Universiti Malaysia PAHANG

RESEARCH REPORT UMP GRANT

Laporan Prestasi Skim Geran UMP

Progress	
Final	√

√ *Please tick*

A

GRANT RDU NO : RDU130339

RESEARCH TITLE : ENGINEERING PROPERTIES OF CONCRETE CONTAINING SYNTHETIC LIGHTWEIGHT COARSE AGGREGATE USING OFFSHORE SAND FOAMED CONCRETE (SYLCAG)

PROGRESS PERIOD : 15/06/2013 - 31/05/2016

PROJECT LEADER : MOHAMMAD AMIRULKHAIRI BIN ZUBIR

PROJECT MEMBERS :

1. NORHAIZA BINTI GHAZALI
2. AZLINA BINTI HAJI ISMAIL
3. MUHAMMAD NURUL FAKHRI BIN RUSLI
4. MOHD HAFIZ AL-KASAH BIN JAMAL AKHSAH
5.

PROJECT ACHIEVEMENT *(Prestasi Projek)*

B

ACHIEVEMENT PERCENTAGE				
Project progress according to milestones achieved up to this period	**0 - 25%**	**26 - 50%**	**51 - 75%**	**76 - 100%**
Percentage (please state %)				100%

RESEARCH OUTPUT		
	ISI	**SCOPUS**
Number of articles/ manuscripts/ books *(Please attach the First Page of Publication)*	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
	International	**National**
Conference Proceeding *(Please attach the First Page of Publication)*	1. Synthetic Lightweight Coarse Aggregate Using Offshore Sand 2. Application of Flexural Timber Reinforcement in Light Concrete Beam Structure	1. 2. 3. 4. 5.
Intellectual Property *(Please specify)*		

HUMAN CAPITAL DEVELOPMENT

Human Capital	Number				Others (please specify)
	On-going		Graduated		
Citizen	Malaysian	Non Malaysian	Malaysian	Non Malaysian	
PhD Student					
Master Student					
Undergraduate Student			9		
Total			9		

Name of Student: MOHD ZAWAWIV BIN AZIZ
ID Matric No: AA10228
Faculty: FKASA
Thesis title: FLEXURAL BEHAVIOUR OF REINFORCED SYNTHETIC LIGHTWEIGHT COARSE AGGREGATE (SYLCAG) CONCRETE
Graduation Year: 2014

Name of Student: MOHD FAIRUZ BIN AZMI
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Thesis title: MECHANICAL PROPERTIES OF CONCRETE USING SYNTHETIC LIGHWEIGHT COARSE AGGREGATE (SYLCAG).
Graduation Year: 2014

Name of Student: MUHAMMAD NAZRIN AKMAL
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Graduation Year: 2014

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Graduation Year: 2014

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Thesis title: SLAB REINFORCED WITH HDPE PIPE (SREHP).
Graduation Year: 2014

Name of Student: MUHAMMAD MAAROF MUSTAPHA
ID Matric No: AE10043
Faculty: FKASA
Thesis title: BAMBOO AS FIBER REINFORCEMENT IN CONCRETE MIX.
Graduation Year: 2014

Name of Student: RASHDAN EMIR BIN MOHD NAWI
ID Matric No: AA10218
Faculty: FKASA
Thesis title: AN EXPERIMENTAL OF REINFORCED ARTIFICIAL AGGREGATES CONCRETE USING LIGHTWEIGHT OFFSHORE SAND AS REPLACEMENT TO COARSE AGGREGATES
Graduation Year: 2014

	Name of Student: **ID Matric No:** **Faculty:** **Thesis title:** **Graduation Year:**	SITI FATIMAH BINTI MOHAMED SALLEH AE11011 FKASA FLEXURAL BEHAVIOUR OF REINFORCED CONCRETE BEAM USING PARTIAL SYNTHETIC LIGHTWEIGHT COARSE AGGREGATE 2015
	Name of Student: **ID Matric No:** **Faculty:** **Thesis title:** **Graduation Year:** *** enter for more space*	SITI NUR AMIRA BINTI HASSAN AE11033 FKASA THE PERFORMANCE OF CONCRETE USING SYNTHETIC LIGHTWEIGHT COARSE AGGREGATE (SYLCAG) ON FLEXURAL BEHAVIOUR 2015

EXPENDITURE *(Perbelanjaan)*

C

Budget Approved *(Peruntukan diluluskan)*	:	**RM 24,300.00**
Amount Spent *(Jumlah Perbelanjaan)*	:	**RM 17,553.65**
Balance *(Baki)*	:	**RM 6,746.35**
Percentage of Amount Spent *(Peratusan Belanja)*	:	72.23 %

ASSET

D

Bil	**Peralatan** *(Equipment)*	**Model**	**No Daftar Aset** *(Asset Tagging No)*	**Amount** (RM)	**Lokasi** *(Location)*
1	Komputer Notebook	Levovo IPAD Y500	FTKA1000 – PB205(R) – 1308 0004 00001	3080.00	Bilik Pensyarah, Ketua penyelidikan

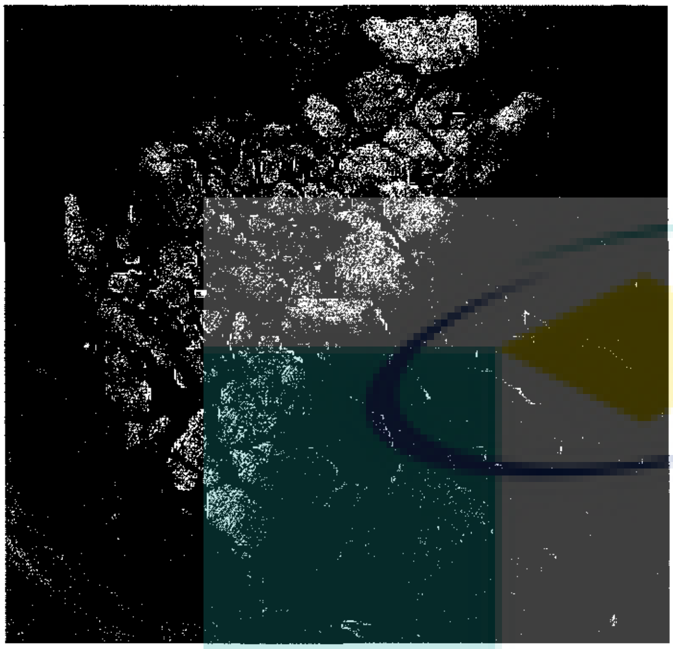
PRODUCT DESCRIPTION FOR UMP R&D DIRECTORY (SHORT & BRIEF) *Only for Final Report*

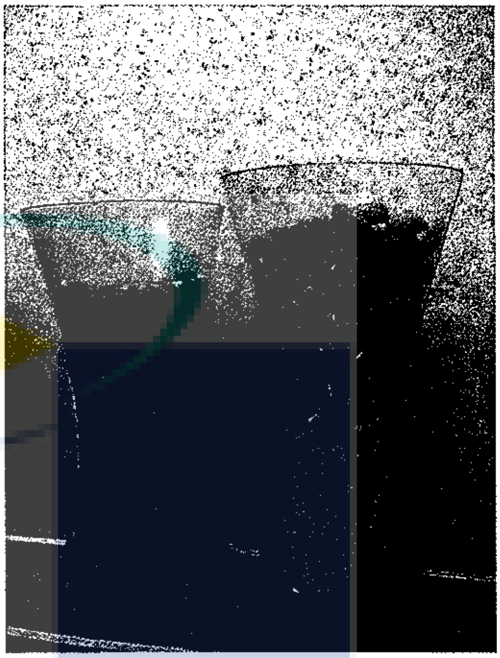
E

SYLCAG is a produced controlled raw synthetic lightweight course aggregate. SYLCAG was developed to contribute toward alternative materials in concrete mix. Rather than just relying on land aggregate, by replacing normal aggregate with SYLCAG it would lead to reduction of land rock harvesting because SYLCAG was produced using offshore sand. Additionally it offers a new material application of lightweight concrete design. The construction industries can utilizes this technologies which lead to another choice in the present-day markets. This invention will reduce the weight of concrete structure up to 17% lesser.

PRODUCT PICTURE FOR UMP R&D DIRECTORY *Only for Final Report*

F





SUMMARY OF RESEARCH FINDINGS *(Ringkasan Penemuan Projek Penyelidikan)*

G

At present, most R&D in concrete technologies emphasis in replacement of the materials with waste product such as industrial sludge, oil palm shell, demolition waste and many more. It is a movement toward green technologies. SYLCAG on the other hand offers alternative material that is lightweight and use offshore sand. Even though it does not apply any waste product, toward the end SYLCAG will reduce the quantity of concrete used for one building. This eventually help to declare this product as one of a green technology innovation. Despite the fact that SYLCAG reduce the density of concrete, it simultaneously maintain the mechanical properties of concrete to meet the specification for structural and non-structural concrete elements.

As a new coarse aggregate for concrete mixture design which means less land aggregate usage, competitive cost and help towards greener environment. With the decreased concrete density with lightweight concrete mix consequently leading to lower material cost.
This research find that SYLCAG have practical compressive strength compared to standard lightweight concrete thus making it a perfect choice for today's construction situation.It is a new innovation in a highly demanded construction materials, especially material for lightweight slab thus putting a strong commercial value on the final product.

PROBLEMS / CONSTRAINTS IF ANY *(Masalah/ Kekangan sekiranya ada)*

H

Source of SYLCAG is not available in the market but can be obtain easily as the material come from natural source. However, for the purpoase of doing this research, the material was obtain from land area that was embanked using offshore sand.

Date : 18/1/2017 *Tarikh*	**Project Leader's Signature:** *Tandatangan Ketua Projek*

COMMENTS, IF ANY/ ENDORSEMENT BY FACULTY *(Komen, sekiranya ada/ Pengesahan oleh Fakulti)*
Recommend / Not Recommend / KIV / Need Ammendment Please proceed accordingly **Name:** DOH SHU ING. *Nama:* **Date:** 18/01/2017 *Tarikh:* **Signature:** *Tandatangan:* DR. DOH SHU ING DEPUTY DEAN (RESEARCH & POSTGRADUATE) FACULTY OF CIVIL ENGINEERING & EARTH RESOURCES UNIVERSITI MALAYSIA PAHANG LEBUHRAYA TUN RAZAK 26300 KUANTAN, PAHANG TEL : +609 549 2002/2099 FAKS : +609 549 2998 ** Dean/TDR

	COMMENTS, IF ANY/ ENDORSEMENT BY RMC PNI *(Komen, sekiranya ada/ Pengesahan oleh RMC PNI)*
I	**Recommend / Not Recommend / KIV / Need Ammendment** **Name:** *Nama:* **Date:** *Tarikh:* **Signature:** *Tandatangan:*

Penerbit Akademia Baru

Journal of Advanced Research in Applied Mechanics
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Synthetic Lightweight Coarse Aggregate Using Offshore Sand

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Abstract –*Offshore sand is a capable alternative replacement for land aggregate in concrete. It is necessity for some country or regional where land aggregate is scarce and sometimes unavailable to be used for development but offshore sand is accessible for replacement. This paper reports about the production and usage of synthetic lightweight coarse aggregate produced using offshore sand (SYLCAG). It was produced with density of 1300 kg/m³ which is nearly 60% lighter than normal aggregate. This SYLCAG was used as a full replacement for coarse aggregate in concrete which then produced as a concrete with density almost 1900 kg/m3. The produced concrete did not have a good strength with design of 25 MPa concrete. However, it still has the potential to be develop with higher design and later used as structural concrete.*

Keywords: Synthetic Aggregate, Offshore Sand, Lightweight Aggregate

1.0 INTRODUCTION

The utilization of land resources as the prime source for construction materials has always been a rising issue for certain country that include Malaysia. In 2008 it was reported that there was almost 2% reduction toward granite and limestone aggregate production which led to importing aggregate where it was 6.3 times higher than the previous year [1]. According to [2], Malaysia consumed 2.76 billion metric tons of natural aggregate in 2010 which most of it came from land resources. This shows that exploration toward other source is essential not with the aim to further exploit natural resource but for reservation of future development.

