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**The Production of Lightweight Aggregates Using  
Ordinary Portland Cement**

by

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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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## TABLE OF CONTENTS

	<b>PAGE</b>
<b>THESIS DECLARATION</b>	i
<b>DEDICATION</b>	ii
<b>ACKNOWLEDGEMENT</b>	iii
<b>TABLE OF CONTENTS</b>	iv
<b>LIST OF TABLES</b>	ix
<b>LIST OF FIGURES</b>	xi
<b>LIST OF ABBREVIATIONS</b>	xvii
<b>LIST OF SYMBOLS</b>	xviii
<b>LIST OF UNITS</b>	xix
<b>LIST OF SPECIALIZED NOMENCLATURE</b>	xx
<b>ABSTRAK</b>	xxi
<b>ABSTRACT</b>	xxii
<b>CHAPTER 1 INTRODUCTION</b>	
1.1 Research Background	1
1.2 Problem Statement	3
1.3 Scope of Work	4
1.4 Objectives of this Study	6
<b>CHAPTER 2 LITERATURE REVIEW</b>	
2.1 Introduction	7
2.2 Historical Background of Lightweight Aggregate Concrete	11
2.2.1 Hayde Lightweight Aggregate	17
2.3 Type of Lightweight Aggregates	20
2.3.1 Synthetic Lightweight Aggregates	20
2.4 Raw Materials	22

2.4.1	Portland Cement	22
	2.4.1.1 Composition and Manufacture of Portland Cement	24
	2.4.1.2 Type of Cements	25
2.4.2	Aggregate	26
	2.4.2.1 Fine Aggregate	27
	2.4.2.2 Coarse Aggregate	27
2.4.3	Water	28
	2.4.3.1 Water as the Hydration Process Agent	29
	2.4.3.2 Water/cementitious Materials Ratio	30
	2.4.3.3 Quality of Mixing Water	33
2.4.4	Linear Alkylbenzenesulfonates	33
2.4.5	Residual Rice Husk	34
2.5	X-ray Fluorescence (XRF)	35
2.6	Characteristic of Lightweight Aggregate	36
	2.6.1 Aggregate Bulk Density	37
	2.6.2 Aggregate Water Absorption	38
	2.6.3 Pore Structure of Lightweight Aggregate	39
	2.6.4 Specific Gravity of Aggregate	42
	2.6.5 Scanning Electron Microscope (SEM)	44
	2.6.5.1 Cold Mounting	45
2.7	Characterization of Lightweight Aggregate Concrete	46
	2.7.1 Slump Test	46
	2.7.1.1 Limitations of The Slump Test	49
	2.7.2 Curing Process	50
	2.7.2.1 Minimum Periods of Curing and Protection	51
	2.7.2.2 Curing Water	52
	2.7.3 Lightweight Aggregate Concrete Bulk Density	53
	2.7.3.1 Density Classes for Lightweight Concrete	54
	2.7.4 Concrete Water Absorption	57
	2.7.5 Concrete Compressive Strength	58
	2.7.6 Physical Appearance	66
2.8	Concluding Remarks	68

## CHAPTER 3 RESEARCH METHODOLOGY

3.1	Introduction	69
3.2	Raw Materials	71
3.2.1	Ordinary Portland Cement	71
3.2.2	Aggregate	71
3.2.2.1	Fine Aggregate	72
3.2.2.2	Coarse Aggregate	72
3.2.3	Water	73
3.2.4	Linear Alkylbenzenesulfonates	73
3.2.5	Residual Rice Husk	74
3.3	Chemical Composition Using XRF	75
3.4	Production of Lightweight Aggregate	76
3.4.1	Lightweight Aggregate Mixed Compositions	76
3.4.2	Lightweight Aggregate Production Using Palletizing Machine	77
3.5	Lightweight Aggregate Characterization	81
3.5.1	Aggregate Bulk Density	82
3.5.2	Aggregate Water Absorption	86
3.5.3	Aggregate Pore Size and Surface Texture of Aggregates	88
3.5.4	Specific Gravity of Aggregate	89
3.5.5	Scanning Electron Microscope	89
3.5.5.1	Cold Mounting	90
3.6	Production of Lightweight Aggregate Concrete	91
3.6.1	Lightweight Aggregate Mixed Compositions	91
3.6.2	Vibrating Table	95
3.6.3	Curing Process	98
3.7	Lightweight Aggregate Concrete Characterization	99
3.7.1	Slump Test	100
3.7.1.1	Procedure of Slump Test	102
3.7.2	Concrete Bulk Density	103
3.7.3	Concrete Water Absorption	104
3.7.4	Concrete Compressive Strength	107
3.7.5	Physical Appearance	109
3.8	Concluding Remarks	110

