OIL PALM SHELL (OPS) AS FINE AGGREGATE IN CONCRETE PROPERTIES

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ABSTRACT

This study was conducted to determine the use of oil palm shell (OPS) as fine aggregate in concrete to replace sand in concrete mixture. The main objective of this study is to determine the effectiveness of oil palm shell to produce concrete. Experimental work was conducted in laboratory to determine the characteristic of oil palm shell concrete by using weight method. In this studies, six different concrete mixes with different the combination of natural material content namely 0%, 5%, 10%, 15%, 20% and 25%. Three sample specimen will be prepared for each concrete mixes. The laboratory tests conducted including sieve analysis, slump test, vebe test, compacting factor test and compressive strength test. The results show that the oil palm shell concrete has strong compressive strength. Using the oil palm shell as aggregate in concrete can reduce the material cost in construction because of the low cost and abundant agricultural waste. In this experiment, there are several things that can be expected when finish. The following are some of the expected result for this experiment is to get higher compressive strength in lower density of concrete and to achieve the specified strength of OPS concrete that same to the control concrete at 28days.

ABSTRAK

Kajian ini dijalankan untuk menentukan penggunaan tempurung kelapa sawit sebagai agregat halus dalam konkrit untuk menggantikan pasir di dalam campuran konkrit. Objektif utama kajian ini adalah untuk menentukan keberkesanan temprung kelapa sawit untuk menghasilkan konkrit. kajian eksperimen telah dijalankan di makmal untuk menentukan ciri-ciri konkrit tempurung kelapa sawit dengan menggunakan kaedah berat. Dalam kajian ini, enam konkrit yang berbeza bercampur dengan kombinasi berbeza kandungan bahan semulajadi iaitu 0%, 5%, 10%, 15%, 20% dan 25%. Tiga sampel spesimen akan disediakan bagi setiap campuran konkrit. Ujian makmal dijalankan termasuk analisis ayak, ujian kemerosotan, ujian vebe, ujian faktor pemadatan dan ujian kekuatan mampatan. Hasil kajian menunjukkan bahawa tempurung kelapa sawit konkrit mempunyai kekuatan mampatan yang kukuh. Menggunakan tempurung kelapa sawit sebagai agregat dalam konkrit boleh mengurangkan kos bahan pembinaan kerana kos rendah dan sisa pertanian yang melimpah. Dalam eksperimen ini, ada beberapa perkara yang boleh dijangkakan apabila selesai. Berikut adalah beberapa keputusan jangkaan bagi eksperimen ini adalah untuk mendapatkan kekuatan mampatan yang lebih tinggi dalam ketumpatan konkrit yang lebih rendah dan untuk mencapai kekuatan tertentu daripada konkrit tempurung kelapa sawit yang sama dengan konkrit kawalan di 28 hari.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

In many developed countries, due to the increasing cost of raw materials and the continuous reduction of natural resources, the use of waste materials is a potential alternative in the construction industry. Waste materials, when properly processed, have shown to be effective as construction materials and readily meet the design specifications. Both natural and artificial aggregates are used in the construction industry. Furnace clinker and sintered pulverised fuel ash aggregates, used in lightweight concrete are well known, but these artificial aggregates are limited in supply.

In developing countries where abundant agricultural and industrial wastes are discharged, these wastes can be used as potential material or replacement material in the construction industry. This will have the double advantage of reduction in the cost of construction material and also as a means of disposal of waste. It is at this time the above approach is logical, worthy and attributable.

The recycling or utilisation of solid wastes generated from most agro-based industries and manufacturing industries is very rewarding. The anxiety about enormous waste production, resource preservation, and material cost has focused attention for the reuse of solid waste. Material recovery from the conversion of agricultural wastes and industrial wastes into useful materials has not only environmental gains, but may also preserve natural resources. It is thus appropriate that research on the effective utilisation of various types of solid wastes has gained greater attention in the past several decades.

