

**MECHANICAL PROPERTIES OF SAWDUST CONCRETE
INCORPORATING PALM OIL FUEL ASH**

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ABSTRACT

Malaysia being a very large producer of agro-waste, the high costs of building construction, environmental and sustainability issues have led to investigations into the use of agro waste as concrete products. Among others, sawdust and palm oil fuel ash (POFA) are complimentary materials when used in concrete. This project studies the use of sawdust, as fine aggregate replacement material in concrete also incorporating POFA. Sawdust is a lightweight aggregate, and can be used to wholly replace sand. POFA being a pozzolanic supplementary material imparts higher ultimate strength, improved workability and reduced water-cement ratio. Sawdust concrete incorporating POFA has been investigated for its workability, strength, modulus of elasticity and above all for its suitability as a cheaper light weight concrete element. As expected, the 1:1 mix shows the higher strength's and better durability while the 1:3 mixes have workability problems and lower strength's but are cheaper in terms of cement use, not to mention the high (34.88%) utilization of waste materials. It is recommended that further study with a 0.5 water- cement ratio to the un-replaced cement only and a 1:2.5 mix ratio will reduce the gap between sawdust concrete incorporating POFA and normal concrete, hence making it a viable alternative.

ABSTRAK

Malaysia menjadi pengeluar yang sangat besar agro-sisa, kos yang tinggi untuk pembinaan bangunan, alam sekitar dan isu-isu kemampanan telah membawa kepada penyiasatan ke dalam penggunaan sisa pertanian sebagai produk konkrit. Antara lain, minyak habuk papan dan abu bahan api sawit (POFA) adalah bahan percuma apabila digunakan di dalam konkrit. Projek ini mengkaji penggunaan habuk kayu, sebagai bahan penggantian denda agregat dalam konkrit POFA juga menggabungkan. Habuk kayu adalah agregat ringan, dan boleh digunakan untuk menggantikan pasir milik. POFA sebagai bahan tambahan pozzolanic menyampaikan kekuatan muktamad yang lebih tinggi, keboleherjaan yang baik dan mengurangkan nisbah air-simen. Habuk papan konkrit menggabungkan POFA telah disiasat untuk keboleherjaan, kekuatan, modulus kekenyalan dan ke atas semua untuk kesesuaian sebagai cahaya yang lebih murah elemen konkrit berat. Seperti yang dijangka, campuran 01:01 menunjukkan ketahanan lebih tinggi kekuatan dan lebih baik manakala campuran 01:03 mempunyai masalah keboleherjaan dan kekuatan yang lebih rendah ini tetapi adalah lebih murah dari segi penggunaan simen, apatah lagi yang tinggi (34,88%) penggunaan bahan-bahan buangan. Ia adalah disyorkan bahawa kajian selanjutnya dengan nisbah 0.5 simen air simen un-digantikan sahaja dan nisbah 1:2.5 campuran akan mengurangkan jurang antara konkrit POFA habuk papan menggabungkan dan konkrit normal, justeru menjadikannya alternatif yang berdaya maju.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	ABSTRACT	iii
	ABSTRAK	iv
	TABLE OF CONTENTS	v
	LIST OF TABLES	xi
	LIST OF FIGURES	xiii
	LIST OF APPENDICES	xv
1	INTRODUCTION	
	1.1 General Introduction	1
	1.2 Background of Study	3
	1.3 Important of Study	3
	1.4 Problem Statements	4
	1.5 Aims and Objectives	5
	1.6 Scope of Study	5
2	LITERATURE REVIEW	
	2.1 Introduction to Concrete	7
	2.2 Malaysia's Climate Review	8
	2.2.1 Rainfall Distribution	8
	2.2.2 Temperature Variation	9
	2.2.3 Relative Humidity	10
	2.2.4 Sunshine and Solar Radiation	10
	2.3 Lightweight Concrete	11
	2.3.1 Structural Lightweight Concrete	12
	2.3.2 Types of Lightweight Concrete	13
	2.3.2.1 Lightweight Aggregate Concrete	13
	2.3.2.2 Aerated Concrete	15
	2.3.3 Advantages of Lightweight Concrete	16
	2.4 Classification of Aggregates	17
	2.4.1 Natural Aggregate	17
	2.4.2 Manufactured Aggregate	18
	2.4.3 Waste Based Aggregates	18
	2.4.3.1 Foamed Blast Furnace Slag (FBS)	18
	2.4.3.2 Fly Ash Aggregates	19
	2.4.4 Recycled Aggregate	19
	2.4.4.1 Re used by-Products	20
	2.4.4.2 Air-Cooled Blast Furnace Slag (BFS)	20
	2.4.4.3 Granulated Blast Furnace Slag (GBS)	21