Offshore sand is one of available natural resource that has potential to be use in construction industries. In Sri Lanka for example, due to limited source of river sand, explorative usage of offshore sand has been progressed [3]. In Malaysia, offshore sand mining have already started to progress in south of Johore to cater the need of sand for development mostly in embankment activities [4]. In the concrete industries of Malaysia there is no record shows application of offshore sand in structural concrete yet. There is too little investigation toward such application.

One of the reason that hinder the use offshore sand in concrete is because the properties of the materials itself is not suitable for concrete. The chloride level of offshore sand is high and will enhance the possibility of corrosion in reinforced concrete. However, [5] found that offshore sand can be treated with gravity drain so that the content of Cl^- ions could be reduced to an acceptable level for OPC concrete mix. They stated that a conservative limit for allowable Cl^-

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Application of Flexural Timber Reinforcement in Light Concrete Beam Structure

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Keywords: timber reinforced concrete; flexural behavior; beam load-deflection

Abstract. Timber is a capable alternative for reinforcement in concrete beam because it possesses high strength ratio compare to its weight although its strength is incompatible to steel. This study was conducted to highlight the flexural behaviour of beam reinforced with two types of timber; *Balau* and *Meranti*. Comparisons of behaviour have been made between samples applying the Reinforced Concrete Design to EC2. The result of flexural test shows that steel reinforcement beam (SRB) carried the utmost loads compared to timber sample beam which reinforced with *Balau* (BRB) and *Meranti* (MRB). Compared to the flexural strength of SRB, BRB reached about 69 % of the value while MRB reached to 66 % respectively. It was found that the failure mode of the timber beam was closely related to the load-deflection behaviour same as conventional steel beam. The larger the load-deflection value, the wider the range of cracking occurred.

Introduction

Structure assembly that constructed from timber have played an important role in construction industry for centuries especially in countries which have good resource of timber. Basically, timber is tough, strong and long lasting element. Timber has been used as a construction material in many ways. Usages for the entire structure are well known for houses and bridges. The usage of timber as a reinforcement material in concrete is rarely known. Its application as a reinforcement material in concrete structure had received very little attention.

Timber and concrete are inexpensive building material. Both are relatively easy to work on. As composite elements, timber can provides tensile strength for the concrete in a same way of steel reinforcement. Several researchers had conducted full scale testing of different means of achieving composite action between timber and concrete. Most studies dedicated on timber–concrete composite floors which focused on load-deflection capacity, mechanical properties, short term behaviour and also connections [1–4].

Near to this study, bamboo was one of the most commonly used study materials to substitute reinforcing steel bar in concrete [5,6]. Prior to the durability of organic materials, treatment and curing are essential consideration before application [6]. A comparison between steel and bamboo shows that there are benefits and ill effects for both materials [6,7] Even though composite mineral materials based on fibre reinforced polymer (FRP) has become outstanding replacement for conventional steel reinforcement [8], this study has the intention to add to the knowledge base of timber reinforced concrete with locally obtainable timber to produce concrete structural elements.

Methodology

In this study three samples of reinforced concrete beam were prepared. Two of them were reinforced with timber reinforcement and one was the control beam which is reinforced with steel reinforcement. The grade of concrete that has been used for this study is 20 N/mm2. Meanwhile, all the beam samples used the same size for its link reinforcement, which is 6 mm diameter (R6), steel of grade 250 N/mm2. Each beam sample was identified and reinforced as SRB (steel

RDU130339

ENGINEERING PROPERTIES OF CONCRETE CONTAINING SYNTHETIC LIGHTWEIGHT COARSE AGGREGATE USING OFFSHORE SAND FOAMED CONCRETE (SYLCAG)

SIFAT-SIFAT KEJURUTERAAN KONKRIT YANG MENGANDUNGI AGREGAT KASAR RINGAN BUATAN DARIPADA KONKRIT RINGAN PASIR LAUT (SYLCAG)

MOHAMMAD AMIRULKHAIRI BIN ZUBIR
NORHAIZA BINTI GHAZALI
AZLINA BINTI ISMAIL
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MOHD HAFIZ AL-KASAH BIN JAMAL AKHSAH

RESEARCH VOT NO:
RDU1203110

Fakulti Kejuruteraan Awam dan Sumber Alam
Universiti Malaysia Pahang

2017

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ABSTRACT

Concrete is a material used in building construction. The concrete consisting of a hard, chemically inert particulate substance known as an aggregate (usually made from different types of sand and gravel), that is bonded together by cement and water. Aggregate is another major part of concrete besides the cement. Currently, there are many construction purposed such as house, office, shop and other building to improve the infrastructure of populations and it is caused the over-exploitation of river sand. This study, the coarse aggregates will be replaced with the synthetic lightweight coarse aggregate using offshore sand in concrete. Offshore sand is a one of alternative for river sand usage in concrete. the synthetic lightweight coarse aggregate (SYLCAG) with 1600 kg/m^3 density using offshore sand. The sample of concrete placed in water tank to curing for 7 days, 14 days and 28 days. The sample was the tested with compressive strength, flexural strength and water absorption test. These tested were conducted to determine the mechanical properties of concrete using SLYCAG.

ABSTRAK

Konkirt merupakan bahan digunakan dalam sektor pembinaan. Konkrit terdiri daripada batu baur kasar dan pasir yang terikat bersama simen dan air. Batu baur kasar merupakan salah satu bahagian utama yang digunakan dalam konkrit selepas simen. Pada zaman sekarang, terdapat banyak pembinaan dengan perlbagai tujuan seperti rumah, pejabat, kedai dan sebagainya bagi meningkatkan infrastruktur penduduk. Secara tidak langsung, mengakibatkan ekspoitasi pasir sungai yang tidak terkawal. Bagi kajian yang dijalan ini, batu baur kasar yang biasa akan diganti dengan batu baur kasar ringan sintetik menggunakan pasir luar pesisir di dalam bancuhan konkrit. Pasir pesisir pantai adalah merupakan salah satu alternatif untuk menggantikan penggunaan pasir sungai di dalam konkrit. Dalam kajian ini, sintetik ringan batu baur kasar (SYLCAG) bertumpatan 1600 kg/m3 dengan menggunakan pasir persisir luar pantai. Sample konkrit diletakkan di dalam tangki air selama 7 hari, 14 hari dan 28 hari. Kemudian, sample diuji dari segi kekuatan mampatan, kekuatan lenturan dan ujian penyerapan air. Ujian ini dijalankan untuk menentukan sifat-sifat mekanikal konkri dengan menggunakan SYLCAG.

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LIST OF ABBREVIATION

ASTM	American Society for Testing and Materials
BS	British Standard
LWA	Lightweight Aggregate
LWAC	Lightweight Aggregate Concrete
OPC	Ordinary Portland Cement
SYLCAG	Synthetic Lightweight Coarse Aggregate
UMP	University Malaysia Pahang

LIST OF EQUATIONS

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Concrete is a material used in building construction. The concrete consisting of a hard, chemically inert particulate substance known as an aggregate (usually made from different types of sand and gravel), that is bonded together by cement and water. The concrete must be low permeability, workable, resistance to freezing, chemicals resistance, water resistance and economy (Metha & Menteiro, 2006). Then, lightweight concrete can be defined as a type of concrete which includes an expanding agent in that increase the volume of the mixture while giving additional qualities such as nailbility and lessened the dead weight (Kamsiah et al, 2003).

Aggregate is another major part of concrete besides the cement. This study, the coarse aggregates will be replaced with the synthetic lightweight coarse aggregate in concrete. Offshore sand is a one of alternative for river sand usage in concrete. Offshore sand should extract from 15 m ocean depth (Dias, 2007). The offshore sand has low chloride content compare the beach sand. The beach sand has high chloride content due to wetting and drying cycles of sea water. Then, the offshore sand must be washed by rain over a period of time to reduce the chlorides content. After that, this study determines the compressive strength, flexural strength and water absorption of concrete using synthetic lightweight coarse aggregate.

1.2 PROBLEM STATEMENT

Currently, there are many construction purposes such as house, office, shop and other building to improve the infrastructure of populations. In this case, when there are many developments, the usage of the concrete must increase to build the building. The over-exploitation of river sand for construction purposes has led to various harmful consequences. There are many suggestions for various river sand alternatives such as offshore sand, dune sand, quarry dust and washed soil has been made (Dias, 1999). In this study, offshore was considered the most viable of the alternatives for river sand with respect to availability, environmental impact, ease of extraction and cost.

1.3 OBJECTIVES

i. To determine the compressive strength and flexural strength concrete using synthetic lightweight coarse aggregate (SLYCAG)

ii. To determine water absorption of concrete using synthetic lightweight coarse aggregate (SYLCAG)

1.4 SCOPE OF STUDY

This research is aimed to determining the compressive strength and water absorption of concrete using artificial offshore sand coarse aggregate. For this research, the sample of offshore sand is taken from reclamation project at Pantai Klebang in Melaka. Then, the size of SYLCAG is 20 mm, 10 mm and 5 mm. This research includes lab works and lab testing on the sample concrete such as compression test, flexural test and water absorption test. Then, hardened specimens such as 150 mm x 150 mm x 150 mm for cube, 150 mm x 150 mm x 750 mm for beam. The research is focus on the compressive strength and tensile strength concrete using artificial offshore sand coarse aggregate.

1.5 EXPECTED OUTCOME

The expected outcome for this research is to determine compressive strength and tensile strength concrete using artificial offshore sand coarse aggregate and compare conventional concrete. The conventional concrete as a guide to the determined the strength of lightweight concrete using artificial offshore coarse aggregate. After that, the concrete using artificial offshore sand coarse aggregate should be lighter density than conventional concrete.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Generally, concrete is product of reaction between hydraulic cement and water but these days, the definition would cover a wide range of product. Today, concrete is made with several types of cement and also containing pozzolan, fly ash, blash-furnance slag, micro-silica, additives, recycled concrete aggregate, admixtures, polymers, fibers, and etc. These concrete can be heated, steam-cured, autoclaved, vacuum-treated, hydraulic pressure, shock-virated, extruded, and sprayed (Neville & Brooks, 2010). There are many research about the concrete is made to fallibility and lessened the dead weight.

Lightweight concrete can be difined as a type of concrete which includes an expanding agent in that it increased the volume of the mixture while giving addition qualities such as nailbility and lessened the dead weight. It is lighter than the conventional concrete with a dry density of 300 kg/m3 up to 1840 kg/m3 about 87 %- 23% lighter *(Kamsiah et al, 2003).*it was first introduced by the Romans in the second century where " The Pantheon" has been constructed using pumice, the most common type of aggregate used in that particular year (Roji,1997). The lightweight concrete is low density and thermal conductivity. It is advantages are that there is a reduction of dead load, fasting building rates in construction and lower haulage and handling costs.

2.2 LIGHTWEIGHT CONCRETE

Lightweight concrete can be prepared either by air in its composition or it can be achieved by omitting the finer sizes of the aggregate or even replacing them by a hollow, cellular or porous aggregate. Then, lightweight concrete can divided by three groups such as no fines concrete, lightweight aggregate concrete and aerated/ foamed concrete. For this study, lightweight aggregate concrete type used because the coarse aggregate replaced with artificial offshore coarse aggregate to make the lightweight concrete. Table 2.1 shows the advantages and disadvantage of lightweight concrete.

Table 2.1 Advantages and disadvantage of lightweight concrete.

Advantages	**Disadvantages**
Significant reduction of overall weight results in saving structural frames, footing or piles.	Very sensitive with water content
Economical in term of transportation as well as reduction in manpower.	Difficult to place and finish because of the porosity and angularity of the aggregate.
Rapid and relatively simple construction	Mixing time is longer than conventional concrete to assure proper mixing.

The differences between the types of lightweight concrete are very mush related to its aggregate grading used in the mixes. Table 2.2 shows the types and grading of aggregate suitable for the different type of lightweight concrete (Roji,1997).

Table 2.2: Types and grading of aggregate suitable for the different type of lightweight concrete.

