MECHANICAL PROPE G PALM OIL BOILER

STONE (POBS) AS E REPLACEMENT

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ABSTRACT

This study deals with the mechanical properties of concrete by using palm oil boiler stone (POBS) as partially fine aggregates replacement material. The objective of this study is to determine the compressive strength, splitting tensile and flexural strength of concrete containing 15%, 25% & 50% POBS as fine aggregate replacement material and obtain the optimum range value of POBS as fine aggregate replacement material. It involves from the early stage of mix design for Grade 30, casting, curing and lastly, mechanical properties testing carry out to determine the strength given by different mix proportions of POBS. Mechanical properties testing are compressive strength test which tested on cube and cylinder samples, splitting-tensile test on cylinder samples only and flexural beam test where mid-point load method is used. The outcome of the results analyzed the optimum strength of concrete is between the range of 10% to 15% of POBS content. The test results shows improvement in concrete strength. In addition, this study indirectly can save cost of material in concrete, solve the issue of landfill mostly been used up for solid wastage and benefits the construction industry by suggestion another method in improving the quality of concrete.

ABSTRAK

Ujikaji ini memperkatakan sifat-sifat mekanikal konkrit yang menggunakan batu hasil pembakaran kelapa sawit (POBS), sebagai pengganti sebahagian aggregat halus. Objektif kajian ini adalah untuk menentukan kekuatan mampatan, tegangan pecah dan kekuatan lenturan konkrit yang mengandungi 15%, 25% & 50% POBS sebagai bahan penggantian aggregat halus dan mendapatkan nilai optimum POBS sebagai bahan ganti. Ia melibatkan peringkat awal reka bentuk campuran bagi Gred 30, pembancuhan, rawatan dan akhir sekali, ujian sifat mekanikal dijalankan untuk menentukan kekuatan yang diberikan oleh nisbah campuran POBS yang berlainan. Ujian sifat mekanikal adalah ujian kekuatan mampatan yang diuji ke atas sampel kiub dan silinder, ujian membelah-tegangan atas sampel-sampel silinder dan lenturan rasuk ujian di mana kaedah beban titik tengah digunakan.Hasil keputusan analisis kekuatan optimum konkrit adalah antara 10% hingga 15% kandungan POBS. Keputusan ujikaji ini menunjukkan peningkatan dalam kekuatan konkrit. Tambahan pula, ujikaji ini secara tidak langsung dapat menjimatkan kos bahan di dalam konkrit, menyelesaikan isu tapak pelupusan yang kebanyakannya digunakan untuk pembaziran sisa-sisa pembuangan, dan memberi manfaat kepada industri pembinaan dengan cadangan kaedah dalam meningkatkan kualiti konkrit.

TABLE OF CONTENTS

		Page
SUPERVISOR'S DECLARATION		ii
STUDENTS'S DECLARATION		iii
ACKNOWLEDGEMENTS		iv
ABSTRACT		v
ABSTRAK		vi
TABLE OF CONTENTS		vii
LIST OF TABLES		xi
LIST OF FIGURES		xii
LIST OF SYMBOLS		xiv
LIST OF ABBREVIATIONS		xv
CHAPTER 1	**INTRODUCTION**	
1.1	Introduction	1
1.2	Problem Statement	2
1.3	Objectives of Study	3
1.4	Scope of Study	3
1.5	Significant of Study	4
CHAPTER 2	**LITERATURE REVIEW**	
2.1	Introduction	5
2.2	Origin of Palm Oil Boiler Stone (POBS)	5
2.3	Production of Palm Oil Boiler Stone (POBS)	6
	2.3.1 Advantages of Palm Oil Boiler Stone (POBS)	8
2.4	Properties of Palm Oil Boiler Stone (POBS)	8
2.5	Concrete	9

2.6	Material of Concrete	9
	2.6.1 Cement	9
	2.6.2 Coarse Aggregate	10
	2.6.3 Fine Aggregate	10
	2.6.4 Water	11
2.7	Mechanical Properties of Concrete	11
	2.7.1 Compressive Strength	12
	2.7.2 Splitting-tensile Strength	13
	2.7.3 Flexural Strength	14
	2.7.4 Modulus of Elasticity and Poisson's Ratio	16
	2.7.5 Drying Shrinkage	17
CHAPTER 3	**METHODOLOGY**	
3.1	Introduction	18
3.2	Flowchart of Methodology	18
3.3	Materials and Samples Preparation	19
	3.3.1 Concrete Mix Design	20
	3.3.2 Batching, Casting, Mixing	20
	3.3.3 Curing	20
	3.3.4 Number of Specimen	21
	3.3.5 Size of Samples	21
3.5	Laboratory Testing	22
	3.5.1 Slump Test	22
3.6	Mechanical Properties Testing	22
	3.6.1 Cube Compressive Testing	22
	3.6.2 Cylinder Compressive Testing	22
	3.6.3 Cylinder Splitting-tensile Testing	24
	3.6.4 Beam Flexural Test	25

