

**MECHANICAL PERFORMANCES OF ECO-
BOARD FROM OIL PALM EMPTY FRUIT
BUNCH (OPEFB) AND MAHANG
(ARTOCARPUS ODDORATISSIMUS)**



MOHD. FAZIL BIN JUNDAM

UMS
UNIVERSITI MALAYSIA SABAH

**FACULTY OF ENGINEERING
UNIVERSITI MALAYSIA SABAH
2021**

**MECHANICAL PERFORMANCES OF ECO-BOARD
FROM OIL PALM EMPTY FRUIT BUNCH (OPEFB)
AND MAHANG (ARTOCARPUS ODDORATISSIMUS)**

MOHD. FAZIL BIN JUNDAM



**THIS IS SUBMITTED IN FULLFILLMENT FOR THE
DEGREE OF MASTER OF ENGINEERING**

**FACULTY OF ENGINEERING
UNIVERSITI MALAYSIA SABAH**

2021

UNIVERSITI MALAYSIA SABAH
BORANG PENGESAHAN STATUS TESIS

JUDUL : **MECHANICAL PERFORMANCES OF ECO BOARD FROM OIL PALM EMPTY FRUIT BUNCH (OPEFB) AND MAHANG (ARTOCARPUS ODDORATTISIMUS)**

IJAZAH : **SARJANA KEJURUTERAAN MEKANIKAL**

BIDANG : **KEJURUTERAAN**

Saya **MOHD. FAZIL BIN JUNDAM**, Sesi **2017-2021**, mengaku membenarkan tesis Sarjanal ini disimpan di Perpustakaan Universiti Malaysia Sabah dengan syarat-syarat kegunaan seperti berikut:-

1. Tesis ini adalah hak milik Universiti Malaysia Sabah
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (/):

SULIT

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA 1972)

TERHAD

(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

UNIVERSITI MALAYSIA SABAH

Disahkan Oleh,

MOHD. FAZIL BIN JUNDAM
MK1711053T

(Tandatangan Pustakawan)

Tarikh : 23 Mac 2021

(Dr. Mohd Kamal bin Mohd Shah)
Penyelia

DECLARATION

I hereby declare that this master thesis is the result of my own efforts and work, with the exception of excerpts and summaries in which i have explained every each of its sources.

23rd February 2020



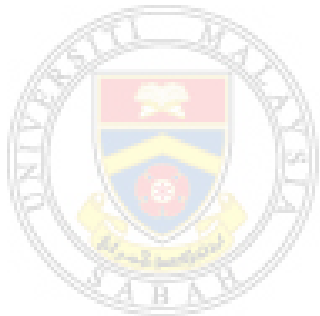
Mohd. Fazil Bin Jundam

MK1711053T

UMMS
UNIVERSITI MALAYSIA SABAH

CERTIFICATION

NAME : MOHD. FAZIL BIN JUNDAM
MATRIC NO : MK1711053T
TITLE : MECHANICAL PERFORMANCES OF ECO-BOARD FROM OIL
PALM EMPTY FRUIT BUNCH (OPEFB) AND MAHANG
(ARTOCARPUS ODDORATTISIMUS)
DEGREE : MASTERS OF ENGINEERING
FIELD : MECHANICAL ENGINEERING
DATE OF VIVA : 27TH JULY 2020



UMS
CERTIFIED BY;
UNIVERSITI MALAYSIA SABAH

SUPERVISOR

DR. MOHD KAMAL MOHD SHAH

SIGNATURE

ACKNOWLEDGEMENT

With the name of Allah the most gracious and merciful, all praise is to Allah S.W.T and peace is upon the holy prophet Muhammad S.A.W, his family and his companions. With his permissions, this research with title of "Mechanical Performances of Eco-Board from Oil Palm Empty Fruit Bunch (OPEFB) and Mahang (*Artocarpus Oddorattisimus*)" was able to be successfully completed within permissible time.

First and foremost, I would like to give my thanks and gratitude to my supervisor, Dr. Mohd Kamal Mohd Shah, Head of Material and Minerals Research Unit (MMRU), Universiti Malaysia Sabah (UMS) for his patience, guidance and advice in the process of completing this research. All the effort through discussions and guidance is really much appreciated. My thanks also dedicated to my sponsorship, the government of Malaysia via Bahagian Pembangunan Modal Insan, Jabatan Perkhidmatan Awam (JPA) for giving me the golden opportunity to improve my knowledge and skills through this study.