Sources: Roji (1997)

Types Of Lightweight Concrete	**Type Of Aggregate**	**Grading of Aggregate**
No-fines concrete	-Natural aggregate -Blast-furnace slag -Clinker	Nominal single-sized material between 20mm and 10mm BS sieve
Partially compacted lightweight aggregate concrete	-Clinker -Foamed slag. -Expanded Clay, shale, slate, vermiculite and perlite. -Sintered pulverized-fuel ash and pumice.	May be of smaller nominal single sizes of combined coarse and fines (5mm and fines) materials to produce a continues but harsh grading to make a porous concrete.
Structural lightweight aggregate concrete	-Foamed slag - Expanded Clay, shale, slate, and sintered pulverized fuel ash	Continues grading from either 20 mm or 14 mm down to dust, with a increased fines content (5mm and fines) to produce a workable and dense concrete.
Aerated concrete	-Natural fine aggregate -Fine lightweight aggregate -Raw pulverized-fuel ash -ground slag and burnt shales	The aggregate are generally ground down to finer powder, passing a 75 m BS sieve, but sometime fine aggregate (5mm and fines) is also incorporated.

2.2.1 No Fines Concrete

No fines concrete can be defined as a lightweight concrete composed of cement and fine aggregate. The uniformly distributed voids are formed throughout it mass. The main characteristics of this type of lightweight concrete is it maintains its large voids and not forming laitance layers or cement film when placed on the wall (Kamsiah et al, 2003). In this no fines concrete does not contain coarse aggregate

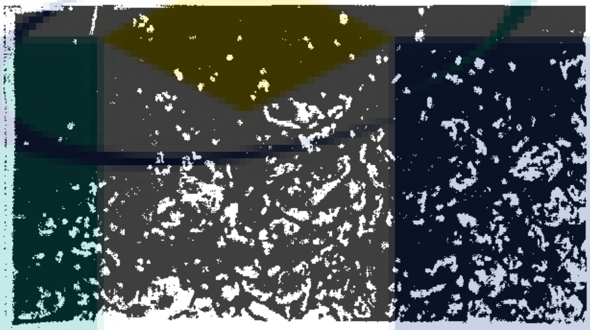


Figure 2.1: No fines concrete

Sources: Kamsiah et al (2003)

2.2.2 Lightweight Coarse Aggregate Concrete

The lightweight aggregate concrete can be divided into two types such as partially compacted lightweight aggregate concrete and structural lightweight aggregate concrete. The partially compacted lightweight aggregate concrete is mainly used for two purposes that are for precast concrete blocks or panels and cast in-situ roofs and walls. Structurally lightweight aggregate concrete is fully compacted similar to that of the normal reinforcement concrete of dense aggregate. It can be used with steel reinforcement as to have a good bond between the steel and the concrete. The concrete should provide adequate protection against the corrosion of the steel. The shape and the texture of the aggregate particles and the coarse nature of the fine aggregate tend to produce harsh concrete mixer (Kamsiah et al, 2003). The lightweight aggregate can be natural aggregate such as pumice, scoria and the artificial aggregate such as expanded blast-furnace slag, vermiculite and clinker aggregate. In this study, we use artificial offshore sand coarse aggregate replaced the natural coarse aggregate. Figure 1 shows the picture of lightweight aggregate concrete.

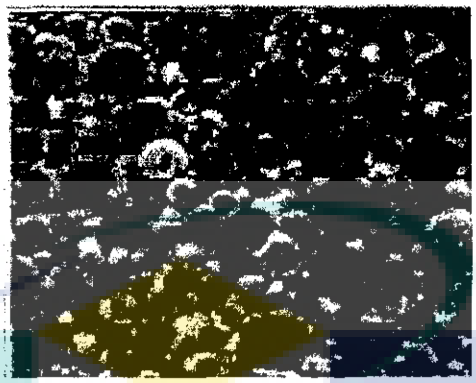


FIGURE 2.2: Lightweight Aggregate Concrete

Sources: Kamsiah et al, 2003

2.2.2.1 Properties of Lightweight Coarse Aggregate Concrete

Neville & Brooks stated there are various type of lightweight aggregate available allow the density of concrete to range from 300 kg/m^3 until 1850 kg/m^3 with a corresponding strength range of 0.3 Mpa until 40 Mpa and sometimes even higher. Then, properties which have to be considered for lightweight coarse aggregate concrete are workability, absorption, drying shrinkage, and moisture movement. For equal workability, lightweight aggregate concrete registers a lower slump and lower compacting factor than normal weight concrete because the work done by gravity is smaller in case of the lighter material (Neville & Brooks, 2010). According to Neville & Brooks (2010), the porous nature of lightweight aggregates means that they have high and rapid water absorption. For example, if the aggregate is dry at the time of mixing, it will rapidly absorb water and the workability will quickly decrease. For this study, we will produce semi - lightweight concrete because only replaced coarse aggregate. Typically, for the same workability, semi- lightweight aggregate concrete will require 12 to 14 per cent less mixing than lightweight aggregate concrete (Neville & Brooks, 2010). After that, Neville & Brooks stated partial replacement of fine aggregate by normal weight fines is also possible. In any case, replacement should be on an equal volume basis.

2.2.3 Aerated Concrete

The other type lightweight concrete is aerated concrete. Aerated concrete does not contain coarse aggregate and can be regarded as aerated mortar. Typically, aerated concrete is made by introducing air or other gas into a cement slurry and fine sand. In commercial practices, the sand is replaced by pulverized- fuel ash or other siliceous material and lime maybe used instead of cement (Roji,1997).

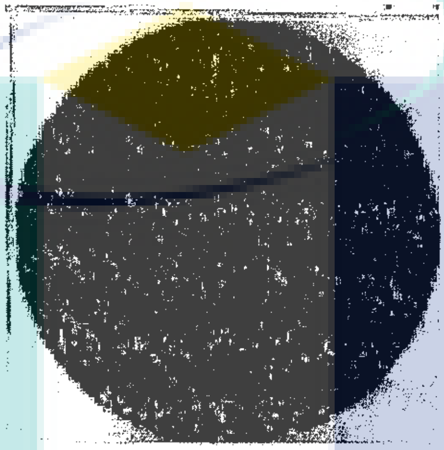


Figure2. 3: Aerated Concrete

Sources: Kamsiah et al (2003)

2.3 COMPRESSIVE STRENGTH

Compressive strength is the primary property of concrete (other are generally defined from it) and is the one most used in design. It is one of the fundamental properties used for quality control for lightweight concrete (Kamsiah et al, 2003). Compression strength of the foam concrete decreases exponentially with a reduction in density of the foam concrete (Kearsley et al ,1996). In this study, we compare the compressive strength of the concrete between using artificial offshore sand coarse aggregate and natural coarse aggregate.

2.4 DENSITY

The density of both fresh and hardened concrete is of interest to the parties involved for numerous reasons including its effect on durability, strength and resistance to permeability. Table 2.2 shows the density of hardened concrete and compressive strength at 28 days (Kamsiah et al, 2003). The dry density of lightweight concrete is 300 kg/m^3 up to 1840 kg/m^3 lighter than the conventional concrete. Lightweight concrete can reduce the dead weight of the structure up to 15 % or more. Then, BS E 206-1 defines lightweight aggregate concrete as concrete produced using lightweight aggregate for all or part of the total aggregate. The aggregate compression about 70 % of the volume of concrete, reduction in density is more easily achieved by replacing all or part of the normal weight aggregates where having a density about 2300 kg/m^3.

Table 2.3: Density of hardened concrete and compressive strength at 28 days

Density (Kg/m^3)	Compressive strength (KN/m^3)	Density (Kg/m^3)	Compressive strength (KN/m^3)
1470	2.52	1840	16.78
1720	5.5	1920	16.73
1770	10.34	1990	16.58
1780	9.19	2040	17.27
1810	13.12	2040	12.18
1820	11.87	2050	9.35
1840	13.21	2060	22.99

Sources: Kamsiah et al (2003)

2.5 WORKABILITY

Workability depend on a number of interacting factors such as water content, aggregate type and grading, cement ration, presence of admixture and fineness of cement. The main factor is the water content of the mix since by simply adding water the inter particle lubrication is increase. Lightweight aggregate tend to lower the workability and a lower compacting factor than normal weight concrete because the work done by gravity is smaller in the case of the lighter material (Neville & Broocks, 2010). The slump for lightweight aggregate concrete will tend to be lower than that of normal concrete of the same workability about 25 mm for lower slump concrete.

2.6 AGGREGATE

Aggregate is one part of three elements in concrete. At least three-quarters of the volume of concrete is occupied by aggregate. After that, not only may the aggregate limit the strength of concrete, but the properties of aggregate can affect the durability and structural performance of concrete. Usually, aggregate only viewed as an inert material dispersed throughout the cement paste largely for economic reasons because aggregate can reduce cement content and it can affect the cost. But, the opposite view aggregate as a building material connected into a cohesive whole by means of the cement paste. In fact, aggregate is not truly inert and its physical, thermal, and sometimes also chemical properties influence the performance of concrete.

2.6.1 Strength Of Aggregate

Neville stated compressive strength of concrete usually not significantly exceeded that of the major part of the aggregate contained in concrete. Additional, the required information has to be obtained usually from indirect test, crushing value of bulk density, force required to compact bulk density aggregate and performance of aggregate in concrete (Neville, 2012). According to Neville (2012), if the aggregate under test leads to lower compressive strength of concrete, and in particular if numerous individual aggregate particles appear fractured after the concrete specimen has been crushed, then the strength of the aggregate is lower than the nominal compressive strength of the concrete mix in which the aggregate was incorporated. Then, Neville also stated the strength of aggregate represents a limiting case because the physical properties of aggregate have some influence on the even strength of concrete even when the aggregate by itself is strong enough not to fracture prematurely.

A good average value of the crushing strength of aggregate is about 200 Mpa but many excellent aggregates range in strength down to 80 Mpa. For these study, granite is usually type of rock used for make concrete sample. Table 2.4 shows compressive strength of America rocks commonly used as concrete aggregates.

Table 2.4: Compressive strength of America rocks commonly used as concrete aggregates.

		Compressive strength					
				After deletion of extremes			
		Average		Maximum		Minimum	
Type of rock	Number of sample	Mpa	psi	pa	MM psi	Mpa	psi
Granite	278	181	26 200	257	37 300	114	16 600
Felsite	12	324	47 000	526	76 300	120	17 400
Trap	59	283	41 100	377	54 700	201	29 200
Limestone	241	159	23 000	241	34 900	93	13 500
Sandstone	79	131	19 000	240	34 800	44	6 400
Marble	4	117	16 900	244	25 400	51	7 400
Quartzite	26	252	36 500	423	61 200	124	18 000
Gneiss	36	147	21 300	235	34 100	94	13 600
Schist	31	170	24 600	297	43 100	91	13 200

Sources: Neville (2012)

- For most samples, the compressive strength is an average of 3 to 15 specimens.
- Average of all samples.
- 10 per cent of all samples tested with highest or lowest values have been deleted as not typical of the material.

After that, there are several mechanical properties of aggregate are of interest to determine the strength of aggregate such as Aggregate Impact Value Test, LA Abrasion Test, Aggregate Crushing Value Test and Ten Percent Fines. According to Neville (2012), attempts to develop a test for lightweight aggregate, similar to the crushing value test, have been made but no test has been standardized. Table 2.5 show average value of crushing strength, aggregate crushing value, and abrasion, impact and attrition value for the different rock group of BS 812: Part 1 : 1975.

Table 2.5: Show average value of crushing strength, aggregate crushing value, and abrasion, impact and attrition value for the different rock group.

	Crushing strength		Aggregate	Abrasion	Impact	Attrition Value +	
Rock group	MMpa	psi	crushing value	Value	Value	DDry	W
Basalt	200	29 000	12	17.6	16	3.3	5.5
Flint	205	30 000	17	19.2	17	3.1	2.5
Gabbro	195	28 500	-	18.7	19	2.5	3.2
Granite	185	27 000	20	18.7	13	2.9	3.2
Gritsone	220	32 000	12	18.1	15	3.0	5.3
Hornfels	340	49 500	11	18.8	17	2.7	3.8
Limestone	165	24 000	24	16.5	9	4.3	7.8
Porphyry	230	33 500	12	19.0	20	2.6	2.6
Quartzite	330	47 500	16	18.9	16	3.0	3.0
Schist	245	35 500	-	18.7	13	4.3	4.3

Sources: Neville (2012)

2.6.2 Lightweight Aggregate

Lightweight aggregate can be made between aggregates occurring in nature and manufactured. The main natural lightweight aggregates are diatomite, pumice, scoria, volcanic cinders and tuff (Neville & Brooks, 2010). For this study, artificial aggregate made from offshore sand was used to replacement the normal aggregate in concrete. Neville & Brooks stated, artificial aggregates are known by variety of trade names but are best classified on the basis of the raw material used and the method of manufacture.

