ENVIRONMENTAL EFFECT ON COMPOSITE MATERIAL

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Report submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Mechanical Engineering (Structure and Material)

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We hereby declare that we have checked
this project report and in our opinion this project
is satisfactory in terms of scope and quality for the award of the degree of
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"I hereby declare this project report is my own work base on my scope except the quotations and summaries which have been duly acknowledged"

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Date : 24 MAY 2010

Special to my beloved mama & ayah…

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ABSTRACT

One of the obstacles hindering the acceptance of composite material in engineering applications is the susceptibility of the composite to degradation initiated by moisture, temperature, and corrosive chemical environments. This thesis was conducted to investigate the environmental effect on the composites material. The primary objective of this study was to determine the flexural properties and the mechanical properties of Glass Fiber Reinforced Plastic (GFRP) after exposed to water and elevated temperatures for extended periods of time. The works done includes a thorough literature review, experiments and determine the flexural properties of the GFRP composites under different environmental conditions. Changes in the modulus of elasticity and flexural properties were evaluated through 3 point bending test machine. The experiment used the Universal Testing Machine model Instron 5585.

ABSTRAK

Satu daripada proses yang menghalang penerimaan bahan komposit didalam aplikasi kejuruteraan adalah kesan buruk komposit terhadap pengaruh kelembapan, suhu dan persekitaran bahan kimia. Tesis ini dihasilkan untuk menyiasat kesan alam sekitar terhadap bahan komposit. Objektif utama dalam tesis ini adalah untuk menyatakan keadaan sifat elastik bahan dan sifat-sifat mekanik bahan Glass Fiber Reinforced Plastic (GFRP) selepas bahan tersebut terdedah di dalam air dan pada suhu berbeza dalam masa yang tertentu. Projek ini berjalan melibatkan kajian ilmiah, eksperimen dan menyatakan sifat-sifat keadaan elastik bahan Glass Fiber Reinforced Plastic (GFRP) dibawah keadaan sekeliling yang berbeza. Perubahan nilai modulus elastik dan sifat-sifat keadaan elastik dicatatkan melalui mesin uji kelenturan tiga titik. Eksperimen ini mengunakan mesin Universal Testing Machine model Instron 5585.

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P	Applied Load
L	Span Length
b	Width
t	Thickness
E	Elastic Modulus
G	Shear Modulus
ks	Shear Coefficient
GFRP	Glass Fiber Reinforced Plastic
FRP	Fiber Reinforced Polymers
CFRP	Carbon Fiber Reinforced Polymers
AFRP	Aramid Fiber Reinforced Polymers
CSM	Chopped Strand Mat
EPMA	Electron Prove Microscope Analyzer
(σ_f)	Stress
R	Rate of Crosshead Motion
Z	Rate of Straining
D	Midspan Deflection
R	Strain, mm/mm (in./in.),
D	Depth of Beam

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CHAPTER 1

INTRODUCTION

1.1 Background of Project

Nowadays, composite materials are commonly used for structure development. Fiber Reinforced Polymers (FRP) bars has gained popularity due to their non-corrosive and non-metallic properties. Of all the different types of FRP bars available Glass Fiber Reinforced Plastic (GFRP) are the most popular to be used in engineering industry applications, especially due to their low cost as compared to the other fibers.

Extensive research has been done on durability of GFRP bars with different chemical compositions and varying environmental conditions. Results varied from the experiment specified by the exposure to a same period of time but at different environmental condition. The primary objective of this study was to determine the flexural properties and the mechanical properties of Glass Fiber Reinforced Plastic (GFRP) after exposed to water and elevated temperatures for extended periods of time. So with the result of the experiment, the environmental effect on the composites material can be analyzed.

1.2 Problem Statement

Glass Fiber Reinforced Plastic (GFRP) are the most popular to be used in engineering industry, especially due to their low cost, non-corrosive and non-metallic properties as compared to the other fibers. Glass Fiber Reinforced Plastic (GFRP), combines glass fibers (which are strong but brittle) with plastic (which is flexible) to make a composite material that is tough but not brittle. However, one of the obstacles preventing the extensive use of composites is the effect of the environmental condition to the flexural properties and the mechanical properties of Glass Fiber Reinforced Plastic. Although there have been numerous studies of environmental effect on composite material in the past three or four decades, only a few studies that dealt with durability issues for glass fiber reinforced plastic after exposed in environmental condition are currently available. That results in difficulties to achieve the designed specification of a construction. This study deals with the reaction of flexural properties and the mechanical properties of Glass Fiber Reinforced Plastic under different environmental conditions.

