SHELTER BASED DESIGN METHOD OF A LIGHTWEIGHT AND PORTABLE BY USING OIL PALM FIBER REINFORCED HONEYCOMB PANEL

MUHAMMAD SALMAN BIN NOR AZMI
B091810189

BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY HEAT VENTILATION AND AIR CONDITIONING (HVAC) WITH HONOURS

2021

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical and Manufacturing Engineering Technology

SHELTER BASED DESIGN METHOD OF A LIGHTWEIGHT AND PORTABLE BY USING OIL PALM FIBER REINFORCED HONEYCOMB PANEL

Muhammad Salman Bin Nor Azmi

Bachelor of Mechanical Engineering Technology Heat Ventilation and Air Conditioning (HVAC) with Honours

2021

SHELTER BASED DESIGN METHOD OF A LIGHTWEIGHT AND PORTABLE BY USING OIL PALM FIBER REINFORCED HONEYCOMB PANEL

(MUHAMMAD SALMAN BIN NOR AZMI

A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology Heat Ventilation and Air Conditioning (HVAC) with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this Choose an item. entitled "Shelter Based Design Method of a Lightweight and Portable by Using Oil Palm Fiber Reinforced Honeycomb Panel" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	
Name	:	Muhammad Salman Bin Nor Azmi
Date	:	18/1/2022

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 Heat Ventilation and Air Conditioning (HVAC) with Honours.

Signature :

Supervisor Name : DR Muhammad Zulkarnain

Date : 26/2/2021

DEDICATION

Alhamdulillah

Praise be to Allah for providing me with the strength, direction, and knowledge necessary to accomplish my research.

&

To my adoring parents and families, I want to express my gratitude for their unwavering support.

&

To my supervisor, Dr Muhammad Zulkarnain for guiding and advising me throughout this project.

&

To everyone who has helped me along the way

ABSTRACT

Conceiving of and selecting concepts with the goal of translating practical users' requirements into a collection of shelter concepts. When faced with extreme weather conditions, the first and most basic requirement is to safeguard the displaced population from external agents. A more efficient alternative honeycomb production method must be pursued in light of the rising costs of electricity and raw materials. The ultimate goal of the cooperative development is to produce sandwich panels that meet technical criteria, are lighter in weight, and are more cost-effective when compared to currently available composite or metal alternatives, among other things. Cold processing is used to adhere the honeycomb preparation to the composite skin, which is made of aluminium alloy. The purpose of this investigation is to establish whether oil palm and epoxy aluminium honeycomb panels are suitable for use in the building of a shelter structure. Furthermore, the goal of this research is to develop a medium for building shelter out of oil palm debris and epoxy aluminium. The next step is to characterise the structure and toughness of a composite made of oil palm and epoxy aluminium alloy.

ABSTRAK

Memahami dan memilih konsep dengan tujuan menterjemahkan keperluan pengguna praktikal ke dalam kumpulan konsep perlindungan. Apabila menghadapi keadaan cuaca yang melampau, syarat pertama dan paling asas adalah melindungi penduduk yang terlantar dari agen luar. Kaedah pengeluaran sarang lebah alternatif yang lebih cekap mesti dilaksanakan memandangkan kenaikan kos elektrik dan bahan mentah. Matlamat utama pengembangan koperasi adalah untuk menghasilkan panel sandwic yang memenuhi kriteria teknikal, lebih ringan, dan lebih menjimatkan kos jika dibandingkan dengan alternatif komposit atau logam yang ada sekarang, antara lain. Pemprosesan sejuk digunakan untuk melekatkan penyediaan sarang lebah pada kulit komposit, yang diperbuat daripada aloi aluminium. Tujuan penyelidikan ini adalah untuk menentukan sama ada panel sarang lebah kelapa sawit dan epoksi sesuai digunakan dalam pembinaan struktur tempat perlindungan. Selanjutnya, tujuan penyelidikan ini adalah untuk mengembangkan media untuk membina tempat perlindungan dari serpihan kelapa sawit dan aluminium epoksi. Langkah seterusnya adalah mencirikan struktur dan ketangguhan komposit yang diperbuat daripada kelapa sawit dan aloi epoksi

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Merciful. Alhamdulillah, I am grateful to Almighty Allah (Subhanahu Wa Taa'la) for providing me with the power and enthusiasm necessary to complete this research throughout my life. I am grateful for His grace, guidance, and generosity in granting my wishes.

I would want to express my heartfelt gratitude to everyone who assisted me during the course of my research. I would like to express my deep gratitude to my respected supervisor, Dr Muhammad Zulkarnain, for his direction, criticism, and willingness to lend a helping hand, counsel, hospitality, intellect, and knowledge during the semester and throughout this project. This research would not have been done without his assistance.

Additionally, I want to express my gratitude to my parents, Nor Azmi Bin Mohd Jamal and Salmi Binti Mohammed Salleh, for their support. I am sure that without their help, this research would not have been possible. I would like to apologise in advance to any those anonymous individuals that assisted me in various ways in order to complete my research.

TABLE OF CONTENTS

		PAGE
DECLARATION		
APPROVAL		
DEDICATION		
ABSTRACT		**i**
ABSTRAK		**ii**
ACKNOWLEDGEMENTS		**iii**
TABLE OF CONTENTS		**iv**
LIST OF TABLES		**vi**
LIST OF FIGURES		**vii**
LIST OF SYMBOLS AND ABBREVIATIONS		**ix**
LIST OF APPENDICES		**x**
CHAPTER 1	**INTRODUCTION**	**11**
1.1	Background	11
1.2	Problem Statement	12
1.3	Objective	13
1.4	Scope of Research	13
CHAPTER 2	**LITERATURE REVIEW**	**15**
2.1	Introduction	15
2.2	Lightweight and portable	15
	2.2.1 Development of a shelter unit	15
	2.2.2 Water filled barrier with internal honeycomb cells.	16
	2.2.3 Mechanical performances.	18
2.3	Honeycomb sandwich panel.	20
	2.3.1 Recent advances metallic honeycomb structure.	20
	2.3.2 Performance of honeycomb support structure.	22
	2.3.3 Dynamic bending responses of CFRP thin-walled square beams.	24
	2.3.4 Mechanical and energy absorption properties.	26
2.4	Natural fibre.	27
	2.4.1 Properties of oil palm	27
	2.4.2 Suitability of oil palm fibre composite for building applications.	30
	2.4.3 Properties of coconut, oil palm and bagasse fibres.	31
2.5	Design and analysis	34
	2.5.1 Honeycomb panel sandwich structure loaded in pure bending	34

2.5.2 Cost effective steel honeycomb structures. 35
2.6 Conclusion 37

CHAPTER 3 METHODOLOGY 38
3.1 Introduction 38
3.2 Experiment method 39
3.2.1 Material 39
3.3 Preparation of ECA composite 40
3.4 Mechanical behavior 42
3.4.1 Flexural testing 42
3.5 Equipment 43
3.5.1 Electronic Balancing 43
3.5.2 Stirrer 44
3.5.3 Oven 45

CHAPTER 4 RESULT AND DISCUSSION 46
4.1 Introduction 46
4.2 Flexural Testing 46
4.2.1 Results 46
4.2.2 Flexural Data Interpret **Error! Bookmark not defined.**

REFERENCES 55

LIST OF TABLES

TABLE	TITLE	PAGE
Table 3.1	Formulation of honeycomb composites	41
Table 3.2	The material mechanical properties	**Error! Bookmark not defined.**
Table 3.3	The material properties of natural fiber	**Error! Bookmark not defined.**

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1	Two-person emergency shelter conceptual design, (Farmer et al., n.d, 2017)	16
Figure 2.2	Surface plot of energy absorption percentage combined with water level and length ratio, (Zhe Wang et al., 2019	17
Figure 2.3	Three-point bending analysis using finite elements: (a) finite element analysis (FEA) model—three-point bending; (b) deflection of specimen; (c) equivalent stress distribution; (d) comparative study of reaction forces, (Zaharia et al., 2020)	19
Figure 2.4	Embedded honeycomb filled with (a) foam (b) smaller circular tubes (c) metallic circular structures (d) specimen, (Zhonggang Wang, 2019)	21
Figure 2.5	SLM manufacturing honeycomb structure, (He et al., 2019)	22
Figure 2.6	SLM thermal analysis model, (He et al., 2019)	23
Figure 2.7	Failure modes of hollow and filled CFRP beams in FE simulation, (Xiao et al., 2018)	24
Figure 2.8	Failure modes of hollow and filled CFRP beams in drop hammer impact test, (Xiao et al., 2018)	25
Figure 2.9	Comparison of densification strain versus impact velocity in the three honeycombs structures, (Li et al., 2020)	27
Figure 2.10	Density and void content of pure and hybrid composites	28
Figure 2.11	Thickness swelling again immersion time of composites, Ramlee et al., 2019)	29

Figure 2.12 TGA and derivative of thermogravimetric (DTG) curves for various flame retardant formulations in the OPFC panel, (Suoware et al., 2020) 31

Figure 2.13 Drying of oil palm fruit fibres, (Danso, 2017) 32

Figure 2.14 Water absorption behaviour of fibres for 14 days, (Danso, 2017) 33

Figure 2.15 Tensile strength of fibres in wet and damp conditions over 120 days, (Danso, 2017) 33

Figure 2.16 Various types of facing sheet failures, (Galletti et al., 2008) 35

Figure 2.17 Force applied on the top surface and Meshed assembly, (Ghongade et al., 2020) 36

Figure 2.18 Design of circular core with dense packing and straight stacking, (Ghongade et al., 2020) 36

Figure 3.1 Force applied on the top surface and Meshed assembly, (Ghongade et al., 2020) 39

Figure 3.3 Universal Test machine (UTM) of Instron 4486 43

Figure 3.4: Electronic Balancing 43

Figure 3.5 Magnetic stirrer 44

Figure 3.6 Laboratory oven 45

LIST OF SYMBOLS AND ABBREVIATIONS

D,d	-	Diameter
m	-	Metre
km	-	Kilometre

LIST OF APPENDICES

APPENDIX	TITLE	PAGE

CHAPTER 1

INTRODUCTION

1.1 Background

For thousands of years, the use of wave modelling has been in place and continues to find new applications in the modern world. Through a wave design, a low density and high-strength material can be produced for various applications. The honeycomb takes its name from the hexagonal form of the bee's wall, which was used in various constructions over the last century with an increasing frequency

Honeycomb structures are natural or man-made structures with the honeycomb geometry to reduce the amount of material used to a minimum weight and material expenses. The geometry of wave structures can vary widely, but the basic characteristic of all such structures is a range of hole cells between thin vertical walls. Sometimes the cells are columnary and hexagonal. A structure in the honeycomb provides a substance with low density and relatively high out of-plane shear properties, (Li, Lin, et al., 2020)

The honeycomb style has been used extensively since the 1980s. In large scale, enormous strength is practical with thermoplastic extruded honeycombs at an extremely low density. The honeycomb applications are all but unlimited. Modern buildings often use wall covered aluminum in a wave pattern for esthetics and strength. In certain cases, honeycomb-based isolation is often used for a compact and robust construction process. Structures such as the Honeycomb Bahamas apartment building, the Honey Bee Hive House in Israel and the modular British Hivehaus home design make use of the wave form to the full. The honeycomb construction process is much better than it used to be with advanced materials, (Kumar & Patel, 2020)

Structural materials made from honeycomb are generally produced by laying a honeycomb material between two thin layers that provide tension resistance. This forms a platform-like mount. Wave materials are commonly used where flat or slightly curved surfaces are necessary and their high specific strength is important. For these reasons, they are commonly used in the aerospace industry and since the 1950s, honeycomb materials in aluminum, fibreglass and state-of-the-art composites have been present in avions and rockets. You can also find them in many other areas, from packaging materials in the shape of a paper carton to sports equipment such as skis and snowboards, (Li, Lu, et al., 2020)

1.2 Problem Statement

Many organic and biological materials in nature show excellent performance in various aspects and varied in mechanical performance. It has been found that the performance of natural fiber can be reinforced in composite enhanced by content and orientation optimization. The thin-walled honeycomb concept is prevailing in optimizing structural mechanical performance. The combination of thin-walled honeycomb structure has been coupled with the composite panel and introducing their mechanical performance. Nature fiber such as Oil Palm fiber needs to explore as the composite panel to improve thin-walled honeycomb in mechanical performance. Due to the lack of information regarding sandwich material between oil Palm fibers panel and thin-walled honeycomb structure, further study needs to explain fiber content optimization to honeycomb structure on mechanical performance. Furthermore, it strong enough to reduce composite cost production by using organic for a reinforced composite that proposes to use the wasted local product

1.3 Objective

The objectives of this project have been identified and should be achieved to produce a successful Lightweight and Portable by Using Oil Palm Fiber Reinforced Honeycomb. The objectives of this project are as followed:

1. To optimize Oil Palm fibre on polyster resin composite on flexural testing.

2. To fabricate sandwich of thin-walled honeycomb with Oil Palm fibre on resin polyster composite panel.

1.4 Scope of Research

In order to produce the best work, the scope is needed to support and guide project progress. These scopes should be properly defined and prepared. The scope of this project are listed as follow:

- Selection of terms to pass the needs of practical users in a range of refuge concepts. In extreme climatic conditions, protecting the displaced people from foreign agents is a first fundamental requirement.

