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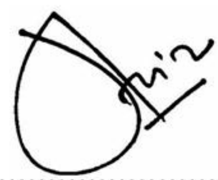

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THE PROPERTIES AND FLEXURAL BEHAVIOUR OF SELF COMPACTING CONCRETE USING RICE HUSK ASH AND ADMIXTURE

MOHD FAKRI BIN MUDA

A project report submitted in partial fulfilment of the Requirements for the award of the degree of Master of Engineering (Civil – Structure)

Faculty of Civil Engineering
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NOVEMBER 2009

I declare that this project entitled "The Properties and Flexural Behaviour of Self Compacting Concrete Using Rice Husk Ash and Admixture" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Especially to…

My beloved **FATHER** and **MOTHER** ;
MUDA BIN AWANG and **ROHANI BINTI ABD KADIR**
Thank you for your softness in take care of me, supporting,
advisory and loving that gives my life
happiness all the time.

My love **BROTHER** and **SISTER** ;
FAIZAL, FAUZI, FAHMI, NOR ILYANI dan **FAIZ**
Your support always motivated me and helping
when I need it most.

To All My Friends ;
Thanks for all the supports.

Wish all the happiness and cheerfulness will always colouring our life.

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ABSTRACT

Technology in concrete has been developing in many ways to enhance the quality and properties of concrete. One of the technological advances in improving the quality of concrete is by using self compacting concrete (SCC). This research was carried out to establish the properties and flexural behaviour of SCC using rice husk ash (RHA) and admixture with mix design of constant water-cement ratio. The main objective of this study is to find the suitable concrete composition which can be categorized as SCC that using RHA as cement replacement material together with admixture. There are nine composition of mixes were prepared and laboratory test was carried out to investigate the properties of fresh SCC and the strength development of hardened SCC. A total of 108 concrete cube specimens 100 mm x 100 mm x 100 mm were prepared for compression test at 1, 7, 14 and 28 days. Three 100 mm x 200 mm x 1500 mm reinforced concrete beams were prepared for flexural test. Two beams were casted using the optimum mix of SCC while the other one made of normal concrete (NC) to act as control. The results for cubes tests indicated that sample with 5% RHA and 1% Sika Viscocrete is the optimum composition for SCC. This composition increased the performance of hardened concrete. While for the flexural test, SCC concrete have better performance than NC and result for adding RHA as a cement replacement material does not give any significant differences in flexural strength of SCC.

ABSTRAK

Teknologi konkrit telah berkembang dalam pelbagai skop bagi meningkatkan kualiti dan sifat-sifat konkrit. Salah satu teknologi maju yang digunakan untuk meningkatkan kualiti konkrit ialah Konkrit Tanpa Mampatan (SCC). Kajian ini dijalankan untuk mengkaji sifat-sifat dan kelakuan lenturan konkrit tanpa mampatan yang menggunakan abu sekam padi (RHA) dan bahan tambah dengan nisbah air-simen dimalarkan. Objektif utama kajian ini adalah untuk mencari nisbah komposisi konkrit yang sesuai yang boleh dikategorikan sebagai konkrit tanpa mampatan dengan menggunakan abu sekam padi sebagai bahan pengganti simen bersama dengan bahan tambah. Sebanyak sembilan komposisi konkrit disediakan dan ujian makmal dijalankan bagi mengkaji sifat-sifat konkrit basah dan juga keras. Sejumlah 108 kuib bersaiz 100 mm x 100 mm disediakan untuk ujian kekuatan mampatan pada konkrit berumur 1, 7, 14 dan 28 hari. Tiga rasuk bertetulang bersaiz 100 mm x 200 mm x 1500 mm disediakan untuk ujian kekuatan lenturan. Dua rasuk dibancuh dengan menggunakan bancuhan optimum konkrit tanpa mampatan dan satu lagi menggunakan bancuhan konkrit biasa bertindak sebagai rujukan. Ujian kiub menunjukkan sampel dengan campuran 5% abu sekam padi dan 1% Sika Viscocrete adalah komposisi optimum untuk konkrit tanpa mampatan. Komposisi ini meningkatkan kekuatan konkrit keras. Untuk ujian kekuatan lenturan, konkrit tanpa mampatan mempunyai kekuatan lenturan yang lebih baik berbanding konkrit biasa dan kesan penggunaan abu sekam padi sebagai bahan pengganti simen tidak memberikan kesan yang besar pada kekuatan lenturan konkrit tanpa mampatan.

