PERFORMANCE OF KENAF FIBER REINFORCED CONCRETE

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A project report submitted in partial fulfillment of
the requirements for the award of the degree of
Master of Engineering (Civil-Structure)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

January 2013

To my beloved parents father and mother,

Manoochehr Razavi and Shahla Mohammad zadeh

To my brother,

Mehrdad and Meisam

Thanks for your support and always there for me in happiness and sadness

.

I am very proud to have all of you

~~~~~ Love you all ~~~~
~~~~~

ACKNOWLEDGEMENT

In preparing this thesis, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my main thesis supervisor, Assoc. Prof. Dr. Abdul Rahman Mohd Sam, for encouragement, guidance, critics and friendship. I am also very thankful to my co-supervisors Assoc. Prof. Dr. Jamaludin Mohamad Yatim for their guidance, advices and motivation. Without their continued support and interest, this thesis would not have been the same as presented here.

I am also indebted to University Technology Malaysia (UTM) for funding my master study technicians in the Structures and Materials Laboratory of Faculty of Civil Engineering also deserves special thanks for their assistance in supplying the relevant literatures.

My fellow postgraduate students should also be recognised for their support. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. I am grateful to all my family members.

ABSTRACT

This experimental research presents a study on the mechanical properties of natural fiber reinforced concrete (FRC) which is made using the bast fibers of the kenaf plant. Appropriate mixture proportions and mixing procedures were tested to produce kenaf fiber reinforced concrete (KFRC) specimens with different chopped fiber volume fractions (0.5%, 1%, 1.5%, and 2%) and fiber lengths (10mm, 15mm, 20mm, 25mm, and 30mm). After finding the optimum percentage of the fiber volume fraction and fiber lengths several tests were conducted including workability, unit weight, compressive, flexural, and modified compressive tests of specimens were studied. Test results showed that the mechanical properties of KFRC are comparable to those of plain concrete control specimens, particularly when accounting for the effect of the increased w/c ratio is required producing workable KFRC. While KFRC increased the short term compressive strength of the specimens (7 days), it reduced the compressive strength of the specimens after 28 days. Further, KFRC generally exhibits more distributed cracking and higher flexural strength than plain concrete. This research indicated that KFRC is a promising 'green' construction material which could potentially be used in a number of different structural and non-structural applications.

ABSTRAK

Ujikaji ini menunjukkan kajian ke atas sifat mekanikal serat semulajadi konkrit bertetulang (FRC) yang dibuat menggunakan ciri gentian kulit tumbuhan kenaf. Campuran perkadaran dan prosedur bancuhan yang bersesuaian telah dibuat untuk menghasilkan spesimen konkrit bertetulang gentian kenaf (KFRC) dengan isipadu dan panjang serat yang berbeza (0.5%, 1%, 1.5%, dan 2%) dan panjang serat (10mm, 15mm, 20mm, 25mm, dan 30mm). Selepas mencari peratusan optimum isipadu gentian dan panjang gentian, beberapa ujian telah dijalankan termasuklah kebolehkerjaan, unit berat, mampatan, lenturan, dan ujian mampatan spesimen yang diubahsuai telah dikaji. Keputusan ujian menunjukkan bahawa sifat-sifat mekanikal KFRC adalah setanding dengan spesimen kawalan konkrit biasa, terutamanya apabila mengambilkira kesan peningkatan nisbah w / c yang diperlukan untuk menghasilkan kebolehkerjaan KFRC. Walaupun KFRC meningkatkan kekuatan jangka pendek mampatan spesimen (7 hari), ia mengurangkan kekuatan mampatan spesimen selepas 28 hari. Seterusnya, KFRC umumnya mempamerkan agihan keretakan yang ketara dan kekuatan lenturan yang lebih tinggi daripada konkrit biasa. Kajian ini menunjukkan bahawa KFRC adalah bahan binaan yang berpotensi digunapakai dalam beberapa aplikasi struktur yang berbeza.

