EFFECT OF SPECIMEN SIZE AND SHAPE ON COMPRESSIVE STRENGTH OF FOAMED CONCRETE CONTAINING KENAF FIBER

ADEB ABOBAKR MOHAMMED QUMAYSH

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

UNIVERSITI MALAYSIA PAHANG

DECLARATION OF THESIS AND COPYRIGHT

Author's Full Name : ADEB ABOBAKR MOHAMMED QUMAYSH
Date of Birth : 12th December 1995

Title : EFFECT OF SPECIMEN SIZE AND SHAPE ON COMPRESSIVE STRENGTH OF FOAMED CONCRETE CONTAINING KENAF FIBER

Academic Session : 2018/2019

I declare that this thesis is classified as:

☐	CONFIDENTIAL	(Contains confidential information under the Official Secret Act 1997)*
☐	RESTRICTED	(Contains restricted information as specified by the organization where research was done)*
☑	OPEN ACCESS	I agree that my thesis to be published as online open access (Full Text)

I acknowledge that Universiti Malaysia Pahang reserves the following rights:

1. The Thesis is the Property of Universiti Malaysia Pahang
2. The Library of Universiti Malaysia Pahang has the right to make copies of the thesis for the purpose of research only.
3. The Library has the right to make copies of the thesis for academic exchange.

Certified by:

_______________________	_______________________
(Student's Signature)	(Supervisor's Signature)
__07633911___________	Pn. Rokiah Binti Othman
New IC/Passport Number	Name of Supervisor
Date: 14th January 2019	Date: 14th January 2019

THESIS DECLARATION LETTER (OPTIONAL)

Librarian,
Perpustakaan Universiti Malaysia Pahang,
Universiti Malaysia Pahang,
Lebuhraya Tun Razak,
26300, Gambang, Kuantan.

Dear Sir,

CLASSIFICATION OF THESIS AS RESTRICTED

Please be informed that the following thesis is classified as RESTRICTED for a period of three (3) years from the date of this letter. The reasons for this classification are as listed below.

Author's Name
Thesis Title

Reasons (i)

(ii)

(iii)

Thank you.

Yours faithfully,

____
(Supervisor's Signature)

Date:

Stamp:

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering.

____

(Supervisor's Signature)

Full Name : Pn. Rokiah Binti Othman

Position : Lecturer

Date : 14 January 2019

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

____

(Student's Signature)

Full Name : ADEB ABOBAKR MOHAMMED QUMAYSH

ID Number : AA14264

Date : 14 January 2019

EFFECT OF SPECIMEN SIZE AND SHAPE ON COMPRESSIVE STRENGTH OF FOAMED CONCRETE CONTAINING KENAF FIBER

ADEB ABOBAKR MOHAMMED QUMAYSH

Thesis submitted in fulfillment of the requirements
for the award of the
Bachelor Degree in Civil Engineering

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

JANUARY 2019

ACKNOWLEDGEMENTS

In the name of Allah SWT, most Grateful and most Merciful, Alhamdulillah, thank to Allah SWT for giving me strength and endurance in finding my thesis. This dissertation would not have been possible without the guidance of several individuals who extended their valuable assistance in preparation and completion of this study.

My sincere gratitude to my supervisor Pn. Rokiah Binti Othman who had given guidance for my work and came up with some inspiring suggestion, in the meantime, his patience in guidance me and for all his knowledge sharing, advices, enable me to develop an understanding of the subject. I also sincerely thanks to Pn. Rokiah Binti Othman for the time spent proofreading and correcting my many mistakes. It is an honour for me to thanks for everything, sir. Also thank to all the staff that help me in many way and their excellent co-operation especially during preparation and testing sample at laboratory, with their helps and guidance I have accomplished the testing according to the time.

Besides that, I would like to thank my parents those who have been supporting me since my childhood with all of their love and kindness who made this possible for me. Also, I would like to thank my wife and my siblings for supporting me all the way through my bachelor's degree. Finally, most thanks go out to my friends for helping me through thick and thin while doing this research. Without all of you, I would not be able to succeed and reach this level so thank you all for helping me.

Last but not least, I would like to thank my beloved family for their everlasting moral support and endless love to make me have the courage to go on in completing my study. Thank you very much to all. Hopefully this research can be shared and thus provide benefits to the needy.

ABSTRAK

Kajian terdahulu mengkaji kesan saiz dan bentuk spesimen pada kekuatan mampatan konkrit berbuih. Terdapat dua campuran konkrit berbuih (FC) dan konkrit berbuih yang mengandungi gentian kenaf (KFC). Semua spesimen telah diuji untuk menentukan kekuatan mampatan dan kebolehkerjaan konkrit berbuih. Saiz dan bentuk spesimen yang digunakan untuk kekuatan mampatan ialah kiub saiz 150 x 150 x 150 mm, 100 x 100 x 100 mm dan 50 x 50 x 50 mm dan silinder 150 x 300 mm dan 100 x 200 mm. Ketumpatan campuran direka sebagai 1600 kg / m^3. Dari hasil eksperimen, kedua-dua campuran menunjukkan peningkatan dalam kekuatan mampatan untuk semua saiz dan bentuk spesimen bentuk 7 hari hingga 28 hari. Berbanding dengan campuran FC, campuran KFC menjana kekuatan mampatan yang lebih tinggi kira-kira 12 MPa dalam saiz kiub 150mm x 150mm x150mm pada 28 hari dan mencapai 10 MPa dan 28 hari dalam saiz silinder 150mm x300mm.

ABSTRACT

Present research studies the effects of specimen size and shape on compressive strength of foamed concrete. There are two mixtures of foamed concrete (FC) and foamed concrete containing kenaf fiber (KFC). All specimens were tested to determine the compressive strength and workability of foamed concrete. The size and shape of specimens used for compressive strength were cubes of size 150 x 150 x 150 mm, 100 x 100 x 100 mm and 50 x 50 x 50 mm and cylinders of 150 x 300 mm and 100 x 200 mm. The mix density was design as 1600 kg/m^3. From the experimental results, both mixtures showed increases in the compressive strength for all sizes and shape of specimens form 7 days to 28 days. As compared to FC mix, the KFC mix generate higher compressive strength about 12 MPa in cube size 150mm x 150mm x150mm at 28 day and achieved 10 MPa at 28 day in cylinders size 150mm x300mm.

TABLE OF CONTENTS

LIST OF TABLES

TABLE OF FIGURES

LIST OF SYMBOLS

%	Percentage
σ	Strength
δ	Deflection

LIST OF ABBREVIATIONS

KFC	Foamed Concrete Containing Kenaf Fiber
FC	Foamed Concrete
KF	Kenaf Fiber
OPC	Ordinary Portland cement
ASTM	American Society for Testing and Materials
FKASA	Fakulti Kejuruteraan Awam dan Sumber Alam
UMP	Universiti Malaysia Pahang
w/c	Water-Cement ratio
s/c	Sand-Cement ratio
NaOH	Hydroxide Sodium
Kg/m^3	Kilogram per meter cube
MPa	Mega Pascal
mm	Millimetre
kN/m	kilo Newton per meter
kPa	kilo Pascal

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Foamed concrete is a lightweight concrete with lower density where it achieved through an elimination of coarse aggregate from the concrete. In addition, density of formed concrete ranged within 300 kg/m^3 up to 1800 kg/m^3 which the usage of lightweight concrete is significantly reduce the dead load of building physically, that in turn cause the decreasing of beam and column size which may cut the cost of the project. Hence, foamed concrete can be considered as the alternative to reduce the cement content, aggregates and environmental problem. Foamed concrete widely used in construction industry as insulation for non-structural application where it is containing air voids produced by adding foaming agents, where these agent creating pores within the concrete without any additional reaction between the chemical and the cement and it has been characterized by its low compressive strength and high insulation against heat and sound (Rudnai G., 2003).

