

# MECHANICAL PROPERTIES AND FAILURE ANALYSIS OF BEMBAN FIBRE REINFORCED THERMOPLASTIC MATRIX COMPOSITE UIGOU DAYANG MA'ASITAH BINTI ABANG ABDUL RAZAK

# BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY WITH HONOURS

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## Faculty of Mechanical and Manufacturing Engineering Technology



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**Bachelor of Mechanical Engineering Technology with Honours** 

#### MECHANICAL PROPERTIES AND FAILURE ANALYSIS OF BEMBAN FIBRE REINFORCED THERMOPLASTIC MATRIX COMPOSITE

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#### UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

#### DECLARATION

I declare that this thesis entitled "Mechanical Properties And Failure Analysis On Bemban Fibre Reinforce Thermoplastic Matrix Composite" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



#### APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology with Honours.



#### DEDICATION

In the name of Allah S.W.T, the most gracious and merciful,

I dedicate this project to my beloved parents,

Abang Abdul Razak bin Bujang Amin & Kalsum Bee binti Mohd Yusuf,

And my siblings.

To my one and only husband, Syed Amir Syahmi bin Syed Abdullah for his support.

Not to be forgotten, my supervisor, Ts. Dr. Mohamad Haidir bin Maslan for guiding me through this PSM. اونيونر،سيتي نيكنيكل مليسيا ملاك

#### ABSTRACT

The purpose of this research is to look into the mechanical properties and failure analysis of Bemban fibre and thermoplastic polyamide turned to composite. The main objectives for this of this this research is to study the mechanical properties of Bemban mix with thermoplastic and effect of water absortion, to investigate the effects of various mixture combinations on the mechanical characteristics of thermoplastics with Bemban and the effect of water absorption and to investigate the failure process of Bemban reinforced thermoplastic. The main material used in this project is Bemban fiber and thermoplastic. Bemban fiber is processed from raw material to get the fibre by using a manual extraction method and grinding the fiber in order to get perfect short size fiber. Mixture ratio of Bemban and polyamide is 1:10, 1:5 and 1:1 by using hot press machine by using moulded with size of 250 mm x 250 mm x 3 mm. After the composites is ready to be cut, two composite mixture samples will undergo a tensile test to get the result for mechanical properties based on ASTM test standards. One of the samples will undergo a water absorption method. It is expected that tensile properties Bemban fibre will increase with increase of fibre fraction. In this study, ratio with 1:1 shows the best plotted line graph and help matrix in strengthen the composite. In this study, matrix itself is already strong enough even without the help of fiber.

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#### ABSTRAK

Tujuan penyelidikan ini adalah untuk melihat sifat mekanik dan analisis kegagalan serat bemban dan poliamida termoplastik yang berubah menjadi komposit. Objektif utama penyelidikan ini adalah untuk mengkaji sifat mekanikal campuran bemban dengan termoplastik, untuk menyiasat kesan pelbagai kombinasi campuran pada ciri mekanikal termoplastik dengan bemban dan kesan penyerapan air dan untuk menyiasat proses kegagalan termoplastik bertetulang bemban. Bahan utama yang digunakan dalam projek ini adalah serat bemban dan termoplastik. Serat bemban diproses dari bahan mentah untuk mendapatkan serat dengan menggunakan kaedah pengekstrakan manual dan mengisar serat untuk mendapatkan serat ukuran pendek yang sempurna. Nisbah campuran bemban dan poliamida adalah 1:10, 1: 5 dan 1: 1 dengan menggunakan mesin tekan panas dengan dibentuk dengan ukuran 250 mm x 250 mm x 3 mm. Setelah komposit siap dipotong, dua sampel campuran komposit akan menjalani ujian tegangan untuk mendapatkan hasil untuk sifat mekanikal berdasarkan standard ujian ASTM. Salah satu sampel akan menjalani kaedah penyerapan air. Dijangkakan bahawa sifat tegangan Serat Bemban akan meningkat dengan peningkatan pecahan serat. Dalam kajian ini, nisbah dengan 1: 1 menunjukkan graf garis plot terbaik dan matriks bantuan dalam menguatkan komposit. Dalam kajian ini, matriks itu sendiri sudah cukup kuat walaupun tanpa bantuan serat.

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## LIST OF SYMBOLS AND ABBREVIATIONS

ASTM	-	American Standards Testing and Materials
FRP	-	Fibre-Reinforced Plastic
MMC	-	Metal Matrix Composite
РМС	-	Polymer Matrix Composites
CMC	-	Ceramic Matrix Composite
C/C	-	Carbon-Carbon (C/C) Composites
NFPC	-	Natural Fiber Polymer Composites
°F	-	Fahrenheit
%	- 14	Percentage
Ε	A TEKINA	Young Modulus
	ملاك	اونيۇم سيتي تيڪنيڪل مليسيا و
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#### **CHAPTER 1**

#### **INTRODUCTION**

#### 1.1 Introduction

Composites has been used since long time ago, and it all started with natural fibres. During the ancient Egypt time which back to 3000 years ago where the uses of straw and clay were mixed to help to build the walls (W.D. (Rik) Brouwer, 2003). Bledzki and Gassan (1999) has reported that the natural fibres were used during 1908 in the fabrication of sheets, where paper or cotton was used to reinforce sheets made of phenol- or melamineformaldehyde resins. Over the last decade, the polymer composites reinforced with natural fibre have been demanding from the academic world and industries. Natural fibers are sustainable materials which are available in nature. Natural fibres also known with low-cost material, lightweight, renewability, biodegradability and high specific properties compared to synthetic composites. Natural fibre composites combine plant-derived fibres with a polymeric matrix. The natural fibre component may be wood, sisal, hemp, coconut, cotton, kenaf, flax, jute, abaca, banana leaf fibres, bamboo, wheat straw or other fibrous material, and as for the matrix can be a polymeric material like thermoset and thermoplastic.

In today's environment scientists around the world are concerned to the protection of the atmosphere and the pollution, engineers and scientists are increasingly turning to natural fibre as a reinforcement polymer matrix composite to create low-cost construction materials and for environment safety. Researchers has been done to develop new material for construction, furniture, packaging and automotive industries. Malaysia riches with natural fibre plant that already been discovered, meanwhile there is a lot potential of natural fibres that still under research such as Bemban and Rattan. Bemban stem are included in the stem fiber. In this experiment Bemban will be reinforced with thermoplastic to analyse the failure of the mechanical properties by tensile test.

#### **1.2 Background of The Studies**

Bemban is also known as Donax Canniformis (*Wikipedia January 2022*). Bemban characteristics comes with dark greenish stem with diameter of 1 - 2.5m and with height of 1 - 2.5m which the sizes of the leaves can grow up to  $10-25 \ge 10-45cm$  (*Flora of China*). This plant usually grows in swampy areas and wet land areas. Bemban area popular in some of countries, especially Asian countries such as Malaysia, Thailand, Cambodia, Indonesia, Philippines, Taiwan and up to west area which is India.

Bemban stem are included in the stem fiber. The bemban reed thrives in wetland areas along streams or on hilly terrain. Water or marsh bemban (bemban air or bemban paya) grows closer to water, is more delicate, and is only used in mats. A closely related species, the Bemban batu or Bemban bukit (stone or hill bemban), is tougher and can be found at higher ground and it used to make basket. This plant usually grows in swampy areas and wet land areas. Figure below shows the Bemban plant.



**Figure 1.1: Bemban Plant** 

The traditional beliefs of Bemban always have been use in certain ways which is the roots will be boiled and the water are used as antidote for snake bites and for blood poisoning. Other than that, juice from young curled up leaves used for sore eyes, juice from crushed roots used for fungal infections and infusion of young shoots drunk for treatment of fever (Philippines Medical Plants 2022 May).

