PROPERTIES OF CONCRETE USING HYBRID FIBERS

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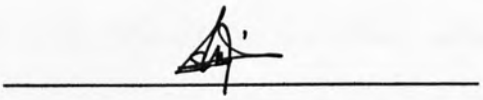

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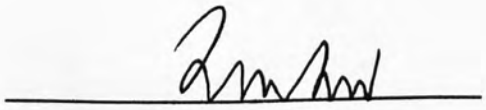

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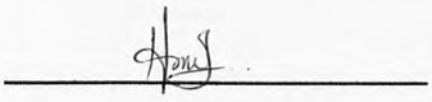

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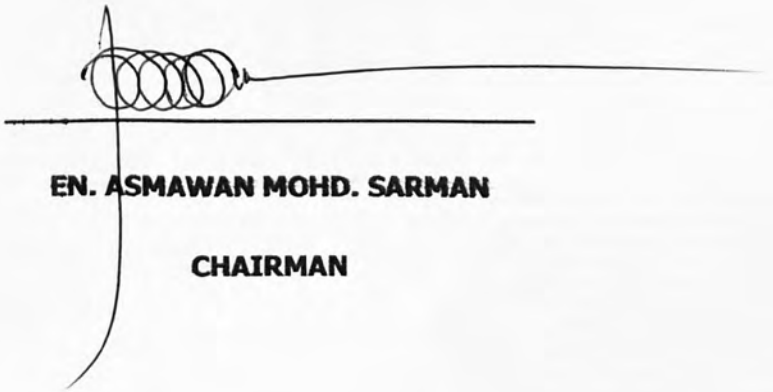

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ABSTRACT

PROPERTIES OF CONCRETE USING HYBRID FIBERS

There are varieties of fiber reinforcement concrete, the purpose of including fiber into concrete mix is to improve its engineering properties. In this research, polypropylene and steel fiber had been taken as the fibers used to reinforce Ordinary Concrete. This research shows that including fiber into concrete will improve its flexural strength. The different types of fiber contributed to different mechanical properties. Fiber reinforcement concrete that consist of polypropylene and steel fiber had a significant influence at flexural strength of the concrete.

ABSTRAK

Terdapat pelbagai jenis fiber konkrit bertetulang, tujuan utama memasukkan fiber ke dalam campuran konkrit adalah untuk meningkatkan ciri –ciri kejuruteraan konkrit. Dalam kajian ini, fiber polypropylene dan fiber keluli digunakan untuk memperkuatkan Konkrit Berprestasi Biasa. Kajian ini menunjukkan tambahan fiber ke dalam konkrit meningkatkan sesetengah ciri-ciri kejuruteraannya. Jenis fiber yang berlainan menyumbang ciri-ciri mekanikal yang berlainan. Konkrit yang diperkuatkan dengan fiber polypropylene dan fiber keluli menunjukkan pengaruh yang besar ke atas kekuatan lentur konkrit tersebut.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Concrete is the major material in construction. Good constructions depend on the quality of concrete. Concrete can be very durable, is wonderfully mouldable and adaptable to myriad applications such as beam, slabs and other members in building construction. Different concrete performs different properties. Concrete properties include brittle, tensile strength, and density. All these properties used to differentiate type of concrete. An ideal concrete would be lightweight, high compressive strength, high durability, high toughness and impact resistance. However in reality, concrete unable to fulfill this requirement.

The portion and ingredients for mixing concrete will affect the outcome of the concrete properties. Ingredient such as coarse aggregate, sand and water is the basic requirement in mixing concrete. However, there is always a limit for normal concrete that mix by these basic ingredients. To improve the properties of the concrete, people start to include additional mixture into concrete mix. Alternative created to improve the properties of concrete increase the duration of concrete work.

Even aggregate, sand and water are all natural resources and inexpensive, but if any additional mixture is applied that is expensive, eventually the price of concrete will increase also. Therefore to prevent the increase cost of concrete, the ingredient would be the cheaper the better. In order to implement this concept, solid waste management had been included into this research. Using solid waste to

improve the performance of concrete not only can maintain the cost and at the meantime can reduce the wastes that keep increase from day to day.