## **CHAPTER 4 RESULTS AND DISCUSSION**

4.1	Introduction	111
4.2	Raw Materials	111
4.3	X-Ray Fluorescence (XRF) Result	118
4.4	Lightweight Aggregate Characterization	119
4.4.1	Aggregate Bulk Density	119
4.4.2	Aggregate Water Absorption	120
4.4.3	Aggregate Pore Size	121
4.4.4	Surface Texture of Aggregates	125
4.4.5	Specific Gravity	127
4.4.6	Scanning Electron Microscope (SEM) Analysis	128
4.5	Concrete Mix Proportioning	132
4.5.1	Concrete Curing	134
4.6	Lightweight Aggregate Concrete Characterization	136
4.6.1	Slump Test	136
4.6.2	Concrete Bulk Density	138
4.6.3	Concrete Water Absorption	140
4.6.4	Concrete Compressive Strength	141
4.6.5	Physical Appearance of the Concrete Cube Specimens	143
4.6.6	Physical Appearance of Aggregate Segregation	144
4.7	Relationship between Aggregate and Concrete Bulk Density	145
4.8	Relationships between Compressive Strength and Concrete Bulk Density	147
4.9	Concluding Remarks	148

## **CHAPTER 5 CONCLUSION AND RECOMMENDATIONS**

5.1	Conclusion	149
5.2	Recommendations	150
5.3	Recommendations for Further Research	152

<b>REFERENCES</b>	<b>153</b>
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<b>APPENDIX A: XRF Sample Results</b>	159
<b>APPENDIX B: Aggregate Bulk Density Results</b>	163
<b>APPENDIX C: Aggregate Water Absorption Results</b>	164
<b>APPENDIX D: Specific Gravity of Aggregates Results</b>	165
<b>APPENDIX E: Concrete Bulk Density Results</b>	166
<b>APPENDIX F: Concrete Water Absorption Results</b>	167
<b>APPENDIX G: Concrete Compression Testing Results</b>	168
<b>LIST OF PUBLICATION</b>	169
<b>LIST OF AWARDS</b>	176

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## LIST OF TABLES

NO.		PAGE
2.1	Oxide and compound compositions of Portland cements	26
2.2	Maximum dry loose bulk density requirements of lightweight aggregates for structural concrete	37
2.3	Density of lightweight aggregate	38
2.4	Water absorption of lightweight aggregate	39
2.5	Specific gravity of pallets and other commercial aggregates	43
2.6	Five classes of slump	49
2.7	Classification of lightweight concrete by density	55
2.8	Classification of lightweight concretes	55
2.9	Density classes for lightweight aggregate concrete	56
2.10	Terms of density	57
2.11	Concrete bulk density	57
2.12	Criteria of water absorption	58
2.13	Standard mixes by weight	60
2.14	Proportions and strength requirements for nominal concrete mixes with Portland cement or Portland-blastfurnace cement and with aggregates	60
2.15	Compressive strength and splitting tensile strength requirements	61
2.16	Concrete compressive strength	66
3.1	Description of aggregate mix design	77
3.2	Standard method for aggregate	81
3.3	Capacity of measures	85
3.4	Standard method for fresh concrete testing	99
3.5	Standard method for concrete testing	100
4.1	Chemical composition of the raw materials (% wt)	118
4.2	Area of aggregates pore size	121