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LIST OF ABBREVIATIONS

SCC	-	Self compacted concrete
NC	-	Normal concrete
RHA	-	Rice husk ash
OPC	-	Ordinary Portland cement
PC	-	Portland cement
w/b	-	Water-binder ratio
CO_2	-	Carbon dioxide
SiO_2	-	Silica Oxide
H_2O	-	Water
Al_2O_3	-	Aluminums Oxide
CRM	-	cement replacement material
GGBS	-	Ground granulated blast furnace slag
ASTM	-	American Standard Test Method

HRWR	-	High range water reducer
POFA	-	Palm oil fuel ash
FA	-	Fly ash
NVC	-	Normally vibrate concrete
MS	-	Malaysian standard
CC	-	Normal concrete
R	-	Concrete with rice husk ash
BS	-	British standard

LIST OF SYMBOLS

E	-	Modules of elasticity
Fcu	-	Compressive strength
H_1	-	Length at start point of L-Box test
H_2	-	Length at end point of L-Box test

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CHAPTER 1

INTRODUCTION

1.1 Background

The importance of concrete in modern society cannot be underestimated. There is no escaping from the impact of concrete on everyday life. Concrete is a composite material which is made of filler and a binder. Typical concrete is a mixture of fine aggregate (sand), coarse aggregate (rock), cement, and water. Nowadays the usage of concrete is increasing from time to time due to the rapid development of construction industry. The usage of concrete is not only in building construction but also in other areas such as road construction, bridges, harbor and many more. Thus technology in concrete has been developing in many ways to enhance the quality and properties of concrete. One of the technological advances in improving the quality of concrete is Self Compacting Concrete.

Self-compacting concrete (SCC) is considered as a concrete which can be placed and compacted under its self-weight with little or no vibration effort, and which is at the same time cohesive enough to be handled without segregation or bleeding. The use of chemical admixtures is always necessary when producing SCC in order to increase the workability and reduce segregation. The content of coarse aggregate and the water to binder ratio in SCC are lower than those of normal concrete. Therefore SCC contains large amounts of fine particles such as palm oil fuel ash (POFA), blast-furnace slag, fly ash and rice husk ash (RHA) in order to avoid gravity segregation of larger particles in the fresh mix.

This research was implemented to develop and to determine the properties and flexural behaviour of Self Compacting Concrete (SCC) by using Rice Husk Ash (RHA) and admixture.

1.2 Problem Statement

The explosive expansion of plantation in Malaysia has generated enormous amounts of vegetable waste, creating problems in replanting operations and tremendous environmental concerns. When left on the plantation floor, these materials create great environmental problems [18]. For this reason, economic utilization of this waste will be beneficial. Some countries are experiencing predicament in disposal of rice husk heaps due to their abundance. Concrete technologists are gradually finding applications in rice husk ash (RHA) as an additive for producing high-strength concrete. The use of rice husk ash, an indigenous agro-waste in its raw form, as a supplementary binder to cement for treatment of contaminated soils not only can create new workable and high strength concrete also assists in alleviating disposal problem of rice husk heaps in Asian countries.

1.3 Objectives

The objective of this study are :

1) To produce a suitable concrete composition which can be categorized as SCC that using RHA as cement replacement material together with admixture.
2) To investigate the properties and strength development of SCC.
3) To compare the flexural behavior of reinforced concrete beam of SCC and normal concrete (NC).

1.4 Research Scope

The scope of this research are :

1) The mixtures of SCC are only using rice husk ash (RHA) as cement replacement material and admixtures (Sika ViscoCrete-15RM)
2) Ordinary Portland Cement (OPC) is used for the proposed SCC mix.
3) The water- binder ratio (w/b) for all the mixes is fixed at 0.38.
4) The comparison in flexural behaviour aspect only involves the most optimum design mix of SCC to be compared with normal concrete.

1.5 Research Significance

Concrete has been used in the construction industry for centuries. Many modifications and developments have been made to improve the performance of concrete, especially in terms of strength and workability. Engineers has found new technology of concrete called Self Compacted Concrete that use pozzolans as a cement replacement material together with admixtures.

The introduction of pozzolans as cement replacement materials in recent years seems to be successful. The use of pozzolan has proven to be an effective solution in enhancing the properties of concrete in terms of strength and workability. The current pozzolans in use are fly ash, silica fume and slag. Development and investigation of other sources of pozzolan such as rice husk ash will be able to provide alternatives for the engineer to select the most suitable cement replacement material for more cheaper material.