- In view of the rising energy and raw material costs, more sustainable alternative output of wave must be the way forward.

- The Oil Palm fibers are collected from the local product by sun-drying process before apply as reinforcement.

- Material thin-walled honeycomb aluminum produces by commercial manufacturing in the market.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

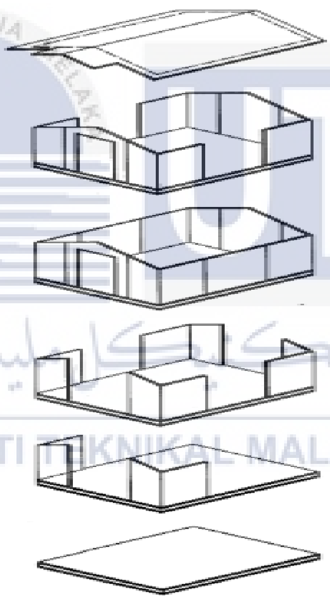
This chapter presenting the theory and research by previous findings that have been done regarding honeycomb panel and whole parameters relate to the honeycomb sandwich project. This project much concerned with developing a lightweight material and portable friendly by applying oil palm fiber reinforced honeycomb sandwich panel.

2.2 Lightweight and portable

2.2.1 Development of a shelter unit

Natural catastrophes evict thousands of people in the United States each year. Thousands more are chronically homeless, living on the streets and in parks throughout our cities. When people become homeless, emergency organizations such as the Federal Emergency Management Agency and the American Red Cross are typically responsible with providing emergency housing. Unfortunately, the present shelter-supply system is both complicated and expensive. Emergency shelter is typically provided by the military in the form of huge tents or through the usage of mobile houses. Both approaches are costly and difficult to implement logistically. The goal of this project is to create and test a novel system for providing emergency shelter. The construction of a recyclable shelter unit made of recyclable corrugated board material will be at the heart of this system. These shelter modules will be intended for short-term usage, generally up to three months, and will be completely recycled after that. The units will be light and affordable, and will be made up of a set of corrugated board panels that can be moved and constructed by two people. The setup and connectivity will be designed to be easy enough for non-technical people to put together with common equipment. After a crisis, the units may be trucked or airlifted into catastrophe-stricken areas to offer nearly instantaneous refuge. These shelters may be supplied directly to the homeless by truck in winter areas to give protection from the dangerously cold weather as shown in Figure 2.1. The shelter may be readily dismantled and the materials recycled when the primary demand has been met. This project will take into account the economics of both the manufacture and distribution of the shelters, in addition to design issues, (Farmer et al., n.d, 2017)

Figure 2.1Two-person emergency shelter conceptual design, (Farmer et al., n.d,

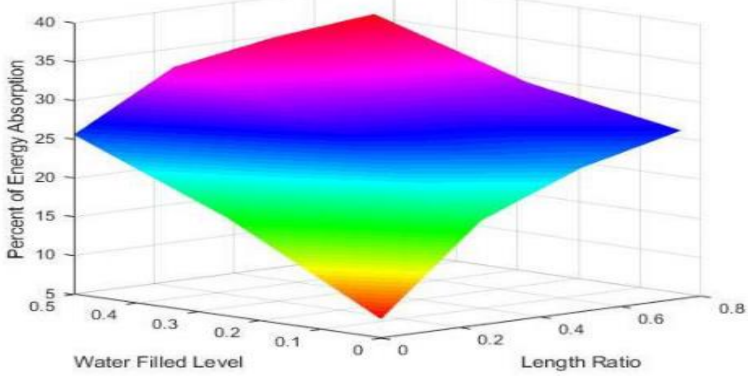


2017)

2.2.2 Water filled barrier with internal honeycomb cells.

Longitudinal traffic barriers are frequently employed as U.S. road safety elements to keep vehicles on the road and prevent them from colliding with harmful obstructions. Portable water-filled barriers (PWFBs) are one type of temporary longitudinal traffic barriers often employed in speed-limit zones and on the roadside. Current market PWFBs are cost-effective, showing great efficiency while enduring low-speed vehicle impact. High-level impact severity, however, leads in structural failure and considerable lateral deflection. Based on evaluation criteria from the Assessment Safety Hardware Manual (MASH), some PWFBs are inefficient to fulfil the standards of recently published evaluation materials. In terms of impact loading, because newly designed PWFB with internal honeycomb cells intends to improve energy absorption behaviour and structural resistance. The PWFB with internal cells is built based on the JB-32 barrier prototype, where quadrangle-shaped honeycomb cells are bounded on the inside surface. In the early stages of this research, small-scale barrier specimens the energy absorption behaviour of water-filled barrier structure. Numerical simulation is accomplished with Finite Element Analysis (FEA) software (ABAQUS). Using the resulting FE, a parametric study is conducted to further validate the test observation. With both testing and numerical data, water absorption and system structural strength may be addressed A design advice and optimal condition is offered for the parametric study conducted, (Zhe Wang et al., 2019)

Figure 2.2 Surface plot of energy absorption percentage combined with water level



and length ratio, (Zhe Wang et al., 2019

Figure 2.2 provides an overall design of variation in energy absorption in terms of the length and water level of friction BC. The overall energy absorption depends on two variables: the proportion of length and the volume of water filled. Overall, optimizing the two variables in terms of total energy absorption will find the ideal solution. The global criteria technique successfully addresses the various objective issues that minimize objective functions.

2.2.3 Mechanical performances.

Fused Filament Manufacturing (FFF) offers a better geometric flexibility than traditional methods in the manufacture of thermoplastic lightweight sandwich structures. This research employed a 3D printer and biodegradable polylactic acid/polyhydroxyalkanoate (PLA/PHA) material to create lightweight sandwich constructions with honeycomb, diamond-celled, and corrugated core geometries as a single part. Compression, three-point bending, and tensile tests were used to assess the performance of lightweight sandwich constructions with various core topologies in this work. Furthermore, the primary failure mechanisms of the sandwich constructions that were submitted to mechanical testing were assessed. Face yielding, face wrinkling, and core/skin debonding were the most common failure mechanisms detected during mechanical tests of the sandwich construction. The use of elasto-plastic finite element analysis enables researchers to forecast the structure's overall behavior and stress distribution in the components of lightweight sandwich constructions. In terms of failure behavior and force response, the comparison of the results of bending experiments and finite element studies revealed satisfactory comparability. Finally, the three core typologies of honeycomb, diamond-celled, and corrugated cores were impact tested in the leading edge of the wing, and the findings established suitable conditions for employing such structures on aircraft models and helicopter blade constructions, (Zaharia et al., 2020)

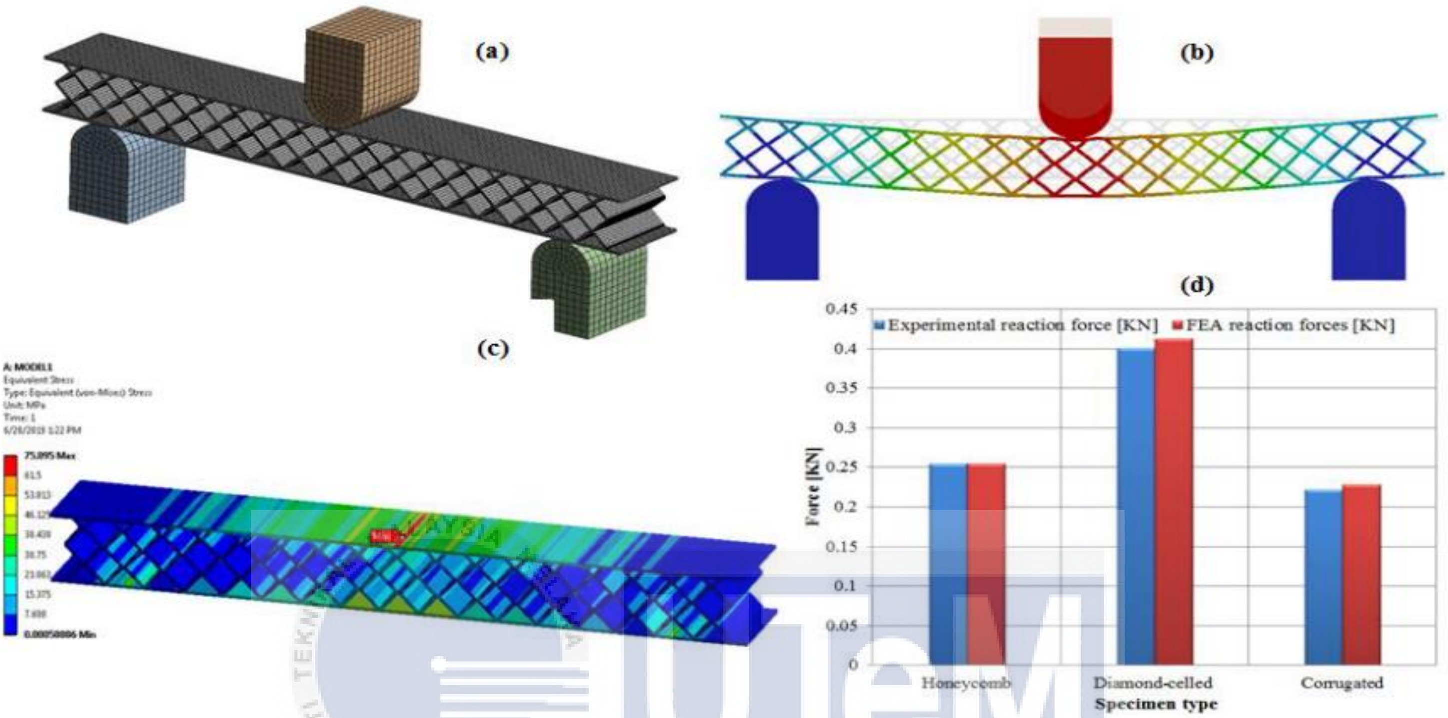


Figure 2.3 Three-point bending analysis using finite elements: (a) finite element analysis (FEA) model—three-point bending; (b) deflection of specimen; (c) equivalent stress distribution; (d) comparative study of reaction forces, (Zaharia et al., 2020)

Once sandwicks with a diamond cell core are examined and tested with finite elements, it can be shown in Figure 2.3, in both situations, the breakage happens on the upper skin of the structure. The equivalent of Von Misses stress is shown in the middle of the top skin of the sandwich constructions as the highest value (75,095 MPa). Thus, it can be noted that the upper skin of the FEA-analyzed sandwich specimens has the same failure mechanism as the bending of the tested specimens, namely facial return.

The results of the comparative study show that the bending reaction forces resulting from experimental testing and the reaction forces found in support of the FEA model provide an adequate validation of the information that has been measured and used to test the specimens and the FEA model.

