MECHANICAL PROPERTIES OF GLASS FIBRE REINFORCED CONCRETE WITH PALM OIL FUEL ASH

LEE YEE KHAI

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Specially dedicated to

my supervisor Associate Professor Dr. A.S.M. Abdul Awal, my family and friends.

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ABSTRACT

In the absence of steel reinforcement, the brittle nature of conventional concrete always results in catastrophic failure without warning. Researches since decades ago shown that the addition of fibres into the concrete enhanced its ductility while admixtures help to strengthen the cement matrix. To study the effects of palm oil fuel ash (POFA) on the mechanical properties of glass fibre reinforced concrete (GFRC), an experimental programme involved Vebe consistency test, ultrasonic pulse velocity test, compressive strength test, splitting tensile strength test and flexural strength test was carried out. Normal concrete and GFRC with 0, 10, 20 and 30% of POFA were prepared and tested at the age of 1, 7, 28 and 90 days. The glass fibre used was 12mm Cem-Fil Alkali-Resistant (AR) glass fibre added into the concrete at a percentage of 0.5 by volume of concrete. The result shows that the addition of glass fibres reduced the workability of the concrete but the use of superplasticiser helped to compensate the loss. In term of mechanical properties, glass fibres reduced the compressive strength of the concrete for about 10.0% but 20% replacement of cement with POFA gave a 5.4% improvement to the compressive strength at later age. With the incorporation of glass fibres into the concrete, the splitting tensile strength and flexural strength were increased by 2.2% and 20.0% respectively. The replacement of 20% cement with POFA further enhance the concrete for another 8.2% and 10.6% of splitting tensile and flexural strength respectively. In conclusion, glass fibres reduced the compressive strength of the concrete but it helped in improving the splitting tensile and flexural strength of the concrete. To strengthen the concrete, 20% replacement of cement with POFA was found to be the optimum value.

ABSTRAK

Konkrit merupakan suatu bahan pembinaan bersifat rapuh yang melibatkan kegagalan struktur secara tiba-tiba sekiranya tidak diperkuatkan dengan batang keluli. Para penyelidik telah membuktikan bahawa sifat kemuluran konkrti juga boleh diperkuatkan dengan gegentian manakala bahan tambahan mineral dapat menguatkan matriks simen. Untuk mengaji kesan abu bakaran kelapa sawit (POFA) ke atas kekuatan mekanikal konkrit dengan gegentian gelas (GFRC), suatu kajian yang melibatkan ujian konsisten Vebe, ujian kelajuan nadi ultrasonik, ujian kekuatan mampatan, kekuatan tegangan pembelahan dan kekuatan lenturan telah dilaksanakan. Konkrit biasa dan GFRC dengan 0, 10, 20 dan 30% abu bakaran kelapa sawit telah disediakan dan diuji pada usia 1, 7, 28 dan 90 hari. Gegentian gelas tahan alkali Cem-Fil 12mm ditambahkan ke dalam konkrit pada bilangan 0.5% daripada isipadu konkrit. Hasil kajian membuktikan bahawa gegentian gelas menurunkan kebolehkerjaan konkrit tetapi superplasticiser dapat memperbaiki kebolehkerjaan konkrit. Selain itu, gegentian gelas juga mengurangkan kekuatan mampatan konkrit sebanyak 10% tetapi penggantian 20% simen dengan POFA berjaya memulihkan kekuatan mampatan konkrit sebanyak 5.4% pada usia 90 hari. Dengan tambahan gegentian gelas, kekuatan tegangan pembelahan dan kekuatan lenturan konkrit telah dinaikkan sebanyak 2.2% dan 20% masing-masing. Penggantian 20% simen dengan POFA pula masing-masing menaikkan lagi kekuatan tegangan pembelahan dan kekuatan lenturan konkrit sebanyak 8.2% and 10.6%. Kesimpulannya, gegentian gelas menggurangkan kekuatan mampatan konkrit tetapi menambahbaikkan kekuatan tegangan pembelahan dan kekuatan lenturan konkrit. Penggantian 20% simen dengan POFA merupakan kuantiti optimum yang dicadangkan.

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LIST OF SYMBOLS

V	-	Ultrasonic pulse velocity
s	-	Distance between centers of transducer faces (travelled by ultrasonic pulse)
t	-	Transit time of ultrasonic pulse
T	-	Splitting tensile strength
P	-	Maximum load applied
l	-	Length of cylindrical specimen
D	-	Diameter of specimen
L	-	Prism span length
b	-	Average width of specimen
d	-	Average depth of specimen

LIST OF ABBREVIATIONS

ARGF	-	Alkaline resistant glass fibres
FRC	-	Fibre reinforced concrete
GFRC, GC	-	Glass fibre reinforced concrete
GGBFS	-	Ground granulated blast-furnace slag
PC	-	Plain concrete
PFA	-	Pelverised fly ash
PGC 10	-	Glass fibre reinforced concrete with 10% palm oil fuel ash
PGC 20	-	Glass fibre reinforced concrete with 20% palm oil fuel ash
PGC 30	-	Glass fibre reinforced concrete with 30% palm oil fuel ash
POFA	-	Palm oil fuel ash
RHA	-	Rice husk ash
SPGC 20	-	Glass fibre reinforced concrete with 20% palm oil fuel ash and superplasticiser
SCC	-	Self-compacting concrete

