EFFECTIVENESS OF CONCRETE STRENGTH USING ARTIFICIAL FINE AGGREGATES FROM PALM OIL DISPOSAL WASTE PRODUCT

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ABSTRACT

Generally, concrete is one of the most mutual construction materials and is applied in a wide-ranging variety of application, alternating from pile to multi-storeys buildings and from railroad connections to dams. A concrete with very less voids or spaces in it, which were fill with fine aggregates will increased the workability and reduces the quantity of cement required to produce a strong concrete. The increasing demands of the aggregates for the usage in construction, lead to the decreasing of natural aggregate. On the other hand, Malaysia was the largest producer of world palm oil and also creates tonnes of waste product, especially palm oil clinker (POC). POC were created in the boiler when the husk fiber and shell of palm oil are burned to generate energy for the refineries. The POC form was like a porous stones which is grey in colour. It's also were flaky, irregular shaped and the broken edge were rough and spiky. Meanwhile, the practise of abundantly available materials to replace normal aggregates in concrete for structural purposes would prove to be economical. Laterite is a ferruginous, vesicular, unstratified and porous material with yellow ochre's due to the presence of high iron content. The main objectives for this study are to determine the compressive strength and workability of concrete using fine palm oil clinker (FPOC) and fine laterite (FL) as artificial fine aggregate. For the purpose of this study, four type's samples were prepared with constant water/cement ratio as 0.51 and 0%, 100% FPOC, 50% FPOC and 25% FPOC with 25% FL as fine aggregate replacement by weight of total fine aggregate. The tests that were conducted are slump test, compacting factor test, vebe test and compression test at curing age of 7, 14 and 28 days. The outcome of this study shows that the replacing of artificial fine aggregates has increases the strength and workability of the concrete.

ABSTRAK

Umumnya, konkrit adalah salah satu daripada bahan binaan yang paling selalu digunakan dalam pelbagai aplikasi, dari tumpukan kepada bangunan berbilang tingkat dan dari sambungan kereta api untuk empangan. Konkrit yang mempunyai rongga atau ruang udara yang sangat kurang di dalamnya, yang akan dipenuhi dengan batu-batuan halus akan meningkatkan kebolehkerjaan dan mengurangkan kuantiti simen yang diperlukan untuk menghasilkan konkrit yang kuat. Peningkatan permintaan batu binaan untuk kegunaan dalam pembinaan, membawa kepada pengurangan batuan asli. Sebaliknya, Malaysia adalah pengeluar terbesar minyak sawit dunia dan juga mewujudkan bertan-tan metrik sisa bahan, terutamanya klinker kelapa sawit (POC). POC diciptakan di dalam dandang apabila serat sekam dan tempurung biji kelapa sawit dibakar bersama-sama untuk menjana tenaga untuk mengerakkan kilang penapisan tersebut. Rupa bentuk POC adalah seperti batu-batu berliang yang berwarna kelabu. Ia juga berkelupas, bentuk yang tidak sekata, permukaan kasar dan berduri. Sementara itu, dengan mengunakan bahan-bahan yang boleh didapati dengan banyaknya bagi menggantikan batu binaan dalam konkrit biasa untuk tujuan pembangunan akan membuktikan penjimatan. Laterit adalah berwarna karat, vesicular, unstratified dan bahan berliang dengan kuning oker disebabkan kehadiran kandungan zat besi yang tinggi. Objektif utama untuk kajian ini adalah untuk menentukan kekuatan mampatan dan kebolehkerjaan konkrit yang menggunakan klinker halus minyak sawit (FPOC) dan laterit halus (FL) sebagai batuan halus buatan. Untuk tujuan kajian ini, 4 jenis sampel telah disediakan dengan nisbah air / simen yang malar iaitu 0.51 dan 0%, FPOC 100%, FPOC 50% dan FPOC 25% dengan FL 25% sebagai penggantian batuan halus dengan jumlah berat batuan halus itu. Ujian yang telah dijalankan adalah ujian turunan, ujian faktor pemadatan, ujian vebe dan ujian mampatan pada waktu merawat iaitu 7, 14 dan 28 hari. Hasil kajian ini menunjukkan bahawa menggantikan batuan halus tiruan telah meningkatkan kekuatan dan kebolehkerjaan konkrit.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Generally, concrete is one of the most mutual construction materials and is engaged in a wide-ranging variety of application, alternating from pile to multi-storeys buildings and from railroad connections to dams. Concrete is a stone like material obtained by letting a wisely proportioned mixture of cement, sand, gravel or other aggregate and water to harden in forms of the shape and dimensions of the desired structure (Nilson et al., 2004). The concrete were undergoes a chemical reaction between cement and water which referred to as hydration process to bind the aggregates to produce this hard, strong and durable material. The compressive strength of concrete mostly was depending on the aggregates when they are denser.

