

**DEVELOPMENT OF
BAMBOOCONCRETE MULTI-PURPOSE PANELS
FOR AFFORDABLE HOUSING SYSTEM**

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MASTER OF SCIENCE (CIVIL ENGINEERING)

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FOR AFFORDABLE HOUSING SYSTEM**

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ABSTRACT

Due to high cost of construction materials and technologies, it is a crucial challenge to deliver a decent mass housing. Cost of construction will be reduced if locally ready available raw materials are used at its optimum. Concrete needs to be reinforced due to its weak in tension. Bamboo is the best alternative as reinforcing material to replace steel as it is sustainable and low in cost. The objective of this study is to determine the physical and mechanical properties of local bamboo, *Gigantochloa Scortechinii* and its durability. It was found that after one year, the strength of bamboo is almost the same and top section of the bamboo culm was recorded as having the highest strength among other sections. Furthermore, the structural lightweight concrete was designed with the use of natural perlite aggregate and palm kernel shell (PKS) that provide an advantage of more lightweight material and to obtain more economical concrete. It is possible to produce 10 MPa compressive strength by using perlite and 16 MPa by using PKS. This paper also assesses the development of affordable bamboocrete multi-purpose panel. Bamboo is used to reinforce the lightweight concrete to form a load-bearing multi-purpose panel. The panels axial load strength are more than 100kN (10 ton) and ultimate bending load of between 32.51 to 35.20kN. The usage of bamboo as the reinforcement in the concrete panel greatly contributed to its bending strength. It showed its flexibility and ductility when the bamboocrete panel returned to its original straight form after the load removal. Total cost of the panel can be reduced by 14% when using bamboocrete panel with PKS as compared to the lightweight PKS concrete reinforced with steel bar, and bamboocrete panel is 23% lighter.

ABSTRAK

Penyediaan perumahan yang cukup amat mencabar disebabkan kos bahan dan teknologi yang tinggi. Kos pembinaan akan dikurangkan jika bahan mentah tempatan sedia ada digunakan secara optimum. Konkrit bertetulang perlu untuk memperkuat daya mampatan dan tegangan. Buluh adalah alternatif terbaik untuk menggantikan keluli kerana ia adalah mampan dan kos rendah. Objektif kajian ini adalah untuk menentukan sifat fizikal dan mekanikal buluh tempatan, *Gigantochloa Scortechinii* dan ketahanannya. Selepas satu tahun, kekuatan buluh hampir sama dan bahagian atas buluh direkodkan sebagai kekuatan tertinggi di kalangan bahagian lain. Selain itu, konkrit berstruktur ringan direka dengan menggunakan agregat perlite dan cengkerang kelapa sawit (PKS) yang memberikan kelebihan bahan yang lebih ringan dan mendapatkan konkrit yang lebih ekonomik. Ia boleh menghasilkan 10 MPa kekuatan mampatan dengan menggunakan perlite dan 16 MPa dengan menggunakan PKS. Kajian ini juga menilai reka bentuk panel pelbagai guna, buluh-konkrit panel yang mampu milik. Buluh digunakan untuk mengukuhkan konkrit ringan untuk membentuk panel pelbagai guna. Kekuatan beban paksi mencapai melebihi 100kN (10 tan) dan kekuatan lentur di antara 32.51 to 35.20kN. Penggunaan buluh dalam panel konkrit menyumbang kepada kekuatan lenturannya. Ia memperlihatkan fleksibiliti dan kemuluran apabila panel bamboocrete kembali ke bentuk asal yang lurus selepas beban tidak dikenakan. Jumlah kos panel boleh dikurangkan sehingga 14% apabila menggunakan buluh dan PKS berbanding konkrit dengan bar keluli, panel bamboocrete juga 23% lebih ringan.

