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PROPERTIES OF MORTAR WITH PALM OIL EMPTY FRUIT BUNCH FIBRE

MOHAMED OMER ELSHIEKH OMER

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

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November 2009

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This work is dedicated to my beloved parents,
my family, my friends and all my
teachers who helped me to become who I'm.

ABSTRACT

The main disadvantage of mortar is the weakness of tension zone. To solve this problem, short fibres can be added to mortar to improve the tensile properties. Fibres divided mainly into two categories synthetic and natural. Palm oil fibre one of the natural fibres showed good ability to withstand the tensile stress inside the mortar and it considered as a waste material after oil extraction from palm oil fruit bunch. Objectives of this study are to study the effect of adding palm oil fibre with different percentage to mortar specimens under bending and compressive stress beside study the effect of curing condition to fibre reinforced mortar specimens. The experimental program was included compression test by using cube specimens (70x70x70 mm) and plates (600x800x50 mm). Second type of tests was flexure test by using prism specimens (40x160x40 mm) and plates (600x800x50 mm). The data collected at different ages of 7, 28 and 56 days. For curing condition, all specimens were cured by two methods wet curing and dry air curing. The results form the tests showed that incorporating palm oil fibre to the mortar improved the tensile strength properties besides changing the failure of the specimens from brittle to ductile mode. For prism specimens the flexural strength increased at 7 days for wet and dry curing but for 28 days the strength decreased slightly. For plates, incorporating palm oil fibre improved the flexural resistance at 7, 28 and 56 days in wet curing while for dry curing this improvement observed only at 7 days. For compression test, the inclusion of palm oil fibre to mortar cubes and plates decreased the compressive strength to the range between 18% and 50% for wet curing and between 25% and 33% for dry curing. In general, the addition of palm oil fibre to the mortar plate or cube improved the flexural strength but did not contribute significantly in compressive strength.

ABSTRAK

Kelemahan utama mortar ialah kekuatan tegangannya yang rendah. Bagi mengatasi masalah tersebut gentian pendek boleh dicampurkan dalam mortar untuk meningkatkan kekuatan tegangannya. Gentian boleh dibahagikan kepada dua kategori iaitu sintetik dan semulajadi. Gentian tandan kelapa sawit merupakan salah satu gentian semulajadi yang menunjukkan kebolehan untuk menanggung tegasan tegangan dalam mortar dan ia dikategorikan sebagai bahan buangan selepas proses pengasingan minyak dari tandan kelapa sawit. Objektif kajian ini adalah untuk mengkaji kesan penggunaan gentian tandan kelapa sawit dengan peratusan yang berbeza dalam campuran mortar terhadap kekuatan lenturan dan mampatan dengan menggunakan pengawetan basah dan kering. Ujikaji yang dijalankan termasuklah ujian kekuatan mampatan menggunakan sampel kiub (70x70x70 mm) dan plat (600x800x50 mm) serta ujian lenturan menggunakan sampel prisma (40x160x40 mm) dan plat (600x800x50 mm). Sampel diuji pada umur 7, 28, dan 56 hari. Keputusan dari ujikaji menunjukkan penambahan gentian dalam mortar meningkatkan kekuatan tegangan disamping menjadikan sampel tidak gagal dalam bentuk yang rapuh. Bagi kekuatan lenturan prisma, kekuatan meningkat pada umur 7 hari bagi kedua-dua kaedah pengawetan tetapi menurun pada umur 28 hari. Bagi sampel plat penggunaan gentian dapat meningkatkan kekuatan lenturan pada semua peringkat umur bagi pengawetan basah tetapi bagi pengawetan kering peningkatan kekuatan hanya pada umur 7 hari. Bagi ujian mampatan, didapati penggunaan gentian dalam mortar bagi kiub dan plat telah mengurangkan kekuatan mampatan diantara 18% hingga 50% untuk pengawetan basah dan 25% hingga 33% bagi pengawetan kering. Secara umumnya penambahan gentian tandan kelapa sawit dalam mortar dapat meningkatkan kekuatan lenturan tetapi tidak dalam kekuatan mampatan.