4.3	Detail of concrete mixes Batch 1 NAC (Control specimen) for 12 cube sample	133
4.4	Detail of concrete mixes Batch 2 LWAC for 12 cube sample	133
4.5	Detail of concrete mixes Batch 3 LWACLA for 12 cube sample	133
4.6	Detail of concrete mixes Batch 4 LWACRH for 12 cube sample	133
4.7	Concrete cube compressive strength	142
4.8	Concrete bulk density and compressive strength at 28 days	147

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## LIST OF FIGURES

NO.		PAGE
1.1	Sample of Light Expanded Clay Aggregate (LECA) fine clay aerated at 3000°C.	5
2.1	Pumice lightweight aggregate	5
2.2	Scoria lightweight aggregate	5
2.3	Tuff lightweight aggregate.	9
2.4	Breccia lightweight aggregate	9
2.5	Volcanic cinders lightweight aggregate	9
2.6	Babylon	12
2.7	Hagia Sophia	12
2.8	The original Pantheon	12
2.9	Vers-Pont-du-Gard, France	13
2.10	The Roman Colosseum	13
2.11	Chichen Itza	14
2.12	Mohenjo-Daro side street	15
2.13	Weight and strength range of concrete	17
2.14	The Southwestern Bell telephone building project in Kansas City Missouri is one of the early landmark uses of Haydite	18
2.15	First National Tower (193 meter), is the tallest building in the upper Midwest between Minneapolis and Denver was build by using Lightweight concrete from Hydate Expanded Shell Aggregate	19
2.16	Lightweight expanded clay aggregate (LECA)	21
2.17	Changes of concrete compressive strength with w/cm ratio and age	31
2.18	Structure of a linear alkylbenzenesulfonate	34
2.19	Bubble structure of Biotite-Rhyolite by Fluidized Bed ALA	40
2.20	Sections showing pore size distribution of (a) lightweight I pallet; (b) lightweight II pellet	41

2.21	Pore structures of the aggregates (a) CLAY-A, 40 % albite floatation, 1100 °C, (b) CLAY-A, 40 % albite floatation, 1250 °C, (c) CLAY-B, 40 % albite floatation, 1200 °C	41
2.22	Surface textures of the aggregates; (a) CLAY-A, 40 % albite floatation, 1100 °C, (b) CLAY-A, 40 % albite floatation, 1250 °C, (c) CLAY-B, 40 % albite floatation, 1200 °C	42
2.23	Slump cone	47
2.24	Slump test	47
2.25	Forms of slump	48
2.26	Compressive strength versus fresh density of LWA concrete mixture with different types of LWA	54
2.27	Effect of ratio of height/lateral dimension of specimen on the compressive strength	59
2.28	Normal and abnormal cube failures	62
2.29	Strength and failure type for 100 mm cubes placed eccentrically in testing machine	63
2.30	Fracture modes for cubes of different qualities of concrete tested using non-plane plates	63
2.31	Satisfactory failures	64
2.32	Some unsatisfactory failures	64
2.33	Stress-strain relationship for concrete	65
2.34	Proven Engineering Blocks stretcher type	66
2.35	Synthetic images of lightweight aggregate concrete sections with global aggregate's fraction	67
3.1	Flow chart procedure of production and testing	70
3.2	Ordinary Portland Cement MS 522 Part 1 - CEM I 42.5R	71
3.3	Matest High Capacity Sieve Shaker	72
3.4	Laboratory Test Sieve aperture 9.50 mm BS 410 (1986) and aperture 6.3 mm. BS 410 (1986) manufactured by Unit Test	73
3.5	The residual rice husk collected at DIBUK Sdn. Bhd. Perlis	74
3.6	Disk Mill Machine Speed 5800 rpm Model FFC—23	74

