The Production of Lightweight Aggregates Using Ordinary Portland Cement

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DEDICATION

To my lovely wife Suhaina Mustafa and my children Muhammad Haziq, Nur Hazwani and Nur Hazirah thank you for your fully understandings and supports all my works.

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LIST OF ABBREVIATIONS

ACI	American Concrete Institute
ASTM	American Society for Testing and Materials Standard
BS	British Standard of Test Method
LAS	liquid Alkylbenzenesulfonates
LWA	Lightweight aggregates using ordinary Portland cement mixed with 15% of cement weight for liquid Alkylbenzenesulfonates and 15% of cement weight for water
LWAC	Lightweight aggregates concrete using LWA aggregate
LWACLA	Lightweight aggregates concrete using LWALA aggregate
LWACRH	Lightweight aggregates concrete using LWARH aggregate
LWALA	Lightweight aggregates using ordinary Portland cement mixed with 30% of cement weight for liquid Alkylbenzenesulfonates
LWARH	Lightweight aggregates using ordinary Portland cement mixed with 50% of cement weight for rice husk and 15% of cement weight for liquid Alkylbenzenesulfonates and 15% of cement weight for water
NA	Natural aggregate (granite)
NAC	Normal weight concrete using NA aggregate
OPC	Ordinary Portland Cement
SEM	Scanning Electron Microscope
XRF	X-Ray Fluorescence

LIST OF SYMBOLS

Al_2O_3	Aluminium oxide
CaO	Calcium oxide
Fe_2O_3	Iron (III) oxide
K_2O	Potassium oxide
SiO_2	Silicon Dioxide
SO_3	Sulfur trioxide
TiO_2	Titanium dioxide

LIST OF UNITS

Density	kilogram per cubic meter	kg/m^3
Length	meter	m
Mass	kilogram	kg
Strength	megapascals	MPa

LIST OF SPECIALIZED NOMENCLATURE

M_a	mass of aggregates in a saturated surface-dried condition	kg
M_s	the mass of oven-dry aggregates sample in air	kg
ρ	density	kg/m^3
m	the mass of the oven-dried specimen in air	kg
V	the volume of the specimen calculated from its dimensions	m^3
f_c	the compressive strength	MPa
F	the maximum load at failure	N
A_c	the cross-sectional area of the specimen	mm^2
M	bulk density of the aggregate	kg/m^3
G	mass of the aggregate plus the measure	kg
T	mass of the measure	kg
V	volume of the measure	m^3

Penghasilan Agregat Ringan Menggunakan Simen Portland Biasa

ABSTRAK

Kajian penyelidikan ini meliputi pengeluaran agregat ringan menggunakan simen Portland biasa (OPC) tanpa melibatkan sebarang proses rawatan haba. Tujuan utama kajian ini adalah untuk menghasilkan agregat ringan sebagai agregat tiruan yang boleh digunakan untuk menggantikan agregat semula jadi seperti granit di dalam bancuhan konkrit. OPC, cecair Alkylbenzenesulfonates dan sekam padi adalah bahan mentah utama yang digunakan dalam kajian ini untuk menghasilkan agregat ringan. Proses pengeluaran agregat ringan daripada OPC melibatkan pengisaran, pergaulan bahan mentah, penggumpalan dan proses pengawetan untuk mengikat zarah. Kajian ini melibatkan kepada sifat-sifat fizikal, mekanikal dan kimia bahan-bahan mentah seperti OPC, cecair Alkylbenzenesulfonates dan sekam padi. Kesan menggunakan cecair Alkylbenzenesulfonates dan sekam padi dalam agregat ringan tertumpu kepada ketumpatan pukal, peratusan penyerapan air liang, dan tekstur, graviti tentu dan juga mikrostruktur agregat ringan telah dianalisa. Sampel mentah telah dicirikan oleh pendarfluor sinar-X (XRF) dan keliangan agregat telah diperiksa dengan mikroskop imbasan elektron (SEM). Keputusan ujian XRF menunjukkan bahawa sekam padi mengandungi SiO_2 yang paling tinggi bersamaan dengan 56.3%. Agregat ringan LWARH yang dihasilkan daripada sekam padi, mempunyai ketumpatan yang rendah iaitu 761 kg/m^3 secara tidak langsung akan mengurangkan berat sendiri konkrit tetapi mempunyai kekuatan hanya 9.80 MPa pada hari ke 28. Agregat ringan LWA yang terbaik diperolehi dari kajian ini terdiri daripada campuran OPC, 15% cecair Alkylbenzenesulfonates dan 15% air berpotensi untuk kajian selanjutnya. Keputusan ujikaji yang diperolehi berjaya menunjukkan agregat ringan LWA mempunyai ketumpatan agregat pukal tahun 1215 kg/m^3 bagi agregat kasar. Kadar penyerapan air selama 24 jam untuk agregat LWA adalah 8.48% dan mengandungi 0.001973 mm^2 keluasan keliangan. LWAC konkrit ringan dihasilkan menggunakan agregat ringan LWA mempunyai purata kekuatan mampatan pada hari ke 28 sebanyak 20.39 MPa (20.39 N/mm^2). Keputusan ini berjaya mencapai kekuatan mampatan yang diperlukan untuk konkrit ringan iaitu 17 MPa pada hari ke 28 menurut ASTM C330 (2009). Walaubagaimanapun, ketumpatan pukal LWAC bersamaan 2080 kg/m^3 tidak dikategorikan sebagai konkrit agregat ringan menurut BS EN 206-1 (2000) kerana ketumpatan pukal adalah lebih daripada 2000 kg/m^3 tetapi hanya 4% lebih tinggi.

