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THE POTENTIAL OF OVEN DRY SEWAGE SLUDGE AS PARTIAL SAND REPLACEMENT IN CONCRETE

MOHD SYUKRAN BIN AB RAZAK

Thesis submitted in fulfilment of the requirements
for the award of the degree of
B.Eng (Hons.) Civil Engineering

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2016

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Signature	:	
Name of Supervisor	:	DR. DOH SHU ING
Position	:	SENIOR LECTURER
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Name : MOHD SYUKRAN BIN AB RAZAK

ID Number : AA12028

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
N/mm^2	Newton per square millimetre
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
R^2	Correlation coefficient
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
IWK	Indah Water Konsortium
SS	Sewage Sludge
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. Sewage sludge has been seen as one of the alternative that can replace sand in concrete mixture production and therefore could reduce the excessive production of sewage sludge. It has been reported that Malaysia produce about 3 million m^3 of sewage sludge per year and it has been estimated to rise to 7 million m^3 in the year of 2020. These situations have contributed to increasing of solid waste generated and have led to environmental issues. This research was ran to study the properties of concrete cube mixture that contained various percentage of sewage sludge that have been sieved as partial sand replacement, which were 0%, 10% and 20%. The size of the specimens that been used were 100x100x100 mm (length x width x height). The specimens subjected to two types of curing method, which were water and air curing for 3, 7 and 28 days period. The specimens then tested for compressive strength test, flexural strength, rebound hammer test and ultrasonic pulse velocity test. The results from these tests shows the suitable percentage of sewage sludge as partial sand replacement and suitable curing method for this concrete mix production.

ABSTRAK

Pengambilan pasir semula jadi yang diambil dari sungai terlalu tinggi kerana penggunaan yang berlebihan dalam konkrit. Permintaan untuk pasir semula jadi telah meningkat dari semasa ke semasa, terutamanya di negara-negara membangun, misalnya, Malaysia. Oleh itu, industri pembinaan berada di dalam situasi tertekan untuk mengenal pasti kaedah dan bahan alternatif untuk mengurangkan permintaan untuk pasir semula jadi. Bahan enapcemar telah dilihat sebagai salah satu alternatif yang boleh menggantikan pasir dalam pengeluaran campuran konkrit dan lantas mampu mengurangkan pengeluaran berlebihan bahan enapcemar. Dilaporkan bahawa Malaysia menghasilkan kira-kira 3 juta m^3 bahan enapcemar setiap tahun dan ia telah dianggarkan akan meningkat kepada 7 juta m^3 pada tahun 2020. Keadaan ini akan menyumbang kepada peningkatan sisa pepejal yang dihasilkan dan boleh membawa kepada isu-isu alam sekitar. Tesis ini adalah untuk mengkaji sifat-sifat campuran kiub konkrit yang mengandungi pelbagai peratusan bahan enapcemar yang telah disaring sebagai pengganti pasir, yang mengandungi peratusan penggantian pasir 0%, 10% dan 20%. Saiz spesimen yang akan digunakan adalah 100x100x100 mm (panjang x lebar x tinggi). Spesimen akan tertakluk kepada dua jenis kaedah pengawetan, iaitu air dan pengawetan udara untuk 3, 7 dan 28 hari. Spesimen itu akan dijadikan ujian untuk ujian kekuatan mampatan, ujian kekuatan lenturan, ujian tukul pemulihan dan ujian halaju denyut ultrasonik. Keputusan daripada ujian ini akan menunjukkan peratusan ideal bahan enapcemar sebagai pengganti separa pasir dan kaedah pengawetan sesuai untuk pengeluaran campuran konkrit ini.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

As the world populations grow from time to time, the amounts and types of wastes being generated by the community have increased tremendously. Most of the wastes that have been produced nowadays will remain in the environment for hundreds or thousands of years. The invention of non-decaying waste materials, combined with the growing of consumer population, has caused in a waste disposal crisis. There were many types of industrial waste material and one of them is sewage sludge.

Sewage sludge or also known as bio solids is a by-product of municipal wastewater treatment. In Malaysia, the sewage sludge was mainly produced from domestic and light industrial area. It has been reported by Indah Water Konsortium Sdn. Bhd. (IWK) (1997) that Malaysia produce about 3 million m^3 of sewage sludge per year and it has been estimated to rise to 7 million m^3 in the year of 2020 (Noorain, 2013). Currently, IWK runs and manages over 4300 public sewerage system all over Malaysia and desludge and treats sludge from over 0.8 million septic tanks regularly and monitors effluent samples from sewage treatment plants to ensure they meet the standards made by Department of Environment.

Rapid urbanization, a consequence of economic development, nationally and globally, and also the increased of population in Malaysia has led to production of large quantities if sewage sludge in Malaysia and has posed serious environmental problems for their disposal. It has been reported that the total cost of managing the sewage sludge

alone is estimated at US$ 0.33 billion per year. However, the treated-sewage sludge is commonly being disposed either at landfills or being burned in incinerators.

1.2 PROBLEM STATEMENT

Concrete is a combination consists of cement, aggregate and water. The most commonly used fine aggregate is sand derived from the river banks. 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.

On the contrary, the advantages of utilization of by-products or materials gained from the sewerage treatment plant, sewage sludge for instance, may reduce the negative environmental load impact and also the waste management cost, reduction of production cost as well as improving the quality of concrete produced.

In this context, the sewage sludge that have been dried and sieve should be similar to sand (fine aggregate) and satisfy the requirement of sand in concrete, which is to solidify and the necessary strength for a certain structure. Sand can fill up the pores or voids inside the concrete which is also a contributing factor for the strength of the concrete. As the sewage sludge would be finer than sand, it will act much better than sand to fill up the voids in concrete.

1.3 OBJECTIVE

The objectives of the study are:

a) To determine the suitability of sewage sludge as partial sand replacement in concrete.
b) To study the mechanical properties of sewage sludge concrete.
c) To compare the effect of air and water curing of sewage sludge concrete.

1.4 SCOPE OF STUDY

This study is focused on the behaviour of the concrete mixture when it containing various percentage of sewage sludge as partial sand replacement. The percentage varies from 0%, 20% and 40% by volume. Two mixes were prepared during this study, which are control mix and modified mix. The different between these two mixes is the percentage of sewage sludge included where the control mix consist 0% of sewage sludge while the modified mix consist varies of sewage sludge percentage.

The size of the concrete cube is fixed to 100x100x100 millimetres dimension and for the flexural test, mould with size of 100mm x 100mm x 500mm is used. For the curing process, the period of the concrete cube subjected to water is from 3, 7 and 28 days. The methods used for curing are air and water curing. The test for compressive and flexural strength of the concrete cube is conducted after the process of curing for each specimen.

1.5 IMPORTANCE OF STUDY

This study will provide all the information and knowledge regarding sewage sludge as the partial sand replacement in concrete. The strength, durability and the effect of the composition will be identified later on this study. The result from this study is expected to help reducing the excessive amount of sewage sludge wastage in Malaysia along with preserving the natural sand for the future usage. Furthermore, the information gained from this study will provide better understanding about this modified concrete mixture for further study and commercialization purpose.