CHAPTER 4 RESULTS AND DISCUSSION

4.1 Introduction 26
4.2 Slump Test 26
4.3 Mechanical Properties 28
4.3.1 Compression Strength 28
4.3.2 Flexural Strength 32
4.3.3 Splitting-tensile Strength 35
4.4 Relationship between Compression Strength and Flexural Strength 38
4.5 Relationship between Compression Strength and Splitting-tensile Strength 40

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion 42
5.2 Recommendations for the Future Research 43

REFERENCES 44
APPENDICES A – C 46

LIST OF TABLES

Table No.	Title	Page
2.1	Physical properties of fine POBS and coarse POBS	8
3.1	Number of specimen based on shape of the sample and day of testing	21
4.1	Slump test result for four different percentages of mixes	27
4.2	Cube compressive strength of all samples	29
4.3	Compressive strength of cylinder and cube concrete mix and ratio of compressive strength between cylinder and cube	32
4.4	Flexural strength of beam concrete mix	33
4.5	Splitting tensile strength of cylinder concrete mix	36
4.6	Equation and R-squared value of different mix for compression strength and flexural strength of six different mix POBS	39
4.7	Equation and R-squared value of different mix for compression strength and splitting-tensile of six different mix of POBS	41

LIST OF FIGURES

Figure No.	Title	Page
2.1	Process of Palm Oil Boiler Stone (POBS)	6
2.2	Palm Oil Boiler Stone (POBS)	9
2.3	Compression Load	13
2.4	Splitting Tensile Load	14
2.5	Beam under 3 point bending	15
2.6	Schematic diagram of the specimen for shrinkage test and the position of demec point	17
3.1	Flowchart of research methodology	18
3.2	Types of Concrete Fracture	23
4.1	Height of slump for different percentages of mix	27
4.2	Slump measurement for (a) 15% POBS and (b) 50% POBS content	28
4.3	Cube compressive strength of cube according to the POBS content at three different curing times.	30
4.4	Graph shows relationship between compressive strength of cube and percentage of mix at 28th day	31

4.5	Flexural strength of beam according to the POBS content with three different curing times	34
4.6	Flexural strength and percentage of mix at 28th day	35
4.7	Splitting tensile strength of beam according to the POBS content with three different curing times	37
4.8	Splitting-tensile strength and six different of percentage mix at 28th day	37
4.9	Relationship between compression strength and flexural strength of six different mix POBS	39
4.10	Relationship between compression strength and splitting-tensile of six different mix of POBS mix of POBS	40

LIST OF SYMBOLS

σ	Stress
E	Young's Modulus
ε	Strain
F_{cc}	Uniaxial stress
F	Load applied
A	Area
F'_{st}	Splitting tensile strength
l	Length
d	Diameter
b	Width
P	Maximum load
a	Average distance
Φ	Phi

LIST OF ABBREVIATIONS

POBS	Palm Oil Boiler Stone
ASTM	American Society for Testing and Materials
BS	British Standard
MOR	Modulus of Rupture
ISO	International Organization for Standardization
PVC	Polyvinyl chloride
MPa	Mega Pascal

CHAPTER 1

INTRODUCTION

1.1 Introduction

Natural aggregates also had been decreasing in Malaysia due to the deforestation and land use for construction (Oglesby, 1982). The aggregates produce naturally after the rocks undergo the physical and chemical process. An alternate material for natural aggregate needed to be obtained for solving up these upcoming problems (Neville, 1995). There are some research been undergo to produce recycled aggregate. The applications of recycled aggregate in construction have started since end of World War II by demolished concrete pavement as recycled aggregate in stabilizing the base course for road construction (Olorusongo, 1999)

On the other hand, one of the main commodities been listed is palm oil industry. It is expected that the growth of palm oil productions will be increased tremendously. As the production of palm oil increased, by-product from this industry which normally be treated as disposal waste will be increased as well. Palm oil boiler stone (POBS) is the by-product from burning of fibers and husks inside the boiler under very high temperature in order to generate the steam engine for oil extracting process.

