UNIVERSITI PUTRA MALAYSIA

STRENGTH PERFORMANCE OF LIGHTWEIGHT CONCRETE USING BEAD AS AGGREGATE

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MASTER OF STRUCTURAL ENGINEERING AND CONSTRUCTION

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MAY 2008

ABSTARCT

Research is being carried out to study the strength performance of lightweight concrete made from crystal plastic bead aggregates. The bead aggregates were used to replace gravels in concrete mix. The replacement was based on a different percentages varying from 20% to 100%. A control normal weight concrete containing 100% gravels aggregate was prepared. All of the materials were prepared in accordance to as weight basis and based on the Building Research Establishment's method. Concrete with beads as coarse aggregate was investigated for workability and cube compressive strength after 7days and 28days curing. The results indicated that lightweight concrete mix with beads reduced approximately 20% of mass compared to conventional normal weight concrete. The highest compressive strength achieved for 28days was found to be 24 N/mm^2 with 20% of bead replacement which is lower than target strength of 30 N/mm^2. However, the compressive strength value was within the normal concrete range for structural purposes. In short, increased amount of bead in concrete mix may reduce the compressive strength of concrete and increased the workability of fresh concrete.

ABSTARCT

Kajian ini dijalankan untuk menyelidik tahap kekuatan Konkrit Ringan dengan menggunakan manik jenis plastik sebagai batu baur. Manik ini digunakan bagi mengantikan agregate batu kasar didalam bancuhan konkrit. Penggantian manik ini berdasarkan beberapa peratusan dari 20% sehingga 100% jumlah berat batu baur yang sebenar. Konkrit biasa yang mengandungi 100% batu aggregate disediakan sebagai perbandingan kekuatan mampatan kiub antara konkrit ringan dan konkrit biasa. Semua bahan untuk bancuhan konkrit disediakan berdasarkan kaedah sukatan berat yang diperkenalkan oleh "Building Research Establishment". Konkrit dengan manik sebagai batu baur diuji kesenangan kerja dan kekuatan mampatan kiub untuk 7 hari dan 28 hari. Keputusan menunjukkan berat sendiri bagi konkrit ringan menggunakan manik menurun sebanyak 20 % berbanding konkrit biasa. Kekuatan mampatan yang tertinggi diperolehi untuk 28 hari adalah 24 N/mm² dengan penggantian manik sebanyak 20 % dimana ianya tidak mencapai kekuatan sebanyak 30 N/mm^2. Walaubagaimanapun, kekuatan mampatan adalah ini masih didalam linkungan kekuatan mampatan bagi konkrit biasa yang digunakan sebagai konkrit struktur. Secara ringkasnya, peningkatan kandungan manik didalam bancuhan konkrit boleh mengurangkan kekuatan mampatan konkrit dan meningkatkan kesenangan kerja untuk bancuhan konkrit.

ACKNOWLEDGEMENT

In the name of Allah s.w.t, The Most Gracious Merciful, I want to express my deepest gratitude to the people who are involved and contribute to completion of this project study.

Special thank to my supervisor, Associate Professor Ir.Dr. Mohd Saleh Bin Jaafar for all his contribution in giving the greatest idea, guidance and opinion. My great deals of thanks also go to an examiner Assoc. Prof Dr. Jamaloddin Noorzaie for his comment and suggestions.

Special thanks to all the technician of concrete laboratory, En Jaafar and En Fairus for their helping in the experiment. Last but not least, to my beloved husband and family members for their patient, understanding and support to making this project successfully.

NOR FAZILAH MOHD HASHIM

APPROVAL FORM

This project report attached hereto, entitle "**Strength Performance of Lightweight Concrete using Bead as Aggregate**" as prepared and submitted by **Nor Fazilah Binti Mohd Hashim** in fulfillment of the requirement of Master in Structural Engineering and Construction to Department of Civil Engineering, Faculty of Engineering, Universiti Putra Malaysia is hereby accepted.

