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# FLEXURAL TEST OF UNTREATED *ELAIS GUINEESIS* POLYMER COMPOSITES

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Bachelor of Engineering with Honours
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Title : Flexural Test of Untreated *Elais Guineesis* Polymer Composites

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# FLEXURAL TEST OF UNTREATED *ELAIS GUINEESIS* POLYMER COMPOSITES

**SAIFUL ADLI BIN YAMAN**

**This project is submitted in partial fulfillment of the requirements for the degree of Bachelor of Engineering with Honours (Mechanical Engineering & Manufacturing System}**

**Faculty of Engineering**
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**To my family**

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# ABSTRACT

The empty fruit bunch (EFB) fibre, natural fibre was combined with unsaturated polyester resin matrix, to produce advance structural composite. The composites were fabricated using random lamination with different fibre volume fraction of 40%, 50%, and 60%. An experimental investigation has been carried out to measure the behavior of empty fruit bunch (EFB) reinforced unsaturated polyester composites when subjected to flexure or three-point loading. A number of tests were carried out and the result was obtained according to the load deflections data. The largest fibre volume fraction demonstrates a high flexural stress and flexural modulus value.

# ABSTRAK

Gentian yang diperolehi daripada hampas kelapa sawit telah diperkukuhkan dengan resin poliester yang tidak tepu untuk menghasilkan komposit gentian semulajadi. Komposit ini telah dibuat dengan menggunakan campuran gentian secara rambang, pada berlainan pecahan isipadu gentian, iaitu 40%, 50%, dan 60%. Eksperimen telahpun dijalankan bagi menentukan sifat-sifat komposit gentian kelapa sawit bersama poliester tidak tepu ini berdasarkan kepada ujian pelenturan atau ujian pada bebanan tiga titik. Sebilangan eksperimen telah dijalankan dan hasil eksperimen yang diperolehi adalah berdasarkan kepada data daya pemesongan. Pecahan isipadu gentian yang paling besar menunjukkan nilai tekanan dan modulus pelenturan yang paling tinggi.

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| | | |
|---|---|---|
| b | – | Specimen width |
| D | – | Deflection of the beam |
| $E_f$ | – | Flexural modulus |
| $F_s$ | – | Shear force |
| h | – | Thickness |
| L | – | Span length |
| m | – | Initial slope |
| M | – | Bending moment |
| N | – | Newton |
| P | – | Force/Load |
| $\rho_f$ | – | Fibre density |
| $\rho_m$ | – | Fibre matrix |
| $V_f$ | – | Fibre volume fraction |
| $W_f$ | – | Fibre weight |
| $W_m$ | – | Matrix weight |
| $\delta$ | – | Centre deflection |
| $\tau$ | – | Shear stress |
| $\sigma$ | – | Normal stress |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

There are various kinds of natural fibres that suitable and easily can be found, such as wool, silk, cotton, hemp, jute, sisal, and flax. All these fibres are in fact comes from animal or plant product, which are widely used for textiles, twine, rope and clothes nowadays.

The natural fibres from the local plant will be extracted and used in this study. The oil palm crop waste is the type of plant that has been identified as a potential fibre for particle reinforced composite. Oil palm, or its scientific name *Elais guineensis*, is originated from West Africa and introduced to Malaysia in 1987 as an ornamental plant (Gurmit *et. al*, 1999). The oil palm empty fibre bunch (EFB) is the one of the fibre sources from the oil palm crops that will be used in this study. These empty fruit bunches are obtained at first stages of the milling process and the strand from the empty fruit bunches are preferred because it can be obtained during regular harvest and oil palm processing.

According to Sirim Berhad Malaysia, the empty fruit fibres (EFB) was identified as the first series of standards on oil palm fibres because the EFB has the highest fibre yields and is the only material commercially utilised for fibre extraction. Compare with the other fibres from other wood species, the EFB fibres are characteristically compatible, clean and biodegradable. These EFB fibres are suitable for the manufacture of mattress, insulation, particleboard, car seat, and composite panel product.

## 1.2 Scopes and Objective

Objectively, the flexural test is a test method for measuring behaviour of materials that subjected to three-point loading. To perform the flexural test in this study, the untreated *Elais guineensis* were used as a materials test specimen. The fibres from *Elais guineensis* or specifically known as oil palm empty fruit bunch (EFB) are extracted through a few processes before performing the flexural test without treated them with chemical solution. To achieve the objective mentioned before, ASTM D790-00 will be utilized to obtain the data regarding to flexural test properties of these natural fibres reinforced polymer composites.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Natural Fibres

According to Ghosh (2004), the natural fibres are basically classified into three groups of their origin: vegetable origin, animal or insect origin, and mineral origin. Among these, natural fibres are important in terms of production volume, industrial activity, and usage patterns. The fibres that were used in this study were the natural fibres of the local plant; oil palm empty fruit bunch (EFB) fibres.

The EFB fibres that were used in this study are the natural structure made of cellulose fibres. The strands of cellulose fibres in different plants are associated with different amounts of other natural substances such as hemicelluloses, lignin, pectinous matter, waxes, and gums (Ghosh, 2004). According to Matthew and Rawlings (1999), the fibres extracted from plants are essentially micro-composites consisting of cellulose fibres in an amorphous matrix of lignin and hemicelluloses and often have a high length to diameter ratio, called the aspect ratio, of greater than 1000. Table 2.1 shows the relative proportion of the major constituents and properties of some of the common natural fibres.

