# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## STUDY ON SANDWICH STRUCTURE USING BANANA PSEUDO-STEM FRP AS SKIN MATERIAL FOR ENVIRONMENT SUSTAINABILITY

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Manufacturing Engineering Technology (Design Product) with Honours.

by

**NUR SYIEFA BINTI ABD JAKFAR**

**B071410553**

**951201595084**

FACULTY OF ENGINEERING TECHNOLOGY

2017

# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Study on Sandwich Structure using Banana Pseudo-stem FRP as Skin Material for Environment Sustainability**

SESI PENGAJIAN: **2017/18 Semester 1**

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# DEDICATION

This re report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Product Design) with Honours. The member of the supervisory is as follow:

……

(Project Supervisor)

# ABSTRAK

Idea penggunaan fiber batang pokok pisang dalam struktur ‘sandwich’ dijana dan dikaji untuk membantu mengekalkan kelestarian alam sekitar. Dalam kajian ini, kekuatan mekanikal fiber batang pisang yang digunakan sebagai kulit bahan untuk struktur ‘sandwich’ telah dikaji. Polyester digunakan sebagai bahan pengikat antara kulit bahan dengan bahan teras dimana didalam projek ini bahan teras yang digunakan adalah ‘PVC foam core’. Matlamat mengutamakan aspek kekuatan struktur bahan, kos dan juga berat struktur ‘sandwich’. Kajian ini membandingkan bahan gentian kaca (fiber sintetik) yang diguna pakai secara meluas dengan fiber batang pokok pisang. Penyediaan struktur ‘sandwich’ ini memerlukan beberapa proses. Pertama adalah fiber dari batag pokok pisang diestrak dan dikeringkan. Seterusnya fiber diperkukuhkan dengan polyester dan kemudian digabungkan bersama bahan teras untuk menjadikan ianya sebuah struktur ‘sandwich’ sebagai spesimen. Kekuatan mekanikal struktur ‘sandwich’ dikaji dan dianalisis. Dari segi perbandingan kos, penggunaan fiber batang pisang pada struktur ‘sandwich’ mengurangkan hampir 50% daripada kos penggunaan fiber sintetik. Hasil kajian ini telah membuktikan kemampuan fiber batang pisang dalam penggunaan ‘sandwich’ dan ianya dijangka mampu memberi kebaikan kepada pelbagai industri antaranya adalah pembuatan kapal dan industri aeroangkasa.

# ABSTRACT

The idea of use of banana fiber in the sandwich structure are generated and researched as to assist environment sustainability. In this study, the mechanical strength of the banana pseudo-stem FRP that act as the skin material for a sandwich structure are studied. The common core used is a cross-linked PVC foam core with the polyester resin as their binder. The goal is on the focus of strength, cost and the weight of Banana FRP sandwich structure compared with the glass fiber skin material (synthetic fiber). The raw banana fiber are extracted, reinforced with the polyester resin, and then embedded with core material in fabrication process of specimens. The flexural test are carried out to study the flexural behavior of the banana FRP of sandwich structure. The main results of the bending test are load-extension and the shear core stress. The results of sandwich with the skin made banana FRP and PVC foam core presented considered high mechanical values such as maximum load. In term of cost, banana FRP sandwich panel gives nearly 50% cost reduction from the synthetic sandwich panel. This valuable results has proven the ability of the banana fiber to be used in the sandwich structure construction thus will gives the huge advantages to the various industry such as shipbuilding (boat) and aerospace.

# DEDICATION

Thanks to Allah S.WT

for giving me chance to complete my PSM.

To my beloved parents, Abd Jakfar bin Ramanoon and Masrawati bt Md Ali,

Thank you for your prayers and moral support.

To my supervisor, En Mohd Azlan bin Mohamed,

I would like to sincerely thank you

for keep encouraging me to complete this project and give me a non-stop guidance

and advices throughout this rough patch and period.

The gratefulness also goes to my co-supervisor,

Dr. Umar Al-Amani bin Haji Azlan

for supporting me throughout this project,

To my friends, I would like to thank all of you for your continuous support.

# ACKNOWLEDGEMENT

All Praise to Allah SWT The Almighty for giving me the strong endurance and strength to complete my PSM. Thanks to Him that I manage to finish my final year project even after all of the hiccup.

I am grateful to have my supervisor, En. Mohd Azlan bin Mohamed for his priceless effort in helping me whenever I find difficulties and lost. I am eternally grateful as he always giving a comments for me to make an improvement of this project. To my co-supervisor, Dr. Umar Al-Amani bin Haji Azlan who is always supporting my back, I am so blessed to have him.

Special thanks to my family, especially my loving parents for the continuous support throughout this journey.

This appreciation also goes to my friends for their time, concerns, effort and always encouraging me when preparing this report. A bounty of love and thanks to everyone that involve in my final year project directly or indirectly. Last but not least thanks to Universiti Teknikal Malaysia Melaka (UTeM) for this opportunity given. May Allah send you all His blessing.