Aggregate is more or less inert, granular, usually inorganic material consisting normally stone or stone like solid. About 70% to 75% of volume of the hardened mass in ordinary structural concretes was occupied by aggregates. It is very important that the aggregate has good durability, strength and weather resistance

(Nilson et al., 2004). Hence, the use of aggregate in concrete greatly reduces the needed amount of cement, which is important from technical and economical perspectives. Therefore, because of the rapid increase of demands of the aggregates for the usage in construction, the decreasing of natural aggregate, which where the natural production of aggregate is naturally and after the rocks undergo the physical and chemical process that takes a long time to produce, makes our country need to solved the problem for our future generation. In the process of producing coarse aggregate from waste concrete, about 25% by weight of fine materials passing 5mm sieve size are generated. But, by replacing the natural fine aggregates with artificial fine aggregates was one of the answers too. Artificial fine aggregates are an inorganic material that has same features of an aggregate that usually for replacing the decreasing of natural aggregates. There are bunch of artificial fine aggregates such as steel slag, fly ash aggregates, blast furnace slag and others. As an alternative, in this research, fine palm oil clinker (FPOC) and fine laterite (FL) will be used as artificial fine aggregates.

Generally, Malaysia is the largest producer of palm oil, by contributing 50.9% of total production in the world (Teoh, 2002). This finding was agreed by Rafidah and Ming Chan (2009) which is this industry was a backbone of Malaysia development especially for rural socio-economic development and political stability. Then, due to the growing cost of raw materials and the nonstop reduction of natural resources, the practise of waste materials in the construction industry is a potentially workable. Waste materials, when properly processed, have shown to be effective as construction materials and readily meet the design specifications. Nevertheless, the method to produce palm oil it also yields tonnes of waste products known as palm oil clinker (POC). POC were produced in the boiler when the husk fiber and shell of palm oil are burned to generate energy for the refineries. According to Tay (1991) about 20% by weight of ash and other wastes are produced after the burning process. However, there are some research about palm oil fuel ash (POFA) has been revealed as one of construction material as cement replacement. But for POC, less research has been made and cause large amount of untreated waste that can cause pollution.

Hence, in this current study, four different percentage of combination of FPOC and FL were used as an alternative raw material as fine aggregates in the mix proportion were tested. The basic approach of this study is to determine the compressive strength of concrete by replacing the sand or fine aggregates with FPOC and FL.

1.2 Objectives of Study

The objectives of this study are:

1. To determine the compressive strength of concrete using fine palm oil clinker and fine laterite as artificial fine aggregates.

2. To determine the workability of concrete using fine palm oil clinker and fine laterite as artificial fine aggregates.

1.3 Problem Statement

The use of aggregate in concrete greatly reduces the needed amount of cement. Normally, natural aggregate necessities are high due to the requirement for the development of the country was rapidly developing. Since the demand is very high, the producer of this material takes advantage by place the price for this material very costly. Besides that, natural aggregate were slowly decreasing because of the fast development. Also, the process that natural aggregate undergoes is very long term that needs to be waited. This will lead the depleted of aggregate in construction material. The needs of research on developing of alternative material such as artificial aggregates were very essential nowadays.

On the other hand, when producing the palm oil there are many wastes that also were produce which usually been dump into the landfills which will lead to air and soil pollution. Nevertheless, some of the waste material already has been commercialize mainly as fertilizer for crop. But, still tonnes of waste product like palm oil clinker (POC) were being thrown away just like that. To condense this problem, usage of disposal waste product such as POC as aggregates replacement were very appropriate. This is because POC had similar physical properties like conventional aggregates and the price for these waste products is still economical. Therefore, this study will help by provide more information for the future development of artificial fine aggregate.