I also would like to give my thanks and gratitude to my beloved mother, Faridah@Lily Catherine Tseu, my dearest wife Hamizah Sidin, daughters, families and friends for the continuous supports, commitment, understanding and endeavor throughout the duration of my studies.

Lastly my gratitude's and thanks also goes to every personnel whom has helping me in completing this research either direct or indirectly, only Allah S.W.T can repay your advice, kindness and supports.

Thanks for all your encouragement
Mohd. Fazil bin Jundam
23rd February 2020

ABSTRACT

This research conducted to develop and study an eco friendly board that been made from a combination of oil palm empty fruit bunch (OPEFB) with *artocarpus odorattisimus* (mahang) mechanical behaviour especially in terms of its tensile and flexural properties. The intention of developing the eco board is to find alternative replacement materials for woods usage in modern industry as the worldwide community became concerned of major deforestation that led into global warming. The fabrication process are done by using hand lay method where the mixture of shredded OPEFB strands and artocarpus odorattisimus chip (with 4 different mixture ratio) being blended together with urea formaldehyde (UF) as binder/resin and hot pressed in a 200 °C mould under 300KN load to form a 150mm x 150mm x 5mm eco board. The tensile testing procedure are done to the specimen in accordance to ASTM D3039/3039m-17 test standard and a fractography of the materials are taken by using scanning electron microscope (SEM) under various level magnification to further understand root causes of materials failure. A flexural test was conducted by using "3 point bend" test method in order to acquire the flexural strength for each specimen in accordance to ASTM D1037-99 standard. From the experiment and analysis, the mixture of oil palm empty fruit bunch and *artocarpus oddorattisimus* in which posses best tensile properties was found and the failure pattern of the board are discussed. The addition of *artocarpus oddorattisimus* (ARTO) seen giving improvement on the tensile properties of the eco board (specimen D with 9.15 N/mm²), while flexural strength and also Young modulus does improve on certain amount of *artocarpus oddorattisimus* (ARTO) content within the mixture (33.3% of ARTO dry weight ratio).

ABSTRAK

PRESTASI MEKANIKAL PAPAN MESRA ALAM DARI TANDAN KELAPA SAWIT DAN MAHANG (*ARTOCARPUS ODDORATTISIMUS*)

Kajian ini dijalankan untuk membangunkan dan mengkaji ciri/sifat mekanikal berkaitan papan mesra alam (*eco board*) yang diperbuat daripada gabungan serat buah kelapa sawit (OPEFB) bersama dengan *artocarpus oddorattisimus* (mahang) terutamanya ciri-ciri tegangan dan lenturan yang terdapat pada spesimen yang dibangunkan. Tujuan pembangunan *eco board* adalah untuk mencari pengganti alternatif yang sesuai untuk menggantikan penggunaan kayu balak dalam industri moden yang mana telah menjadi kekusaran komuniti sedunia disebabkan pembalakan secara meluas yang membawa kepada pemanasan global dan banyak lagi. Proses pembuatan dijalankan dengan menggunakan kaedah manual secara tangan dimana campuran serat kelapa sawit yang telah dicarik dan juga serpihan *artocarpus oddorattisimus* (dengan 4 jenis nisbah campuran) digaulkan sekata bersama *urea formaldehyde* (UF) sebagai material pengikat dan seterusnya dimampatkan menggunakan kaedah mampatan panas pada suhu 200°C dan juga pada daya tekanan 300KN untuk menghasilkan papan *eco board* bersaiz 150mm x 150mm x 5mm. Proses ujian tegangan dijalankan ke atas specimen adalah berdasarkan standard ASTM D3039/3039m-17 dan ujian fraktografi turut dijalankan ke atas specimen menggunakan *scanning electron microscope* (SEM) dibawah pelbagai kuasa pembesaran untuk lebih mengetahui punca-punca kegagalan specimen setelah ujian tegangan. Seterusnya ujian kelenturan diadakan menggunakan kaedah "*3 point bend*" bagi mendapatkan nilai kekuatan lentur pada setiap jenis specimen dengan merujuk kepada standard ASTM D1037-99. Daripada eksperimen dan juga analisis yang dijalankan, nisbah campuran antara serat kelapa sawit dan juga *artocarpus oddorattisimus* yang memberikan ciri-ciri mekanikal yang terbaik ditemui dan corak kegagalan pada specimen juga dibincangkan. Dengan penambahan serat *artocarpus oddorattisimus* (ARTO) ke dalam *eco board* yang difabrikasi, daya tegangan menunjukkan hasil yang positif (spesimen D dengan 9.15 N/mm²), manakala nilai kekuatan lentur dan juga modulus Young dilihat meningkat pada sesetengah nisbah campuran *artocarpus oddorattisimus* (ARTO) dalam campuran bahan *eco board* (33.3% berat kering ARTO).