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# CHAPTER 1
# INTRODUCTION

## 1.1 Background

The widespread use of the sandwich panel such in transportation and aerospace field has arose the concern on the environment as it used a synthetic fiber skin material. Hence this project aim to use the natural fiber skin material where banana pseudo-stem will be used as it is expected to have a comparable ability to be sandwiched to common core material.

The sandwich structure made up from the core material known as central compound and also the skin sheet. As for core material that will be used in this project is Cross Linked PVC Foam core because of its compatibility with the polyester resin that also be used as a binder. A common fiber material (synthetic) known as fiber glass will be compared to natural fiber in terms of their mechanical strength.

The main interest of this project is to know its strength, cost and weight compared to current sandwich structure. At the end, sandwich structure @ panels will be fabricated and tested. As to get the results analysis, several test will be carried out where the universal testing machine used.

## 1.2 Problem Statement

The current synthetic fiber sandwich structures are favored to the vast type of field as the results of their excellent performance on the mechanical properties. However the environment friendly aspects of the synthetic sandwich structure are very incompetent. In addition the banana pseudo-stem are often become the wasted natural sources as they are left to rot after giving its fruit and even the price are often cheap or sometimes free. Hence the idea to utilize the banana pseudo-stem and the used of it in sandwich structure as its skin material are studied so that the environment can be sustained.

## 1.3 Objective

The objective of this project is:

I. To utilize the banana pseudo-stem and the used of it in sandwich structure as its skin material so that the environment can be sustained.

## 1.4 Scope

The scopes of this project are:

I. Studying and comparing the existing or current product with the banana pseudo-stem fiber reinforced plastic.
II. Fabricate the prototype of sandwich structure using banana pseudo-stem FRP.
III. Perform flexural testing with the Universal Testing machine. Determine and analyze the mechanical properties of the sandwich structure.

# CHAPTER 2
# LITERATURE REVIEW

## 2.0 Introduction

India has the largest land under banana cultivation in the world followed by Brazil contributing about 30 % of the total world production. It is known as a giant herbaceous plant with adventitious roots and yields fruits. The yearly banana plant waste (tree trunk) will always be on the increase as a result of banana growth plantation and the high demand for banana (Ebisike et al, 2013).

### 2.1 Banana Plant

Banana is the second most consumed fruit in Malaysia. It is estimated that about 10 million banana trees are cut down every year to produce enough banana to meet the demand in Malaysia. After fruiting, the pseudo-stem dies, but offshoots will normally have developed from the base, so that the plant as a whole is known as plant that lives only up to a year or two (Internet sources; https://en.wikipedia.org/wiki/Banana ). These banana trees are then left to rot in the banana plantation and by product of the rotting process is methane gas which is one of the greenhouse gases (a pollutant).

Figure 2.1; Banana plantation (Internet sources; www.africa-uganda-business-travel-guide.com)

Figure 2.2; Banana that thrown out to be rot (Internet sources;http://www.alamy.com)

## 2.2 Fibers

Fiber or fibre is a natural or synthetic substance that is extremely longer than it is wide. Fiber are often used in manufacture of other materials and the robust engineering material usually incorporate fibers.

### 2.2.1 Synthetic Fiber

The production of synthetic fiber depends mainly on fossil fuels and needs nearly ten times more energy. Both the energy-consumption and the emissions for the production of polymers used as matrix in composites are significantly high (Begum and Islam, 2013). The list of synthetic fiber are metallic, carbon, glass fiber and many more. Fiber glass is an immensely versatile material due to its light weight, inherent strength, weather-resistance finish and variety of surface textures. It is appealing type of fiber to the aviation sector / industry. While carbon fiber can resist very high temperature up to 1000 Celsius (Internet sources; altairenlighten.com). The drawbacks of these synthetic fiber is that they are fairly expensive materials and non-biodegradable which is why the research are carried out to replace the natural fiber as an alternative for synthetic fiber.

#### 2.2.1.1 E-glass fiber strength properties

Table 2.1; E-glass strength properties

| Property | Range |
|---|---|
| Density ($g/cm^3$) | 2.5 |
| Elongation at break (%) | 5.3 |
| Young's modulus (GPa) | 29 |
| Tensile strength (MPa) | 800-1400 |

Figure 2.3; Fiberglass sheet (Internet source; www.lakesidepottery.com)