For foamed concrete with cast density of 1440kg/m^3 or above, water reducing admixtures may be used to reduce the water to cement ratio in the mix and hence increase the compressive strength. According to (Siram KKB, 2013), studying foamed concrete and present generation's building solution had concluded that foamed concrete, having gained importance because of its wide range of applications which include thermal insulation, Fire resistance, Chemical resistance, Workability, Flow-ability, Sound absorption, Self-compacting, Density and Energy adsorption which become the problem solver for wide variety of challenges in construction, mining and manufacturing applications.

A Kenaf fiber is a type of natural fiber and is an annual growing to 1.5-3.5 m tall with woody base. The stems are 1-2 cm diameter often but not always branched. (Wang, Lam & Ramil, 2011), also, is seen as a promising green material as it reused natural resources in the concrete. Furthermore, owning to the benefits of fiber's tensile properties, inclusions of kenaf fiber in concrete resulted in better flexural and shear strength and ductility of the reinforced concrete structure. However, to ensure good performance, kenaf fiber similar like other type of natural fibers need to undergo some treatment to reduce high water absorption characteristic of the fiber One of the treatments recommended found to use a chemical such as sodium hydroxide (NaOH) to reduce the hydrophobic characteristic of the fiber. Thus, enhancing the adhesion between the fiber surface and the matrix. This was done by removing the hydroxyl group in cellulose and increasing the surface roughness which resulted in the improvement of the tensile properties of kenaf fibers as compared to untreated kenaf fibers (Elsaid et al., 2011).

The mechanical property that focused in this scope of study was compressive strength. In theory, foamed concrete produced a different value of compressive strength due to different density. The value of compressive strength for density 1200 N/mm^2 4.5 to 5.5 N/mm^2 then, the value of compressive strength for density 1400 N/mm^2 was 6.0 to 8.0 N/mm^2 and density 1600 kg/m^3 the value of compressive strength was 7.5 to 10.0 N/mm^2 (Aldridge, 2000).

Presently, this research was to investigate the effect of specimen size and shape on compressive strength of foamed concrete containing kenaf fiber. There are 2 common types of compression test which are cube test and cylinder test. In this study, the cube and cylinder strength was analysed in order to determine the relationship between them. Nowadays, the concrete structures was designed according to BS 8110 and the compressive strength referred by cube strength. However, in a few years, the European Standard, Euro-code 2 (EC2) will be used to replace British Standard (BS 8110) and described by characteristic of cylinder strength.(M.A.S. Sudin 2011).

1.2 Problem Statement

Nowadays, rapid development in our country makes the excessive uses of Ordinary Portland Cement (OPC). OPC produces approximately one tone of carbon dioxide per tons produced (Mahachi J, Golinger A M & Wagenaar F, 2004), raising significant environmental concerns. As the OPC is not very much economical friendly, many researches have been done to replace the use of OPC, as an example the aggregate is replaced with foam. Thus, makes the concrete lighter. It is found that the compressive strength of foamed concrete is mainly influenced by density (E. P. Kearsley & H. F. Mostert, 2005). So, the size and shape of specimen becomes an important parameter for the compressive strength of foamed concrete (Sarıdemir,2013).

1.3 Objective of Study

The goal of this study was to investigate the effect of specimen size and shape on compressive strength of foamed concrete containing kenaf fiber. The specific objectives of this study are:

i. To study the effect of specimen size on compressive strength of foamed concrete.
ii. To study the effect of specimen shape on the compressive strength of foamed concrete.
iii. To determine the workability of foamed concrete by using flow table test.

1.4 Scope of Study

This study was done to determine the effect of specimen size and shape on compressive strength of foamed concrete containing kenaf fiber. There are two mixtures of foamed concrete (FC) and foamed concrete containing kenaf fiber (KFC). All specimens were tested to determine the compressive strength and workability of foamed concrete. The size and shape of specimens used for compressive strength were cubes of size 150 x 150 x 150 mm, 100 x 100 x 100 mm and 50 x 50 x 50 mm and cylinders of 50 x 300 mm and 100 x 200 mm according to ratio of 5% of kenaf foamed concrete. All materials and specimens preparation were done based on standard code practice requirement of ASTM. The data from the results were analysed to determine the effect the specimen size and shape on the compressive strength of foamed concrete.

1.5 Significant of Study

Provide more knowledge on the performance of foamed concrete containing Kenaf fiber. The use of foamed concrete as the concrete replacement becomes more useful and promotes better environment compared to plain concrete.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discussed the studies related to the effect of specimen size and shape on compressive strength. It discussed about the materials, production and effect of using kenaf fiber in foamed concrete.

2.2 Foamed Concrete

Foamed concrete is a cementations material having a minimum of 20 percent (by volume) of mechanically entrained foam in the plastic mortar. It is known for its high flowability, low cement content, low usage of aggregate and good insulation of heat (R.C. Valore Jr, 1954). The difference between foamed concrete and aerated concrete is the bubbles are chemically formed through the reaction of aluminium powder with calcium hydroxide and other alkalis released by cement. Foamed concrete has a surprisingly long history and was first patented in 1923, mainly for use as an insulation material. Although there is evidence that the Romans used air entertainers to decrease density, this is not really a true foamed concrete (Sach and Seifert, 1999). However, the lack of specialist material and equipment, limited its use to small scale projects. Significant improvements over the past 20 years in production equipment and better-quality surfactants or foaming agent has enabled the used of foamed concrete on a larger scale (Walker and Clark, 1988).

One of the earliest, significant research develop on foamed concrete was carried out in the Netherlands in the late 1980s and 1990s (van, 1991). In addition to considering a range of constituent materials and different production methods, the extensive test programmed aimed at obtaining a database of foamed concrete properties as a function of its density. Some of the properties considered were compressive and bending tensile strengths, modulus of elasticity, heat conductivity, freeze-thaw resistance and absorption (Saridemir 2014).

Foamed concrete, which is sometimes referred to as cellular concrete but contrasts with air concrete, is a versatile material which consists principally of a cement- based mortar or paste mixed with at least 20% by volume of air. The most attractive characteristics of foamed concrete are flow ability, self-compacting and self-levelling nature, low dimensional change and ultra-low density.

In addition, the material can be designed to have controlled low strength, excellent thermal insulation properties, good load-bearing capacity and can easily re-excavated, if necessary, which is particularly useful in highway applications. The excellent durability performance of lightweight concrete has strengths comparable to normal-weight concrete, yet is typically 25% to 35% lighter, reducing the transportation and placement costs of precast elements (Aldridge, 2005).