According to Neville & Brooks (2010), the finer particles of lightweight aggregate generally have a higher apparent specific than the coarser ones. This is because by the crushing process fracture occurs through the large pores so that the smaller the particle the smaller the pores in it. Table 2.6 show typical range of density of concrete made with various lightweight aggregate.

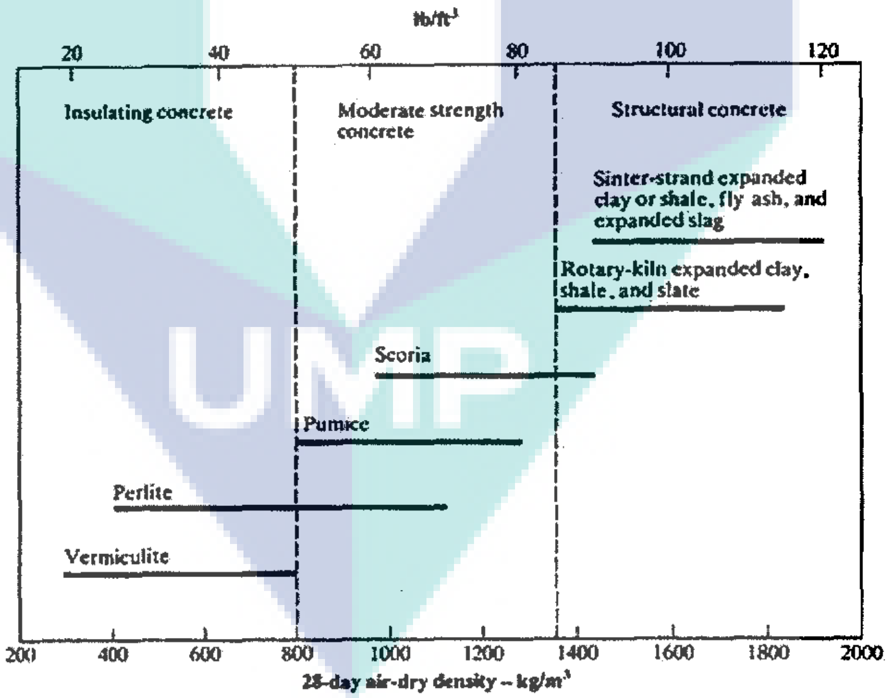


Figure 2.4: Typical range of density of concrete made with various lightweight aggregate.

Sources: Neville & Brooks (2010)

2.7 OFFSHORE SAND

Offshore sand is feasible and financially viable option for reclamation project but suggested offshore sad taken from 1.5 km away with depth greater than 10 m (Abdullah, 1992). In this study, offshore sand take from land reclamation project in Pantai Klebang at Melaka. Dias (2007) stated there is a study done on Sri Lanka beach sands has also shown fairly high chloride levels in some samples. The use of sea water for batching or for curing and would also promote corrosion. The purpose of using offshore sand is because the environmental and ecological impact from extracting the sand from 15 m below sea level is minuscule. Using sea sand is not a viable solution due to the impacts it has such coastal erosion, salt water intrusion into rivers and collapsing of river banks (Dias, 2007). In these study, there are new alternative of using offshore sand as a viable replacement for river sand.

Table 2.6: Chloride content with used Silver Nitrate solution

Sources: Shantha *(2006)*

2.7.1 Chloride Content in Offshore Sand

The chloride content in offshore sand depends on the chloride content in sea water. The offshore contains relatively constant chloride content but more moisture content in sand retains more chloride around particles. In hot climates, through the moisture content is less, due to evaporation of moisture chloride coating will be formed around particles (Shantha, 2006). Offshore sand should be removed the chloride content until achieve the acceptable level. The most commonly used limit for total chlorides is the 0.4% limit (by weight of cement) specified in BS 5328: Part 1: 1997 for reinforced concrete (Dias et al, 2007). According to Shantha (2006), and by reference BS 812-117:1988 using Silver Nitrate solution. Table 2.4 show the chloride content of sand and offshore sand.

Samples	Cl^- content (%)
Sample form sea shore	0.16
Samples from stock pile (Offshore)	0.03

After that, Table 2.1 shows the result from the sand column test for typical offshore sand. Where the test method itself is concerned, it appears that generally high level of moisture remain at the bottom of the column. This may be due to capillary action in the sand that retains moisture. The $Cl^{-\%}$ in offshore sand saturated with sea water can be obtained from the level D value in Set 2: the sand at the Set 1 stage may be "oversaturated", having 15.7 % moisture. At the Set 2 stage the moisture at level D is around 12%, similar to the upper limits quoted and the chloride level around 0.3 % (Dias et al, 2007).

Table 2.7: Result of sand column test.

Sources: Dias *et al, 2006*

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter will discuss in detail the procedure in carrying out the experimental work and laboratory test to achieve objective of this study. There are variety test involved in project such as test chloride and X- Ray Fluorescence (XRF) test for both between

Sampling level	Set 1 – sea water; 5 days' drainage		Set 2 – sea water; 27 days' drainage		Set 3 – 80 mm rain water; 5 days drainage		Set 4 – additional 240 mm rain water; 5 days drain	
	Moisture (%)	Cl^- (%)	Moisture (%)	Cl^- (%)	Moisture (%)	Cl^- (%)	Moisture (%)	Cl^- (%)
A	2.1	0.044	1.37	0.115	2.22	0.008	2.37	0.0003
B	3.94	0.088	2.38	0.054	3.44	0.007	3.58	0.0002
C	3.2	0.061	2.79	0.069	2.96	0.03	2.99	0.0016
D	15.69	0.387	12.39	0.314	8.88	0.075	9.97	0.0459

offshore sand and river sand, test artificial offshore sand coarse aggregate, fresh concrete test like slump test and hardened concrete testing like compressive strength and flexural test.

As in this project, these tests have to be carried out on the artificial offshore sand coarse aggregate as well as the concrete produced from these aggregate. The data and result as obtained from their test will not imply to the actual properties and performance of lightweight concrete produced from the artificial offshore sand coarse aggregate as found in Malaysia.

There are 2 grade of concrete mix such as lightweight concrete with density of concrete is 1600 kg/m^3 and grade 35. All the detailed is shows in Table 3.1 below and Table 3.2 shows the test will be conduct to completing of this project and Table 3.3 shows the details of the hardened concrete test.

Table 3.1: Grade of the concrete mix

No of lightweight concrete	Type of concrete mix
1	Lightweight concrete with 1600 kg.m^3 density.
2	Grade 35 (Fully artificial offshore sand coarse aggregate)

Table 3.2: Different Type of Test Conducted

Category of Test	Type Of Test
Element content offshore sand and river sand	X- Ray Fluorescence (XRF) Test

Chloride content offshore sand and river sand	Test Produce Chloride Content
Lightweight aggregate strength	LA Abrasion Test Aggregate Crushing Value
Fresh Concrete Test	Slump Test
Hardened Concrete Test	Compressive Strength Test Flexural Strength Test

Table 3.3: Details of The Hardened Lightweight Concrete Test

Types of The Hardened Lightweight Concrete Test	**Type of concrete mix**
Compressive Strength Test	-To be carried out at 7, 14 and 28 days of age -Involving all 2 type of concrete mix -3 samples of cube for each day
Flexural Strength Test	-To be carried out at 28 days of age -Involving all 2 type of concrete mix -3 samples of cube for 28 day

3.2 MATERIALS AND THE PREPARATION

This section will mainly focus on the raw materials needed in the lightweight concrete production. These raw materials include Ordinary Portland Cement

(OPC), natural aggregate as fine and coarse aggregate, artificial offshore coarse aggregate and water.

3.2.1 Ordinary Portland Cements

There are variety types of Portland Cements currently available in market. In this study used Ordinary Portland Cement (OPC) to produce the concrete. This is because the kind of cement is widely used and is so prevalent that is assumed to be applied in most construction environment unless otherwise stated. Additional, Ordinary Portland cement is readily available in the laboratory.

Cement is cohesive upon mixing with water. It is binder to bind the coarse aggregate as well as fine aggregate. It is therefore important to select the correct type of the cement due to different construction environment.

3.2.2 Natural Coarse Aggregate

Natural aggregate is readily available in the laboratory. Before it can be used in concrete mixing, it has be cleaned form any impurities and organic matter because it can affect the properties of the hardened concrete. It also needs to be sieved analysis to obtain the particle size distribution for the conventional concrete. As in this project, the artificial coarse offshore sand coarse aggregate size required is 10 mm, 20 mm and 30 mm.

To obtain a quality mix of concrete, the aggregate used should not have in access of water. It should be in saturated surface dry stage so that the amount of water used in mixing concrete can cater the hydration process of cement property. However, in actual practices it is difficult to obtain aggregates have saturated dry condition.

3.2.3 Offshore Sand

Artificial offshore sand coarse aggregate is used to replace coarse aggregate in producing lightweight concrete. It is not readily available in the laboratory. Offshore sand collected on site at Pantai Klebang, Melaka. The location is choosing because in these areas are new reclamation project in Malaysia and the offshore sand.

3.2.4 Natural Fine Aggregate

Natural fine aggregate as used in concrete normally is a sand. It is filler materials is a sample of concrete mix to fill up all possible voids which appear in the mix. Before used the natural fine aggregate to produce a concrete mix, it is need to be sieve to ensure the uniformly of the particle size and remove all impurities which might appear in it.

3.2.5 Water

In concrete, water is needed to initiate the cohesive properties of the binder Portland cement through hydration process. It is important to have sufficient water but not excessive or insufficient water used in mixing concrete. It is because insufficient water results in incomplete hydration process of the Portland Cement in forming Calcium Silicate Hydrate gel. In the presence of excessive water, the hardened concrete will lose the strength. Water used in mixing concrete shall be fit for drinking which contain no injurious materials. In this study, tap water is chosen to mix the concrete.

3.3 CONCRETE MIX DESIGN

Concrete mix design is the process of determining required and specifiable characteristics of concrete mixture and the most popular and widely used is the DOE method. In the British usage, the selection of the mix ingredients and their proportions is referred to as mix design. After that, the American term mixture proportioning is unexceptional. The design imposes two criteria such as strength of concrete and its durability. There five stages of the DOE method:

Stage 1: Deals with strength leading to the free-water/cement ratio.

Stage 2: Deals with workability leading to the free-water content.

Stage 3: Combines the results of Stage 1 and Stage 2 to give the cement content.

Stage 4: Deals with the determination of the total aggregate content.

Stage 5: Deals with the selection of the fine and coarse aggregate contents.

For the purpose of this study, the concrete will be designed grade 35. Then, the same grade had fully of lightweight coarse aggregate for lightweight coarse aggregate concrete to compare the result between with natural concrete. The size of each cube will be 150mm x 150mm x 150mm and beam size will be 150mm x 150mm x 750mm.

3.4 MOULD PREPARATION

The required dimension of cube mould is 150mm x 150mm x 150mm and dimension of beam is 150mm x 150mm x 750mm is prepared and clear from all possible dusty materials. A layer must applied grease to the surface and bottom plate before pouring the concrete to avoid the hardened concrete from sticking to the mould wall. So, it eased removal of hardened concrete samples for curing.

3.5 SYNTHETIC LIGHTWEIGHT COARSE AGGREGATE PREPARATION

Before produce artificial offshore coarse aggregate, the offshore sand must be test the chloride content. It is because the chloride content of offshore sand must in acceptable level before it can produce the lightweight concrete. The artificial offshore coarse aggregate is making manually mixing the offshore sand, cement and water and foam. To produce the SLYCAG, we must control the form because we must control the density of the artificial coarse aggregates. Only the suitable density is used to produce the lightweight concrete and the density of the artificial coarse aggregate is 1600 kg/m^3 in this study. Figure 3.1 is show foam and compressor machine to make lightweight concrete.

