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We hereby declare that we ... ır opinion this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor in Civil Engineering.

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ABSTRACT

Oil palm 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 OPS as partial fine aggregate replacement 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 moisture absorption of concrete consisting finely crushed OPS as partial and fully fine aggregate replacement. Two types of mixes are prepared. One consists of a control mix and another one consist various percentages of finely crushed OPS. The influenced of finely crushed OPS with several replacements on the properties of concrete have been investigated. The workability and compressive strength decrease with an increase in the percentage of finely crushed OPS used. Moisture absorption of concrete increase as the amount of finely crushed OPS added becomes larger. The results revealed that mix consisting around 25% of finely crushed OPS is suitable for the application in the structural concrete material.

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ABSTRAK

Tempurung kelapa sawit merupakan salah satu bahan sisa terbuang yang telah banyak dihasilkan dan dilupuskan di tapak pelupusan oleh industri minyak sawit Malaysia. Kesan daripada bahan terbuang ini telah menyebabkan berlakunya pencemaran alam serta memberi impak negatif terhadap generasi akan datang. Penggunaan tempurung ini sebagai bahan alternatif di dalam pembuatan konkrit bagi menggantikan pasir dapat mengurangkan kuntiti bahan sisa terbuang di tapak pelupusan. Tesis ini membentangkan satu kajian eksperimen terhadap kebolehkerjaan, kekuatan mampatan dan penyerapan lembapan konkrit yang mengandungi kulit kelapa sawit yang telah dihancur halus untuk menggantikan pasir secara separa. Dua jenis sampel telah disediakan di dalam kajian eksperimen ini. Salah satunya terdiri daripada campuran normal konkrit dan satu lagi terdiri daripada pelbagai peratusan kulit kelapa sawit yang telah dihancur halus digantikan sebagai pasir. Kesan jumlah peratusan kulit kelapa sawit yang telah dihancur halus terhadap sifat konkrit telah diuji. Keputusan kajian ini menunjukkan kebolehkerjaan dan kekuatan mampatan menurun apabila kadar peratusan penggantian kulit kelapa sawit yang telah dihancur halus meningkat. Manakala, penyerapan kelembapan konkrit meningkat apabila jumlah kulit kelapa sawit yang telah dihancur halus meningkat. Kajian mendapati campuran konkrit yang mengandungi sekitar 25% kulit kelapa sawit dihancur halus sesuai untuk diaplikasikan sebagai bahan struktur konkrit.

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LIST OF ABBREVIATIONS

C&D	Construction and Debris
CS	Coconut shell
FA	Fly ash
FFB	Fresh fruit bunch
GGBS	Granulate blast-furnace slag
LWC	Lightweight concrete
OPC	Ordinary Portland cement
OPS	Oil Palm Shell
PKS	Palm Kernel shell
POFA	Palm oil fuel ash
PORIM	Palm Oil Research Institute of Malaysia
RHA	Rice husk ash

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Malaysia is the world's largest producer and exporter of palm oil. The total area planted with oil palm in Malaysia covers about 2.6 million hectares, with capability of oil palm shell (OPS) production of over 3.13 million tonnes annually, (PORIM, 1998). Because of that, large amounts of oil palm waste are produced through the processing of palm oil and this is one of the main contributors to the nation pollution problem. At the same time, the worldwide consumption of sand as fine aggregate in concrete production is very high and it causes the depletion of natural sand hence imbalance ecological system. The continuous reduction of natural resources and the environmental pollution would pose negative impact to the future generation.

Efforts taken to investigate OPS in concrete production is one of the ways to reduce waste ending at landfill and at the same time reduce consumption of natural sand. So far, OPS have been used widely as partial coarse aggregate replacement in lightweight concrete (Mannan and Ganapathy, 2003) and high strength lightweight aggregate concrete (Payam Shafigh et al., 2011). However, the utilization of finely crushed OPS as partial aggregate fine aggregate in concrete is not yet studied. Therefore, the present research would be looking into the possibility of integrating this material as partial fine aggregate replacement in concrete. Hence, by exploiting this waste material as partial fine aggregate in concrete would help reduce the dumping of OPS waste and also preserve natural resource as well as to maintain ecological balance.