Applying "specified density" technology may save money often even as moderate reduction in weight will allow for transportation advantages. For example, if a pre-cast element produced with lightweight aggregate concrete weighs 25% less than conventional concrete, you may be able to ship two double-tees together. Additionally, the ability to utilize "specified density" technology may assist with poor soil conditions (Alexander, 1977).

2.2.1 Advantages and Disadvantages of Foamed Concrete (FC)

The foamed concrete (FC) have advantages and disadvantages. The details were discussed in this present chapter.

2.2.2 Advantages

FC have many advantages such as it can reduces the dead weight of a structure which economies the design of supporting structure including the foundation and walls of lower floors, possesses high workability, ecological compatibility, produce protect from fire safety, good thermal and sound insulation properties. There are many benefits using FC such as substantial material saving like no gravel used and little cement used, easy and fast production, reduced costs and transportation and many more. However, the biggest advantages are the fact that it can be produced right on the spot of construction and be casted according to necessary shapes by pumping straight to where it is required (Alex, 2003). In addition, the FC also offers the advantages such as thermal insulation, cost savings and high durability.

2.2.3 Disadvantages

The process of proposing to utilize foamed concrete it is important to consider all design criteria particularly in the following area, compressive and flexural strength will degrade typically as a function of density, retention values of attachment fixtures again this is a function mainly of density. Particular attention needs to be given to those areas where continuous impact may occur and unless purpose designed equipment is used mixing may be a problem as the foam tends to float at the surface of the mix and thus its effectiveness is diminished. Issue readily addressed is injecting foam into rather than on to mix in the case of an open mixer or in the case where foam is introduced into a flowing product line it is not a problem (Lee 2003).

2.2.4 Applications of Foamed Concrete (FC)

Foamed concrete can be adopted in a wide variety of aspects in a building construction work. Some applications include wall panels, lightweight foundations, deep foundation backfills, load reducing fills (for vertical and lateral loading), roofing, trench reinstatement, road foundations, bridge abutments and void filling (voton, 2002).One of the most major applications in Malaysia is the SMART tunnel project in Kuala Lumpur. The foam concrete specified was of density 1800 kg/m^3 which achieved compressive strength of 3 N/mm^2 at the age of 28 days. The completed foamed concrete block serves to protect the diaphragm wall when the tunnelling machine is coming out into the junction box (Hung et al., 2005).

Other applications used were building houses. Houses can be built completely from foamed concrete for footings, ground beams, structural beams, roof beams and bricklaying. Foundations can be cast using raft foundation methods with foamed concrete with a density of 1800 kg/m^3 and all internal and external walls cast with foamed concrete up to the roof level. No columns and beams would be required as the walls cast can be considered as shear and load-bearing wall. Roofs can Even ceilings and be cast using foamed concrete. The cost to produce a house using foamed concrete is three times cheaper than that using normal concrete. However, foam concrete applications are significantly due to its strength the strength of foam concrete is determined by its various densities from 300 kg/m^3 to 1800 kg/m^3. The lists of the various density of foam concrete due to its applications were tabulated look to the table 2.1. (Thakrele 2014).

Table 2.1: Density of Lightweight Foam Concrete Due to Applications

Density (kg/m^3)	Applications
≤ 300	Insulation boards similar to mineral-based and other man-made insulation boards such as polystyrene, polyurethane or mineral wool with no hazardous threat to health, environment or fire.
350-550	Thermal insulation or fire protection, block filling, roof decking and void filling materials.
600-800	Void filling, such as in landscaping (above/underground construction), behind archways and refurbishing damage sewerage systems, as well as producing masonry units.
800-1000	Production of blocks, other non-loading building elements such as balcony railings, partitions, parapets, etc.
1100-1400	Prefabricated and cast in place walls, either loads bearing or non-load bearing. It can be successfully used as floor screeds.
1500-1800	Recommended for slabs, foundations and other load-bearing element where higher strength is obligatory.

(Source: Alex, 2005)

2.3 Materials Used in Foamed concrete

2.3.1 Cement

Cement is an important part to bind the sand to form a foamed concrete. According to Brocken and Nijland (2004), cement bind with water and turn harder through chemical reaction. Cement is also very sensitive to water which makes it easy to fill the void inside a concrete. Davidson, (1977) stated that cement will become harder once it is near water. Kearsley and Wainwright, (2001) reported that used of rapid hardening Portland cement from Pretoria Portland Cement (PPC) produced foamed concrete with densities of 1500kg/m^3 and the compressive strength increased at 7 days and continue to increase as the age increases. According to Tan et al., (2015), a lightweight foamed concrete with 5:1 cement-sand ratio and density of 1500kg/m^3 produced foamed concrete with compressive strength of 9.387 MPa.

2.3.2 Sand

Sand consists of small grains or particles of mineral and rock fragments. Although these grains may be of any mineral composition, the dominant component of sand is the mineral quartz, which is composed of silica (silicon dioxide) with density of 1000kg/m^3 to 1800kg/m^3 (Nambiar, Ramamurthy, and Asce 2008). Other components may include aluminium, feldspar and iron-bearing minerals. Sand with particularly high silica levels that is used for purposes other than construction is referred to as silica sand or industrial sand

2.3.3 Water

The amount of water to be added to the blend relies on the moisture content of the sand, yet as a normal 40-45 litres of water is used for each 100 kilograms of cement. Additional water is added as a content of the foam, in this way, bringing the total water-cement ratio up the requested to 0.6. Generally, higher amount of foam with respect to lighter densities, the amount of water will decrease (Pacific, n.d, 2012).

To avoid unneeded shrinkage in the moulds the water-cement ratio must be kept as low as possible but to keep in mind that if the amount of water added to cement and sand is too low, the necessary moisture to make a workable mix will be not enough, thus destroy some of the foam which is naturally an expensive way of adding water to the mix (Pacific n.d,2012).

2.3.4 Foaming Agent

Abdullah et al. (2012) stated that a foamed concrete is produced by using mortar or cement paste in where large volume of air are entrapped by using a foaming agent. There are many types of foaming agent that could be used to produce foamed concrete such as detergent, spooning and hydrolysed proteins. The biggest advantage of foamed concrete is that it is lightweight which is suitable to the design of supporting structures like foundation and wall of lower floor. Aluminium powder as foaming agent gives a high degree of thermal insulation and considerable savings in material due to the porous structure (Narayanan and Ramamurthy 2000).

2.3.5 Kenaf Fiber

Kenaf is a plant in the malvaceae family also called Deccan hemp and Java jute. Hibiscus cannabinus is in the genus Hibiscus and is native to southern Asia, though its exact origin is unknown. The name also applies to the fibre obtained from this plant. Kenaf is one of the allied fibres of jute and shows similar characteristics (Awang, Ahmad,&Al-Mulali,2015).

2.3.5.1 Characteristics of Kenaf Fiber

It is an annual or biennial herbaceous plant (rarely a short-lived perennial) growing to 1.5-3.5 m tall with a woody base. The stems are 1–2 cm diameter, often but not always branched. The leaves are 10–15 cm long, variable in shape, with leaves near the base of the stems being deeply lobed with 3-7 lobes, while leaves near the top of the stem are shallowly lobed or un-lobed lance late. The flowers are 8–15 cm diameter, white, yellow, or purple; when white or yellow, the centre is still dark purple. The fruit is a capsule 2 cm diameter, containing several seeds. (M.F.Omar, A. S.Safiee, Z. Abu Bakar).