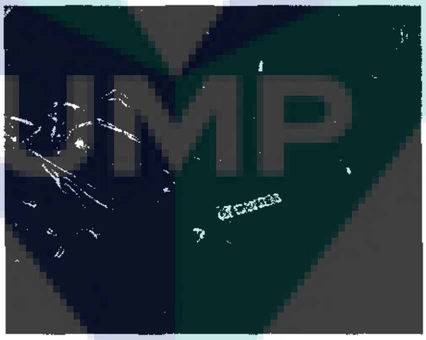


Figure 3.1: Foam and compressor machine

After that, the cube must be crush using jaw crusher before sieve the lightweight concrete with size 20 mm, 10 mm and 5 mm to obtain the particle size distribution for artificial offshore sand coarse aggregate. Then, grading requirement for coarse aggregate according to BS 882: 1992 to determine the percentage of SLYCAG. In this study, for size 20 mm is 60 percent, 10 mm is 35 percent and 5 mm is 5 percent. Figure 3.2 and figure 3.3 show Jaw Crusher and Sieve machine to produce artificial coarse aggregate.

Figure 3.2: Jaw crusher

Figure 3.3: Sieve machine

3.6 CONCRETE PREPARATION

There are three basic stages for concrete preparation. First stage is the mixing process of the raw materials, followed by placing and compacting and finally the curing process until the age of testing.

3.6.1 Mixing Process

Mixing of concrete is done suing concrete mixer. It is mean to coat the surface of all aggregates with cement paste, and to blend the concrete constituents into a uniform mass. The raw materials are measured and weighed to the amount as obtained from design calculation. Then, all the raw materials except water are mixed first to achieve uniformity. The mixing for concrete using SLYCAG, we change by volume for coarse aggregates.

Table 3.4: Mix proportion for Synthetic Lightweight Coarse Aggregate (SYLCAG) per m^3

Concrete label	Cement content, Kg	Water content, Kg	Offshore sand, Kg	Foam	Wet density. Kg/m^3	Dry density, kg/m^3
1600 kg/m^3	400	169	1110	yes	1699	1600

Table 3.5: Mix proportion for concrete grade 35 sample per m^3

Concrete label	Cement content, Kg	Water content, Kg	Fine sand, Kg	Coarse aggregate, Kg	Aggregate density. Kg/m^3	Concrete density, kg/m^3
G35	356	210	660	1150.5	2400	2296.30
SYLCAG	356	210	660	767	1600	2066.55

3.6.2 Placing and Compacting Process

Ready mixed concrete is then to be poured into the mould. For cube and beam, each mould is filled with three layers of concrete. For each layer of concrete must filled is about one-third of the height of mould, it is then followed by compacting process using vibrating. The purpose of using vibrating is to ensure each and every sample is subjected to constant effect of compaction. After all, the top surface of each mould leveled by towel. The concrete in mould is left to harden for 24 hours before proceed with curing process.

3.6.3 Curing Process

Curing process is important to ensure proper hydration of concrete to achieve the required strength at the early days. After the samples are hardened for 24 hours under room temperature, their moulds are removed respectively. These samples are then soaked in water for the curing process according to BS 1881, part 111 (1983). The curing period for this project are 7 days, 14 days and 28 days of concrete age for cube and for beam on 28 days concrete age.

3.7 LABORATORY TESTING

There are various tests involved in this project. This section will explained the procedures for each test to be carried out.

3.7.1 LA Abrasion Test

Los Angeles Abrasion Test accurately indicates the quality of the aggregate. In this study, the artificial offshore sand coarse aggregate and normal aggregate must be test to compare the result between normal aggregate and artificial aggregate.

The procedure of Los Angeles Abrasion Test:

i. The balance shall have a capacity of at least 5500 g and a sensitivity of 1 g or less.
ii. These sieves should be at least 300 mm in diameter. Standard 14, 12.5, 9.5 and 1.70-mm woven wire sieves shall conform to AASHTO Designation: M 92. These sieves should be at least 300 mm in diameter.

iii. Each abrasive charge shall consist of a solid, steel sphere having a mass between 390 and 445 g. A solid, steel sphere with a diameter of 46.5 ± 0.5 mm will typically meet this requirement. There should be 11 of them.

3.7.2 Aggregate Crushing Value (ACV) Test

The aggregate crushing value (AVC) test method consists of subjecting a compacted specimen of aggregate particles to a static load, the measuring the amount of breakdown. In this study, the aggregate crushing value test is also same like the LA abrasion test to determined the quality of aggregate between normal aggregate and artificial offshore coarse aggregate. Figure 3.2 show the Aggregate crushing Value Test machine.

The procedure of Aggregate Crushing Value Test:

i. Open ended steel cylinder of nominal 150mm internal diameter with plunger and base plate.

ii. A tamping rod with a16mm diameter and 600mm long.

iii. Balance weight 3kg minimum capacity.

iv. British standard sieve of sizes 14.0mm, 10.0mm and 2.36 mm beaker.

v. Compression testing machines which is capable of applying force of 400kN.

vi. Cylinder metal measure for measuring the sample.

Figure 3.4: Aggregate crushing value test machine.

3.7.3 Sieve Analysis

This test is customary for aggregates for concrete to be continuously, graded from their maximum size down to the size of cement grain. Since this ensures that all voids between larger particles are filled without an excess of fine material. Then, both crushed and uncrushed natural gravel have naturally continuous grading, but to comply with the standard the grading must be within certain limit. Sieve analysis test to produce a "Grading Curve" for fine and coarse aggregate according to BS 882. Figure 3.1 shows the mechanical sieve used to carry out the sieve analysis on coarse and fine aggregates.

Figure 3.5: Mechanical sieve

The procedure of sieve analysis:

i. A certain amount of coarse and fine aggregates let say 500 gram for each is collected.

ii. Prepare a stack of sieves having larger opening sizes (i.e lower numbers) are placed above the ones having smaller opening sizes (i.e higher numbers). Size of sieves for aggregates testing complies with BS 410. For coarse aggregate, standard sieve size of 20.0mm, 10.00mm, 5.0mm, 2.36mm and 1.18mm is used.

As for fine aggregates, standard sieve size of 5.00mm, 2.36mm, 1.18mm, 600µm, 300µm and 150µm is used.

iii. Put the sample inside on the top of sieve set.

iv. Shake the material trough each sieve individually into the collecting tray around 10 to 15 minutes.

v. When sieving is done, the weight of aggregates retained in each sieve is recorded and percentage of passing is calculated.

3.7.4 Slump Test

The workability of concrete mix defined as the case with which it can be mixed, transported, placed and compacted in position. Slump test is carried out to measure the consistency of plastic concrete. It is suitable for detecting changes in workability. This test is being used extensively on site. Figure 3.2 is show apparatus in used for slump test.

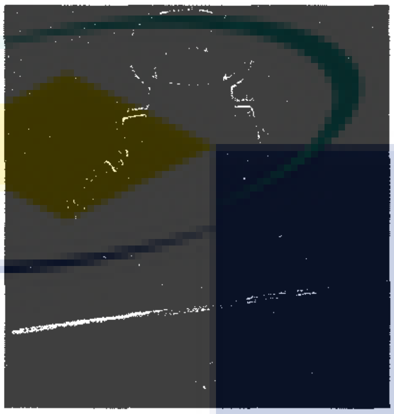


Figure 3.6: Apparatus in used for Slump test

Procedures involved in slump test are:

i. Ensure the internal surface of the mould is clean and damp but free from superfluous moisture before commencing the test.

ii. Place the mould on a smooth, horizontal, rigid and non-absorbent surface free from vibration and shock.

iii. Hold the mould firmly against the surface below. Fill in three layers, each approximately one-third of the height of the mould when tamped.

iv. Tamp each layer with 25 strokes of the tamping rod, the strokes being distributed uniformly over the cross-section of the layer.

v. After the top layer has been tamped, strike off the concrete level with the top of the mould with a saving and rolling motion of the tamping rod.

vi. With the mould still held down, clean from the surface below any concrete which may have fallen onto it or leaked from the lower edge of the mould.

vii. Remove the mould from the concrete by raising it vertically, slowly and carefully in 5 to 10 seconds, in such a manner as to impact minimum lateral or torsional movement to the concrete.

viii. The entire operation from the start of filling to the removal of the mould shall be carried out without interruption and shall be completed within 150 seconds.

ix. Immediately after the mould is removed, measure the slump to the nearest 5mm using a measuring scale to determine the difference between height of the mould and highest point of the specimen.

Generally, there are three possibilities of slump such as true slump, shear slump and collapse slump. Figure 3.3 shown the type of slump and only true slump is accepted on site and if happens that shear slump and collapse slump occurred, another sample has to be collected and the same procedures being repeated to obtain the amount of slump following BS 1881-102, 1983.

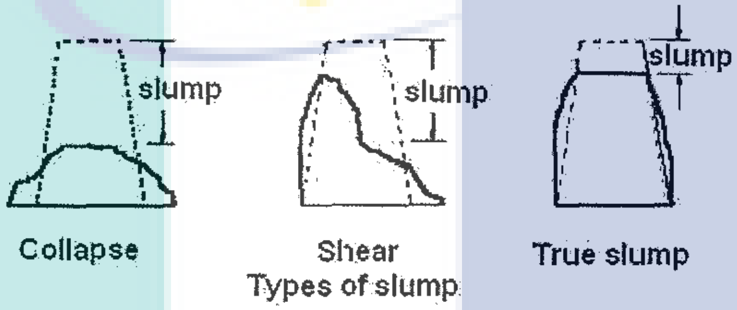


Figure 3.7: Types of slump (BS 1881 part-102, 1983)

3.7.5 Compressive Test

Compressive test of moist-curved specimen is conducted immediately after the removal of specimens from curing tank, with three hardened concrete specimens shall be used in the measurement of concrete strength at 7, 14 and 28 days. The test is carried out on cube samples which undergone curing for 7, 14 and 28 days. Details of the test are illustrated in BS 1881, Part 116 (1983). In compression test, concrete specimen is subjected to the compression load and obtaining the maximum load. The samples are further compressed to determine the type of failure. Figure 3.4 shows the compressive strength test machine and Figure 3.5 shows the type of failure.

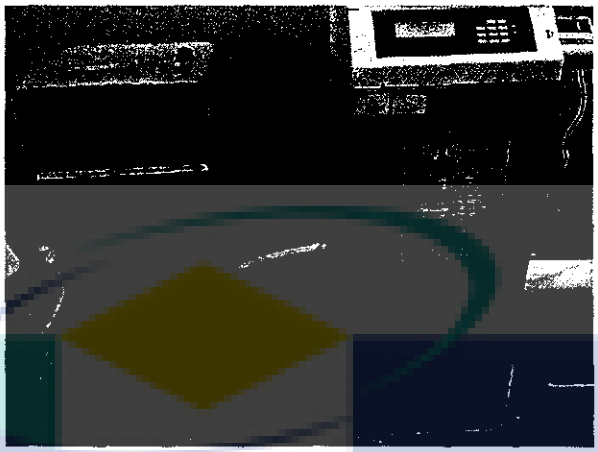


Figure 3.8: Compressive Strength Test Machine

The procedures in this test are:

i. Cubes for testing are removed from curing water after reaching the required curing days.

ii. The cubes and the testing machine bearing surfaces are cleaned to remove any possible loose grit so that the cubes can have full contract with the platens.

iii. Carefully placed the cube to the centre position of the platen so that loads can be applied equally to the cube.

iv. Load is applied continuously in an increasing nominal rate until no greater load can be sustained. The maximum load is recorded.

v. The load is applied again to the sample to determine for the type of failure. Compressive strength is calculated from equation below:

$$\text{Compressive strength} = \frac{P}{A}$$

Where,

P = Maximum load applied on the cube, kN

A = Surface area of concrete sample, m2

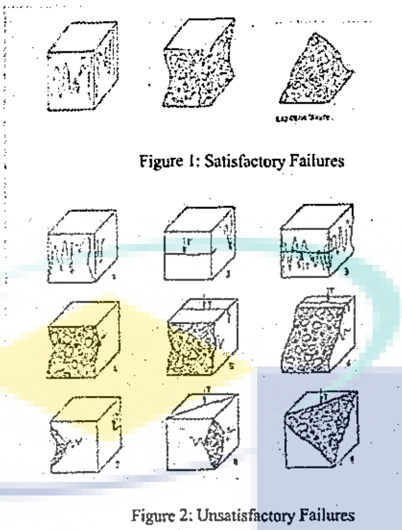


Figure 3.9: Type of Compressive Strength Test Failure

3.7.6 Flexural strength Test

Flexural test of moist-curved specimen is conducted immediately after the removal of specimens from curing tank, with two plain concrete beams shall be used in the measurement of concrete flexural strength at the 28 days. The concrete specimen is a plain (unreinforced) concrete beam that is subjected to the loading at the specified rate until failure occurs. The standards used are BS 1881: Part 118 and ASTM C 78-02. Figure 3.6 shows Flexural test machine.

