PERFORMANCE OF CEMENT GROUT INCORPORATING CERAMIC WASTE AS FILLER

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To my beloved late mother, father and families

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ABSTRACTS

The large bulk of ceramic waste nowadays leads to serious environmental problem since these materials are not reusable and recyclable. In second concern is related to the deterioration due to crack problem facing by concrete structure. The use of cement grout as one of repair materials for minor crack has been applied for many years. However, the natural sand as filler used in cement grout somehow needs another alternate material to substitute it due to depletion issue and has become expensive. Therefore, reuse of ceramic waste as substitute in natural sand has been proposed to minimise those problems. This research conducted focus on the performance of cement grout incorporating ceramic tile waste as filler. The experimental tests were performed to determine engineering properties consists of consistency, setting time, shrinkage behavior, water absorption, compressive and flexure strength. Different size particle of ceramic waste in range 150 µm to 850 µm were selected as partial replacement of sand as filler in cement grout. The result indicated the optimum of size particle that give better performance in their engineering properties was filler with size around 150 µm, without affecting significantly in design strength. The incorporating of ceramic waste has no negative effects on cement grout properties and thus can be used as alternate construction material in future. Besides, cement grout made from ceramic waste as filler may minimise the disposal problem as was mentioned earlier.

ABSTRAK

Dewasa ini, lambakan sisa seramik telah membawa masalah yang serius kepada alam sekitar kerana bahan ini tidak digunapakai dan dikitar semula. Manakala, perhatian juga diberikan kepada masalah berkaitan dengan kerosakan yang dihadapi oleh struktur konkrit iaitu keretakan. Penggunaan grout simen sebagai salah satu bahan pembaikpulihan bagi keretakan kecil sudah lama digunapakai sejak bertahun lamanya. Namun, pasir asli perlu diganti dengan bahan alternatif kerana faktor kekurangan dan harganya yang kian mahal. Oleh itu, mengunapakai sisa seramik sebagai bahan ganti bagi pasir asli telah dicadangkan untuk mengatasi masalah tersebut. Penyelidikan ini menerangkan tentang prestasi grout simen menggunakan sisa seramik sebagai pengisi. Beberapa siri ekperimen telah dijalankan bagi mengenalpasti sifat-sifat kejuruteraan iaitu konsistensi, masa ketetapan, sifat pengecutan, penyerapan air, daya mampatan dan juga lenturan. Sisa seramik dari saiz butiran yang berbeza iaitu 150 μm hingga 850 μm telah dipilih bagi mengantikan separuh daripada pasir asli sebagai pengisi dalam grout simen. Keputusan menunjukkan saiz butiran yang memberikan prestasi paling optimum dari segi sifat-sifat kejuruteraan adalah pengisi bersaiz lingkungan 150 μm, tanpa memberikan kesan ketara dalam kekuatan rekaan. Penggunaan sisa seramik tidak memberi sebarang impak negatif kepada sifat-sifat grout simen dan seterusnya boleh digunakan sebagai bahan pembinaan alternatif di masa hadapan. Selain itu, grout simen yang dibuat bersama sisa seramik sebagai pengisi juga mampu mengurangkan masalah pelupusan seperti yang dimaklumkan sebelum ini.

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LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
CM	-	Control mix
Demec	-	Demountable mechanical strain
Kg/m^3	-	Density
MPa	-	Strength (Mega Pascal)
M1	-	Mix 1
M2	-	Mix 2
M3	-	Mix 3
M4	-	Mix 4
M5	-	Mix 5
SiO_2	-	Silicon dioxide
w/c	-	water cement ratio

LIST OF SYMBOLS

b	-	width
d	-	depth
f_{cu}	-	Compressive strength
Kg	-	Kilogram
L	-	span
m	-	meter
min	-	minute
N	-	Newton
P	-	maximum load at or prior to the moment of crack
S	-	stress
WA	-	The water absorption
W_d	-	Weight of specimen before water immersion
W_s	-	Weight of specimen after water immersion
µ	-	Micro
ºC/ ºF	-	Degree Celsius/ Fahrenheit
%	-	Percentage

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CHAPTER I

INTRODUCTION

1.1 Background of Study

Recent years have witnessed rising social concern about the problem of waste management in general, and industrial waste and waste from the construction industry in particular. Conserving natural resources and preserving the environment is the essence of any development. The problem that occurs from continuous technological, industrial and construction development is the disposal of waste material. Besides that, in recent years the concrete structures has been facing with durability problem such as deterioration or distress and many repair, rehabilitate and remedial works are required. One of the major problems being concern was cracking issue. Cracking occurred when stresses in the concrete exceed the concrete strength, lack of site workmanship, and overall as mentioned due to general lack of durability in concrete itself. Cracks provide a path for water, chlorides and oxygen to hack the concrete and cause the freeze-thaw damage and attack reinforcement by corrosion that affects the structural integrity.

