EXPERIMENTAL STUDY ON CONCRETE OF BLENDED CEMENT WITH EGGSHELL POWDER AND FLY ASH

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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 B. ENG (HONS.) 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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ABSTRACT

Cement as a vital material of concrete production plays an important role in construction field. However, production of cement had brought severe negative impact to environment. Research found that there is approximately 780 kg of carbon dioxide (CO_2) is emitted to atmosphere for every ton of cement produced. In order to minimize the negative effect of cement production, alternative environmental friendly material should be determined. In the past decade, consumer waste and industrial by-product handling method always become an environmental issue. Disposal of egg shells through landfilling might detrimental to human health as it may become the habitat for vermin. Fly ash as industrial by product had led to severe disposal and leachate problem also. Recent researches have proposed that these waste materials can be recycled and added to concrete as an effort to minimize post-consumer wastes and industrial by-products entering the landfills. Egg shells riches in pure form of calcium carbonate ($CaCO_3$) which is nearly similar as composition of limestone. The composition of fly ash includes substantial amounts of silicon dioxide (SiO_2), aluminium oxide (Al_2O_3) and calcium oxide (CaO). When they mix with Portland cement and water, it will result in production of calcium-silicates hydrates (C-S-H) which primarily responsible for the strength of concrete. As there is potential of developing these waste product as construction material, investigation is conducted to determine the mechanical properties and optimum mix design of blended cement with egg shells powder and fly ash. In this investigation, a combination of 30% of fly ash and four different percentages of eggshell powder with respect to cement were added into the concrete mix of Grade M30. The materials used in this experimental study involved non-composite Portland cement, coarse aggregate, fine aggregate, sand, Class C fly ash and eggshell powder. From the investigation, all the casted concrete has achieved the designated compressive strength of 30MPa. 30% of fly ash and 5% of eggshell powder is the optimum dosage for concrete to achieve higher flexural strength. Besides, the splitting tensile strength of concrete decrease with the further increase in proportion of fly ash and eggshell powder.

ABSTRAK

Simen merupakan bahan penting dalam pembuatan konkrit. Walau bagaimanapun, penghasilan simen telah membawa impak negatif yang berterusan kepada alam sekitar. Kajian mendapati bahawa terdapat kira-kira 780 kg karbon dioksida (CO_2) akan dibebaskan ke atmosfera bagi penghasilan setiap tan simen. Untuk mengurangkan kesan negatif penggunaan simen, bahan mesra alam sekitar harus dikenalpasti. Kebelakangan ini, produk sampingan industri telah menjadi isu alam sekitar. Pelupusan sisa kulit telur melalui kaedah pelupusan telah menjejaskan kesihatan manusia kerana ia mungkin menjadi habitat untuk vermin. Serbuk abu terbang sebagai hasil sampingan industri penjanaan elektrik telah menyebabkan isu pelupusan yang teruk dan masalah larut resapan juga. Penyelidikan baru-baru ini telah mencadangkan bahawa bahan buangan ini dapat dikitar semula dan ditambahkan dalam konkrit sebagai usaha untuk mengurangkan sisa pasca-pengguna dan produk sampingan industri yang memasuki tapak pelupusan sampah. Kulit telur mengandungi kalsium karbonat ($CaCO_3$) yang hampir sama dengan komposisi batu kapur. Komposisi serbuk abu terbang terdiri daripada silikon dioksida (SiO_2), aluminium oksida (Al_2O_3) dan kalsium oksida (CaO). Apabila mereka bercampur dengan simen dan air, ia akan menghasilkan hidrat kalsium-silikat (C-S-H) yang terutamanya bertanggungjawab terhadap kekuatan konkrit. Oleh sebab potensi produk sisa ini sebagai bahan binaan, penyiasatan turut dijalankan untuk menentukan sifat mekanik dan reka bentuk campuran optimum simen campuran dengan serbuk kulit telur dan serbuk abu terbang. Dalam penyiasatan ini, gabungan 30% serbuk abu terbang dan empat jenis percent serbuk kulit telur yang berbeza merujuk kepada kandungan simen telah dimasukkan ke dalam campuran konkrit Gred M30. Bahan-bahan yang digunakan dalam kajian eksperimen ini meliputi Portland simen yang tidak komposit, agregat kasar, agregat halus, pasir, serbuk abu terbang kelas C dan serbuk kulit telur. Daripada hasil penyiasatan, didapati bahawa semua konkrit telah mencapai kekuatan mampatan yang ditetapkan sebanyak 30MPa. 30% serbuk abu terbang dan 5% serbuk kulit telur adalah dosis optimum bagi konkrit untuk mencapai kekuatan lenturan yang lebih tinggi. Selain itu, kekuatan tegangan pemecahan konkrit berkurang dengan peningkatan kandungan serbuk abu terbang dan serbuk kulit telur.