1.3 Objective

1. To analyze the environmental effect on composite material.
2. To determine the flexural properties and the mechanical properties of Glass Fiber Reinforced Plastic under different environmental conditions.

1.4 Scopes

Scope is the subject that is needed to be focus during performs a research. The main scopes of this research are:

1. This composite are limited to glass fiber reinforced plastic.
2. Studies through theories and literature review.
3. Fabricate test specimen by using hand lay-up process.
4. Specimens have been exposed at selected environmental condition.
5. Going through mechanical testing for materials through flexural testing.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this century, our life in advanced society mostly depends on composite materials as main material to construct any structure. These materials replace other traditional engineering material such as metal in order to achieve some performance that traditional material cannot achieve (Pendhari et al., 2007). Some example, carbon fiber is a material that comes with many advantages. Compare to alloy, carbon fiber is harder, stronger, more resistance to impact, and also very light. Same with Kevlar, it had been used in bullet-proof vest. Fiber glass that developed late 1940 is the first modern engineering composite material and it still used till today. It makes up about 65 percent of all the composites produced today and is used for boat hulls, surfboards, sporting goods, swimming pool linings, building panels and car bodies.

2.2 What Makes A Material A Composite?

Composite materials are formed by combining two or more materials that have quite different properties. The different materials work together to give the composite unique properties, but within the composite you can easily tell the different materials apart because they do not dissolve or blend into each other.

Composites exist in nature. A piece of wood is a composite, with long fibres of cellulose (a very complex form of starch) held together by a much weaker substance called lignin. Cellulose is also found in cotton and linen, but it is the 4 binding power of the lignin that makes a piece of timber much stronger than a bundle of cotton fibres (Gutkowski et al., 2007).

2.3 History of Composite Materials

Humans have been using composite materials for thousands of years. Take mud bricks for example. A cake of dried mud is easy to break by bending, which puts a tension force on one edge, but makes a good strong wall, where all the forces are compressive. A piece of straw, on the other hand, has a lot of strength when you try to stretch it but almost none when you crumple it up. But if you embed pieces of straw in a block of mud and let it dry hard, the resulting mud brick resists both squeezing and tearing and makes an excellent building material. Put more technically, it has both good compressive strength and good tensile strength.

Another well-known composite is concrete. Here aggregate (small stones or gravel) is bound together by cement. Concrete has good strength under compression, and it can be made stronger under tension by adding metal rods, wires, mesh or cables to the composite (so creating reinforced concrete).

2.4 Advantages of Composites

The greatest advantage of composite materials is strength and stiffness. By choosing an appropriate combination of reinforcement and matrix material, manufacturers can produce properties that exactly fit the requirements for a particular structure for a particular purpose.

Modern aviation, both military and civil, is a prime example. It would be much less efficient without composites. In fact, the demands made by that industry for materials that are both light and strong has been the main force driving the development of composites.

In thinking about planes, it is worth remembering that composites are less likely than metals (such as aluminum) to break up completely under stress. A small crack in a piece of metal can spread very rapidly with very serious consequences (especially in the case of aircraft). The right composites also stand up well to heat and corrosion. This makes them ideal for use in products that are exposed to extreme environments such as boats, chemical-handling equipment and spacecraft. In general, composite materials are very durable. Another advantage of composite materials is that they provide design flexibility. Composites can be molded into complex shapes – a great asset when producing something like a surfboard or a boat hull.

The downside of composites is usually the cost. Although manufacturing processes are often more efficient when composites are used, the raw materials are expensive. Composites will never totally replace traditional materials like steel, but in many cases they are just what we need. And no doubt new uses will be found as the technology evolves.