The purpose of this study by using palm oil boiler stone (POBS) as to replace the material of concrete due to, one of the reason is, it is a wastage of palm tree in the process of extracting the palm oil from the seeds. Thus, it is environmental friendly material and it is good for recyling objectives rather than it is handle in a earth-harming way.

In addition, fibre reinforced concrete material, now many institutions have study about replacing the material in concrete method. The purpose is to increase the strength in the concrete for advancing and pro-long the life time of concrete in construction industry.

1.2 Problem Statement

Generally, the wastage of the palm oil from the palm oil industry was increasing eventually since the growth of palm oil production increasing as well. It is become a major problem to palm oil power plants because this wastage from palm oil are not reused and recycle in any works.

In addition, the by-product from palm oil industry being treated as disposal waste. Palm oil boiler stone one of the by-products from burning of fibers and husks. At the same time, the natural aggregates had been decreasing in Malaysia. This is due to the land used for construction, and then causes the aggregates decreasing.

Thus, this waste material can be utilized as a fine aggregate replacement material. These palm oil boiler stone are used for reduce the fine aggregates in concrete and aggregates production.

1.3 Objectives of Study

The objectives of the study are:

i. To determine the compressive strength, splitting tensile and flexural strength of concrete containing 15%, 25% & 50% POBS as fine aggregate replacement material

ii. Determine the optimum value of POBS as fine aggregate replacement material.

1.4 Scope of Study

Scopes of this study are:

i. Design concrete of grade 30 for the testing;

ii. Using 15%, 25% and 50% of POBS by weight as fine aggregates replacement material in concrete;

iii. Three types of samples which are cube (150mm x 150mm x 150mm), cylinder (150mm dia. X 300mm) and beam (100mm x 100mm x 500mm) for compression, splitting tensile and flexural test, respectively;

iv. Using water curing method for the concrete;

v. Carry out testing on 7th, 14th, and 28 days;

vi. Carry out splitting, flexural and compression testing for the design concrete material as accordance to ASTM C496, ASTM C78, ASTM C39, and ASTM 109 respectively.

1.5 Significant of Study

Concrete an important role in the beneficial use of these materials in construction. Many modification and developments have been made to place industrial waste such as concrete itself and waste material like palm oil boiler stone as a fine aggregate material replacement. This research is to investigate and propose another way as an alternative to revealed that the replacement fine aggregates in concrete to solve the issue to increasing number of solid waste on earth and still could maintain the strength of concrete in construction industry.

One of the main goals of sustainable waste management is to maximize recycling and reuse. Recycling is a logical option for materials not suitable for composting. With increasing environmental pressure to reduce waste and pollution and to recycle as much as possible, the concrete industry has begun adopting a number of methods to achieve these goals.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides current knowledge including substantive findings as well as theoretical and methodological contributions to the waste material used in concrete as a replacement material. Waste material used is palm oil boiler stone (POBS) and partial of the material replace is fine aggregates.

2.2 Origin of Palm Oil Boiler Stone (POBS)

As a major manufacturer of palm oil, Malaysia produces lots of palm oil products. Palm oil industry is also an establish business in Malaysia which is still developing and growing. In the palm oil mill, after it is being processed, the palm oil shells are used as burning fuel and as a result, the waste produced by this process is called the palm oil boiler stone (POBS).

The palm oil boiler stone is normally treated as waste and has no economical value. Therefore, it will be very useful if the palm oil boiler stone can be recycled as a form of industrial material, thus eliminating waste and providing a cheap option to manufacture concrete. It will be of much benefit to the construction industry as to minimize cost at the same time preserve natural aggregates.

Due the limitation and difficulties in finding strong natural aggregate in certain region, artificial aggregate has been used widely to replace the natural aggregates. Current technologies and discoveries have made it possible to create a strong artificial aggregate that out performs natural aggregates.

Many studies and research has been carried out to improve and refine on the aggregate itself. In many cases, natural aggregate has been substituted with artificial aggregate to provide that extra strength that natural aggregate are difficult to provide.