Depending on the nature of crack damage, one or more repair methods may be selected, for example, sealing of crack by using material grout. Sealing of cracks

repair should be used in conditions where structural repair is not necessary. Isolated cracks whether extending through the concrete section or partially into it, should be sealed at the concrete surfaces. Grout material commonly identifies as cement grout, cement mortar and epoxy grout. Cement grout is formed of cement normally Portland cement powder mixing with or without aggregate together with specific ratio of water.

For developing countries like Malaysia, the depletion of natural resource is a common phenomenon due to rapid urbanization and industrialization involving construction of infrastructure and other facilities. B.V. Bahoria et. al., 2013 have mentioned in their previous study about comprehensive literature review on use of waste product in concrete that in the last 15 years, it has become clear that availability of natural sand with good quality is decreasing. The existing natural sand deposits are being depleted at the same rate as increasing in construction industries for development process. Besides, issue regarding uncontrolled extraction of natural sand becomes one of environmental concern in this decade.

In concern on those issues, it is believe that some waste material that ends up in the landfill can be utilized in suitable filler grouting making, whereby the amount of waste entering the landfill will be reduced. Ceramic waste is one of those waste materials that have recently gained attentions to be used as recycled material in cement and concrete production. The use of ceramic waste products as filler in grout mix not only makes it economical but also solves some of the disposal problems. As known, producing grout mixing is quite expensive by using natural resources. Therefore, if ceramic waste able to performed as filler in conventional cement grout with equivalent and even higher characteristic properties, the cost of grouting for repair works could be reduced which ultimately leads us one step closer to a sustainable future.

1.2 Problem Statement

The mind set of most individuals for many years has been the disposal of waste products directly to landfills and is seen as the most convenient way of getting rid of the waste. The consequence being that landfills are filling up rapidly and the amount of landfill space is decreasing accordingly whilst the earth's natural resources are continued to be exploited. The need to managed these wastes has become one of the most pressing issues of our time, requiring specific action aimed at preventing waste generation such as promotion of resource recovery system like reuse, recycle and waste to energy systems as means of exploiting the resources contained within waste, which would otherwise be lost, thus reducing the environmental impact. Apart from that issue, one must recognize that many numbers of existing concrete structures nowadays are in state of deterioration or distress. The most serious deterioration processes leading to repair failures are caused by the cracking.

Cracks are inevitable, and neglect will lead to a more rapid deterioration of the concrete. Preventative maintenance can help to restore and increase strength thus extend the life of the concrete itself. Maintenance activities can range from crack sealing and filing, to other, more involve in surface treatments. The minor crack at the surface ranging in depth from 6 to 25mm and minimum opening at surface of 6mm can undergo the surface sealing repair by using grout material. In Malaysia, there are few types of grout materials used in repairing works such as cementitious grout and epoxy grout. However, cemetitious grouts are usually used in Malaysia due to their lower cost and availability in market.

To mentioned, other than cement material, fine aggregate normally natural sand is one of the most common cement grout material used for the purpose of filling cracks or voids in the concrete or other cement base materials structure member. However, the use of natural sand has become very expensive and also becoming scarce due to depletion of river bed. As regard in the ceramic industry the production

goes as waste, which is not undergoing the recycle process yet. Large bulks of ceramic tiles change into wastage because these waste materials are not reusable and recyclable due to lack understanding of their physical and chemical structure.

Realizing this need, this study used ceramic waste as useful filler material instead of fully used of sand in cement grout mix design. Different size particle of ceramic waste were selected as partial replacement of sand as filler in cement grout and characteristic properties of cement grout incorporating ceramic waste being observed. Using ceramic wastage in cement grout production causes no remarkable negative effect in the properties of concrete. The properties of ceramic waste grout were found not significantly different from those of conventional cement grout since it contained natural pozzolanic material. In addition to helping protect the environment, use of ceramic waste offers a series of advantages such as a reduction in the use of other raw materials and contributing to an economy of natural resources. Moreover, reuse also offer benefit to reduce the consumption of industrial space or productive land for dumping such waste.

