STUDY OF THE MECHANICAL PROPERTIES OF BOTTOM ASH AS A PARTIAL SAND REPLACEMENT IN A NON-LOAD BEARING FLY ASH BRICKS

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I hereby declare that I have checked this thesis/project* and in my opinion, this thesis/project* is adequate in terms of scope and quality for the award of the degree of Engineering/ Civil Engineering

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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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DEDICATION

I dedicate my work to my precious Mother, Khaizaran Hadi Saleh Alghothaifi, My adorable father Ali Mohammed Al-hokabi, to my great sister's soul who passed away on 12/02/2018, she left a huge effect on me and all my other three sisters and my 19 brothers as well as my precious supportive wife Nabiha Yahya Mohammed Al-raidi.

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ABSTRACT

The worldwide production of coal ashes is estimated to more than 800 million tonnes in 2012. Coal use is forecast to rise over 50% to 2030, with developing countries responsible for 97% of this increase worldwide. The estimated worldwide production of coal ashes is around 13.33 billion tonnes in 2030. The reuse rate for fly ash is around 47% whereas the reuse of bottom ash is only around 5.28%. It has contributed to environmental problems such as contaminating ground and surface water due to limitation of dumping space, where it is still treated as waste and put in impoundment ponds, silos or landfills. By using Coal waste to replace cement production, the environmental benefits occur and lead to decrease CO2 emissions by 0.9 tonnes for each ton of fly Ash used. According to the Environmental Protection Agency (EPA), living next to a coal ash disposal site can increase human health risk of cancer or other diseases. It can also affect drinking water from a well where humans may get cancer from drinking water contaminated with arsenic. In Malaysia, there are seven coal fired electric power station for the time being. In peninsular Malaysia, there are four coal fired electric power station that produced at least 1400 MW of electric power. Coal waste is produced which includes coal ash in the fraction of about 75-85 % Fly Ash (FA) and 15-25 % Bottom Ash (BA). The study was conducted using the waste products from Tanjung Bin power plant which located in Mukim Serkat, Daerah Pontian, and Johor, Malaysia that started operation in September, 2006 with a capacity of (2100MW) electricity generating capacity. It is one out of the four thermal power plants that utilize pulverized coal in the generation of electricity. Tanjung Bin power station produce 180 tonnes per day of bottom ash and 1,620 tonnes per day of fly ash from 18,000 tonnes per day of coal. This study presents the results of investigation the probability of using Bottom-ash products in producing Fly-Ash bricks by substituting 20% of cement with FA and fine aggregate (river sand) with partial replacement of 5%, 10%, 15% and 20% of BA where sand replacement can save the natural sand resources from depletion and also reduce the coal ash (CA) in Malaysia which classified under the Scheduled Waste (SW 104) Environmental Quality Act. The results of compressive strength at 7,14 and 28 days of air curing showed that the compressive strength and flexural strength decrease with the increasing of sand replacement of the bottom ash while noticed an obvious increment of the water absorption ratio with increasing BA percentage.

ABSTRAK

Pengeluaran abu arang batu di seluruh dunia dianggarkan lebih daripada 800 juta tan pada tahun 2012. Penggunaan arang dijangka meningkat lebih 50% hingga 2030, dengan negara-negara membangun bertanggungjawab untuk 97% peningkatan ini di seluruh dunia. anggaran pengeluaran abu arang batu di seluruh dunia adalah sekitar 13.33 bilion tan pada tahun 2030. Kadar penggunaan semula abu terbang adalah sekitar 47% manakala penggunaan semula abu bawah hanya sekitar 5.28%. ia telah menyumbang kepada masalah alam sekitar seperti mencemarkan tanah dan permukaan air disebabkan oleh pembatasan ruang lambakan, di mana ia masih dirawat sebagai sisa dan dimasukkan ke dalam kolam penimbunan, silo atau tapak pelupusan. Dengan menggunakan sisa Batubara untuk menggantikan pengeluaran simen, manfaat alam sekitar berlaku dan menyebabkan penurunan emisi CO_2 sebanyak 0.9 tan untuk setiap ton fly Ash yang digunakan. Menurut Agensi Perlindungan Alam Sekitar (EPA), tinggal di sebelah tapak pelupusan abu arang batu boleh meningkatkan risiko kesihatan manusia terhadap kanser atau penyakit lain. Ia juga boleh menjejaskan air minum dari telaga di mana manusia boleh mendapat kanser daripada minum air yang tercemar dengan arsenik. Di Malaysia, terdapat tujuh arang batu yang melepaskan stesen janakuasa elektrik buat masa ini. Di Semenanjung Malaysia, terdapat empat arang batu yang melepaskan stesen janakuasa elektrik yang menghasilkan sekurang-kurangnya 1400 MW kuasa elektrik. sisa arang batu dihasilkan termasuk abu arang batu di sekitar 75-85% Fly Ash (FA) dan 15-25% Bawah Abu (BA). Kajian itu dijalankan dengan menggunakan produk buangan dari kilang kuasa Tanjung Bin yang terletak di Mukim Serkat, Daerah Pontian, Johor, Malaysia yang mula beroperasi pada September 2006 dengan kapasiti kapasiti penjanaan elektrik (2100MW). Ia adalah salah satu dari empat loji janakuasa termal yang menggunakan arang batu beralun dalam penjanaan elektrik. Stesen kuasa Tanjung Bin menghasilkan 180 tan sehari abu bawah dan 1,620 tan sehari abu terbang daripada 18,000 tan metrik sehari. Kajian ini membentangkan hasil penyelidikan kebarangkalian menggunakan produk-produk Abadi di dalam menghasilkan bata Fly-Ash dengan menggantikan 20% simen dengan FA dan agregat halus (pasir sungai) dengan penggantian separa 5%, 10%, 15% dan 20 % daripada BA di mana penggantian pasir dapat menyelamatkan sumber pasir semulajadi daripada kekurangan dan juga mengurangkan abu arang batu (CA) di Malaysia yang diklasifikasikan di bawah Akta Kualiti Alam Sekeliling (SW 104). Keputusan kekuatan mampatan pada 7,14 dan 28 hari pengawetan udara menunjukkan bahawa kekuatan mampatan dan kekuatan lentur berkurang dengan peningkatan penggantian abu bawah pasir sambil melihat kenaikan ketara nisbah penyerapan air dengan peningkatan peratusan BA.