2.3 Honeycomb sandwich panel.

2.3.1 Recent advances metallic honeycomb structure.

Materials with improved mechanical capabilities and special functions, innovative honeycomb-based structures have received a lot of attention in recent years. The presented work produced a comprehensive overview on the evolution of the unique honeycomb-based structures in the past two decades, including filled-type, embedded, tandem, hierarchical, auxetics with Negative Poisson's Ratio (NPR), etc. Mechanical performances of these structures were commented with advantages and disadvantages, based on their geometric configurations, mechanical performance and dynamic response, respectively. The obstacles as well as future directions were also analysed. The achievements provide crucial guidelines in designing of new generation light-weight honeycomb-based structures, (Zhonggang Wang, 2019)

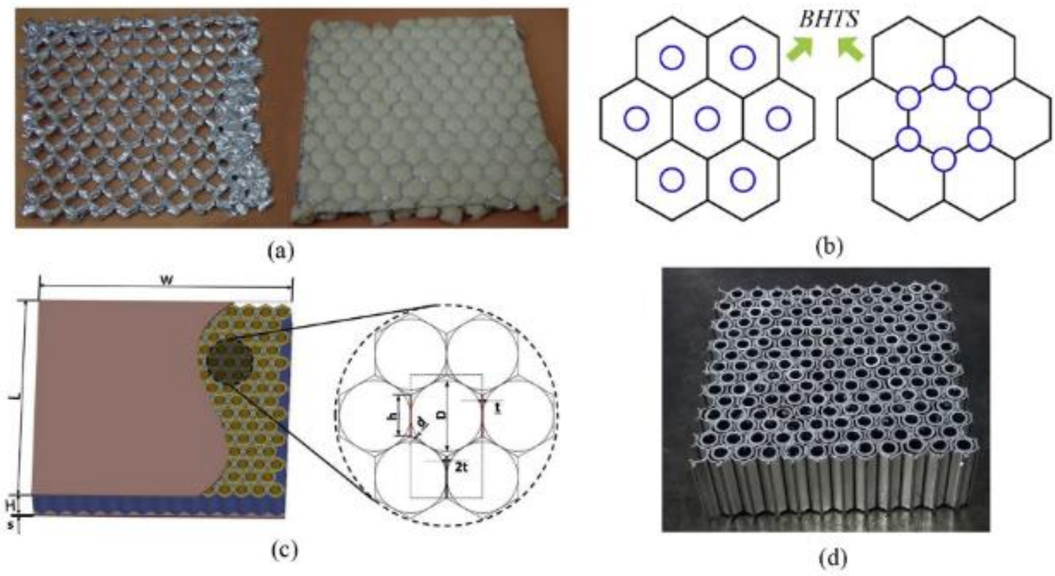


Figure 2.4 Embedded honeycomb filled with (a) foam (b) smaller circular tubes (c) metallic circular structures (d) specimen, (Zhonggang Wang, 2019)

According to dynamic numerical crushing simulations, BHTS with filled columns on its walls absorbs more energy than BHTS without filled columns on its walls. It should be noted that the diameter of the circular tubes packed with honeycomb is significantly less than the cell length of the honeycomb. Meanwhile, the embedded structures presented in are distinct from the BHTS in that their inner circular tubes are perpendicular to the honeycomb walls, as illustrated in Figure 2.4 (c) (d). As demonstrated in these works, embedded honeycomb structures not only retain the superior mechanical properties of the classic hollow honeycomb core, but also improve energy absorption. Due to the honeycomb cells relatively limited volume, the inside circular tubes have a modest dimension. This way of loading considerably increases their specific energy absorption. A great deal. Similar to the honeycomb-filled structure, an appropriate filling method is critical for embedded structures, as it has a direct effect on their mechanical behaviour.

2.3.2 Performance of honeycomb support structure.

SLM can overcome the limitations of conventional manufacturing technologies and enable the creation of lightweight and complicated products. However, in the SLM manufacturing process, the overhang structure cannot be created satisfactorily without a support structure. At the moment, the conventional support structure is a lattice structure, which is difficult to manufacture, and the manufacturing faults in some of the bars cause the structure to yield prematurely, resulting in low reliability. We create honeycomb structures with a variety of parameters in this article. We obtained a set of structural parameters with exceptional performance. Compression testing was performed on the WDW-100 universal material testing machine, demonstrating that the honeycomb structure of this set of parameters is extremely strong and meets manufacturing requirements. Finally, using the sensor mount as the object, this set of parameter honeycomb structure is used for light weight reconstruction, which can achieve a greater weight reduction effect while maintaining the structural integrity of the parts, providing technical support for the lightweight design of parts, (He et al., 2019)

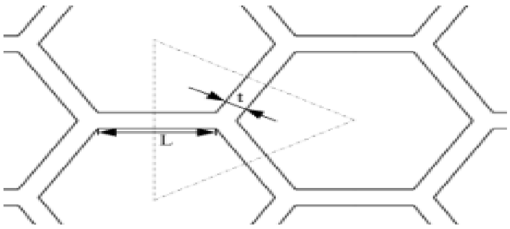


Figure 2.5 SLM manufacturing honeycomb structure, (He et al., 2019)

$$\overline{\rho} = 1 - \frac{3}{(\sqrt{3} + \frac{t}{L})^2}$$

Equation (2.1)

Equation (2.1) shows that the relative density of the wave structure is related only to the side length and wall thickness of the hole irrespective of the height. The relative density variation is less impacted by the side length and is more susceptible to variations in the structure of the wall. By altering the wall thickness of the honeycomb construction, the relative density of the wave structure may be swiftly altered.

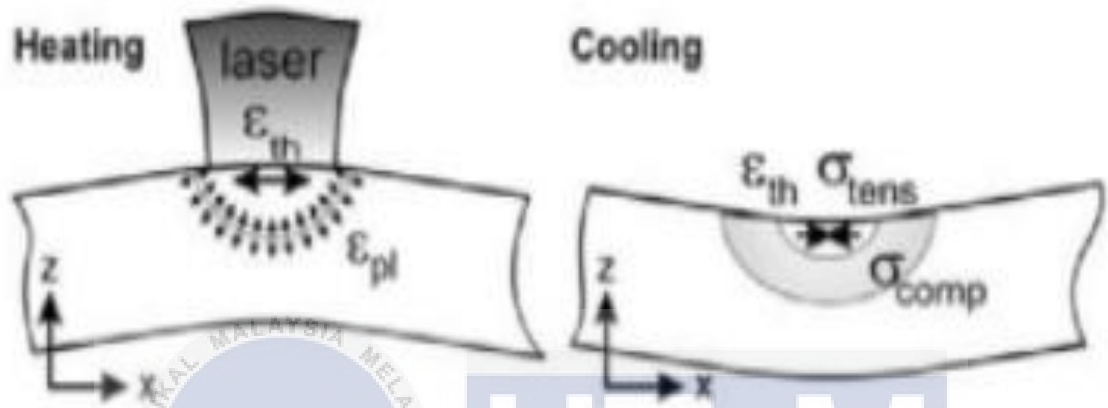


Figure 2.6 SLM thermal analysis model, (He et al., 2019)

In terms of cooling rate, according to Fourier's law of thermal conduction

$$Q = -\lambda A \frac{dT}{dx}$$

Equation 2.2

Q is the amount of heat transferred per unit time, A is the area of the heat transfer cross section, T is the temperature, and x denotes the direction of heat conduction coordinates. The rate of heat transmission is proportional to the thermal conductivity, the cross-sectional area, and the rate of change in temperature perpendicular to the cross-section.

2.3.3 Dynamic bending responses of CFRP thin-walled square beams.

Thin-walled square beams (CFRP) are a new energy absorption component, with aluminum honeycomb-filled carbon fiber enhanced plastic (CFRP). In this article, dynamic impact tests are carried out for bending aluminum honey-filled CFRP beams with different configurations, and mode and force reactions of failures are explored. Modified Chang-Chang failure criteria are used to prevent the failure of tensile and compressive fiber as well as the failure of tensile and compressive matrix. Numerical simulations of the tests are also carried out and the correctness of the test results is checked. Influences on bending resistance are analysed for several factors, which include the wall thickness, the fiber direction, the stacking sequence and the impact velocity. The influence of the aluminum wave filler on the properties of crash resistance is also explored. The findings demonstrate that the energy absorption and the specific energy absorption of filled composite tubes can increase greatly by 104,3% and 26,8% compared with CFRP hollow beams, respectively. This study demos strate the potential of aluminum pumped CFRP beams to be employed as energy absorbers, (Xiao et al., 2018)

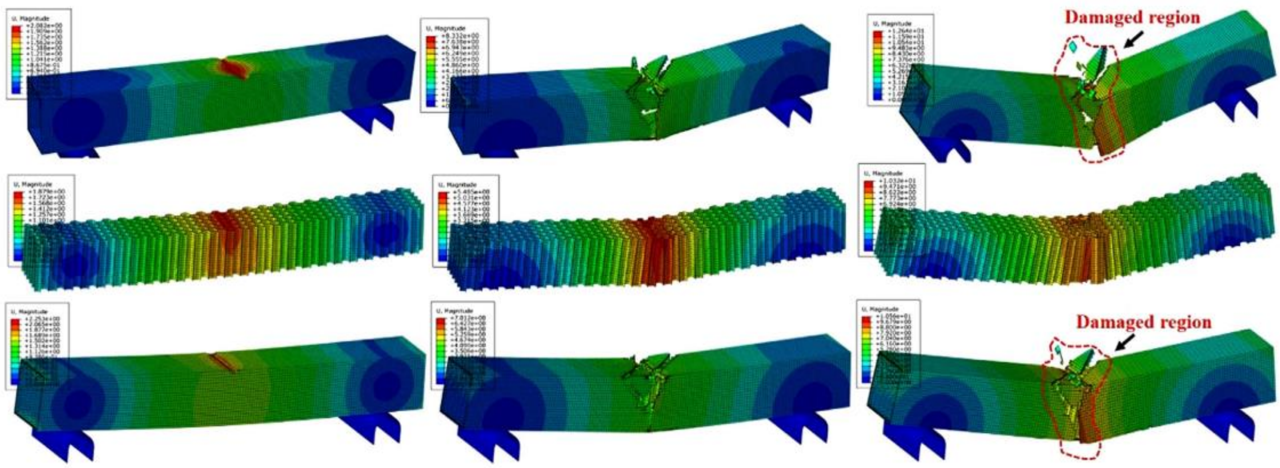


Figure 2.7 Failure modes of hollow and filled CFRP beams in FE simulation, (Xiao et al., 2018)

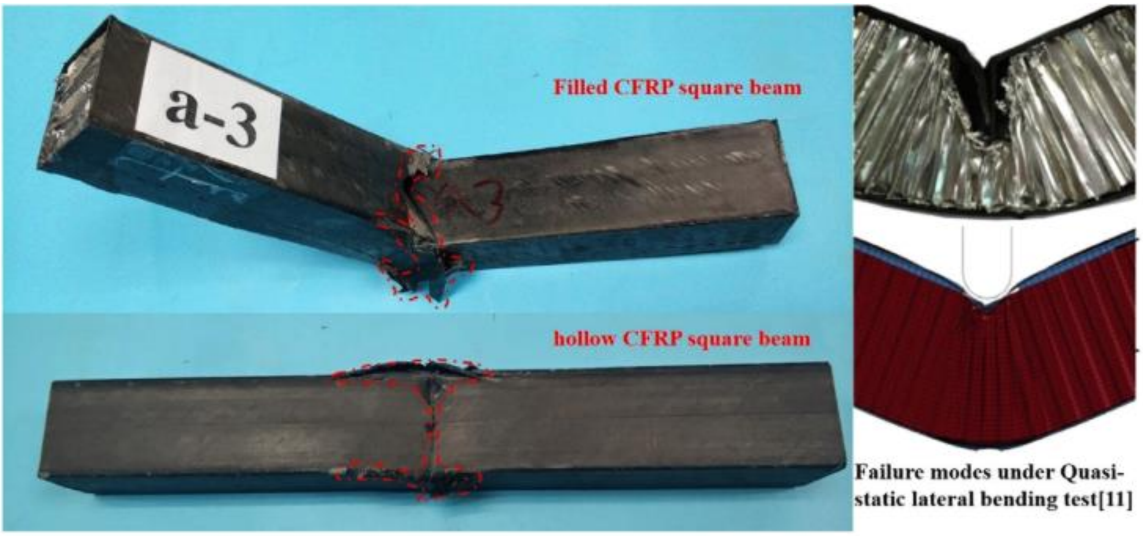


Figure 2.8 Failure modes of hollow and filled CFRP beams in drop hammer impact test, (Xiao et al., 2018)

The failure mechanisms of hollow and filled CFRP beams are given under the FE simulation and drop hammer impact test 2.7 and 2.8 its display a complicated mechanism of failure comprising plastic hinges, buckling, core failure and shear interaction. It is obvious that the microfracture in the corner of the top wall is caused by the force of the drop-hammer. The cracks spread along the hinge line from the top wall to the bottom of the CFRP tube. In the first stage, a micro fracture in the corner of the top wall, caused by the concentration of stress, comes into contact with the drop hammer; fractures extend to the perpendicular direction of the beam axis, and the cracks on the side walls spread from top to lower. This produces many crossings on the CFRP beam side walls. The strength of composites compared to their strength is often much lower; so the initial breakdown happens on the top surface of the CFRP tube and extends into the bottom surface.

