BEHAVIOR OF SELF-COMPACTING CONCRETE INCORPORATING RECYCLE MATERIALS AT HIGH TEMPERATURE

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This thesis is dedicated to:

My respected father, Majed Mohammed Abou sharkh

My beloved mother, Manal Ahmed Abou sharkh

My supportive brothers, Mohamed, Majdi, morad

My only Lovely sister ; mai majed

my sweet nephews and nieces ;majed, majed, yusuf, rimas and manal

My dear Fiancee ; Princess. Hatice Kubra caliskan and her dear family

Thank you from the bottom of my heart for being my inspirations and for always supporting me.

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ABSTRAK

Penggunaan Palm Oil Fuel Ash (POFA) mempunyai had isu pengasingan hanya apabila penambahan sehingga 15%, Pulverized Burnt Clay (PBC) didapati dapat meningkatkan rintangan pengasingan dalam konkrit dan ia bertindak sebagai agen pengubahsuaian kelikatan. Taburan tekanan liang yang lebih halus bersama-sama dengan penyambungan liang yang lemah yang dipamerkan, oleh Self Compacting Concrete (SCC) menyimpan air yang terperangkap dalam struktur membawa kepada pertumbuhan dalam tekanan liang. Pembentukan tekanan meyebabkan serpihan letupan konkrit terutama apabila W/B di antara 0.30 hingga 0.35 pada 30% daripada POFA dicampur dan PBC. Oleh itu, penyelidikan ini memberi tumpuan kepada keberkesanan kedua-dua bahan PBC dicampur POFA di W/B 0.42 terutamanya pada suhu tinggi. Peratusan penggantian POFA dan PBC adalah 0/0% (C1 sebagai campuran konkrit kawalan), 5:5% (C2), 10:10% (C3), 15.15% (C4) dan 20/20% (C5). Kekuatan sisa mampatan SCC selepas terdedah kepada suhu tinggi 100, 300, 600 dan 800 ° C telah diambil. Keputusan menunjukkan bahawa campuran SCC Peratusan yang mengandungi penggantian yang lebih tinggi menunjukkan kebolehkerjaan yang sangat baik. Bagi kekuatan mampatan dan kekuatan tegangan, didapati bahawa campuran C2 dan C3 melebihi kekuatan campuran kawalan pada 56 hari sebanyak 12%, 19% manakala campuran C4 dan C5 menunjukkan nilai yang lebih rendah daripada campuran kawalan. Ini menunjukkan bahawa tingkah laku specimen meningkat apabila peratusan penggantian POFA dan PBC juga meningkat pada suhu tinggi. C1 menunjukkan pengurangan berterusan dalam kekuatan mampatan sisa apabila suhu meningkat manakala C5 menunujukkan peningkatan suhu antara 100 °C dan 300 ° C sebanyak 4%. Ini mungkin disebabkan oleh dehidrasi penghidratan simen. Pada suhu 600 °C, 10% daripada C5 memberikan kekuatan mampatan yang lebih tinggi berbanding C1, serta kehilangan jisim yang lebih rendah dan tidak retak. Campuran simen dengan kurang kandungan kurangkan simen telah menunjukkan tingkah laku yang lebih baik pada suhu tinggi. Walau bagaimanapun, semua campuran menunjukkan keputusan yang baik apabila terdedah kepada suhu sehingga 600 °C tanpa sebarang tanda-tanda tetapi specimen meletup sebelum suhu mencapai 800 °C.

ABSTRACT

The use of Palm Oil Fuel Ash (POFA) only has a limitation of segregation when added up to 15% in concrete, whereby the Pulverized Burnt Clay (PBC) was found to increase the segregation resistance as it acts as viscosity modifying agent. The finer pore pressure distribution along with the poor pore connectivity that Self Compacting Concrete (SCC) exhibits keeps the free and chemically bound water trapped inside the structure leading to a growth in pore pressure. The buildup pressure resulted in the explosive spalling of the concrete particularly at W/B ranging between 0.30 to 0.35 at 30% of blended POFA and PBC. Thus, This research work focus on the effectiveness of both POFA and PBC blended at 0.42 W/B mainly against elevated temperature. The replacement percentages of POFA and PBC are 0/0% (C1 as control mix concrete), 5/5% (C2), 10/10% (C3), 15, 15% (C4) and 20/20% (C5). The residual compressive strength of SCC after exposure to elevated temperatures at 100, 300, 600 and 800 °C was noted. The results revealed that SCC mixes containing higher replacement percentages exhibited excellent workability. For compressive and splitting tensile strength, it was found that C2 and C3 mixes exceeded the strength of control mix at 56 days by 12%, 19 % respectively while C4 and C5 showed lower values than control mix. It was found that behaviors of tested specimen at elevated temperature were improved by the increment of POFA and PBC replacement percentage. C1 showed a continuous decrement in residual compressive strength as temperature increased, while C5 showed an increase in strength by 4% between 100 °C and 300 °C. This could be due to the hydration of anhydrated cement. At 600 °C, C5 gave 10% higher residual compressive strength compared to C1 as well as lower mass loss and no cracks. The mixes with less cement content had shown better behavior at elevated temperatures. Nevertheless, all mixes showed good results when exposed to temperature up to 600°C with no explosion occurred but exploded before temperature reaching 800°C.

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CHAPTER 1

INTRODUCTION

1.1 Background

Self-compacting concrete (SCC) is a type of concrete that does not require an external or internal compaction force, because it becomes leveled and compacted under its own self-weight. SCC can spread and fill up every corner of the formwork, purely by means of its self-weight and thus, the need for vibration or any external compacting force is omitted. SCC as has been used to shorten the construction period, and ensures adequate compaction in complex structural forms, independent of the skills of workers and also omitting noise that is usually associated with vibration.

