

THE MECHANICAL PROPERTIES OF
MICROWAVE SEWAGE SLUDGE ASH (MSSA)
AS PARTIAL CEMENT REPLACEMENT IN
CONCRETE

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Thesis submitted in fulfilment of the requirements
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LIST OF SYMBOLS

%	Percentage
mm	Millimeter
N/mm ²	Newton per millimeter square
kg	Kilogram
N	Newton
kN	Kilonewton
kg/m ³	Kilogram per meter cubic
w/c	Water to cement ratio
mm ²	Millimeter square
m ³	Meter cubic
Pa	Pascal
MPa	Mega Pascal
psi	Pounds per inch square
pH	Potential of Hydrogen

LIST OF ABBREVIATIONS

ACI	American Concrete Institute
ASTM	American Society for Testing and Materials
BS	British Standard
CEM	Certified Energy Manager
EN	European Standards
SSA	Sewage Sludge Ash
MSSA	Microwave Sewage Sludge Ash
POFA	Palm Oil Fuel Ash
RHA	Rice Husk Ash
SCBA	Sugarcane Bagasse Ash
OPC	Ordinary Portland Cement
UPV	Ultrasonic Pulse Velocity (UPV)
XRD	X-ray Diffraction

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ABSTRACT

Rapid urbanization in the developing country leads to prosper of construction sector due to the demand of house, building and infrastructure with the increasing urban population. Hence, cement is highly demand in any construction project. Non-renewable natural resources such as limestone, clay, coal, petroleum, natural gas and fuel oil are consumed in the production of cement will be depleted eventually. Huge quantities of sewage sludge being produced every year and needed to be disposed. Solid waste disposal had come into discussion for years to resolve the space limitation in landfills. An alternative method of sewage sludge disposal is to utilize it as one of the construction materials. Despite of incineration method to reduce the quantities of sewage sludge, microwave heating which is more efficient in term of time and energy consumption is used in this research. Microwave Sewage sludge ash (MSSA) is proposed as partial cement replacement in concrete. 0%, 5%, 10% and 15% MSSA which were heated at medium and medium-high temperature are used in this research. Compressive strength, flexural strength, UPV and XRD were performed. The mechanical properties of MSSA concrete were compared among each other and conventional concrete G30. The results showed that 5% MSSA which was microwave heated at medium-high temperature is the optimum percentage replacement in concrete.

ABSTRAK

Proses pambandaran yang pesat dalam pembangunan negara membawa makmur kepada sektor pembinaan disebabkan oleh permintaan rumah, bangunan dan infrastruktur dengan penduduk bandar yang semakin meningkat. Oleh yang demikian, simen adalah sangat permintaan dalam apa-apa projek pembinaan. Sumber alam yang tidak boleh diperbaharui seperti batu kapur, tanah liat, arang batu, petroleum, gas asli dan minyak yang digunakan dalam pengeluaran simen akan dihabiskan akhirnya. Kuantiti yang besar daripada kumbahan sludge dihasilkan setiap tahun dan perlu dilupuskan. Perbincangan tentang pelupusan sisa pepejal telah diadakan sepanjang tahun demi menyelesaikan had ruang di tapak pelupusan sampah. Satu kaedah alternatif untuk pelupusan kumbahan sludge adalah menggunakan ia sebagai salah satu bahan pembinaan. Walaupun kaedah pembakaran dapat mengurangkan kuantiti kumbahan sludge, ketuhar Pemanas yang lebih cekap dari segi penggunaan masa dan tenaga telah digunakan dalam kajian ini. Ash kumbahan sludge ketuhar gelombang mikro (MSSA) adalah dicadangkan sebagai gantian simen separa dalam konkrit. 0%, 5%, 10% dan 15% MSSA yang telah dipanaskan pada suhu sederhana dan sederhana-tinggi digunakan dalam kajian ini. Kekuatan mampatan, kekuatan lentur, UPV dan XRD telah dijalankan. Sifat-sifat mekanikal konkrit MSSA dibandingkan antara satu sama lain dan G30 konkrit konvensional. Keputusan menunjukkan bahawa 5% MSSA yang ketuhar dipanaskan pada suhu sederhana-tinggi adalah penggantian peratusan optimum dalam konkrit.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Development in urbanization is growing rapidly due to the increasing population in a developed country. In 2015, urban population in Malaysia is reported as 74.7% of total population with 2.66% annual rate of change of urbanization (Central Intelligence Agency, 2015). This population rate indicates the importance of construction industry in leading to the development of country for the construction of houses, buildings, roads and infrastructures. Therefore, cement which is the main component of concrete is essential and common in any construction projects. From the Table 1.1, the world cement production had revealed a significant increment yearly from year 2004 to year 2013. The statistics reflect the continued highly demand of cement production from year to year throughout the world.

According to Naik (2008), it is necessary to search for the sustainable solution for future concrete construction due to the limitation of natural resources such as limestone, which will eventually affect the cement production along with the increasing population. Replacement of the cement in concrete construction is essential with the utilization of industrial, agriculture and domestic waste product (Imbabi et al., 2012) in order to overcome the sustainability issue.