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LIST OF SYMBOLS

V_f	-	Volume Fraction
d	-	Diameter
s	-	Fiber Space
π	-	p_i = 3.145
m	-	Mass
V	-	Volume
F	-	Tensile Force
A	-	Cross Section Are
L	-	The Specimen Length
n	-	Number Of Data
σ	-	Stress
M	-	Moment
y	-	Neutral Axis
I	-	Moment Of Inertia
ε	-	Strain
E	-	Young's Modulus

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CHAPTER 1

INTRODUCTION

1.1 Introduction

It is known that concrete is a relatively brittle material. Reinforcement of concrete with randomly distributed short fibers may improve the toughness of cementitious matrices by preventing or controlling the initiation, propagation, or coalescence of cracks. It has been shown recently that by using the concept of hybridization with 2% fiber volume contents 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 composite. However, the hybrid composites studied by previous researchers were focused on cement paste or mortar. Therefore, the objective of this project is to determine systematically the basic characteristics of the five types of beam fiber-reinforced concretes with normal concrete (OPC), fiber reinforced concrete (FRC), and mix fiber concrete with normal concrete combinations in terms of tensile tests.

In the past, natural fibres were used in early human civilization in fabric applications. High strength natural fibres like jute, cotton, silk and kenaf are used

extensively and directly in one-dimensional products like lines, ropes and cloths. Others natural fibres like oil palm fibres, banana leaf fibres, and rice stalks fibres are residual agriculture product. They are usually disposed into land fill or disposed by open burning.

Environmental issues arise when these materials are in large quantities. Landfill method becomes not economical whilst open burning results air pollution and global warming. Until recent decade, there is an increasing interest on natural fibres reinforced polymer. The potential of natural fibres replacing synthetic fibres in composite is possible.

In general, natural fibres offer high specific properties, low cost, nonabrasive, readily available and environmental friendly where no synthetic fibres can surpass these advantages. These advantages attract scientists and technologists especially automobile industry to study on the behavior of the natural fibres and the characteristic of the natural fiber reinforced composites. However, certain drawbacks such as incompatibility with hydrophobic polymer matrix, the tendency to form aggregates during processing, poor resistance to moisture greatly reduce the potential of natural fibres to be used as reinforcement in polymer. Moreover, no literature is made on the potential of natural fiber composites in structural application. Therefore, a detail study on the characteristic of natural fiber composites is required to investigate the potential of natural fiber composites in structural use.

Mechanical characterization of concrete reinforced with natural fibers investigated in this work to analyze the possibility of substitution by natural fibers. Kenaf fibers were used in this study. These fibers come from their specific products after they have prepared. As the natural fibers are agricultural waste, manufacturing natural product is, therefore, an economic and interesting option.

1.2 Statement of the Problem

As the 21st century, approaching there is a greater awareness of the need for materials in an expanding world population and increasing affluence. At the same time, there are aware that our landfills are filling up and our resources are getting deteriorate, our planet is being polluted, non-renewable resources will not last forever, the need on environmental friendly materials need to be taken into consideration.

Nowadays, many studies have been done to find another alternative for replacement the use of steels because of the expensive costs and high maintenances of the structure damaged by corrosion. Nevertheless, bio-product appears to have a great inhibit termites attack to provide good strength and stiffness of the materials. On the other hand, many bio-composites use renewable materials or fast-growing plant fibers. In turn, they are recyclable materials that are designed to decompose rapidly. Green materials have been developed and attract global attention around the world in recent years. One of the main materials that develop from this green materials currently used in green building and structure is bio-composites. Bio-composites are the combination of natural fibers or bio-fibers usually derived from plants or cellulose. Bio-fibers offer many advantages such as renewability, recyclability, biodegradability, low specific gravity and high specific strength [1]. Bio-composites are structural materials made from renewable resources that emerging as the replacement to fiber polymer bio-composites. Therefore, bio-composites significantly offer environmental benefits such as light weight. Good mechanical properties and resistance to corrosion.

