COCONUT FIBER REINFORCED WALL PANELLING SYSTEM

MOHD HISBANY BIN MOHD HASHIM

UNIVERSITI TEKNOLOGI MALAYSIA

UNIVERSITI TEKNOLOGI MALAYSIA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA

JUDUL: COCONUT FIBER REINFORCED WALL PANELLING SYSTEM

SESI PENGAJIAN: 2004/2005 II

Saya MOHD HISBANY BIN MOHD HASHIM
(HURUF BESAR)

mengaku membenarkan laporan projek (PSM/Sarjana/Doktor Falsafah)* ini disimpan di Perpustakaan Universiti Teknologi Malaysia dengan syarat-syarat kegunaan seperti berikut:

1. Laporan Projek Sarjana adalah hakmilik Universiti Teknologi Malaysia.
2. Perpustakaan Universiti Teknologi Malaysia dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan projek sarjana ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (4)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi /badan di mana penyeledikan dijalankan.
☑	TIDAK TERHAD	

(TANDATANGAN PENULIS)

Alamat Tetap:
NO.12A LORONG PAUH JAYA ¾
TAMAN PAUH JAYA
13700 PRAI, PULAU PINANG

Tarikh: 4/4/2005

Di sahkan oleh

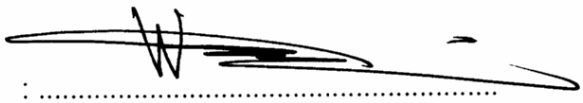
(TANDATANGAN PENYELIA)

PROF. IR. DR. HJ. MOHD WARID HJ. HUSSIN

Tarikh: 4 April 2005

CATATAN: * Potong yang tidak berkenaan.
** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu

"I/~~We~~* hereby declare that I/~~we~~* have read this project report and in my/our* opinion this project report is sufficient in terms of scope and quality for the award of the degree of Master of Engineering (Civil – Structure)"

Signature : 

Name of Supervisor I : PROF. IR. DR. HJ. MOHD WARID HJ HUSSIN

Date : 4 April 2005

Signature : NOT APPLICABLE

Name of Supervisor II : .....

Date : .....

Signature : NOT APPLICABLE

Name of Supervisor III : .....

Date : .....

* *Delete as necessary*

COCONUT FIBER REINFORCED WALL PANELLING SYSTEM

MOHD HISBANY BIN MOHD HASHIM

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

APRIL 2005

I declare that this project report entitled "Coconut Fiber Reinforced Wall Panelling System" is the result of my own preliminary research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : MOHD HISBANY BIN MOHD HASHIM

Date : 04 April 2005

TO MY BELOVED PARENT,

HJ. MOHD HASHIM BIN ISMAIL

AND

HJH. CHE NAH BINTI HJ. MOHD YATIM

ACKNOWLEDGEMENT

In preparing this project report, I wish to express my sincere appreciation to my main supervisor, Professor Ir. Dr. Hj. Mohd Warid bin Hj. Hussin, for encouragement and guidance in contributing towards my understanding and thoughts.

I would like to thank Mr. Leow Yuen Fooi from Boral Plasterboard (M) Sdn Bhd for his contribution on the ideas and materials namely, gypsum plasterboard and coconut fiber used in this investigation. My thank is also extended to the carpenters from Alor Star, Encik Piji and Encik Azam that bring in the energy to help me in preparing the samples. Also, the lab technicians at Heavy Structural Lab of Faculty of Civil Enginering, Universiti Teknologi Mara, Pulau Pinang for their assistance in highlighting on the uses and condition of equipment and facilities at the laboratory.

My fellow graduates students and colleagues should also be recognized for their supports in their invaluable views.

I promise that I will never fail to remember how very grateful I am to all my family members. My parents for their relentless prayer. My wife, Robiha Md Sabirin and my three boys, Nazhif, Naufal and Nudzran for their patient and tolerant in allowing me to complete this report.