2.3.5.2 Uses of Kenaf Fiber

Kenaf fiber have the capability to enhances the flexural strength of the slab, reduces the cracking propagation and improves the ductility of the reinforced concrete slab (Syed Mohsin, Baarimah, and Jokhio 2018) . The alkalization treatment has improved the tensile properties of the short kenaf fibers significantly as compared to untreated short kenaf fibers. It is also highlight that, 6% NaOH yields the optimum concentration of NaOH for the kenaf treatment (Masud S.Huda, 2009). The mechanical properties of kenaf fiber-reinforced composite decreased with increasing concentration rate and immersion time of NaOH solution (Lawrence T.Drzal Ąmar K.Mohanty, 2016).

Uses of kenaf fibre include engineered wood, insulation, clothing-grade cloth, soilless potting mixes, animal bedding, packing material, and material that absorbs oil and liquids. It is also useful as cut best fibre for blending with resins for plastic composites, as a drilling fluid loss preventative for oil drilling muds, for seeded hydro mulch for erosion control. Kenaf can be made into various types of environmental mats, such as seeded grass mats for instant lawns and mouldable mats for manufactured parts and containers. (Tara Sen and H. N. Jagannatha Reddy).

2.4 Properties of Foamed Concrete

2.4.1 Density

Generally, density of foam concrete is dependent on the amount of foam used. The density has significant influence on the strength of FC. (Hamidah et al., 2001) stated that the compressive strength of foam concrete with density up to 1300 kg/m^3 did not behave normally as conventional concrete. It increased as the density increased. However, for density less or equal to 1000 kg/m^3, the compressive strength only achieved up to 10MPa. Meanwhile, for density of 1600 kg/m^3 it is noted that the compressive strength of FC increased rapidly. Hamidah et al. (2001) found that the compressive strength of cube specimen with density 1600 kg/m^3 and 1400 kg/m^3 at 28 days are 26 MPa and 14 MPa respectively.

Fresh density and oven dry density both have relationship to each other. According to Memon et al. (2012), it could be seen that, increase in percentage of betonies, caused the fresh and dry density to decrease. The betonies mixes have produced fresh state with 2482kg/m^3. It is shown that oven dry density is 5% lesser that fresh density of foamed concrete for curing in water. It has been observed that as the number of betonies increase, the oven dry density decreased due to specific gravity of the cement which is higher than betonies. Also, the control specimen that produced by 100% of cement have higher density than concrete mixed with materials.

2.4.2 Workability

Workability of foamed concrete shows an excellent performance through the presence of air-voids in the fresh mix due to the addition of stable foam agent [Karl, S., Worner, J.D, 2013]. Workability test, commonly conducted by a flow table test for the normal concrete is not applicable for low density fresh concrete specified by BS EN 12350: [N.NarayananK.Ramamurthy, 2011]. Foamed concrete workability performance is visually evaluated, which aims to achieve an appropriate viscosity of the mix. Besides, [Brewer,2005] measured the workability of foamed concrete using a method called spread ability. Brewer recommended this test on a fresh mix of low-strength materials (e.g. foamed concrete) by measuring the spread in two directions of a sample placed in a 75 mm diameter and 150 mm long open-ended cylinder, after the cylinder was raised vertically. The average of the two measured diameters was calculated and reported to the nearest 5 mm. Dhir et al. (1152) recommended that for an acceptable workability of foamed concrete the spread ability of the base mix should be between 85 and 125 mm for a cement sand mix and between 115 and 140 mm when fly ash was also included. To date, few research works have been undertaken to determine the minimum workability required for the desirable mix. For example, high workability of foamed concrete was reported in mixes with GCBS. Albeit,(2014) segregation was also observed. It was reported that the plasticizers should not be commonly used in foamed concrete unless the amount is limited to less than 0.2 % by weight of cement to improve the workability for the case of low w/c ratio. P.Mellin,(2010).

2.4.3 Compressive Strength

The compressive strength of the foamed concrete was affected by some factors such as water content, cement content and sand grading entrained air content. An increase in sand, water and air content would reduce the strength of foamed concrete while increase in cement content would give a higher strength to the foamed concrete. Kearsley and Wainwright (2001) stated that foamed concrete was made of entraining relatively large volume of air into the cement paste. Although foamed concrete is a lightweight concrete it has high compressive strength.

2.4.4 Effect of Specimen Size and shape on Compressive Strength of Foamed Concrete

Increase the compressive strength values of 100 and 150 mm cube and 100 x 200 and 150 x 300 mm cylinder concrete containing fly ash at different proportions (Saridemir, 2014). Foamed concrete is 100mm cube l/d = 1.0 produced a comparable compressive strength compared with that of the 100mm dia. x 200mm cylinder l/d = 2.0 (M.A.S. Sudin, 2011). The strength increases with the increase in fly ash percentages; however, the rate of increase of strength decreases with the increase in fly ash content. This is between 40% and 50% replacement level (Krishna, Kumar, & Srinivas, 2009).

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter discussed the materials preparation, mixing process and methods to perform the test. Most of all the work had been done in Concrete Laboratory of Civil Engineering and Earth Resources at University Malaysia Pahang (UMP).