CONTENTS

	PAGE
TITLE	i
DECLARATION	ii
CERTIFICATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
ABSTRAK	vi
CONTENTS	vii
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF CHARTS	xiii
LIST OF ABBREVIATIONS	xiv
LIST OF APPENDICES	xv
CHAPTER 1 INTRODUCTION	
1.1 Introduction	1
1.2 Background of Study	2-3
1.3 Problem Statement	4
1.4 Objectives	4-5
1.5 Significance of Research	5
1.6 Scope of Study	5-6
1.7 Research Methodology	6-7
1.8 Thesis Organisation	8-9
CHAPTER 2 LITERATURE REVIEW	
2.1 Introduction	10

2.2 Materials	10-11
2.2.1 Oil Palm Empty Fruit Bunch (OPEFB)	11-13
2.2.2 Artocarpus Oddorattisimus	13-15
2.2.3 Urea Formaldehyde (UF)	15-17
2.2.4 Composite Material	17-18
2.2.5 Fibers	18-19
2.2.5.1 Natural Fiber	19-20
2.2.5.2 Synthetic Fiber	20-21
2.3 Mechanical Properties	21-22
2.3.1 Tensile Test	22-24
2.4 American Society for Testing & Materials (ASTM)	24-29
2.5 Morphological Study	29-30
2.6.1 Cracks	31-32
2.6 Eco Board	32-33
CHAPTER 3 METHODOLOGY	
3.1 Introduction	34
3.2 Materials	35
3.2.1 Oil Palm Empty Fruit Bunch (OPEFB)	35-36
3.2.2 Artocarpus Oddorattisimus	36-37
3.2.3 Urea Formaldehyde (UF)	37-38
3.3 Experimental Equipments	38
3.3.1 Mould	38
3.3.2 Compressive Machine	39
3.3.3 Oven	40
3.3.4 Universal Cutting Machine	40-41
3.3.5 Universal Mechanical Test Machine	41
3.3.6 Scanning Electron Microscope (SEM)	42
3.4 Sample Specimen Fabrication	42
3.4.1 Sample Specimen Ratio	43-44

3.4.2 Fabrication Procedure	44-49
3.5 Tensile Test	49-52
3.6 Flexural Test	52-55
3.7 Scanning Electron Microscope (SEM)	56-57
3.8 Data Analysis	57-58
CHAPTER 4 RESULTS AND DISCUSSIONS	
4.1 Introduction	59
4.2 Experimental Results – Tensile Test	60-65
4.2.1 Comparison between Eco Board with different Reinforcement Materials	65
4.2.2.1 Tensile Properties and Maximum Loads	65-69
4.2.2.2 Elongation before Break	70-72
4.3 Experimental Results – Flexural Test	72-77
4.4 Scanning Electron Microscope (SEM) Result	77-83
CHAPTER 5 CONCLUSION	
5.1 Overview	84-86
5.2 Recommendation	86-87
REFERENCES	88-96
APPENDICES	97-98