1.3 Objective of Study

In view of the problems as described in section 1.2, a research program involving laboratory experiment were carried out to enhance the knowledge in characteristic properties of cement grout incorporating ceramic waste as filler. The objectives of this study include the following tasks.

I. To reuse the ceramic waste as potential construction material in cement grout production in order to reduce use of natural resource and environmental impact causes by dumping and depletion of natural sand.

II. To investigate the effect of various size particle of ceramic waste (150 µm to 850 µm) at different replacement level as filler for fine aggregate (sand) for providing better understanding and guidelines in the application of such cement grout as concrete repair material.

III. Study of the properties of conventional cement grout and cement grout using ceramic waste as filler for representative determination of the important engineering grout parameter including consistency, setting time, water absorption, compressive and flexural strengths behavior and shrinkages effect.

1.4 Scope of Study

This research conducted focus on characteristic properties of cement grout made with utilizing of ceramic waste from floor and wall tile (Figure 1.1). The scopes of this study are:

I. Mix samples of cement grout made using different size of graded sand that passing 1.18 mm without incorporating ceramic waste are prepared as control sample. Meanwhile, different mix design also made using various size particles of ceramic wastes (850 µm, 600 µm, 300 µm and 150 µm) were used to replaced part of sand as filler. The proportion of ceramic waste used to replace proportion of sand was fixed to be half of the total proportion of filler. The water cement ratio was selected by trial mix design.

II. The major properties of grout which is consistency and strength characteristic were study. In order to understand the engineering influence on the properties of the cement grout with the addition of the ceramic waste powder, a series of experimental tests were performed. The tests were conducted under fresh state and hardened state condition.

III. The flow table testing for the fresh grout and the setting time were both examined in fresh state of cement grout. For the hardened state, the 50 x 50 x 50 mm cement grout cube was casted to determine the compressive strength characteristic. Different size particle of ceramic waste from 150 to 850 µm were added in mix design together with plain cement grout mix design. For every mix proportion, three samples are made and test were carried out at 7 days, 28 days and 40 days by using universal testing machine (UTM) in order to determine the development of strength for each cube. In addition, test on flexural strength, shrinkage and water absorption were performed for grout in hardened state in order to studies the influence of engineering properties when using various size ceramic wastes as filler

The comparisons of performance between cement grout with ceramic waste replacement and conventional cement grout were observed throughout the experiment. Base on finding, the suitable size particle of ceramic waste that gives optimum result was discussed.

Figure 1.1 Ceramic floor and wall tile waste

1.5 Limitation of Study

The limitation in the study is necessary to avoid any waste and undesirable material or work that may encountered during research progress. In this research, mainly three materials were used namely ceramic waste, sand and cement. Ceramic wastes were used come from ceramic industry source which is wall and floor tiles only. The experimental work focused on physical properties and strength development of cement grout with ceramic powder for their performance study. The strength development only focuses on their compressive and flexural behavior. The cube sample provided for compression test used the 50 mm x 50 mm x 50 mm in their size rather than 100 mm x 100 mm x 100 mm of sizing. This common size comply the standard requirement as defined in ASTM C 942 (Compressive Strength of Grouts). Indeed, cubes of size 50 mm give comparable compressive strength when compared to the larger cube and wastage of concrete can be avoided. Meanwhile,

due to time constraint, the strength development tests of grout were performed up to 40 days. Other unnecessary tests are not carried out in this study.

1.6 Significant Contribution

The results, obtained in the frame of this study, are expected to provide the information and highlight the contribution of ceramic waste as a substitute for natural sand to structural concrete field area. Previous study has showed that reuse of ceramic wastes in construction has improved or provide similar performance as natural sand without associating with negative effect. Otherwise, the reuse of ceramic wastes in concrete and grout technology will reduce the consumption of natural resources and reduce the burden pollutants on the environment. This study also expected to form basis data for selection of size particle of ceramic waste that will give optimum performance in engineering properties for cement grout. With high content of pozzolanic material and non negative effect in grout performance, the ceramic wastes are hoping to become one of eco-efficient material in grout and concrete construction for the future.

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