta Region, Asuansi and Assin Nyankomasi in the Central Region, Benso, Ayiem,Shama and Axim in the Western Region, Kade in the Eastern Region and Juziben in the Ashanti Region. The study showed that the generation and availability of the raw materials coconut shells and palm kernel shells were linked to the production of the main products coconut oil, palm oil and palm kernel oil. Production of all these oils by the small scale or traditional producers is spread over various areas in the country, whilst the established industries engage mostly in the production of palm oil.

Access to palm kernel shells is relatively easier as many of the established industries crack the nuts to produce the kernels and shells. The kernels are either further processed by the factory or sold, whilst the shells are dumped as waste. Coconut shell wastes, on the other hand, are spread over wider area in the country and collection will require more effort than that of palm kernel shells. Both the coconut shells and palm kernel shells produced by the traditional producers are sold as fuel. For instance coconut shell sells between ¢18 and ¢25 per full piece of dry pod and a maxi bag of palm kernel shells sells at around ¢2000. In the established palm oil industries only about 5% of the kernel shells generated are sometimes burnt together with fibre to generate heat for the boiler. The rest dumped as waste could be available for activated carbon production at no cost, at least for the present time (Acquah, F. et-al 1999).

Table2.2: Statistic Production of Malaysia Palm oil

Month	Exports (Metric Ton)		Imports (Metric Ton)	
	Year		Year	
	2015	2014	2015	2014
Jan	1,191,276	1,367,962	89,908	15,782
Feb	972,645	1,351,441	63,515	8,259
Mar	1,163,869	1,245,766	41,574	15,140
Apr	1,175,248	1,268,648	65,007	43,059
May	1,613,566	1,416,958	101,108	50,698
June		1,483,191		10,993
July		1,446,060		13,308
August		1,437,795		17,574
Sep		1,643,294		38,491
Oct		1,611,459		82,917
Nov		1,514,051		98,940
Dec		1,519,622		90,353
Jan-Dec		17,306,247		485,567

2.6.2 Types of Palm Kernel Shell

There are two predominant varieties of palm fruits namely Tenera and Dura; produce about 1.5 million tons of palm kernel shells per annum in Nigeria. The dura consists of a thick pericarp or exocarp, 2 – 8 mm thick, a thin mesocarp (which is responsible for the low palm oil content of this variety), thick endocarp (shell) and generally large kernels (which make it suitable for kernel oil production). Its mesocarp content is 35 – 55%. The tenera type possesses thick mesocarp (much pulp), thin endocarp and a reasonably sized kernel. It is useful in the production of mesocarp oil but less kernel oil when compared with the dura variety. It is now commonly used as a planting material because of its superior yield of palm oil. Sincethe tenera and dura varieties of palm fruit are useful in production of palm oil and palm kernel, respectively, it becomes imperative to characterise the fruits with a view to understanding the