EFFECT OF BOTTOM ASH ON THE STRENGTH CHARACTERISTICS OF FLY ASH AND BOTTOM ASH MIXTURES

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To my beloved parent, siblings, and friends

Thanks for your never ending love and support

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ABSTRACT

One of the sources to produce electricity is coal. The major problem of the coal combustion based power plant is producing huge quantities of solid waste. Fly ash (FA) and bottom ash (BA) are two major contributions in the coal combustion products (CPP). Generally, most CPP are just dumped into the waste pond. The insufficient place for waste dumping is becoming an issue since the amount of CPP waste is increasing drastically. Recently, there are efforts to use the FA and BA together as mixtures in geotechnical engineering works. This paper focuses on the effect of BA content on the strength characteristic of fly ash and bottom ash mixtures, for coal ash taken from the Tanjung Bin power plant in Johor, Malaysia. This study investigates the effect of curing period on the morphology, chemical and strength characteristic of FA-BA mixtures that consists of 30 % and 70% BA.The mixtures had been tested in laboratory through Scanning Electron Microscopic test, X-Ray Fluorescences test and Consolidated Undrained triaxial test. Major chemical compostion of FA-BA mixtures are silica, alumina, ferum oxide and calcium oxide. The value of modulus of elasticity decreased with the increase of bottom ash content from 30% to 70% in the ash mixtures. The internal friction angle at critical state, ϕ_c', was decreased as the content of BA is increased from 30% to 70%. Without curing periods, the increased of BA content from 30% to 70% did not give any significant effect on the critical state shear strength. However, after 28 days curing periods, the ϕ_c' was increased, but it is not that significant. It is also observed that the ϕ_c' of both mixtures with 30%BA and 70%BA are in the same range as the typical dense sands. Generally, it can be concluded that there is no significant effect on the shear strength properties at critical state for FA-BA mixtures at 30%BA and 70%BA. Hence, there will be a great potential to use a large quantity of BA in the mixtures without compromising the strength which can be a great benefit for usage in various geotechnical engineering works.

ABSTRAK

Arang batu merupakan salah satu sumber untuk menghasilkan elektrik. Masalah utama bagi pembakaran arang baru di loji kuasa adalah pembakaran arang batu telah menghasilkan sisa pepejal dalam kuantiti yang banyak. Abu terbang (FA) dan abu dasar (BA) adalah dua sumbangan besar dalam produk pembakaran arang batu (CPP). Secara umumnya, CPP hanya akan dibuang ke dalam kolam sisa. Tempat pelupusan sisa buangan yang tidak mencukup telah menjadi satu isu. Ini berpunca daripada jumlah sisa CPP telah menunjukkan peningkatan yang drastik. Kebelakangan ini, terdapat usaha-usaha untuk menggunakan FA dan BA bersama-sama sebagai campuran dalam kerja-kerja kejuruteraan geoteknik. Kajian ini memberi tumpuan kepada campuran abu arang batu dari loji kuasa Tanjung Bin di Johor, Malaysia. Kajian ini menyiasat kesan tempoh pengawetan pada ciri morfologi, kimia dan kekuatan campuran abu terbang dan abu dasar (FA-BA) yang mana ia terdiri daripada 30% dan 70% campuran BA. Campuran abu ini telah diuji dalam makmal melalui ujian pengimbasan elektron mikroskopik, ujian x-ray fluorescences dan ujian tiga paksi pengukuhan tak tersalir. Komposisi kimia yang utama dalam campuran FA-BA adalah silika, alumina, ferum oksida dan kalsium oksida. Nilai modulus keanjalan menurun dengan peningkatan kandungan abu dasar dari 30% ke 70% dalam campuran abu. Sudut geseran dalaman pada keadaan kritikal telah menurun apabila kandungan BA meningkat dari 30% ke 70%. Tanpa pengawetan, peningkatan kandungan BA daripada 30% kepada 70% tidak memberi apa-apa kesan yang besar ke atas kekuatan ricih dalam keadaan kritikal. Walaubagaimanapun, selepas 28 hari pengawetan, ϕ_c' telah meningkat, tetapi tidak ketara. Semua ϕ_c' ditemui dalam campuran FA-BA adalah hampir sama seperti ϕ_c' yang ditunjukkan oleh pasir padat yang biasa. Secara umumnya, ia boleh membuat kesimpulan bahawa campuran FA-BA pada 30% BA dan 70% BA tidak memberi kesan yang ketara ke atas sifat-sifat kekuatan ricih pada keadaan kritikal. Maka, potensi untuk menggunakan BA dalam kuantiti yang besar ke dalam campuran tanpa menjejaskan kekuatan adalah besar. Ini boleh menjadi manfaat yang besar dalam pelbagai kerja kejuruteraan geoteknikal.