2.5 Glass Fiber Reinforced Plastic (GFRP)

Glass Fiber Reinforced Plastic is a substance composed of a plastic matrix that is embedded with glass fibers to provide strength and reinforcement. Fiber reinforced polymer is used to build architectural elements, car parts, bridges, and consumer products. Fiber Reinforced Polymer reinforcing bars are typically made up of one of three types of fibers –glass, carbon and aramid. Glass fibers are the most popular of all the fibers used for reinforcement due to their relatively lower costs. Table 1 presents some mechanical properties of the reinforcing bars made up of different fibers as compared to steel.

Table 1 –Mechanical properties [13, 14]

	Tensile Strength	Modulus of Elasticity	Density
	MPa	GPa	g/cc
GFRP	483-1035	35-45	2.58
CFRP *	600-2900	120-300	1.8
AFRP **	1000-1400	60-87	1.45
Steel	483-690	200	7.8

* CFRP is Carbon Fiber Reinforced Polymers.

** AFRP is Aramid Fiber Reinforced Polymers.

2.6 Style of Woven Fabrics

Fabrics consist of at least two threads, which are woven together: the warp and the weft. The weave style can be varied according to crimp and drapeability. Low crimp gives better mechanical performance because straighter fibres carry greater loads: a drapeable fabric is easier to lay-up over complex forms. There are four main weave styles (see Figure 1).

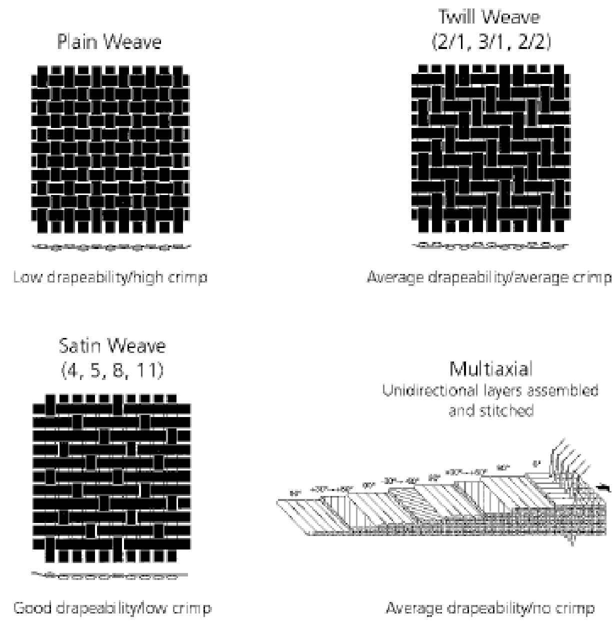

Figure 1: Weave styles

2.7 Chopped Strand Mat (CSM)

Chopped strand mat is made from E-glass fiber strands chopped to different lengths and bonded in one of two ways either powder or emulsion. It is the most common form of reinforcement. Chopped strand mat is used primarily for hand lay-up processes, filament winding and press molding of FRP products including bathroom accessories, pipes, automobiles and other building applications.

Figure 2: Chopped strand mat (CSM)

Chopped strand mat (CSM) is a non-woven material which as its name implies, consists of randomly orientated chopped strands of glass which are held together. Despite the fact that PVA imparts superior draping handling and wetting out characteristics users in a marine environment should be wary of its use as it is affected by moisture and can lead to osmosis like blisters. Today, chopped strand mat is rarely used in high performance composite components as it is impossible to produce a laminate with high fiber content and by definition, a high strength-to-weight ratio.

2.8 GFRP Fabrication: How it's made

Although all types of Glass Fiber Reinforced Plastic are composed of a plastic matrix and glass fibers, there are actually several fiber reinforced polymer manufacturing methods that are commonly used.

The first method of manufacturing Glass Fiber Reinforced Plastic is what is known as the hand lay-up method. Although very precise, this method is also quite labor intensive. In the hand lay-up method, a resin that has been combined with a catalyst is placed inside of a mold. Fiberglass is then packed into the mold with steel rollers. This process may be repeated one or more times. The resin will usually start to cure quite quickly, depending on the exact amount of catalyst used, so the task must be completed relatively fast when this method of GFRP fabrication is used.

Another common method of GFRP fabrication is the spray lay-up process. It is similar to the former method in many respects. The main difference is how the resin and glass fibers are placed into the mold. Instead of being placed into molds by hand, these substances are sprayed in. Not surprisingly, this method of fabricating fiber reinforced polymer is faster than the previous.