3.2 Experimental Programme

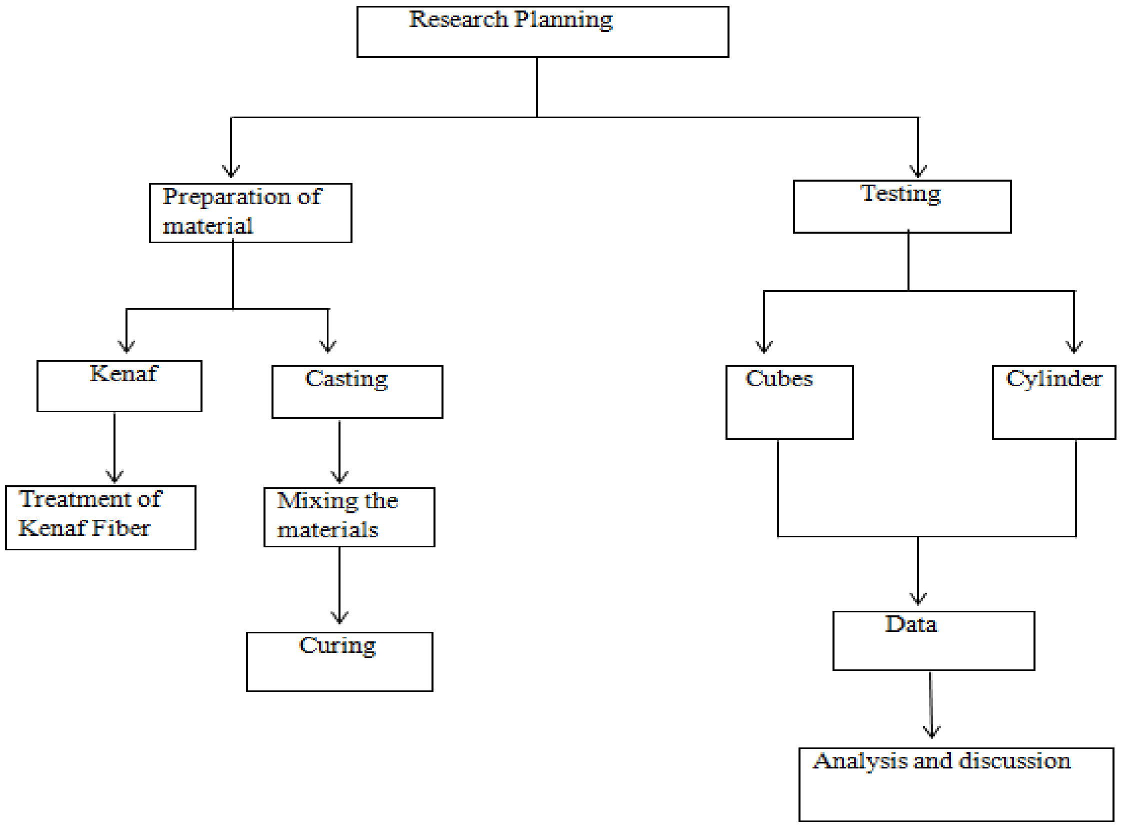

Figure 3.1: Research Planning

3.3 Preparation of Material

3.3.1 Cement

Cement used in this research was Ordinary Portland Cement (OPC) brand Orang Kuat with 32.5 MPa following the standard BS EN 197 – 1:2011. Figure 3.2 shows the type of cement used in this study.

Figure 3.2**:** Ordinary Portland cement

3.3.2 Silica Sand

Silica sand is a high purity silica sand product with controlled sizing, where it is more precise in size compare to common sand (Jignesh 2015). Silica sand named after it chemical composition, where it is silica sand has solely silicon and oxygen, SiO_2. Silica exists in many different shapes and crystalline structure. In this investigation, silica sand that being used has passed sieves 300 micron, provided and supplied by Johor Silica Industry Sdn Bhd. Figure 3.3 shows the type of cement used in this study.

Figure 3.3**:** Silica Sand

3.3.3 Water

Water was one of the most important ingredients for concretes. Cement was chemically reacted with water and produced a high strength concrete. In this research, the water used was clean and free from any dirt.

3.3.4 Foaming Agent

The foaming agent was supplied by LCM Technology Sdn. Bhd. Kuantan, Pahang. By following the procedure, 1 liter of foaming agent was diluted into 25 liters of water in the foam machine to produce preformed foam. Figure 3.4 shows the foaming agent in the study.

Figure 3.4: Foaming Agent

3.3.5 Kenaf fiber

Kenaf fiber supplied by Lembaga Kenaf Tembakau Negara Sdn, Bhd. Furthermore, one of the treatments recommended is to use a chemical such as sodium hydroxide (NaOH) to reduce the hydrophobic characteristic of the fiber, as we used 1L of water equal 2.4g of NaOH.

Figure 3.5: Kenaf Fiber

Figure 3.6: Treatment of Kenaf Fiber

Table 3.1 : Properties of Kenaf fiber

Properties	Kenaf Fiber
Length, L(mm)	5
Weight, W(kg)	5.625
Aspect Ratio, L/D	9.81
Tensile Strength (MPa)	3.9
Unit Weight (kg/m^3)	0.8

3.4 Mix Proportion of Foamed Concrete

There are two mixtures of foamed concrete FC and foamed concrete containing kenaf fiber KFC. All specimens were tested to determine the compressive strength and workability of foamed concrete. The size and shape of specimens used for compressive strength were cubes of size 150 x 150 x 150 mm, 100 x 100 x 100 mm and 50 x 50 x 50 mm and cylinders of 150 x 300 mm and 100 x 200 mm. The mix density was design as 1600 kg/m^3

Table 3.2: Mix proportion of foamed concrete

Mixture	kg/m^3	s/c	w/c	Cement	Sand	Foam	% kenaf
FC	1600	1.5	0.5	16.1	24.1	0.75	-
KFC (0.5% KENAF)	1600	1.5	0.5	16.1	24.1	0.75	0.8

3.4.1 Production of Foamed Concrete

In this study, foamed concrete was prepared by mixing cement, silica sand, water and preformed foam according to ASTM C796. Preformed foam has been prepared by diluting 1 litre of foaming agent with 25 litres of water into the foam machine where the density of foam should be in the range of 50 to 60 kg/m^3. The preformed foam was mix with the cement paste continuously until there is no sign of foam during the mixing and until the slurry become homogenously mixed. 1 litre of the fresh foamed concrete was weighted to determine the fresh density of 1600 kg/m^3. Flow table test was conducted according to ASTM C1437 to determine the workability of the fresh foamed concrete. The fresh foamed concrete has been filled into cubes and cylinder in water for duration of 24 hours as shown in Figures 3.13

Figure 3.7: Greasing the specimens cubes and cylinders

Figure 3.8: Mixing the materials by using mixture

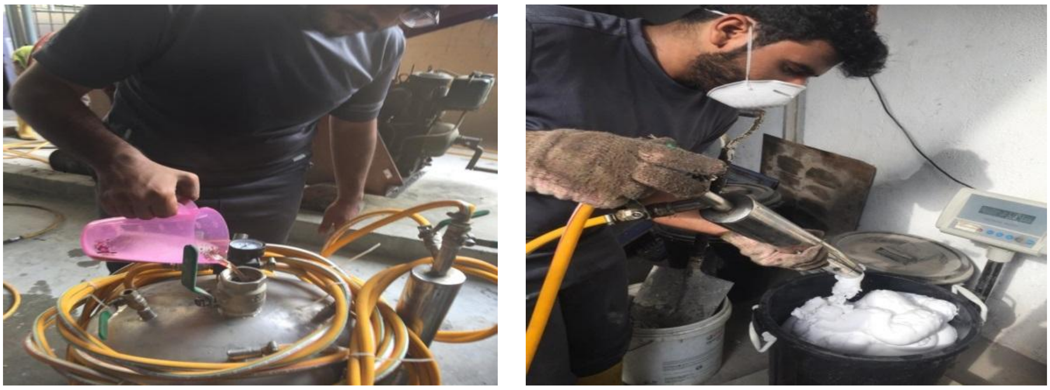

Figure 3.9: Repairing the foamed agent by using the machine and measure it

Figure 3.10: Filling up the specimens

Figure 3.11: Specimens size and shape and measure it after drying

Figure 3.12: Curing the samples for 28 days

Figure 3.13: Preparation of Foamed Concrete Specimens

3.5 Testing

3.5.1 Workability

In this study, the workability of the foamed concrete has been determined by conducting flow table test. The flow table test used to measure workability of foamed concrete has been followed ASTM C1437 (Hamed and Saeed, 2015). The flow table test has been conducted by using flow table with diameter of 310mm and flow mold with diameter of 430mm. Before starting the workability test, make sure the flow table and flow mold are clean and in dry condition. Gently wipe the flow table and flow mold to ensure it is clean and dry. Then, place the flow mold at the center of flow table. The flow mold was filled with the fresh foamed concrete by two equal layers that were about 25mm in thickness for the first layer. Tamp 20 times with tamping rod to ensure uniform filling. Then, over fill the flow mold for second layer and tamp 20 times with tamping rod. Strike off the over fills mix to ensure flat and smooth surface on top of the flow mold. Lift the flow mold properly and after 1 minute drop the table immediately for 25 times in 15 seconds. By using measuring tape, measure the flow diameter. According to the previous research, the flow table test for foamed concrete should be in the range 180-200mm for 0.55 water cement ratio. (Engineering & Madras, 2008). for calculating the workability we using equation 1:

$$\text{flow} = \frac{\text{Spread dia (mm)} - 25}{25} \times 100 \qquad \text{(Equation 1)}$$