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B.M	-	Bending Moment
BS	-	British Standard Institute
FFB	-	Fresh Fruit Bunch
MOR	-	Modulus Of Rapture
MS	-	Department of Standards Malaysia
OPC	-	Ordinary Portland Cement
POEFBF	-	Palm Oil Empty Fruit Bunch Fibre

CHAPTER 1

INTRODUCTION

1.1 General

The palm oil industry in Malaysia started 80 years ago in a modest way. Today it is the largest in agricultural plantation sector, exceeding rubber plantation by more than double in area planted. In terms of hectare, the total area under palm oil cultivation is over 2.65 million hectares, producing over 8 million tones of oil annually. The oil consists of only 10% of the total biomass produced in the plantation. The remainder consists of huge amount of lignocelluloses materials such as palm oil fronds, trunks and empty fruit bunches. The projection figures of these residues are as follows:

i) 7.0 million Tones of palm oil trunks.
ii) 26.2 million Tones of palm oil fronds.
iii) 23% of Empty Fruit Bunch (EFB) per tone of Fresh Fruit Bunch (FFB) processed in palm oil mill.

Recent report shows that the mesocarp fibre and shell are used as boiler fire source to produce steam and generate power. Empty fruit bunches are mainly

incinerated to produce bunch ash to be distributed back to the field as fertilizer .The empty fruit fibre (EFB) was identified as the first of the series of standards on palm oil fibres. The (EFB) has the highest fibre yield and is the only material commercially utilized for fibre extraction but there are good potentials for the exploitation of the other two materials (palm oil fronds and trunks). The critical parameters affecting the quality of the end product of palm oil fibre include the fibre length, moisture content, oil content and impurities [1].

1.2 Properties of palm oil fibre

The palm oil fibre which is derived from the palm fruits consists of a series of thin strands and leathery skin which surrounds the kernel and provides reinforcement for the outer fleshy part of the fruit. The fibres are obtained as waste products after the palm oil and kernel has been extracted in the oil mills. The fibre length varies between 10 to 40 mm while the diameter varies from 3- 70 µm [2]. Different properties of palm oil fibres are shown in Table 1.1 and Table 1.2 while Figures 1.1 to 1.3 show palm oil fruit bunch fibre.

Table 1.1 Morphological properties of palm oil fibre [3].

Properties	**Empty fruit bunch fibre**	**Palm oil frond fibre**	**Palm oil trunk fibre**
Diameter of fibre (µm)	12.50	15.10	20.50
Diameter of lumen (µm)	7.90	8.20	17.60
Runkel ratio	0.59	0.84	0.26
Area of fibre (μm^2)	75.60	126.20	86.70

Table 1.2 Chemical compositions of palm oil components [4].

Plant fibre	Cellulose (%)	Hemicelluloses (%)	Lignin (%)	Extractives (%)
Empty fruit bunch fibre	47.9	17.1	24.9	3.7
Palm oil frond fibre	42.2	26.4	22.3	3.3

Figure 1.1 Palm oil fruit bunch

Figure 1.2 Empty fruit bunches in oil mill

Figure 1.3 Palm oil fibre after extracting from empty fruit bunch

1.3 Usage of palm oil fibres in cementitious composites

It is obvious that palm oil fibres have been a target of various studies in Malaysia as well as throughout the world. It is no surprise that the fibres derived from various components of the palm tree have not so far found a solid economic value. Thus, finding useful applications for these materials will surely alleviate environmental problems related to the disposal of palm oil wastes and produce materials that could offer a favorable balance of quality, performance and cost [5].

Natural fibre reinforced concrete (including cement paste, mortar and other cement based matrices) is essentially a special purpose concrete which consist of small diameter discontinuous, discrete natural fibres of different origin randomly distributed in a cementitious matrix. The uniform dispersal of fibres in a cementitious matrix distributes stress and enhances resistance to cracking, impact and shock loading and also improves ductility for better energy absorption. This new distinct group of construction materials possesses good acoustic and thermal properties [6].