ABSTRACT

A new material for wall boards in a composite of cement, gypsum and coconut fiber as reinforcement is expected to be developed as replacement to brick layering or to be used with the existing gypsum boards. Gypsum which is obtained from crushing or calcining of natural gypsum, extracted from quarries has an advantage of early hardening and fine finish, but it is limited to internal used due to its sensitivity to water. Hardened Portland cement is strong and durable, but it does not possessed early hardening or finishing characteristic for pre-cast components of building material. The performance of eight flat board plates of 0.45 and 0.55 water/binder ratio with certain percentage of coconut fiber ranging from 2% to 4% of weight of cement are tested for bending strength (flexural), compression strength, density , moisture content and water absorption according to the procedure in BS 5669: Part 1 for particleboards. The sizes of specimen tested are 650 mm x 100 mm x 25 mm for bending, 160 mm x 40 mm x 40 mm for compression, and 100 mm x 100 mm x 40 mm for density, moisture content and water absorption. Specimens are cured under water for maximum 28 days before testing at 3, 7 and 28 days. It is found that addition and increase of coconut fiber do not contribute to bending strength. Compressive strength increases with addition of coconut fiber, even tough compressive strength decreases with increases in water content. Increasing water content does increase the density. Densities increase with lower water content of coconut fiber. The densities are less than normal concrete at 2400 kg/m^3 and comparable to other new wall materials between 600 kg/$m^3$to 1800 kg/m3. There is no significant change of moisture content with coconut fiber. Moisture content increases with time. There is also no significant effect to water absorption on increasing coconut fiber content. Hence, it indicates that the formulation can resist the penetration of water better.

ABSTRAK

Sejenis produk baru untuk kegunaan pembuatan dinding yang mengandungi komposit bercampur simen, gypsum, dan sabut kelapa (gentian kelapa) sebagai tetulang adalah diharapkan dapat dibangunkan sebagai pengganti kepada cara lama penyusunan batu bata atau untuk digunakan dalam dinding pelapis gypsum sedia ada. Gypsum didapati daripada proses penghancuran atau 'calcining' batuan gypsum asal yang dikeluarkan daripada kuari mempunyai keistimewaan cepat mengeras dan kehalusan rupa permukaan , tetapi ianya terbatas untuk kegunaan dalaman kerana sentisif terhap air. Simen yang telah keras adalah kuat dan tahan lama, tetapi tidak mempunyai sifat cepat mengeras atau rupa permukaan yang halus. Keupayaan lapan jenis spesimen rata yang mempunyai nisbah air kepada bahan 0.45 dan 0.55 serta dicampurkan beberapa peratus gentian kelapa berdasarkan berat simen yang digunakan, telah diuji untuk kekuatan lenturan, kekuatan mampatan, ketumpatan, kelembapan dan penyerapan air mengikut piawaan BS 5669: Bahagian 1. Ukuran spesimen yang digunakan adalah 650 mm x 100 mm x 25 mm untuk lenturan, 160 mm x 40 mm x 40 mm untuk mampatan, 100 mm x 100 mm x 40 untuk ketumpatan, kelembapan, penyerapan air. Spesimen diawetkan didalam air selama 28 hari dan diuji untuk 3, 7, dan 28 hari. Adalah didapati menambah dan meningkatkan kuatiti gentian kelapa tidak memperbaiki kekuatan lenturan. Kekuatan mampatan meningkat dengan penambahan gentian kelapa walaupun kekuatan mampatan menurun dengan kenaikan kuatiti air. Ketumpatan meningkat dengan peningkatan kuantiti air. Ketumpatan didapati kurang daripada ketumpatan konkrit biasa iaitu pada 2400 kg/m^3 dan sepadan dengan bahan baru yang lain diantara 600 kg/m^3 dan 1800 kg/m^3. Kelembapan tidak banyak berubah dengan penambahan gentian kelapa. Kelembapan juga tidak banyak berubah dengan peningkatan kuantiti gentian kelapa. Oleh itu, formulasi baru ini didapati baik untuk mengawal kemasukan air.

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURES

LIST OF SYMBOLS

P	-	flexural strength
W	-	load
Y	-	span (length)
B	-	width
T	-	thickness
K_p	-	compressive strength
A	-	area
P	-	density
M	-	mass
V	-	volume
W_m	-	moisture content
M_h	-	mass
M_o	-	mass
O	-	Absorption
M_1	-	mass
M_2	-	mass

CHAPTER 1

INTRODUCTION

1.1 Background

Panelized wall paneling system is commonly used in industrialized countries such as Singapore, Hong Kong, Taiwan, Korea and Japan. The used of these types of pre-cast housing material is strongly promoted by their respective construction authority.