1.4 Scope of Study

This research will be focused on the identifying the effectiveness of concrete by replacing the fine aggregate with an artificial aggregate from palm oil waste product namely as palm oil clinker (POC). This waste product was taken at FELDA Lepar Hilir Palm Oil Factory and the laterite was taken from Pasir Mas, Kelantan. The POC and laterite then was crush into the required size using crusher machine which is the standard size for a fine aggregate is below 5 mm and will be sieve to it required fine aggregate size. The normal concrete will be stand as the control mixture.

The design concrete of characteristic strength is 25 N/mm^2 at 28 days. The concrete will be design with constant water cement ratio (w/c) as 0.51 which were calculated from concrete mix design (DOE). There percentages of combination from total weight of the aggregates that been calculated in the concrete mix design; different quantity of fine palm oil clinker (FPOC) as dominant material and fine laterite (FL) to be considered to partially substitute the aggregates that will be comparing with the control mixture. There are four types of different percentages of FPOC and FL replacing sand shown in Table 1.1 below.

Table 1.1: Percentages of FPOC and FL replacing fine aggregate

No. of specimens	Composition of mixing		
	FPOC	FL	Sand
S1	0 %	0 %	100 %
S2	100 %	0 %	0 %
S3	50 %	0 %	50 %
S4	25 %	25 %	50 %

Concrete workability test (BS 1881) which is slump test, compaction factor test and VEBE consistormeter will be tested for all mixes. The concrete will be cast and poured into mould with size 150 mm x 150 mm x 150 mm and the hardened concrete was taken out from the mould after one day. Then, the hardened concrete was cured in water for 7, 14 and 28 days for all mixes and will be tested in terms of compression strength according to BS 1881: Part 116: 1983.

1.5 Expected Outcomes

The outcome that should be gained at the end of this study is:

1. When the concrete were replace fine aggregate with fine palm oil clinker (FPOC) and fine laterite (FL), the compressive strength is better than conventional concrete.

2. The workability of concrete using fine palm oil clinker (FPOC) and fine laterite (FL) as artificial fine aggregates were better-quality than conventional concrete.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

For the last several decades, concrete has been used in the largest quantity for the construction material. The element that concrete has been choosing as the construction material is it can be form into any shape desired. As concrete dries, it acquires a stone-like consistency that renders it ideal for constructing roads, bridges, water supply and sewage systems, factories, airports, waterways, mass transit systems, and other structures. Concrete has a high compressive strength compared to tensile strength, low thermal and electric conductivity and low toxic. As it's good to its benefit, it's also giving the bad effect due to environment and high cost toward its increased used by year. Besides that, wastes are produced in large quantities from agro-based industries and the use of these waste materials in construction industry would contribute towards a cleaner environment (Mannan & Ganapathy, 2003). Hence, by substituting a partial percentage of sand or fine aggregate used in concrete with fine palm oil clinker (FPOC) and fine laterite (FL), its can reduce the environmental problem, making goods of unrecyclable wastage furthermore to gain an improved concrete product with less cost.

2.2 Overview of Concrete

2.2.1 Definition of Concrete

Concrete is a manufactured building material that looks like stone. Combining cement with aggregate and adequate water makes concrete. Water allows it to set and bind the materials together. Different mixtures are added to meet specific requirements. By the way, concrete is a stone like material obtained by letting a wisely proportioned mixture of cement, sand, gravel or other aggregate and water to harden in forms of the shape and dimensions of the desired structure (Nilson et al., 2004). Concrete is one of the most common construction materials and is employed in a wide variety of application, ranging from pile to multi-storeys buildings and from railroad ties to dams (Shan, 2001). The concrete were go through a chemical reaction between cement and water which referred to as hydration process to bind the aggregates to create this hard, strong and durable material.