Bemban also famous in Borneo Malaysia, the women loves to to make good Bemban mats with awesome patterns. In order to have the beautiful mat that comes from Bemban, there are few steps need to be done. Initially the stem's of Bemban need to be cut from the main stem of the plant. The outer surface of the stem were ripped for weaving purposes.



Figure 1.2: Stem Of Bemban Weaving Into Basket



Figure 1.3: Bemban Matress

#### **1.3 Problem Statement**

The advantages of using natural fibre composite are cost-effective, the sustainability and strengthness. Bemban's are one of the natural fibre. Bemban is a potential natural fibre that still under research for future reference. Bemban are easy to get in Malaysia especially in Borneo, Sabah and Sarawak. It is cheap and affordable. This plant has been used by traditional community for roof construction, furniture and handcrafts. Bemban plant has a high strengthness and resistance to tropical environment, this advantages make the Bemban to be a good natural composites. In order to commercial this composite, few tests need to be run to identify the mechanical characteristics and to analyse the failure of Bemban reinforce with thermoplastics.

A tensile test will be done to examine the failure of this composite by using following the criteria of America society for Testing and Materials (ASTM). The results will be used to analyze the mechanical properties of unretter long fibre composites. However, the problem arises during extraction of the Bemban stem, the fibre will get split, these splits in the cuticle can travel up the rest of the length of the fibre and lead to breakage Therefore, the desire requirement for the length from ASTM cannot be fulfilled. There are few methods to extract the fibre which is by mechanical extraction, chemical extraction, retting process. In these experimental studies, manually extraction process are the suitable and cheapest that can be used to.

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#### 1.4 Objectives

- 1. To study the mechanical properties of Bemban fibre reinforced thermoplastic and effect of water absorbtion.
- 2. To investigate the effects of various mixture combinations on the mechanical characteristics of thermoplastics with Bemban and effect of water absorbtion.
- 3. To investigate the failure process of Bemban reinforced thermoplastic.

#### 1.5 Scope of Research

- This study uses Bemban fibre as composite reinforcement. Bemban Fiber was self processed from fresh Bemban stem.
- Thermoplastic was used as composite matrix. This study the effect of different matrix to reinforcement ratio from 1:10, 1:5 and 1:1 also it will be compared with samples that soak in water for 24 hours.
- Two mechanical test were choosen, the tensile and impact test upon mixture of Bemban fibre with thermoplastic ASTM D3039 by using Universal Testing Machine.

#### **CHAPTER 2**

#### LITERATURE REVIEW

#### 2.1 Introduction

In order to get a smooth outcome in this chapter, multiple readings must be taken before beginning the experiment tensile and impact test on Bemban + Thermoplastics. This literature review will ensure that any data on Bemban and thermoplastics is gathered from any relevant sources to ensure that the experiment run smoothly.

#### 2.2 Composites

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A composite is made up of two materials that have distinct physical and chemical properties. When these two ingredients are combined, a material is created that is designed to do a specific task, such as becoming stronger, lighter, or more resistant to electricity. It is combined and offer their most beneficial features to improve the result or final output. Composites are typically designed to achieve a certain goal, such as enhanced strength, efficiency, or durability.

Composites, also known as Fibre-Reinforced Polymer (FRP), are constructed of a polymer matrix reinforced with a man-made, manufactured, or natural fibre such as glass, carbon, or aramid, or another reinforcing material. The matrix protects the fibres from external and environmental damage while also distributing the load. The fibres provide strength and rigidity to the matrix, allowing it to endure cracks and fractures. Composites, also known as Fibre-Reinforced Polymer (FRP), are constructed of a polymer matrix reinforced with a man-made, manufactured, or natural fibre such as glass, carbon, or aramid, or another reinforcing material. The matrix protects the fibres from external and environmental damage while also distributing the load. The fibres provide strength and rigidity to the matrix, allowing it to endure cracks and fractures.

Composites provide a lot of benefits. Strength, lightweight, corrosion resistance, design flexibility, and durability are all essential factors.

- Durability Composites last longer than metals like steel. The two primary components of composites, fibres and resins, contribute to their strength. The load is carried by the fibres, and the weight is dispersed throughout the composite portion as needed by the resins.
- Corrosion resistance Ordinary materials can be eroded by weather and corrosive chemicals, whereas composites can survive this. As a result, it is a suitable for applications that are exposed to salt water, dangerous chemicals, temperature changes, and other hostile environments for extended periods of time.
- ★ Lightweight Composites are lighter in compared to most woods and metals.
- Versatile Composites allow for a wide range of material combinations, giving designers more design options. The materials can be customized to meet the needs of the application. Composites can also be easily shaped into complicated shapes.

#### 2.2.1 Type of Reinforcement

To improve the physical qualities of the finished composite material, reinforcement material was added to the matrix material. Mud, grease, ice, or any other substance that reduces the enforcement's capacity to bond must not be applied on the reinforcement material. The researchers primarily employed two types of reinforcement material: synthetic fibre and natural fibre.

Synthetic fibres are constructed from synthetic materials that are usually created via chemical procedures. A spinneret, which is a device that accepts polymers and forms fibres, is typically used to remove fibres throughout the chemical process. Synthetic fibres were developed as a cheaper and more easily mass-produced replacement to natural fibres by the textile industry. Because synthetic fabrics are constructed of man-made, artificial fibres, they have a number of advantages for everyday use, including cost and stain and water resistance.

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Affordable UNIV	Synthetic fibres are a cheaper alternative to natural fibres because
	most natural fibres are extremely expensive, especially in their
	purest form. Many synthetic materials, such as wool and silk, are
	imitations of natural
	fibres.
Stain Resistant	Synthetic fabrics tend to be more stain resistant, and some are even
	designed to resist staining, therefore synthetic clothing can be great
	for daily, regular wear.

Table 2.1: Advantage of Synthetic Fibre

Waterproof	and	While some natural fibres are water resistant, synthetic fibres may
Resistant	to	be manufactured to be nearly entirely waterproof, making them ideal for outdoor and rain gear.
Waterproof		

Example of Synthetic Fibre:

Polyester	Polyester is a coal and petroleum-based synthetic fabric. Polyester is
	known for its long-lasting properties. However, because the material is
	not breathable and does not absorb liquids efficiently, it is not suitable for
	use during the summer.
4	
Spandex	Spandex, often known as Lycra or elastane, is a synthetic material with
E	exceptional elasticity. Spandex is a stretchy fabric that is combined with
	a variety of fibres and used in everything from trousers to athleisure to
5	hosiery. Spandex is an anagram of the word expands, which is a fun fact.
Ravon	Rayon is a reconstituted wood pulp-based semi-synthetic fibre. Despite
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	the fact that rayon is made from plant fibres, it is classified as semi-
	synthetic due to the chemicals employed in the manufacturing process,
	such as sodium hydroxide and carbon disulphide. Rayon comes in the
	form of modal, viscose, and lyocell, and can be used to imitate silk,
	wool, and other materials.
Thermoplastic	Thermoplastic fibres are man-made fibres that are formed by extruding
	polymer ingredients through spinnerets into a filament. The most widely
	used method is melt spinning.

# Table 2.2: Example of Synthetic Fibre

Microfibers	Microfibers are extremely thin and short fibres with a diameter of less
	than 10 micrometres that are used in cleansing cloths due to their
	propensity to trap dirt. Polyester is commonly used, and they can be
	woven or non-woven.

According to Mohanty et al. (2003), in automotive parts, compared to glass composites, the composites made from natural fibres reduce the mass of the component and can lower the energy needed for production by 80 %. Natural fibres are effective at detecting sound, are more fracture resistant, and have superior energy management properties than glass fibre reinforced composites. The use of six natural fibres is prompted by a mix of environmental friendliness and economic feasibility, natural occurrences, fibre resource renewability, and biodegradability.