The Production of Lightweight Aggregates Using Ordinary Portland Cement

ABSTRACT

The research study covers the production of lightweight aggregates using Ordinary Portland cement (OPC) without involved any heat treatment. The main aim of this research was to produce lightweight aggregate as artificial aggregate which can be used to replace natural aggregate such as granite in concrete. OPC, liquid Alkylbenzenesulfonates and rice husk were the main raw materials were used in this study in order to produce lightweight aggregate. The production processes of lightweight aggregate from OPC involved grinding, mixing of raw materials, agglomeration and curing process for binding of the particles. This study involved on the physical, mechanical and chemical properties of raw materials such as OPC, liquid Alkylbenzenesulfonates and rice husk. The effect of using liquid Alkylbenzenesulfonates and rice husk in lightweight aggregate on bulk density, percentage of water absorption, pore and texture, specific gravity and also microstructure of lightweight aggregates were examined. The raw samples were characterized by X-ray fluorescence (XRF) and the porosity of aggregate was examined by scanning electron microscope (SEM). XRF result showed that rice husk of highest contained of SiO_2 equal to 56.3%. Lightweight aggregates LWARH produced from rice husk have low density equal to 761 kg/m^3 indirectly will reduce the self weight of concrete but the strength only 9.80 MPa at 28 days. The best lightweight aggregates LWA obtained from this study consisted of OPC, 15% of liquid Alkylbenzenesulfonates, 15% of water and potential for further research study. Successfully test result obtained showed the lightweight aggregate LWA had aggregate bulk density of 1215 kg/m^3 for coarse aggregates. The 24 hours water absorption for aggregate LWA was 8.48% and contained 0.001973mm^2 area of porosity. Lightweight concrete LWAC was produced using the lightweight aggregates LWA. The compressive strength at the average of 28 days compressive strength was recorded as 20.39 MPa (20.39 N/mm^2). This result successfully achieved the required compressive strength of lightweight concrete is 17 MPa at 28 days by ASTM C330 (2009). However, the bulk density equal to 2080 kg/m^3 is not categorized as lightweight aggregate concrete by BS EN 206-1 (2000) because the bulk density is more than 2000 kg/m^3 but only 4% higher.

CHAPTER 1

INTRODUCTION

1.1 Research Background

Focusing in general view of the increasing environmental problems faced today and also considering the rapid depletion of conventional aggregates, the use of aggregates from by-products and solid waste materials from different industries are highly desirable (Teo et al., 2006). As concerns about the excessive exploitation of natural aggregates have increased, the using of synthetic lightweight aggregate produced from environmental waste is a viable new source of structural aggregate material. The successful application of structural lightweight aggregate suggests that these aggregate used for precast structural elements can be used in building construction. This may increase the speed of construction, keep dust levels on site to the minimum, reducing the wet trade on site and reduce various environmental issues (Lo and Cui, 2004).

The use of lightweight aggregate in concrete can result in a decrease in the cross sections of columns, beams, slabs and foundations (Rattanachan and Lorprayoon, 2005). According to Setareh and Darvas (2007), lightweight structural concrete is more expansive than normal weight concrete, but its lighter weight often reduces the overall cost of the structure.