



**Faculty of Mechanical and Manufacturing Engineering
Technology**

**RESEARCH ON DEVELOPMENT OF COMPOSITE DECK FOR
ELECTRIC VEHICLE**

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Bachelor of Manufacturing Engineering Technology (Process and Technology)

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**RESEARCH ON DEVELOPMENT OF COMPOSITE DECK FOR ELECTRIC
VEHICLE**

TAN RUI JIE

**A thesis submitted
in fulfillment of the requirements for the degree of Bachelor of Manufacturing
Engineering Technology (Process and Technology)**

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DECLARATION

I hereby, declared this report entitled “Research on Development of Composite Deck for Electric Vehicle” is the results of my own research except as cited in references.

Signature :

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours. The member of the supervisory is as follow:

Signature :

Supervisor Name : PROF. MADYA. IR. TS. DR MOHD YUHAZRI BIN YAAKOB

Date :

DEDICATION

Dedicated to

My parents, the reason for who I am today

my appreciated father, Tan Hock Meng

my beloved mother, Chan Soo Shyan

my adored siblings, Tan Yi Fang, Tan Rui Jie, Tan Yi Suan

Thank You So Much for All the Support

ABSTRACT

Composite deck is the solution to conventional wood deck due to the weight reduction possibilities during design, excellent durability, resistant to weathering and excellent mechanical strength it provides. Problem statements for composite decking design is the weight and mechanical performance of the composite as well as sustainability issues. The aim of this research is to study the implementation of different type of woods as a core for sandwich panel to tackle the issue. The wood utilized as cores also have hexagonal cells designated onto for weight reduction of the sandwich panels as a whole. Wood cores variation along with hexagonal cell presence is manipulated for studies of mechanical properties. The wood variation utilised in the research are rubber, pine and balsa wood while hexagonal cell parameters are constant with 7 mm diameter and 3 mm wall thickness. The sandwich composite is fabricated with machined wood cores, woven glass fiber and epoxy resin. Fabrication of the sandwich panel is done using hand lay up method followed by vacuum bagging process to ensure quality sample or product. Testing of mechanical properties are done based on reference of ASTM standards. Mechanical tests carried out includes shear tension, flexural and compression tests. Rubber wood with hexagonal cells achieved the highest weight reduction percentage compared to the pine and balsa while also remaining as the core with highest flexural and compressive strength among the hexagonal cell cores. For shear tension strength, the presence of hexagonal cells on rubber wood increased the shear strength by 1.38 % with pine and balsa increasing 18.09 % and 75.75 % respectively. Nonetheless, hexagonal cell rubber wood core have the highest flexural and compressive strength compared to hexagonal cell pine and balsa while losing in terms of shear tension against hexagonal cell pine core. By factoring in the highest density reduction percentage, hexagonal rubber wood core is deemed the optimum design for composite decks in terms of weight reduction and mechanical strength.

ABSTRAK

Dek komposit adalah penyelesaian kepada dek kayu konvensional kerana kemungkinan mengurangkan berat badan semasa reka bentuk, ketahanan yang sangat baik, ketahanan terhadap cuaca dan kekuatan mekanik yang sangat baik yang disediakan. Pernyataan masalah untuk reka bentuk pengikat komposit adalah berat dan prestasi mekanikal komposit serta isu-isu kelestarian. Tujuan penyelidikan ini adalah untuk mengkaji pelaksanaan pelbagai jenis kayu seperti kayu getah sebagai teras untuk panel lapis. Kayu yang digunakan sebagai teras juga mempunyai sel-sel hexagonal yang ditetapkan untuk pengurangan berat badan panel lapis sebagai keseluruhan. Perubahan teras yang baik bersama dengan kehadiran sel heksagonal dimanipulasi untuk kajian sifat-sifat mekanik. Variasi kayu yang digunakan dalam penyelidikan adalah kayu getah, pinus dan balsa manakala parameter sel heksagon selalunya mempunyai diameter 7 mm dan ketebalan dinding 3 mm. Pembuatan panel lapis dilakukan menggunakan kaedah pemasangan tangan yang diikuti oleh proses pembungkus tekanan untuk memastikan sampel atau produk berkualiti. Ujian sifat mekanikal dilakukan berdasarkan ASTM. Ujian mekanikal yang dijalankan termasuk ujian ricih, lenturan dan mampatan. Kayu getah dengan sel hexagonal mencapai peratusan pengurangan berat badan tertinggi berbanding dengan pinus dan balsa sementara juga kekal sebagai teras dengan kekuatan lentur dan mampatan tertinggi di antara teras sel heksagon. Bagi kekuatan ketegangan ricih, kehadiran sel-sel heksagon pada kayu getah meningkatkan kekuatan ricih sebanyak 1.38 % dengan pinus dan balsa meningkat 18.09 % dan 75.75 % masing-masing. Walau bagaimanapun, teras kayu getah sel heksagonal mempunyai kekuatan lentur dan mampatan tertinggi berbanding dengan pinus sel hexagonal dan balsa manakala kehilangan ketegangan ricih terhadap teras pinus sel heksagon. Dengan pemfaktoran dalam peratusan pengurangan berat badan tertinggi, inti kayu getah heksagon dianggap sebagai reka bentuk optimum untuk dek komposit dari segi pengurangan berat badan dan kekuatan mekanikal.