These natural fibres must, however, be isolated or purified from other elements (lignin, hemicelluloses, wax, and proteins) present in the respective sources before being used in composites. Natural fibres as a reinforcement phase in composites are primarily used to improve mechanical qualities and the development of lightweight materials. Natural fibres are those made from natural materials such as plants, animals, and minerals. Natural raw materials are spun into threads and yarns, which are then woven or knitted into natural fabrics. Natural fibres are divided into two types: animal-based and plant-based. Silk and wool are examples of animal-based natural fibres, while cotton, linen, and jute are examples of plant-based natural fibres can be seen from Table 2.2. Natural fibres are popular for many different reasons, as the fabric is generally more environmentally friendly and durable. Detail of advantages of natural fibre listed in Table 2.1.

Eco-friendly	Natural fibres have a lower environmental impact than
	synthetic fibres since the manufacturing process does not
	utilise as many chemicals. Because some plants demand
	more water, some natural fibres are less eco- friendly than
	others.
Absorbent	Natural fibres, both plant and animal, have a strong affinity
	for water, thus they absorb a lot of moisture. Natural fibres
	are therefore a good choice for bed sheets and towels, as
	absorbency is vital for these goods because they are used on
MALA	
a de la companya de l	dry surfaces and are used frequently.
Durable	Most plant-based fibres are extremely strong due to the
IIIo	structure of cellulose, which makes up natural materials.
*JAINO	Silk and wool, for example, are strong animal-based fibres.
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#### Table 2.3: Advantages of natural Fibre

Examples For Natural Fibres:

#### Table 2.4: Examples for Natural Fibres



Figure 2.1: Silk Fibre

Silk is a natural fibre that is used by insects to make nests and cocoons. Silkworms produce the most prevalent sort of silk. Silk is a material that is noted for its sheen and softness. It is formed mostly of a protein called fibroin.





Jute is a coarse natural plant fibre derived from the jute plant and used to weave garments such as burlap. Jute is common material for rugs and burlap sacks.

**Figure 2.5: Jute Plant** 

Bemban



Figure 2.6: Bemban Plant

The bemban reed thrives in wetland areas along streams or on hilly terrain. Water or marsh bemban (bemban air or bemban paya) grows closer to water, is more delicate, and is only used in mats. A closely related species, the Bemban batu or Bemban bukit (stone or hill bemban), is tougher and can be found at higher ground and it is used to make baskets.

## 2.2.2 Type of Matrix

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There are four types of fibre reinforced composites as shown in Figure 2.7, which is Matrix composites (MMCs), ceramic matrix composites (CMCs), carbon / carbon composites (C/C), and polymer matrix composites (PMCs). Matrix helps to hold the reinforcement in place. PMCs are divided into thermoset, thermoplastic, and elastomeric composites, which separate themselves from other varieties primarily due to their light weight. Thermosets have crosslinked polymer chains, which the result cannot be moulded. Meanwhile, thermoplastics can be heated and remelted again, this will help to reshaped into a new product and can be receycle which can help to proetct environment. What is most advantageous for thermosets is that they can be used at elevated temperatures as they do not lose structural rigidity when heated. Typical examples for thermosetting polymer matrices are polyester, vinyl ester, epoxy, phenolic, cyanate ester, polyurethane, polyimide, and bismaleimide.



Thermoplastic polymer matrices includes the polyamide, polyethylene, polypropylene, thermoplastic polyimide, thermoplastic polyurethane, polycarbonate and polyphenylene sulphide. Conjoin happened in elastomers and thermosets through a process known as vulcanization. Rubber is a well-known elastomeric material, hence elastomeric composites are commonly known as rubber composites. Elastic mechanical nature of elastomers distinguishes it from thermosets and thermoplastics. Polyester fibre reinforced hoses, aramid fibre-reinforced vehicle tyres, steel-wire, or mesh- reinforced heavy-duty truck tyres are examples of elastomeric composites. Recent advancements have also led to research into the inclusion of carbon nanotubes into rubbers in an attempt to replace carbon black or mineral fillers. Composite materials are divided into two classification systems. The first is based on the matrix material (metal, ceramic, polymer, carbon/graphite), while the second is based on the reinforcing material geometry (fibre, whisker, flake, and particulate). Four widely accepted composites are based on matrix materials:

- MMCs are composite made up of two constituent parts, which is a metal (aluminium, magnesium, iron, cobalt, or copper) known as matrix phase. The other substance could be something else entirely (oxides, carbides, organic compound). Carbide drills, tank armour, automobile disc brakes, automotive engines, and the F-16 Fighting Falcon are examples of engineering structures that contain MMC.
- PMCs are made up of a thermoset (epoxies, phenolics) or thermoplastic (polycarbonate, polyvinyl chloride, nylon, acrylics) matrix with glass, carbon and steel. Compared to CMC, the reinforcement is primarily utilised to improve fracture toughness, the reinforcement in a PMC is to offer high strength and stiffness. The advantages of PMC are low weight, high stiffness and strength in the reinforcement, greater corrosion and fatigue resistance when compared to metals. PMC examples such as bullet proof jacket, brakes, clutch linings and radio controlled vehicles.
- Carbon fibres are incorporated in a carbonaceous matrix in carbon–carbon composites (C/C). Carbon can be found in amorphous, graphite, diamond, pyrolytic graphite, carbon black, carbon nanotube and graphene. Carbon is a high-temperature material when mix in a non-oxidizing or inert environment.
- CMC is made up of a ceramic matrix with fibres of other ceramic materials incorporated in it. The advantages of CMC high service temperature limitations for ceramics, low density and chemical High strength and hardness at very high

temperatures, high service temperature limitations for ceramics, low density, and chemical inertness. CMCs are used at high temperature reliability (beyond the capability of metals) as well as corrosion and wear resistance.

#### 2.3 Natural Composites

Natural and manmade composite materials are available. Natural fibre composites are made up of plant-derived fibres and a polymeric matrix. The natural fibre component can be made of bemban, wood, sisal, hemp, coconut, cotton, kenaf, flax, jute, abaca, banana leaf fibres, bamboo, wheat straw, or any other fibrous material, and the matrix can be made of polymeric material.

Natural fibre reinforced polymer matrix has received considerable attention in recent years due to its superior properties and superior advantages over synthetic fibres in terms of its relatively low weight, low cost, less damage to processing equipment, good relative mechanical properties such as tensile modulus and flexural modulus, improved surface finish of moulded parts composite, renewable resources, abundance, flexibility during processing, and biodegradability. Natural Fibre Polymer Composites (NFPC) with high specific stiffness and strength can be made by integrating a tough and light-weight natural fibre into a polymer (thermoplastic and thermoset). Natural fibres, on the other hand, contain substantial defects and properties inadequacies.

Natural fibres (cellulose, hemicelluloses, lignin, pectin, and waxy substances) have a structure that allows moisture to be absorbed from the environment, resulting in weak fibrepolymer bonds. Couplings between natural fibre and polymer are also regarded a problem because the chemical structures of both the fibres and the matrix differ. These are the reasons for inefficient stress transfer at the contact of the manufactured composites. As a result, natural fibre changes using specialised treatments are unavoidable. A recurrent motif in these alterations is the introduction of reagent functional groups capable of responding to fibre architectures and changing their composition. As a result, fibre modifications diminish natural fibre moisture absorption, resulting in improved fibre-polymer matrix incompatibility.

NFPC are composite materials made composed of high-strength natural fibres contained in a polymer matrix, such as bemban, jute, oil palm, sisal, kenaf, and flax. Thermoplastics and thermosets are the two main forms of polymers. Thermoplastic matrix materials soften at higher temperatures and then roll back their qualities as they cool because their structure is built up of one or two dimensional moleculars. Thermoset polymers, on the other hand, are highly cross-linked polymers that cure with heat, heat and pressure, or light irradiation alone. This structure of thermoset polymers has good features such as high flexibility for tailoring desired ultimate qualities, tremendous strength, and modulus.