The use of natural fibres in concrete is relatively recent in spite of the fact that the concept of fibre reinforcement was recognized more than fifty years ago and now utilized it has been more traditional than technical. They have long served many useful purposes but the application of materials technology for the utilization of natural fibres as the reinforced in concrete has only taken place in comparatively recent years. In the late 1960s and 1970s, investigations began on the possibility of using organic fibres of various origins as reinforcement in thin concrete sheets and other cement-based composites. These investigations soon indicated the possibility of manufacturing products of natural fibre reinforced concrete [6]. Figure 1.4 describes in more details the most important fibre characteristics of interest in fibre reinforced cement composite [7].

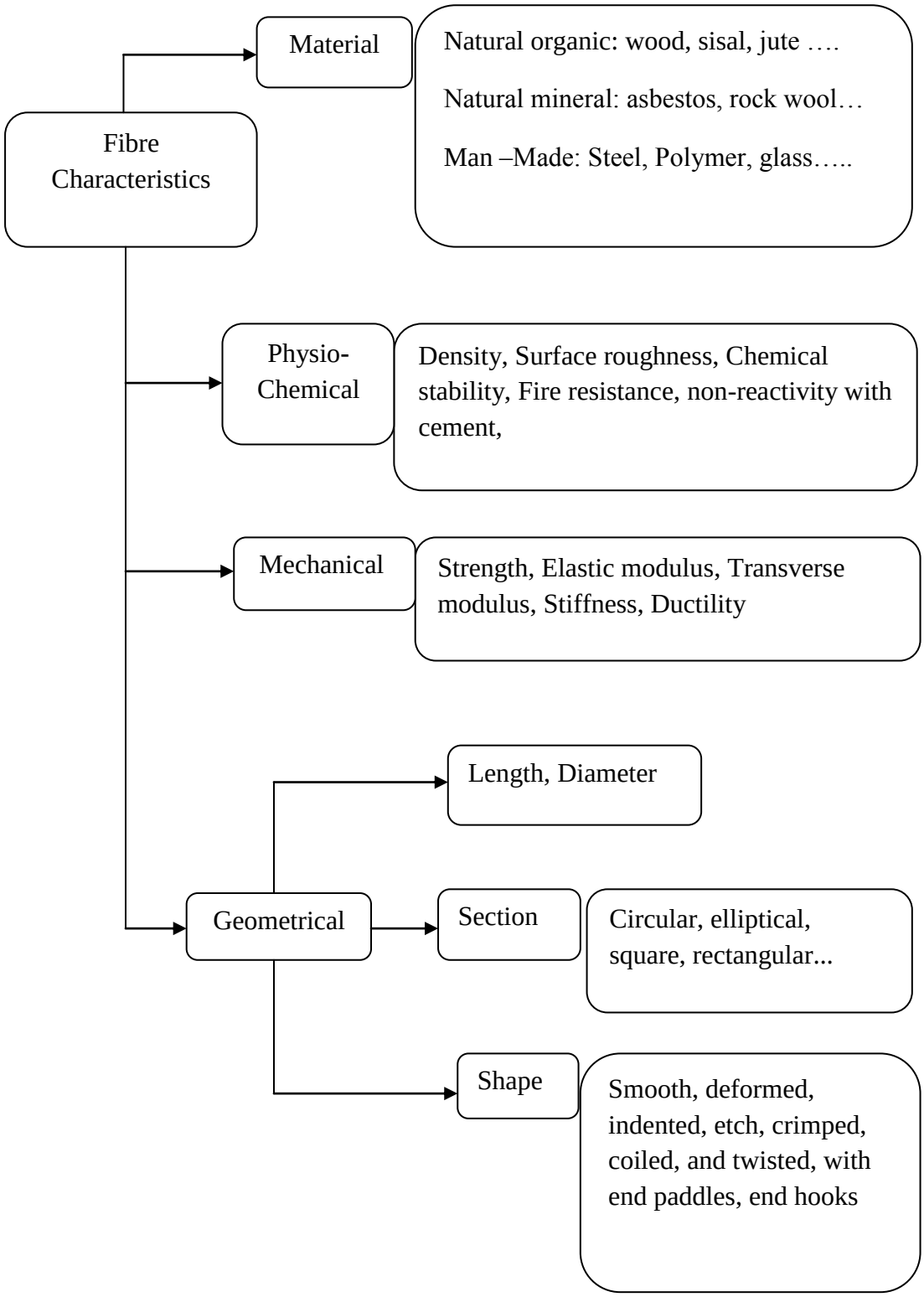

Figure 1.4 Main fibre characteristics of interest in fibre reinforced cement composites

Natural fibres are available in most developing countries (e.g. Malaysia) and require only a low degree of industrialization for their processing. In comparison with an equivalent volume or weight of the most common synthetic reinforcing fibres, the energy required for their production is small and hence the cost of fabricating these composites is also low. In addition, the use of a random mixture of natural fibres in cementitious matrix leads to a technique that requires only a small number of trained personnel in the construction industry.

There are different technologies to produce fibre reinforced cementitious material which classified as [8]:

i) Premix process: In this method the fibres are combined with the cementitious matrix in a mixture. They are treated simply as an extra ingredient in the most common method of producing a cementitious mix. However, because of the fibres reduce the workability, only up to about 2% fibres by volume can be added by this way.
ii) Spray up process.
iii) Shotcreting.
iv) Pulp up process: The fibre is dispersed in cement slurry, which is then dewatered to produce thin sheet materials.
v) Hand lay up: In this method, layers of fibres in the form of mats or fabrics can be placed in moulds, impregnated with cement slurry, and then vibrated or compressed, to produce dense materials with very high fibre contents.

1.4 Problem Statement

A major factor contributing in slow development to make natural fibre(palm oil fibre) ready or automatic choice as reinforcing medium in cement matrix is the