LIST OF TABLES

	PAGE
Table 2.1 Properties of Oil palm Empty Fruit Bunches fibers	12
Table 2.2 Physical properties of <i>Artocarpus Oddorattisimus</i>	15
Table 2.3 Natural Fiber Classification	20
Table 2.4 ASTM D3039 Tensile Specimen Geometry Requirement	27
Table 2.5 ASTM D3039 Tensile Specimen Geometry Recommendation ^A	27
Table 3.1 Properties of Oil Palm Empty Fruit Bunches fibers	36
Table 3.2 Properties of Urea Formaldehyde (UF)	38
Table 3.3 Mixture ratios of Oil Palm Empty Fruit Bunch (OPEFB) to <i>Artocarpus Oddorattisimus</i>	44
Table 4.1 Tensile test result for Eco board (OPEFB embedded with <i>Artocarpus oddorattisimus</i>)	60
Table 4.2 Tensile test result for eco board made from OPEFB with <i>Artocarpus oddorattismus</i> , rice husk and waste paper	66
Table 4.3 Displacement result from tensile test for eco board made from OPEFB with <i>artocarpus oddorattismus</i> , rice husk and waste paper	70
Table 4.4 3 points bend test result for Eco board (OPEFB embedded with <i>Artocarpus oddorattisimus</i>)	73

LIST OF FIGURES

	PAGE
Figure 2.1 Raw Oil Palm Empty Fruit Bunch (OPEFB)	12
Figure 2.2 <i>Artocarpus Oddorattisimus</i>	14
Figure 2.3 Urea Formaldehyde liquid (UF)	16
Figure 2.4 Fiber Classification	19
Figure 2.5 Tensile Test Instrument	23
Figure 2.6 Stress-Strain Curve	24
Figure 2.7 ASTM D3039 – Gauge Location for System Alignment Coupons	26
Figure 2.8 Codes of Tensile Specimen Test Failure Pattern	28
Figure 2.9 Scanning Electron Microscope (SEM)	30
Figure 3.1 Chopped empty fruit bunches	35
Figure 3.2 <i>Artocarpus Oddorattisimus</i> chip	37
Figure 3.3 KENCO concrete mould for specimen fabrication	39
Figure 3.4 KENCO Compressive Strength Machine	39
Figure 3.5 Memmert industrial ovens	40
Figure 3.6 Struers Discotom – 5 Universal Cutting Machine	41
Figure 3.7 Gotech/AI-7000M Electronic Mechanical Testing Machine	41
Figure 3.8 ZEISS EVO MA 10 Scanning Electron Microscope	42
Figure 3.9 Different ratios of eco board	43
Figure 3.10 Oil Palm Empty Fruit Bunch (OPEFB)	44
Figure 3.11 OPEFB dry weight measurement	45
Figure 3.12 Mixing urea formaldehyde (UF) to the fiber mixture	45
Figure 3.13 Mould placed on the compressive strength machine	46
Figure 3.14 Hot press compressive processes	47
Figure 3.15 Fabricated eco board	47
Figure 3.16 Sample specimen reshaping process	48
Figure 3.17 Reshaped sample specimen in accordance to ASTM D3039 requirement	48

Figure 3.18 Reshaped sample specimen in accordance to ASTM D1037-99 requirement	49
Figure 3.19 GOTECH/AI-7000M Electronic Mechanical Testing Machine	49
Figure 3.20 Length of narrow section	50
Figure 3.21 Sample specimen placement on GOTECH/AI-7000M Electronic Mechanical Testing Machine	51
Figure 3.22 The Stress-Strain Graph	52
Figure 3.23 Test specimen for 3 point bend test	54
Figure 3.24 3 point bend test instruments arrangement – GOTECH/AI-7000M Electronic Mechanical Testing Machine	55
Figure 3.25 Sample specimen being tested on 3 point bend test machine - GOTECH/AI-7000M Electronic Mechanical Testing Machine	55
Figure 3.26 ZEISS EVO MA 10 Scanning Electron Microscope (SEM)	56
Figure 4.1 Scanning Electron Microscope (SEM) of Specimen A - pure (100% OPEFB)	78
Figure 4.2 Scanning Electron Microscope (SEM) of Specimen B - (93.3% OPEFB; 6.7% ARTO)	79-80
Figure 4.3 Scanning Electron Microscope (SEM) of Specimen C - (86.6% OPEFB; 13.4% ARTO)	81
Figure 4.4 Scanning Electron Microscope (SEM) of Specimen D - (66.7% OPEFB; 33.3% ARTO)	82-83