The procedures in this test are:

i. The concrete beam accordance to the standard had been prepared.
ii. The diameter of each specimen was measured. In several locations, both horizontally and vertically would measurement. The point on the beam specimen was marking at the loading and reaction point.
iii. The concrete specimen was placed between the loading points.
iv. The load was applied slowly without a shock. The highest load reached until the beam fail was observe and recorded.
v. The modulus of rupture for the beam was calculated.

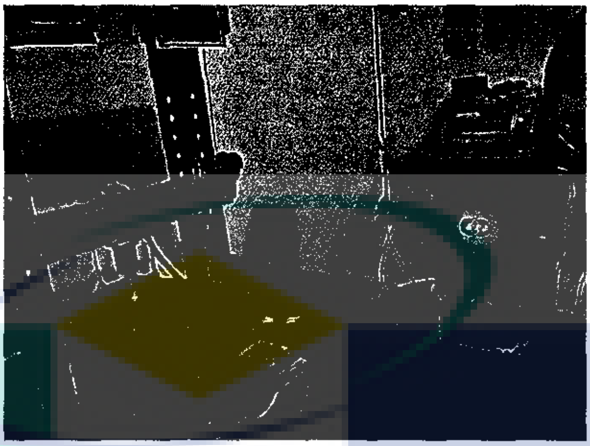


Figure 3.10: Flexural Strength Test Machine

3.7.7 Water absorption

The amount of water of water will absorb is measured using the water absorption test. The objective of this test is to determine the percentages of water absorb by concrete between concrete using SYLCAG and concrete using normal coarse aggregate. This test was performed three samples each concrete using SYLCAG and concrete normal aggregate at specified age and record its weight. After that, these samples were immersed completely in water for 24 hours and then weighing again on a balance. The percentages of water absorbed by concrete were calculated and take average result for concrete using SYLCAG and concrete using normal coarse aggregate. Below, show the formula to estimate water absorption of samples.

$$Wa = \frac{Ws - Wd}{Wd} \times 100$$

Wa = Percentage of water absorption

Ws = Weight of immersed blocks

Wd = Weight of dry blocks

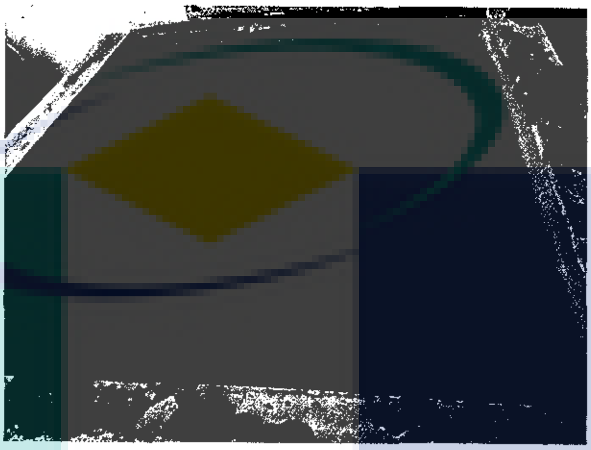
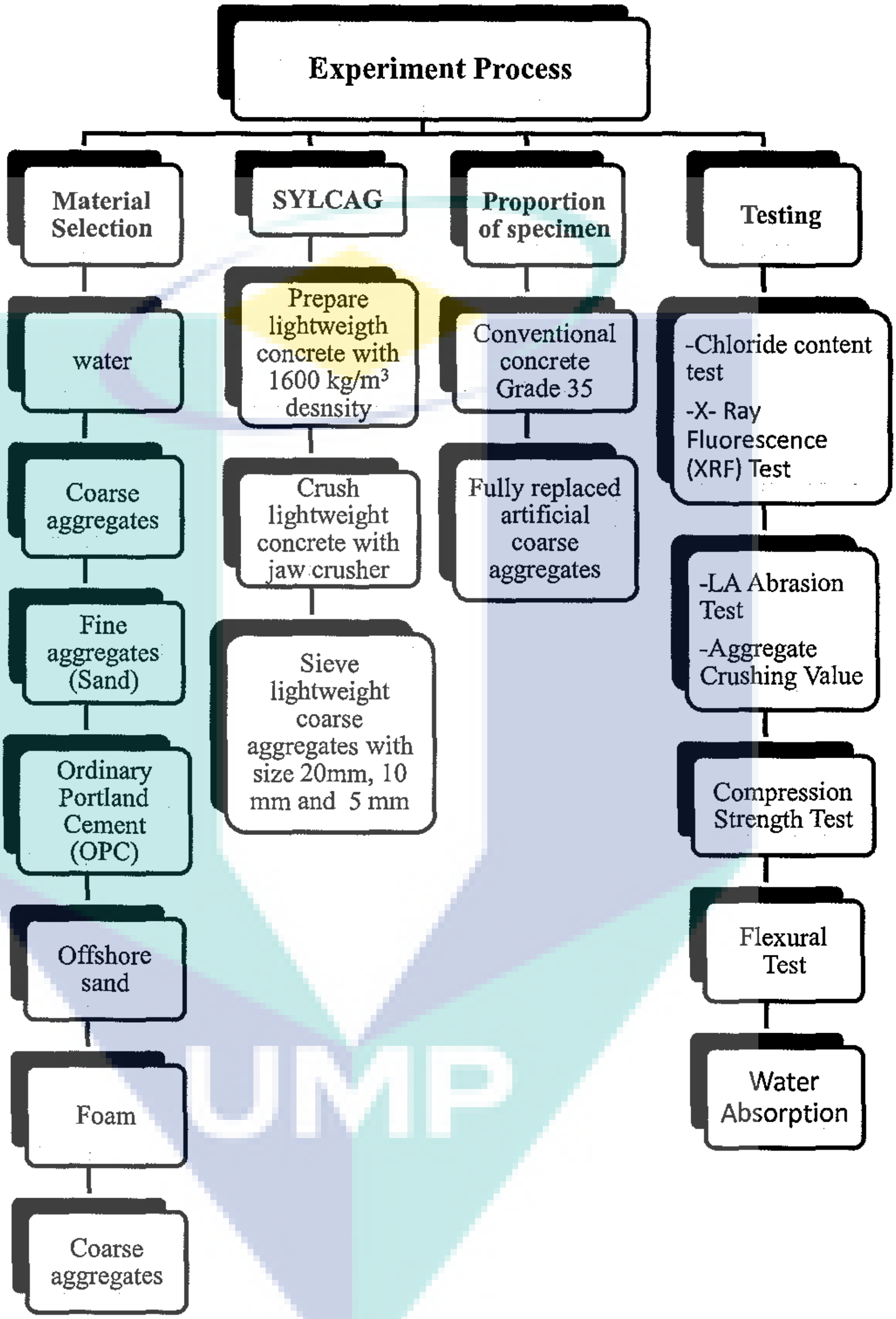


Figure 3.11: Water absorption

3.8 METHODOLOGY CHART


Experiment Process
Material Selection
SYLCAG
Proportion of specimen
Testing
water
Coarse aggregates
Fine aggregates (Sand)
Ordinary Portland Cement (OPC)
Offshore sand
Foam
Coarse aggregates
Prepare lightweigth concrete with 1600 kg/m³ desnsity
Crush lightweight concrete with jaw crusher
Sieve lightweight coarse aggregates with size 20mm, 10 mm and 5 mm
Conventional concrete Grade 35
Fully replaced artificial coarse aggregates
-Chloride content test
-X- Ray Fluorescence (XRF) Test
-LA Abrasion Test
-Aggregate Crushing Value
Compression Strength Test
Flexural Test
Water Absorption

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter presents the discussion and result of the testing from various tests conducted from this study. The results concrete using Synthetic Lightweight Coarse Aggregate (SYLCAG) consists compressive strength and flexural strength and water absorption of the concrete. After that, in this study also find the toughness and mechanical strength of the synthetic lightweight aggregate with 1600 kg/m^3 density with LA abrasion test and aggregate crushing value test. In term of presentation, all the analyzed data will be presented using table and graph to show the relationship between tested parameter.

4.2 OFFSHORE SAND AND RIVER SAND CHARACTERIZATION

The result obtained from the X-ray Fluorescence Test (XRF) to identifying the material content in offshore sand and river sand and make compare between two sand. It is because to seen the different between offshore sand and river sand except chloride content.

4.3 CHLORIDE TEST

The table 4.1 is show the chloride test between river sand and offshore sand.

No	Sample	Result of chloride	Unit	Test method
1	River sand	48	mg/L	In-House
2	Offshore sand	133	mg/L	In-House

Table 4.1: Result of Chloride

The result shows offshore sand have highest chloride content is 133 mg/L or 0.00133% content compare river sand is 48 mg/L or 0.0048%. It is show the offshore sand taken from surface in Pantai Klebang (reclamation project) is good and the chloride content is less than 0.4%. According Dias et all (2007), commonly used limit for total chloride is the 0.4% limit.

4.4 Sieve analysis

The result sieve analysis obtained as follows:

BS Sieve (mm)	Weight of Sieve (g)	Weight of Sieve + Sample (g)	Weight of Sample Retained (g)	Percent Mass Retained (%)	Cumulative (%)	Percent Finer (%)
20.000	1300.00	1300.00	0.00	0.00	0.00	100.00
14.000	1150.00	1250.00	100.00	16.67	16.67	83.33
10.000	1100.00	1200.00	100.00	16.67	33.33	66.67
5.000	950.00	1100.00	150.00	25.00	58.33	41.67
2.360	800.00	900.00	100.00	16.67	75.00	25.00
Pan	800.00	950.00	150.00	25.00	100.00	0.00
		Total	600.00	100.00		

Table 4.2: Sieve analysis data for SYLCAG

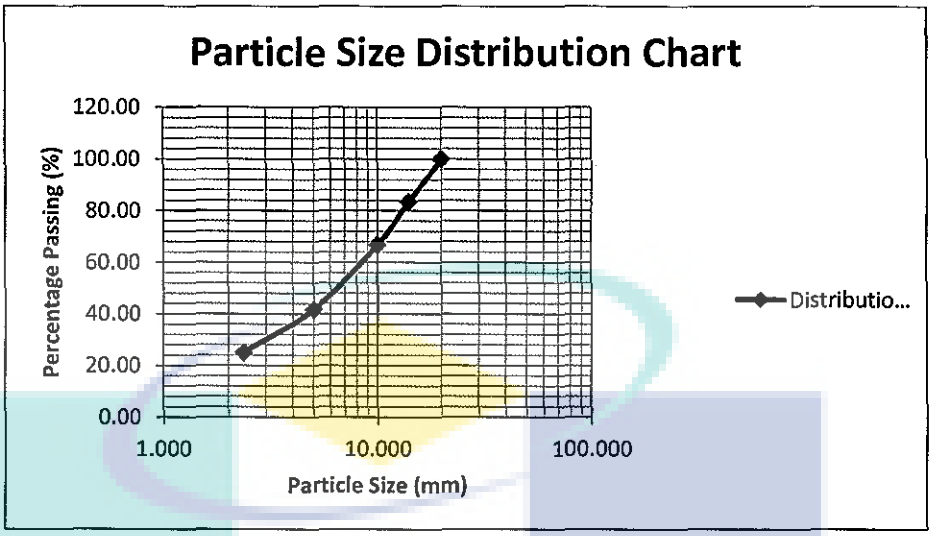


Figure 4.1: Particle size distribution chart for SYLCAG

BS Sieve Size (mm)	Weight of Sieve (g)	Weight of Sieve + Sample (g)	Weight of Sample Retained (g)	Percent Mass Retained (%)	Cumulative (%)	Percent Finer (%)
20.000	1300.00	1300.00	0.00	0.00	0.00	100.00
14.000	1150.00	1200.00	50.00	10.00	10.00	90.00
10.000	1100.00	1200.00	100.00	20.00	30.00	70.00
5.000	950.00	1200.00	250.00	50.00	80.00	20.00
2.360	800.00	900.00	100.00	20.00	100.00	0.00
Pan	800.00	800.00	0.00	0.00	100.00	0.00
		Total	500.00	100.00		