2.2.2 History and Improvement of Concrete

The Romans were first created what today we call hydraulic cement-based concrete. They built various concrete structures, including the Pantheon in Rome, one of the finest examples of Roman architecture that survives to this day, which a 42 meter diameter dome has made of poured concrete (Lea, 1956). The name concrete originates from the Latin "concretus", which means to grow together. Roman concrete bears little resemblance to modern Portland cement concrete. It was never in a plastic state that could flow into a mould or a construction of formwork. Indeed, there is no clear dividing line between what could be called the first concrete and what might be more correctly termed cemented rubble. Roman concrete was constructed in layers by packing mortar by hand in and around stones of various sizes. A better understanding of the future of cements, coupled with improvements in cement manufacturing techniques, will make it possible to produce cements designed for particular purposes (S.Popovics, 1992). With an appropriate modification of the proportions of the constituent materials, a very wide-ranging of concrete properties can be gained. Special cements (such as high early strength cement), special aggregates (such as various lightweight or heavy weight aggregates), admixtures (such as plasticizers, air-entraining agents, silica fumes and fly ash), and special curing methods (such as steam-curing) permit an even wider variety of properties to be obtained (Nilson et al., 2004).

2.2.3 Properties of Concrete

According to Kovler and Roussel (2011), the literature related to the properties of hardened concrete published after the previous congress (the 12th International Congress on the Chemistry of Cement). There are four main properties of concrete which are workability, strength, durability and cohesiveness. Workability means how easy the concrete mixture is to place, handle, compact and finish. When the concrete mixture is stiff or dry, it will be difficult to handle, place, compact and finish. Hence, the concrete will not be as strong or durable when it's hardened. The workability can be test which are the slump test, compacting factor test and Vebe test. Workability were affected when, the cement paste is soft or liquid part of the concrete, more paste mixed with the coarse and fine aggregates, the mixed will be more workable. Also, the aggregate grading will improve the workability when the aggregate is well-graded, smooth, rounded shapes. On the other hand, by adding more water, it will make the mixture more workable but the strength and durability of the concrete will be decrease.

Well-made concrete is naturally strong and durable materials which are dense, reasonably watertight, able to resist changes in temperature, as well as wear and tear from weathering (CCCA, 2004). The durability of concrete was increasing with the strength. The strength of the concrete commonly was measured by the compressive strength test when the concrete is hardened. The concrete strength and durability basically can be affected by compaction, curing, weather, type of cement, and water cement ratio. By removing the air from concrete and proper compaction, the concrete will be denser which is stronger and more durable. According to CCCA (2004), curing means to cover or damp the concrete with water for a period, which is when the concrete moist the bond between the paste and the aggregate will gets stronger, which will lead to allow it to reach maximum strength. The concrete must be cure after finishing the concrete surface to prevent it from the pre-setting cracks or plastic shrinkage. Besides that, warm weather will cause concrete to have a higher early strength. Also, by using different type of cement will affect the concrete properties. The concrete will be weaker and less durable when too much water and less cement or the water cement ratio is high.

Then, cohesiveness is how well concrete holds together when the concrete mixture in the plastic state. Cohesiveness can be affected by the aggregate grading which is there is a range of size of aggregates, from large rocks to small sands (CCCA, 2004). More cohesive mix when well-graded aggregates were use, but boney mix when there are too much coarse aggregate. Water content also affect the cohesiveness, which is when the mixture is too much water the concrete mix will not be cohesive and may separate and bleed.

2.3 Conventional Fine Aggregates

2.3.1 Definition of Conventional Fine Aggregates

In ordinary structural concrete the aggregates occupy about 70 to 75 percent of the volume of the hardened mass concrete. There are three general classes of bedrocks, based on origin: igneous, sedimentary and metamorphic. According to S.Popovics (1992), igneous rocks that are fine grained is well interlocked and contain low percentages of feldspars have the best concrete making properties. Besides that, according to Kronlof (1994), in many areas good-quality coarse gravel is no longer available, and manufacturers have had to optimize for alternatives such as crushed aggregate and finer gravel. Fine aggregate that were used in construction is natural sand which has been washed and sieved to remove particles larger than 5 mm. A concrete with very less voids or spaces in it, which were fill with fine aggregates will increased the workability and reduces the quantity of cement required to produce a strong concrete.

Aggregate occupies roughly three-fourths of the volume of concrete, so its quality can be considerable importance on the concrete quality (S.Popovics, 1992). The gradation of the particle sizes in the aggregate is important to produce close packing in the concrete. According to S.Popovics (1992), a better estimate of the actual grading is obtained by accumulating a sample randomly by means of a large number of small increments, such as scoopfuls, than by taking a few larger increments, such as shovelfuls. Fine aggregates have to meet with the water requirement of round and/or smooth particles are less than that of angular and/or rough particles. The particles shape is controlled by two relatively independent properties which are roundness and sphericity.