2.3.4 Mechanical and energy absorption properties.

This work has experimentally examined the dynamic mechanical and energy absorption responses of 3 samples: single-layer hexagonal aluminum honeycomb and combination of two stacking angles (0° and 90°) hexagonal aluminum honeycombs. The combined honeycombs consist of two layers of undivided honeycombs. Dynamic studies were carried out by means of a gas-gun high-pressure system with impact speeds of 30–70 m/s. The results demonstrated that the integrated honeycombs largely respond dynamically through cluded cuts and buckling processes. The cutting stress on the plateau grew at a greater pace, but reached a lower ultimate value in 0°-layered pine nurseries than in 90°-layered pine nurseries. The buckling of the two combined honeycombs was almost identical, and their quasi-static values were around 1.5–2 times. In addition, a dimensional empirical formula was presented to characterize the honeycomb density and pressure rate effects on the plateau stresses. It determined that in the 90° layer wafer the energy absorption capacity was high and in the single layer wafer the lowest. Finally, the two merged honeycombs explored energy absorption methods, (Li et al., 2020)

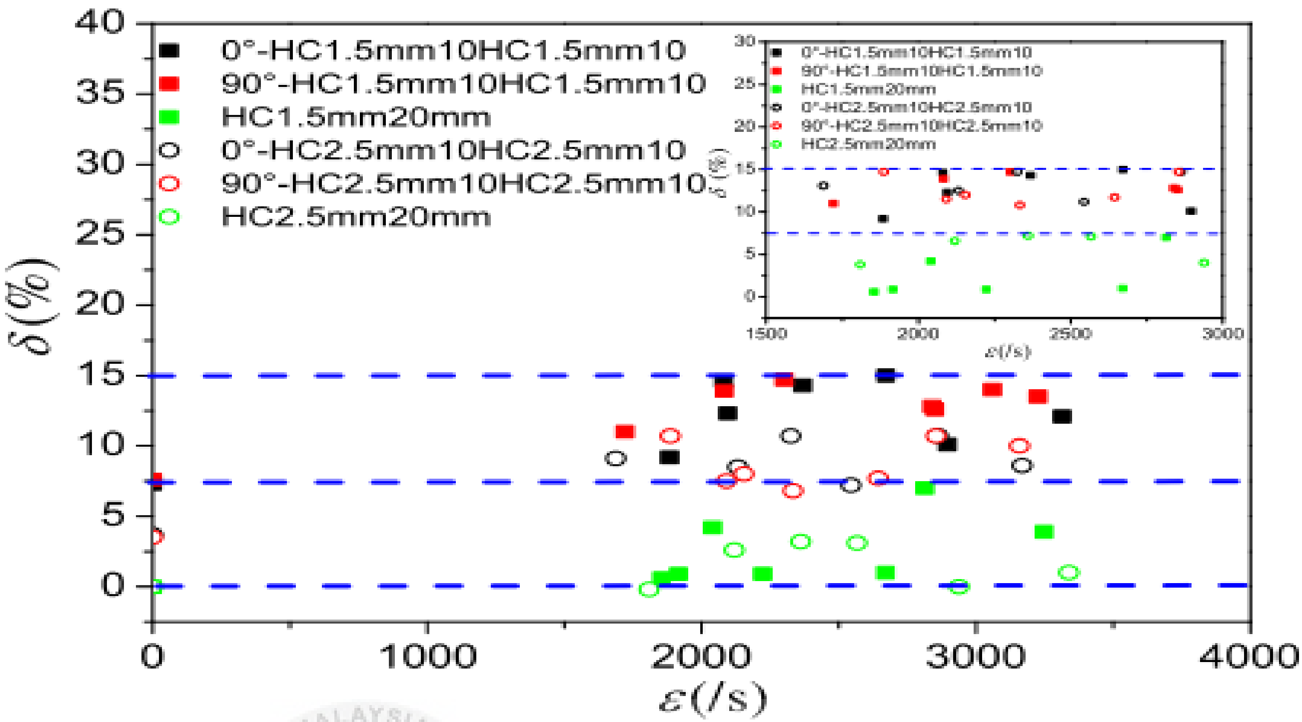


Figure 2.9 Comparison of densification strain versus impact velocity in the three honeycombs structures, (Li et al., 2020)

As mentioned in Figure 2.9, the energy absorption capacity of the two-layer structures was greater than the one-layer honeycomb. The densification strain is probably one explanation. Taking as a reference the SHAH densification strain under quasi-static circumstances, Figure 2.11 shows an increase of the SHAH densification strain amplitude compared to the strain rate. The dynamic influence, in relation to the reference, improved the densification strain by 7.5–15% in CHAH, but by at most 7.5% in SHAH.

2.4 Natural fibre.

2.4.1 Properties of oil palm

Agricultural residues like the OPEFB and the fiber SCB have recently attracted attention to researchers as a high-potential reinforcing material for composite materials in the building industry. Agriculture biomass for composite industries is biodegradable, sustainable, low cost and lighter materials. OPEFB and SCB fibers are employed as a filler in a variable ratio in this document for manufacturing hybrid composites, while retaining a total fiber load of 50 wt percent. Power test use of UTM INSTRON, water absorption, expansion of thickness, density, empty content and hybrid composite and pure micrographs were determined. This study found that OPEFB/SCB composite hybridization suggests enhanced performance and attributes comparison with composites of pure fiber. Results demonstrated that hybrid 7OPEFB:3SCB composites with 5.56 MPa and 661.MPa have the maximum tensile strength and modulus, each with a reduced pore and void area in comparison to pure composites. During 3OPEFB:7SCB after a 24 hour examination, hybrid composites demonstrate decreased water absorption and thickness swelling. This research focuses on agricultural residues as an alternative material to green products use as a thermal insulation and retention of heat in walls that are vital in buildings in the building sector for energy conservation purposes, (Ramlee et al., 2019)

Composites	Density (g/cm^3)	Void content (%)
Pure OPEFB	0.531	10.95
Pure SCB	0.521	6.45
3OPEFB/7SCB	0.525	6.89
5OPEFB/5SCB	0.535	7.76
7OPEFB/3SCB	0.545	8.20

Figure 2.10 Density and void content of pure and hybrid composites

However, the treatment of fibers essential for future developments in building composites to produce smooth surface, good links between fiber/matrix interface and also homogenous mixtures of composites is reasonably studied after researching SEM imagery

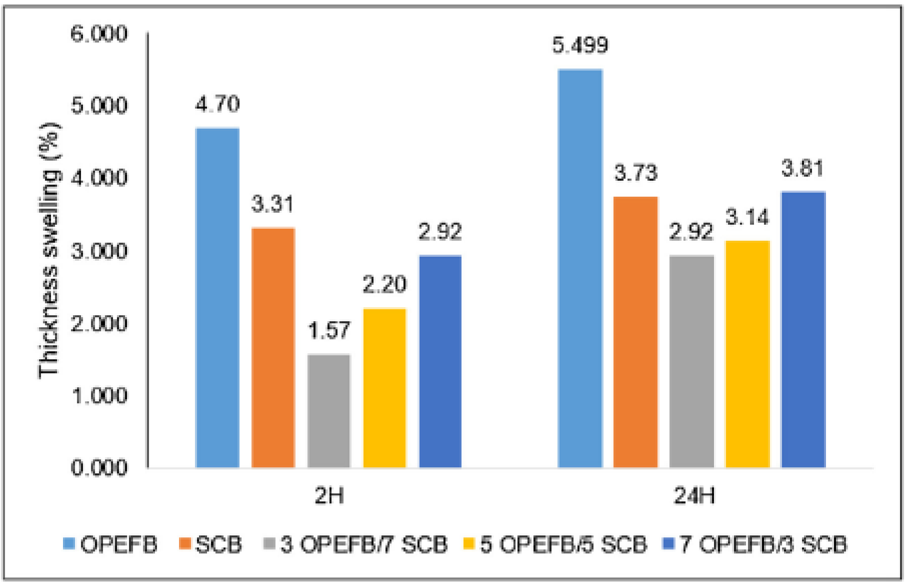


Figure 2.11 Thickness swelling again immersion time of composites, Ramlee et al., 2019)

The thickness swelling of the pure and hybrid composites was shown to increase with time for the water immersion of 2 hours and 24 hours as shown in Figure 2.10. The same trend was discovered for the thickness swelling with water absorption. It can be observed that the hybrid composite 3OPEFB:7SCB was more stable to a swelling trend that resulted in a low swelling percentage after 24 hours. This might be caused by the interfacial adhesion, as well as water absorption, between the fiber and the hydrophobic polymer matrix. In general, thickness swelling is directly linked to the dimensional stability of composites which affect the temperature exposure and variations in humidity.

2.4.2 Suitability of oil palm fibre composite for building applications.

Fire-reinforced composites (OPFC) have required study to enhance the yield of oil palm fiber reinforced composites (OPFC) to limit fire spread. Researchers have depended on FR (Flamm Retardants) to improve the performance of composites with an emphasis on flame retardant qualities (FP). The major goal of this article is to assess the influence of six non-halogenated FR species in OPFC to satisfy needed building fire safety criteria. A loaded ratio of 0, 15 and 18 percent was used with OPFC in six FR-species containing aluminum tri-hydroxide (ATH), ammonium polyphosphate (APP), gum arabic powder (GAP) and carbon black (CB). Specimens cut from OPFC panels have been evaluated with thermogravimetric analyses (TGA/DSC Metlar Toledo) and the cone calorimeter devices for flammability and thermal characteristics. The thermal investigation has demonstrated that the panel was thermally stable at 391,6OC, compared to those without FR, while high flame proof at heat, mass loss and smoke generation rates indicated that the OPFC quick fire reaction panels decreased dramatically by 67.4%, 50.9% and 37.5%. It can be inferred that the APP-GAP hybrid FR displayed a stable car structure during fire and avoided a fire exhaust that lowered the FP peak of the OPFC panels. These inflammability features can be stated to fulfill the necessary fire safety criteria for construction applications, (Suoware et al., 2020)

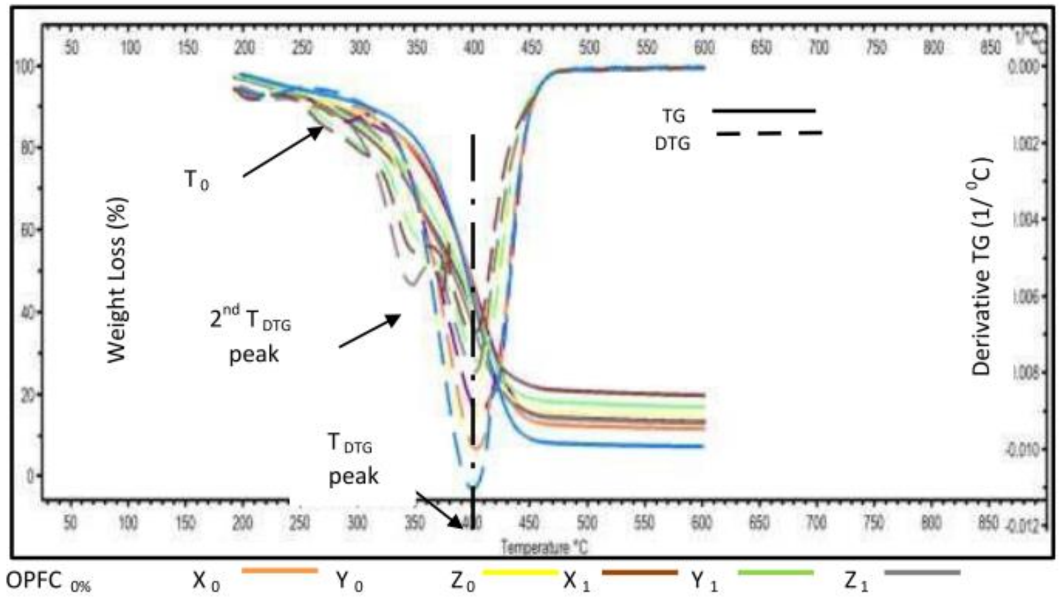


Figure 2.12 TGA and derivative of thermogravimetric (DTG) curves for various flame retardant formulations in the OPFC panel, (Suoware et al., 2020)

TGA curves in sigmodal form showed in Figure 2.11that the FR had a typical single WL deterioration. It also shows that the species X0 and X1 in the OPFC panel had improved thermal stability, with the initial decomposition (T0) starting at approximately 376,3OC and 391,6OC, respectively, improving by 5,1OC, or 20,48OC, in comparison with the OPF C0 percent panel at 371OC, while the other FR worsened. This improvement might be driven by the cellulose elements of oil palm fiber of 65% and lignin of 29%. Early lignin breakdown into a char that slowly decomposes thermally. The Y0 and Y1 panels showed the least thermal stability, but the early disintegration of the FR indicating a strong flame retarder might trap the escape of the volatiles of fuel.