2.3 Production of Palm Oil Boiler Stone (POBS)

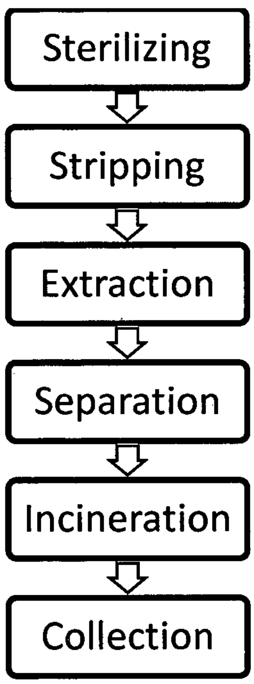

Figure 2.1: Process of Palm Oil Boiler Stone (POBS)

The first step of production palm oil boiler stone is sterilizing. The raw palm oil is transferred from the farm to the factory and is boiled in hot water to sterilize the palm oil. This sterilization process also softens the palm oil to make it easier for stripping later on.

The second step of production palm oil boiler stone is stripping. The trunk of the palm oil is stripped in a rotating drum "stripper" and the palm oil fruits are separated from the tusk. The tusk is thrown away and regarded as waste.

The third step of palm oil boiler stone is extraction. It is a process where the palm oil is crushed so that the palm oil in the fruit section will be extracted. This process will extract the juice (palm oil) and leaves the skin, seed and the remaining fibrous material.

The forth step of palm oil boiler stone is separation. This separation process separates the seed with the skin and the fibrous material because the seed is useless. The fibrous material still contains some palm oil and is ideal for burning to regenerate power.

The fifth step of palm oil boiler stone is incineration. The remaining fibrous material is sent to a furnace where it is burnt in temperature more than 500 degrees Celsius to power the steam engine which in turns generates power. The incineration process can last for more than 24 hours to give a complete burn.

The last step of palm oil boiler stone is collection. After the burning process, the fibrous material is now transformed into a hard and solid compound which we called the "Palm Oil Boiler Stone". The palm oil boiler stone is then collected at the base of the furnace where it is either disposed of as landfill or being recycled for better usage.

2.3.1 Advantages of Palm Oil Boiler Stone (POBS)

Malaysia for many decades has been known as the main manufacturers of palm oil. The waste that been produced in palm oil mill known as clinker (Omar, 2001). As the aggregates were decreasing rapidly, clinker was explored as a suitable material to replace aggregate in concrete. Palm oil boiler stone (POBS) can be found easily in our country as Malaysia is the largest manufacturer of palm oil products. Malaysia is holding the main production for world palm oil production as 51%, 62% for the world exports and 30% for the oils and fats exportation.

Combustions of shell and fiber from the palm oil create POBS as waste material which will be thrown away from mill (Omar, 2001). The significant usage of POBS as the artificial lightweight aggregate in concrete will benefit us from the aspect of waste management from palm oil mill and minimize the demand on natural aggregate in the construction industry (Omar, 2001). Usage of POBS also will minimize the cost of the construction due to the rate of POBS is cheaper than the natural aggregate (Neville, 1995).

2.4 Properties of Palm Oil Boiler Stone (POBS)

Palm oil boiler stone (POBS) categorized as waste by-product and has appearance of a porous stone with gray in color as shown in Figure 2.2. The clinkers forms are usually flaky and irregular with rough and spiky broken edges. The physical properties of POBS are as listed in Table 2.1.

Table 2.1: Physical properties of fine POBS and coarse POBS (Ahmad and MohdNor, 2008).

Physical Properties	Fine	Crushed Stone
Specific gravity (*SSD condition)	2.17	2.60
Moisture content (%)	0.08	0.05
Water adsorption (%)	4.65	1.79
Bulk density (kg/m^3)	863.65	1815.23
Fineness modulus	2.84	2.65

*saturated surface dry

Figure 2.2: Palm Oil Boiler Stone (POBS)

2.5 Concrete

The word concrete comes from the Latin word "concretus" (meaning compact or condensed), the perfect passive participle of "concrescere", from "con-" (together) and "crescere" (to grow). There are many types of concrete available, created by varying the proportions of the main ingredients below. In this way or by substitution for the cemetitious and aggregate phases, the finished product can be tailored to its application with varying strength, density, or chemical and thermal resistance properties.

2.6 Material of Concrete

Concrete is a composite construction material, composed of cement (commonly Portland) and other cementitious materials such as fly ash and cement, aggregate (generally a coarse aggregate made of gravel or crushed rocks such as limestone, or granite, plus a fine aggregate such as sand), water and chemical admixtures.