The oil palm industry in Malaysia accounts for over half of the world's total palm oil output and is set to grow further with the global increase in vegetable oil demand. However, it is also the main contributor to the nation's pollution problem, which includes the annual production of 2.6 million tonnes of solid waste in the form of oil palm shells (OPS) (M.N. Amiruddin, 1998). OPS are the hard endocarp that surrounds the palm kernel. The vast availability of this resource is still unutilised commercially. The current waste disposal practice of incineration within the industry is normally done in an uncontrolled manner and contributes significantly to atmospheric pollution.

OPS are light and naturally sized; they are ideal for substituting aggregates in concrete construction. Being hard and of organic origin, they will not contaminate or leach to produce toxic substances once they are bound in concrete matrix. OPS concrete can potentially be utilised in concrete applications that require low to moderate strength such as pavements and infill panel for floorings and walls. The use of oil palm shell will result in concrete that is lighter because of low density (Mannan, M. A and Ganaphaty,C , 2002).

One of the suggestions in the forefront has been the sourcing, development and use of alternative, non-conventional local construction materials including the possibility of using some agricultural wastes and residues as construction materials. As the natural fibers are agriculture waste, manufacturing natural product is, therefore, an economic and interesting option. Coconuts show a wide diversity in size, weight, shape and color, depending on genetic variety and maturity of the nut at harvest (Ohler, 1999).

1.2 Problem Statement.

In view of this country more produced oil palm-based products such as cooking oil, and then the resulting waste will not be processed in industries such as oil palm shell. Oil palm shell can be used in the concrete mix to replace the aggregate in order to produce concrete. Therefore, the initiative to examine in more detail about the properties of this material is done to demonstrate its use in the construction industry.

1.3 Objective of the Study.

The main objective of this study is to determine the effectiveness of using oil palm shell in the production of the concrete. The following are some of the objectives set to achieve these goals:

1) To determine the compressive strength of concrete using oil palm shell than ordinary concrete.
2) To investigate whether different percentage for oil palm shell concrete mixing will affect the compressive strength.

1.4 Scope of Study.

The scope of the study will focus on the influence of the use of oil palm shell as a substitute for aggregate in the production of the concrete. It may be used as a high quality building materials and can be applied in construction in the near future.

1.5 Expected Result.

In this experiment, there are several things that can be expected when finish this experiment. The following are some of the expected result for this experiment:

1) To get higher compressive strength in lower density of concrete.
2) To achieve the specified strength of OPS concrete that same to the control concrete at 28 days.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction.

In construction, concrete plays an important role and it is a key ingredient in the structure. In general, they consist of a mixture of cement, aggregates, sand and water in the ratio of the specified or designed. Concrete is a widely used construction material in civil engineering projects throughout the world for the following reasons: It has excellent resistance to water, structural concrete elements can be formed into a variety of shapes and sizes and it is usually the cheapest and most readily available material for the job (Mehta and Monteiro, 2006).

According to (Alexander M.G. and Sydney Mindness, 2005), between 70 to 80 per cent out of the total volume of concrete is occupied by aggregate. With this large proportion of the concrete occupied by aggregate, it is expected for aggregate to have a profound influence on the concrete properties and its general performance. Aggregates are essential in making concrete into an engineering material. They tend to give concrete its volumetric stability; they also have a unanimous influence on reducing moistures related to deformation like shrinkage of concrete.

Oil palm shell is an organic waste that is easily available in Malaysia. Its use as a substitute aggregates in concrete can reduce the density of ordinary concrete as well as reduce environmental pollution (Mannan, M. A and Ganaphaty,C , 2002).

2.2 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 modem 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.

Concrete consists of a mixture of cement, fine and coarse aggregate are blended well with water according to the ratio set. This mixture will harden according to the required grade to the designs done. There are various types of cement used in concrete production according to the properties of concrete required. As well as the aggregate of varying types, structure and size. Other basic materials, there are also other additional material to alter the properties of concrete such as increasing the strength of concrete.

2.2.1 Cement.

Cement is a material having adhesive properties and cohesion, which enables fine and coarse aggregate binding to one whole. Cement clinker produced from the powder which usually contains Lime (CaO), Silica (SiO2), Alumina (Al2O3) and Iron Oxide (Fe2O3). In construction, cement is used as bonding to unite aggregate, bricks, blocks and others.