3.7	XRF PAN analytical MiniPal 4 Machine	75
3.8	Stainless Steel sieve aperture 63µm	75
3.9	The lightweight aggregates production technique	77
3.10	20 liter mixer industrial mixture	78
3.11	Illustration of pelletizing machine	79
3.12	Pelletizing machine	80
3.13	Flow chart methods to determine the aggregate bulk density	83
3.14	Aggregate was dried at 110°C using Oven Beschickung	84
3.15	Apparatus to measure aggregate bulk density (a) tamping rod with having the tamping both ends with rounded to a hemispherical tip and, (b) cylindrical metal measure with 150 mm diameter and 170 mm height with handles (capacity of measure equal to 0.0028m <sup>3</sup> )	84
3.16	Flow chart for method to determine water absorption of aggregate	87
3.17	(a) AbCELLON micro-optic Input 230v-50Hz; (b) Optical Microscope Olympus SZ61	88
3.18	Electronic Densimeter MD-300S to measuring specific gravity	89
3.19	Scanning Electron Microscope Model JEOL JSM 6460 LA	90
3.20	Flow chart of the lightweight aggregate concrete making process and its characterization	92
3.21	Illustration of mix proportion 124 (a) OPC; (b) fine aggregate (sand); (c) coarse aggregate	93
3.22	Forced action mixer used to mixed concrete	94
3.23	100 mm x 100 mm x 100 mm cube mould with clamp and base plate	94
3.24	Flow chart of method for making test cubes from fresh concrete	97
3.25	Curing tank	98
3.26	Flow chart of the slump test procedure	101
3.27	Slump test apparatus used for this work	103
3.28	Method for determination of concrete water absorption	106

3.29	Compression concrete machine model GOTECH Testing Machines Inc.	107
3.30	Abrasive Cutoff Saw (355mm) 2100W RYOBI C-356NA	109
3.31	Illustration of concrete cube cut surface (a) Concrete cube 100 mm x 100 mm x 100 mm; (b) shape after cutting	109
4.1	Raw material after mixing process	111
4.2	The dough ball with the diameter size approximately 100 mm	112
4.3	Straw pellet of the LWA sample	112
4.4	Granule pellet of the LWA sample	113
4.5	Residual rice husk	113
4.6	Rice husk; (a) before and, (b) after grinding process; sample was passing 1 mm disk mill filter	114
4.7	Pellet dry process 24 hours at room temperature	114
4.8	Lightweight aggregate was immersed in normal water for 14 days	115
4.9	Produced lightweight aggregate granules mixed with water and liquid Alkylbenzenesulfonates (LWA) (size 6.3 mm – 9.5 mm)	116
4.10	Produced lightweight aggregate granules mixed with liquid Alkylbenzenesulfonates (LWALA) (size 6.3 mm – 9.5 mm)	116
4.11	Produced lightweight aggregate rice husk granules mixed with water and liquid Alkylbenzenesulfonates (LWARH) (size 6.3 mm – 9.5 mm)	117
4.12	Natural aggregate (NA) granite (size 6.3 mm – 9.5 mm)	117
4.13	Average particle size of raw passing sieve aperture 63 $\mu$ m for XRF analysis; (a) Ordinary Portland Cement (CEM I 42.5R) mixed with liquid Alkylbenzenesulfonates, (b) Ordinary Portland Cement (CEM I 42.5R), (c) Residual rice husk	118
4.14	Aggregate bulk density for natural and lightweight aggregate.	119
4.15	Aggregate water absorption	121
4.16	Area of aggregates pore size	122