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The thermoplastics utilised for biofibres include polyethylene, polypropylene (PP), and polyvinyl chloride (PVC), whereas thermosetting matrices include phenolic, polyester, and epoxy resins. A range of factors can have an impact on the features and performance of NFPCs. The hydrophilic character of natural fibres, as well as fibre loading, affect composite performance. High fibre loading is usually necessary to attain good NFPC characteristics. The tensile characteristics of composites generally improve as the fibre content increases. Another key aspect that influences the properties and surface features of composites is the process parameters utilised. As a result, in order to produce the best composite features, relevant process techniques and parameters should be carefully selected.

#### 2.4 Thermoplastics

A thermoplastic is a form of plastic that softens when heated and hardens when cooled. It is made up of polymer resins. Thermoplastics are simple to recycle since it does not alter chemical properties when heated or cooled repeatedly. Fibres are used to strengthen many thermoplastic polymers. Reinforcement is used to increase physical qualities, particularly the temperature of heat deflection. The most frequent reinforcing material is glass fibres. The use of aramid reinforcement improves the wear resistance and abrasion resistance of thermoplastic polymers.



Fibers and matrix operate in tandem to create a composite material with unique qualities that benefit from the contributions of both components. Matrix polymers have also gained a lot of interest in laboratories all over the world in the years since. The following are the most common thermoplastic polymers that can be utilised with fibres.

- Polyamide polymers use glass fibres to control brittleness. Tensile strengths are increased by heat deflection temperature increases from 150 to 500°F.
- Polycarbonate compounds using 10, 20, 30 and 40% glass fibre loading have their physical properties greatly improved.

 Other polymers benefiting from the addition of glass fibres include polyphenylene sulphide, polypropylene, and polyether sulfone.

Epoxy resin, melamine formaldehyde, polyester resin and urea formaldehyde are the main thermosetting plastics. Healthy electrical insulator, strong, brittle unless reinforced is well resistant to chemicals. Adhesives, bonding of other components, used for casting and encapsulation. Depending on many factors, any product and material can be potentially or inherently toxic or safe. TPU is not necessarily toxic; is safe in many applications. It is also used for applications of biomedicine. Some factors may be causing the possible toxicity of polymers. There are several examples of thermoplastics which is:

- Polyethylene and Polypropylene
  Polyamide
  Polyvinyl Chloride
  Polystyrene
  Polybenzimidazole TEKNIKAL MALAYSIA MELAKA
- Acrylic
- Nylon
- Teflon

#### 2.5 Mechanical and Failure Properties of Natural Composite

The abundant availability and accessibility of natural fibres are the major reasons for an emerging new interest in sustainable technology. Natural fibres have recently garnered the attention of researchers as a reinforcement material due to their benefits over other wellestablished materials. They are non-toxic, non-abrasive, renewable, and inexpensive, as well
as being environmentally benign and totally biodegradable. Composite materials include some of the most advanced engineering materials today.

Running test on composite, two main thing need to be through, the mechanical properties and failure properties of composites. These two are the main major to run the test and to see the strength of the composite.

#### 2.5.1 Mechanical Properties of Natural Composite

Mechanical properties is known as the reaction of an object due to the mechanical load. Mechanical properties identified the reaction of the material during test due to certain force. Sometimes, mechanical properties can be defined as engineering properties which including the tensile strength, creep, fatigue and compressive strength (D.K.Singh, 2008). There are strong relationship between the mechanical properties and it is microstructure or structure of materials. Most of the materials can be determined by conducting from an experiment or testing, some of the relationship between stress and strain curves (Huyett, 2000). Stress strain curves will be explain advanced in point.

Young's Modulus (E) measures the material's elasticity, where it is defined as the relationship between a material's deformation and the force required to deform it. The equation of the Young Modulus is stated below:

$$E_{\rm C} = E_{\rm F} \, V_{\rm F} + E_{\rm M} \, V_{\rm M}$$

The tensile strength is used to measure the maximum stress that a material can hold. There is the limit between the plasticity and rupture zones. The fibre can be mix with any matrix such as thermoplastics, thermoset, dammar and many more. As for the fibres, Kenaf and Jute are the most popular rather than Bemban. Reza Mahjoub did prepared the tensile experienced for kenaf. The work concluded that the tensile modulus and tensile strength of unidirectional kenaf fibre-reinforced epoxy composite increased with the increase in volume fraction of kenaf fibre The aims of the study are to characterize and evaluate the physical and mechanical properties of continuous unidirectional kenaf fiber epoxy composites with various fiber volume fractions (Reza Mahjoub 2014)



Figure 2.9: Tensile strength and tensile modulus versus kenaf fibre volume content in kenaf fibre-reinforced epoxy composites (R. Mahjoub, 2014)

Meanwhile for the other side, (Januar Parlaungan Siregar 2014) has prepared the addition of 5% volume fibre with less than 0.5 mm length of fibre in unsaturated polyester composite, the result of tensile strength and tensile modulus is in range between 29.80 Mpa and 981 Mpa. The data shows that the increasing size of fibre from less than 0.5 mm to 1-2 mm increases the tensile strength of Pineapple Leaf Fibre reinforced Unsaturated Polyester composites.



Figure 2.10: Tensile properties of PALF/UP composites with different fibre length (J. P. Siregar 2014)

Figure 2.10 shows that the fibre length has a significant impact on the properties of composites. Matrix roles is important which in transferring applied load to the fibre for compiling them together. The effectiveness of a fibre reinforced composite is determined by the fibermatrix interface and the capacity to transfer stress from the matrix to the fibres (R. Karnani, 1997). To summarise, tensile strength is low when the fibre size is less than 0.5 mm because the length may not be sufficient for proper load distribution. Specimen failure is common when the necessary length for stress distribution is not available. While the Pineapple Leaf Fibre reinforced Unsaturated Polyester composites with longer fibre from 1 mm to 2 mm has the highest tensile strength and tensile modulus compared to other sizes (J. P. Siregar 2014). (kena tukar)

#### 2.5.2 Failure Properties of Natural Composites

Failure of a composite sample may occur in a specific way, but its propagation and final failure modes may differ dramatically. Most common, composite failure gets initiated internally, and it is only once failure has propagated beyond a certain extent, that changes in composite's behavior and appearance are observed. The failure of a composite sample inside it, could be, breaking fibers, development of micro-cracks in matrix, debonding between fibers and matrix and separation of different layers of a laminate. The basic failure mechanisms at the microscopic level include tensile, compressive or shear fracture of the matrix, bond failure of the fiber-matrix interface and tensile or compressive (buckling) failure of the fibers. Under observation before, many defects arise from composites materials in fibers, lamina and matrix. All of theses, exist cause of misalignment of fibres, cracks in matrix, voids in fibres and initial stress in lamina ad the result of the manufacture. These defects tend to propagate as the lamina is loaded creating an accelerated rate of failure.



Progressive failure of composite laminates due to mechanical loading is essentially a process of crack generation, propagation and interaction. The commonest crack types observed from the experiments are single material crack and bimaterial crack, and both of them may be involved in a failure process. Numerical modelling of progressive failure in composite laminates is still challenging. A reliable numerical framework for the prediction of the material performance by investigating the failure mechanism at multiple length scales is desired in engineering.



Figure 2.11: Different Tension (Left Tension Failure Modes of a Unidirectional Lamina in Longitudinal: Brittle Failure, Center: Brittle Failure with Fiber Pullout, right: Brittle Failure with Debonding and/or Matrix Cracking)



Figure 2.12: Major Types of Failure

## **CHAPTER 3**

#### **METHODOLOGY**

#### 3.1 Introduction

Methodology explains on how to conduct the experiment tensile and impact test. Based on the flow chart, which will illustrate the entire procedure from start to finish. This helps to see the progress of the experiment in this project from time to time. In every section, every method or process will be explained in detailed.