Table 4.3: Sieve analysis data for normal coarse aggregate

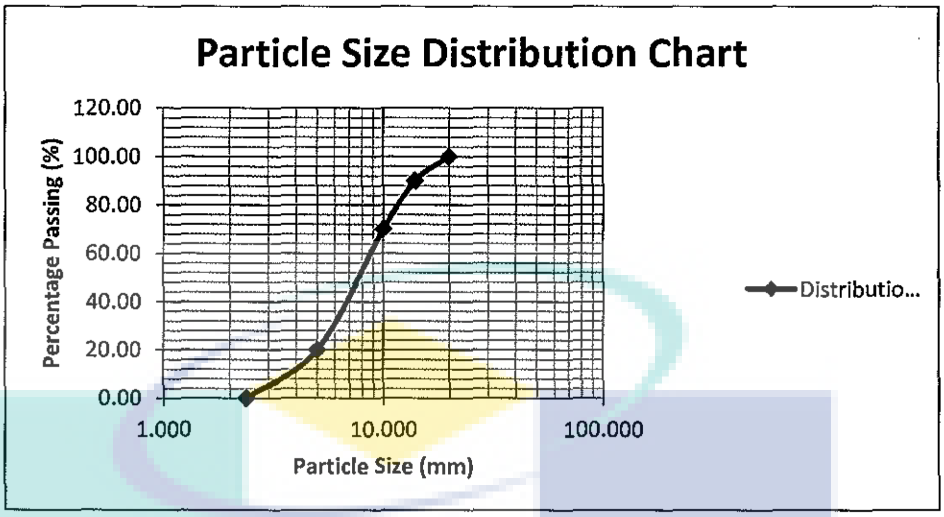


Figure 4.2: Particle size distribution chart for natural coarse aggregate

According to figure 4.1 above, 16.67 % of SYLCAG is retained at the sieve size 20 mm and 14 mm, 16.67% retained at the sieve size 10 mm and 25% retained at the sieve size 5 mm. After that, according to figure 4.2 above, 10 % of coarse aggregate is retained at the sieve size 20 mm and 14 mm, 20 % retained at the sieve size 10 mm and 50% retained at the sieve size 5 mm. The coarse aggregate grading replacement of SYLCAG in concrete is 65 % of 20 mm, 30% of 10 mm and 5% of 5 mm. The grading requirement to BS 882:1992. The grading can change to make the good result for example take the maximum percentages each coarse aggregate size.

4.5 LA ABRASION TEST

The result obtained and compare between SYLCAG and normal coarse aggregate.

Aggregate size (mm)	Weight of sample (g)		Loss (g)	Loss (%)
	Before	After		
19 - 14	**2500**	**5030**	**1390**	**27.8 %**
14 - 10	**2500**			**(Pass <40%)**

Table 4.4: LA Abrasion data for normal coarse aggregate

Percent wear (%) $= \frac{\text{weight loss}}{\text{initial weight}} \times 100$

$= \frac{1390}{5000} \times 100$

$= \mathbf{27.8\ \%}$

Aggregate size (mm)	Weight of sample (g)		Loss (g)	Loss (%)
	Before	After		
19 - 14	**2500**	**4970**	**2300**	**46%(not pass >40%)**
14 - 10	**2500**			

Table 4.5: LA Abrasion data for SYLCAG

Percent wear (%) $= \frac{\text{weight loss}}{\text{initial weight}} \times 100$

$= \frac{2300}{5000} \times 100$

$= \mathbf{46\ \%}$

There are two specifications limit given by Malaysia Public Work Department (JKR) and Los Angeles test that:

Malaysia Public Work Department (JKR)	LA
Max 50% for use in concrete	$\leq$ 40% if to be used in concrete
Max 40% for use in bituminous road surfacing	$\leq$ 45% for road base materials

Table 4.6: Specification limits Malaysia Public Work Department and L.A Test

According to table 4.5 above, the percentages loss for normal coarse aggregate is 27.8 %. Refer for Malaysia Public Work Department specifications, the quality and strength of aggregate is passed because the value less than 50 % for use in concrete. After that, refer for Los Angeles test also passed because the value less than 40% for used in concrete. Then, according to table 4.6 above, the percentages loss for SYLCAG is 46 % more than 40% refer Los Angeles test is not passed. Although, refer the Malaysia Public Work Department specifications, the percentages loss passed because more than 50% for used in concrete.

4.6 AGGREGATE CRUSHING VALUE

The result obtained and compare between SYLCAG and natural coarse aggregate.

Sample	Aggregate Size (mm)	Weight of Crushed Agg.(g)			% Loss
		Before(m1)	After(m2)	Loss(m3)	
SYLCAG	14-10mm	1600	1067	533	**33.31 > 30 (not pass)**
Normal coarse aggregate	14-10mm	2681.61	2050	630	**23.49 < 30 (pass)**

Table 4.7: Aggregate crushing Value data

According table 4.8 above, the percentages loss of SYLCAG is 33.31% and not passed because the value more than 30%. After that, for normal coarse aggregate is 23.49% less than 30% and the result passed. The lower percentages loss means the greater its ability to resist crushing.

4.6 COMPRESSIVE STRENGTH

The results obtained were divided by two which are synthetic lightweight coarse aggregate and comparison concrete using SYLCAG and using normal aggregate. The results are as follows:

DAYS	Sample	Weight (kg)	Max. Load (kN)	Stress (Mpa)
7 days	1	5.40	144.30	6.41
	2	5.35	140.80	6.26
	3	5.35	129.10	5.74
	Average	**5.37**	**138.07**	**6.14**
14 days	1	5.70	151.70	6.51
	2	5.75	149.70	6.44
	3	5.60	150.50	6.42
	Average	**5.68**	**150.63**	**6.46**
21 days	1	5.75	169.70	7.16
	2	5.80	150.18	6.66
	3	5.70	170.50	7.24
	Average	**5.75**	**163.46**	**7.02**
28 days	1	5.80	181.90	8.08
	2	6.00	228.60	10.16
	3	5.80	175.70	7.81
	Average	**5.87**	**195.40**	**8.68**

Table 4.8:Compressive strength of Synthetic Lightweight Coarse Aggregates.

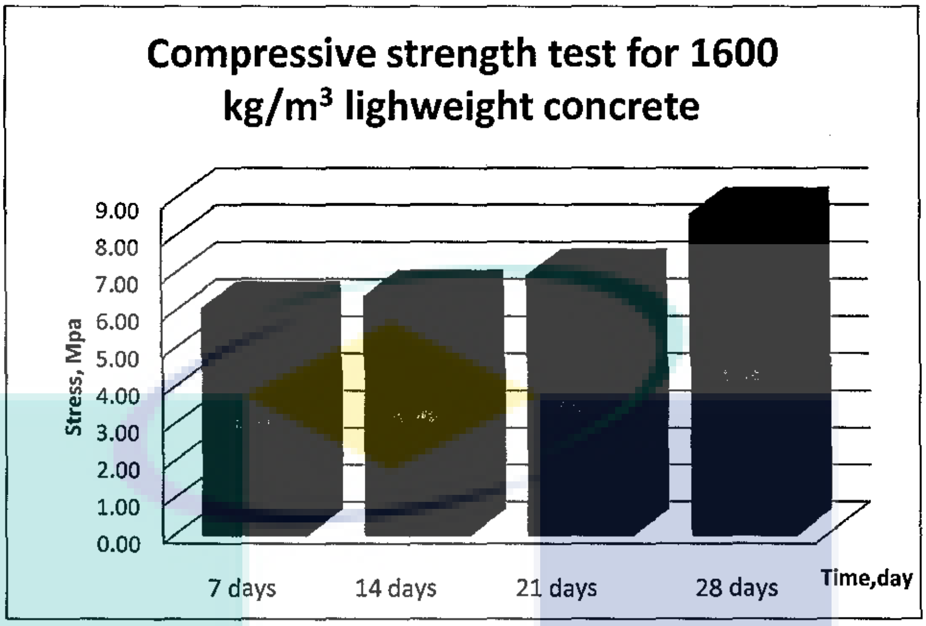


Figure 4.3: Compressive strength of Synthetic Lightweight Coarse Aggregates.

DAYS	Sample	Weight (kg)	Max.Load(KN)	Stress (Mpa)
7 days	1	6.80	376.00	16.71
	2	6.60	351.10	15.60
	3	6.71	358.52	16.25
	Average	**6.70**	**361.87**	**16.19**
14 days	1	6.90	384.30	17.08
	2	6.75	380.40	16.91
	3	6.86	382.10	17.05
	Average	**6.83**	**382.27**	**17.01**
28 days	1	7.05	395.30	17.57
	2	6.85	382.70	17.04
	3	7.05	395.30	17.57
	Average	**6.98**	**391.10**	**17.39**

Table 4.9: Compressive strength of concrete using SYLCAG

DAYS	Sample	Weight (kg)	Max. Load (kN)	Stress (Mpa)
7 days	1	7.60	533.20	23.70
	2	7.80	580.80	25.82
	3	7.70	572.40	25.44
	Average	**7.70**	**562.13**	**24.99**
14 days	1	7.60	533.10	23.70
	2	7.65	613.40	25.82
	3	7.70	630.20	25.44
	Average	**7.65**	**598.90**	**26.56**
28 days	1	7.70	761.40	33.84
	2	7.75	740.00	32.89
	3	7.80	709.10	31.52
	Average	**7.75**	**736.83**	**32.75**

Table 4.10: Compressive strength of concrete using normal aggregate

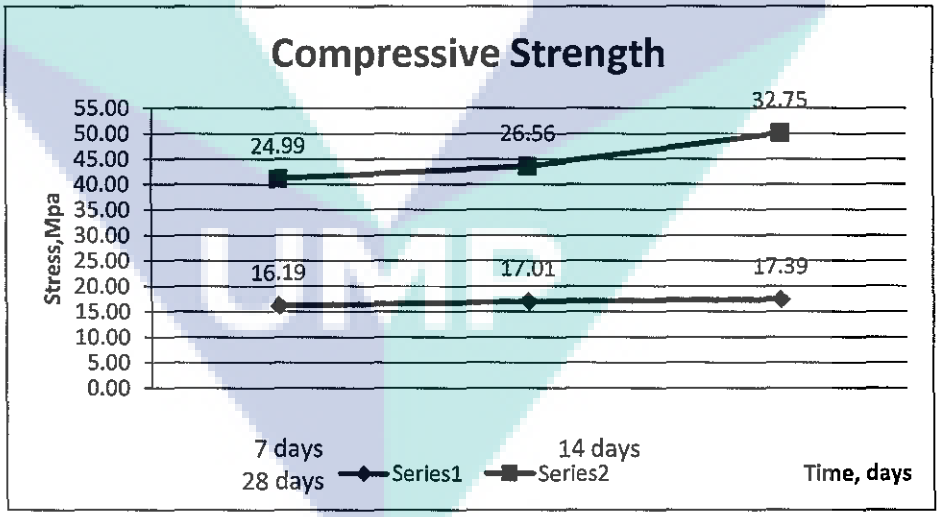


Figure 4.4: Compressive strength of concrete using SYLCAG and normal coarse aggregate.