Recently, sustainability issues have arisen as a result of the increment in depletion of non-renewable resources and climate change. Worldwide, the construction and building industries generate a Substantial waste stream including materials from brick and concrete demolition. For instance, in 2003, the US produced an estimated 170 million tons of building related construction and demolition material(EPA, 2003).In Canada, construction, renovation and demolition waste generated 15.5 million tonnes in 2004 (Ministry of Industry Canada. 2004).17.3million tonnes in 2008 (Ministry of Industry Canada. 2004).Showing a continued increase in waste production. By-products from industrial waste such as fly ash (FA), blast furnace slag (BFS), silica fume (SF) and other biomass/volcanic ashes are also a concern. Governments worldwide are encouraging research efforts to use these materials in a greater quantity as secondary building materials. Supplementary cementing materials (SCMs) as cement substitutes have become widely accepted with civil engineers, architects and contractors. Although these industrial materials are used in significant quantities, greater amounts are currently sent to landfills for disposal. In general, maximizing the amounts of recycled materials in concrete provides a more sustainable material. Given this potential for widespread implementation of recycled materials in concrete, more information on the performance of these sustainable concretes in fire conditions is needed.

Presently, pozzolans from agricultural waste are receiving more attention since their utilization do not only improve the properties of the blended cement concrete but also reduce the environmental problems (Chindaprasirt, et al. 2008). In fact, it has been suggested that Palm Oil Fuel Ash (POFA) can be used as pozzolan in normal and high strength concrete (Weerachart, et al.2009) However, depending upon the intended purpose of a structure, materials employed for both normal and high strength concrete must satisfy certain fire resisting requirements as set out by the various standards.

In the same time, the fire resistance capacity of ordinary concrete alone is very complicated because concrete is a composite material with components having different thermal characteristics, it also has properties that depend on moisture and porosity. despite the fact that , different opinion were recorded on the changes in OPC concrete particularly in the range 100–300 °C, OPC products are generally regarded as good structural materials regarding to fire resistance; that is, the period of time under fire during which concrete continues to perform satisfactorily (Savva A, et al.2005). Moreover, compressive strength of Portland-based cement paste and concrete can be maintained without significant loss for temperatures up to about 550–600 °C by the judicious choice of materials. It is feared therefore that inclusion of new materials into the normal concrete might alter the current situations (Khoury GA.1992). Furthermore, most research data related to residual strength after exposure to high temperatures were obtained under conditions of natural cooling which obviously differ from cooling regimes in a real fire. Water-spray is normally applied instead (Peng et al .2006). Therefore, residual mechanical properties reported in most previous Literature might be overestimated. Combining changes in rules of strength, colour and temperature during fire, the retained compressive strength can be inferred primarily (Li Z, et al.2003).

To sum up, various comprehensive literature reviews in the area of concrete containing recycled materials exposed to elevated temperature have been taken a place. Concrete containing ordinary Portland cement (OPC) has been investigated thoroughly in the past for its elevated temperature properties (Naus NJ. 2006). However, the properties of combination of (PBC) and (POFA) in (SCC) at elevated temperature has not been studied in depth yet, while FA, BFS and SF have been incorporated into concrete and are currently being used in the industry (Hooton. 2000). Very few investigations have evaluated the residual strength of concrete containing recycled materials at elevated temperatures. Furthermore, the literature suggests a lack of standards or guidance for these materials mixed with concrete and exposed to fire conditions.

1.2 Problem Statement

The finer pore pressure distribution along with the poor pore connectivity that SCC exhibits keeps the free and chemically bound water trapped inside the structure leading to a growth in pore pressure (Sideris, et al.2007),(Ye G, Liu, et al.2007). The built up pressure resulted in the explosive spalling of the concrete particularly at W/B ranging between 0.30 to 0.35 at 30% of blended POFA and PBC (Hassan 2015). Thus, This research work focuses on the use of blend of POFA and PBC at W/B 0.42.

1.3 Research Aim and Objectives

This research aims to study the performance of SSC containing POFA and PBC after exposure to elevated temperature. The objectives of this research being conducted are:

(i) To determine the fresh properties of the SCC.
(ii) To determine the harden strength of the SCC.
(iii) To Evaluate the Fire endurance of the SSC concrete at different temperature ranges (100,300,600,800 °C).

1.4 Research Scope

The research scope focuses on:

i. The mixtures of SCC are only using POFA and PBC as cement replacement material. While Polycarboxylic based Glenium ACE 388 super plasticizer is used as water reducing admixture.
ii. The percentage of cement replacement is taken up to 20%, 20% POFA and PBC respectively.
iii. The water- binder ratio (w/b) is taken as 0.42.
iv. The comparison of the mechanical and fresh properties is to be done only between the most optimum design mix of SCC and the normal concrete.
v. The temperature in which the concrete is tested are (100, 300, 500 and 800) °C.
vi. The tests are conducted on 7, 28 and 56 days from casting the concrete.
vii. The fire endurance tests are done only on cube samples at 56^{th} day.

1.5 Research Significance

The Significance of this work is to provide experimental data on the residual mechanical properties of blended cement concrete subjected to heat, containing POFA and PBC as pozzolanic materials. These properties are very important for a safe design of concrete and in the repair of concrete structures. The fire endurance of SCC at elevated temperature needs to be improved. Moreover, this replacement reduces the cost of concrete due to the increase of cement p
as well as reduce the huge amount of palm oil industry waste material th
produced.

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