**Figure 3.1: Research Flow Chart** 

#### 3.3 Process of Raw Bemban

The process of raw Bemban was done manually to extract the fibre. The stem of Bemban were cut about 30cm length. The diameter of the stem were measured. After measure the diameter, the stem will cut into two pieces in the bark of the stem. It will be pound to ensure the surface of the stem is flat. Few equipment were used in this manual extraction, which is rolling pin, millet, scraper, and knife.

The flat surface of the Bemban will be rolled by using rolling pin to make it more flatter which to ease the activity of extracting the fibre. Next, the scraper will be use to throw the excess of the inner stem to avoid mositure that will rotten the fibre. After all the procedure were finished, extraction will be done manually. The fibres that were collected will be dried under the sun to make sure no moisture is still trap inside the fibres.



Figure 3.2: Bemban Plant Before Cut



Figure 3.3: Rolling Pin



Figure 3.4: Scraper



# Fibre Extraction Step Picture Cut the stem of Bemban with 30 cm length. Figure 3.6: Stem of Bemban After Cut Diameter of big and small stem are measured. ALAYS/A Figure 3.7: Bemban Plant Ready For Extraction Cut the stem into two pieces and pound the surface of the stem to make it flat. 6 **UNIVERSITI T** EKNIKAL M Figure 3.8: Bemban Stem Cut Into Two Extracted the fibre manually **Figure 3.9: Fibre Extracted**

## Table 3.1: Process of Bemban Fibre

#### 3.4 Sample Preparation

In the making of composite, Polyamide (PA1212-based) sintering powder is needed as the matrix of the composite. This Polyamide is compulsory for this task along with Bemban.



Figure 3.10: Polyamide Thermoplastics

This Polyamide will be mix with natrural fibre, Bemban in the specific size of mould that suitable for hot press machine. Mould for this experiment are made off from mild steel, this is because to follow the safety instruction for hot press machine. Natural fibre, which is Bemban will be grind to get the dust form or small fibre size in order to ease the procedure of mixing so that the thermoplastic and fibre will spread nicely on the mould. Before mix the thermoplastic with fibre, there is three ratio that need to be followed. The ratio that will be using for this experiment are 1:10, 1:5 and 1:1.



Figure 3.11: Moulding



Figure 3.12: Grinding Fibre



In order to put the thermoplastics and fibre together, the mould need to be applied with vaseline to ensure the thermoplastcis would not stick on the surface of the moulding metal. In this process, laminate paper also will be placed on the top and bottom of the moulding to ease the procedure of opening the mould after press on the hot machine.



Figure 3.14: Vaseline Applied On The Mould



Figure 3.15: Laminate Paper

After the process of applying vaseline on mould, the fibre will be weigh to ensure it will follow the ratio accordingly and then will be mix together with thermoplastic to be place in the mould.



Figure 3.16: Weighing The Polyamide and Bemban



Figure 3.17: Polyamide and Fibre are Mixed Together

Next, after everything is already in place, the mould will be ready to be placed into hot press machine. The setup for this experiment will take about 18 minutes to press and 10 minutes to cool down with the pressure of 20kPa. Temperature used are about 180  $^{\circ}$ C to 210  $^{\circ}$ C.



## Figure 3.18: Inserting Mould Into Hot Press Machine

Cooling down the mould is compulsory. This is because to avoid hazardous accident due to the temperature during the pressing process. After cooling down, the composite will be removed from the mould.



#### Figure 3.19: Removing The Composite



Figure 3.20: Sample In Moulding



Figure 3.21: Composites

After few times attempting of making composite, the perfect composite will be cutted by using band saw. Cutting composite size need to follow the ASTM D3039 requirement to ensure the tensile test can be run perfectly and smoothly. The composite will be measured by using ruler before cutting process, this to ensure to cut it correctly and follow the ASTM D3039 requirement.

The band saw will be used for cutting process, this is the best way or method to be used to cut the composite other that using laser cutting machine. The thermoplastics resistance will be effected if laser cutting machine are used. The reason for this is that thermoplastics can melt at temperatures of 200 °C and higher. Meanwhile laser cutting are using 600 °C temperature to cut the sample. Hence, it is not suitable to use the laser cutting machine to cut the composite.

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Figure 3.22: Cutting Composite Process

Last but not least, after cutting the composites, tensile test will be the next procedure for this project. Tensile test are required in order to know the strength of this composite. Samples are separeted into two sets. One set of the samples will be soaked into water for 24 hours, this is to study the effect of the water on the composite. Result will be disscused by using the graph that are plotted from the result of the tensile test experiment.

#### 3.5 Test

Two mechanical test were chosen for this project, the tensile and impact test upon mixture of Bemban fibre with thermoplastic ASTM D3039 by using Universal Testing Machine at a cross-head speed of 2 mm/min and a gauge length of 200 mm and will be observed with the result of the graph. This observation is to identify any failure or damage occur during the tests. All the tests were performed at room temperature. 21 samples were tested for each combination and the average values were reported. To find the effect of water absorption on the mechanical properties of composites, the tensile test was conducted with the same procedure. The water absorbed samples were dried and then used for experiments.

#### 3.5.1 Tensile Test

Tensile test is a destructive test method that determines the tensile strength, yield strength, and ductility. It determines how much force is required to break a composite or plastic specimen, as well as how far the specimen stretches or elongates to reach that breaking point. In this experiment will be conduct base on standard ASTM.



Figure 3.23: Tensile Test Machine

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#### 3.5.2 Tensile Test With Effect of Water

One of the composite applications is utilize in the water and seawater environments like boats, ships and float device of amphibious aircraft. This environment can affect the mechanical properties of composites since water can diffuse into the composites. This review is conducted to see the durability of composites in water using tensile test machine. The water absorption test for bemban mix polyamide thermoplastics composites was carried out in accordance with ASTM D3039 protocol by soaking in distilled water at room temperature for 24 hours. Prior to the experimentation, composites were placed in box covered by cotton to ensure no residual moisture remained and weighed using a precision balance. Immediately after the weighing of the composites, they were immersed in water. After 24 hours, the composite specimens were periodically taken from the water and the specimen surface was wiped using tissue paper. After that, the composite specimens were weighed to determine the mass of the water they absorbed. In the present investigation, all the composites specimen were absorbed by water around 1 to 2 grams only within 24 hours.



Figure 3.24: Composite Soak With Water



Figure 3.25: Composite Soak With Water Mixing Ratios

## **CHAPTER 4**

#### PRELIMINARY RESULT

#### 4.1 Introduction

Chapter 4 describes in details regarding the results getting from an experiment conducted. Tensile testing was conducted by using Universal Testing Machine. In this chapter, comparision will be done between normal specimen with effect of water on the specimen.

#### 4.2 Tensile Test

Main objective for this testing is to determine the strength of material due to simple stretching material. At one stage, plastic deformation is happen, material facing the damage at microstructural stages. These cause by the reducing in strain-hardening in the tensile test (Z. Marckiniak, J.L. Duncan, S.J. Hu. 2002).

## 4.3 Tensile Test Results

In order to get the specific gram according the ratio, calculation of volume, density and and mass need to be done.

