STRENGTH PROPERTIES OF 10 MM TIMBER CLINKER AGGREGATE CONCRETE

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To my beloved family, lecturers and friends

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ABSTRACT

This paper presents some experimental results and discusses the use of timber clinker as partial aggregate replacement in producing concrete. A number of tests were conducted to identify the physical properties of timber clinker aggregate such as density, aggregate impact value (AIV) test and aggregate crushing value (ACV) test, slump, X-Ray Fluorescence (XRF) test and compressive strength of timber clinker aggregate concrete. Two series of concrete mixes with Supracoat SP1000(C0, C10, C20, C30) and without Supracoat SP1000(CA0, CA10, CA20, CA30) with various percentage of 0%, 10%, 20% and 30% 10 mm sieve size timber clinker aggregate were used as partial replacement in producing the concrete. A total of forty 150 x 150 x 150 mm cubes samples were prepared for both series of concrete mixes and tested at 7, 14 and 28 days of water curing. The results showed that the timber clinker aggregate concrete gained highest compressive strength for both series of concrete mixes, that is, C20 and CA20 with results of 37 MPa and 34 MPa respectively. The optimum percentage use of timber clinker aggregate in producing the concrete was 20%. This is because exceeded percentage would decrease the compressive strength. Here, Supracoat SP1000 was added in order to improve the concrete slump. The physical properties test had contribute to the concrete strength development. Based on the results and observation conducted, this study suggested that timber clinker aggregate has successfully use as partial replacement in producing concrete and performed better strength development.

ABSTRAK

Kertas penyelidikan ini melaporkan keputusan ujikaji dan membincangkan penggunaan klinker kayu sebagai pengganti separa kepada aggregat semulajadi dalam penghasilan konkrit. Sifat-sifat fizikal aggregat klinker kayu dikenalpasti melalui ujian ketumpatan aggregat, ujian nilai hentaman aggregat(AIV), ujian nilai hancuran aggregate(ACV), ujian penurunan, ujian Sinar-X Pendarfluor dan ujian kekuatan mampatan konkrit. Dua siri campuran konkrit yang mengandungi Supracoat SP1000 (C0, C10, C20, C30) dan tanpa Supracoat SP1000(CA0, CA10, CA20, CA30) dengan 0%, 10%, 20% dan 30% campuran aggregat klinker kayu bersaiz 10 mm sebagai pengganti separa aggregat dihasilkan. Sejumlah empat puluh sampel kuib konkrit bersaiz 150 x 150 x 150 mm disediakan untuk kedua-dua siri campuran konkrit dan diuji kekuatan mampatan pada usia 7, 14 dan 28 hari selepas direndam dalam air. Keputusan ujikaji menunjukkan konkrit beraggregat klinker kayu bagi kedua-dua siri campuran C20 dan CA20 mencapai kekuatan mampatan yang lebih tinggi daripada konkrit konvensional iaitu masing-masing 37 MPa dan 34 MPa. Peratus penggunaan aggregat klinker kayu dalam penghasilan konkrit pada takat optimum ialah 20% dan penggunaan Supracoat SP1000 boleh memperbaiki tahap kebolehkerjaan konkrit. Ujian sifat-sifat fizikal aggregat klinker kayu juga menunjukkan penyumbangan kepada kekuatan konkrit. Secara rumusannya, keputusan ujikaji dan pemerhatian daripada penyelidikan ini menunjukkan aggregat klinker kayu boleh digunakan sebagai pengganti separa aggregat biasa dalam penghasilan konkrit dan menunjukkan sifat kekuatan konkrit yang lebih tinggi.

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LIST OF SYMBOLS/ ABBREVIATIONS/ TERMINOLOGY

AIV	-	Aggregate Impact Value
ACV	-	Aggregate Crushing Value
ASTM	-	American Society for Testing and Materials
BS	-	British Standards
C	-	Samples with Supracoat SP1000
CA	-	Samples without Supracoat SP1000
COV	-	Coefficient of Variance
DOE	-	Department of Environment
EN	-	European Standard
FA	-	Fly Ash
IEA	-	International Energy Agency
LA	-	Los Angeles Abrasion
NA	-	Natural Aggregate
OPC	-	Ordinary Portland Cement
OPS	-	Oil Palm Shell
RHA	-	Rice Husk Ash
TIA	-	Timber Industrial Ash
POFA	-	Palm Oil Fuel Ash
POC	-	Palm Oil Clinker
UPM	-	Universiti Putra Malaysia
UTHM	-	Universiti Tun Hussein Onn Malaysia
WBA	-	Washed Bottom Ash
XRF	-	X-Ray Fluorescence
CO_2	-	Carbon Dioxide
RAC	-	Recycled Aggregate Concrete
ppm	-	Parts per million
m	-	Mass in kg