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DECLARATION

I hereby declare that this project is based on my original work except for equation and citation, which have been duly acknowledged, also declared that it has not been previously or currently submitted for any other degree at Universiti Putra Malaysia or other institutions.

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(NOR FAZILAH BINTI MOHD HASHIM)

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INTRODUCTION

1.1 Background

Lightweight Concrete (LWC) is an advanced finding in concrete technology. Lightweight concrete is known as a concrete that has less weight or low density compared to the conventional normal weight concrete. An example of the lightweight concrete is shown in Figure 1.1. This figure shows a concrete cube that is very light in weight which can be held by using one hand. Based on this specialty, dead weight or self-weight of the structures can be reduced to the optimized value and it will effect the whole loading of building. Reducing in weight of structures could give many benefits especially in transportation, erection, manpower, sizes, space of land use and many more. Thus, many researches have been concluded to investigate deeply on the lightweight concrete characteristics and how it is affects concrete industry.

Figure 1.1: Lightweight concrete block is light in weight.

Lately, more attention has been paid to the development of Lightweight concrete. This is also influenced by some other problems in construction by using conventional concrete. For example, self-weight of normal weight concrete is usually heavy and this becomes difficult in supporting the structures during construction work especially for high rise building or massive structures like bridges. Another problem is transportation for big and heavy structure especially for precast member. The precast units usually come in a big segment and needs a suitable transport to carry and to erect it together. It becomes more difficult if the site is located in congested cities. Heavy weight of structures also increases the risk of damage due to earthquake forces (Yasar).

1.2 Characteristic of LWC

Over the years, lightweight concrete is used for non-load bearing structures such as partition, cladding or floor for any building especially high rise building whenever high strength is not required and even when the dead load of concrete did not affect overall structures design. New technologies should be created to enhance the purpose of lightweight for structural application. If this finding can be commercialized, it would contribute more benefits to concrete industry. Meaning that development on high strength lightweight concrete is important and beneficial for concrete structural industry in terms to replace the conventional normal weight concrete especially to minimize loading problems.

Lightweight concrete is produced by either using special materials which is lighter in weight or density and it is to be added or replace in concrete mixes or by using special methods of construction such as air bubbles. Lightweight concrete has a density in the range of 800kg/m³-1800kg/m³. Whereas, normal weight concrete (NWC) is a conventional concrete and has a density about 2400 kg/m³. Based on this criterion, it is known that lightweight concrete is lighter that normal concrete.

Lightweight concrete offers many advantages over the normal weight concrete. The advantages are lightweight concrete has higher strength/weight ratio, better strain capacity, lower coefficient of thermal expansion, heat and sound insulation (Al-Khait). In construction view, reducing concrete mass may result to minimizing the cross section of structural element, hence resulting to smaller columns and foundation. This is important especially for multi-storey building and bridges. Heffington et al (2001) summarized that for highway bridges, reduction of overall weight can be between 15-20% if the entire element uses lightweight concrete segment compared with normal weight structure.

Although the lightweight aggregate cost is more than common aggregate especially in Malaysia, but this higher cost may cover the erection cost for the whole structure (Dhir). Lightweight aggregate also has better fire resistance. It is because lightweight aggregate have already been pre-fired, stable and does not decompose in high temperature (Hunaiti, 1997). He also said that lightweight aggregate could save the environment in terms of less mining activities.

Good quality of aggregate must be used in concrete mix to ensure great bonding between cement matrix and aggregate particles could be achieved. To achieve this situation, all properties of the aggregate should be taken into consideration such as shape, texture, pores, cleanliness, surface area and others. Great bonding between cement matrix and aggregate will produce high strength of concrete. Therefore, this characteristic should be taken into consideration. In fact, lightweight aggregate offer higher bond strength than normal weight concrete where in the researches done by Hunaiti (1996), he found that results from his experiment show that lightweight concrete offered higher bond strength than normal concrete.