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Sample of calculation :

Density : 1.14 g/cm3 V = 25 cm X 25 cm X 0.3 cm = 187.5 cm<sup>3</sup>

p = m / v

# 1.14 = m / 187.5 cmm = 213.75 g

Since the size of the mould is 213.75g by theoritical. After discussing with supervisor, 200 gram is decided to be use as the size of the mould. Sample are categorized in different type of ratio :

Sample Ratio	Fibre (Natural Fibre – Bemban)	Matrix (Thermoplastics)
1:1	100 gram	100 gram
1:5	40 gram	160 gram
1:10	20 gram	180 gram

Table 4.1: Mixing Ratio Table



Figure 4.1: Mixing Ratio

# 4.3.1 Sample With Mixing Ratio 1 : 1



Figure 4.2: Stress Strain Curve for Sample 1:1



Figure 4.3: Samples of 1:1

Table	4.2:	Mixing	Ratio	1:1
-------	------	--------	-------	-----

Sample	Elongation, ε	Stress Yield, σ	Stress Ultimate, σ	Е
	(kpa)	(kpa)	(kpa)	
1	0.028	13700	13900	266 667
2	0.040	14000	14200	400 000
3	0.026	16900	17200	400 000
Avg	0.115	44600	45300	355 556

Figure 4.2 shows tensile test results for sample with fibre and matrif mixing ratio 1:1. samples that run on the tensile test are successfully done and this ratio is giving the most good result compared to the other ratio. Yield strength occurs when the stress is the same as the amount of composite deformation. Yielding occurs during the beginning of the process of plastic deformation. Young's Modulus is the ratio of stress and strain in the elastic region which is also known as elastic modulus. From Young's Modulus, it can determine or predict the elongation of the sample as the result of stress is less than the yield strength of the sample. Ultimate Tensile Strength is the maximum stress that can be found in the stress-strain curve. These three main result are discussed below.

From sample 1, the elongation,  $\varepsilon$  is at 0.028 kpa and The Yield Stress is 13 700 kpa followed by The Ultimate Stress 13 900 kpa. The Young's Modulus calculated are 266 667 from the sample 1.

Next, for sample 2, the elongation,  $\varepsilon$  is 0.040kpa followed by Stress Yield around 14 000 kpa and the 14 200kpa for Stress Ultimate and the Young's Modulus is 400 000 kpa which is the Young Modulus sample 2 are equal to sample 3.

For elongation, ε sample 3 is 0.026kpa which slightly different from sample 1. Meanwhile the Stress Yield is 16 900 kpa followed by The Stress Ultimate 17 200 kpa.

Average of this sample are 0.115 for elongation,  $\mathcal{E}$ , stress yield 44 600 and the ultimate stress is 45 300. From Table 4.2, the pattern of the average specimen among the 3 specimens tested is 355 556 kPa for Young's Modulus. On table 4.2, average of yield strength 44 600 kpa and followed by the Ultimate Tenisle Strength is at the maximum stress that can be found is 45 300 kpa.

# 4.3.2 Sample With Mixing Ratio 1 : 5



Figure 4.4: Stress Strain Curve for Sample 1:5



Figure 4.5: Samples of 1:5

Table 4.3: Mixing Ratio 1:5

Sample	Elongation, ε (kpa)	Stress Yield, σ (kpa)	Stress Ultimate, σ (kpa)	E
1	0.0340	9600	9800	266 667
2	0.0275	6400	6800	280 000
3	0.0230	10700	10900	600 000
Avg	0.0282	8900	9167	382 222

From Figure 4.4 above, results from this ratio are moderate compared to ratio 1:1. As can be seen from the picture attached, it was broken near the bench line where it is consider not okay for this experiment. The Yield Stress, Young's Modulus and Ultimate Tensile Strength are discussed below.

In Table 4.3, for sample 1. The elongation  $\varepsilon$ , found at 0.0340 kpa. Where the Stress Yield strength are found at 9 600 kpa followed by the Ultimate Tensile Strength at 9 800 kpa. In Table 4.3, the Young's Modulus are detected at 266 667.

Next for sample 2 of ratio 1:5, The elongation  $\varepsilon$ , found at 0.0275 kpa. Where the Stress Yield strength are found at 6 400 kpa followed by the Ultimate Tensile Strength at 6 800 kpa. In Table 4.3, the Young's Modulus are detected at 280 000.

For the last sample for the ratio of 1:5, as per shown in Table 4.3, the elongation  $\varepsilon$ , of sample there are at the point of 0.0230 kpa, which followed by the Stress Yield at 10 700 kpa and The Ultimate Strength at 10 900 kpa. Here the Young's Modulus are seen at the highest value which is 600 000.

Average of this sample are 0.0282 kpa for elongation,  $\varepsilon$ , Stress Yield at point of 8 900 kpa and The Ultimate Stress is 9 167 kpa. From Table 4.3, the pattern of the average specimen among the 3 specimens tested is 382 222 kPa for Young's Modulus

# 4.3.3 Sample With Mixing Ratio 1 : 10







Figure 4.7: Samples of 1:10

Sample	Elongation, ε (kpa)	Stress Yield, σ (kpa)	Stress Ultimate, σ (kpa)	E
1	0.043	10500	10700	270 000
2	0.048	11300	11800	270 000
3	0.031	7800	8100	250 000
Avg	0.0407	9867	10200	263 333

From Figure 4.6 above, this ratio was the most not suitable and the fibre does not bring any beneficial to the matrix in term to strengthen the composite with this ratio. This can be seen from the result table.

In Table 4.4, for sample 1 of ratio 1:10. The elongation  $\varepsilon$ , is found at 0.043 kpa. Where the Stress Yield strength are found at 10 500 kpa followed by the Ultimate Tensile Strength at 10 700 kpa. In Table 4.4, the Young's Modulus are detected at 270 000.

Next for sample 2 of ratio 1:10, The elongation  $\varepsilon$ , found at 0.048 kpa. Where the Stress Yield strength are found at 11 300 kpa followed by the Ultimate Tensile Strength at 11 800 kpa. In Table 4.4, the Young's Modulus are detected at 270 000 which is equal to sample 1.

For the last sample for the ratio of 1:10, as per shown in Table 4.4, the elongation  $\varepsilon$ , of sample there are at the point of 0.031 kpa, which followed by the Stress Yield at 7 800 kpa and The Ultimate Strength at 8 100 kpa. Here the Young's Modulus are seen at the lowest value which is 250 000.

Average of this sample are 0.0407 kpa for elongation,  $\varepsilon$ . Meanwhile for the Stress Yield at point of 9 867 kpa and The Ultimate Stress is 10 200 kpa. From Table 4.4, the pattern of the average specimen among the 3 specimens tested is 263 333 for Young's Modulus detected.

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# 4.3.4 Sample With Matrix Only







**Figure 4.9: Samples of Matrix** 

Table 4.5:	Matrix	Result
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Sample	Elongation, ε (kpa)	Stress Yield, σ (kpa)	Stress Ultimate, σ (kpa)	E
1	0.070	5800	11000	300 000
2	0.051	13000	13500	333 333
3	0.048	13500	13900	400 000
Avg	0.056	10767	12800	344 444

From the Figure 4.8 above, matrix itselves is already a good reinforcement for this composite. Thus the ratio is only to study the how good the fibre in order to help the matrix to strengthen the composites.

In Table 4.5, for sample 1 of Matrix Polyamide. The elongation  $\varepsilon$ , is found at 0.070 kpa. Where the Stress Yield strength are found at 5 800 kpa followed by the Ultimate Tensile Strength at 11 000 kpa. In Table 4.5, the Young's Modulus are detected at 300 000.

Next for sample 2 of ratio Matrix Polyamide, The elongation  $\varepsilon$ , found at 0.051 kpa. Where the Stress Yield strength are found at 13 000 kpa followed by the Ultimate Tensile Strength at 13 500 kpa. In Table 4.5, the Young's Modulus are detected at 333 333.

For the last sample for the ratio of Matrix Polyamide, as per shown in Table 4.5, the elongation  $\varepsilon$ , of sample there are at the point of 0.048 kpa, which followed by the Stress Yield at 13 500 kpa and The Ultimate Strength at 13 900 kpa. Here the Young's Modulus are seen at the lowest value which is 400 000.

