

THE EFFECT OF RICE HUSK ASH AND
METAKAOLIN AS PARTIAL CEMENT
REPLACEMENT IN CONCRETE TOWARDS
CORROSION RESISTANCE

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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 Bachelor Degree of Civil Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRACT

Pozzolanic materials are natural or artificial materials produced from combustion of the waste. In Malaysia, the utilization of the pozzolanic materials has been widely used in concrete construction which used as a partial replacement material in concrete. In this study, Rice Husk Ash (RHA) and Metakaolin (MK) were utilized as pozzolanic material in concrete. Rice husk ash is a by-product material obtained from the combustion of rice husk which consists of non-crystalline silicon dioxide with a high specific surface area and high pozzolanic reactivity. It also has demonstrated significant influence in improving the mechanical and durability properties of concrete. Other than that, metakaolin is a new active mineral admixture used in cement concrete product and it also has a good effect on the mechanical properties of cement. The behaviours of RHA + MK performance in improving corrosion resistance, water absorption and compressive strength due to the different percentage of partial cement replacement in concrete were assessed in this study. Besides, the percentage of concrete containing rice husk ash and metakaolin were 10%, 20%, and 30% and their combinations as the partial replacement of cement in concrete was (1:1 ratio). Next, water absorption test was done to determine the percentage of water absorption in the concrete and the test for corrosion resistance was accelerated corrosion test with impressed voltage. From the result, it was found that the incorporation of rice husk ash and metakaolin have the potential to be used as partial cement replacement in concrete to reduce the water absorption and increase the corrosion resistance. Therefore, rice husk ash and metakaolin can be used as partial cement replacement in concrete and the optimum percentage of partial cement replacement was up to 20% of rice husk ash and metakaolin in concrete.

ABSTRAK

Bahan Pozzolan adalah bahan semulajadi atau tiruan yang dihasilkan daripada pembakaran sisa. Di Malaysia, penggunaan bahan pozzolan telah digunakan secara meluas dalam pembinaan konkrit yang digunakan sebagai bahan gantikan separa dalam konkrit. Dalam kajian ini, abu sekam padi dan metakaolin digunakan sebagai bahan pozzolanic dalam konkrit. Abu sekam padi adalah bahan sampingan yang diperoleh daripada pembakaran sekam padi yang terdiri daripada silika dioksida yang bukan kristal dengan luas permukaan spesifik yang tinggi dan tinggi pozzolanic kereaktifan. Ia juga telah menunjukkan pengaruh yang penting dalam meningkatkan sifat mekanikal dan ketahanan konkrit. Selain itu, metakaolin adalah campuran baru yang aktif yang digunakan dalam produk konkrit simen dan ia juga mempunyai kesan yang baik terhadap sifat mekanik cement. Tingkah laku abu sekam padi dan metakaolin dalam meningkatkan rintangan kakisan, penyerapan air dan kekuatan mampatan disebabkan oleh peratusan yang berbeza daripada penggantian simen separa dalam konkrit dinilai dalam kajian ini. Selain itu, peratusan konkrit yang mengandungi abu sekam padi dan metakaolin adalah 10%, 20% dan 30% dan kombinasi mereka sebagai penggantian simen separa dalam konkrit adalah (nisbah 1: 1). Seterusnya, ujian "*water absorption*" dilakukan untuk menentukan peratus penyerapan air di dalam konkrit dan ujian untuk ketahanan kakisan ialah "*accelerated corrosion test with impressed voltage*". Daripada hasil kajian ini, didapati bahawa penggabungan abu sekam padi dan metakaolin berpotensi digunakan sebagai pengganti separa simen dalam konkrit untuk mengurangkan penyerapan air dan meningkatkan ketahanan kakisan. Oleh itu, abu sekam padi dan metakaolin boleh digunakan sebagai pengganti separa simen dalam konkrit dan peratusan yang optimum daripada penggantian separa simen tersebut adalah sehingga 20% abu sekam padi dan metakaolin dalam konkrit.