Like other pozzolans, rice husk ash is a by-product which can be abundantly found in this country. Therefore, using rice husk ash should promise some advantages in reduce the environmental problems. In this case, studies are needed to determine the properties and behaviour of SCC using rice husk ash.

In addition, the use of rice husk ash as a cement replacement material is not common in the Malaysian construction sector. This study will be able to enhance the understanding on the suitability of rice husk ash as cement replacement material.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There has been an increase in using self-compacting concrete (SCC) in recent years and numerous of papers have been published. SCC was first developed in Japan in the late nineteen eighties to be used in the construction of skyscrapers. The introduction of SCC represents major technological advances, which leads to a better quality concrete and an efficient construction process. SCC allows the construction of more slender building elements and more complicated and interesting shapes. The production of SCC allows the pumping of concrete to a great height and the flow through congested reinforcing bars without the use of compaction other than the concrete self-weight. As a result, the use of SCC can lead to a reduction in construction time, labour cost and noise level on the construction site.

2.2 Self Compacting Concrete

Self compacting concrete (SCC), is a new kind of high performance concrete (HPC) with excellent deformability and segregation resistance. It is a flowing concrete without segregation and bleeding, capable of filling spaces in dense reinforcement or inaccessible voids without hindrance or blockage. The composition of SCC must be designed in order not to separate and not to excessively bleed. Concrete strength development is determined not only by the water-to-cement ratio, but also is influenced by the content of other concrete ingredients like cement replacement material and admixtures.

Two important properties specific to SCC in its plastic state are its flowability and stability. The high flowability of SCC is generally attained by using highrange-water-reducing (HRWR) admixtures and not by adding extra mixing water. The stability or resistance to segregation of the plastic concrete mixture is attained by increasing the total quantity of fines in the concrete and/or by using admixtures that modify the viscosity of the mixture[1]. Increased fines contents can be achieved by increasing the content of cementititious materials or by incorporating mineral fines. Admixtures that affect the viscosity of the mixture are especially helpful when grading of available aggregate sources cannot be optimized for cohesive mixtures or with large source variations. A well distributed aggregate grading helps achieve SCC at reduced cementitious materials content and/or reduced admixture dosage. While SCC mixtures have been successfully produced with 1½ inch (38 mm) aggregate, it is easier to design and control with smaller size aggregate. Control of aggregate moisture content is also critical to producing a good mixture. SCC mixtures typically have a higher paste volume, less coarse aggregate and higher sand-coarse aggregate ratio than typical concrete mixtures.

Retention of flowability of SCC at the point of discharge at the jobsite is an important issue. Hot weather, long haul distances and delays on the jobsite can result in the reduction of flowability whereby the benefits of using SCC are reduced. Job site water addition to SCC may not always yield the expected increase in flowability and could cause stability problems. Full capacity mixer truck loads may not be feasible with SCCs of very high flowability due to potential spillage. In such situations it is prudent to transport SCC at a lower flowability and adjust the mixture with HRWR admixtures at the job site. Care should be taken to maintain the stability of the mixture and minimize blocking during pumping and placement of SCC through restricted spaces. Formwork may have to be designed to withstand fluid concrete pressure and conservatively should be designed for full head pressure. Once the concrete is in place it should not display segregation or bleeding/settlement.

SCC mixtures as shown in Figure 2.1 can be designed to provide the required hardened concrete properties for an application, similar to regular concrete. If the SCC mixture is designed to have a higher paste content or fines compared to conventional concrete, an increase in shrinkage may occur.

Figure 2.1 : Self compacted concrete

2.3 Development of SCC

For several years beginning in 1983, the problem of the durability of concrete structures was a major topic of interest in worldwide. To make durable concrete structures, sufficient compaction by skilled workers is required. However, the gradual reduction in the number of skilled workers in construction industry has led to a similar reduction in the quality of construction work. One solution for the achievement of durable concrete structures independent of the quality of construction work is the employment of self-compacting concrete, which can be compacted into every corner of a formwork, purely by means of its own weight and without the need for vibrating compaction (Figure 2.2). The necessity of this type of concrete was proposed by Okamura in 1986. Studies to develop self-compacting concrete, including a fundamental study on the workability of concrete, were carried out by Ozawa and Maekawa at the University of Tokyo[19].