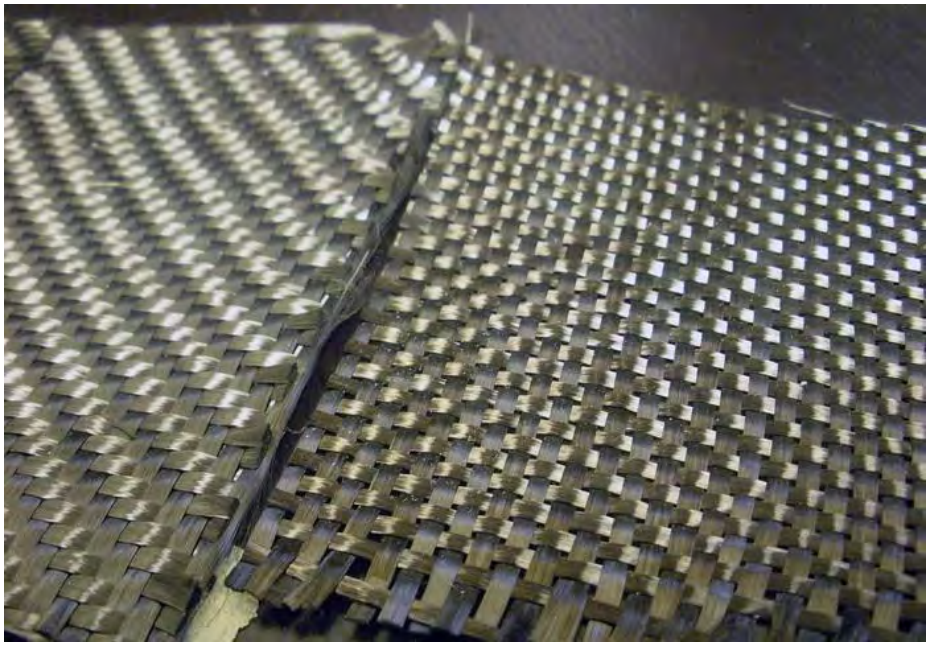

Figure 2.4; Carbon Fiber Sample (Internet source; www.audizine.com)

### 2.2.2 Natural Fiber

Natural fibers, characterized by sustainability, have gained a considerable attention in recent years, due to their advantages of environmental acceptability and commercial viability (Jusoh et al., 2016). The natural fibers are renewable, non-abrasive, bio-degradable, possess a good calorific value, exhibit excellent mechanical properties and can be incinerated for energy recovery have low density and are inexpensive. This good environmental friendly feature makes the materials very popular in engineering markets such as the automotive and construction industry thus proved their advantageous to the industry. (Ramesh et al., 2014).

Natural plant fibers' usage in mass industries such as automotive, construction, sports and medicine has already seen rapid increase due to its good properties such as high tensile strength, acoustic insulate, light weight, low cost, and more importantly less health risk. From the various studies, plant fibers has found to be had a good mechanical properties which almost equivalent with glass fibers (Mathivanan et al., 2016).

However there are some disadvantages for natural fibers as well such as poor compatibility with hydrophobic polymer matrix. These drawbacks need several treatments to improve compatibility, such as alkali treatment and coupling agent. Moreover, alkali treatment increased the mechanical properties of the composites itself, resulting improved surface wettability of the fiber against the matrix. (Jusoh et al., 2016)

Table 2.2; Natural Fiber Reinforced Composites properties

| **Fiber** | **Matrix Material** | **Resin Comp.** | **Fabrication** | **Ref.** |
|---|---|---|---|---|
| Kenaf | Polyethylene & Polypropylen e | 30, 67, 3 wt% | Hot press molding | [21] |
| Kenaf | Epoxy | 90% | Hand lay-up | [23] |
| Banana | Bisphenol epoxy based Vinyl ester | - | Hand lay-up | [24] |
| Hemp | High Density Polyethylene HDPE | 70%,80%, 90% | Injection molding | [25] |
| Wood Dust | Epoxy + Hardener (10:8) | 0, 2.5, 5, 7.5, 10, 12.5, 15 (wt%) | Vacuum glass chamber | [26] |
| Jute | Epoxy | 100, 88, 76, 64, 52(wt%) | Hand lay-up | [27] |

Natural fibers often specify as vegetable fibers are classified into three categories where it depends on the part of the plant they are extracted from. The first one is fruit fibers that are extracted from the fruits of the plant and usually they are light, hairy and allow the wind to carry the seeds. Cotton which are widely used for textile industry and coconut fiber that used as rope, fishing nets and mattresses is one of them. Next is bast fibers (stem fiber) which are found in the stem of the plant. The Banana, Jute, Flax, Ramie and Hemp is the famous fiber of stem fibers. Jute is used as carpet backing and ropes etc., Flax as linen and canvas, Ramie for curtains,

wallpaper and furniture cover and Hemp used as rope production, fire hoses and textile. Lastly is leaf fibers where it extracted from the leaves thus it rough and sturdy fiber which sisal is one of them. (Internet sources; http://www.fao.org).

Figure 2.5; Abaca Fiber (Internet sources; www.save-on-crafts.com)

#### 2.2.2.1 Natural Fiber Application

Natural Fiber is used in Mercedes-Benz in order to achieve higher performance of the door panels which applied at Mercedes-Benz E-Class and the new M-Class and the R-Class. The previous fiber of the door panels is the wood fiber. This replacement savings the weight up to 30% which is found to be a remarkable achievement. (Internet sources; www.naturalfibersforautomotive.com)

Figure 2.6; Rug made from Jute Fiber (Internet source; www.overstock.com)

Figure 2.7; A scarf that made from bamboo yarn (Internet source; en.wikipedia.org)