**Table 2.1: Relative Proportions of the Major Constituents and Properties of Some the Common Natural Fibres** (Matthew and Rawlings, 1999)

| | Density ($Mg/m^3$) | Cellulose (%) | Hemicellulose (%) | Lignin (%) | Young's Modulus (GPa) | Tensile Strength (MPa) | Specific Modulus [(GPa)/ (Mg/m3)] | Specific Strength [(MPa)/ (Mg/m3)] |
|---|---|---|---|---|---|---|---|---|
| Wood | 1.5 | 40 | 40 | 20 | - | 500 | - | 333 |
| Jute | 1.3 | 72 | 14 | 14 | 55.5 | 442 | 43 | 340 |
| Hemp | - | 71 | 22 | 7 | - | 460 | - | - |
| Sisal | 0.7 | 74 | - | 26 | 17 | 530 | 24 | 757 |

## 2.2 Polymers Matrix Composites

Polymers are the most common matrix materials for composites and classified into three classes, which are thermoplastic, thermosets and rubbers (Matthew and Rawlings, 1999). Irfan (1998) defined polymer as a macromolecule formed by the chemical combination of identical units called monomers. The process by which polymers are formed is known as polymerization, which occurs via addition reaction or condensation reaction. According to Matthew and Rawlings (1999), the mechanical properties of polymers are generally inadequate for many structural purposes. The strength and stiffness of polymers are lower than metals and ceramics. This means there is a considerable benefit to be gained by reinforcing polymers and the reinforcement without having exceptional properties.

### 2.2.1 Thermosets

In this study, only the thermosets polymer will be adopted. McGrum *et. al.* (1997) mentioned that thermosets polymers are those whose precursors are heated to an appropriate temperature for a short time, so that they will flow as a viscous liquid with the reaction of chemical cross-linking then causes the liquid to solidify to form an infusible mass. The used of thermosets polymer as matrices in reinforced plastics have some reason such as low viscosity at the precursors liquids that prior to cross-linking. Economical forming is possible for large component and the high softening points can be achieved in materials of only moderate cost. According to Matthew and Rawlings (1999), thermosetting polymers or thermosets are resins, which readily cross-link during curing. Furthermore, the application of heat and pressure or the additions of a curing agent or hardener are involved in the curing process.

Harper (2000) has defined resins as any class of solid, semi solid, or liquid organic material, generally the product of natural or synthetic origin with a high molecular weight and with no melting point. By gluing bundles of fibres together with resin matrices, materials are made were strong, stiff fibres are able to carry most of the stress whilst the matrix distributes the external load to all fibres as well as affording protection and preventing fibre buckling under compressive forces (Hollaway, 1994). According to Harper (2000), the important beneficial factor lies in the inherent enhancement of thermoset resins is in their physical, electrical, thermal, and chemical properties when they are exposed to severe environmental conditions. There is various kind of thermosets resin such as epoxies, polyester, phenolics, polyurethanes, polyimides, bismaleimides and vinyl ester. Only the unsaturated polyester resin will be used for fibre reinforcement polymer in this study.

### 2.2.2 Unsaturated Polyester Resins

Historically, the first polyester product produced by reacting tartaric acid with glycerol in 1847 and then prepared with well-defined polymeric structure in 1920. The commercial application of unsaturated polyester was made in 1941 and like many other fields of research and development, the development of polyester accelerated during and after the Second World War (Irfan, 1998). The thermosets polyester has been the most popular family of polymers for many years. This polyester is versatile, inexpensive, used extensively with glass fibre reinforcement and often in substantial plastic component (McGrum *et. al* 1997).

According to McGrum *et. al* (1997), thermosetting polyester is derived from the condensation effects of combining an unsaturated maleic anhydride or fumaric acid with a polyhdric alcohol. When utilised as a molding compound, this unsaturated polyester resin is dissolved in a cross linking monomer such as styrene with the addition of an inhibitor such as phenolic derivatives to prevent cross linking until the compound is ready for use in the molding process. The compounds are further enhanced with additives and use the free radical addition to polymerize the resin. The catalyst such as benzoyl peroxide and methylethyl ketone peroxide becomes the source for the free radical and with elevated temperature the heat decomposes the peroxide, producing free radicals.

Irfan (1998) has stated that the cross linking of unsaturated polyester occurs via free radical polymerisation, after addition of vinyl monomer such styrene and catalyst. The catalyst is added in concentrations of 0.5%-2.0% to initiate formation of free radicals, the amount depending on the temperature and the type of catalyst. In order to obtain a high quality product, it is desirable that the styrene and fumerate radicals react either alternately or in the proportion existing before cross-linking occurs. In commercially available unsaturated polyester, 30% styrene or vinyl monomer is present. The curing reaction converts the viscous resin to a hard thermoset within a few hours. In the absence accelerator, oxygen in the air has an inhibiting effect on the curing process, resulting in a softer surface on the product, despite the hardening of the inner portion. The use of accelerator such as cobalt naphthenate eliminates such an effect.

Hollaway (1994) stated that the polyester resins are cured via a free radical co-polymerisation reaction, which can be initiated at room temperature with the organic peroxides, by heat or radiation, such as ultra violet and visible light. It is able to cold-cure polyester resins from liquid that makes them more suitable than any other resin system for the manufacture of very large structures. The catalyst system consists of organic