1.2 PROBLEM STATEMENT

The high demand for traditional 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 natural sand, the extensive use of concrete has lead high consumption of this fine aggregate. Continuous usage of this non-renewable 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 by-products produce at oil palm mills. In Malaysia, over 3.13 million tonnes 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 OPS waste in the production concrete material would reduce only reduced the environmental problem and also reduces the cost of the green concrete.

1.3 OBJECTIVE

The objectives of the study are:

i) To investigate the effect of finely crushed oil palm shell as partial sand replacement on the workability of normal concrete.

ii) To investigate the effect of finely crushed oil palm shell as partial sand replacement on the compressive strength of normal concrete.

iii) To determine the effect of finely oil palm shell as partial sand replacement on the moisture absorption properties of normal concrete.

1.4 SCOPE OF STUDY

This study concentrates on the effect of finely crushed OPS as partial replacement sand towards workability, compressive strength, and water absorption in normal concrete. In the first stage of the laboratory work, a mix proportion for normal concrete was developed as well as producing a normal concrete that was used as control subject. Then, four series of concrete mix design with finely crushed OPS as partial sand replacement were composed as an unconventional mixes comprises of 25%, 50%,75%, and 100% from the total weight of fine aggregate.

In order to study the effect of workability, slump, compacting factor and Vebe test have been conducted on all mixes. These workability tests is conducted to determine the ease and homogeneity of the fresh concrete which it can be mixed, placed, consolidated and finished. Compressive strength tests were conducted on the hardened concrete mixes at the age of 7, 14, and 28 days in order to determine the compressive strength of concrete cube. The total specimens have been cast for compressive strength test were 45 cubes. Lastly, moisture absorption test has been carried out on the mixes to determine the effect of finely crushed OPS content on moisture absorption of concrete.

1.5 SIGNIFICANCE OF STUDY

Utilization of oil palm shell (OPS) as partial sand replacement in concrete would be able reduce amount of OPS thrown at landfill. Moreover, the high consumption of natural aggregate can be reduced by using this waste concrete. Therefore, the utilization of this waste as a replacement in concrete production will ensure ecological balance for future generation. Success in producing concrete containing OPS would provide an alternative green concrete material to the local contractor.

1.6 LAYOUT OF THESIS

This thesis has been divided into five chapters. Chapter 1 in this thesis gives a brief overview about the background study of this research. It is consists of introduction, problem statement, objective, scope of study, and also the significance of the study. Hence, a briefly explanation on the OPS as waste material and the problem issue create by OPS waste was discussed in this chapter. Next, a scope of study related to the objective that has been listed in this study was also prepared to explain the process from the beginning to ending of the study.

Chapter 2 covers about the summary and research that has been done previously by researchers. On issues related to use of waste material in concrete production. Findings from previous research about the characteristic and the application of OPS in concrete have also been discussed in this chapter. Chapter 3 describes the characterization and explanation about the method and equipment of the experimental work that has been done in this research. The early part of this chapter, presents about the preparation of the materials for concrete making. It is then followed by the elaboration on the preparation of mixes and testing methods.

Chapter 4 presents the results and discussions about workability, compressive strength and water absorption of finely crushed OPS were shown in this chapter. Each of the results has been discussed by analyzing the data which then presented in form of charts such bar and line chart. Finally, chapter 5 presents the conclusion for the results obtained for each of the objective investigated in this study. The thesis is ended with some recommendations to expand the study in future.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Issues on the high demand for concrete in construction industry and the generation of oil palm shell (OPS) which dumped at landfill have led towards efforts in solving this problem through innovation of newly modified concrete material. The increasing use of concrete material has causes depletion of natural aggregate used for the concrete production. OPS dumped at landfill are also one serious problem in Malaysia which contributes to the environment pollution.

It is expected the creation of sustainable and environmental friendly construction would be able to reduce amount of waste dumped at landfill thus causing environmental pollution. Integrating this material as a mixing ingredient in concrete would reduce the quality disposed as waste. At the same time, the use of this waste as partial aggregate replacement in concrete would assist towards reduction in the consumption of natural aggregate from the environment.

2.2 INGREDIENTS FOR NORMAL CONCRETE

Concrete is a combination of cement, fine and coarse aggregates, and water which are mixed in a particular proportion to get a particular strength. Olufemi and Joel (2002) state that a good knowledge of the properties of cement, aggregates and water is required in understanding the behaviour of concrete.