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TABLE OF CONTENTS

	PAGE
DECLARATION	
APPROVAL	
DEDICATION	
ABSTRACT	i
ABSTRAK	ii
ACKNOWLEDGEMENT	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	vii
LIST OF FIGURES	viii
LIST OF ABBREVIATIONS	xiv
LIST OF SYMBOLS	xvi
CHAPTER 1: INTRODUCTION	1
1.1 Background	1
1.2 Problem Statement	4
1.3 Objectives	6
1.4 Scope	6
1.5 Rationale of Research	7
1.6 Summary of Methodology	8
1.7 Thesis Organization	10
CHAPTER 2: LITERATURE REVIEW	11
2.1 Introduction	11
2.2 Composite	12
2.2.1 Natural fiber and wood plastic composite	12
2.2.2 Composite laminate	13
2.2.3 Sandwich panel	14
2.2.4 Honeycomb core	15
2.3 Bamboo Laminate/Panel	16
2.3.1 Mechanical properties of bamboo laminate	17
2.3.2 Applications of bamboo laminate	18
2.4 Wood/Lumber Laminates	19
2.4.1 Mechanical properties of wood laminate	20
2.4.2 Applications of wood laminate	21
2.5 Fabrication Process	22
2.5.1 Hand layup	24
2.5.2 Vacuum bagging	25
2.5.3 Resin infusion	26
2.6 Testing	27
2.6.1 Tensile test	28
2.6.2 Flexural test	29
2.6.3 Compression test	30
2.7 Natural Material Applications	32
2.7.1 Kenaf	34
2.7.2 Jute	35
2.7.3 Balsa wood	36
2.8 Summary	37

CHAPTER 3: METHODOLOGY	40
3.1 An Overview of Methodology	40
3.2 Raw Material Preparation	42
3.2.1 Rubber wood	42
3.2.2 Pine wood	43
3.2.3 Balsa wood	44
3.2.4 Glass fiber	45
3.2.5 Epoxy and hardener	46
3.3 Design of the Sandwich Core	47
3.3.1 Core parameters	47
3.3.2 Core fabrication	48
3.4 Fabrication of Sandwich Structure	49
3.4.1 Face sheets designation	49
3.4.2 Consolidation of wood core onto face sheet	50
3.4.3 Formation of sandwich panel	51
3.5 Mechanical Testing	51
3.5.1 Shear tension testing	51
3.5.2 Three-point flexural test	52
3.5.3 Flatwise compression test	54
CHAPTER 4: RESULT AND DISCUSSION	56
4.1 Overview	56
4.2 Properties of GFRP Sandwich Panel with SRW	58
4.2.1 Flexural performance of SRW sandwich structure	59
4.2.2 Compressive performance of SRW sandwich structure	62
4.2.3 Shear tension performance of SRW sandwich structure	63
4.3 Properties of GFRP Sandwich Panel with SPW	65
4.3.1 Flexural performance of SPW sandwich structure	66
4.3.2 Compressive performance of SPW sandwich structure	68
4.3.3 Shear tension performance of SPW sandwich structure	70
4.4 Properties of GFRP Sandwich Panel with SBW	72
4.4.1 Flexural performance of SBW sandwich structure	73
4.4.2 Compressive performance of SBW sandwich structure	75
4.4.3 Shear tension performance of SBW sandwich structure	76
4.5 Properties of GFRP Sandwich Panel with HCRW	78
4.5.1 Flexural performance of SRW sandwich structure	79
4.5.2 Compressive performance of SRW sandwich structure	81
4.5.3 Shear tension performance of SRW sandwich structure	82
4.6 Properties of GFRP Sandwich Panel with HCPW	84
4.6.1 Flexural performance of HCPW sandwich structure	85
4.6.2 Compressive performance of HCPW sandwich structure	87
4.6.3 Shear tension performance of HCPW sandwich structure	88
4.7 Properties of GFRP Sandwich Panel with HCBW	90
4.7.1 Flexural performance of HCBW sandwich structure	91
4.7.2 Compressive performance of HCBW sandwich structure	92
4.7.3 Shear tension performance of HCBW sandwich structure	94
4.8 Analysis Summary	96
4.8.1 Mass and density analysis	96
4.8.2 Flexural performance analysis	98