v	-	Volume in meter cubic
ρ	-	Density in kg per meter cubic
W	-	Weight in gram
σ	-	Compressive Strength/ Stress in MPa @ N/mm^2
P	-	Maximum Compression Axial Force in Newton
A	-	Cross Sectional Area in mm^2
<	-	Less or Not Greater Than

CHAPTER 1

INTRODUCTION

Concrete is one of the most importance building construction materials and the second most used material after water. Current global issues related to environmental sustainability for concrete in construction more emphasize on material resources in producing concrete. To ensure future sustainability of concrete in construction, alternative ingredient materials for concrete such as aggregates need to be sourced for. In producing concrete, an essential ingredient is aggregates, ordinary Portland cement along with water.

Aggregate are inert granular materials such as sand, gravel, or crushed stone that need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete. An aggregate is one of the most importance ingredients in producing concrete which account for approximately 60 to 75 percent of the total volume of concrete. According to Suchorski (2007), aggregate can be divided into two distinct categories such as fine aggregate ($\leq$ 4.75mm diameter sieve) and coarse aggregate (Ranging 10mm to 37.5mm diameter sieve). Aggregate is produced from mining process which has raised concerns on its impact on the global carbon footprint and their ecological damage has become an environmental issue in many countries currently. As such, initiatives have been set up address the issue of sustainability of concrete as a construction material.

In Malaysia, agricultural activities such as palm oil, timber, rice, sugarcane etc contributed to the nation economy development but these kinds of activities also

generates high amount of waste. The disposal of such waste poses an environmental problem as landfills are limited. All these kinds of waste can be turned into by-products waste after treated through combustion process at the factory which called biomass wastes. It is therefore natural to consider the use of such waste in the production of concrete especially in partial aggregate replacement purpose.

1.1 Problem Background

Biomass is organic material which contains stored energy made from plants and animals. Biomass is a renewable energy source because we can always grow more trees and crops, and waste will always exist. Recently, many research come out with the used of renewable energy (biomass) as the replacement of natural resources in construction materials. According to Kawano (2000), the ultimate purpose of recycling materials is to minimize the impact of human activities on the environment and the planet. Reuse of concrete materials is not easy technically or economically. Researcher must take a broad perspective when evaluating the relevant technologies for reusing and recycling concrete materials.

The production of concrete is one of the construction materials concerned where the biomass aggregate is used for the aggregate replacement. According to Diah and Koh (2008), the consumption of concrete in the world is estimated 10 to 15 billion metric tones per year. The exploration of the natural resources will affect the ecology of environment. The Business Magazine has reported that the recycling of aggregates for other uses such as a simple gravel product or for use in concrete products has greatly reduced the need to dig quarries to mine for gravel. The recycled aggregate sizes ranging 5 mm to 20 mm can be employed as a sub-base material for construction jobs and also can be utilized in road construction or at home on driveways (Moonwalker, 2010).

In Malaysia, one of the common wastes generated by agriculture industry is well known from palm oil which called Palm Oil Fuel Ash (POFA). This is a by-product of oil mills arising from the use of palm oil shell and palm oil bunches which

are used to power oil mill plants for electricity generation (Awal and Abubakar, 2011). The utilization of palm oil fuel ash as a pozzolanic material to partially or wholly replace Portland cement has not been thoroughly investigated when compared to other materials such as fly ash, especially in high strength concrete. According to Awal and Abubakar (2011), most research records have limited the use of pozzolanic materials to a partial replacement, ranging from 0-30% by weight of the total cementitious material in the production of concrete. Indeed, the partial replacement has a beneficial effect on the general properties of concrete as well as cost.

Biomass aggregate is one of the potential wastes by-product which generate from plywood industry like palm oil fuel ash (POFA) through the combustion process in boiler. Biomass aggregate can be used as aggregate for partial replacement in producing concrete. The development of new construction materials using renewable sources will led to the environmental benefit and also sustainable economic values for concrete products industries. Previous research were done by using Timber Industrial Ash (TIA) in producing concrete has tends to enhance strength development and reduce water permeability of concrete. Concrete with reduced water permeability is suitable for concrete products and substructure (Lee *et al.*, 2010).