Cement is a fine grey powder which when reacted with water, hardens to form a rigid chemical mineral structure which gives concrete its high strengths. Cement is the substance that holds concrete together. There are many types of cement production. The main type of cement usually use in concrete production is ordinary Portland cement (OPC). Next, water is the key ingredient, which when mixed with cement, forms a paste that binds the aggregate together. The water causes the hardening of concrete through a process called hydration. It is also facilitates mixing, placing, compacting of the fresh concrete. It is also used for washing the aggregates and for curing purposes.

Between 70 to 80 percent out of the total volume of concrete is occupied by aggregate, (Alexander and Sydney, 2005). There are two types of aggregates namely fine and coarse aggregates. Fine aggregate is generally natural sand and is graded from particles 5mm in size down to the finest particles but excluding dust. While, coarse aggregate is natural gravel or crushed stone usually larger than 5mm and usually less than 16mm in ordinary structure.

2.3 MODIFIED CONCRETE USING WASTE

Continuous reduction of natural resources and environmental problem in many countries has caused the research on the effective utilisation of various types of solid waste such as agricultural, industrial, mining and domestic waste to gain greater attention in the past several decades. These waste materials have potential to be utilized as construction material to replace conventional Ordinary Portland Cement (OPC), sand and aggregate in the formation of concrete. The integration of these wastes as replacement material in concrete at suitable proportion result in concrete material possessing enhanced strength and durability.

2.3.1 Waste as Partial Cement Replacement Material

There are many type of wastes that have been added as mixing ingredient in production of normal concrete. Palm oil fuel ash (POFA), rice husk ash (RHA), and baggase ash are among the agricultural wastes that have been used as cement replacement materials in concrete making. The by-product from industries such as fly ash and waste glass which are classified as industrial waste also used in concrete making.

POFA and RHA have been subjected to numerous investigations in order to discover its potential in concrete making. These materials have been used not only in normal concrete but also in special concretes. POFA which is waste from palm oil mill has been found to possess good pozzolonic activity when it is properly processed (Abdullah et al., 2006; Sata et al., 2004; Hussin and Awal, 1997). Types of special concrete produced by adding POFA as partial cement replacement are normal concrete (Abdul Awal, 1996), high-strength concrete (Sata et al., 2004), high-performance concrete (Awal and Hussin, 1999), and aerated concrete (Hussin and Abdullah, 2009). Other than that, RHA has been identified as extremely reactive pozzolonic material has been used in concrete production. RHA has been used as partial cement substitute to produce high-strength concrete (Ismail and Waliuddin, 1996), high performance concrete (Zhang and Malhotra, 1996) and self consolidating concrete (Nehdi et al., 2004). Use of RHA in concrete improves the corrosion resistance to sulphate attack, thus enhancing the durability of concrete. Overall, the utilization of POFA and RHA as partial cement replacement enhances the strength and durability of concrete.

Industrial waste such as fly ash (FA) has been found to play an effective role as partial cement replacement. Ferreira (2003) stated that fly ash can be used as a low or zero cost raw materials. Fly ash reduces the rate of penetration of chloride ions into concrete (Bijen, 1996). Moreover, Pei Wei (2007) also found that the pozzolanic properties of fly ash improve the strength of concrete, and its small spherical particle makes the concrete mixture more workable. A clean dry glass powder which is come from industrial waste is useful as a substitute for Portland cement in concrete. Shao et al. (2000) reported that the finely ground glass having a particle size finer than 38 μm contain a high amount of amorphous silica, which exhibits a pozzolanic behaviour. Hence, the use of ground glass in concrete can be advantageous with respect to hardened properties and durability. Basically, the use these industrial waste ash as partial cement replacement effectively saves land and energy, and would decrease the environmental pollution.

2.3.2 Waste as Partial Coarse Aggregate Replacement Material

Waste produced by the industries or agricultural sector also can be used as partial coarse aggregate replacement in concrete. Palm kernel shell and coconut shell generated from agricultural sector has been used in concrete production. By product from industries namely rubber tyre, recycled aggregate concrete and ceramic waste has also been added as mixing ingredient in concrete.