Average of this sample are 0.056 kpa for elongation, ε. Meanwhile for the Stress Yield at point of 10 767 kpa and The Ultimate Stress is 12 800 kpa. From Table 4.5, the pattern of the average specimen among the 3 specimens tested is 344 444 for Young's Modulus detected.

# 4.3.5 Compare Different Mix Ratio



Figure 4.10: Comparision Ratio with Matrix

Sample	Elongation, ɛ	Stress Yield, $\sigma$	Stress Ultimate, $\sigma$	Е
(Le	(kpa)	(kpa)	(kpa)	
1:1	0.028	13700	13900	266 667
1:5 UNI	VER 0.027 TEK	NK 6400 AL	AYSIA 6800LAKA	280 000
1:10	0.031	7800	8100	250 000
Matrix	0.048	13500	13900	400 000
Avg	0.0335	10350	10675	299 166.75

From Figure 4.10 above, samples that run on the tensile test are successfully done. Here, ratio 1:1 are seen to be the best for this composite compared to ratio 1:5 and followed by 1:10. Meanwhile, for the ratio 1:5, it was moderate in term of strengthen the matrix. For matrix, it is shows that matrix itselves works perfectly without bemban fibre as a support to strengthen the composite. Thus in this task, a mixing fibre can be implement to see how far it will help the strength on composite. A similar work by Graupner & Müssig (2011) using the carding process in order to produce the multilayer webs of the PLA at 40 wt.% of kenaf fibres prior to the compression molding process to see the strngths on mixing fibres and ratios.

In Table 4.6, for ratio 1:1 of bemban fibre reinforced with thermoplastic. The elongation ε, is found at 0.028 kpa and The Yield Stress is 13 700 kpa followed by The Ultimate Stress 13 900 kpa. The Young's Modulus calculated are 266 667 from the ratio 1:1.

Next for ratio of 1:5, The elongation  $\varepsilon$ , found at 0.0275 kpa. Where the Stress Yield strength are found at 6 400 kpa followed by the Ultimate Tensile Strength at 6 800 kpa. In Table 4.6, the Young's Modulus are detected at 280 000.

After that, for sample of ratio 1:10, as per shown in Table 4.6, the elongation  $\varepsilon$ , of sample there are at the point of 0.031 kpa, which followed by the Stress Yield at 7 800 kpa and The Ultimate Strength at 8 100 kpa. Here the Young's Modulus are seen at the lowest value which is 250 000.

Last but not least, for matrix result in Figure 4.10, as per shown in Table 4.6, the elongation  $\varepsilon$ , of sample there are at the point of 0.048 kpa, which followed by the Stress Yield at 13 500 kpa and The Ultimate Strength at 13 900 kpa. Here the Young's Modulus are seen at the lowest value which is 400 000.

Average of this sample are 0.0335 kpa for elongation,  $\varepsilon$ . Meanwhile for the Stress Yield at point of 10 350 kpa and The Ultimate Stress is 10 675 kpa. From Table 4.6, the pattern of the average specimen among the 3 specimens tested is 299 166.75 for Young's Modulus detected. Matrix itselves is already a good reinforcement for this composite. Thus the ratio is only to study the how good the fibre in order to help the matrix to strengthen the composites.

# 4.4 Effect of Water On Samples



Figure 4.11: Stress Strain Curve for Sample 1:1 (Water Absorption)



Figure 4.12: Sample 1:1 Water Absorption

Table	4.7:	Ratio	1:1	Water	Absorpt	ion
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Sample	Elongation, ε (kpa)	Stress Yield, σ (kpa)	Stress Ultimate, σ (kpa)	E
1	0.037	9500	9900	350 000
2	0.028	7800	8200	360 000
3	0.033	8500	9200	360 000
Avg	0.03267	8600	9100	356 666.67

From Figure 4.11 above, samples 1:1 water absorption it was broken near the benchline where it is considered not okay because a good sample should be break at the middle of the specimen. The Yield Stress, Young's Modulus and Ultimate Tensile Strength are discussed below.

In Table 4.7, for sample 1. The elongation  $\varepsilon$ , found at 0.0370 kpa. Where the Stress Yield strength are found at 9 500 kpa followed by the Ultimate Tensile Strength at 9 900 kpa. In Table 4.7, the Young's Modulus are detected at 350 000.

Next for sample 2, The elongation  $\varepsilon$ , found at 0.0280 kpa. Where the Stress Yield strength are found at 7 800 kpa followed by the Ultimate Tensile Strength at 8 200 kpa. In Table 4.7, the Young's Modulus are detected at 360 000.

For the last sample, as per shown in Table 4.7, the elongation  $\varepsilon$ , of sample there are at the point of 0.0330 kpa, which followed by the Stress Yield at 8 500 kpa and The Ultimate Strength at 9 200 kpa. Here the Young's Modulus are seen at the highest value which is 360 000.

Average of this sample are 0.03267 kpa for elongation,  $\varepsilon$ , Stress Yield at point of 8 600 kpa and The Ultimate Stress is 9 100 kpa. From Table 4.7, the pattern of the average specimen among the 3 specimens tested is 356 666.67 kPa for Young's Modulus.



Figure 4.13: Stress Strain Sample 1:5 Water Absorption



Figure 4.14: Sample 1:5 Water Absorption

Sample	Elongation, ε (kpa)	Stress Yield, σ (kpa)	Stress Ultimate, σ (kpa)	Е
1	0.043	7400	7900	330 000
2	0.054	7900	8100	170 000
3	0.047	6600	6800	150 000
Avg	0.048	7300	7600	216 666.67

Table 4.8:	Ratio 1	1:5 Wate	r Absorpti	on

From Figure 4.13 above, samples 1:5 water absorption run successfully since it was broke in the middle of the specimen. The Yield Stress, Young's Modulus and Ultimate Tensile Strength are discussed below.

In Table 4.8, for sample 1. The elongation  $\varepsilon$ , found at 0.0430 kpa. Where the Stress Yield strength are found at 7 400 kpa followed by the Ultimate Tensile Strength at 7 900 kpa. In Table 4.8, the Young's Modulus are detected at 330 000.

Next for sample 2, The elongation  $\varepsilon$ , found at 0.0540 kpa. Where the Stress Yield strength are found at 7 900 kpa followed by the Ultimate Tensile Strength at 8 100 kpa. In Table 4.8, the Young's Modulus are detected at 170 000.

For the last sample, as per shown in Table 4.8, the elongation  $\varepsilon$ , of sample there are at the point of 0.0470 kpa, which followed by the Stress Yield at 6 600 kpa and The Ultimate Strength at 6 800 kpa. Here the Young's Modulus are seen at the highest value which is 150 000.

Average of this sample are 0.0480 kpa for elongation,  $\varepsilon$ , Stress Yield at point of 7 300 kpa and The Ultimate Stress is 7 600 kpa. From Table 4.8, the pattern of the average specimen among the 3 specimens tested is 216 666.67 kPa for Young's Modulus.

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Figure 4.15: Stress Strain Sample 1:10 Water Absorption



Figure 4.16: Sample 1:10 Water Absorption

Table 4.9	: Ratio	1:10	Water	Absorption
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Sample	Elongation, ε (kpa)	Stress Yield, σ (kpa)	Stress Ultimate, σ (kpa)	E
1	0.043	7900	8200	220 000
2	0.039	7600	8000	220 000
3	0.049	9700	9900	230 00
Avg	0.0437	8400	8700	223 333.33

From Figure 4.15 above, samples 1:10 water absorption run successfully since sample 2 and 3 are broken at the middle of the specimen. Meanwhile, sample 1 is broken near the benchline. The Yield Stress, Young's Modulus and Ultimate Tensile Strength are discussed below.

