TIMBER CLINKER AS PARTIAL REPLACEMENT OF 20mm NATURAL COARSE AGGREGATE IN CONCRETE

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To my beloved family, lecturers and friends

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ABSTRACT

This dissertation presents the results of an experimental investigation carried out to evaluate effects of partially replacing coarse aggregates with that of timber clinker on the concrete strength properties. A series of tests were conducted to determine the physical properties of Timber Clinker Aggregate (TCA), namely aggregate density, X-Ray Fluorescence (XRF) test, Aggregate Crushing Value (ACV), Aggregate Impact Value (AIV), slump and properties of Timber Clinker Aggregate Concrete (TCAC) in terms of density and compressive strength. Four (4) series of concrete mix with targeted compressive strength of 30 MPa is produced with partial replacement ratio of 0%, 10%, 20% and 30% of 20mm sieve size TCA to the natural course aggregate and incorporating superplasticizer, known as Supracoat SP800. A total nos. of forty (40) concrete cube specimens (150mm x 150mm x 150mm) were casted and tested for 7 and 28 day's strength characteristic. The study indicated that with the increase of replacement ratio, the compressive strength gradually decreases. However, C10 is managed to achieve the strength of 32.27 MPa while C20 still acceptable for structural use, with strength of 28.40 MPa. Workability decrease as the replacement ratio increase, which indicating TCA is high in water adsorption. A close study on the physical properties reveals that TCA is lower in mechanical strength that might contribute to the lower compressive strength of TCAC. Based on this study, TCA is still acceptable for the structural uses purposes with optimum replacement ratio of 20%.

ABSTRAK

Tesis ini berbentuk kajian kesan kepada sifat kekuatan konkrit dengan menggantikan agregar kasar kepada klinker kayu. Beberapa siri ujian telah dijalankan untuk mengenal pasti sifat-sifat fizikal Kayu Klinker Agregat (TCA), seperti ketumpatan agregat, X-Ray pendarfluor (XRF) ujian, Agregat Nilai Penghancuran (ACV), Agregat Kesan Nilai (AIV), kemerosotan dan sifat semula jadi kayu Klinker Konkrit Agregat (TCAC) dari segi ketumpatan dan kekuatan mampatan. Empat siri campuran konkrit dengan kekuatan mampatan sasaran 30 MPa dengan nisbah penggantian separa 0%, 10%, 20% dan 30% daripada 20mm TCA untuk agregat kursus semula jadi dan penggabungan superplasticizer (Supracoat SP800). Sebanyak empat puluh spesimen kiub konkrit (150mm x 150mm x 150mm) telah dihasilka dan diuji kekuatan ciri pada hari ke 7 dan 28. Kajian ini menunjukkan bahawa peningkatan nisbah penggantian akan menyebabkan kekuatan mampatan berkekurangan secara berskala. Walau bagaimanapun, C10 mencapai kekuatan 32,27 MPa manakala C20 telah menerima kekuatan 28,40 MPa dan ianya dapat diterima untuk penggunaan struktur bangunan. Peningkatan nisbah pnggantian telah menyebabkan keberkesanan menurun dimana TCA telah mencatatkan penyerapan air yang tinggi. Satu kajian menyeluruh terhadap sifat fizikal mencatatkan TCA adalah rendah dalam kekuatan mekanikal dan ia mungkin menyumbang kepada kemerosotan atau lemah terhadap kekuatan mampatan TCAC. Berdasarkan kajian ini, TCA masih boleh diterima bagi tujuan kegunaan struktur dengan nisbah penggantian optimum sebanyak 20%.

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g	-	Orig
CO_2	-	Carbon dioxide
SiO_2	-	Silicon dioxide
CaO	-	Calcium oxide
CI	-	Chloride
Al_2O_3	-	Aluminium oxide
Na_2O	-	Sodium oxide
Fe_2O_3	-	Iron oxide
MgO	-	Magnesium oxide
K_2O	-	Potassium oxide
SO_3	-	Sulfur Trioxide
TiO_2	-	Titanium oxide
P	-	Phosphorous
σ	-	Compressive Strength
N	-	Maximum Compression Axial Load Applied (N)

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CHAPTER 1

INTRODUCTION

1.0 Introduction

Concrete is the most widely used construction material in the world, far exceeding other materials. It is used in many different structures such as dam, pavement, building frame or bridge. The present consumption of concrete is over 10 billion tons a year, that is, each person on earth consumes more than 1.7 ton of concrete per year. It is more than 10 times of the consumption by weight of steel (Diah and Koh, 2008).

Concrete is a composite material composed of aggregate materials that embedded in a hard matrix of cement or binder that fills up the void between the aggregate particles and hold them together. Aggregates are inert granular materials such as sand, gravel, or crushed stone. Its need to be clean, hard and strong particles that free from absorbed chemicals or coatings of clay or other fine materials that could deteriorate the concrete. All these granular materials came from natural resources, which have significant influences towards environmental sustainability. With the increase demand of the concrete products, the issue of environmental sustainability

also will be in stack. Therefore, to ensure sustainability in construction industry, alternative ingredient materials, predominantly the aggregates need to be sourced for.

