THE POTENTIAL OF PALM OIL FUEL ASH AS PARTIAL SAND REPLACEMENT IN CONCRETE

MOHAMAD HAFIZUDDIN BIN RASID

B.ENG (HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

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MOHAMAD HAFIZUDDIN BIN RASID

Thesis submitted in fulfilment of the requirements
for the award of the degree of
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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering (Hons.) Civil Engineering.

Signature	:	
Name of Supervisor	:	DR. KHAIRUNISA MUTHUSAMY
Position	:	SENIOR LECTURER
Date	:	

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree

Signature :
Name : MOHAMAD HAFIZUDDIN BIN RASID
ID Number : AA13256
Date :

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LIST OF SYMBOLS

%	Percent
mm	Millimetre
mm^2	Millimetre square
m^3	Cubic metre
μm	Micro metre
g	Gram
kg	Kilogram
kg/m^3	Kilogram per cubic metre
MPa	Mega Pascal
kN	Kilo newton
°C	Degree Celsius
°	Degree
kN/sec	Kilo newton per second
f_c	Compressive strength of concrete specimen
P	Maximum load carried by the specimen during testing
A	Area
R	Modulus of Rupture
l	Distance between the support
b	Net width
d	Depth

LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
BS	British Standard
MS	Malaysian Standards
MPOB	Malaysia Palm Oil Board
POFA	Palm Oil Fuel Ash
i.e.	That is
e.g.	For example

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ABSTRACT

The consumption of natural sand taken from the river was too high due to its excessive use in concrete. The demands for this natural sand were increasing from time to time, especially on developing countries, for instance, Malaysia. Thus, the construction industries are in stress to identify alternative methods and materials to reduce the demand for natural sand. Palm oil fuel ash has been seen as one of the alternative that can replace sand in concrete mixture production and therefore could reduce the excessive production of palm oil fuel ash. In 2011, Malaysia has been reported that 5 million ha area of the land was used for oil palm plantation. This resulted in the annual production of about 61.1 million tone of solid waste such as empty fruit branches, fibres and kernels in the country. It's also produced about 3 million tons of POFA in 2007. This situation will contribute to increasing of agro waste generated and could led to environmental issues. The main aim of this research is to study the mechanical performance of concrete containing palm oil fuel ash as partial sand replacement. The objectives of this study is to investigate the effect of unground palm oil fuel ash as partial sand replacement on workability, compressive and flexural strength of concrete. Two mix were prepared in this research which are control mix and modified mix. Where the modified mix consist various percentage of palm oil fuel ash as partial sand replacement, which are 0 to 20%. The size of the specimens that is going to be use is 100x100x100 mm (length x width x height). The specimens were subjected to water curing for 7, 28, and 60 days period. The specimens then test for workability, compressive strength test, and flexural strength test. The increase of slump value is attributed by the characteristic of POFA as low water absorption. As the POFA content increases, the slump value is increases. The slump value fall in the range of only 100mm to 120mm at water cement ratio of 0.70. The concrete mix made using POFA as partial replacement of sand showed good workability and fluidity similar to normal concrete mixes The test resulted showed that for 10% ratio of POFA in concrete, the increase in the compressive strength was about 19% compared to normal concrete. Similar results were also observed for the flexure. Conclusively, 10% of POFA is the best recommended amount to be used as partial sand replacement to produced concrete with better strength.

ABSTRAK

Penggunaan pasir semula jadi diambil dari sungai terlalu tinggi disebabkan penggunaan berlebihannya dalam konkrit. Permintaan untuk pasir semula jadi ini menambahkan dari semasa ke semasa, terutamanya di negara-negara membangun, misalnya, Malaysia. Maka, industri pembinaan dalam tekanan mengenal pasti kaedah-kaedah lain dan bahan mengurangkan permintaan untuk pasir semula jadi. Abu bahan api minyak sawit telah kelihatan sebagai salah satu alternatif yang boleh menggantikan pasir dalam pengeluaran campuran konkrit dan oleh itu boleh mengurangkan pengeluaran berlebihan abu bahan api minyak sawit. Pada 2011, Malaysia telah dilaporkan 5 juta ha kawasan tanah digunakan untuk perladangan kelapa sawit. Ini mengakibatkan pengeluaran tahunan lebih kurang 61.1 juta nada sisa pepejal seperti cawangan-cawangan buah kosong, gentian dan inti dalam negara. Ia telah juga menghasilkan kira-kira 3 juta banyak POFA pada 2007. Keadaan ini akan menyumbang kepada penambahan sisa agro menghasilkan dan boleh membawa kepada isu-isu alam sekitar. Tujuan utama penyelidikan ini adalah untuk belajar prestasi mekanikal konkrit mengandungi abu bahan api minyak sawit sebagai penggantian pasir yang separa. Objektif kajian ini adalah untuk menyiasat kesan bahan api minyak sawit unground abu sebagai penggantian pasir yang separa di kebolehkerjaan, kekuatan mampat dan lenturan konkrit. Dua campuran telah disediakan dalam penyelidikan ini yang mana ialah kawal campuran dan mengubahsuai campuran. Di mana campuran diubah suai mengandungi pelbagai peratusan abu bahan api minyak sawit sebagai penggantian pasir yang separa, iaitu 0 hingga 20%. Saiz spesimen yang akan guna ialah 100x100x100 mm (panjang x kelebaran x ketinggian). Spesimen melalui air pemulihan untuk 7, 28 , dan 60 tempoh hari. Spesimen kemudian menguji untuk kebolehkerjaan, ujian kekuatan mampatan , dan ujian kekuatan lenturan. Peningkatan nilai kemelesetan sifat oleh yang biasa daripada POFA sebagai penyerapan air surut. Sebagai POFA kandungan peningkatan, nilai kemelesetan ialah peningkatan. Kejatuhan nilai kemelesetan dalam lingkungan satu-satunya 100mm kepada 120mm di nisbah simen air 0.70. Campuran konkrit dibuat menggunakan POFA sebagai penggantian separa pasir menunjukkan kebolehkerjaan baik dan kebendaliran sebagaimana konkrit biasa mencampurkan ujian The menyebabkan menunjukkan bahawa untuk 10% nisbah POFA dalam konkrit, peningkatan dalam kekuatan mampatan ialah kira-kira 19% berbanding dengan konkrit biasa. Kajian serupa juga diperhatikan untuk liku. Dengan pasti, 10% daripada POFA ialah jumlah yang terbaik dicadangkan diguna pakai sebagai penggantian pasir yang separa dihasilkan konkrit dengan kekuatan lebih baik.