The main reasons for the popularity of these dry wall systems are higher productivity, site cleanliness, and improve wall finishes strength. Under the 8th Malaysian Plan, the Malaysian Government has targeted 650,000 residential units should be built by both the government and private sectors to meet the market demand [1]. The targeted units will create a huge opportunities for the demand of internal wall partition system for the bedroom, kitchen, bathroom and living rooms.

The majority of the existing internal wall partition system for residential building is made of clay bricks and cement sand bricks which require 20 mm plastering on both sides. There are readily available and cheap to construct with recognized disadvantages of heavy loading, low productivity, high wastage and requiring skill labor to install. Aerated concrete blocks are also being used. Even though this material is found to be lightweight, good fire resistance, uniform appearance, it is said to be generally brittle, weak and has high water absorption rate.

As such, the development of an alternative material such as natural fiber reinforced paneling wall is expected to offer better improvement in term of the weight (loading), speed in erection, superior finishes compare to the traditional plastering of brick wall. The application of fiber reinforced cement in plasterboards as wall partitioning has been widely accepted in the construction industries.

Basically there are two classification of fiber in the reinforcement of concrete namely synthetic fibers and natural fibers. Usually the synthetic fibers come from the family of polymer and some of the examples are glass fiber, polypropylene and Kevlar. Natural fibers can be extracted from bamboo, sisal, jute, vegetable fibers and etc [2]. Asbestos cement fiberboard is one examples of the used of fiber reinforced material. Asbestos cement fiberboard has been used in Brazil extensively even though the material is considered hazardous and damaging the environment.

A study conducted by Fadhadli [3] on the used of coconut fiber in cement sheet for roofing demonstrated significant increment of flexural strength of flat plates roofs. According to a survey conducted by the Agricultural Ministry of Malaysia [4] there are about 156,000 hectares of coconut plantation in Peninsular Malaysia alone. As such, there is a huge potential waste of these materials in this country that can be utilized for construction industry especially in the production of new material.

1.2 Problem Statement

A large amount of agricultural waste was disposed in most of tropical countries especially in Asia for countries like Thailand, Philippine and Malaysia. If the waste cannot be disposed properly it will lead to social and environmental problem.

Recycling of the disposed material is one method of treating the agricultural waste. The used of coconut fiber from the dispose of coconut shell could be a valuable material in the formation of a composite material that can be used as an

internal panel wall in housing construction. At present, there is a material made from gypsum that is used as a partition wall either in dry or wet area. However, the used of these gypsum boards involve a lot of steel bracing and bolt connections in the installation works. Moreover, the space between the layers of the gypsum boards will be void or fill up with wool in order to reduce noise and heat transfer or for insulation purposes.

As such, a new material for plasterboards in a composite of cement, natural fiber (coconut fiber) and gypsum is expected to be developed as replacement to brick layering or to be used with the existing gypsum boards.

1.3 Objective and scope of study

The main purpose of the investigation is to determine the basic physical behavior of the coconut fiber reinforced wall paneling system with cement and gypsum binder with regards to physical properties, strength and durability.

The specific aims of the investigation are:

(i) To find the optimum mix design with regards to the amount of water, fibers, cement, and gypsum ratio required.

(ii) To investigate the physical properties of the fiber reinforced boards – density (lightweight), strength (bending and compression), water absorption and moisture content

1.4 Significant of Research

(a) To show the improvement of the composite material in term of weight (density) so the material provides faster and easy erection process.

(b) To increase the amount of information on physical or behavior of the composite material.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The research activities for the last two decades has shown a considerable effort towards the application of vegetable or plants fibers which exist in abundance in the tropical and subtropical countries as reinforcing material for the production of building components. The component comprises of the combination with cement mortar or cement paste matrix. The revolution in the agricultural sector has resulted in significant increases in the quantities of agricultural by product and wastes of different types. The types of agro wastes that has been studied as reinforcement in thin and plate sections in the production of wall or ceiling boards or particles boards are coconut (shell and husks), jute, bagasse, sisal, wood, palm oil biomass to names a few. The most common product of wall partitioning system is gypsum boards.