	2.4.4.4 Fly Ash (FA)	22
	2.4.4.5 Furnace Bottom Ash (FBA)	22
	2.4.4.6 Incinerator Bottom Ash (IBA)	23
2.5	Organic Materials in Concrete	24
	2.5.1 Timber in Malaysia	24
	2.5.2 Sawdust	25
	2.5.2.1 Sawdust Concrete	28
2.6	Mineral Admixtures	28
2.7	Supplementary Cementing Materials	29
	2.7.1 Pozzolanic Reaction	29
	2.7.2 What is POFA	30
	2.7.2.1 Manufacture of POFA	32
	2.7.2.2 Physical and Chemical Properties	33
	2.7.2.3 Effect of Fineness	34
	2.7.2.4 Roles and Advantages of POFA	35
	2.7.2.5 Mineralization Effect	36
2.8	Sawdust Concrete incorporating POFA	36
2.9	Engineering Properties of Concrete	37
	2.9.1 Density	37
	2.9.2 Compressive Strength	38
	2.9.3 Tensile Strength	39
	2.9.4 Flexural Strength	39
	2.9.5 Modulus of Elasticity	40
	2.9.6 Ultrasonic Pulse Velocity Test	40
	2.9.7 Water Absorption	41
3	RESEARCH METHODOLOGY	
3.1	Introduction	43
3.2	Control	43
3.3	Preparation of Materials	44
	3.3.1 Sawdust	44
	3.3.2 Cement	45
	3.3.3 Water	46
	3.3.4 POFA	46
3.4	Chemical Composition of POFA	47
3.5	Design Mix	47
	3.5.1 Trial Mixes	48
3.6	Tests on Concrete	48
	3.6.1 Density of the Concrete	48
	3.6.2 Workability Test	49
	3.6.3 Compressive Strength Test	49
	3.6.4 Indirect Tensile Strength Test	50
	3.6.5 Flexural Strength Test	50
	3.6.6 Modulus of Elasticity Test	50
	3.6.7 Ultrasonic Pulse Velocity Test	50
3.7	Durability of Concrete	51
	3.7.1 Water Absorption Test	51
3.8	Testing Procedure	52
	3.8.1 Preparation of Test Specimens	52
	3.8.2 Mix Proportions	53

3.8.3	Mixing of Concrete	53
3.8.4	Curing Condition	54
3.9	Laboratory Tests	54
3.9.1	Density of the Concrete	54
3.9.2	Workability Test	55
3.9.3	Strength Tests	55
3.9.3.1	Compressive Strength Test	55
3.9.3.2	Indirect Tensile Strength Test	57
3.9.3.3	Flexural Strength Test	58
3.9.3.4	Modulus of Elasticity	60
3.9.3.5	Ultrasonic Pulse Velocity Test	61
3.9.4	Durability of Concrete	62
3.9.4.1	Water Absorption Test	63
4	RESULTS AND DISCUSSION	
4.1	Introduction	64
4.2	Physical and Chemical Properties of POFA	64
4.2.1	Chemical Composition of POFA	64
4.2.2	XRD of POFA	66
4.3	First trial Mixes	66
4.4	Density Analysis	68
4.5	Workability Test	70
4.6	Strength Tests	71
4.6.1	Compressive Strength Test	71
4.6.2	Indirect Tensile Strength Test	74
4.6.3	Flexural Strength Test	76
4.6.4	Modulus of Elasticity Test	77
4.6.5	Ultrasonic Pulse Velocity Test.	78
4.7	Relationship of Various Strength Properties of Sawdust Concrete	79
4.7.1	Compressive To Split Tensile Strength.	79
4.7.2	Compressive To Flexural Strength	80
4.8	Durability Tests	82
4.8.1	Water Absorption Test	82
4.9	Utilization of Waste Materials and Cost Effectiveness	83
4.9.1	Utilization of Waste Materials	83
4.9.2	Cost Effectiveness of the Concrete	84
5	CONCLUSIONS AND RECOMMENDATIONS	85
5.1	Conclusions	85
5.2	Recommendations	86
	REFERENCES	87
	APPENDICIES	90

LIST OF TABLES

TABLE NO:	TITLE	PAGE
2.1	Physical and Chemical Properties of POFA	33
2.2	Particle Size and Compressive Strength.	35
3.1	Results of Pilot-Experiment used as Control.	43
3.2	Pulse Velocity and Quality of Concrete.	51
3.3	Relations between Pulse Velocity and Quality of Concrete.	62
4.1	Chemical Composition of POFA and OPC Based on XRF.	65
4.2	Density of Sawdust Concrete.	69
4.3	Workability of Sawdust Concrete.	70
4.4	Compressive Strength of Sawdust Concrete MPa or N/mm ² .	72
4.5	Split Tensile Strength (N/mm ²).	75
4.6	Flexural Strength Test of Sawdust Concrete.	77
4.7	Modulus of Elasticity of Sawdust Concrete-GPa.	77
4.8	The ultrasonic pulse velocity (UPV) of sawdust concrete (m/s).	78
4.9	Relationship between Splitting Tensile Strength and Compressive.	79
4.10	Relationship between Flexural Strength and Compressive Strength of Sawdust Concrete.	81
4.11	Water Absorption of Sawdust Concrete as Percentage (%) of Dry Mass.	83
4.12	Percentages of Waste Materials.	84
4.13	Cost Effectiveness of the Concrete.	84