In Table 4.9, for sample 1. The elongation  $\varepsilon$ , found at 0.0430 kpa. Where the Stress Yield strength are found at 7 900 kpa followed by the Ultimate Tensile Strength at 8 200 kpa. In Table 4.9, the Young's Modulus are detected at 220 000.

Next for sample 2, The elongation  $\varepsilon$ , found at 0.0390 kpa. Where the Stress Yield strength are found at 7 600 kpa followed by the Ultimate Tensile Strength at 8 000 kpa. In Table 4.9, the Young's Modulus are detected at 220 000.

For the last sample, as per shown in Table 4.9, the elongation  $\varepsilon$ , of sample there are at the point of 0.0490 kpa, which followed by the Stress Yield at 9 700 kpa and The Ultimate Strength at 9 900 kpa. Here the Young's Modulus are seen at the highest value which is 223 333.33.

Average of this sample are 0.0437 kpa for elongation,  $\varepsilon$ , Stress Yield at point of 8 400 kpa and The Ultimate Stress is 8 700 kpa. From Table 4.9, the pattern of the average specimen among the 3 specimens tested is 223 333.33 kPa for Young's Modulus.

## 4.5 Comparision of Composite Effect Water Absorption



Figure 4.17: Comparision of Composite Effect Water Absorption

<b>Table 4.10:</b>	Comparision	of C	Composit	te Effec	t Wate	er Ab	sorption
	•		-				

Sample	Elongation, ε (kpa)	Stress Yield, σ (kpa)	Stress Ultimate, σ (kpa)	E
1:1	0.032	8400	9200	540 000
1:5	ل ما 0.04 ما لار	7400	اوييو-7800 يېيې د	300 000
1:10		8300	8600	140 000
Avg	0.03867	8033.33	8533.33	326 666.67

From Figure 4.17 above, samples that run on the tensile test are successfully done. In Table 4.10, for ratio 1:1 of bemban fibre reinforced with thermoplastic. The elongation  $\varepsilon$ , is found at 0.032 kpa and The Yield Stress is 8 400 kpa followed by The Ultimate Stress 9 200 kpa. The Young's Modulus calculated are 540 000 from the ratio 1:1.

Next for ratio of 1:5, The elongation  $\varepsilon$ , found at 0.041 kpa point of elongation. Where the Stress Yield strength are found at 7 400 kpa followed by the Ultimate Tensile Strength at 7 800 kpa. In Table 4.10, the Young's Modulus are detected at 300 000.

After that, for sample of ratio 1:10, as per shown in Table 15, The elongation  $\varepsilon$ , found at 0.043 kpa which is not that far from sample ratio 1:5 point of elongation. Where the Stress Yield strength are found at 8 300 kpa followed by the Ultimate Tensile Strength at 8 600 kpa. In Table 4.10, the Young's Modulus are detected at 140 000.

Average of this sample are 0.03867 kpa for elongation, ε. Meanwhile for the Stress Yield at point of 8033.33 kpa and The Ultimate Stress is 8533.33 kpa. From Table 4.10, the pattern of the average specimen among the 3 specimens tested is 326 666.67 for Young's Modulus detected.

#### 4.6 Summarize

In short, the experiment for natural fibre reinforced with thermoplastic has been succesfully done. By doing this experiment, the most suitable ratio for this composite is 1:1 where the fibre and polyamide are equally in same weight. This can be seen through the graph that plotted from an excel. Matrix itselves is already a good reinforcement for this composite. Thus the ratio is only to study the how good the fibre in order to help the matrix to strengthen the composites. Bemban fibre does not help much in term to strength the composite in this task because polyamide itselves hold the strong bond among itselves. In future, mixing fibre can be consider such as coconut fibre mix with bemban or kenaf fibre mix with bemban in order to test the strength of mixing fibre in composite.
### **CHAPTER 5**

### **CONCLUSION AND RECOMMENDATIONS**

## 5.1 Conclusion

In present research, effect of bemban fiber ratio and effect of water on those fibers on physical and mechanical properties of bemban fiber reinforced polyamide thermoplastics composites are observed. Composites were prepared with bemban fiber in 1:10, 1:1 and 1:5 ratio and soaked composites bemban fiber at 1:10, 1:1 and 1:5 using hot press machine. Mechanical properties tensile were higher for 1:1 fiber ratio composites compared to the other fiber ratio. Effect of water does not show much effect eventhough has been soaked for about 24 hours before running an experiment of tensile test. In short, the experiment for natural fibre reinforced with thermoplastic has been succesfully done. Matrix itselves is already a good reinforcement for this composite. Thus the ratio is only to study the how good the fibre in order to help the matrix to strengthen the composites. By doing this experiment, the most suitable ratio for this composite is 1:1 where the fibre and polyamide are equally in same weight and spread evenly on the composite but, bemban fibre does not help much in term to strength the composite in this task because polyamide itselves hold the strong bond among itselves. The main source of reference of natural composites for Bemban fibre are Kenaf and Pineapple. Thus, most of the journal refered, fibre with ratio 1:1 are the best for composite. But, compare natural fibre with synthetic fibre, synthetic fibre are most suitable in other to make composite. Based on previous findings, the tensile properties of kenaf/natural fiber hybrid samples are too low compared to hybrid composites made from kenaf/synthetic fibers (Atiqah A, Maleque MA, Jawaid M, 2014).

## 5.2 Recommendations

For future reference on Bemban fibre as a reinforcement and thermoplastic as a matrix, some suggestion and recommendation may be drawn to produced better results.

### i. Rolling Machine

This rolling machine is a piece of heavy machinery designed to strip the outer layer of material from seeds, plants and small shrubs and trees. These devices are used all over the world for everything from hulling sunflower material to preparing fibres. This is the other option that can be use to extract Bemban fibre rather than peeling off using knife. It will save time and ease the procedures.

## ii. Injection Moulding

Injection Moulding is an optional for making composite other than Hot Press machine. For Injection Moulding, no moulding required cause it can form the dog bone size according to ASTM that will be use. But the negative side of it is, the fibre will stuck during the mixing process of matrix and fibre.

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iii. Impact Test

The Izod and Charpy tests are the two most used impact tests. Both experiments require striking a standard specimen with a controlled weight pendulum moving at a defined pace. The amount of energy absorbed in breaking the test piece is calculated, giving an indicator of the test material's notch toughness.

iv. Mixing Fibres

Based on the previous research conducted, the main limitations of the natural fibers as the reinforcement in composites are lack in interfacial adhesion between the fibers and the polymeric matrices. These phenomenon results in the poor properties of the final product

fabricated (Akil et al. 2011). Mixing both fibre can increase the durability in composite and help matrix to strengthen the composite either. The alternative of combining bemban fiber with other natural fibers is one of the robust approaches to enhance the mechanical properties of bemban matrix composites.



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## **APPENDICES**

## **APPENDIX A: Gantt Chart PSM 1**

Planning	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Literature Review	х	х	х	х	x										
Research Methodology						х	х	х	х						
Introduction						х	х	х	х						
Chapter 4 (Conclusion)											х	х	х		
Pre-Submission														х	
Correction	LAY	SIA	M.C.												х
Final Submission			PRA												x
Presentation									-	-	V				х

# APPENDIX B: Gantt Chart PSM 2

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Planning	1	2	3	4	5	6	7 📲	8	9	10	11	12	13
UNIVERS	SITI	TE	KNI	KAL	. M.	ALA	YSI	AM	EL/	AK/			
Tensile Test	х	х	х	х	х								
Impact Test	х	х	х	х	х								
Result Discussion					х	х	х						
Conclusion & Recommendation					х	х	х						
Correction								х	х				
Final Submission												x	
Presentation													x