LIST OF CHARTS

	PAGE
Chart 4.1 : Graph of Stress (N/mm^2) against Strain for Each Type of Specimen	61
Chart 4.2 : Graph of Young's Modulus against Type of Specimen	63
Chart 4.3 : Graph of Variation of Fracture Point against Type of Specimen	64
Chart 4.4 : Graph of Tensile Strength (N/mm^2) against Type of Specimen	66
Chart 4.5 : Graph of Maximum Load (N) against Type of Specimen	68
Chart 4.6 : Graph of Displacement (mm) against Type of Specimen for Eco Board with Different Fiber Reinforcement	71
Chart 4.7 : Graph of Modulus of Flexural (N/mm^2) against Type of Specimen for Eco Board with Different Fiber Reinforcement	73
Chart 4.8 : Graph of Maximum Deflection (mm) against Type of Specimen for Eco Board with Different Fiber Reinforcement	75
Chart 4.9 : Graph of Load (N) against Deflection (mm) for Each Type of Specimen	76

LIST OF ABBREVIATIONS

OPEFB	: Oil Palm Empty Fruit Bunch
ARTO	: Artocarpus Oddorattisimus (Mahang/Madang/Tarap)
WP	: Waste paper
UF	: Urea formaldehyde
FAO	: United Nation Foods and Agriculture Organization
MPOB	: Malaysia Palm Oil Berhad
ASTM	: American Society for Testing and Materials
PF	: Phenol formaldehyde
CAD	: Computer aided design
SEM	: Scanning electron microscope
LKW	: Lesser known woods
SCC	: Stress corrosion cracking
F	: Force
FEG	: Field emission gas
CAE	: Computer aided engineering
GAB	: Grip, angled, bottom (ASTM cracks pattern)
Ha	: Hectares
MDF	: Medium Density Fibre board

LIST OF APPENDICES

	PAGE
Appendix A - The manufactured Specimen with different ratio	97
Appendix B - The specimen after the tensile test with the crack	98



UMS
UNIVERSITI MALAYSIA SABAH

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Since the ancient time, forest and woods has been contributing important role in human being daily life. Started from providing human with resources of fire as fuel, house hold equipment, structures and building material, transportation, foods, furniture and much more where woods used as the main materials. Aside from being used as raw material for goods and structures, forest also plays one important and crucial role in order to maintain stability of the world that is to produce oxygen and consume carbon dioxide. On the same time, forest also playing a role to prevent land slide by holding earth and soil structure through its roots. Living being such as human and animals consume oxygen daily by breathing and at the same time produce carbon dioxide, forest functioning to consume the carbon dioxide that produced by living being and the same time produce oxygen. This cycle run in repetition in order to keep the world and earth stable.

As the global world transformed into more modernized where industrialization been introduced widely, mass production of materials and goods has taken its place on most of developing and urban countries. This situation has led to mass deforestation where the demand of woods supplies increased as a raw material for building houses, structures, furniture and much more. It can't be denied that industrialization and modernization of the world has taken its toll to the global forest.

The worldwide woods industry nowadays has facing a lot of transformation, started from just producing basic furniture during the ancient time; currently the

woods industry has varied its production as to meets consumers demand. This situation led to major deforestation globally as to meets the manufacturer's requirement and demand for woods as their raw materials. Based on the United Nation Foods and Agriculture Organization (FAO), the global forest reserve worldwide in 1990 is 4128 million ha while in 2015 worldwide forest reserve has decreased to 3999 million ha in which shows a change in percentages from 31.6% to 30.6% through stated time period. (MPOB, 2018)

The drastic decreased pattern of global forest area has come into worldwide community attention, in which deforestation has causes a lot of global problems such as global warming that may led into many side effect problems to living being, land slide, major floods and many more. So it has come into global community concern, that is to decrease the dependency of the manufacturers on woods as a raw material in which their wanted to invent an alternative materials in order to replace the usage of woods. Although through the years, there are many suggestions on a new raw materials such as the usage of plastics and composites, there are another problems arose where the degradability of the materials come into attention. This is due to the fact that plastics possess a characteristics of anti- degradable in which may pollute the soil and earth.