LIST OF FIGURES

FIGURE NO	TITLE	PAGE
2.1	Lightweight-Sawdust Concrete.	13
2.2	Lightweight Aggregate Concrete.	15
2.3	Natural Aggregate.	17
2.4	Sawdust Samples as Used in Concrete.	26
2.5	Coarse Sawdust, as Used in Concrete.	27
2.5	POFA as Used in Sawdust Concrete.	31
2.6	Weight measurement of POFA for Density.	34
3.1	Both Types of Sawdust Materials	45
3.2	Cement, Open and in Bags.	46
3.3	POFA as Used in the Study.	47
3.4	Compression Strength Test.	49
3.5	Various Molds.	52
3.6	Mixing Machine.	54
3.7	Split-Tensile Strength Test on Cylinder Sample.	58
3.8	Flexural Strength Test on Beam Sample.	60
3.9	UPV Machine.	62
4.1	XRD of POFA.	66
4.2	Sawdust from the Rubber Tree.	68
4.3	Comparisons of Density with Mix Proportions.	69
4.4	Sample Cube after Compressive Strength Testing.	73
4.5	Relative Compressive Strengths for the Three Mix Proportions.	73
4.6	Comparisons of Density with Compressive Strength.	74
4.7	Indirect Tensile Strength of Sawdust Concrete-MPa orN/mm ² .	75
4.8	Relationship Between splitting tensile strength and compressive strength of sawdust concrete.	80
4.9	Relationship between flexural strength and compressive strength of sawdust concrete.	82

LIST OF APPENDIX

APPENDIX	TITLE	PAGE
A.4.1	Density of Sawdust Concrete	91
A.4.2	Compressive Strength of Sawdust Concrete	92
A.4.3	Relationship between Density and Compressive Strength	93
A.4.4	Split Tensile Strength of Sawdust Concrete	94

CHAPTER 1

INTRODUCTION

1.1 General Introduction

The rising cost of building construction, environmental concerns and sustainability issues has led to investigations into the use of agro-waste materials as concrete products. Engineering consideration on the use of waste, cheaper and locally available materials is highly attractive. Successful utilization of waste materials depends on its use being economically competitive with alternative natural materials. Malaysia produces, as solid wastes about 8 million tons/year of palm oil fuel ash (POFA) [1]. Sawdust is also abundantly available everywhere in the country. There arises the need for engineering consideration of the use of cheap, locally available materials to meet desired need, self-efficiency, and lead to an overall reduction in construction cost, for sustainable development.

Sawdust has been used from time to time for making light weight concrete, it could also be classified as waste based concrete but it has severe limitations [2], low strength and durability problems. However its combination with (POFA) remains to be tested? POFA is a good pozzolanic material [3], it can be used to replace up to 30% of the OPC [4] and it has been extensively studied. Its use in ordinary portland

cement (OPC) increases the long term strength and durability performance of concrete [4]. As such, sawdust and POFA appear to be unique complimentary materials. If this combination proves to have even a few merits, then the large scale use of agro-waste materials will offset the limitations and open the way towards further development, ever increasing usage and business alternatives. However the performance and stability of combination, waste based concrete products over the expected lifespan is of utmost importance and it will require time based, long term testing.

Today, the construction industry in Malaysia has increased rapidly from day to day. Malaysia as an emerging country also got no exception to receive new technology in the construction industry. Since the large demand has been placed on building material industry especially in the last decade owing to the increased population which causes a chronic shortage to building materials, the civil engineer has been challenged to convert the industrial waste to useful building and construction material. Accumulating of unmanaged waste especially in developing countries has resulted in an increasing environment concern. Recycling of such wastes as building material appears to be viable solution not only to the pollution problem but also to the problem of economic design of building the increase in the popularity of using environmentally friendly, low-cost and light weight construction material in building industry has brought about the need to investigate how this can be achieved by benefiting to the environment.

The majority of wood sawdust wastes is accumulated from the countries all over the world and causes certain serious environmental problem and health hazards [5]. Sawdust, a relatively abundant and inexpensive material is currently being investigated as an admixture in lightweight concrete blocks to decrease the weight of the concrete. Sawdust is an industrial waste in the timber industry and causes a nuisance both to the health and environment when they are not properly disposed.