2.4.3 Properties of coconut, oil palm and bagasse fibres.

Through use of natural fibers in composites attracts international research attention because of the fibers' capacity to boost strength, to lessen environmental impacts and to save material costs. This study examined the characteristics of cocoa fiber, oil palm fruit fiber and sugarcane bagasse fiber. Length and diameter experiments, specific weights and stresses, elasticity modules, moisture content and water absorption tests on the fibers have been carried out to identify their attributes for prospective usage as a composite reinforcement. Various fibers have different characteristics and comparable behavior was seen in humid and humid circumstances. The study concluded that all fibers had qualities appropriate to be employed in blocks of soil as natural fibres.

Figure 2.13 Drying of oil palm fruit fibres, (Danso, 2017)

Oil palm fruit fibers from palm oil mining factory in Kumasi, Ghana were collected. The fruits were crushed and the oil was removed so that fibers and shells could be thrown away or burnt as garbage. The debris has been gathered and the fibers removed from the shells. The fibers were rinsed in warm water to eliminate any remaining oil content. They dried up in the sun two weeks later.

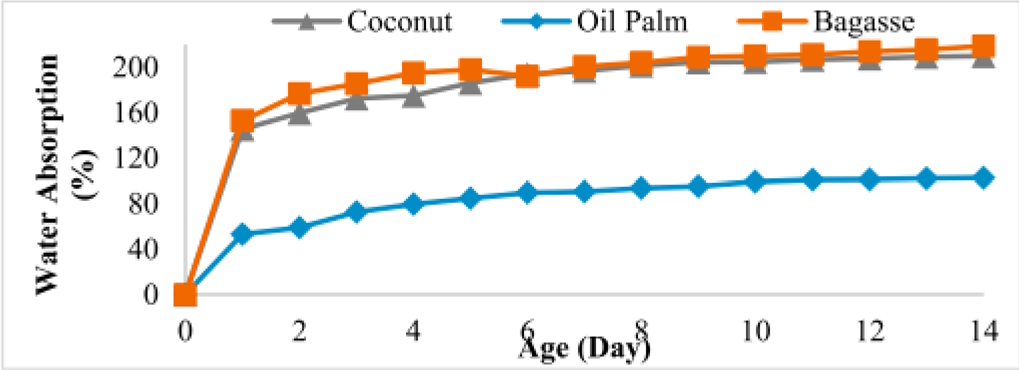


Figure 2.14 Water absorption behaviour of fibres for 14 days, (Danso, 2017)

The absorption rates of bagasse and coconut fibers were near to high, with bagasse having reached the greatest, a rise of between 153% during the first 24 hrs and 219% on the fourteenth day. On the first 24 hours as shown in figure 2.13, oil palm fiber reported lowest absorption ranging from 54% to 103% on the fourteenth day. Similar absorption rates were reported in the Sen and Reddy sisal, coir and bamboo fibre study. The kenaf fibers examined by Millogo received, however, an extremely high water absorption of 307 percent.

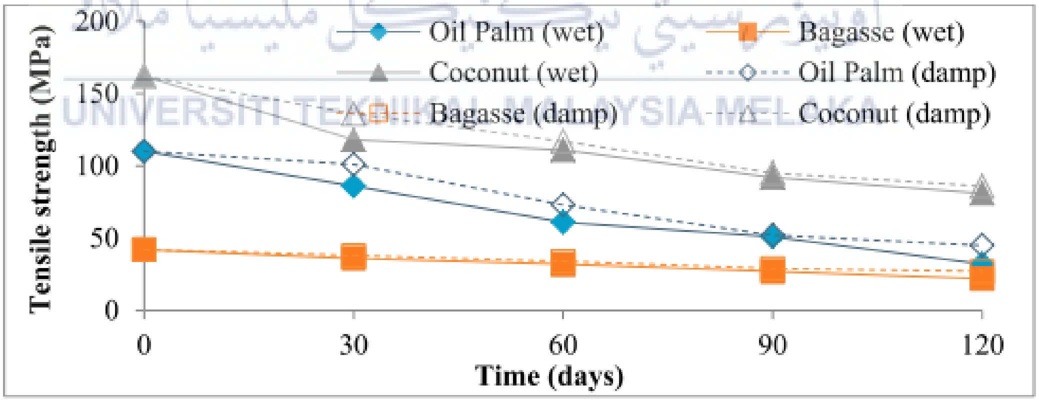


Figure 2.15 Tensile strength of fibres in wet and damp conditions over 120 days, (Danso, 2017)

The variations in the strength of tensile fibers in water (wet) and damp (damp) tissue are documented. The graph's day zero (0) is a tensile strength of the dry fibres. All fibers show diminishing tensile strength both in wet and humid situations over age. At day 120, tensile strength decreased by roughly 50 percent for all fibers in both humid and wet circumstances as comparison to dry fibers' tensile strength. The tensile strength of the damp fiber was somewhat enhanced over the wet conditions of all fiber types, although the difference appears to be quite small.

2.5 Design and analysis

2.5.1 Honeycomb panel sandwich structure loaded in pure bending

This article examines the design and analysis of a honeycomb panel sandwich construction on a theoretical and quantitative level. The original design is determined by the exact specifications that the panel must meet before failing under load. The materials for the front and core are chosen in accordance with the specified parameters. The face sheets and core are examined for failure using the materials chosen. Failure happens when the panel's stresses surpass the material's characteristics in any mode, (Galletti et al., 2008)

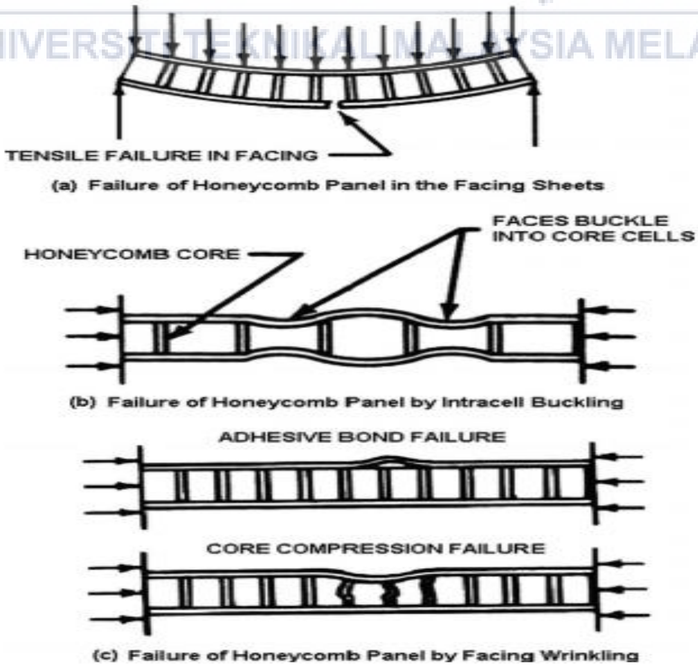


Figure 2.16 Various types of facing sheet failures, (Galletti et al., 2008)

The facing sheets are analysed for bending stress, intracell buckling, and facing wrinkling. The various types of facing sheet failures are depicted in Figure 2.15 to determine the bending stress of a honeycomb panel that has been created, it is necessary to first assume that the facing sheets are isotropic or quasi-isotropic. Additionally, the facing sheets are expected to be of similar thickness.

2.5.2 Cost effective steel honeycomb structures.

In industrial applications, lightweight honeycomb structures assist to reduce weight significantly. The effect of reinforcement on the circular core honeycomb structure under axial compression behavior is investigated in this work. Abaqus-CAE is used to do the numerical analysis for load bearing capability. Steel honeycomb panels (with and without reinforcements) are manufactured in a continuous furnace using furnace-brazing technique for experimental validation. Despite the fact that the reinforcements increased the panel's weight, there was a significant gain in load bearing capability (44 percent). The reinforced honeycomb construction with a cell diameter of 10 mm has the maximum load bearing ability, according to the findings. The findings of the experiments back up the numerical model that was created, (Ghongade et al., 2020)

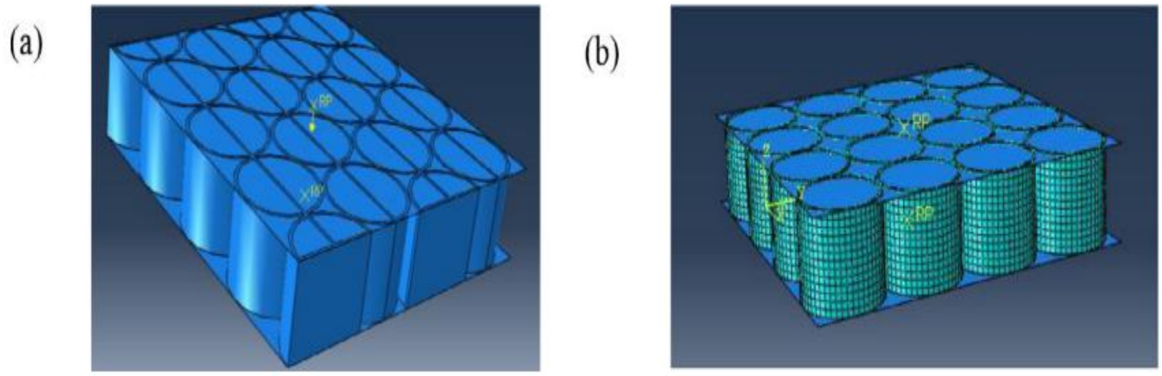


Figure 2.17 Force applied on the top surface and Meshed assembly, (Ghongade et al., 2020)

Figure 2.17 shows the finalized model and meshing system. The top and bottom plate were treated as 3D rigid analysis. The limit conditions were applied to the reference point on the upper and lower plate.

Figure 2.18 Design of circular core with dense packing and straight stacking, (Ghongade et al., 2020)

Mild steel has been involved in the manufacturing of honeycomb panels as shown in figure 2.18. In this work, compressive tests were conducted to explore the behaviour of mild steel wave panels, as demonstrated. The centre of the honeycomb was made by brushing the hollow round tubes into a continuous brazing furnace. The core was thoroughly cleaned using acetone. Copper alloy has been used for brazing. An optical microscope was used to conduct microstructural analysis

2.6 Conclusion

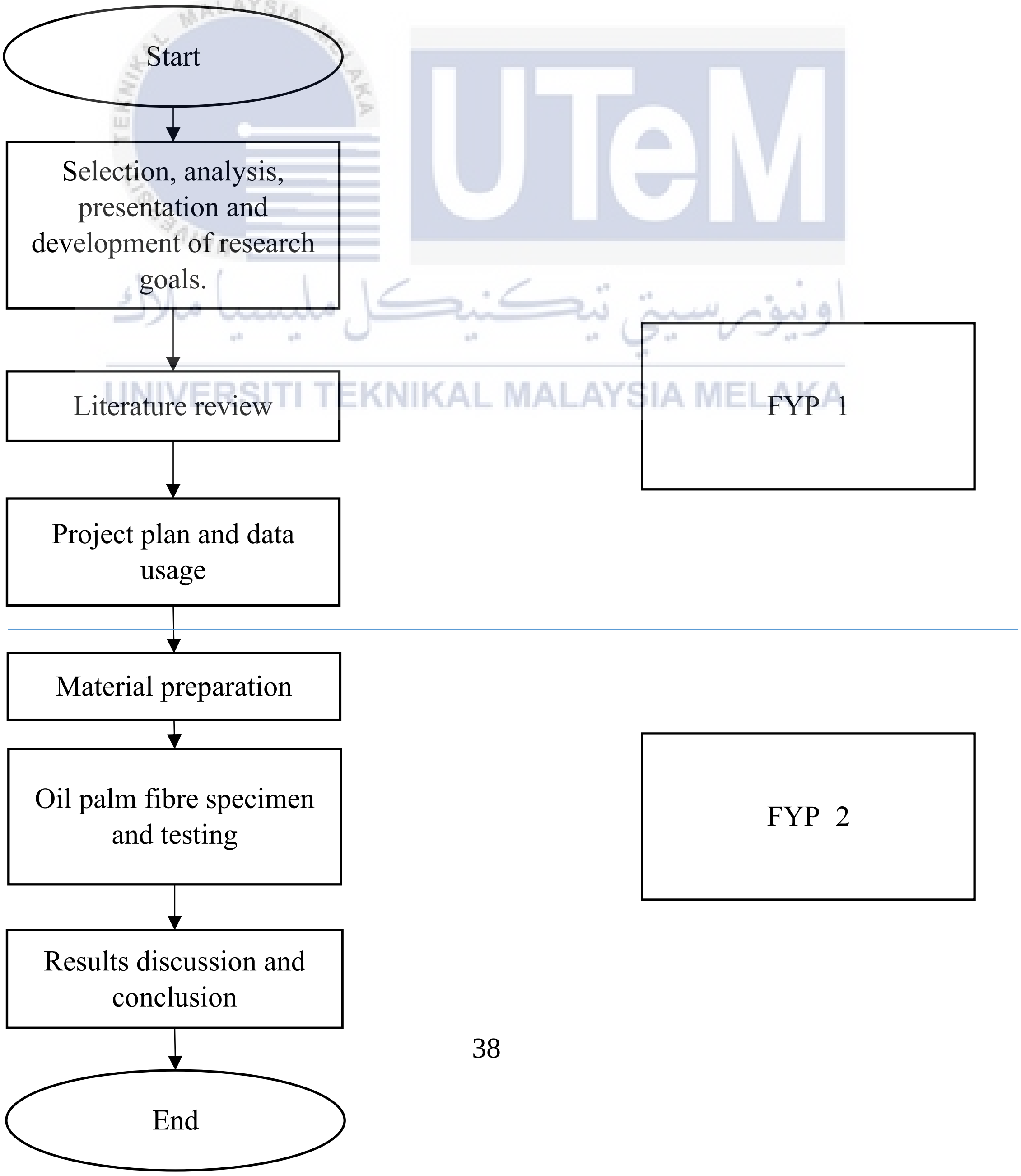
All related information from various research that also included the theoretical knowledge is accumulated and constructed in this chapter to study the shelter based design method of a lightweight and portable by using oil palm fiber reinforced honeycomb panel. From the literatures review that have been there, it has been given to know that honeycomb panel may innovates to oil palm. Here any parameter will consider in chapter 3 such as Performance of honeycomb support structure, Honeycomb panel sandwich structure loaded in pure bending, Properties of oil palm and Performance of honeycomb support structure.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will outline the approach and recommended technique for evaluating the research analysis. It is critical to use the proper technique to ensure that the plan accomplishes its objectives. The methodology section outlines the steps in the technique utilised to conduct the research and support the study from its inception to conclusion.