Figure 3.14**:** Method for flow table test

3.5.2 Compressive Strength Test

In this study, the compressive strength of the foamed concrete was determined on cube specimens of dimensions 50mm x 50mm x 50mm, 100mm x 100mm x 100mm and 150mm x 150mm x 150mm and cylinder 100mm x 200mm and 150mm x 300mm were cured by water curing and tested for 7, 14 and 28 days as per ASTM C513-11. All the specimens for compressive strength test have been stored in the curing tank until the testing day for the age of 7, 14 and 28 days. Three specimens have been tested for each curing age to obtain the average compressive strength. The compression test was performed by using 2000kN UTM machine. The compressive strength test has been conducted according to the following steps. Removed specimens from water tank and ensure the specimens were dried before beginning the test. Weight the entire specimens to determine the sample weight. Checked the compression testing machine to make sure the upper and lower bearing blocks are clean and dry. Gently wipe and clean the bearing faces to ensure it is clean and in dry condition. Place the sample on the lower bearing block. Setup the Universal Testing Machine (UTM) by select correct sample size and run the machine. The maximum load sustained by the specimen was recorded and the compressive strength of each specimen was calculated by dividing the maximum load with the specimen cross sectional area. Calculate the average compressive strength of the specimens based on equation:

$$\text{Compressive Strength } \sigma = \frac{P}{A} \qquad \text{(Equation 2)}$$

Where,

P is Maximum load (in N) and A is the cross-sectional dimension of specimen (surface area of cube) (in mm^2).


Figure 3.15: Compressive Strength Test

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

The goal of this study is to investigate the effect of specimen size and shape on compressive strength of foamed concrete containing Kenaf fiber. The workability and compressive strength, of controlled of foamed concrete and foamed concrete containing Kenaf fiber had been investigated and the details results are presented as follow.

Table 4.1 shows the average of compressive strength of FC. In general , The size and shape of specimens used for compressive strength were cubes of size 150 x 150 x 150 mm, 100 x 100 x 100 mm and 50 x 50 x 50 mm and cylinders of 150 x 300 mm and 100 x 200 mm. From the experimental results, the mixtures showed increases in the compressive strength for all sizes and shape of specimens form 7 days to 28 days. , the FC mix generate higher compressive strength about 6.01 MPa in cube size 150mm x 150mm x150mm at 28 day, and achieved 6.4 MPa at 28 day in cylinders size 150mm x300mm.

Table 4.1: The average of compressive strength of FC mixture

Samples	Size (mm)	Height (mm)	Weight (Kg)	Compressive strength N/mm^2		
				7days	14days	28days
Cubes	50x50x50 mm	50	0.21	4.4	4.7	5.1
	100x100x100mm	100	1.79	4.5	4.9	5.8
	150x150x150mm	150	5.93	4.8	5.3	6.01
cylinder	100x200mm diameter	200	2.79	2.3	2.5	2.8
	150x300mm diameter	300	9.67	3.0	3.3	6.4

Table 4.2 shows the average of compressive strength of KFC. In general , The size and shape of specimens used for compressive strength were cubes of size 150 x 150 x 150 mm, 100 x 100 x 100 mm and 50 x 50 x 50 mm and cylinders of 150 x 300 mm and 100 x 200 mm. From the experimental results, the mixtures showed increases in the compressive strength for all sizes and shapes of specimens form 7 days to 28 days. , the KFC mix generate higher compressive strength about 12 MPa in cube size 150mm x 150mm x150mm at 28 day, and achieved 10 MPa at 28 day in cylinders size 150mm x300mm.

Table 4.2: The average of compressive strength of KFC mixture

Samples	Size (mm)	Height (mm)	Weight (Kg)	Compressive strength N/mm^2		
				7days	14days	28days
Cubes	50x50x50 mm	50	0.23	8.0	9.42	9.8
	100x100x100mm	100	1.82	8.9	10.5	11
	150x150x150mm	150	5.99	9.5	10.9	12
cylinder	100x200mm diameter	200	2.88	6.43	6.5	7.5
	150x300mm diameter	300	9.76	6.97	8.75	10

4.2 Influence of specimen size of cubes on compressive strength

Figure 4.1 shows the development of compressive strength of foamed concrete due to the size of cube specimen. Overall, both mixtures increase in the compressive strength for all sizes of cube specimens from 7 days to 28 days. The average of compressive strength of KFC for cube of size 50mm was found to have 9.8 MPa, following by size 100 mm was 11 MPa and size 150 mm was 12 MPa at 28 days respectively. Hence, the increases in cube size increased the compressive strength. The compressive strength of KFC was increased according to the kenaf fiber. The results are conducted to realize the size effect on the compressive strength of high performance lightweight foamed concrete. The compressive strength of 50mm cube for mix S3 increased by 38% and 15% compared with the same mix, but different in size of 150 mm and 100 mm cube (S1 and S2), respectively (Hamad 2017).

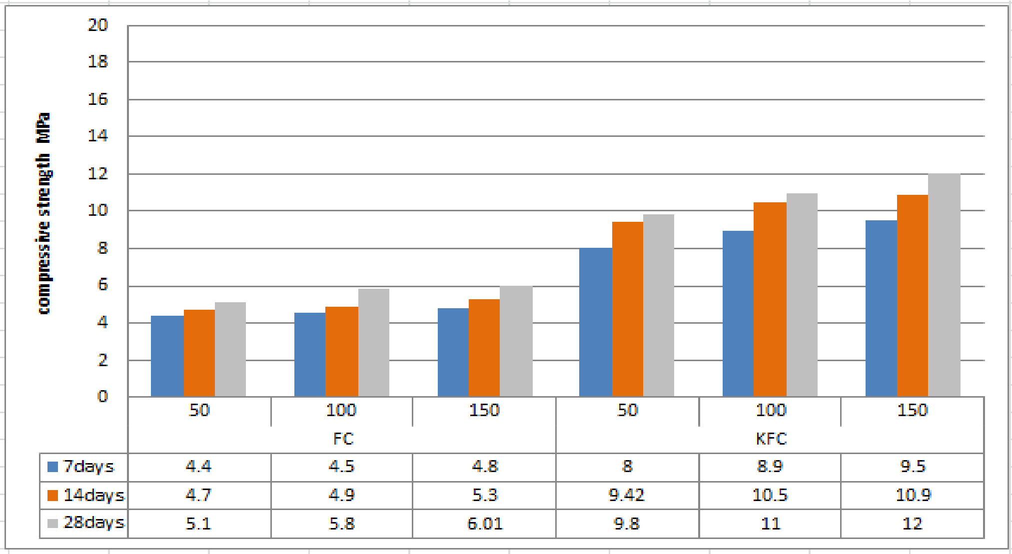

Figure 4.1: Development of Compressive Strength of foamed concrete due to size of cubes.