Various studies have been conducted to find an effective and efficiency way to increase the concrete properties. Method such as adding admixtures, air entrance agent, reinforcement bar, fly ash, and blast furnace show a very good outcome to the properties of concrete. But including admixture into concrete will also increase the cost of the concrete; therefore some industrial has started to concentrate study in other alternative such as fiber to reinforce in concrete. In the recent research, it showed that there are many high potential fibers that can improve concrete in certain aspect

Concrete is a relatively brittle material. Reinforcement of concrete with randomly distributed short fiber may improve the toughness of cementations matrices by preventing or controlling the initiation, propagation, or coalescence of crack. The fiber chosen in this research is steel fibers and polymer fibers. However, concrete is a complex material with multiphases. The phases include large amount of C-S-H gel in micron-scale size, sand in millimeter-scale size, and course aggregates in centimeter-scale size. Thus, the properties of concrete will be improved in certain level, but not in whole levels if reinforced only by one type of fiber.

Recent research shown that by using concept of hydration with two different fibers incorporated in a common cement matrix, the hybrid composite can offer more attractive engineering properties because the presence of one fiber enables the more efficient utilization of the potential properties of the other fiber. However, most of the research works on utilization of fiber reinforcement are about the fiber of monotype. Using hybrid fibers as reinforcement to improve the performance of concrete seldom reported.

1.2 OBJECTIVE

The objective of this project is to understand the engineering properties of hybrid fiber concrete. In order to differentiate the properties between conventional high performance concrete, mono fiber concrete and hybrid fiber, the portion or volume of fiber have been stated at 2% of the total weight of the cement from the concrete mix. To achieve this outcome the investigation is performed in the following manner:

- Compare the properties of conventional concrete, mono fiber concrete (steel fiber concrete and polymer fiber concrete) and hybrid fiber concrete (steel fiber plus polymer fiber concrete).
- Study the improvement in performance of hybrid fiber concrete.

1.3 SCOPE OF WORK

The scope of work of this research work and project is to investigate the engineering properties of concrete that contain fibers. Specifically, scope of work include determine the properties of mono fiber concrete (steel fiber concrete and polypropylene fiber concrete) and hybrid fibers concrete (steel fiber plus polypropylene fiber) with 2% of fiber weight of the total cement weight. At same time, compare the properties of each type of concrete to understand the improvement of properties with different kind of fiber.

Laboratory testing need to be carried out to mixing concrete mixed to make sure the concrete portion for ordinary concrete is mixed accordingly to British Standard Institute's BS 1881 standard or American Society for Testing and Material (ASTM) standard

Test carried out on the concrete samples are slump test, compressive test, flexural test and splitting tensile test.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Concrete, as the most commonly used construction material, is developing towards high performance, high strength, high toughness, high durability, and good workability. During these recent years, concrete demand had increased in tandem with construction and development project around the world. To increase the performance of concrete, additional mixture had been included in concrete mix and for recent improvement; industrials are showing a good support to mono fiber and also hybrid fiber concrete. Fiber concrete gives a better performance in certain properties such as improving crack control and fracture toughness.

Utilizing fiber concrete has been started in worldwide to aim to the possibility to improve concrete engineering and performance in the pass few years. Adding fiber into concrete mix is not a fresh idea, previous journal showed that included steel fiber in concrete improve concrete properties and so to polymer fiber. But the mix of these 2 hybrid fibers into concrete mix is lack of information. Therefore this is reason for this experiment to be carried out. Since steel fiber concrete and polymer fiber concrete and been carried out by so many researchers before, this research is more emphasize on the performance of hybrid fiber concrete.

Fibers in concrete provide a means of arresting crack growth. Reinforcing steel bars in concrete have the same beneficial effect because they act as a long continuous fiber. However, short discontinuous fibers have the advantage of being uniformly mixed and dispersed throughout the concrete. Fibers are added to a concrete mix which normally contains cement, water and fine and coarse aggregate. Among the more common fibers used are steel, glass, asbestos and polypropylene.