For coastal areas and cold countries, high strength lightweight concrete could require in resisting chloride, sulfate attack and frost on the structures. Lightweight aggregate particles had been proved as a hard material and can resist abrasion and fewer problems reported on the carbonation effects (Neville). Using lightweight as a concrete mixture can improve our environment from bad pollution. For example, ordinary cement production will release carbon dioxide in the air, however if we use fly ash in the concrete, the emission of this gas can be reduced. Replacing cement with other lightweight aggregate (i.e fly ash) can also save energy of cement manufactured and contribute to less mining activities.

Lightweight concrete can be classified into a few groups which is *lightweight aggregate concrete (LWAC)* where it is made using lightweight or low density aggregate, *no fines concrete* which is air void and is used between coarse particles instead of fine aggregate. Air void is placed in cement and is called *cellular concrete* as shown in Table 1.1.

Table 1.1: Group of Lightweight Concrete. *(Andrew and William, 1978)*

No-fines concrete	**Lightweight aggregate**	**Aerated concrete**	
		Chemical aerating	**Foaming mixture**
Gravel	Clinker	Aluminium powder method	Pre-foamed foam
Crushed stone	Foamed slag	Hydrogen peroxide and bleaching powder method	Air-entrained foam
Coarse clinker	Expanded clay		
Sintered pulverized-fuel ash	Expanded shale		
Expanded clay or shale	Expanded slate		
Expanded slate	Sintered pulverized fuel ash		
Foamed slag	Exfoliated vermiculite		
	Expanded perlite		
	Organic aggregate		

Besides the natural aggregate that is shown in the table above, there are recycled materials aggregate that can be used to produce lightweight concrete such as fiberglass waste material or cullet glass, granulated plastic, paper, wood, fluorescent bulb, polystyrene bead, palm oil shell and crushed recycled concrete itself to replace either fine or coarse aggregate. However, all those waste materials are still in research and are not yet established to be implemented in the concrete structure.

1.3 Problem Statement

Normal weight concrete has almost 26% higher density compared to the lightweight concrete. Higher density will increase the mass of concrete elements and leads to bigger sizes especially substructure. Massive structure elements will have many problems in construction method such as the needs of cranes to lift up the bigger elements, transportation to carry this heavy structure, improper thermal that will cause to concrete cracking, difficult access for maintenance and others. Reduction in density is an alternative to minimize this mass and cross section of concrete element. Minimizing concrete size is effect to the overall cost and energy consumption in construction especially manpower. Significantly, this lightweight concrete technology is an important development as an alternative to minimise these problems.

Commonly, lightweight concrete is being widely used for non-structural such as wall and floor element because those elements do not support any load and contribute less weight compare to the normal weight. Beside that, LWC also boasts good

characteristics due to its ability to reduce concrete weight and consequently to the overall load of structures. It also has good thermal and sound insulation compared to the normal concrete, has great fire resistance and it is economic.

1.4 Objective of Study

This study focuses on the development of lightweight concrete using beads as coarse aggregate. It would replace either partial or fully to the gravel aggregate based on weight basis. The main simple objective for this project is:

- To produce lightweight concrete that can be used for structural purpose which is the compressive strength achieved between 25-30 N/mm² by using beads as coarse aggregate and sand as fine aggregate.

- To investigate the fresh concrete workability using beads as aggregate.

1.5 Scope of Study

Beads is chosen to replace coarse aggregate according to the percentage which is 100%, 60%, 50%, 40% and 20%. The target strength is 30N/mm². One batch with 0% of bead is prepared to use as a control concrete. The concrete mixture is calculated in weight basis and referred to the method introduced by the Department of Environment, Building Research Establishment in London.

Six (6) cubes of concrete are prepared in each mix where three (3) cubes are used for seven (7) days and the other three (3) are used for 28 days for compressive strength testing. It focuses on the strength of hardened lightweight concrete with the cube size of 150mm x 150mm concrete used along the experiments. Besides that, a slump test is done for the workability of fresh concrete. Then the hardened concrete is cured in the water tank until the test day. The cubes are tested for compression strength using a machine provided in the laboratory. An average value of compression strength from the 3 cubes is calculated.

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