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APPROVAL

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TABLE OF CONTENTS

	Page
ABSTRACT	ii
ABSTRAK	iii
ACKNOWLEDGEMENTS	iv
APPROVAL	v
DECLARATION	vii
TABLE OF CONTENTS	viii
LIST OF TABLES	xi
LIST OF FIGURES	xiii
LIST OF ABBREVIATIONS	xv
CHAPTER	
1	
INTRODUCTION	1
1.1 Background	1
1.2 Problem Statement	2
1.3 Objectives	3
1.4 Research Scope	4
1.5 Significance of Research	5
1.6 Thesis Outline	7
2	
LITERATURE REVIEW	8
2.1 Introduction	8
2.2 Definition of Affordable Housing	9
2.3 Housing Policy	10
2.4 Current Affordable Housing Technologies	13
2.5 Affordable Housing Issues and Challenges	17
2.5.1 High Population	17
2.5.2 Housing Unit Prices Increasing Rapidly	18
2.5.3 Cost for Construction Materials and Technologies	19
2.5.4 Income	20
2.5.5 Inadequate Demand and Land Supply	20
2.5.6 Financial Constraints and Difficulties in Applying Housing Loan	22
2.6 Bamboo as Structural Material	23
2.6.1 Properties of Bamboo	24
2.6.2 <i>Gigantochloa Scortechinii</i> Bamboo	25
2.7 Perlite Lightweight Concrete	27
2.8 Palm Kernel Shell (PKS) Lightweight Concrete	30
2.9 Bamboo Reinforced Concrete	31
2.10 Summary of Literature Review	32

3	METHODOLOGY	34
3.1	Introduction	34
3.2	Research Flow Chart Diagram	35
3.3	Literature Review	36
3.4	Physical and Mechanical Properties of <i>Gigantochloa Scortechinii</i>	36
3.4.1	Compression Strength Test	38
3.4.2	Shear Strength Test	39
3.4.3	Flexural Bending Test	41
3.4.4	Tensile Strength Test	43
3.4.5	Moisture Content and Density	44
3.4.6	Durability Test	46
3.5	Preparation of Lightweight Concrete Material	46
3.5.1	Cement	47
3.5.2	Coarse Aggregate	47
3.5.3	Fine Aggregate	47
3.5.4	Perlite Aggregate	47
3.5.5	Palm Kernel Shell (PKS)	48
3.5.6	Water	48
3.5.7	Superplasticiser	48
3.6	Lightweight Concrete Mixture Proportion	48
3.6.1	Perlite Lightweight Concrete	49
3.6.2	PKS Lightweight Concrete	50
3.6.3	Compressive Strength Test	51
3.7	Bamboocrete Multi-Purpose Panel	53
3.7.1	Bamboo and Formwork Preparation	53
3.7.2	Perlite Lightweight Concrete Panel Reinforced with Untreated Bamboo	56
3.7.3	PKS Lightweight Concrete Panel Reinforced with Treated Bamboo	57
3.7.4	Axial Load Test	58
3.7.5	Flexural Bending Test	60
3.8	Cost Analysis	61
4	RESULTS AND DISCUSSION	63
4.1	Introduction	63
4.2	<i>Gigantochloa Scortechinii</i> Bamboo Properties	64
4.2.1	Compression Strength	64
4.2.2	Shear Strength	67
4.2.3	Flexural Bending Strength	70
4.2.4	Tensile Strength	74
4.2.5	Air-dried Moisture Content and Density	77
4.3	Compression Strength of Perlite Lightweight Concrete	79
4.4	Compression Strength of PKS Lightweight Concrete	80
4.5	Bamboocrete Multi-Purpose Panel	81
4.5.1	Axial Load Strength	81

4.5.2 Flexural Bending Strength	83
4.6 Structural Analysis using Steel Bar as Reinforcement	85
4.7 Cost Analysis	87
5 CONCLUSION AND RECOMMENDATIONS	
5.1 Conclusion	92
5.2 Contribution to Knowledge	94
5.3 Recommendation	95
REFERENCES/BIBLIOGRAPHY	96
APPENDICES	
A. The Calculation of Axial Load Targeted Capacity	103
B. Structural Analysis of 20 kN Load Applied on Panel (Perlite, $f_{ck}=10\text{MPa}$)	104
C. Structural Analysis of 20 kN Load Applied on Panel (PKS, $f_{ck}=16\text{MPa}$)	106
D. Structural Analysis of 30 kN Load Applied on Panel (Perlite, $f_{ck}=10\text{MPa}$)	108
E. Structural Analysis of 30 kN Load Applied on Panel (PKS, $f_{ck}=16\text{MPa}$)	110
BIODATA OF STUDENT	112
LIST OF PUBLICATIONS	113