According to figure 4.3 above show the compressive strength of Synthetic Lightweight Coarse Aggregate (SYLCAG) for 7 days, 14 days, 21 days and 28 days. The compressive strength for 7 days is 6.14 Mpa, 14 days is 6.46 Mpa, 21 days is 7.02Mpa and 28 days is 8.68 Mpa. The expected compressive strength for SYLCAG is more than 5 Mpa with density 1600 kg/m^3. In this study, the compressive strength at 28 days is higher than 5 Mpa. After that, according figure 4.4 above show the compressive strength concrete using SLYCAG and concrete using normal coarse aggregate. The compressive strength at 28 days for concrete using SYLCAG is 17.39 Mpa and concrete using normal coarse aggregate is 32.75 Mpa for grade 35. In this study, the expected compressive strength for concrete using SYLCAG is range 20 Mpa until 25 Mpa before make a new design for concrete using SYLCAG. So, the compressive strength for concrete using SYLCAG is not achieved. In this study, the concrete using normal aggregate only as a guide or limit and determine strength of compressive strength concrete using SYLCAG.

4.8 FLEXURAL STRENGTH

The results obtained were divided by two which are synthetic lightweight coarse aggregate and comparison concrete using SYLCAG and using normal aggregate. The results are as follows:

Group Name	Sample	Weight (g)	Length ,m	Max. Load (N)	bd^{2}, m	Stress (Mpa)
SYLCAG	1	3465	0.45	14640	0.003375	1.952
	2	3490	0.45	14600	0.003375	1.947
	3	3510	0.45	14670	0.003375	1.956
	Average	3488	0.45	14637	0.003375	1.952

Table 4.11: Flexural strength of Synthetic Lightweight Coarse Aggregate

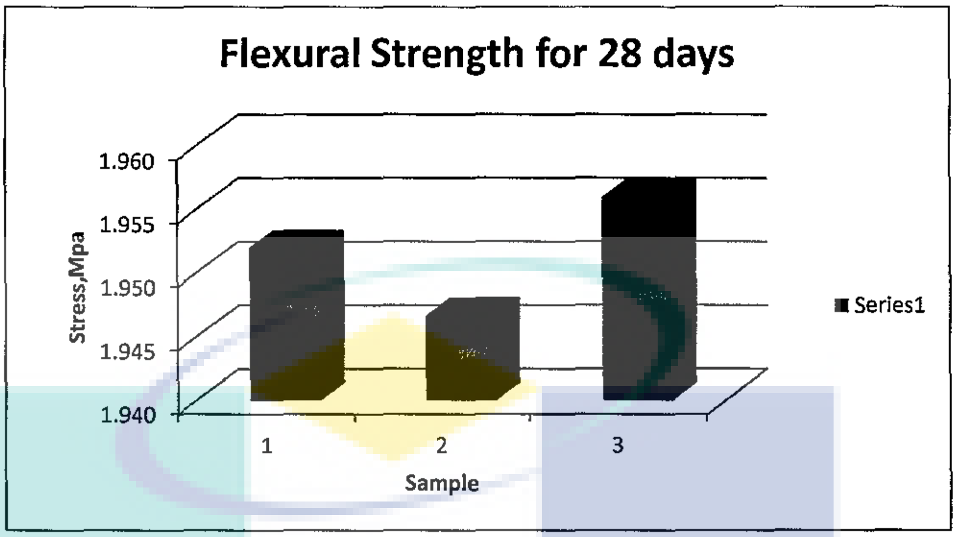


Figure 4.5: Flexural strength of Synthetic Lightweight Coarse Aggregates.

Sample label	Sample	Weight (g)	Length ,m	Max. Load (N)	bd^2, m	Stress (Mpa)
concrete using SYLCAG	1	3465	0.45	13900	0.003375	1.853
	2	3490	0.45	10900	0.003375	1.453
	3	3510	0.45	7000	0.003375	0.933
	Average	**3488**	**0.45**	**10600**	**0.003375**	**1.413**

Table 4.12:Flexural strength of concrete using Synthetic Lightweight Coarse Aggregates.

Concrete label	Sample	Weight (g)	Length, m	Max. Load (N)	bd^2, m	Stress (Mpa)
concrete using natural aggregate	1	3825	0.45	31800	0.003375	4.240
	2	3935	0.45	31310	0.003375	4.175
	3	3840	0.45	31600	0.003375	4.213
	Average	**3867**	**0.45**	**31570**	**0.003375**	**4.209**

Table 4.13:Flexural strength of concrete using normal coarse aggregate.

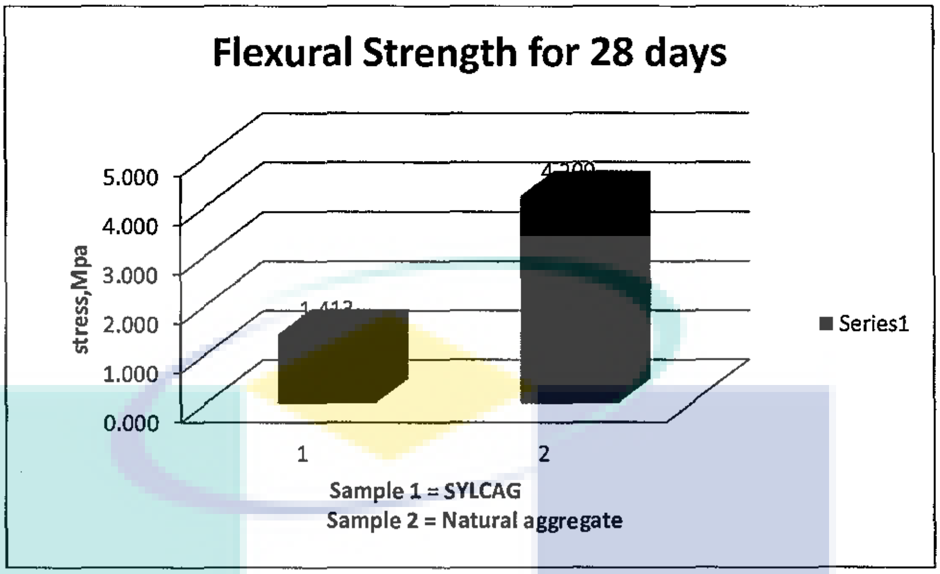


Figure 4.6:Flexural strength concrete using SYLCAG and normal coarse aggregate.

According figure 4.5, the flexural strength of the SYLCAG is not uniform between sample 1, sample 2 and sample 3. The flexural strength for sample no 1 is 1.952 Mpa, sample no 2 is 1.947 Mpa and sample no 3 is 1.956 Mpa. Although, the value is not same but the value still in range or the value still close each other. So, the flexural strength of SYLCAG can take average between 3 samples and the strength is 1.952 Mpa. After that, according figure 4.6 show the flexural strength of concrete using SYLCAG and using normal coarse aggregate. The flexural strength of concrete using normal coarse aggregate is 4.209 Mpa higher than concrete using SYLCAG. The flexural strength related with the density of the concrete. The density concrete using normal aggregate is high than concrete using SYLCAG. This is because the foam is used on SYLCAG to reduce the density of coarse aggregate and the foam has many voided in concrete. In this study, the concrete using normal aggregate only as a guide or limit and determine strength of flexural strength concrete using SYLCAG.

4.9 WATER ABSORPTION

The result of water absorption was obtained divided by two which are concrete using synthetic lightweight coarse aggregate and concrete using SYLCAG. The results are as follows:

Group Sample	Sample	Dry Weight (Kg)	Immersed Weight (Kg)	Water Absorption (%)
Concrete using SYLCAG	1	6.80	6.95	2.21
	2	6.80	7.00	2.94
	3	6.90	6.98	1.16
	Average	**6.83**	**6.98**	**2.10**
Concrete using normal coarse aggregate	1	7.70	7.83	1.
	2	7.75	7.85	15.09
	3	7.80	7.95	12.96
	Average	7.75	7.88	13.98

Table 4.14:Water absorption between concrete using SYLCAG and concrete using normal coarse aggregate.

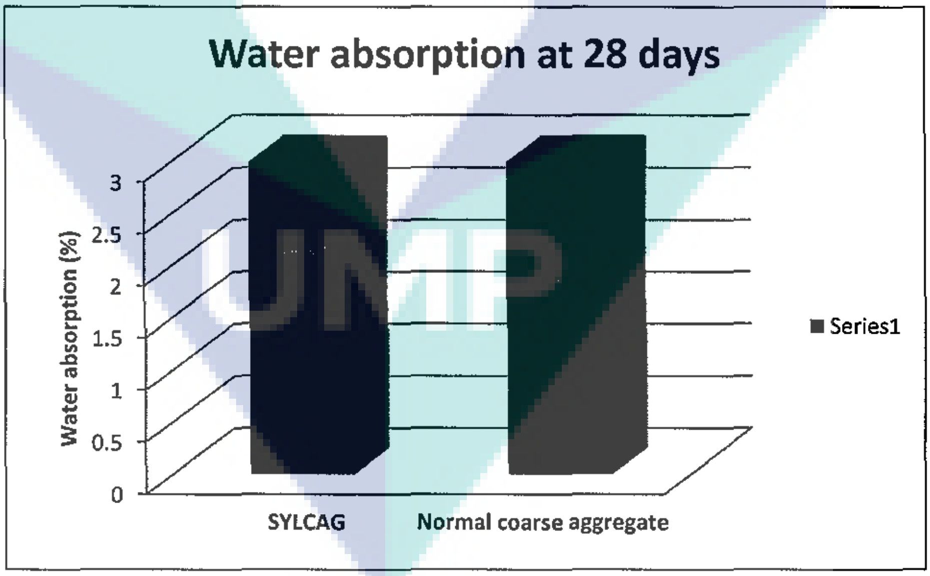


Figure 4.7:Water absorption of concrete using SYLCAG and normal coarse aggregate.

According to figure above, the percentage of water absorb by concrete using SYLCAG is higher than concrete using normal coarse aggregate. This is because the concrete using SLYCAG have foam and the foam absorbed more water because there are many air void on concrete compare concrete using normal coarse aggregate. The higher percentages of water absorb can decreased the strength of the concrete compared to the less percentages of water absorbed.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

As a conclusion drawn can be summarized based on the result and analysis of the test carried out from in this study as follows:

i. The compressive strength of SYLCAG with density 1600 kg/m^3 is 8.64 Mpa and the expected the compressive strength is more than 5 Mpa. So, the compressive strength of SYLCAG is passed on target or expected value.

ii. The density of the concrete using SYLCAG is 2024.69 kg/m^3 and it is lighter than concrete using normal coarse aggregate is 2400 kg/m^3 at 28 days.

iii. The compressive strength of concrete using SYLCAG is 17.39 Mpa and concrete using normal coarse aggregate is 32.75 Mpa with design grade 35 at 28 days. The expected strength is 20 until 25 Mpa. So, the compressive strength is not passed and must increase the design grade before make the new mix design concrete.

iv. The flexural strength of concrete using SYLCAG only 1.413 Mpa and concrete using normal coarse aggregate is 4.209 Mpa. The result of flexural strength is low because the concrete have lower strength for tensile strength but strength for compaction strength. In construction, reinforced concrete is used to apply on structure.

v. The water absorption of concrete using SYLGAG is 2.37 % and concrete using normal coarse aggregate is 2.10 % water absorption.

5.2 RECOMMENDATION

Concrete using SYLCAG is new in construction industry especially the synthetic lightweight coarse aggregate using offshore sand as alternative for river sand. Lightweight concrete in Malaysia is something new and have been exposed to the benefits. The strength of lightweight concrete is not strength but it still can apply to wall or slab element on building. However, regarding to result of this study, there are some improvement must be taken to ensure the desired requirement can be achieve in the future. The recommendations for future study are as follow:

i. Try to increase the grade concrete such as grade 40 or 45 is high strength concrete to achieve the expected strength concrete using SYLCAG.
ii. Make more sample of concrete using SYLCAG for this study to get more accurate result.
iii. Make sure the curing process is done properly because hydration process is very important toward strength of concrete.
iv. Make sure all the procedure must be follow to avoid mistake at reading and process because it can influence the strength of concrete.

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