There are various types of cement used in construction on the properties of concrete required. The most common type of cement to make concrete has set and hardened properties of aqueous conditions through a chemical reaction between cement and water. This type of cement known as hydraulic cement. There is also a need air to cement hardened, the cement is known as non-hydraulic cement (Gambir. M.L. , 1995).

There are various types of cement produced for a particular purpose and fulfilment of the specific properties required. Among the most common type of cement used was ordinary portland cement. Cement in hardened more quickly, lower heat and white.

2.2.1.1 Chemical Composition of Portland Cement

Compounds of raw materials such as lime, silica, alumina and iron oxide will interact with each other in the kiln to form a series of more complex products. Of these reactions produce the four major compounds such as Table 2.1.

Table 2.1 The main compounds of Portland cement (Ismail,M.A.K, Mohd Sam,A.R, Sumadi,S.R, Hussin,M.W , 2007).

Compounds	Chemical formulae	Basic formulae	Used (%)
tricalcium silicate	$(CaO)_3 \cdot SiO_2$	C_3S	45-60
Dicalcium silicate	$(CaO)_2 \cdot SiO_2$	C_2S	15-30
Tricalcium aluminate	$(CaO)_3 \cdot Al_2O_3$	C_3A	6-12
Tetracalcium aluminoferit	$(CaO)_4 \cdot Al_2O_3 \cdot Fe_2O_3$	C_4AF	6-8

Result of the compound C3S and C2S hydration will produce the desired characteristics of the concrete. While alumina and iron that produce C3A and C4AF will help to reduce the temperature required to produce the C3S from 2000°C to 1350°C (Ismail,M.A.K, Mohd Sam,A.R, Sumadi,S.R, Hussin,M.W, 2007). This will save energy and costs to produce portland cement.

2.2.1.2 Types of Portland Cement

The ASTM has designated five types of portland cement, designated Types I-V. Physically and chemically, these cement types differ primarily in their content of C3A and in their fineness. In terms of performance, they differ primarily in the rate of early hydration and in their ability to resist sulfate attack. The general characteristics of these types are listed in Table 2.2

Table 2.2 The types of Portland cement (ASTM)

Types	**Classification**	**Characteristics**	**Applications**
Type I	General purpose	Fairly high C_3S content for good early strength development	General construction (most buildings, bridges, pavements, precast units, etc)
Type II	Moderate sulfate resistance	Low C_3A content (<8 percent (%))	Structures exposed to soil or water containing sulfate ions
Type III	High early strength	Ground more finely, may have slightly more C_3S	Rapid construction, cold weather concreting
Type IV	Low heat of hydration (slow reacting)	Low content of C_3S (<50 percent (%)) and C_3A	Massive structures such as dams. Now rare.
Type V	High sulfate resistance	Very low C_3A content (<5 percent (%))	Structures exposed to high levels of sulfate ions
White	White color	No C_4AF, low MgO	Decorative (otherwise has properties similar to Type I)

2.2.2 Aggregates.

Aggregates play an important role in the concrete for strength and durability depends on the aggregates. Aggregates are usually classified into two types, fine and coarse aggregates. Fine aggregate consists of sand and crushed stones which have a maximum size not exceeding 5mm. While the coarse aggregate consists of gravel whether crushed or not crushed with a size not less than 5mm (Nevelle A.M. , 1995). Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material.

Workability of concrete usually depends on the texture and aggregates form. Good aggregate is rounded, angular and irregular, while the form of a flat is not good form and should be avoided from the concrete mix. Quality and strength of the resulting concrete depends on the size and shape of the aggregate used and the content of the mixture. Based on these factors, the characteristics of the aggregates must be known before making a selection. By (Ismail,M.A.K, Mohd Sam,A.R, Sumadi,S.R, Hussin,M.W, 2007), characteristics of the aggregates can be found by carrying out laboratory tests such as:

1) Sieve analysis
2) Specific gravity
3) Bulk density
4) Porosity
5) Absorption
6) Moisture content
7) The content of organic impurities and other.

Different types of aggregates have different average compressive strength. Granite rocks can be used as a high compressive strength compared to other types of aggregates such as the Table 2.3. Although the quartzite has a higher compressive strength than granite, but granite is more readily available and cost saving.