4.3 Influence of specimen size of cylinders on compressive strength

Figure 4.2 shows the development of compressive strength of foamed concrete due to the size of cylinder specimen. Overall, both mixtures increase in the compressive strength for all cylinder sizes form 7 days to 28 days. The similar trend also obtained in cylinder which the average compressive strength of 150 mm diameter recorded as 10 MPa and 100 mm diameter was 7.5 MPa which mean that 150 mm diameter cylinder was 25% greater than 200 mm diameter at 28 days. The strength test results and standard deviations for different sized cylinders it was observed that as the strength level increases standard deviations also increase. The highest apparent strengths were obtained for 100 x 200mm cylinder specimen (Tokyay 1997).

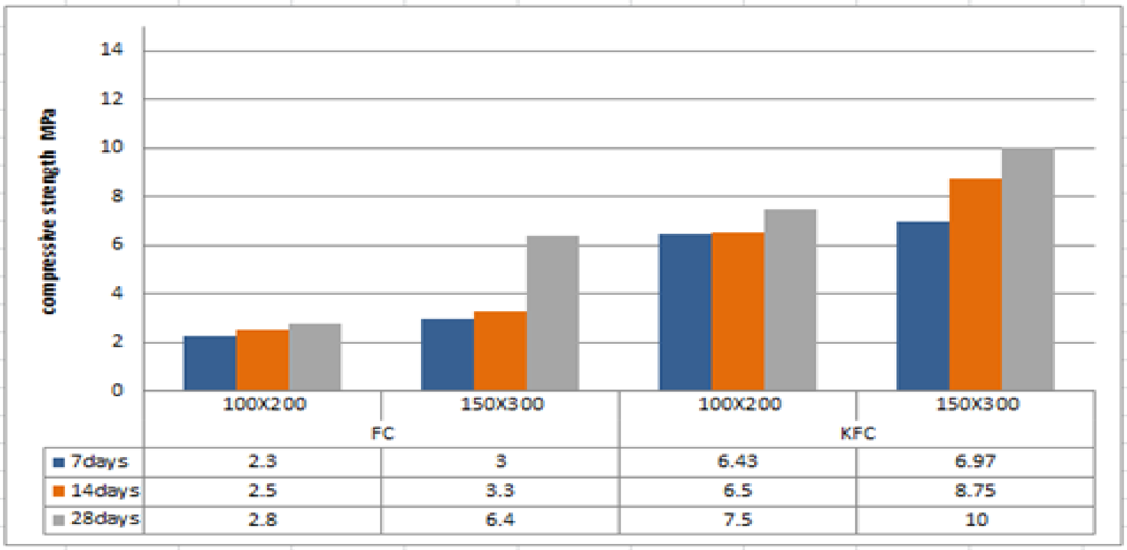

Figure 4.2: Development of Compressive Strength of foamed concrete due to size of cylinders

4.4 Influence of specimen shape on compressive strength

Figure 4.3 shows the graph comparing the compressive strength between 150 mm cube and 150 mm diameter of cylinders for FC and KFC. The highest values were 12 MPa given by cube 150 mm at 28 days in KFC. It was 17 % greater than 150 mm diameter of cylinder. There is a marginal increase in the average compressive strength with glass fiber addition. The increase is more in 100mm cubes as compared to 100x200mm cylinders. In general, the compressive strength based on 150mm cubes is slightly more than 100mm cubes. Meanwhile, 150mm cubes is the optimum the larger cubes like 150x300mm cylinders (Krishna, Kumar, and Srinivas 2011).

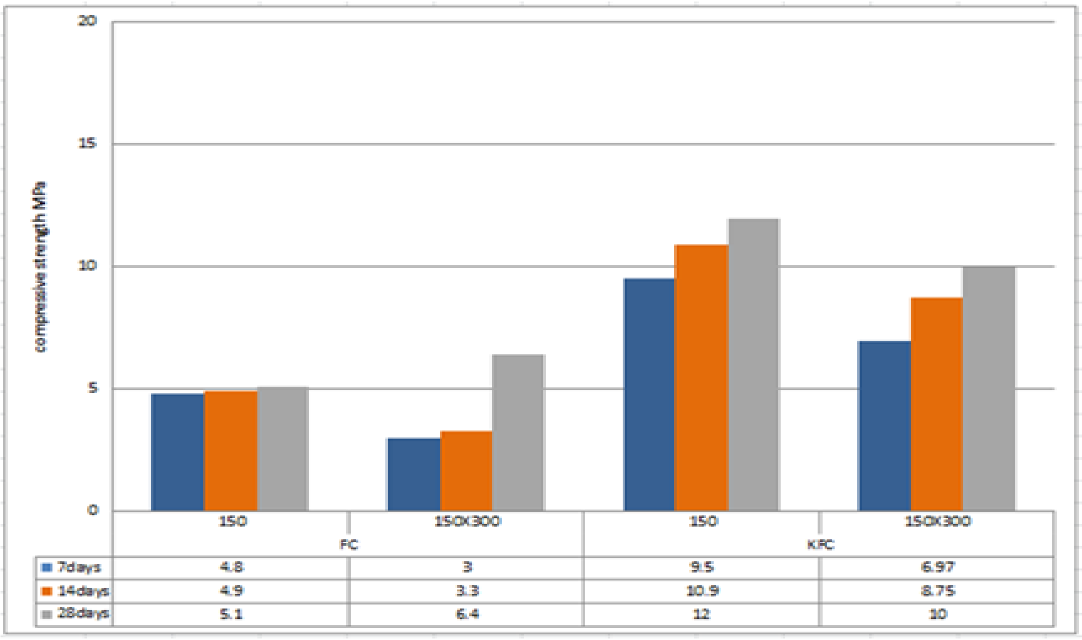

Figure 4.3: Compressive Strength between 150mm cube and 150mm x 300mm cylinder.

Figure 4.4 shows the graph comparing the compressive strength between 100 mm cube and 100 mm diameter of cylinders for FC and KFC. The highest values were 11 MPa given by cube 100 mm at 28 days in KFC. It was 31.8 % greater than 100 mm diameter of cylinder. There is 16.4% compressive strength reduction, when the l/d ratio of cube and prism increased from 1.0 to 2.0; however, for cylinder, the strength became 15.4% higher for the same l/d ratio. By referring to the CEB-FIP standard of comparison, when 100 x 100 x 100mm cube (l/d = 1.0) was compared to 100dia x 100mm cylinder (l/d = 2.0), there was only 5% difference in strength; which could be treated as a margin of error during sample preparation, curing, or testing (M.A.S. Sudin 2011).