1.2 Research Problem

Biomass wastes generated from industries currently becomes an environmental problem around the world especially for development country such as Malaysia. This kind of problem is integral part of our lives and also ecology system. According to United States Environmental Protection Agency (2012), industrial waste from recycling by-product materials generated from industrial processes can be used as substitutions for raw materials in the manufacture of consumer products, roads, bridges, buildings, and other construction projects. Thousands of manufacturing and industrial processes and electric utility generators create hundreds of millions of tons of non-hazardous industrial materials that are often wasted. Non-

hazardous industrial materials, such as coal ash, foundry sand, construction and demolition materials, slags, and gypsum, are valuable products of industrial processes. Each material may be recycled in a variety of diverse applications. These materials have many of the same chemical and physical properties as the virgin materials they replace which can even improve the quality of a product.

Normally, industrial by-products agricultural waste will generated through combustion processed before discharge to landfill. This kind of waste has values of utilization as supplementary cementing materials such as aggregate replacement purpose. Due to continuous increasing demand and the cost of cement, recently, the utilization of supplementary cementing materials such as industrial by-product (fly ash, silica fume and slag) and agricultural wastes (rice husk ash, palm oil fuel ash, bagasse ash and ash from timber) has become an important issue for the researchers in concrete industry (Karim *et al.*, 2011).

According to Hassan *et al.* (2006) from Faculty of Biotechnology, University of Putra Malaysia (UPM) stated the main contributor for biomass is palm oil industry and wood industry is the third contributors for the biomass production. Currently, more than 2 million tones agricultural wastes are produced annually and potentially an attractive feedstock for energy production as it contributes little or no net carbon dioxide to the atmosphere (Karim *et al.*, 2011). Major agricultural products are palm oil, saw logs, paddy and tropical fruits.

Recently, biomass ashes have attracted a lot of research with a focus on the application of science and technology terms. Despite the range of feedstock and techniques available to produce biomass ashes, very little work has been reported on properties of biomass ashes. Thus, detail investigation to evaluate their strength properties behavior and characteristics is important before they were applied to the superstructure such as biomass aggregate concrete. Physical properties and experimental studies of biomass aggregate concrete will be determined using standard procedures compared with normal concrete. The application of biomass aggregate (timber clinker) in producing concrete will be performed and the study will identify some strength properties and physical properties.

1.3 Research Aim and Objectives

The main goal of this research is aim to identify the biomass aggregate (timber clinker) concrete strength and physical properties in concrete as partial aggregate replacement. The experimental measurement will be carried out to identify the parameters and compared with the control parameters. Through this study, it is expected will contribute to the problem solving of industry waste, reduce natural aggregate usage and environmental benefit globally. The following are the objectives to achieve the research aim:

1. To identify the physical properties of timber clinker aggregate.
2. To design the timber clinker aggregate concrete mix with difference timber clinker aggregate content.
3. To determine the compressive strength of timber clinker aggregate concrete.

1.4 Research Scope

This research is related to partial aggregate replacement in concrete where the study involving the experimental field work at laboratory to examine the biomass aggregate (timber clinker) concrete strength and physical properties will be measured which are compressive strength, biomass aggregate loose and bulk density, aggregate crushing value (ACV) test, aggregate impact value (AIV) test, chemical composition test using XRF, slump, concrete dry and wet density. The aggregate size is specified with 10mm sieve size coarse aggregate. The 10mm sieve size aggregate also tend to produce higher workability of timber clinker aggregate concrete. The experimental results will be compared with the normal weight concrete as control parameters. The biomass aggregate (timber clinker) obtained from WTK Holdings at Kuching, Sarawak.

1.5 Significance of Research

The findings from this research will lead to the new innovative solution for by-product waste and exploration of natural aggregate in producing concrete. The benefits expected from this research are:

1. The exploration of natural aggregate can be minimized with the partial replacement of biomass aggregate (timber clinker) in producing concrete and overall can reduced the natural resources consumption.
2. It will be the significant impact to our consumption of natural resources for producing concrete because about 30% ingredient in concrete mix is aggregate.
3. Apart from that, the research also contributed the green and sustainable concrete which emphasize on renewable energy. It will beneficial to our environment and new generation globally.
4. It will be the solution for local plywood industries in disposes their by-product waste from discharge to landfill and sustain our environment.

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