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BA	-	Bottom ash
E	-	Modulus of elasticity
FA	-	Fly ash
H	-	The slope of the Hvorslev on the q-p’ plane
M	-	The slope of critical state line on the q –p’ plane
p’	-	Mean normal effective stress
q	-	Deviator stress
q_p	-	Deviator stress at peak
q_c	-	Deviator stress at critical
Y	-	Specific volume = 1+ e
Γ	-	Intercept of critical state line with the υ-axis
λ	-	The slope of normal consolidated line in υ – p’ plane
ϕ_c’	-	Internal friction angle at critical state
ϕ_p	-	Internal friction angle at peak
ε_p	-	Axial strain at peak
ε_c	-	Axial strain at critical state

CHAPTER 1

INTRODUCTION

1.1 Background

One of the sources to produce electricity is coal. The major problem of the coal combustion based power plant is producing huge quantities of solid waste. The coal combustion residues (CPP's) including silica (61%), alumina (22%) and iron oxide (7%), which make up of 90% of the ash. The others element are calcium (Ca), magnesium (Mg), sodium (Na), kalium (K) and sulfur (S) (Chang *et al.* 1979, Adriano *et al.* 1980, Saxena *et. al*. 1998a).

Coal-burning power plant has produced a large volume of coal ash and bottom ash. The ratio of production between fly ash and bottom ash is 80:20 by weight (ACAA 2001). Most of the CCRs are disposed off as slurry to ash ponds. It is due to low in cost as well as easily operated. The solid CCRs are collected and mixed with water, and the slurry is pumped through a series of pressurized pipes to ash ponds. (Asokan *et al.* 2004).

In Malaysia, the study of the coal ash and bottom ash is still limited. The disposal problem of coal ash and bottom ash is becoming critical by the times going.

Thus, some studies have been made to utilize the fly and bottom ash as replacement material in geotechnical works. For instance, fly and bottom as can be used in soil replacement, soil embankment even in material filling (Abdul Rahim *et al.* 2012).

1.2 Problem of Statement

There is limited study on local coal ash compared to other countries. The local companies do not have enough information and laboratory evaluation on fly and coal ash. The ash pond for disposing the coal combustion products becoming lesser and the authorities have to find other alternative routes to solve coals ash accumulative problems.

The use of fly and bottom ash as the substitution in geotechnical works is still in essential stage. Hence, the study of the strength characteristic of the fly and bottom mixture is significant and critical. Apart from this, the appropriate proportion of fly and ash mixtures is also important to maximize the strength of the mixtures. Respective mixture may be used for highway embankment construction, reclamation and others geotechnical works.

1.3 Objective of the Study

The purpose of the study is to investigate the effect of bottom ash content on the strength characteristics of fly ash and bottom ash mixtures. Thus, the following study objectives have been formulated:

1. To evaluate the morphology and chemical properties of different FA:BA mixtures at various curing period.

2. To determine the modulus of elasticity and strength parameters of different FA:BA mixtures

3. To evaluate the strength behavior of different ratio of FA: BA mixtures at various curing periods under undrained condition using critical state method.

1.4 Scope and Limitation of Study

The study is focusing the morphology, chemical and strength characteristic of fly ash and bottom ash mixtures from the Tanjung Bin power plant in Johor, Malaysia. The mixtures used in this study is including, 30% and 70% of the bottom ash in the mixtures. The curing periods of the samples concerned were 0 and 28 days. The morphology characteristic had been tested by scanning electron microscopy, the chemical properties tested by x-ray fluorescence and the strength test was carried out using consolidation undrained triaxial test.

1.5 Significant of the Study

The result that obtained from this study can be determined the suitability of fly and bottom mixture ratio in beneficial the geotechnical works. The variety of strength that obtained can investigate the suitability in different scope of geotechnical works such as soil replacement, soil embankment or back filling materials.

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