This research is intended to invent a new eco-friendly material as a replacement to the woods for furniture, automotive or constructions industry. The new materials is introduced and verified for its reliability especially on mechanical characteristics such as tensile and flexural strength aside from its main purpose of invention that is nature friendly. The introduction of these materials comes with the hope that it will able to delay deforestation and reducing the global warming so that the world become safe for all living being.

1.2 BACKGROUND OF STUDY

Furniture and woods industry in Malaysia especially in Sabah contributes a portion of percentage (23%) to the country economic growth (MTIB, 2019). But as the industry utilize woods as its raw materials, major deforestation has happened especially in Sabah where based on the research conducted by Malaysia Ministry of

Science and Technology (MOSTI) there is about 120 furniture plant at Sabah region alone (MOSTI,2016). The drastic logging activities and deforestation has come into both the government and manufacturer consideration where both parties started to find new alternatives to replace the usage of woods as raw materials in furniture industry.

Another big potential business in Malaysia and especially in Sabah is oil palm industry. Based on presentation by director general of Malaysia Palm Oil Berhad (MPOB) on Palm Oil Economic review and Seminar 2017, Malaysia contributes 30% of oil palm production in which is the second largest producer of palm oil in the world after Indonesia. Apart from each states in Malaysia, Sabah contributes to the largest planted palm oil area in which covered 1,551,714 ha or about 27% from Malaysia's planted oil palm area (MPOB, 2017).

The oil palm industry where its main intention is to produce oil consists of several procedures and process to convert the raw palm oil fruit into crude oil. Along the process of transforming oil palm fruit to gain the palm oil, there are wastes, the waste are usually dumped or ignored on a dump site so it can be decayed as time goes by or used as bio energy to run the mills. Among oil palm waste such as fruit bunch, fiber and shells.

Oil Palm Empty Fruit Bunch or known as OPEFB, a palm oil waste. This material has a potential to be used as a replacement for woods as a raw materials but need to undergo several processes on the first hand. As this material (OPEFB) easily to be obtained throughout Malaysia especially in Sabah, the possibility of oil palm empty fruit bunch (OPEFB) replacing woods as a raw material in furniture manufacturing process or even other industries such as automotive became brighter.

This research intention is to invent an eco-friendly materials (board) from Oil Palm Empty Fruit Bunch (OPEFB) and investigate its mechanical properties such as tensile and determining whether the materials is suitable in replacing conventional raw materials of woods in furniture and related industry.

1.3 PROBLEM STATEMENT

Modern industries such as furniture and construction has been long utilize woods as their raw materials in order to manufacture their final products. The high demand and living style of a modern society nowadays has led to a major worldwide deforestation where furniture industries became one of large consumer of woods. The inclination trend of global forest reserve has come into worldwide community attention. Drastic deforestation while on the same time low rate of forest planting effort cause a lot of harmful side effects to the global world such as greenhouse effect, major land slide, global warming and much more. So to overcome the issue, where to lower the rate of deforestation globally, an alternative of raw materials are needed to replace woods by using locally available materials within the country. As for that, Oil Palm Empty Fruit Bunch (OPEFB) which can easily obtained in Malaysia, can be used as a raw material replacement to the conventional woods after undergoing certain processes (board fabrication). *Artocarpus Oddorattisimus* (Madang), in which also available in Malaysia is used to reinforce the fabricated board from Oil Palm Empty Fruit Bunch (OPEFB) in order to improve the board mechanical properties. The problems arose from the capability of the new introduced materials to cope with the standard of the conventional raw materials in terms of its mechanical and other characteristics such as tensile and flexural strength, bio degradability and much more.

1.4 OBJECTIVE

The main objective of this research is to develop eco board from Oil Palm Empty Fruit Bunch (OPEFB) with *Artocarpus Oddorattisimus* (Madang) as the board reinforcement material. In this research, there are several objectives stated and need to be investigated to answer the research problems. The objectives of this study are as stated as below:

- (i) To fabricate eco-board from oil palm empty fruit bunch (OPEFB) embedded with *Artocarpus Oddorattisimus* (Madang) as composite for specimen preparation.
- (ii) To determine mechanical properties from fabricated eco-board such as tensile and flexural properties.
- (iii) To obtain the material morphology of the specimen by using Scanning Electron Microscope (SEM)