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	The Public Affordable Housing Programmes in Malaysia	16
2.2	The Number of Housing Units Developed in Malaysia	16
2.3	Compressive Strength and Mix Proportions for Perlite Concrete	29
2.4	Perlite Lightweight Concrete Mix Proportion	29
2.5	OPS Lightweight Concrete Mix Proportion	31
3.1	Mix proportion for Perlite Lightweight Concrete.	49
3.2	Mix Proportion for PKS Lightweight Concrete.	51
3.3	Design Alternatives Considered to Cost Analysis	62
4.1	Compressive Strength for Untreated Bamboo (Immediate Test)	65
4.2	Compressive Strength for Untreated Bamboo (One Year)	65
4.3	Compressive Strength for Treated Bamboo (Immediate Test)	66
4.4	Compressive Strength for Treated Bamboo (One Year)	66
4.5	Shear Strength for Untreated Bamboo (Immediate Test)	68
4.6	Shear Strength for Untreated Bamboo (One Year)	68
4.7	Shear Strength for Treated Bamboo (Immediate Test)	69
4.8	Shear Strength for Treated Bamboo (One Year)	69
4.9	MOR and MOE Results for Untreated Bamboo (Immediate Test)	73
4.10	MOR and MOE Results for Untreated Bamboo (One Year)	73
4.11	MOR and MOE Results for Treated Bamboo (Immediate Test)	74
4.12	MOR and MOE Results for Treated Bamboo (One Year)	74
4.13	Ultimate Tensile Strength Results for Untreated Bamboo	75
4.14	Ultimate Tensile Strength Results for Treated Bamboo	76
4.15	Moisture Content and Density Results (Immediate Test)	78
4.16	Moisture Content and Density Results (One Year)	78
4.17	Compression Strength of Perlite Lightweight Concrete	79
4.18	Compression Strength of PKS Lightweight Concrete	80
4.19	Flexural Bending Load for Bamboocrete panel.	83

4.20	Steel Bar for Reinforced Concrete Panel (20kN Applied)	86
4.21	Steel Bar for Reinforced Concrete Panel (30kN Applied)	86
4.22	Material's Unit Price	87
4.23	Volume and Mix Proportion for 1 Panel.	89
4.24	Cost for 1 Panel	90
4.25	Percentage of Price and Weight Reduced for Bamboocrete Panel	91
5.1	Properties of <i>Gigantochloa Scortechinii</i> Bamboo	93

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	Strategy canvas in providing adequate and quality affordable house	12
2.2	The production of bamboo mat corrugated roofing sheets from bamboo mat board	13
2.3	Two-storey bamboo housing system	14
2.4	The compressing laterite clay to produce earth block	14
2.5	The model house in Kigali using the earth block	15
2.6	The process of housing development in Malaysia	21
2.7	Green School, Bali, Indonesia	25
2.8	Failure Behaviour of <i>Gigantochloa Scortechinii</i> during Bending Test	27
2.9	Fire resistance of the wall panels	28
2.10	Bamboo strips as reinforcement in concrete	32
3.1	Research flow chart	35
3.2	<i>Gigantochloa Scortechinii</i> bamboo in Hulu Langat, Malaysia	37
3.3	<i>Gigantochloa Scortechinii</i> treated by using borax and boric acid	37
3.4	Compression strength test	39
3.5	Shear strength test	40
3.6	Flexural bending test by using Magnus Frame machine	42
3.7	Wedge-shaped test piece for tensile strength test	43
3.8	Tensile strength test	44
3.9	Moisture content and density determination	46
3.10	Perlite lightweight concrete cube	50
3.11	PKS lightweight concrete cube	51
3.12	General set-up for cube compression strength test	52
3.13	<i>Gigantochloa Scortechinii</i> bamboo wrapped with wire mesh	53
3.14	Wooden formwork mould for bamboocrete multi-purpose panel	54