Palm kernel shell (PKS) and coconut shell (CS) are agricultural waste products obtained in the processing of palm oil and coconut oil respectively which has been used in concrete research. Both of PKS and CS are often dumped as agricultural wastes. However, with the quest for affordable housing system for both the rural and urban population of developing countries, non-conventional local construction materials including the possibility of using some agricultural waste such as PKS and CS has been suggested. Previous studies by Ogedengbe (1985), Nuhu-koko (1999), Olateju, (1992), Falade (1992), Omange (2001), and Ayangade et al. (2004) have shown that PKS is suitable as granular filter for water treatment, as a suitable in plain, light and dense concretes and as a road building material. CS waste is more suitable to be used as low strength-giving lightweight aggregate when use to replace common coarse aggregate in concrete production (Adeyemi, 2003). Use of these agricultural wastes provides solution to reduce amount of waste thrown as environmental polluting element besides reducing the cost of construction material.

Another researcher elsewhere, Kanaka Sabai et al. (1992) reported that crushed ceramic aggregate can be used to produce lightweight concrete without affecting strength. The mass failure of about 30 to 50% of the total production in ceramic insulator industry due to improper mixing of raw materials, excessive water, improper drying and too much heating lead to availability of ceramic scrap. Effort made to integrate this waste in concrete making found that, ceramic scrap can be partially used to replace conventional coarse aggregates in range 10 to 20% without affecting its structural significance.

The use of recycled rubber tyre as partial aggregate in concrete has great potential to positively affect the properties of concrete in a wide spectrum. Khatib and Bayomy (1999) reported that concrete containing rubber aggregate has a higher energy absorbing capacity referred to as toughness and also lower density compared to OPC concrete. Besides that, the concrete rubble separated from other construction and demolition (C&D) debris can be crushed and used as a substitute for natural coarse aggregate. This material which is known as recycled concrete aggregate can be utilized in producing concrete (Sherwood, 1995). Rao et al. (2007) highlighted that recycled aggregate concrete can be used for making good structural concrete with the addition of fly ash and condensed silica fume. Generally, a right proportion of these waste materials would be able to produce concrete with enhanced strength and durability.

2.3.3 Waste Used as Partial Fine Aggregate Replacement

The availability of waste in fine form without cementitious element has initiated ideas to integrate the material as partial fine aggregate replacement. Wastes that have been used as partial fine aggregate replacements in concrete are waste glass, quarry dust, bottom ash, crumb rubber, granulate blast-furnace slag (GGBS) and oyster shell. Most of this waste enhances the strength performance of concrete when right proportion is added in the concrete mix.

Large amount of waste from oyster farming known as oyster shell thrown in South Korea has lead initiatives towards integrating this material in concrete production. Yang et al. (2009) found that long-term strength of concrete with 10% oyster replacement is almost identical to that of normal concrete and durability of concrete does not decrease due to the concrete oyster has no apparent effect on carbonation and chemical attack.

The environmental problems caused by the large-scale depletion of the natural resources of river and mining sands has lead utilization of quarry dust in concrete making (llangovana et al., 2008). Study conducted by Safiuddin et al. (2007) discovered that the use of quarry waste does not affect the compressive strength, ultrasonic pulse velocity and elastic modulus of concrete. This material has also be used in producing self consolidating concrete (Ho et al., 2002) and high performance concrete (Safiuddin, 2000).

Other than that, waste known as bottom ash has also been used as partial sand replacement to improve corrosion resistance concrete (Mana et al., 1989). Performance of concrete using crumb rubber has also been investigated by Mohd Al Bakhri et al. (2007). However, studies on utilization of finely crushed OPS remain silent. Thus, this research would look into the behaviour of concrete containing finely crushed OPS. It is expected that success in integrating this material in concrete production would be an alternative to manage the waste effectively and also reduce the consumption of natural fine sand.

2.4 OIL PALM SHELL FROM MALAYSIAN PALM OIL INDUSTRY

2.4.1 Oil Palm Shell

Oil palm is a fruit of Palm Tree. It grows in a region where the temperature is very hot and rains a lot such as Malaysia and Nigeria. Oil palm fruit consists of two major parts which are pulp and kernel. Pulp consisting a yellow fruit and when crushed, it produces a palm oil, while kernel is bounded in the shell of the seed. When it crushed, it produces palm kernel oil. 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 et al., 1999; Okpala, 1990). Their colour ranges from dark grey to black.