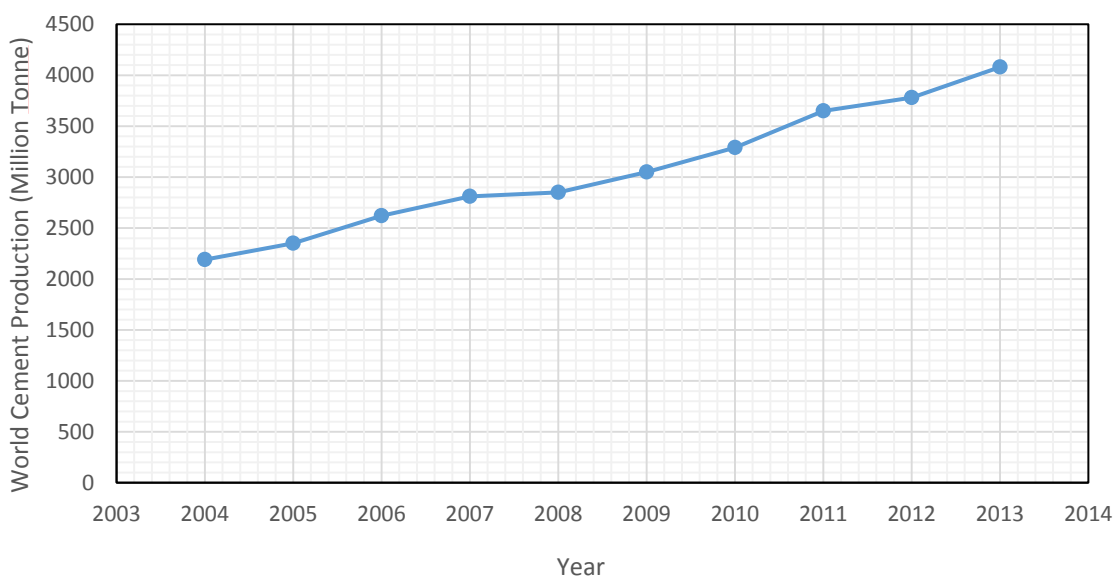


Figure 1.1: Statistic of World Cement Production, 2004-2013

Source: United State Geological Survey (2011)

Sewage sludge is a by-product from domestic and light industrial area which being treated in wastewater treatment plant. The production of sewage sludge increase drastically every year due to the rapid urbanization in the developing country such as Malaysia. Indah Water Konsortium (2010) reported that around 3 million metric tons of sewage sludge is produced annually and estimated it will be reached to 7 million metric tons in the year 2020. This alarming increment of production of sewage sludge arise environmental issues for their disposal. One of the common waste disposal is controlled landfills. However, Monzo et al. (2003) stated that space limitation for disposal on the existing landfills and the problem of waste stabilization for environmental control as sewage sludge contains organic and inorganic matters. Incineration is another way to disposal which can resulting in optimum volume reduction and stabilization for sewage sludge, but the incinerated residue still being disposed in landfill, emission of gases and heavy metal which can lead to environment issue (Yen et al., 2011). Pavsic et al. (2013) mentioned that reuse of sewage sludge is difficult to implement in agriculture due to the presence of pathogens and heavy metals. Thus, there is a need to develop alternative disposal methods to overcome the environmental issues. Researches have conducted experiments on uses of sewage sludge ash (SSA) as construction materials due to its

pozzolanic properties which could increase the mechanical strength and durability of cement.

1.2 PROBLEM STATEMENT

Rapid urbanization in the developing country leads to prosper of construction sector due to the demand of house, building and infrastructure with the increasing urban population. Hence, cement is highly demand in any construction project. Non-renewable natural resources such as limestone, clay, coal, petroleum, natural gas and fuel oil are consumed in the production of cement will be depleted eventually. Sewage sludge ash (SSA) is proposed as partial cement replacement to overcome this sustainability issue.

According to Mat, Shaari & How (2012), estimated 2.97 billion cubic meters of wastewater is generated by municipal and industrial sector every year. This figure indicates the huge quantities of sewage sludge being produced every year and needed to be disposed. Solid waste disposal had come into discussion for years to resolve the space limitation in landfills. An alternative method of sewage sludge disposal is to utilize it as one of the construction materials. A huge reduction in volume of sewage sludge which facilitate the waste disposal can be achieved via the burning of sludge in order to obtain the sewage sludge ash (SSA).

Altwair & Kabir (2010) stated that the production of Portland cement emits significant amount of carbon dioxide and other greenhouse gases (GHGs). This greenhouse gases are corresponding to the greenhouse effect and global warming which increase the temperature of earth. Without exception, cement industries contribute negative impact to the environment. One approach to reduce the carbon dioxide emission is through green concrete. Research had been done for the SSA which exhibit pozzolanic behavior can be utilized as one of the component of green concrete.