3.15	Casting of Bamboocrete Multi-purpose Panel	55
3.16	Perlite lightweight concrete with untreated bamboo reinforcement	57
3.17	PKS lightweight concrete with treated bamboo reinforcement	58
3.18	Simulated loads distribution on wall panel	59
3.19	Axial load test general set up	60
3.20	Flexural bending test general set up	61
4.1	Compression strength test. (a) End bearing failure mode (b) Splitting failure mode	67
4.2	Shear strength test: Internode and bamboo with node	70
4.3	Untreated bamboo flexural bending test (Immediate test)	70
4.4	Untreated bamboo flexural bending test (One year)	71
4.5	Treated bamboo flexural bending test (Immediate test)	71
4.6	Treated bamboo flexural bending test (One year)	72
4.7	Flexural bending test. (a) General set up (b) Failure mode	72
4.8	Stress-strain curve for untreated bamboo	76
4.9	Stress-strain curve for treated bamboo	77
4.10	Axial load test on perlite-untreated bamboocrete panel	82
4.11	Axial load test on PKS-treated bamboocrete panel	82
4.12	Flexural bending test on perlite-untreated bamboocrete panel	84
4.13	Flexural bending test on PKS-treated bamboocrete panel	84
4.14	Control panel failed with load less than 5 kN	85
4.15	Bamboocrete panel turns into straight form after load is removed	85

LIST OF ABBREVIATIONS

B40	Bottom 40% of households with monthly income of RM3, 900 and below.
PKS	Palm Kernel Shell
RMK	Rancangan Malaysia Ke (Malaysia Plan)
BMB	Bamboo Mat Board
BMTPC	Building Materials and Technology Promotion Council
RISD	Rwanda Initiative for Sustainable Development
OPS	Oil Palm Shell
OPKS	Oil Palm Kernel Shell

CHAPTER 1

INTRODUCTION

1.1 Background

In many developing countries, the governments are committed in providing an adequate, affordable and a quality low-cost house to the low and middle income group. Housing prices nowadays are too expensive and hike rapidly. The challenges arise in providing the affordable houses to the B40 households when the building materials and labour cost rise in price.

To reduce the escalation in housing prices, the construction projects have to use suitable low-cost materials. Couple with do-it-yourself construction technology will push housing price to an affordable level. The significant contributor to the cost-effective construction projects is the materials and labours as materials contribute higher amount than other inputs.

This research studies the properties of bamboo hybrid with concrete by preparing the multi-purpose panel sample made from bamboo and concrete known as bamboocrete. The prepared bamboocrete wall panel will contribute to affordable and environmental-friendly materials, using bamboo as the reinforcement in the

lightweight concrete. Furthermore, lightweight concrete is produced from the lightweight aggregate, perlite and palm kernel shell (PKS).

1.2 Problem Statement

B40 households face difficulty in accessing the housing market due to the increasing prices of new houses, building materials and labour. High cost of materials is a serious challenge to build and deliver a decent mass housing. Other challenges arise when the existing housing developers insist to use the conventional building materials and technologies.

Most widely used material in construction is concrete. Concrete needs to be reinforced due to its weak tension carrying capacity. For the conventional building structures, steel bars usually act as the reinforcing materials. But steel has various disadvantages such as non-renewability, high in cost and is the major source of greenhouse gas emission. Wide use of concrete has also led to high demand for stone and aggregate resulting in the demolition of natural stone deposits. Massive construction which requires concrete can cause a vital issue in ecological imbalances.

In previous research, bamboo was cut into stripes to act as the reinforcement in concrete. During samples preparation in cutting bamboo into stripes, bamboo culm structure can be damaged, then crack propagation can occur and its tensile strength may be affected. Further, bamboo need to be treated to enhance its

durability. Most of the journals report the performance of the immediate strength of bamboo properties. The usage of whole bamboo in concrete has not been reported yet even though it has the advantages of increasing the strength of concrete panel, reducing the weight of concrete panel and reducing the use of steel, cement and aggregate.

Based on the statements above, the research aims to solve the problem by using suitable, low-cost and green materials in structural components. This can be done by innovating the conventional method of construction technology through the replacement of steel bar with bamboo in concrete since bamboo is a raw material that grows fast and has great strength capability. Perlite and palm kernel shell (PKS) can replace the conventional coarse aggregate to produce more lightweight structural material and contribute to a sustainable construction.

1.3 Objectives

The objectives of this research are:

1. To determine the physical and mechanical properties of local bamboo, *Gigantochloa Scortechinii* (Buluh Semantan) and its durability.
2. To develop the lightweight concrete using natural perlite aggregate and palm kernel shell (PKS).
3. To develop the affordable composite bamboocrete panel.