3.2 Experiment method

3.2.1 Material

NORSODYNE , also known as Polyster Resin 3338 , was used in this experiment as in Figure 3.1. Polyster resin is an innovative substance that has been developed for the conservation and long-term preservation of biological items. H 13212 TAE is the classification we use (Polynt Composites USA, Inc., Bergamo, Italy). This polyester resin in styrene has a low styrene content and is unsaturated. At 20°C, epoxy has a density of 1.10 g/cm2. The Brookfield viscosity at 23°C was determined by the manufacturer using the MT-CUT23V test method. When using a 23°C temperature, the jelly will begin to form in 14-18 minutes. For example, according to the ISO 527 (2012) test findings, Norsodyne tensile strength is 57 MPa, and flexural strength is 98 MPa (2011).

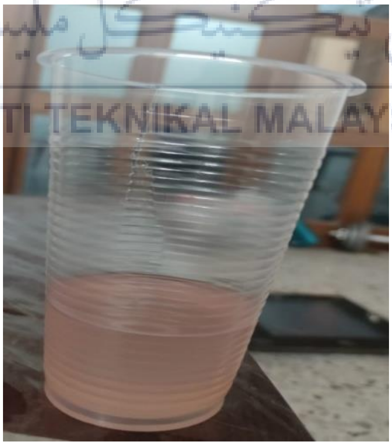


Figure 3.1 Norsodyne Resin 3338

3.2.2 Honeycomb

Honeycomb as shown in Figure 3.2 produces high-quality aluminium honeycomb core material, which is used in a wide range of applications around the world. Aluminium honeycomb is highly desirable due to its extremely high strength-to-weight ratio, and it can be used anywhere lightness and strength are required.

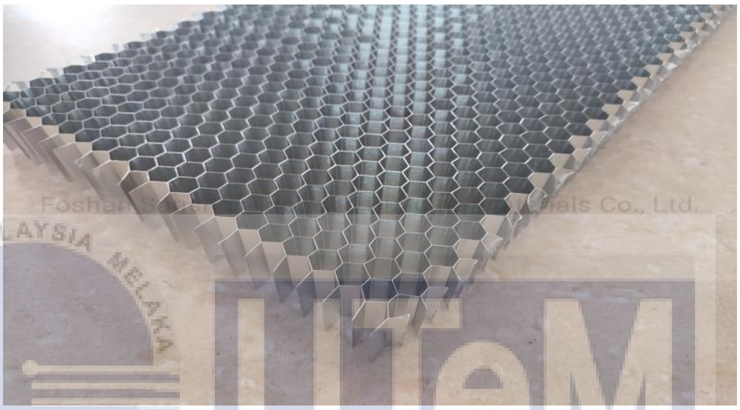


Figure 3.2 Honeycomb pnael

3.3 Preparation of ECA composite

Collect all of the palm fibres as shown in figure 3.3 that were chosen for the experiment then purified water treated with natural fibres was exposed to water within just 24 hours to eliminate undesired substances that impair mechanical performance, such as oil or sugar. Additionally, dried palm fibre is dried for 24 hours until exact. Ascertain that there is no remaining oil or water. Dry fibres are collected and stored in a cool, dry location. All of these fibres will be employed in this project as experimental materials.

Fillers ranging from 0% to 10% weight by weight were used to make the Natural Fiber composites, as shown in Table 3.3. To promote easier filler dispersion, the polyster resin and Natural Fibers combination was mixed with a homogenizer for roughly

10 minutes, and then the mixture was sonicated for 30 minutes. After the vacuum of 0.5 hours, the mixture was let to stand at ambient temperature (35 °C) for an additional 2 h to allow any remaining bubbles to rise to the surface. EPON 828 (100 parts) was combined with the curing agent (follow the Table 3.1) and mixed for another 10 minutes. The final mixture was placed in a vacuum oven and allowed to sit for two hours at room temperature before it was cooked in an oven at 100 °C for one hour and then baked at 125 °C for three hours afterward.

Figure 3.3 Oil palm fibre

Table 3.1 Formulation of honeycomb composites

Sample designation	Resin (wt %)	Hardener (wt %)	Natural Fiber Filler (wt %)
Sample 1	98.0	2.0	0
Sample 2	96.0	2	2
Sample 3	92.0	2	6
Sample 4	88.0	2	10

Honeycombs can be manufactured into flat or curved composite structures and can be shaped to conform to compound curves without the need of excessive mechanical effort or heat. Typically, thermoplastic honeycombs are formed by extrusion followed by slicing to desired thickness. Other honeycombs, such as those made of paper or aluminium, are created in phases of the process. Following that, the stack of sheets is sliced across its thickness. Later, the slices are gently stretched and expanded to produce a continuous sheet of hexagonal cell forms.

The stack of bound paper sheets is slowly extended to produce a massive, several-foot-thick honeycomb block. After being enlarged, this delicate paper honeycomb block is dipped in resin, drained, and cured in an oven. Once the dipping resin has set, the block is strong enough to be chopped to the desired thicknesses. By adjusting the degree of pull during the expansion process, it is possible to make conventional hexagon-shaped cells or over-expanded (elongated) cells, each with a unique mechanical and composite properties.

3.4 Mechanical behavior

3.4.1 Flexural testing

Flexural qualities specified by these test methodologies are particularly beneficial for quality control and detail purposes as in Figure 3.4. Typically, the sample is supported by a supporting span and is coupled to the load by a loading nose that generates a specified rate of bending of three points. The supporting extent, the stacking rate, and the maximum amoistureance of the test are the test parameters. These criteria are dependent on the thickness of the test specimens and are defined variously by ASTM and ISO. When the example reaches amoistureances, Shimadzu TCE-N300 universal machine.

Figure 3.4 Shimadzu TCE-N300 universal machine

3.5 Equipment

3.5.1 Electronic Balancing

Figure 3.5: Electronic Balancing

Laboratory balances as shown in Figure 3.5, in general determine the mass of an object; in the laboratory, they are used to determine the mass of solids, liquids, and tissue. They have a wide variety of applications in practically any laboratory context, including clinical, scientific, and environmental. The triple beam balance, analytical balance, micro and semi-micro balances are only a few types of laboratory balances. These balances can be used to determine the weight of a variety of substances, ranging from a single grain of a chemical solid to the weight of a huge beaker using a triple beam balance.

3.5.2 Stirrer

Figure 3.6 Magnetic stirrer

A magnetic stirrer as shown in Figure 3.56is a device that uses a revolving magnetic field to create a magnetic field. The magnetic stirrer generates a spinning field around a rotating magnet bar or plate. In general, the bar magnet is plastic-coated, while the plate magnet is magnetic. A revolving magnet can be used to generate a rotating magnetic field.

3.5.3 Oven

Figure 3.7 Laboratory oven

A magnetic stirrer as shown in figure 3.7 is a device that uses a revolving magnetic field to create a magnetic field. The magnetic stirrer generates a spinning field around a rotating magnet bar or plate. In general, the bar magnet is plastic-coated, while the plate magnet is magnetic. A revolving magnet can be used to generate a rotating magnetic field.

3.5.4 Mold

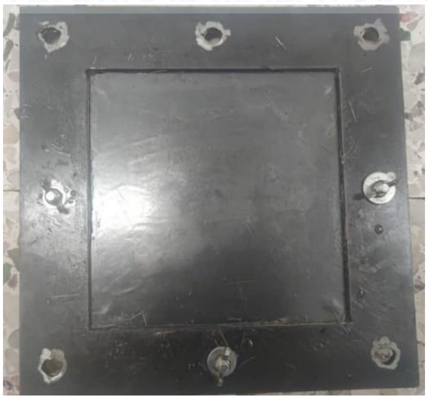


Figure 3.8 Steel molding

To prevent polyester resin from leaking out of the mould during processing, use a poring device as shown in figure 3.8

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

In this section, all data from the from the physical and flexural testing was recorded. The data obtained will be recorded in table form and will be discussed.

4.2 Flexural Testing

4.2.1 Introduction

The force required to bend a plastic beam is used in flexural testing to determine a material's resistance to flexing or stiffness. A material's flex modulus tells us how much it can bend without going permanently distorted. In a TPB test, the convex side of the sheet or plate is tensioned and the outside fibres are subjected to the most stress and strain. In cases where strain or elongation exceeds the material's limits, the sample fails. Tests to determine fracture toughness include the TPB flexural test. Tensioning the convex side of a sheet or plate causes the outside fibres to be exposed to maximum stress and strain.

4.2.2 Results

In order to conduct the flexural strength test, a Shimadzu TCE-N300 universal machine with a maximum load capacity of 100kN was used. As shown in Figure 4.1, the strength of a sample measuring 150 mm x 50 mm x 30 mm was determined in accordance with ASTM C393 using a sample measuring 150 mm x 50 mm. In this example, a honeycomb panel is sandwiched between two layers of oil palm fibre reinforcement and polyester resin, with the honeycomb panel sandwiched between them. As evidenced by the test findings, the increase in flexural strength of the component can be linked to the presence of oil palm fibre in the component. This test was carried out at a speed of 2 millimetres per minute.

Figure 4.1 Sandwich honeycomb panel with oil palm fibre reinforced with resin polyester

Using this experiment, we were able to plot the stress (MPa) to strain (percent) relationship. When discussing stress-strain curves, it is common to refer to the relationship between stress and strain. Uniaxial, biaxial, or multiaxial normal, shear, or mixed stress and strain can be uniaxial, biaxial, or multiaxial. Testing with TPB provides a visual representation of a material's elasticity. Unless otherwise stated, the stress–strain curve refers to the relationship between the axial normal stress and the axial normal strain of materials during a tension test.