Sawdust concrete is used to a limited extent because it possesses very low strengths. Typically, 1:2 and 1:6 mixes (cement: sawdust by volume) yield a 7-day compressive strength of 7.5 MPa and 0.75 MPa, respectively. In spite of this, sawdust concrete has a good insulation value, resiliency, low thermal conductivity, and can be sawed and nailed. But in locations where water accumulates or is in constant contact with it, sawdust concrete can absorb large amounts of water and expand. Sawdust must be pre-soaked to remove soluble matter before use in concrete. Sawdust from red oak, Douglas fir, cottonwood, maple, birch or red cedar makes very low-strength concretes, whereas that from spruce or Norway pine yields concretes of acceptable properties [6].

1.2 Background of Study

Concrete are commonly used in the construction industry. Since concrete is a heavy substance, it is desirable to make concrete lighter for ease of use and to help prevent injury to workers caused by lifting the concrete. Various methods have been proposed in the prior art to form lightweight concrete utilizing waste materials (sawdust & POFA) as a component. Considerable reduction in self-weight of the structure, thereby reducing the dead loads transmitted to the foundation. It can reduced damage and prolonged life of formwork due to lower pressure being exerted and also more easier to handling, mixing and placing as compared with other type of concrete.

1.3 Importance of Study

Concrete is the most widely used building material. This is particularly true in the Malaysian construction scenario for both normal and lightweight concrete. Malaysia is blessed with natural resources where timber is vastly available. Thus the use of products such as POFA and sawdust in the concrete mix has the potential

produce lightweight concrete. The use of lightweight concrete will also reduce operating and transportation costs saving the environment from pollution.

1.4 Problem Statements

Disposal of abundant agro-waste is a global problem including Malaysia. On the other hand concrete remains the most popular construction material. Researchers have attempted to use waste as concrete materials for obvious reasons; sustainability, low cost, recycling and environmental factors. However the success of this philosophy will depend on effective, large scale utilization of agro-waste as concrete materials. This in turn depends on the acceptance, quality and practicality of the final products. Concrete made with agro-waste products will need to have high compressive strength, durability, performance and cost effectiveness as compared to OPC concrete only.

In many parts of the world there is a critical deficiency or shortage of aggregate, crushed or uncrushed. This may be due to quality, local availability or logistic problems. Sawdust without a large amount of bark has proved to be usable as sand (fine aggregate) replacement material [5]. A substantial amount of OPC i.e. up to 30% can easily be replaced by POFA without any loss in strength [4]. Both POFA and sawdust are cheaper than OPC and fine aggregate respectively.

The increasing demand for high performance, durable and yet can minimize the cost of concrete making using new technique and new material have encouraged this study to be conducted. This research will determine the performance of sawdust with POFA in making lightweight concrete.

1.5 Aims and Objectives

The aim of this research is to study the use of agro-waste materials like Sawdust and POFA to obtain lightweight, cheaper and environment-friendly concrete. The objectives of this research are to look at the performance of sawdust concrete. The specific objective are follows:

- To study the feasibility of sawdust concrete incorporating palm oil fuel ash.
- To study the physical and mechanical properties of this concrete.
- To experimentally determine the maximum and optimum limits of both these materials in combination.
- To determine the maximum replacement limits of fine aggregate by sawdust, if possible completely, 100%.
- To recommend and identify specific uses and applications of this concrete material.
- To introduce this concrete as a cheaper alternative to existing products.
- To recommend further, long term, time based testing.

1.6 Scope of Study

The versatility of concrete has made it the most widely accepted construction material. Sawdust in combination with POFA has the potential to be developed as waste based alternative/ aggregate replacement material. In order to achieve practical expectations and to keep this study within the scopes of time, limitations as followed have been set up. In conducting the research, the boundaries of the scope must be defined and a number of factors that limit can be made to avoid a very wide scope of research and study unfocussed. Factor of the scope and limitations of these studies are:

- The target characteristic strength of 20N/mm² at 28 days.

- Three different mix proportions of cement and sawdust in the ratio of 1:1, 1:2 and 1:3 by volume will be tested.
- Percentages of POFA, 30% cement replacement, at optimum values.
- Value of constant water cement ratio (W/C) 0.5.
- Sizes of test samples are 100mm cube for compressive strength test (BS 1881: Part 116), 100x100x500mm plain concrete beam for flexural strength test (BS 1881: Part 118) and cylinder test sample with 150mm diameter and 300mm height for tensile strength (ASTM C496-11) test and modulus of elasticity test (ASTM C469-10).
- Source of water use are from Universiti Teknologi Malaysia (UTM) tap water.
- Wrapped and dry cured at room temperature till testing date.
- Sawdust used, is that locally available as agro-waste.

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