There are advantages of using fiber as reinforcement which had summarized as below:

- Controlled Plastic Shrinkage
- Minimized Crack Growth
- Reduced Permeability
- Improved Surface Durability
- Uniform Reinforcement In All Directions

2.2 VARIETIES OF FIBERS

2.2.1 Carbon Fiber

Carbon is a very good fiber in fiber reinforced concrete type. Previous research show that splitting strength increase of **85%,** a flexural toughness increase of **205%** and compressive strength increase 22% at **28** days of curing compare to conventional concrete. (Dr. Deborah D.L Chung, 1992)

Besides that, carbon fiber also has been used in reinforced concrete for traffic monitoring and weighing in motion. The research result showed that the stress of concrete up to 1MPa. (Zeng-Qiang Shi al et, 1999)

2.2.2 Nylon

100% Virgin 6 Denier Nylon. Nylon fiber has less static and is easier to work with - perfect for use in ornamental concrete. Previous experiment showed that nylon fiber reinforcement concrete increased the compressive strength by 12.4% over the conventional concrete. For the splitting tensile strengths of the nylon reinforcement concrete were 17.1% higher than the unreinfiorced concrete and for modulus of rupture of nylon reinforcement concrete showed that 5.9% increase over the none fiber control concrete. (P.S. Song, 2004)

2.2.3 Steel Fibers

It is well known that the use of steel fibers raises the ductility of concrete and the fracture energy. This phenomenon is transferable to the shear strength of concrete. Former researchers as reported about an increasing shear capacity of steel fiber reinforced concrete beams. The work introduces a test program to understand the punching behavior of steel fiber reinforced plates. In the effects of steel fibers on the ultimate behavior of pre-stressed plates is described.

At the University of Leipzig a test program on reinforced concrete beams is carried out to find out the effects of steel fibers on the ductility and the ultimate shear strength of concrete.

2.2.4 Polypropylene

Polypropylene is widely used in the production of fibers, for use in carpeting, rope and twine, automobile interiors, textiles and in other applications. Fibers are one of the most important applications for polypropylene homo-polymer. Due to its melt flow properties, fiber formation is easier when compared to other polymers. Its low density results in a higher yield of fiber per pound of material. (R. Brown, A. Shukla and K.R. Natarajan, September 2002)

Polypropylene demonstrates an interesting example of the need for regularity of structure to secure crystallization in a polymer. During polymerization, the successive chain sequences of --CH2--CH(CH3) can be added on in either a right-handed or a left-handed screw direction, owing to the stereochemistry of the chain. If these forms occur at random, the chain will have an irregular shape and will not crystallize. This is atactic PP that is unsuitable for making fibers. But if successions of units are added on to give the isotactic form the molecular will be regular and will crystallize. It was the discovery of means of controlling the polymerization that led to the production of *isotactic* polypropylene fibers (10). (R. Brown, A. Shukla and K.R. Natarajan, September 2002)

2.2.5 Fibrillated

100% Virgin polypropylene fibrillated fiber. Most effective for minimizing cracking throughout the life of the concrete. Fibrillated fibers are proven to deliver maximum post-peak flexural strength. This type of fiber also delivers superior impact, abrasion and shatter resistance while decreasing permeability.

2.2.6 Fiber-Reinforced Plastics (FRP)

Fiber-reinforced plastic (FRP) (also Fiber-reinforced polymer) is a composite material comprising a polymer matrix reinforced with fibers. The fibers are usually fiberglass, carbon, or aramid, while the polymer is usually an epoxy, vinylester or polyester thermosetting plastic. Fiber-reinforced plastics (FRP) have been intensively used in the repair and strengthening of aerospace structures. Though the study of using FRP to strengthen reinforced concrete structures just started in the 1990s the technology is currently widely used. (Hsuan-Teh Hu, 2003)

FRP is often chosen because it is light. Perfect when overall weight is an issue. Fiber reinforcement can add as much strength in some cases then heavier materials for which it is being substituted. Pound for pound Fiberglass is much stronger than steel.