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Nowadays construction industries tend to use environmental friendly materials and better for a sustainable society, as a result of that many of scientists, engineering students and researchers conduct investigations on various waste materials and justify their properties in order to utilize them as benefit to our society. Engineers and contractor also encounter the issue of depletion of the main raw materials in construction projects such as fine, coarse and aggregate as well as cement or increasing their cost which may lead to high expenditure of money. The new idea of using waste materials in these projects helps a lot in this aspect especially the toxic waste such as coal plant waste which can be in high quantities in many countries and their existence lead into many troubles to environment and human's health. Coal plant waste (fly ash and bottom ash) is one of the hazardous materials effects negatively on our environment where they are non-combustible materials produced from the furnace in different percentage where fly ash takes three-fourth 75% of the produced ash and bottom ash is the rest which is one-fourth 25% of the total produced ash from the furnace.

Depletion of aggregate, cement or increasing their price nowadays is also encouraged to use the wasted materials as long as it has the properties that are qualified and suitable to be used as a replacement material in producing concrete or bricks.

Fly and bottom ash produce better properties for bricks and concrete in terms of workability, durability, compressive strength, reducing bleeding and plastic shrinkage. That encourage engineers and researchers to study in details these materials and trying to enhance concrete by substituting apart of these materials into concrete either as fine or coarse aggregate or even cement. Success in using coal plant waste in producing bricks and concrete reduce the dependency on the natural materials of sand and coarse aggregate and in the same time it assists

to reduce the emissions of CO_2 where the cement industry has always been among the greatest CO_2 discharge sources as 900 kg CO_2 released to the environment for producing one ton of cement (Benhelal et al., 2013).

The success in using coal plant waste has a key role to decrease the waste that many countries suffer of its huge quantities especially in Malaysia where it has around 7 coal-fired plants. Many governments demand and encourage engineers to utilize the renewable resources especially in Malaysia where the policy of green technology states that.

1.2 Problem statement

Aggregate and cement are extensively used especially in Malaysia because of the rapid development while have other waste material produced from coal factories that also effect negatively on the environment and human's health. Coal plant waste also produce a hazardous contamination to the land if used as landfill and thus effect on the water which indirectly lead to death of large scale of fish due to the risky leachate as reported in South Korea in 2009. Coal combustion products (fly ash, bottom ash) is also affected and killed large scale of birds and in that time Korean researchers investigate that issues to produce solutions for that matter. Natural sand also encounters the problem of depletion in term of quantity or even if it's available it's not in a good quality. In the other hand producing cement affect the environment of its CO_2 emissions.

Mining activities of natural sand impact negatively on the environment, it may cause channel erosion and other troubles so government and other private parties are trying to reduce the usage of natural sand material and reduce the effect of coal plant waste of ash as well as getting satisfactory properties for better concrete quality and more economical cost.

1.3 Objective of research

The main objective of this research is:

I. To study the potential of using coal waste in brick production.
II. To investigate the mechanical properties of coal plant waste brick
III. To measure the initial water absorption rate & density of fly ash brick when replaced.

1.4 Scope of this research

The experiment conducted in concrete laboratory of University Malaysia Pahang and the proposed study is to investigate and justify the properties of coal plant waste of fly and bottom ash when replaced instead of cement and aggregate to produce unloaded bricks in many aspects like workability, durability, compressive strength, flexural strength, water absorption, water content and other structural properties. The used mix design for brick is usually cement: aggregate ratio is 1:6 which is considered according to JKR standard. So, cement is partially replaced by 20% of fly ash and the aggregate is substituted with bottom ash in different percentages (5%, 10%, 15% and 20%) and then conduct all the needed tests to evaluate the results of coal waste replacement in making unloaded brick.

1.5 Significance of Study

In order to minimize that problem on how to minimize the coal plant Ash waste is to substitute it partially into cement sand brick. Using coal plant waste in making cement sand brick reduces the pollution because we can minimize the disposal of fly and bottom waste materials reduce CO_2 emissions and in the other hand it decreases the sand mining activity and also can reduce dependency on uses of natural sand resources. So, by utilizing this fly and bottom ash in brick making industry it is s a beneficial for the environment and industry to convert the hazardous disposed materials into civil construction field. That also decrease the expended cost to dispose the waste materials to the landfill. Thus, environment can be more sustainable by minimizing the pollution.

The incorporation of coal plant industry in cement sand brick is beneficial where the brick properties is enhanced and developed as well as the Malaysian government encouraged us to be more aware to achieve green technology and sustainable environment as previous prime minster declared in 2016.

1.5 Thesis Outline

Overall there are 5 chapters in this thesis where the chapter 1 is an introduction. It explains about the introduction of this research and it contains various sub-chapter.

The first sub chapter explains about the background of study and problem statement, scope of study and the significance of this research. This chapter also describes the purpose and main objectives of the study and the outline or layout thesis.

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