4.8.3	Compressive performance analysis	101
4.8.4	Shear tension performance analysis	104
4.9	Summary of Analysis Finding and Proposition for Composite Deck	107
CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS		110
5.1	Conclusion	110
5.2	Recommendation	112
5.3	Sustainability Element	113
5.4	Commercial Value and Potential	114
5.5	Research Achievement	115
REFERENCE		117
APPENDICES		124
Gantt Chart for PSM I		124
Gantt Chart for PSM II		126

LIST OF TABLES

TABLE	TITLE	PAGE
2.1	Composite structures and natural fiber materials for deck application	38
3.1	Strength properties of rubber wood	42
3.2	Strength properties of pine wood	43
3.3	Strength properties of balsa wood	44
3.4	Specifications of auto-fix 1345-A and auto-fix 1345-B	46
3.5	Schematic of cell geometry in wood core used	47
3.6	Recommended minimum specimen facing area (ASTM C365)	55
4.1	Code for type of wood core sandwich composite with GFRP face sheet	57
4.2	Variation of wood core sandwich composite with GFRP face sheets	57
4.3	Mass and density for each variation of wood based core sandwich composite fabricated	96
4.4	Average flexural strength and specific stiffness of wood based core sandwich composites	98
4.5	Average compressive strength and specific compression of the sandwich composites	101
4.6	Average tensile strength and specific tensile strength for wood base sandwich composite	104
4.7	Ranking of wood based core sandwich composite from the properties tested	109

LIST OF FIGURES

FIGURE	TITLE	PAGE
1.1	Methodology flow chart summary	9
2.1	Decking board (a) solid, (b) channeled, (c) capped, (d) coated	12
2.2	Schematic picture of a composite laminate	14
2.3	Sandwich panel	15
2.4	Honeycombs (a) truss (b)conventional (c) reentrant	17
2.5	Laminated bamboos: (a) three-ply LBL having a total thickness of 24 mm and (b) glubam sheet with thickness of 28 mm	19
2.6	Cross laminated timber	21
2.7	Manufacturing process for fiber reinforced composites	23
2.8	Hand lay-up process	25
2.9	Vacuum bagging process	26
2.10	Resin infusion process	27
2.11	Tensile test for plastic and composites	29

2.12	Three types of flexural test diagram (a)three-point (b)four-point-1/4 point (c)four-point-1/3 point	30
2.13	Compression test of trapezoidal corrugated sandwich panel	32
2.14	Kenaf (a) woven (b) non-woven	34
2.15	Jute (a) plant (b) raw fabric (c) unidirectional fiber (d) woven fiber	35
2.16	The CFRP-Balsa sandwich structure	36
3.1	Flow chart of methodology	41
3.2	Wood grain of rubber wood <i>Hevea brasiliensis</i>	43
3.3	Parallel wood grain of balsa wood	44
3.4	Woven roving glass fiber	45
3.5	Epoxy resin and hardener	46
3.6	Fabrication of hexagonal cell wood core with CNC gantry router MDX-540	48
3.7	Woven E-glass fiber consolidated with epoxy resin	50
3.8	Hexagonal wood cores consolidated to GFRP face sheet	50
3.9	Vacuum bagging process to fabricate the wood based core sandwich structure	51
3.10	Sandwich panel clamped onto fixture for testing on UTM	52

3.11	Universal Testing Machine (UTM) with flexural fixture	53
3.12	Universal Testing Machine with compression fixture loaded	54
4.1	Solid rubber wood <i>hevea brasiliensis</i>	58
4.2	Flexural strength and specific stiffness of SRW sandwich structure	59
4.3	Failure mechanism in SRW sandwich structure composite	60
4.4	Delamination of GFRP face sheet in the sandwich structure composite	61
4.5	Tensile strength and specific tensile of SRW sandwich structure	63
4.6	Failure mechanism of shear tension sample from delamination (a) core bonding surface (b) facesheet bonding surface	64
4.7	Pine wood grain	65
4.8	Flexural strength and specific stiffness of SPW sandwich structure	66
4.9	Face wrinkling failure on the SPW sandwich structure composites	67
4.10	Compressive strength and specific compression of SPW sandwich structure samples	68
4.11	Barrelling failure mechanism of the SPW sandwich structure composite	69
4.12	Tensile strength and specific tensile for SPW sandwich structure	70