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LIST OF SYMBOLS

%	Percent
mm	Millimeter
MPa	Mega Pascal
kg	Kilogram
N	Newton
kN	Kilo newton
mm^2	Millimeter square
m^3	Meter cubic
w/c	Water to cement ratio
N/mm^2	Newton per millimeter square
µm	Micro meter
wt%	Weight percent

LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
BS	British standard
$CaCO_3$	Calcium carbonate
CO_2	Carbon dioxide
C-S-H	Calcium silicate hydrate
e.g.	For example
EN	European standards
ESP	Eggshell powder
etc.	Et cetera
FA	Fly ash
i.e.	That is
MS	Malaysian standard
OPC	Ordinary Portland cement

CHAPTER 1

INTRODUCTION

1.1 RESEARCH BACKGROUND

Cement as a vital material of concrete production plays an important role in construction field. Cement mainly consists of compounds including lime (calcium oxide, CaO) mixed with silica (silicon dioxide, SiO_2) and alumina (aluminum oxide, Al_2O_3). However, production of cement had brought severe negative impact to environment. Carbon dioxide (CO_2) is released during the calcination process of cement production whereby the calcium carbonate undergoes thermal decomposition to produce cement clinker. This greenhouse gas emission will gradually lead to global warming and other environmental issue that will endanger living organisms on earth. In order to minimize the negative effect of cement production, alternative environmental friendly material should be determined.

In the past decade, consumer waste and industrial by-product handling method always become an environmental issue. For instance, disposal of egg shells through landfilling might detrimental to human health as it may become the habitat for vermin. Furthermore, rotting egg shells allows methane and carbon dioxide to seep out of the ground and up into the air which indirectly causes global warming. Fly ash as industrial by product is generated by coal-fired electric and steam generating plants. Although it can be disposed through dry landfill, the Environmental Protection Agency (EPA) had discovered that there is a higher risk of getting cancer or other diseases if living next to a fly ash disposal site. Recent researches had proposed that these renewable waste materials have shown a potential to be recycled and added to concrete as an effort to minimize post-consumer wastes and industrial by-products entering the landfills. According to Bandhavya et al., (2017), compressive

strength of concrete with 5 % and 10% egg shell powder replacement was higher than conventional concrete at 3, 7 and 28 days of curing ages. Research from Doh and Chin (2014) had shown that the inclusion of eggshell powder as filler into concrete had improved the flexural behavior of concrete up to 22.9% compared to the control concrete. The blending of pumice powder and fly ash in cement decreased the early age compressive and splitting tensile strength of concretes, however at later ages (28, 90 and 180 days) the strength values were comparable with that of the reference concrete (Nihat Kabay et al., 2015). As there is potential of developing these waste product as construction material, investigation is conducted to determine the mechanical properties and optimum mix design of blended cement with egg shells powder and fly ash.

1.2 PROBLEM STATEMENT

Concrete is a construction material composed of cement, fine aggregates (sand) and coarse aggregates mixed with water which hardens with time. It is considered as a chemically combined mass where the inert material acts as a filler and the binding materials act as a binder. The most important binding materials are cement and lime while the inert materials used in concrete are aggregates. Despite of its contribution in construction industry, cement production had led to relentless impact towards our earth in terms of environmental pollution.

The production of cement involves the consumption of large quantities of raw materials, energy, and heat. Cement production also results in the release of a significant amount of solid waste materials and greenhouse gaseous emissions including carbon dioxide (CO_2). The CO_2 emission from the concrete production is directly proportional to the cement content used in the concrete mix. 900 kg of CO_2 are emitted for the fabrication of every ton of cement, accounting for 88% of the emissions associated with the average concrete mix (Michael et al., 2002). It has long been known that carbon dioxide emissions contribute to climate change. Constantly increasing CO_2 emissions are responsible for an increase in temperatures, which is expected to continue over the coming decades reaching up to +1.4˚ to +5.8˚C globally by the year 2100. Increasing temperature can cause severe droughts in some parts of the world,

extreme weather conditions, the loss of ecosystems and potentially hazardous health effects for people (Shraddha Mishra et al., 2014). In addition to the generation of CO_2 the cement manufacturing process produces millions of tons of the waste product cement kiln dust each year contributing to respiratory and pollution health risks. Although the cement industry has made significant progress in reducing CO_2 emissions through improvements in process and efficiency, but further improvements are limited because CO_2 production is inherent to the basic process of calcination limestone (Stajanča and Eštoková, 2012).

As one of the potential alternative construction material in replacing cement, egg shells riches in pure form of calcium carbonate ($CaCO_3$) which is nearly similar as composition of limestone. $CaCO_3$ will further undergo thermal decomposition and hydration with water to form calcium silicate (C_2S, C_3S) which contributes to strength of concrete during mixing. Malaysia has been ranked 14^{th} in terms of egg consumption per capita within the group of 159 countries, which almost 14.0 kg egg consumption per capita in year of 2013 (Teo Seng Capital Bhd, 2015). Majority sources of egg shells can be easily obtained from egg breaking plants which produces liquid eggs for food and non-food products usage. While the minor source of egg shells can be found from restaurant and household in term form of food waste. However, most of the eggshell waste is deposited as landfills. Eggshell waste in landfills attracts vermin due to attached membrane and causes problems associated with human health and environment.

Fly ash is the finely divided residue that results from the combustion of pulverized coal and is transported from the combustion chamber by exhaust gases. One of the major problems of all coal combustion power plants is the unused fly ash and bottom ash that bring environmental problems, such as air pollution and groundwater contamination, due to the leaching of metals from the ashes, especially the accumulation of the very fine particles of fly ash. In Malaysia, fly ash is an industrial waste material commonly deposited in landfills. This brings no benefits, but rather environmental nuisance. The production of fly ash in Malaysia is believed to be approaching two million tons annually. 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 burning alone (Abdulhameed et al., 2012) . The disposal of fly ash has reached an alarming proportion such that its application in construction is a necessity

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