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LIST OF SYMBOLS

$\%$	Percentage
μm	Micrometre
mm	Millimeter
$^{\circ}C$	Degree Celcius
Kg/m^3	Kilogram per Meter Cube
m^3	Meter Cubes
kg	Kilogram
g	gram
h	hour
V	volt

LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
Ca(OH) ₂	Calcium Hydroxide
DC	Direct Current
FA	Fly Ash
FKASA	Fakulti Kejuruteraan Awan dan Sumber Alam
mA	milliampere
MK	Metakaolin
MPa	Mega Paskal
NaCl	Sodium Chloride
OPC	Ordinary Portland Cement
RHA	Rice Husk Ash
RH	RH
SF	Silica Fume
UMP	Universiti Malaysia Pahang

CHAPTER 1

INTRODUCTION

1.1 RESEARCH BACKGROUND

It is an undeniable fact that concrete is the most widely utilized man-made construction material in the world today, and will remain so for decades to come. The concrete is largely used in construction due to the abundance of raw material, low manufacturing and maintenance cost, excellence in compression, and corrosion aspects, durability to weathering, fire hazards, etc. However, the cement industry is also highly energy intensive, and the emission of carbon dioxide during cement manufacturing has created enormous environmental concerns (Parande et al., 2008). Cement should not be confused as concrete because the term, cement refers only to the dry powder substance used to bind the aggregate materials of concrete. Thus, Ordinary Portland cement (OPC) is a type of cement that was used in this research.

In recent years, many researchers have established that the use of pozzolanic materials like blast furnace slag, silica fume (SF), metakaolin (MK), fly ash (FA), palm oil fuel ash (POFA), and rice husk ash (RHA) that not only improve the various of concrete properties but also can contribute to economy in construction costs (Amrutha et al., 2011). Several investigations have been carried out to utilize waste materials in construction. Apart from getting rid of these materials, their use in construction protects the environment from contamination. Therefore, in this research, RHA and MK were used as a pozzolanic material for the preparation of cement concrete as it is not only a partial replacement for cement but also a replacement for the influence of toxic waste (Swaminathen & Ravi, 2016).

The uses of RHA as a partial replacement of cement provide an economic use of the by-product and consequently produce cheaper materials for low-cost construction materials. The employment of RHA in cement and concrete has gained considerable importance because of the requirements of environmental safety and more durable construction in the future (Givi et al., 2010). Other than that, the partial replacement of cement with MK reduced the water penetration into concrete by capillary action and can also cause substantial changes in the chemical composition of the pore solution phase of the hydrated material which may achieve the objective of this research (Siddique & Klaus, 2009). The use of metakaolin in mortars and concretes is growing as is not only can reduce the hardened cement permeability to liquids and gases but also can reduces carbon dioxide emissions and increases the service life of buildings (Aiswarya et al., 2013).

The research about partial replacement materials in OPC is done because a certain level of cement replacement with those pozzolans is highly advantageous in terms of cost, energy efficiency, ecological and environmental benefits as well as durability properties such as reduced water absorption and improved the corrosion in steel to reduce the time of cracking in concrete. Based on previous researchers, incorporation of metakaolin and rice husk ash also increase the compressive strength of concrete. Therefore, rice husk ash and metakaolin are the pozzolanic materials that have high potential to be a partial replacement of cement in concrete as both have their own advantages to improve concrete performance.

1.2 PROBLEM STATEMENT

The corrosion of the reinforcing steel in concrete is the major problems facing by civil engineers today as they maintain an ageing of infrastructure. Potentially, it is very large market for those who develop the expertise to deal with the problem. Therefore, to overcome the problems, there is the combination of RHA and MK as pozzolanic materials to replace the cement in concrete partially. This interest is part of the widely spread attention directed towards the utilization of wastes and industrial by-products. This is because to minimize the Portland cement consumption which is being environmentally damaging (Sabir, Wild, & J.Bai, 2001).

In recent years, the usage of metakaolin and rice husk ash as a pozzolanic material for the preparation of cement concrete had become more important than any other material. This is because, the manufacture of Portland cement (PC) is not eco-friendly in environment and the utilization of PC is increasing day by day. Thus it affects the environmental balance and the emission of more CO₂ results in the depletion of the atmospheric layer (Swaminathen & Ravi, 2016). Hence, it is necessary to have a partial replacement with pozzolanic materials which is obtained from calcined clay and from rice husk. Moreover, this research also gives better solutions for the abundant waste of RHA produced from agricultural product in this country which create acute environmental problems both in terms of their treatment and disposal.

The conscious about the importance of protecting the environment is increasing for the concrete industry. Many approaches are proposed in order to produce concrete that is more environmentally friendly. Special term for example 'green concrete' start to be used to show the concern about environment matter. Hence, in this modern era a great curiosity has received for the usage of calcined clay in the form of MK and the combusted RH in the form of RHA as a pozzolanic material for the cement concrete which is may not only can reduce water absorption, improve corrosion in steel and increase concrete strength but also may reduce of negative environmental effects (Chindaprasirt & Rukzon, 2008).

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