4.17	The area of porosity for different type of aggregates	123
4.18	Cross-sections of aggregates	125
4.19	Surface textures of the aggregates	127
4.20	Specific gravity of aggregates	127
4.21	Aggregates specimens in (a) mounting compound; (b) cut surface (i) NA; (ii) LWA; (iii) LWALA; (iv) LWARH	128
4.22	The microstructure of (a) NA; (b) LWA; (c) LWALA; (d) LWARH under 6 kV X75 magnification	130
4.23	The microstructure of (a) NA; (b) LWA; (c) LWALA; (d) LWARH under 6 kV X100 magnification	132
4.24	The mix proportion 124 (a) OPC; (b) fine aggregate (sand); (c) coarse aggregate	132
4.25	Fresh lightweight aggregate concrete moulded in the 100 mm x 100 mm x 100 mm cube	134
4.26	Samples were stored at concrete laboratory with wet gunny bag covering for 24 hours	134
4.27	Samples of lightweight aggregate concrete cube LWACLA after demoulded	135
4.28	Samples of lightweight aggregate concrete cube immersed in normal water at curing tank	135
4.29	Slump test result all concrete mixed	136
4.30	Slump test	138
4.31	Concrete bulk density	139
4.32	Sample of LWACRH was weighed for concrete bulk density	140
4.33	Concrete water absorption	140
4.34	Compressive strength of normal and lightweight aggregate concrete	141
4.35	Failure of cubes in compression (a) at 7 days, (b) at 14 days, (c) at 28 days, (d) at 90 days	144
4.36	Physical appearance of the cut surface specimens after 28 curing days (a) NAC; (b) LWAC; (c) LWACLA; (d) LWACRH	145
4.37	Relationship between aggregate and concrete bulk density	146



4.38	Relationships between compressive strength at 28 days and concrete bulk density	148
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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

$\text{Al}_2\text{O}_3$	Aluminium oxide
$\text{CaO}$	Calcium oxide
$\text{Fe}_2\text{O}_3$	Iron (III) oxide
$\text{K}_2\text{O}$	Potassium oxide
$\text{SiO}_2$	Silicon Dioxide
$\text{SO}_3$	Sulfur trioxide
$\text{TiO}_2$	Titanium dioxide

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## LIST OF UNITS

Density	kilogram per cubic meter	$\text{kg/m}^3$
Length	meter	m
Mass	kilogram	kg
Strength	megapascals	MPa

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## 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
$\rho$	density	kg/m <sup>3</sup>
$m$	the mass of the oven-dried specimen in air	kg
$V$	the volume of the specimen calculated from its dimensions	m <sup>3</sup>
$f_c$	the compressive strength	MPa
$F$	the maximum load at failure	N
$A_c$	the cross-sectional area of the specimen	mm <sup>2</sup>
$M$	bulk density of the aggregate	kg/m <sup>3</sup>
$G$	mass of the aggregate plus the measure	kg
$T$	mass of the measure	kg
$V$	volume of the measure	m <sup>3</sup>

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## 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  $\text{SiO}_2$  yang paling tinggi bersamaan dengan 56.3%. Agregat ringan LWARH yang dihasilkan daripada sekam padi, mempunyai ketumpatan yang rendah iaitu  $761 \text{ kg/m}^3$  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  $1215 \text{ kg/m}^3$  bagi agregat kasar. Kadar penyerapan air selama 24 jam untuk agregat LWA adalah 8.48% dan mengandungi  $0.001973 \text{ mm}^2$  keluasan keliangan. LWAC konkrit ringan dihasilkan menggunakan agregat ringan LWA mempunyai purata kekuatan mampatan pada hari ke 28 sebanyak 20.39 MPa ( $20.39 \text{ N/mm}^2$ ). 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  $2080 \text{ kg/m}^3$  tidak dikategorikan sebagai konkrit agregat ringan menurut BS EN 206-1 (2000) kerana ketumpatan pukal adalah lebih daripada  $2000 \text{ kg/m}^3$  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<sub>2</sub> equal to 56.3%. Lightweight aggregates LWARH produced from rice husk have low density equal to 761 kg/m<sup>3</sup> 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<sup>3</sup> for coarse aggregates. The 24 hours water absorption for aggregate LWA was 8.48% and contained 0.001973mm<sup>2</sup> 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<sup>2</sup>). 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<sup>3</sup> is not categorized as lightweight aggregate concrete by BS EN 206-1 (2000) because the bulk density is more than 2000 kg/m<sup>3</sup> 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.