1.5 SIGNIFICANCE OF RESEARCH

Eco-board from oil palm empty fruit bunch (OPEFB) act as an alternative raw materials to replace the usage of woods in manufacturing furniture and other appliances. By introducing the eco-board, the furniture industry may convert from woods based product into eco-board based product in which will solve the worldwide problems of major deforestation that may led into many bad side effects such as global warming (greenhouse effects), landslide tragedy, major floods and much more. Another benefits that can be obtained from this study is the availability of the continuous raw material (oil palm empty fruit bunch) to the woods/furniture/automotive industry especially in Malaysia as oil palm industry is one of major business in this country thus it is easy to gain oil palm waste from any states in Malaysia in which solving the shortage of raw materials supply to the manufacturer. In terms of cost effectiveness, it is predicted that eco-board are much more cheaper to be processed compared to woods as its only need short range transportation from the palm oil estates to the factory while woods needs us to go deep in the forest to gain a matured tree to cultivate, long range transportation from the forest and river to the factory and processing the woods into desired shape before it can be finalized into end products.

1.6 SCOPE OF STUDY

In order to ensure that this research keeping on its track and not misguided from its original intention, certain research scope are listed down as guidance. Among the scope of study in this research are:

- (i) Materials of Oil Palm Empty Fruit Bunch (OPEFB) used in this research came from palm oil fruit bunch gathered at Sabah, Malaysia.
- (ii) Sizing of eco-board prototype specimen in this research is prepared according to American Society for Testing and Materials (ASTM) standard – ASTM D3039 & ASTM D1037-99.
- (iii) The material characteristics and behaviour will be tested using mechanical tests to ensure the accuracy of mechanical properties obtained in accordance to ASTM D3039 & ASTM D1037-99.
- (iv) The morphological study will be conducting by using Scanning Electron Microscope (SEM).

1.7 RESEARCH METHODOLOGY

Research procedure underlines main and complete steps plus necessary approach taken in executing the studies in order to gain research objectives. In this study, research procedure can be categorized into 6 different steps, in any way correlated to the research milestones. Among the research procedure of this study are listed as below:

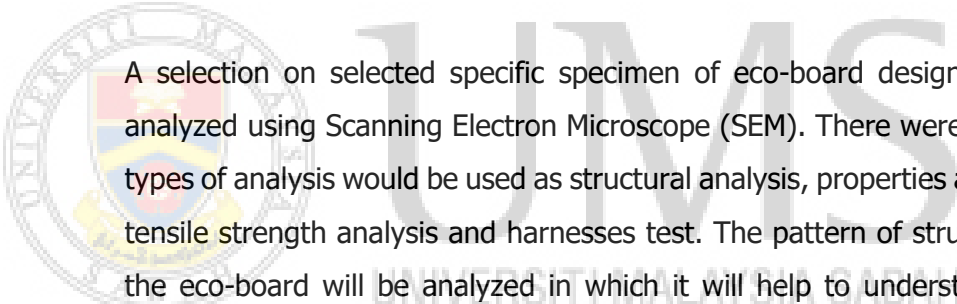
(a) Fabrication of research specimen

This step comprise of procedure and process of fabricating sample of specimen that will be used for testing. Based on journals, books and publication on other almost similar research, a prototype of oil palm empty fruit bunch (OPEFB) board will be fabricated according to American Society for Testing and Materials (ASTM) standard and the selection of resin/binder such as urea formaldehyde (UF) and phenol formaldehyde (PF).

(b) Experimental Mechanical Testing using Universal Mechanical Test Machine

In this section, a series of mechanical testing procedure will be conducted on the fabricated specimen in order to obtain the specimen mechanical properties that are tensile strength and flexural strength and the results will be compared to the pure Oil Palm Empty Fruit Bunch (OPEFB) board mechanical properties.

(c) Specimen analysis using Scanning Electron Microscope (SEM)



A selection on selected specific specimen of eco-board design will be analyzed using Scanning Electron Microscope (SEM). There were several types of analysis would be used as structural analysis, properties analysis, tensile strength analysis and harnesses test. The pattern of structure of the eco-board will be analyzed in which it will help to understand the reason of related properties of the specimen.

(d) Thesis writing

In this section, comprehensive literature overview, methodology taken, data and results obtained, analysis, discussion, final conclusion and recommendation are combined for review.