CHAPTER 1

INTRODUTION

1.1 INTRODUTION

In construction, concrete is the most important thing or material that has been used since a long time ago. Continuous research in area of concrete material has resulted in many types of concrete known in various names each having unique characteristics to fulfill the current construction industry demands. However, Malaysia is the second largest exporter of palm oil and it was reported in 2011 that 5 mil ha area of land was used for oil palm plantation (Lim *et al*., 2013). This resulted in the annual production of about 61.1 million tons of solid waste such as empty fruit branches, fibres and kernels in the country. These waste materials are usually discarded on-site after the palm oil extraction process. This cause unnecessary piling of wastes in the vicinity of factories and posed serious land pollution.

Palm oil fuel ash (POFA) is produced by the palm oil industry as a result of the burning of empty fruit bunch (EFB), fiber and oil palm shell (OPS) as fuel to generate electricity at temperatures of about 800–1000 °C and the waste, collected as ash, becomes POFA (Nagaratnam *et al*., 2015). Malaysia produced about 3 million tons of POFA in 2007 (Johari *et al.,* 2012) while 100,000 tons of POFA is being produced annually in Thailand, and this production rate is likely to increase due to increased plantation of palm oil trees (Chindaprasirt *et al*., 2007). The POFA produced in the palm oil mills is dumped into open fields without any profitable return resulting in massive solid disposal which occupies vast fields and causes environmental pollution (Chindaprasirt *et al*., 2007). In view of environmental contamination, palm oil industry has started to look for an effective solution so that this huge volume of waste can be

utilized. A successful approach to this problem can be linked to utilizing POFA as an alternative material in concrete and construction material. It is seen that utilizing waste materials from the palm oil industry such as Palm Oil Fuel Ash (POFA) as replacement for conventional materials in the production of concrete would reduce amount waste disposed at landfill.

1.2 PROBLEM STATEMENT

Concrete is a combination consists of cement, aggregate and water. The consumption of natural sand taken from the river was too high due to its excessive use in concrete. The demands for this natural sand were increasing from time to time, especially on developing countries, for instance, Malaysia. For every concrete structure basically required tons of sand and gravel coated together with cement. Only some sands are suitable to use for making concrete. In fact, the properties of the sand utilized as a part of concrete can affect its quality. For example, desert sand generally not suitable to use for construction because the wind erosion of sand in the desert results in smooth and desert grains are too round which do not bind well. Furthermore, desert sand is mono-grained which means similar size. This sand is absolutely makes it unsuitable to use in concrete because concrete required sand which is small, intermediate, and coarser particles to prevent voids between grains to reduce the amount of water necessary. Generally, sand which is use for concrete was obtained by mined from land quarries and riverbeds. Natural sand is being extracted at an increasing rate due to growing global population which leads an expanding demand for building and housing. This action has caused the expansion of mining to coastal areas and dredging of the seafloor and indirectly increasing the possibility of flooding, affect the marine and river biodiversity, causing coastal and inland erosion, exacerbating the risk of drought and lowering the water table in some areas. Thus, the construction industries are in stress to identify alternative methods and materials to reduce the demand for natural sand.

Palm oil is the main product in tropical climate countries and Malaysia is the top producer of it. Generally, after combustion process was completed, about 5% palm oil fuel ash by weight of solid waste is produced (Sata *et al*., 2004). Palm oil fuel ash

(POFA) is one of the most abundant wastes found in Malaysia. If this waste were not managed properly, it will become hazardous to the surrounding residential area. This problems also have been highlighted by Tay and Show (1995) who stated that this ash has also coused potential health hazard and environmental problems. The utilization of waste materials from the palm oil industry provides immense benefit to various sectors of the construction industry. Channelling this waste material into the building industry helps to promote sustainability besides overcoming waste disposal problems. Environmental pollution due to inappropriate waste management system can also be drastically reduced. In order to overcome this problem, use the waste as the main substance in the production of concrete containing palm oil fuel ash (POFA) as partial sand replacement.

1.3 OBJECTIVES

The main aim of this research is to study the mechanical performance of concrete containing palm oil fuel ash as partial sand replacement. The objectives of this study are as follows:

i) To investigate the effect of unground palm oil fuel ash as partial sand replacement on workability and compressive strength of concrete.
ii) To investigate the effect of unground palm oil fuel ash as partial sand replacement on flexural strength of concrete.

1.4 SCOPE OF RESEARCH

This study is focused on the behavior of the concrete mixture when it containing various percentage of POFA as partial sand replacement. The percentage varies from 0%, 5%, 10%, 15%, and 20% by weight of sand. Two mixes were prepared during this study, which are control mix and modified mix. The different between these two mixes is the percentage of POFA included where the control mix consist 0% of POFA while the modified mix consist varies of POFA percentage. Slump test readied performed to determine the workability of the concrete which comply the ASTM C143/C143M (2005). For the compression strength test, the dimension used for the cubes is 100mm x

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