Palm oil processing is separated into six stages which are sterilization, threshing, pressing, depiricarping, separation of kernel and clarification (Abdullah, 1996). Shells are one of the wastes produced during this process. OPS are lighter than natural granite aggregate. It comes with various shape such as roughly parabolic and irregular shape, and porous hence have high water absorption. The capability of production OPS shell is over 3.13 million tonnes annually (Mohd Noor et al., 1990). Hence, this waste is main contributor to the nation pollution problem because this waste materials are stockpiled and dumped, such have caused storage problem in the vicinity of the factories as large quantities of these wastes are produced every day (Alexandar and Sydney, 2005). It is seen that success in adding this crushed shell as partial sand replacement in concrete would reduce amount of waste dumped thus causing pollution to environment.

2.4.2 Use of OPS in Concrete Production

The availability of OPS in large amount has lead towards the studies on utilization of this material as partial coarse aggregate replacement in production of normal concrete, lightweight concrete and high strength concrete.

2.4.2.1 Normal concrete

OPS have been used as partial coarse aggregate replacement in normal concrete. Okafor (1988) discovered that the smooth surfaces of OPS may have led to a better workability, slump and compaction factor, than the normal concrete for the same w/c ratio of 0.41. Another researcher, Mannan, and Ganapathy (2001) found out that mix design of OPS concrete adding by FDN superplasticizer, has shown better workability than the normal OPS concrete. OPS concrete with 1% FDN superplasticizer shown the highest workability compared with the mixes without this superplasticizer which is 14 times higher of slump than normal concrete. The durability of OPS concrete can be enhanced when adequate cover is provided to the reinforcement.

2.4.2.2 Lightweight Concrete

The most type of production OPS concrete in construction is lightweight concrete. Research shows that OPS can be used as a lightweight aggregate for producing structural lightweight aggregate concrete (Teo et al., 2007; Abdullah, 1996; Teo et al., 2006; Basri et al., 1999; Mannan and Ganapathy, 2001-2004). Furthermore, it was found that OPS structural lightweight concrete is a good thermal performance material for low cost housing. Harimi et al. (2007), and Okafor (1988) reported that the maximum compressive strength of lightweight concrete produced using this agricultural shell is approximately 25 to 35 MPa and it is comply the range of the typical compressive strength for structural lightweight concrete which is within 20 - 35 MPa (Kosmatka et al., 2002).

Mannan et al. (2006) suggested improving the quality of OPS aggregates, will possible to decrease the water absorption of this aggregate to about 82% which is from 23.3 to 4.2%, and achieving better adhesion between the OPS and cement paste. This will be improved the compressive strength to 35.3, 38.8 and 39.2% for 3, 7 and 28-day respectively. The best performance treatment to reach the higher compressive strengths at early and later ages were obtained using OPS pre-treated with 20% poly vinyl alcohol as a PVA solution.

The recent research conducted by Alengram and Shafigh (2011) discovered that the use of OPS aggregate from crushing the larger original OPS aggregate can be a new method to significantly enhance the compressive strength of OPS lightweight concrete. It is because, the higher stiffness of the OPS grains and better bond between the OPS and paste, which consequently led to better compressive strength. Furthermore, high workability OPS lightweight concrete with 28 day compressive strength of approximately 53 MPa can be obtained. They also stated that by using crushed OPS aggregate as partial coarse aggregate replacement is possible to produce grade 30 OPS concrete with significantly lower cement content which is can be lower about 28 - 36 % of cement content.

Use of OPS as partial aggregate replacement in concrete would be able to reduce consumption of natural aggregate and assist towards production of green concrete. Mannan and Ganapathy, (2001) reported that OPS develops into a lightweight concrete can be used as a very cost effective construction material in many situations especially as precast concrete products in the areas where oil palm shells are in abundant supply. It can occupy about 40% of total volume of concrete saving the conventional construction material and has a great saving, economically, as the material is free of cost at production place. Conclusively, successful utilization of OPS as a mixing ingredient in concrete would be able to reduce amount of waste landing at landfill.