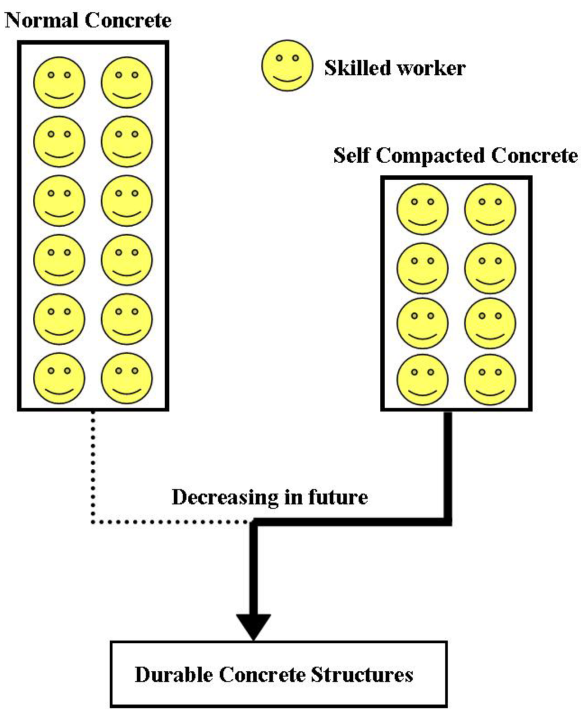

Figure 2.2 : Necessity of SCC

The prototype of self-compacting concrete was first completed in 1988 using materials already on the market. The prototype performed satisfactorily with regard to drying and hardening shrinkage, heat of hydration, denseness after hardening, and other properties. This concrete was named “High Performance Concrete.” and was defined as follows at the three stages of concrete. At almost the same time, “High Performance Concrete” was defined as a concrete with high durability due to low water-cement ratio by Professor Aitcin. Since then, the term high performance concrete has been used around the world to refer to high durability concrete. Therefore, Okamura has changed the term for the proposed concrete to “Self-Compacting High Performance Concrete”[19].

2.4 Application of SCC in Worldwide

Since the development of the prototype of self-compacting concrete in 1988, the use of self-compacting concrete in actual structures has gradually increased. A typical application example of Self-compacting concrete is the two anchorages of Akashi-Kaikyo (Straits) Bridge opened in April 1998, a suspension bridge with the longest span in the world (1,991 meters). The volume of the cast concrete in the two ahchorages amounted to 290,000 m^3. A new construction system, which makes full use of the performance of self-compacting concrete, was introduced for this. The concrete was mixed at the batcher plant beside the site, and was the pumped out of the plant. It was transported 200 meters through pipes to the casting site, where the pipes were arranged in rows 3 to 5 meters apart. The concrete was cast from gate valves located at 5 meter intervals along the pipes. These valves were automatically controlled so that a surface level of the cast concrete could be maintained. In the final analysis, the use of self-compacting concrete shortened the anchorage construction period by 20%, from 2.5 to 2 years [19].

Self-compacting concrete was used for the wall of a large LNG tank belonging to the Osaka Gas Company, whose concrete casting was completed in June 1998. The volume of the self-compacting concrete used in the tank amounted to 12,000 m^2. The adoption of self-compacting concrete means that the number of lots decreases from 14 to 10, as the height of one lot of concrete casting was increased and the number of concrete workers was reduced from 150 to 50. The construction period of the structure also has decreased from 22 months to18 months [19].

2.5 Advantages and Benefits of SCC

SCC offers many advantages and benefits for the precast, prestressed industry and for the cast-in-place construction as follows:

1. Can be placed at a faster rate with no mechanical vibration and less screeding, resulting in savings in placement costs.
2. Improved and more uniform architectural surface finish with little to no remedial surface work.
3. Ease of filling restricted sections and hard-to-reach areas. Opportunities to create structural and architectural shapes and surface finishes not achievable with conventional concrete.
4. Improved consolidation around reinforcement and bond with reinforcement
5. Improved pumpability.
6. Improved uniformity of in-place concrete by eliminating variable operator-related effort of consolidation.
7. Labour savings.
8. Shorter construction periods and resulting cost savings.
9. Quicker concrete truck turn-around times enabling the producer to service the project more efficiently.
10. Reduction or elimination of vibrator noise potentially increasing construction hours in urban areas.
11. Minimizes movement of ready mixed trucks and pumps during placement.
12. Increased jobsite safety by eliminating the need for consolidation.