4.13	Failure mode of SPW sandwich structure (a) Adhesive failure (b) Cohesive failure	71
4.14	Incomplete/ pseudo adhesion failure in SPW sandwich structure sample tested	71
4.15	Wood grain of sealed balsa wood	72
4.16	Flexural strength and specific stiffness of SBW sandwich structure with GFRP	73
4.17	Failure mechanism of SBW sandwich structure (a) Top view (b) Side view	74
4.18	Compressive strength and specific compression of SBW sandwich structure	75
4.19	Compressed SBW sandwich panel with barrelling failure mode	76
4.20	Shear tension strength and tensile modulus for SBW sandwich structure	77
4.21	Failure mechanism of SBW sandwich structure shear tensile sample	77
4.22	HCRW sandwich composite fabricated, trimmed and sawed	78
4.23	Flexural strength and specific stiffness of HCRW sandwich structure composite	79
4.24	Failure mode present in HCRW sandwich structure composite: (a) Top view (b) Side view	80
4.25	Compressive strength and modulus of HCRW sandwich structure	81

4.26	Failure mechanism of HCRW sandwich composite subjected to compression	82
4.27	Shear fatigue performance of the HCRW sandwich composite	83
4.28	Failure mechanism of HCRW sandwich samples (a) Side View (b) Top View	83
4.29	HCPW sandwich composite with HCPW core sandwiched by GFRP face sheets	84
4.30	Flexural strength and specific stiffness of HCPW sandwich composite samples	85
4.31	Buckling behavior of the HCPW sandwich composite under flexural fixture loading (a) Face wrinkling on loading surface (b) Delamination from face wrinkling	86
4.32	Compression strength and specific compression of HCPW sandwich samples	87
4.33	Buckling of cell wall in HCPW sandwich composite samples tested	88
4.34	Shear tension strength and modulus of HCPW sandwich sample tested	89
4.35	Buckling behavior of HCPW sandwich composite samples through shear fatigue (a) Side view adhesion failure (b) HCPW core surface view	89
4.36	HCBW sandwich composite before trimming in to sample size	90
4.37	Flexural strength and specific stiffness for each samples of HCBW sandwich structure	91

4.38	Failure mechanism of HCBW sandwich composite tested from flexural testing (a) Face sheet surface (b) Core side view	92
4.39	Compressive strength and modulus of HCBW sandwich composite samples tested	93
4.40	Failure mechanism of HCBW sandwich composite under compressive loading	93
4.41	Tensile strength and modulus of HCBW sandwich composite from shear fatigue test	94
4.42	Failure behavior of HCBW sandwich composite in different views and surfaces (a) Side view of HCBW sandwich structure (b) View of GFRP face sheet	95
4.43	Density of wood based core sandwich composite with GFRP face sheets	97
4.44	Average flexural strength and specific stiffness of each variant of wood core based sandwich structure composite	99
4.45	Average compressive strength and specific compressive strength of wood based core sandwich composite in solid and hexagonal cell variant	103
4.46	Average tensile strength and specific tensile strength for wood based sandwich composite	106
4.47	Rating of wood based core sandwich composite from properties	109
5.1	Hexagonal cell rubber wood sandwich composite for Velocifero electric vehicle decking	115
5.2	Picture taken during the closure of UTeMEX 2019	116

LIST OF ABBREVIATIONS

3D	-	3 Dimensional
ASTM	-	American Society for Testing and Material
CATIA	-	Computer Aided Three-dimensional Interactive Application
CFRP	-	Carbon fiber reinforced polymer
CLT	-	Cross laminated timber
CNC	-	Computer Numerical Control
DT	-	Destructive test
GFRP	-	Glass fiber reinforced polymer
HCBW	-	Hexagonal cell balsa wood
HCPW	-	Hexagonal cell pine wood
HCRW	-	Hexagonal cell rubber wood
ISO	-	International Organization for Standardization
KFRP	-	Kenaf fiber reinforced polymer
LBL	-	Laminated bamboo lumber
LVL	-	Laminated veneer lumber
MACM	-	Magnet assisted composite manufacturing
NDT	-	Non destructive testing
NFC	-	Natural fiber composite
PVC	-	Polyvinyl Chloride
SBW	-	Solid balsa wood
SPW	-	Solid pine wood

SRW	-	Solid rubber wood
UTM	-	Universal Testing Machine
WPC	-	Wood plastic composite