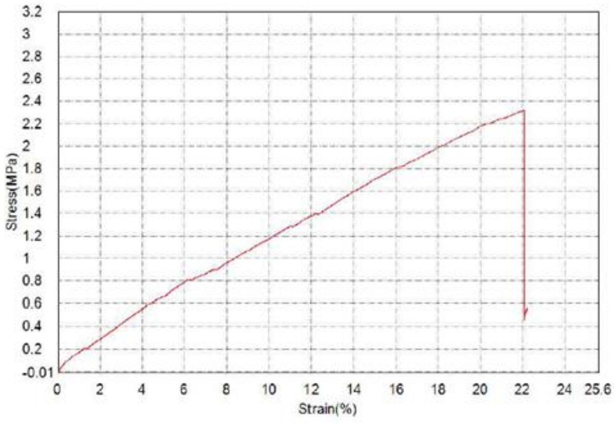


Figure 4.2 Sample 1 for 0gram fibre

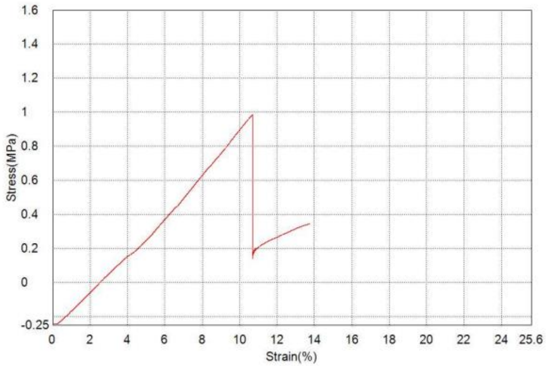


Figure 4.3 Sample 1 for 4gram fibre

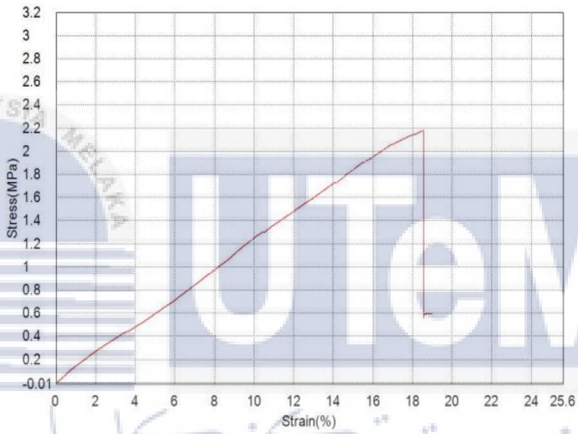


Figure 4.4 Sample 2 for 4gram fibre

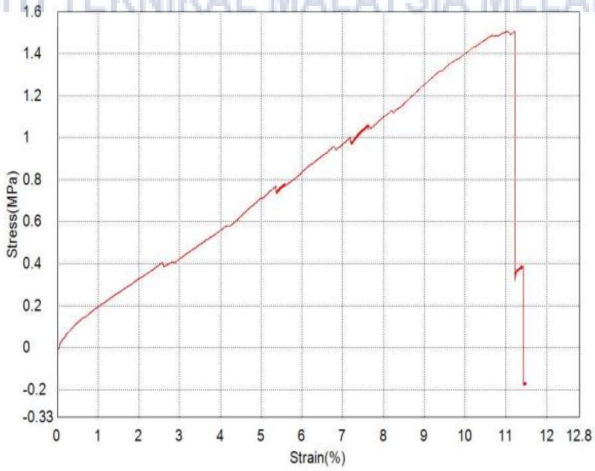


Figure 4.5 Sample 3 for 4gram fibre

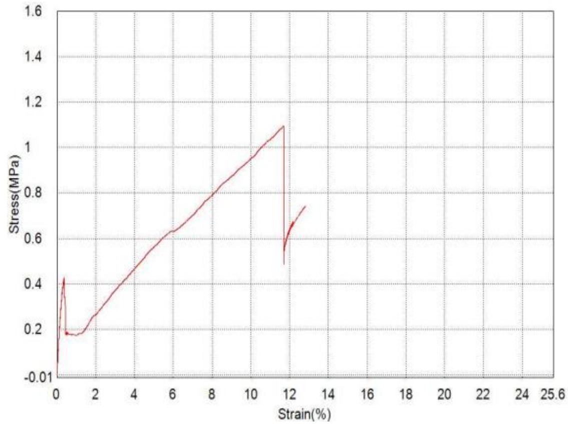


Figure 4.6 Sample 1 for 12 gram fibre

Figure 4.7 Sample 2 for 12 gram fibre

Figure 4.8 Sample 3 for 12 gram fibre

Figure 4.9 Sample 1 for 20 gram fibre

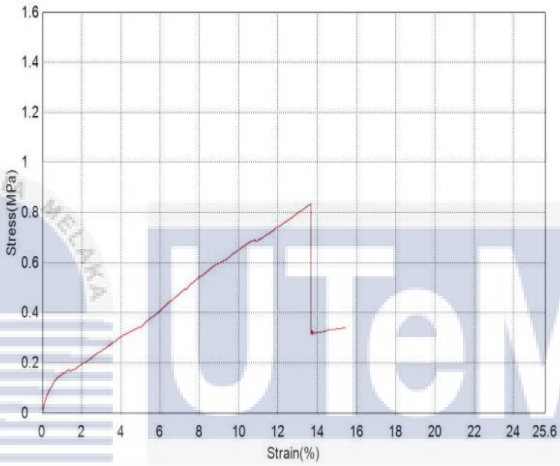


Figure 4.10 Sample 2 for 20 gram fibre

Figure 4.11 Sample 3 for 20 gram fibre

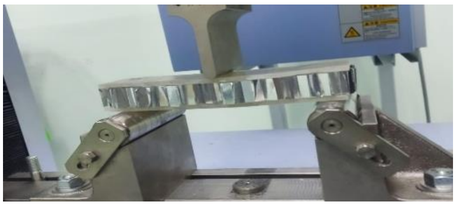
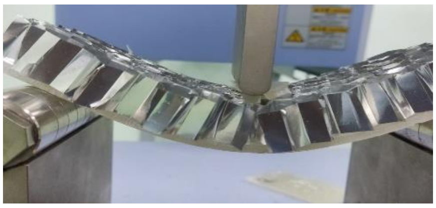
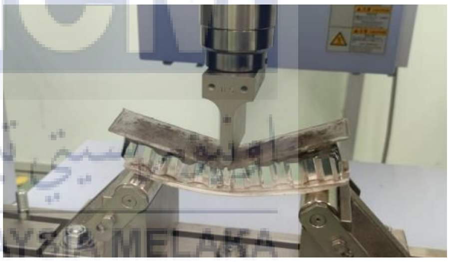
The graph Stress Versus Strain was created using software that was used to conduct flexural tests on a desktop computer in the laboratory, as seen in Figure above. There were ten specimens tested, ranging from 0% to 10% coconut fibre combined in the sandwich panel, with 0gram, 4gram, 12gram, and 20gram of fibre mixed in the specimen panel. The graph represents the applied stress and strain on the specimen until it reaches the end peak or the specimen panel splits in half.

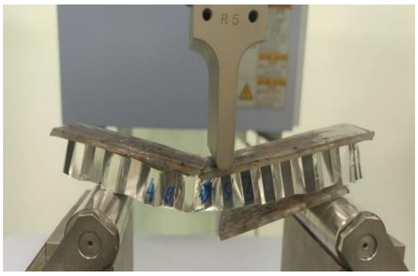
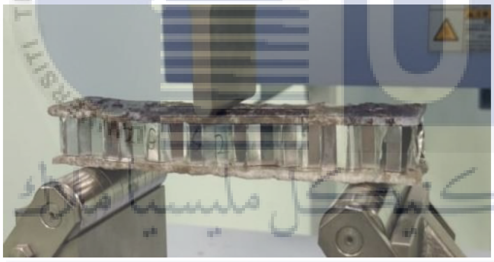
Table 4.1 The average maximum stress and strain

Specimen	Average max. stress (MPa)	Average max strain (%)
0 gram	2.3206	22.0749
4 grams	0.98602	10.697
12 grams	1.32799	13.7335
20 grams	1.51547	15.9746

Table 4.1 shows the average maximum stress and strain values for fibre samples weighing 0gram, 4gram, 12gram, and 20gram, respectively. According to the statistics, the specimen weighing 20 gram has the highest maximum stress. This shows that the fibres in the specimen contribute to the specimen's ability to resist breaking through its tensile strength. Despite the fact that the maximum strain of the 0gram specimen occurs at a great height, it has the lowest maximum stress of any of the specimens tested. Meanwhile, Table 4.2 indicates how the sample is affected by the testing process. Because there is no fibre present in the 0g fibre sample, it completely disintegrates on the table. Additionally, the additional specimens that contain fibres that break at the top or bottom of the specimen are included.

Table 4.2 Every sample testing after and before

Sample	Before	After
0g fibre		
1		
4g fibre		
1		
2		

3		
12g fibre		
1		
2		
3		
20g fibre		

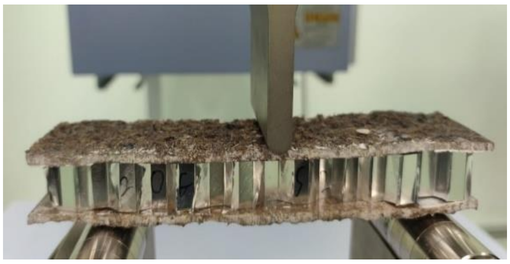
1		
2		
3		

Table 4.2 show the results of flexural properties and flexural elastic modulus. When the oil palm fibre reinforcement ratio is increased from 6 percent to 10 percent, the maximum stress and maximum strain values on the graph increase modestlyas in figure 4.1. As the percentage of oil palm reinforcement increases from 6 percent, the maximum stress and maximum strain also increase. The oil palms make up 10% of the crop, resulting in the greatest amount of stress and strain conceivable. To make oil palm composite fibre stronger, a 2% drop in the ratio is required.

The 2% fibre from an oil palm fibre was employed as reinforcement in the composite, and the results of an examination of the oil palm fibre that had previously been discharged are displayed in this data. This investigation found that the maximum stress and maximum strain generated both decreased as a consequence of the discharge process. According to the data acquired, there is a little increase in the maximum stress and strain values on the graph when the oil palm fibre ratio is increased from 6% to 10%. Maximum stress and maximum strain increase proportionately as the amount of oil palm at 10%. Simultaneously, 10% is the fraction of oil palm fibre reinforcement, which results in the highest feasible stress and force value.

4.3 Summary

This chapter discussed the results of laboratory experiments on flexural three-point bending. The purpose of this experiment was to determine the deformation that occurred when a force was applied to the centre sandwich specimen and to determine its mechanical characteristics. There were four different types of specimens with varying amounts of oil palm fibre in 0gram, 4gram, 12gram, and 20gram mixed with polyester resin in the specimen panel. The specimen dimension of 150 50 30mm was used as the test standard for the ASTM D7249 non-standard three-point bending test. Shimadzu TCE-N300 Universal Testing Machine was utilised to perform the flexural three-point bending test on the specimen.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

As conclusion, appearance of the building's structure is enhanced by the use of honeycomb. As far as the development industry is concerned, honeycomb should be widely utilised. So, when oil palm fibre is mixed with polyster resin needed to properly measure, it should not appear sticky or gummy when it is withdrawn from the mould. In order to carry out structural testing, the specimen must be faultless. The primary goal of this study is to improve the oil palm fibre composite against polyster resin in a flexural test, as stated in the abstract. The oil palm composite polyster resin and oil palm against 0g, 4g, 12g, and 20g are also used to produce a honeycomb sandwich.

Based on the flexural testing that has been done on four oil palm fibers of different weights with polyster resin 0g, 4g, 12g, and 20g with honeycomb to obtain max stress and max strain data. In every 200 grammes of polyester resin, each gramme reflects the amount of fibre. The results showed that each specimen showed a clear change that each weight would produce different data. The higher the max stress on the material, the better for the material because this shows the material is able to withstand a higher force than it breaks. While the higher the max strain obtained indicates that the specimen will be better because it is able to bend at a high value before changing to deform.

5.2 Recomenddation

It is possible to make some recommendations for future work. Mechanical testing guidelines for sandwich sugarcane fiber/polyester and aluminium honeycomb panel must be modified.

The recommendations are as follows:

1. Analysis test

- The flexural test is the focus of this investigation. There are a variety of additional ways to do testing. Tensile and impact tests are two good examples.