Table 2.3 Average compressive strength of Rock-bridge (Nevelle A.M, 1995)

Types of rock.	The average compressive strength		Range, MN/m2
	MN/m2	Ib/in2	
Quartzite	252	36500	423-124
Granite	181	26200	258-115
Lime stone	159	23000	241-93
narmar	117	16900	245-51
Felsite	324	26200	258-115
Syis	170	24600	298-91

2.2.3 Water.

Water in the concrete mix is to the hydration and workability of concrete. Water used should be clean and free from impurities as this will affect the hardening process, the stability of the volume, durability, discoloration and corrosion of reinforcement (Wong, Like Kee, 2001). The impurities are acids, alkalis, sulfates, chlorides, and others.

Water used in mixing concrete should also be free from impurities such as suspended solids, organic matter and sea salt. Water containing the algae is not suitable for mixing concrete for algae to trap air and air content in concrete will reduce the strength of the concrete. Algae from the 0.09 percent (%) increase to 0.23 percent (%) would increase the air content of 10.6 percent (%) and lead to concrete strength decreased by 50 percent (%) (Kumar Mehta,R, 1991). Uses of sea water in reinforced concrete mixing are not suitable because it will cause danger due to reinforcement corrosion due to chloride content in water.

Suitable water is water containing dissolved solids less than 2000-ppm. Therefore, the water supplied in the water supply system can be used safely because it contains dissolved solids less than 2000-ppm (Kumar Mehta,R, 1991).

2.3 Concrete Quality

Concrete is considered as a quality of having a high compressive strength, durable and not easily permeable in water. While a good quality concrete structures is the vanes smooth, dense and not porous when the mould is removed. Low-quality concrete will be fragile and easily cracked permeable in water.

Therefore, to ensure good quality of concrete, several things need to be addressed before, during and after the concrete is provided. Concrete compressive strength, density and workability of concrete are the main parameter to be determined before designing the structural members. While at the construction site, the process of casting, compacting and curing operations must be addressed to ensure a good quality concrete.

Strength and durability of concrete depends on the amount of water in the concrete mix and the degree of compaction applied. Therefore, these matters should be noted (Wong, Like Kee, 2001):

1) Viscosity of the mixture must be appropriate to allow the concrete is mixed well.
2) May be carried, cast, and worked with ease.
3) Does not occur separation of a mixture of original material.

2.4 Factors Affecting the Strength of the Concrete

In designing a concrete mix, the aspect of concern is to obtain concrete with high strength levels without compromising on other features such as durability and permeability. There are many factors influencing the strength of concrete cutter, not least the influence of water-cement ratio, aggregate-cement ratio, degree of compaction and grading.

2.4.1 Water-Cement Ratio

Water-cement ratio can be defined as the ratio of water weight by weight of cement used in concrete mix. For fully compacted concrete, concrete strength is inversely proportional to the water-cement ratio.

Water-cement ratio will determine the porosity of the cement at the level of complaints specific hydration. Addition of water-cement ratio will reduce the compressive and tensile strength and increase shrinkage of the concrete. Therefore, for a good mix of water-cement ratio should be lowered. However, if the concrete lack of water, the level of workability will be less.

2.4.2 Aggregate-Cement Ratio

Aggregate-cement ratio of concrete strength influences the level of either medium or high. There is no doubt that the aggregate-cement ratio is only a secondary factor in influencing the strength of concrete (Nevelle A.M., 1995).

In a mixture of less cement or a mixture with the aggregate-cement ratio, high air voids, voids will form and it will have adverse effect on the strength and durability of concrete.

2.4.3 Degree of Compaction

Compaction of concrete will be more convenient if the water content in the concrete mix a lot. Compaction is done is to remove the air-air trapped in the aggregate, coarse aggregate, fine and cement in concrete mixtures. Therefore, compaction is done to ensure that the concrete is at a maximum level of strength and have minimal porosity.

2.4.4 Grading

Aggregate gradation is also a determining factor on the strength and quality of concrete. One method is through the sieve analysis. Sieve analysis done by using a sieve-BS410 British Standard sieve. This aggregate gradation direct impact on the workability of concrete. Affect the workability of concrete strength; it indirectly