lack of information on the structure and properties of natural fibres, their compatibility with the various matrices and the properties of composites itself. In spite of the fact that there are also sufficient researches and practical experience in the use of natural fibres in cement based matrices and by comparison with synthetic fibres, natural fibre reinforced mortar have not yet enjoyed the same sort of development and applications they deserve.

Natural fibres in general have many problems for example the hemicelluloses inhibit the normal setting and strength development properties of the cement matrix and decomposition of the fibre is much faster in an alkaline medium than the water which the pore water of an Ordinary Portland Cement is saturated with alkali ions [9].

1.5 Aim and objectives

In order to find out part of solution of these problems, there is a need to explore the interaction between fibres and cement matrix by focusing on different parameters controlling these relationship which included properties of fibre and contribution of fibre to resist the bending and compressive stresses. In this research the fibre was used without previous chemical or physical processing, besides changing the percentage of it in each mix.

The objectives of this project are:

i) To study the effect of adding (palm oil empty fruit bunch fibre) with different percentage to the mortar under bending and compressive stresses.

ii) To study the effect of curing condition to fibre reinforced mortar.

iii) To investigate the failure mode of fibre reinforced mortar and the relationship between failure mode and fibre distribution.

1.6 Importance of the study

Usage of natural fibres in concrete matrices poses a special challenge to science and technology. Their usage can save energy, conserve scare resources and protect environment beside alleviating the housing problem and enhancing a country's infrastructure. Natural fibres have thus a unique irreplaceable role in the ecological cycle and their natural abundance, plentiful supply, relative cheapness and swift replenish ability are the strongest arguments to utilize them in the construction industry [9].

Currently, in developing countries (e.g. Malaysia) and elsewhere there is a resurgence of interest in natural fibres, this project use palm oil empty fruit bunch fibre (POEFBF). This has brought about by the energy crisis, a general oversupply and hence relatively cheap source of fibres which in Malaysia the empty fruit bunch consider as waste after exploited it, in addition the need to reduce foreign reserve expenditures on importing other fibres. The need for cheaper building materials and the need to replace asbestos fibres on health ground have also produced a renewed interest in the application of vegetable fibres to produce low cost building elements [10].