2.6.1 Cement

There are three types of cement which is Portland Cement, Portland Cement Blends and Non-Portland Hydraulic Cements. Portland cement is the most common type of cement in general usage. It is a basic ingredient of concrete, mortar and plaster. English masonry worker Joseph Aspdin patented Portland cement in 1824; it was named because of its similarity in color to Portland limestone, quarried from the English Isle of Portland and used extensively in London architecture. It consists of a mixture of oxides of calcium, silicon and aluminium. Portland cement and similar materials are made by heating limestone (a source of calcium) with clay and grinding this product (called clinker) with a source of sulfate (most commonly gypsum) according to (Francis,1796).

2.6.2 Coarse Aggregates

Construction aggregate, or simply "aggregate", is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. Aggregates are the most mined material in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material. Due to the relatively high hydraulic conductivity value as compared to most soils, aggregates are widely used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and road side edge drains.

Aggregates are also used as base material under foundations, roads, and railroads. In other words, aggregates are used as a stable foundation or road/rail base with predictable, uniform properties such as to help prevent differential settling under the road or building, or as a low-cost extender that binds with more expensive cement or asphalt to form concrete. This size is at least minimum size of 20mm (Nelson,2008).

2.6.3 Fine Aggregates

Fine aggregate is also known as sand. Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. The composition of sand is highly variable, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO_2), usually in the form of quartz.

ISO 14688 grades sands as fine, medium and coarse with ranges 0.063 mm to 0.2 mm to 0.63 mm to 2.0 mm. In the United States, sand is commonly divided into five sub-categories based on size: very fine sand (1⁄16 – ⅛ mm diameter), fine sand (⅛ mm – ¼ mm), medium sand (¼ mm –½ mm), coarse sand (½ mm – 1 mm), and very coarse sand (1 mm – 2 mm).

These sizes are based on the Krumbein phi scale, where size in Φ = -log base 2 of size in mm. On this scale, for sand the value of Φ varies from −1 to +4, with the divisions between sub-categories at whole numbers. Sand is often a principal component of this critical construction material.

2.6.4 Water

Combining water with a cementitious material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it and allows it to flow more freely

2.7 Mechanical Properties of Concrete

Typical mechanical properties of concrete normal strength are compressive strength, flexural strength, tensile strength, modulus of elasticity, permeability, coefficient of thermal expansion, drying shrinkage, drying shrinkage of reinforced concrete, Poisson's ratio, shear stress, and specific heat capacity. A material's property is an intensive, often quantitative property of a material, usually with a unit that may be used as a metric of value to compare the benefits of one material versus another to aid in materials selection (Majid,2001)

A material property may be a constant or may be a function of one or more independent variables. Material's properties often vary to some degree according to the direction in the material in which they are measured.

Some material's properties are used in relevant equations to determine the attributes of a system a priori. Materials properties may be determined by standardized test methods. Many test methods have been documented by their respective user communities and published through ASTM International.

2.7.1 Compressive Strength

Compressive strength is the capacity of a material or structure to withstand axially directed pushing forces. When the limit of compressive strength is reached, materials are crushed (Mikell, 2002)

According to BS1881:Part116:1983, this test is to determine the compression strength of the concrete cubes specimens. The test method consists of applying a compressive axial load to molded cube at a rate which is within a prescribed range until failure occurs as shown in Figure 2.3. The compressive strength of the specimen is calculated by dividing the maximum load attained during the test by the cross-sectional area of the specimen.

The compressive strength of the material would correspond to the stress at the red point shown on the curve. Even in a compression test, there is a linear region where the material follows Hooke's Law. Hence for this region $\sigma = E\varepsilon$ where this time E refers to the Young's Modulus for compression.

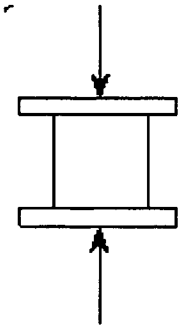

Figure 2.3 Compression Load

This linear region terminates at what is known as the yield point. Above this point the material behaves plastically and will not return to its original length once the load is removed. There is a difference between the engineering stress and the true stress. By its basic definition the uniaxial stress as given in Eq. (2.1)

$$Fcc = \frac{F}{A} \tag{2.1}$$

Where,

F = Load applied [N]

A = Area [m^2]

2.7.2 Splitting Tensile Strength

It is method of determining the tensile strength of concrete using a cylinder which splits across the vertical diameter. It is also known as Brazilian Test and Dimetrial compression test.