The environmental issues examined are climate change, fossil fuel depletion, ozone depletion, human toxicity to air and water, eco-toxicity, waste disposal, water extraction, acid deposition, eutrophication (over enrichment of water sources), summer smog (low level ozone creation) and minerals extraction. This issue caused the increasing on carbon dioxide, CO_2 gaseous which creates harmful environment

and human health [2]. Furthermore, the emission produced by automobile could bring to the global warming and increasing in greenhouse effect. Bio-composites typically use natural binding agents to reduce the petrochemicals or other fossil-fuel products. Therefore, kenaf fibers have been introduced but still a lot of researches have to be done for improvements. Kenaf cultivation reveals that natural fibers could reduce the amount of carbon dioxide, CO_2 emissions. The duration for fibers harvesting is 4 to 5 months which is short term compare to other plants. Therefore, kenaf fibers tend to be more sustainable compare to glass fibers. Fiber reinforced polymer (FRP) based on glass, carbon and aramid were introduced and until now was applied to the area of construction such as buildings, bridges and pipelines. Glass fibers are produces from silica which is come from sea sand will arises another whole new problems. Sea sand will run out if been use continuously and the production of glass fiber requires high costs. Bio-fibers have many desirable performance qualities including high temperature resistance, excellent thermal insulation, sound-damping properties and corrosion resistance. Among the various bio-fibers, kenaf fibers were chosen because it is a good potential reinforcement in polymeric materials. Further research has to be done to develop the feasibility of kenaf fibers as reinforcement in structure in order to produce more economical bio-composites.

Cracked and weakened reinforced concrete beams will make the whole structures become unstable. Reconstructing or rebuilding the reinforced concrete beam is not the best way because it will increase the cost and time. By considering these factors, internally reinforcing the beam is a technique that currently adopted and developed in construction industry [3].

Nowadays, synthetic fiber reinforced polymers (FRP) such as carbon, glass, and aramid are commonly used for strengthening of RC structures due to their mechanical properties such as high modulus of elasticity, relative low extension coefficient, and corrosive resistance. However, these materials are expensive in terms of costs and material production. In addition they are also not biodegradable materials.

To overcome this problem, bio fibers were introduced to the industry. Bio fibers material offer many advantages such as renewability, recyclability, and biodegradability. From these advantages, it shows that bio fibers can help to promote the sustainability concept [4].

Natural fibers have become increasingly used in many applications not only because they are environmental friendly, but also because of their various desirable properties which include high specific strength and high specific stiffness. The use of natural fibers is highly beneficial because the strength and toughness of the resulting composites are greater than those of the unreinforced plastics. Moreover, cellulose-based natural fibers are strong, light, cheap, abundant, and renewable source. In recent years, natural fibers reinforced polymer materials are used in many applications such as automotive, sporting goods, marine, electrical, industrial, construction, and household appliances.

1.3 Purpose of the Study

Reinforced concrete structures have slowly gained the popularity in the construction industry. This is because it is far easier and it can save much more time compared to reconstructing the whole deteriorating structure. Initially, steel fibers are been used but some other problems might occurred such as corrosion and heavy weight.

However, other materials are sought to replace steel after it is found to corrode due to salt and chloride moisture exposure. Nowadays, composite materials act as an internal reinforcement are being used in construction industry.

Bio composite materials are the combination of natural fibers with polymer matrices. In this study, kenaf fibers were used as an internal reinforcement as they are likely to be more eco-friendly. Other than that, bio composite can help to reduce the increasing cost of using petroleum-based material.

1.4 Objectives

The objectives of this project are:

i) To study the effects of length and volume fraction of the kenaf fibers on the performance of the kenaf fiber reinforced concrete.

ii) To study the effects of the optimum length and fiber volume fractions on the performance of the KFRC beams.

iii) To study the effects of treated and untreated kenaf fibers on the mechanical performance of the reinforced concrete beams.

1.5 Significance of the Study

The finding of this study could develop green material by using natural fiber to produce bio composites. In order to maintain sustainability, natural fibers could be used since it is a renewable material.

On the other hand, this study can help to reduce the usage of steel and non-renewable materials which participate in global warming. By using kenaf which only

takes four months to grow, it will replace the use of non-biodegradable to environment sustainability.

1.6 Scope of Study

This study involves laboratory work such as compressive and flexural test. In this study, a total number of 85 samples produced for the test. Test specimens covering different fiber lengths (10mm, 15mm, 20mm, 25mm, and 30mm) of 1% fiber volume fraction and fiber volume contents (0.5%, 1%, 1.5%, and 2%) of optimum length. Thirty-three cube samples and thirty-three concrete prisms with different fiber content and length were employed to investigate the behavior of the materials under compressive and flexural test, respectively. Finally, nine cylinders and ten concrete beams with different fiber contents and configuration were produced. Compressive and flexural tests were carried out by using Universal Testing Machine.

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