2. Type of resin

- This research uses polysenter resin. apart from using polyster it can also be used with vinyl resin to obtain mechanical testing for flexural testing and impact testing

3. Sample fabrication

- the size of the honeycomb taken needs to be varied so that it can be tested to various testing. The length and width of the honeycomb play a role in mechanical testing

REFERENCES

Danso, H. (2017). Properties of Coconut, Oil Palm and Bagasse Fibres: As Potential Building Materials. *Procedia Engineering*, *200*, 1–9. https://doi.org/10.1016/j.proeng.2017.07.002

Galletti, G. G., Vinquist, C., & Es-Said, O. S. (2008). Theoretical design and analysis of a honeycomb panel sandwich structure loaded in pure bending. *Engineering Failure Analysis*, *15*(5), 555–562. https://doi.org/10.1016/j.engfailanal.2007.04.004

He, L., Zi, F., Zhang, Z., Tang, L., & Li, P. (2019). Research on the Performance of Honeycomb Support Structure Based on SLM. *IOP Conference Series: Materials Science and Engineering*, *612*(3). https://doi.org/10.1088/1757-899X/612/3/032148

Li, X., Lu, F., Zhang, Y., Lin, Y., & Meng, Y. (2020). Experimental study on out-of-plane mechanical and energy absorption properties of combined hexagonal aluminum honeycombs under dynamic impact. *Materials and Design*, *194*, 108900. https://doi.org/10.1016/j.matdes.2020.108900

Ramlee, N. A., Jawaid, M., Zainudin, E. S., & Yamani, S. A. K. (2019). Tensile, physical and morphological properties of oil palm empty fruit bunch/sugarcane bagasse fibre reinforced phenolic hybrid composites. *Journal of Materials Research and Technology*, *8*(4), 3466–3474. https://doi.org/10.1016/j.jmrt.2019.06.016

Suoware, T. O., Edelugo, S. O., Amgbari, C. O., & Sorgbara, F. L. (2020). Determination of the Suitability of Oil Palm Fibre Composite for Building Applications By Cone Calorimeter and Thermal Analysis. *Open Journal of Engineering Science (ISSN: 2734-2115)*, *1*(2), 30–39. https://doi.org/10.52417/ojes.v1i2.151

Wang, Zhe, Chen, A., & Laflamme, S. (2019). *Portable water filled barrier with internal honeycomb cells*.

Wang, Zhonggang. (2019). Recent advances in novel metallic honeycomb structure. *Composites Part B: Engineering*, *166*(August 2018), 731–741. https://doi.org/10.1016/j.compositesb.2019.02.011

Xiao, Y., Hu, Y., Zhang, J., Song, C., Liu, Z., & Yu, J. (2018). Dynamic bending responses of CFRP thin-walled square beams filled with aluminum honeycomb. *Thin-Walled Structures*, *132*(August), 494–503. https://doi.org/10.1016/j.tws.2018.09.023

Zaharia, S. M., Enescu, L. A., & Pop, M. A. (2020). Mechanical performances of lightweight sandwich structures produced by material extrusion-based additive manufacturing. *Polymers*, *12*(8). https://doi.org/10.3390/POLYM12081740

Danso, H. (2017). Properties of Coconut, Oil Palm and Bagasse Fibres: As Potential Building Materials. *Procedia Engineering*, *200*, 1–9. https://doi.org/10.1016/j.proeng.2017.07.002

Galletti, G. G., Vinquist, C., & Es-Said, O. S. (2008). Theoretical design and analysis of a honeycomb panel sandwich structure loaded in pure bending. *Engineering Failure Analysis*, *15*(5), 555–562. https://doi.org/10.1016/j.engfailanal.2007.04.004

He, L., Zi, F., Zhang, Z., Tang, L., & Li, P. (2019). Research on the Performance of Honeycomb Support Structure Based on SLM. *IOP Conference Series: Materials Science and Engineering*, *612*(3). https://doi.org/10.1088/1757-899X/612/3/032148

Li, X., Lu, F., Zhang, Y., Lin, Y., & Meng, Y. (2020). Experimental study on out-of-plane mechanical and energy absorption properties of combined hexagonal aluminum honeycombs under dynamic impact. *Materials and Design*, *194*, 108900. https://doi.org/10.1016/j.matdes.2020.108900

Ramlee, N. A., Jawaid, M., Zainudin, E. S., & Yamani, S. A. K. (2019). Tensile, physical and morphological properties of oil palm empty fruit bunch/sugarcane bagasse fibre reinforced phenolic hybrid composites. *Journal of Materials Research and Technology*, *8*(4), 3466–3474. https://doi.org/10.1016/j.jmrt.2019.06.016

Suoware, T. O., Edelugo, S. O., Amgbari, C. O., & Sorgbara, F. L. (2020). Determination of the Suitability of Oil Palm Fibre Composite for Building Applications By Cone Calorimeter and Thermal Analysis. *Open Journal of Engineering Science (ISSN: 2734-2115)*, *1*(2), 30–39. https://doi.org/10.52417/ojes.v1i2.151

Wang, Zhe, Chen, A., & Laflamme, S. (2019). *Portable water filled barrier with internal honeycomb cells*.

Wang, Zhonggang. (2019). Recent advances in novel metallic honeycomb structure. *Composites Part B: Engineering*, *166*(August 2018), 731–741. https://doi.org/10.1016/j.compositesb.2019.02.011

Xiao, Y., Hu, Y., Zhang, J., Song, C., Liu, Z., & Yu, J. (2018). Dynamic bending responses of CFRP thin-walled square beams filled with aluminum honeycomb. *Thin-Walled Structures*, *132*(August), 494–503. https://doi.org/10.1016/j.tws.2018.09.023

Zaharia, S. M., Enescu, L. A., & Pop, M. A. (2020). Mechanical performances of lightweight sandwich structures produced by material extrusion-based additive manufacturing. *Polymers*, *12*(8). https://doi.org/10.3390/POLYM12081740

APPENDICES

Project Activities	Week															
Bachelor's degree Project 2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Briefing PMS 2									MIDTERM SEMESTER BREAK							
Meeting with Supervisor																
CHAPTER 2 : LITERATURE REVIEW																
Literature Review																
Chapter 2 Writing																
CHAPTER 3 METHODOLOGY																
Prepation of WEDM electrode fiber																
Preparation of veniyl ester resin																
Chapter 3 writing																
CHAPTER 1 INTRODUCTION																
Identify problem																
Chapter 1 Writing																
Chapter 4 PRELIMINARY RESULT																
Preliminary Findings																
Chapter 4 Writing																
Submission First Draft Report PSM 1																
Slide preparation																
Presentation																
Report Correction																
Submission Final Report PSM 1																

Turn it in Salman Azmi

ORIGINALITY REPORT

28%	15%	19%	7%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Universiti Teknikal Malaysia Melaka Student Paper	3%
2	www.mdpi.com Internet Source	2%
3	Yong Xiao, Yefa Hu, Jinguang Zhang, Chunsheng Song, Zhaobing Liu, Jingui Yu. "Dynamic bending responses of CFRP thin-walled square beams filled with aluminum honeycomb", Thin-Walled Structures, 2018 Publication	2%
4	Wang, Zhe. "Portable Water Filled Barrier with Internal Honeycomb Cells.", Iowa State University, 2019 Publication	2%
5	Gouri Ghongade, Kota Pavan Kalyan, R. Vaira Vignesh, M. Govindaraju. "Design, fabrication, and analysis of cost effective steel honeycomb structures", Materials Today: Proceedings, 2020 Publication	1%

DR Muhammad Zulkarnain

26/2/2021

6	Lijun He, Feiyue Zi, Zhixiong Zhang, Li Tang, Po Li. "Research on the Performance of Honeycomb Support Structure Based on SLM", IOP Conference Series: Materials Science and Engineering, 2019 Publication	1%
7	Zhonggang Wang. "Recent advances in novel metallic honeycomb structure", Composites Part B: Engineering, 2019 Publication	1%
8	Nor Azlina Ramlee, Mohammad Jawaid, Edi Syams Zainudin, Shaikh Abdul Karim Yamani. "Tensile, physical and morphological properties of oil palm empty fruit bunch/sugarcane bagasse fibre reinforced phenolic hybrid composites", Journal of Materials Research and Technology, 2019 Publication	1%
9	shellbuckling.com Internet Source	1%
10	www.sciencegate.app Internet Source	1%
11	iopscience.iop.org Internet Source	1%
12	umpir.ump.edu.my Internet Source	1%

13	cyberleninka.org Internet Source	1%
14	Xiangcheng Li, Fangyun Lu, Yuwu Zhang, Yuliang Lin, Yi Meng. "Experimental study on out-of-plane mechanical and energy absorption properties of combined hexagonal aluminum honeycombs under dynamic impact", Materials & Design, 2020 Publication	1%
15	researchportal.port.ac.uk Internet Source	1%
16	www.ijsrd.com Internet Source	1%
17	Venkateshappa, Harish. "Analysis of honeycomb core properties under different parametric conditions for the head injury criteria compliance in aerospace applications ", Proquest, 20111108 Publication	<1%
18	network.bepress.com Internet Source	<1%
19	Lekhani Tripathi, B. K. Behera. "Review: 3D woven honeycomb composites", Journal of Materials Science, 2021 Publication	<1%
20	Submitted to UCSI University Student Paper	

<1%

21	Galletti, G.G.. "Theoretical design and analysis of a honeycomb panel sandwich structure loaded in pure bending", Engineering Failure Analysis, 200807 Publication	<1%
22	www.ncbi.nlm.nih.gov Internet Source	<1%
23	doaj.org Internet Source	<1%
24	Submitted to Aston University Student Paper	<1%
25	Submitted to Universiti Selangor Student Paper	<1%
26	Zhendong Li, Zhonggang Wang, Xinxin Wang, Wei Zhou. "Bending behavior of sandwich beam with tailored hierarchical honeycomb cores", Thin-Walled Structures, 2020 Publication	<1%
27	Submitted to Solihull College, West Midlands Student Paper	<1%
28	eprints.utem.edu.my Internet Source	<1%

29 Submitted to Leyton Sixth Form College, London
Student Paper
<1%

30 T. O. Suoware, S. O. Edelugo. "Thermal, mechanical and flame spread properties of hybridized flame retardant in oil palm fibre-polyester panel", SN Applied Sciences, 2018
Publication
<1%

31 docplayer.net
Internet Source
<1%

32 Submitted to CSU, San Jose State University
Student Paper
<1%

33 en.wikipedia.org
Internet Source
<1%

34 etd.uum.edu.my
Internet Source
<1%

35 text-id.123dok.com
Internet Source
<1%

36 Submitted to Emirates Aviation College, Aerospace & Academic Studies
Student Paper
<1%

37 Faizan S. Awan, Mohsin A. Fakhar, Laraib A. Khan, Usama Zaheer, Abdul F. Khan, Tayyab Subhani. "Interfacial mechanical properties of carbon nanotube-deposited carbon fiber
<1%

epoxy matrix hierarchical composites", Composite Interfaces, 2018
Publication

38	Submitted to Universiti Kebangsaan Malaysia Student Paper	<1 %
39	psasir.upm.edu.my Internet Source	<1 %
40	pt.slideshare.net Internet Source	<1 %
41	homefrontdc.com Internet Source	<1 %
42	ise.ait.ac.th Internet Source	<1 %
43	www.tesionline.com Internet Source	<1 %
44	doras.dcu.ie Internet Source	<1 %
45	portal.fke.utm.my Internet Source	<1 %
46	Yueping Jiang, Min Liu, Haitao Liu, Shao Liu. "A critical review: traditional uses, phytochemistry, pharmacology and toxicology of Stephania tetrandra S. Moore (Fen Fang Ji)", Phytochemistry Reviews, 2020 Publication	<1 %

47	Basim Abu-Jdayil, Mohamed Saeed Barkhad, Abdel-Hamid I. Mourad, Muhammad Z. Iqbal. "Date palm wood waste-based composites for green thermal insulation boards", Journal of Building Engineering, 2021 Publication	<1%
48	Submitted to Universiti Malaysia Perlis Student Paper	<1%
49	Akula, Venkata M. K. "Constitutive modeling of damaged unidirectional composite laminae", Proquest, 20111109 Publication	<1%
50	Gondaliya, Akash Madhav. "Comparative Analysis of Different Lignins as Partial Polyol Replacement in Polyurethane Flexible Foam Formulations.", Michigan State University, 2020 Publication	<1%
51	dokumen.pub Internet Source	<1%
52	dspace.unimap.edu.my Internet Source	<1%
53	pdfs.semanticscholar.org Internet Source	<1%
54	www.diplomarbeiten24.de Internet Source	<1%

55 M. K. Krokida, V. T. Karathanos, Z. B. Maioulis. "EFFECT OF OSMOTIC DEHYDRATION ON VISCOELASTIC PROPERTIES OF APPLE AND BANANA", Drying Technology, 2000 <1%

Publication

---

56 Yong-jing Wang, Zhi-jia Zhang, Xiao-wei Xue, Jian Zhou, Zhong-xiao Song. "Axial and lateral crushing performance of plate-lattice filled square sandwich tubes", Composite Structures, 2021 <1%

Publication

---

57 M. K. Krokida, Z. B. Maroulis. "EFFECT OF MICROWAVE DRYING ON SOME QUALITY PROPERTIES OF DEHYDRATED PRODUCTS", Drying Technology, 1999 <1%

Publication

---

58 Ode-Martins, Olayemi. "Challenges of Biometrics Technology in Nigeria to Enhance Information Security: A Qualitative Exploratory Case Study.", University of Phoenix, 2021 <1%

Publication

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		