2.2.7 Synthetics Fiber

Main functions and application of synthetic fiber are strengthen inner tensile strength; reduce retraction capability of inner capillary control forming of plastic constraint cracks or settlement cracks. Improve impact resistance, anti-wearing and breaking resistance. Advance tenacity, impermeability, fatigue resistance, anti-frozen and anti-melting capability and anti stripping capability and also improve crack resistance in low temperature, stability in high temperature and water stability.

2.2.8 Basalt

Spun basalt fiber, long available in Eastern Europe, has become available in the U.S. and Western Europe. Basalt fiber is stronger and less expensive than glass, but historically, has not resisted the alkaline environment of Portland Cement well enough to be used as direct reinforcement. New materials use plastic binders to isolate the basalt fiber from the cement. (Tibor CZIGÁNY al et. 2004)

Basalt fiber has been used to produce concrete reinforcement rod. With the unidirectional basalt fiber, the rods are reportedly 89 percent lighter than steel reinforcement rods, have the same coefficient of thermal expansion as concrete and are less susceptible to degradation in an alkaline environment. The company claims that that 1 ton of basalt rods can provide reinforcement equal to 4 tons of steel rods.

2.2.9 Monofilament

100% Virgin Polypropylene monofilament fiber. This fiber provides effective crack resistance coupled with a smooth finish.

2.3 TYPE OF CONCRETE

2.3.1 Ordinary Concrete

Concrete materials in most ordinary concretes produced today contain materials in addition to Portland cement to help achieve the compressive strength or durability performance. These materials include fly ash, silica fume and ground-granulated blast furnace slag used separately or in combination. At the same time, chemical admixtures such as high-range water-reducers are needed to ensure that the concrete is easy to transport, place and finish. For concretes, a combination of mineral and chemical admixtures is nearly always essential to ensure achievement of the required strength. Recent research for improving the properties of ordinary performance concrete, fiber reinforcement has been applied into it. This method has further increased the properties of the performance the concrete. (Henry G. Russell, 1999)

2.3.2 High Performance Concrete

High performance concrete, formerly named high strength concrete, can mean concrete having a high durability (low permeability) as well as high strength. In some applications, a high modulus of elasticity is the property desired. Nowadays, high performance is term of strength is taken as a compressive strength in excess of 80MPa (12000 psi).

Fiber reinforcement also applied in high performance concrete. Fibers that used to reinforce high performance concrete are depending on the demand of the concrete performance used for the construction.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This project is about experimenting the properties of ordinary concrete without fiber reinforcement and with fiber reinforcement therefore the first thing need to carry out is to outline objective and scope of work. Next will be literature review and studies that carried out to review similar research work or experiment that has been done before this project. In the mean time, study of material quantities and concrete mix portion need to be carried out. Before starting the laboratory work, material searching and collecting need to be done.

Raw materials such as cement, coarse aggregate, sand and admixture was supply directly from SKTM School of Engineering and Information technology. Fibers such as steel fiber was obtained from mechanical workshop from SKTM and for polypropylene was obtained from residential area, commercial centre and recycle centre.

Concrete engineering properties are determined through testing on concrete mixed. Test for fresh concrete mixed are slump test for workability. For hardened concrete, cube test, flexural test, and splitting tensile test for 3, 7 and 28 days hardened concrete mixed.

3.2 MATERIAL USED

3.2.1 Cement

Cement is the main material that provides strength and bind between other material such as aggregate and sand during casting concrete. This project conducted with the Cap Gajah brand ordinary Portland cement (OPC) which obtained directly from the laboratory of SKTM.

Cement used in the whole process must be in good condition which mean without any cement that already hardened. Sieving process used to prevent hardened cement particles used in this project. This is to prevent the result of the concrete properties affected by hardened cement.

3.2.2 Aggregate

Aggregate occupy the major (70%) volume of concrete and is the largest constituent material in concrete in term of volume. It is also used to improve both the volume stability and durability of the concrete.

Two kinds of aggregate used in this experiment which are coarse aggregate and fine aggregate. For coarse aggregate, the size is 20mm and fine aggregate is 1.18mm. Both aggregate is sieved and tested according to ASTM method.

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