Gypsum and Portland cement are viable cementation material used widely for the production of building materials. Gypsum is added to clinker in grinding at the end of the manufacturing process of cement to control the hardening velocity of the cement. Gypsum has an advantage of early hardening and fine finish, but it is limited to internal used due to its sensitivity to water. Hardened Portland cement is strong and durable, but it does not possessed early hardening or finishing characteristic for pre-cast components of building material.

2.2 Gypsum product

Gypsum is found in many parts of the world. Gypsum is one of the common minerals in sedimentary environment. Gypsum deposits were formed millions of years ago when salt water oceans covered most of the earth. As the deposit receded and with the process of evaporation continued, they became more and more salty. As those salts precipitated, they formed various compounds one of which was gypsum. Through millions of years processed , these salt deposits combined with decayed vegetation and other minerals, and eventually the result was stratified rock, with layers of gypsum and layers of limestone alternating, the whole covered over with many feet of glacial deposits.

The used of gypsum can be routed to many earlier years ago where the ancient Assyrians called the beautiful rock Alabaster and it was used for sculpturing. The Egyptians at five thousand years ago had learn to make plaster from gypsum where they apply gypsum to line the wall of their palaces and their tombs. Its use by the Greeks influences certainly in the name by which the rock is known. They called it Gypsos, the source of the word "gypsum." The forerunner of wallboard, plasterboard was invented in the United States in 1894 by one Augustine Sackett. A highly ingenious system, it is based on the principle of a panel sandwich made up of a gypsum core and sheets of cardboard stuck on each face.

2.2.1 Composition of gypsum

It is non-metallic mineral that composed of 79.1% calcium sulfate and 20% water by weight. It is a major rock-forming mineral that produces massive beds usually from the precipitation of highly saline waters. In chemistry term it is called calcium sulfate dehydrate with chemical formula of $CaSO_4.2H_2O$. Pure gypsum, like limestone, is white in color, however in the presence of impurities the gypsum rock may appear gray, brown, pink or even almost black.

Gypsum is produced commercially from open pit quarries. The gypsum rock would be grounded a white powder and it has to go through the process of calcinations to remove its water content to produce calcium sulfate hemi hydrate ($CaSO_4.1/2H_2O$) commonly called stucco in order to be produced for plaster or wallboards. Heating gypsum above approximately above 150^oC will partially dehydrates the mineral, by driving off exactly 75% of the water content in its chemical structure as shown in the chemical equation.

$CaSO_4.2H_2O$ + heat → $CaSO_4.1/2H_2O$ + 1 ½H_2O (steam).

The gypsum powdered can be molded into any desired shape after mixing with water where it forms a pliable, plastic mass. After which it will harden and retain that shape and recrystallize and technically has been restored to its original rock-like state.

2.2.2 Manufacturing of gypsum wallboards

The largest part of gypsum used goes into internal wallboard or drywall of offices and homes. Wallboard is made from plaster obtained from the crushing and calcining of natural gypsum extracted from quarries, or from chemical gypsum, called desulfogypsum. In the manufacturing process of wallboard, stucco from storage is first mixed with dry additives such as perlite, starch, fiberglass or vermiculite. This dry mix is combined with water, soap foam, accelerators and shredded paper in a mixer. The gypsum boards are formed by sandwiching a core of wet plaster between two sheets of heavy paper that serve as a mold. The heavy paper are continuously unwound, one unrolls under the mixer, and the other above it. The top sheet of wallboard paper closes the mold which is thus formed, and the edges are glued to the folded edges of the bottom sheet. The entire unit is laminated by a roller or a forming plate and transported to the conveyor belt, then by rollers, up to the shearing stage.

Once the plaster has set, the boards are cut to the proper length, turned over so that the wallboard paper is not damaged in the following transfer steps, then distributed among the various shelves in the dryer. Still wet at this stage, the wallboard dries for approximately 45 minutes, then it is removed from the drying oven. The sandwich will become strong, rigid, and fire proof building material called gypsum or calcium sulfate dehydrate when the cores dry out. The wallboard is then cut again to the specific length by rotary saws, assembled, then stacked in piles, depending on the thicknesses and later use. The wallboard is now ready to be distributed to the site.

Figure 2.1 shows the schematic diagram in the manufacturing of plasterboard. A typical used of gypsum board is shown in Figure 2.2 for the dry areas and Figure 2.3 for a wet area.