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CHAPTER 1

INTRODUCTION

1.1 Background of Research

Concrete is by far the most commonly used material in construction sector due to its superior load bearing capacity and flexibility to be modified with different properties. However, its brittle nature always results in catastrophic failure which involves total collapse of the structure in a short time. With regard to this, reinforcement is needed. Besides the conventional way of tensile strengthening using steel reinforcement bars, fibre reinforced concrete (FRC) was introduced since decades ago. The idea was to disperse fibres into the concrete to improve the tensile strength of the concrete.

The randomly distributed fibres in the concrete play the role of redistributing the tensile force applied on it and interrupt the propagation of cracks hence enhances its post-cracking ductility. With this mechanism, the failure of the concrete becomes ductile and catastrophic failure can be prevented. However, fibre reinforced concrete is not meant for heavy loading application. This is mainly because of its inferiority in term of improving the strength of concrete as compared to conventional steel reinforcement bars.

Many types of fibres are available in the concrete industry nowadays, for instant, steel fibres, synthetic fibres such as carbon fibres and polypropylene fibres, glass fibres as well as natural fibres. Each type of fibres has their own advantages and drawbacks. The selection is mainly based on the application of the concrete. For example, steel fibres and carbon fibres are high in tensile strength, therefore they are commonly used in structural components. Glass fibres and natural fibres on the other hand are favoured for their lightweight.

The inclusion of glass fibres in concrete was initially not encouraged because the byproducts (calcium hydroxide) from the hydration of cement will create an alkaline environment which weakens the bonding between glass fibres and cement matrix through chemical attack [1]. To overcome this problem, alkali-resistant glass fibres were used. The protective zirconia layer on the glass fibres helps to mitigate the intrusion of chemical substances and slow down the rate of etching of the surface of glass fibres.

One major problem with glass fibre reinforced concrete is debonding between the fibres and concrete. The weak interfacial bonding between the fibres and cement matrix always results in the failure of concrete. So, it is important to have a strong concrete matrix. To achieve this, mineral admixtures such as fly ash, granulated blast-furnace slag, silica fume, metakaolin, rice husk ask and palm oil fuel ash can be used. These materials contain high amount of silicate which contributes to the development of the ultimate strength of the concrete.

1.2 Problem Statement

Mineral admixtures such as fly ash, granulated blast-furnace-slag, silica fume, metakaolin and rice husk ash are beneficial to the improvement of the mechanical properties of concrete [2]. POFA, being another widely available mineral admixture in Malaysia were also proved to the capable of improving the strength of concrete [3, 4]. However, study on the use of POFA in glass fibre reinforced concrete (GFRC) is still scarce. Having similar properties as other pozzolanic materials, it is believed that POFA is capable of enhancing the mechanical properties of glass fibre reinforced concrete. To look into this aspect, this research was conducted.

1.3 Aim and Objectives of Research

The aim of this research is to study the effects of POFA on the mechanical properties of glass fibre reinforced concrete. The objectives are listed as the following:

i. To compare the mechanical properties of GFRC with and without POFA.
ii. To check the possibility of improving the mechanical properties of GFRC by using POFA.
iii. To know the effects of glass fibre towards flexural strength of concrete.

1.4 Scope of Research

This study focuses on comparing the effects of POFA on the mechanical properties of GFRC. Among the many factors that govern the properties of GFRC, some of them were held constant. In this research, one a single type and dimension of glass fibres was used. Besides that, the type and content of the coarse and fine aggregates used were also remained constant for all the specimens.

Since the effects of fibre's volume and water/cement ratio are significant, trial mixes were performed to obtain the optimum fibre and moisture content to be used in the actual testing. For the trial mix specimens, compressive strength test and splitting tensile strength test were carried on the cubes that had been wet-cured for 7 days. The result obtained from the trial mixes was then used in the actual testing.

To check the possibility of POFA in enhancing the mechanical properties of GFRC, compressive test, splitting tensile test and flexural test were performed on the specimens at the age of 1 day, 7 days, 28 days and 90 days. Adding up to that, non-destructive test and testing on the workability of fresh concrete were also been carried out.

1.5 Significance of Study

Palm oil fuel ash is a waste material that can be found abundantly in Malaysia. It is a byproduct from burning palm oil shells and fiber in thermal power plant or palm oil mills. If not disposed properly, it will affect the environment and the health of human negatively. If the contribution of POFA to the development of mechanical strength of glass fibre reinforced concrete is found to be satisfactory, there will be an additional use of POFA in this sector. With the additional usage of POFA, the disposal of industrial waste materials to the environment can be reduced. Besides that, with the replacement of cement using POFA, the pollution due to the emission of carbon dioxide from the production of cement clinker can be improved.

The impacts of this study are remarkable especially in the current trend where fibre reinforce concrete emerge to be a popular construction material and environmental issue concerns everyone in society.

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