2.3.2 Physical Properties of Fine Aggregates

The physical properties of fine aggregates are specific gravity, bulk density, absorption, moisture content, bulking of sand and soundness. These properties were to determine the corresponding property of the concrete. According to S.Popovics (1992), the greater the porosity of the aggregate, the differences between the various specific gravities will be greater. The bulk specific gravity is defined as the ratio of the oven-dry weight in air of an aggregate particle at 73.4°F (23°C) to the weight of water displaced by the particle in its saturated surface-dry state at 73.4°F (23°C). Since the materials of aggregates always contain more or less pores inside, practically all dry particles are capable of absorbing water. The amount of the water being absorbed were relates to the abundance and continuity of the pores in the particle. The size of particles also affects the absorption capacity.

Absorption capacity is the maximum amount of water that the aggregate can absorb under the prevailing circumstances. When an aggregate particle is subjected to a large fluid pressure from the internal porosity of the rocks on one side, it will be permeable. Absorption and permeability are the most important aggregate characteristics because, either per se or as characteristics of the internal porosity, they strongly influence the chemical stability, hardness, strength, deformability, and thermal properties of the aggregate (S.Popovics, 1992). Also, the author write that, free or surface moisture holds the fine-aggregate particles apart; hence, there may result a marked decrease in the unit weight of the aggregate, that is, an increase in the percentage of voids which is known as bulking. This can be discuss that, in the free water content, the ore water, the greater the bulking. Sand that is completely submerged shows no bulking.

Then, the soundness of the aggregate is used as a more general term that includes not only frost resistance but also the ability to withstand the aggressive actions to which the concrete containing it may be exposed to the weather (S.Popovics, 1992). It can be describe that, soundness includes the ability of aggregate to resist excessive volume changes caused not only by freezing and thawing but also by other temperature changes and alternating wetting and drying.

Bond between aggregate and cement paste is an important factor in the strength of concrete, especially the flexural strength. Bond is due, in part; to the interlocking of the aggregate and the hydrated cement paste due to the roughness of the surface of the former. In any case, for good development of bond, it is necessary that the aggregate surface be clean and free from adhering clay particles (Neville, A. M, 2005). According to Salem (2009), the compressive strength of concrete cannot significantly exceed that of the major part of the aggregate contained therein. If the aggregate under test leads to a lower compressive strength of concrete and in particular if numerous individual aggregate particles appear fractured after the concrete specimen has been crushed, then the strength of the aggregate is lower than the nominal compressive strength of the concrete mix in which the aggregate was incorporated (Salem, 2009). Table 2.1 shows the physical properties of aggregates (R. Siddique, 2003).

Table 2.1: Physical properties of aggregate

Property	Fine aggregate	Coarse aggregate
Specific gravity	2.63	2.61
Fineness modulus	2.25	6.61
SSD absorption (%)	0.86	1.12
Void (%)	36.2	39.6
Unit weight (kg/m^3)	1690	1615

2.3.3 Application of Aggregates

Aggregate is a kind of mixture of crushed stone, sand and gravel, which used as a part of the construction material in building road, highway, structures and anything that require aggregate. A high-quality aggregate consists of particles that are strong, durable, clean, favourably graded, and not flat or elongated; that do not slake when wetted and dried; whose surface texture is somewhat rough; and that contain no constituents that interfere with cement hydration or react with cement hydration products to produce excessive expansion (S.Popovics, 1992). The most common application of aggregates is to resists compressive stress and provides bulk to the composite material. In high-strength concrete, careful courtesy must be given to aggregate size, shape, surface texture, mineralogy, and cleanness.

Aggregates are a constituent of combination materials such as concrete and asphalt concrete; the aggregate supports as reinforcement to increase strength to the overall combination material. Also, aggregates are broadly used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and road side edge drains, due to the relatively high hydraulic conductivity value of the aggregate. Besides that, aggregates are also applied as base material under foundations, roads, and railroads. This means that, aggregates are functional as a stable foundation or road/rail base with expectable, unchanging properties or to avoid differential settling below the road or building, or as a low-cost extender that binds with more expensive cement or asphalt to form concrete.