2.2.3 Properties of hardened gypsum board

Mixing gypsum and Portland cement is usually unfeasible because it can result in the formation of entringite or thaumasite depending on the amount of blend of gypsum which will cause expansion and deterioration in concrete [5]. Entringite is the result of blend with minor gypsum and thaumasite is the result of major component of gypsum in the blend. A definition of ettringite is found in the American Concrete Institute's "Cement and Concrete Terminology" (ACI 116R) in which ettringite is described as a mineral, high-sulfate calcium sulfoaluminate occurring in nature or formed by sulfate attack on mortar and concrete through expanding crystalline growth within the voids (or cracks) in the concrete, creating internal stresses that disrupt the concrete eventually cause loss of strength in concrete [6].

Entringite and thaumasite occurs in the forms of spalling, expansion, cracking, loss of strength and adhesion to the composite that contain gypsum. Entringite formation in general associated primarily with expansion, cracking and

spalling, whilst, thaumasite formation further aggravate the hardened composite into pulpy masses due to loss in strength [7].

It is known that gypsum with an addition of Portland cement and pozzolana has potential for developing improved durability in water environment. Study indicated that a blend of 75% gypsum plaster (calcium sulfate hemihydrate), 20% Portland Cement and 5% Silica fume as pozzolana was recommended for obtaining gypsum based material for improving resistance in humid environment [5].

Other material used as pozzolons that give similar results has been obtained for the gypsum-Portland cement blend are fly ash [8], granulated blast furnace [9,10], or natural pozzolan [11]. A study by Colak [12] recommended that gypsum - portland cement - natural pozzolan blend of composition 41:41:18 and 41:41:18S1 (with 1% superplastizer) give an excellent retention properties after ageing in water at 20^{o}C for 95 days.

The most important result was that the wet strength and the wet/dry strength ratio in the gypsum – cement – silica fume paste continue to increase compared to pure gypsum alone because of dissolution of gypsum in water over time [13]. Figure 2.4 [13] shows the difference composition ratio with regards to wet/dry strength and time of water immersion.

The results of the composition of 41:41:18 gypsum – Portland Cement – natural pozzolan are shown in Figure 2.5, Figure 2.6 , Figure 2.7 and Figure 2.8 [12]. The finding shows that there is a general increase in the density as the content of Portland Cement increases, the density of the blend decreases as the natural pozzolan content increases, increasing of superplastisizer content decreases wet/binder ratio, and increasing of gypsum content between 51% and 75% does not provide reduction in density of the blend.

The test mentioned above showed that there is a general increase in density of gypsum- Portland cement blend as the component of cement is increasing (Fig 2.5));

the increase of gypsum content leads to decrease in density and more or less stable in the range of 50% - 75% (Fig 2.6); the density of blends decreases with rising natural pozzolan content and becomes constant in the range of 20% -30% (Fig 2.7); and increasing superplasticisers permit greater water reduction (Fig 2.8).

2.3 Natural Fiber reinforced partition wall

Vegetables fibers are complex natural composite with a cellular structure The last three decades has seen many efforts by researchers in studying the application of natural fibers such as coconut fibers, bagasse, jute, flax, sisal, vegetable fibers, and cellulose fibers as reinforcement in construction material [14]. Coconut fiber has been studied in the production of thin plate concrete for replacing asbestos cement product [3] and as mortar composite [14]. A study using other part of coconut fruit, such the coconut shell has shown an encouraging result [15]. The research demonstrated that an increase in cement content to grounded coconut shell increased the bending strength and resistance to water absorption.

Great public concerned on the disposal of waste material may offer a solution to high demand of construction material due to urbanization and fast population growth that contribute to the growth of construction industry. As such, coconut fiber has the potential to be used as reinforcement in internal wall paneling system with binder component of cement and gypsum.

2.3.1 Coconut Fiber

Coconut cultivation can be found spreading across the tropical and subtropical regions between the latitudes 20^{o}N and 20^{o}S. It can be seen in most of Asia countries especially Thailand, Indonesia and India and Malaysia and the tropical climate countries like Hawaii and Fiji Islands. Coconuts are mainly cultivated on the coastal clays and sands. Coconut tress can grow up to 30 m height.