1.4 Research Scope

The project consists of laboratory test to determine the physical and mechanical properties of treated and untreated local bamboo. This study focuses only on one type of matured bamboo age of 3 to 4 years, *Gigantochloa Scortechinii*, called by locals as buluh semantan with size of 53 mm \pm 10 mm. The test included moisture content, density, compression, shear and tensile strength. The same test for durability was conducted after 1 year from the time the bamboo was harvested.

This study focuses on the bamboo hybrid with lightweight concrete as the intention is to prepare the multi-purpose panel sample made of bamboo and concrete known as bamboocrete. Lightweight concrete uses perlite and palm kernel shell (PKS) as the partial replacement of coarse aggregate.

Whole solid bamboos, untreated and treated, were placed in the lightweight concrete to act as the reinforcement. Bamboocrete panel undergoes axial load and flexural test. Untreated bamboocrete undergoes immediate, three month, six month and one year test on axial and flexural test for durability. Due to time and resource constraints, durability test for treated bamboocrete was limited to immediate test only.

1.5 Significant of Research

This study will help to evaluate and develop the best possible materials and design to obtain an affordable housing system. Bamboo seems to have good strength as building materials and may reduce the cost compared to similar products in the market. Physical and mechanical properties of local bamboo, *Gigantochloa Scortechinii* (*Buluh Semantan*) will be discovered to fit the design as the structural component.

By partially replacing the coarse aggregate with the perlite and palm kernel shell (PKS) in concrete, it will help to produce lightweight structural material and also contribute to a sustainable construction. Lightweight concrete from perlite and palm kernel shell (PKS) as additional materials is expected to give impact on reducing the cost of labour and man-hour. With advanced and improved construction technologies, construction time and cost will be reduced and affordable houses can be constructed. By substituting perlite and PKS as a replacement for the coarse aggregate, the use of natural resources can be reduced. Compared to normal weight concrete, perlite and PKS concrete reduce the density and increase the workability.

The increase in building cost is due to the cost of construction materials. Therefore, the construction materials' cost needs to be reduced by using the readily available raw materials. Bamboocrete technology can help to reduce cost of materials and enhance sustainability. The outcome of this research is the innovation of multi-purpose panel with proven strength and durability that can be used as wall

panel, floor panel, pathway panel, and drain covers. The prepared bamboocrete panel will contribute to affordable and environmental-friendly materials since bamboo is one of the main materials. The housing strategy to construct low-cost houses for lower income group can be implemented. This research will give impact on higher selectivity to the bamboocrete panel towards the affordable construction materials.

1.6 Thesis Outline

This thesis contains five chapters as follows:

Chapter 1 Introduction: The first chapter consists of background of the research and problem statement. Next, the research objectives are presented followed by the research scope. Significance of the research is also briefly outlined.

Chapter 2 Literature Review: This chapter provides a review on worldwide affordable housing system. The concepts and provision of adequate affordable housing are presented in detail. Gaps are identified where the affordable materials must be used to obtain the aim in providing affordable houses. This chapter discusses and fills in these gaps.

Chapter 3 Research Methodology: The chapter discusses about the strategy, materials and methods used in this study. The experimental procedure and data analysis techniques are also discussed in this chapter.

Chapter 4 Results and Discussion: This chapter describes the result obtained from the experiment. Materials used, Perlite and Palm Kernel Shell (PKS) aggregates and bamboo were evaluated according to their strength and overall cost in obtaining the affordable housing concept.

Chapter 5 Conclusion and Recommendation: This final chapter discusses and concludes the outcomes of the research. Outcomes were linked to the previous studies in the literature and discussed in detail. Suggestion and recommendation for future study are also presented in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the literature from all sources in the aspect of affordable housing system provided worldwide and the usage of suitable and low-cost materials were reviewed. It generally covers the definition and understanding of affordable housing, worldwide housing policy and discusses the current provision of affordable house. Furthermore, issues and challenges in provision of affordable housing were also reviewed.

The properties and advantages that suit bamboo as the structural construction materials were discussed. The study covers the properties of local bamboo, *Gigantochloa Scortechinii* (Buluh Semantan), which is most widely used as structural component in the construction industry. This chapter also covers how perlite and palm kernel shell (PKS) replace the coarse aggregate in concrete mix to achieve the aim in producing lightweight concrete. The substituent of bamboo in concrete to act as the reinforcement is further discovered.