LIST OF SYMBOLS

°	-	Degree
cm	-	Centimeter
g	-	Gram
GPa	-	Giga Pascal
kg	-	Kilogram
kg/m ³	-	Kilogram per cubic meter
kPa	-	Kilo Pascal
mm	-	Millimeter
MPa	-	Mega Pascal
kNm/kg	-	Kilo Newton meter per kilogram

CHAPTER 1

INTRODUCTION

1.1 Background

The improvement of technology and the rising awareness of the global environment, the population of electric vehicle user has a rapid growth during the past decade. Electric scooter is one of a type of electric vehicle mentioned which is available in normal type and self-balancing type. As electric scooter is a type of vehicle albeit a vehicle which operates on electricity, its structural design is important. There are variety of parts used to construct electric scooter and a vehicle deck is one of them. Vehicle decks are typically made of woods and lumbers but recent researches shows that composites deck are an excellent alternative to wooden deck. Saba *et al.* (2017) highlighted green composites as a significant environmental key for aerospace, automotive, decking and structural applications due to a high strength to weight ratio compared to metals.

Composite deck are deck fabricated by using composite different from that of traditional or conventional deck which typically uses variety of lumber and woods. Composite deck can come in different forms but typical composite deck are made using wood plastic composites (WPCs) in the form of laminates. WPCs offers better durability, better bending stiffness, corrosive and chemical resistance followed by good mechanical performance compared to conventional lumbers. WPCs which is considered natural fiber composites (NFCs) are one of the hot topics for researching interests, product development and applications trending over the decades among industries and researchers. Mazzanti *et al.* (2015) introduced WPCs as a thermoplastic polymer reinforced natural fibers from

lignocellulosic origin to substitute conventional lumbers and plastic in terms of mechanical properties. As a matter of fact, Sanjay *et al.* (2016) mentioned that the efficiency of NFCs as composites are better than that of synthetic composites due to its lower density and better energy conservation in applications.

WPCs are typically fabricated in the form of composite laminates which is layers of fibers embedded in thin matrix known as lamina bonded surface to surface in a stacking sequences as stated by Birman and Genin (2018). Composite laminates with different fiber orientations and materials composition offers excellent properties in strength to weight ratio and stiffness to weight ratio compared to homogeneous and isotropic materials counterparts. Fiber volume fractions and fiber orientations can be utilized as design variables to minimize mass in composite laminate according to Liu and Paavola (2016).

Another structure of composite which offers excellent stiffness to weight ratio are sandwich panels which is fabricated from two strong and stiff faces separated by a low density core as mentioned by Vitale *et al.* (2016). The sandwich core increases the flexural stiffness of the sandwich panel with increased moment of inertia under bending. Typical core used in sandwich panels are PVC foams, balsa wood and honeycomb core with the more prominent one in research being honeycomb core. Honeycomb cores demonstrates good compressive strengths which are affected by wall thickness and the core height as mentioned by Sun *et al.* (2016).

Laminated bamboos are a fine example of NFC with excellent mechanical properties which can serves as a good reference for composites development. The physical and mechanical properties of bamboo are generally better than conventional timber species making engineered bamboo in industry increases as mentioned by Xiao (2016). Applications

of bamboo laminates can be found in laminated panels, fiberboards, particle boards, furnitures and floor panels as stated by Varma (2016).

Other NFCs such as kenaf, jute, and flax also serve as a possibilities to be applied into composite development research due to excellent mechanical properties and low density characteristics. Ramesh (2016) quoted that substitution of synthetic fibers composites with NFCs is possible due to advantages such as biodegradability, renewability, recyclability, abundant, permeability, corrosion resistance, non-toxicity, reduced energy consumption, excellent mechanical properties and minimum waste disposal problems. Chemical treatment towards natural fibers also helps to increase the overall mechanical properties of the fibers where researches on this particular area is increasing, contributing to a stronger NFCs development trend.

Fabrications of both laminates and sandwich structures in composites typically involves processes such as hand lay-up, vacuum bagging or resin infusion which requires manual handling with care and are design dependent. Lozano *et al.* (2015) stated that design and manufacturing in composite are dependent where design influence manufacturing efficiency and quality whereas manufacturing process limits design with constraints.

There are significant amount of researches regarding the utilization of natural fibers in composites structures including laminates and sandwich panels. Examples of the applications of natural fibers in sandwich panels includes flax fiber made honeycomb core researched by Riccio *et al.* (2018) and rice husk fiber reinforced polymer as honeycomb core which is fabricated by Zaini *et al.* (2018) using mould injection process. As far as the researches of natural fibers for composites go, there are still natural materials which is left out such as other types of wood based core excluding balsa core which is to be explained in this research. This creates a foundation for the development of new composites deck for this