1.1 Problem Background

In Portland cement concrete, aggregate constitute 60% to 75% of the volume and 79% to 85% of the mass. Aggregate can be generally divided into fine and coarse aggregate. Extraction of aggregate from natural resources involved mining processes that significantly impact the global carbon footprint. Meanwhile, harvesting of sand and gravel also results in deforestation and ecological damage to the Mother Nature, which has become an international environmental issue in many developed countries. With the increases awareness of current issues, various initiatives have been set up to address the sustainability of concrete as a construction material.

Nevertheless, improvement of standard of living and increases of economy and industry sector had contributed to dramatic increase of the solid waste generation, namely paper, plastic, glass, construction debris etc. In our country, agriculture sector such as palm oil, timber, rice, sugarcane etc contributed on the nation's economy development. However, those sectors also generates high amount of biomass waste that have a much lower recycling rate compared to construction waste. With the limitations of available landfills around the country, improper disposed of all those waste will post an impact towards environmental sustainability.

As such, wastes generated from agriculture sector shall be treated properly to become into by-products waste with the means of current advanced technology, namely incineration process through engineered furnace. The by-product of this process is called Biomass Aggregate (BA) that can be utilized as replacement of aggregate materials in the production of concrete. The research and development of

this new renewable construction material is important to ensure the sustainability of the construction industries and environment, as well as for the future of our mankind.

1.2 Research Problem

Many researches had been done on the application of biomass materials as substitution for natural resources in the concrete production. Recycling of concrete materials is not easy in terms of technical and economy wise. Hence, it does apply the same to the use of other by-products, i.e. Biomass Aggregate. Researcher must take a broad perspective when evaluating the relevant technologies for utilization of these by-product waste materials.

As the construction industry ever increasing, the demand for concrete rose and coupled with the high cost of cement, 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 and ash from timber) has become an important subjects for the researchers in concrete industry with many paper and journal being published (Karim *et al.*, 2011). Previous studies show that there is possibility of cement content substitution of 40% without affecting the compressive strength. However, besides substituting cement materials, the aggregate materials, which are from natural resources, also shall be replacing with other renewable materials. Based on the previous study, since cement can be substituted with certain amount, it's suggest that there also possibility to replaced the natural aggregate with other materials.

In Malaysia, wood industries contribute 3.7% on the average annual collection of biomass waste, amounting to nearly 2.6 million tons (Hassan *et al*., 2006). Timber clinker, a type of biomass aggregate, is by-product from the wood industry whereby

biomass wastes generated from the industry activity undergo a controlled incineration process. Despite the abundance of these timber clinker biomass aggregate, very little work has been reported on utilization of these biomass aggregate in the concrete production. Therefore, details researches and investigations to evaluate their strength properties and characteristics are vital before their application as aggregate replacement in concrete products, known as Timber Clinker Aggregate Concrete (TCAC).

Therefore, if the timber clinker biomass aggregate can be utilized as aggregate replacement (partially or wholly) in the production of concrete, we can reduce the dependency on the natural resource that eventually help in preserving the environmental sustainability. Moreover, utilization of the wood's waste by-product promoting green concrete and minimized the generations of untreated biomass waste that will significantly impact the environment.

1.3 Research Aim and Objectives

The main goal of this research is to determine the optimum mix design of Timber Clinker Aggregate Concrete (TCAC) by substitution of main course aggregate with the timber clinker biomass aggregate. The maximum size of coarse aggregate will be 20.0 mm or 6/8 in. diameter.

The following are the objectives to achieve the research aim:

1. To identify the physical and chemical properties of timber clinker biomass aggregate.

2. To design the mix proportions of Timber Clinker Aggregate Concrete (TCAC).

3. To measure the workability of fresh concrete, the compressive strength and density reduction of hardened Timber Clinker Aggregate Concrete (TCAC) with comparison to normal concrete.

1.4 Research Scope

This research is related to the partial replacement of coarse aggregate with timber clinker biomass aggregate in the concrete. The study involved the experimental work at laboratory to examine the physical and chemical properties of timber clinker biomass aggregate and TCAC's strength properties. The parameters measures during the test will be biomass aggregate loose and bulk density, Aggregate Crushing Value (ACV), Aggregate Impact Value (AIV), biomass aggregate chemical composition using X-Ray Fluorescence (XRF), slump, concrete's dry and wet density and compressive strength. The experimental results will be compared with the normal weight concrete as control parameters. All the experimental work will be carried out accordance to British Standard (BS) as guidelines. The source of timber clinker biomass aggregate is obtained from WTK Holdings at Kuching, Sarawak.

1.5 Significance of Research

The significant findings through this research will create a new innovative solution for the by-product of waste and exploration of new renewable biomass aggregate (timber clinker) in the production of concrete. With the use of this renewable biomass aggregate as part of the course aggregate in the biomass aggregate

concrete production, we are a step forward to make concrete as a green building construction material.

The benefits expected from this research are:

1. Minimization of excavation, digging and miming work for natural aggregate with the introduction of partial replacement of course aggregate in concrete with timber clinker biomass aggregate which in turn preserved the sustainability of the environment.

2. Timber clinker biomass aggregate is lighter than natural aggregate and in overall it can reduced the total dead load of the concrete structure which eventually reduced the reinforcement required for the structure as well as the cost.

3. The results will be useful for the timber industry's player. Instead of disposed of the timber waste to landfill, they still can increase the company income by sell off the by-product of timber waste to the potential buyer and doing favour in preserving the sustainability of the environment.

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