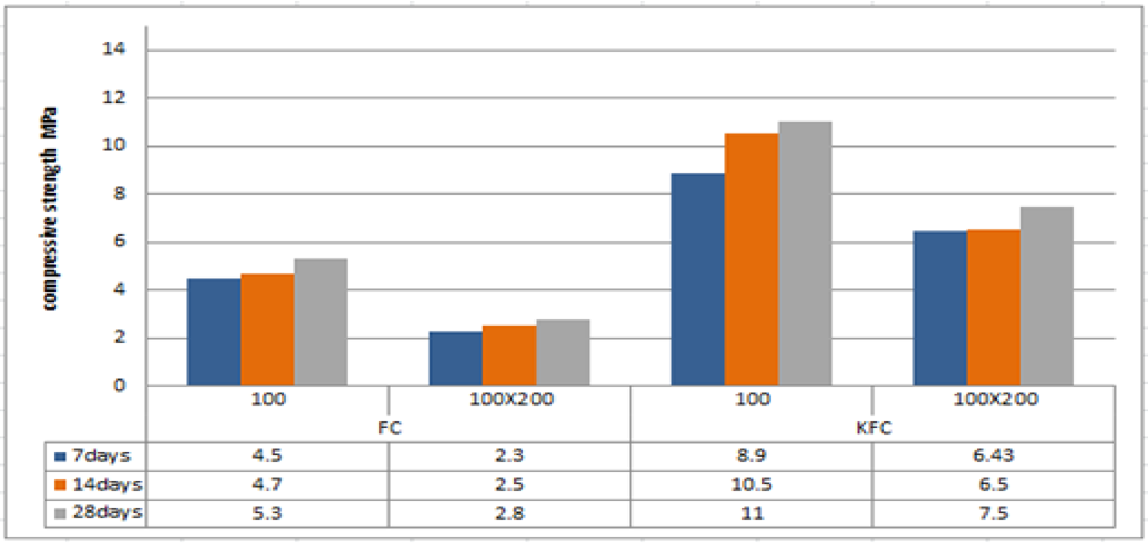

Figure 4.4: Compressive Strength between 100mm cube and 100mm x 200mm cylinder

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

From the laboratory test conducted, the performance of Kenaf Fiber in foamed concrete application showed a positive result. This indicates that Kenaf Fiber can be recommended to be used as a new material admixture for construction materials. There are still some improvements that should be made for future works that can be made for this study in order to obtained and achieve a better result for the application of foamed concrete containing Kenaf Fiber.

5.2 Conclusion

From the experimental results, the effect of size and shape of a specimen on the compressive strength of foamed concrete conclusions may be derived:

i. As compared to FC mix, the KFC mix generate higher compressive strength about 12 MPa in cube size 150mm at 28 day and achieved 10 MPa at 28 day in cylinders size 150mm diameter.
ii. Cubes could carry a higher load than cylinder in KFC compared to FC which the cubes carry higher compressive strength.
iii. By comparing, the compressive strength of 100mm cubes produced 31.8 % greater than 100 mm diameter of cylinder in KFC.
iv. The compressive strength of 150mm cubes produced 17 % greater than 150 mm diameter of cylinder in KFC.

5.3 Recommendation

Kenaf Fiber composite shows a bright future among other natural fiber composites for the several specific reasons that were highlighted in the previous discussion. From the research that has done, it is recommended to conducted for further study as follows:

i. It is recommended to conduct a series of investigation on effect of curing age on the compressive strength.
ii. It is recommended to conduct a series of investigation on the resistance to chloride and sulphate attach.

REFERENCES

Abdullah, Mohd Mustafa Al Bakri et al. 2012. "Fly Ash-Based Geopolymer Lightweight Concrete Using Foaming Agent." *International Journal of Molecular Sciences* 13(12):7186–98.

Brocken, Harold and Timo G. Nijland. 2004. "White Efflorescence on Brick Masonry and Concrete Masonry Blocks, with Special Emphasis on Sulfate Efflorescence on Concrete Blocks." *Construction and Building Materials* 18(5):315–23.

Hamad, Ali Jihad. 2017. "Size and Shape Effect of Specimen on the Compressive Strength of HPLWFC Reinforced with Glass Fibres." *Journal of King Saud University - Engineering Sciences* 29(4):373–80. Retrieved (http://dx.doi.org/10.1016/j.jksues.2015.09.003).

Jignesh, Kerai. 2015. "Effect of Use of Silica Sand as Fine Material in Concrete." 2(1):266–71.

Kearsley, E. P. and P. J. Wainwright. 2001. "The Effect of High Fly Ash Content on the Compressive Strength of Foamed Concrete." *Cement and Concrete Research* 31(1):105–12.

Krishna, Rao, Rathish Kumar, and B. Srinivas. 2011. "Effect of Size and Shape of Specimen on Compressive Strength of Glass Fiber Reinforced Concrete (GFRC)." *Facta Universitatis - Series: Architecture and Civil Engineering* 9(1):1–9. Retrieved (http://www.doiserbia.nb.rs/Article.aspx?ID=0354-46051101001K).

Lcc. 2003. "HIGH-STRENGTH STRUCTURAL LIGHTWEIGHT CONCRETE A New Direction towards Advanced Construction Techniques Using High-Strength Lightweight Cellular Concrete in the Development of Concrete in Building and Civil Engineering Construction SPECIFIED DENSITY CONCRE."

M.A.S. Sudin, M.Ramli. 2011. "Effect of Specimen Shape and Size on Compressive Strength of Concrete." *Advanced Materials Research* 163–167:0–5.

Memon, Shazim Ali, Rao Arsalan, Sardar Khan, and Tommy Yiu Lo. 2012. "Utilization of Pakistani Bentonite as Partial Replacement of Cement in Concrete." *Construction and Building Materials* 30:237–42.

Narayanan, N. and K. Ramamurthy. 2000. "Structure and Properties of Aerated Concrete: A Review." *Cement and Concrete Composites* 22(5):321–29.

Saridemir, Mustafa. 2014. "Effect of Specimen Size and Shape on Compressive Strength of Concrete Containing Fly Ash: Application of Genetic Programming for Design." *Materials and Design* 56:297–304.

Syed Mohsin, S. M., A. O. Baarimah, and G. A. Jokhio. 2018. "Effect of Kenaf Fiber in Reinforced Concrete Slab." *IOP Conference Series: Materials Science and Engineering* 342(1).

Thakrele, M. H. 2014. "Experimental Study on Foam Concrete." *International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development*.

Tokyay, M. 1997. “Pp. 1281-1289.1997.” 27(8):1281–89.

J.E. Aubert, P. M. 2015. Towards a simple compressive strength test for earth bricks . *Materials and structures* , 1641-1654.

morel, J.-C. 2005. compressive strenght testing of compressed earth blocks . *ELSEVIER Construction and Building materials* , 303-309.

Siram KKB. Foam concrete – The present generation’s building solution. International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD). ISSN:2249-6866. 2013;3(4):59-62

Kearsley, E. P. and P. J. Wainwright. 2001. “The Effect of High Fly Ash Content on the Compressive Strength of Foamed Concrete.” *Cement and Concrete Research* 31(1):105–12.

Indu Siva Ranjani, G. and K. Ramamurthy. 2012. “Behaviour of Foam Concrete under Sulphate Environments.” *Cement and Concrete Composites* 34(7):825–34. Retrieved (http://dx.doi.org/10.1016/j.cemconcomp.2012.03.007).

Amran, Y. H. Mugahed, Nima Farzadnia, and A. A. Abang Ali. 2015. “Properties and Applications of Foamed Concrete; A Review.” *Construction and Building Materials* 101:990–1005. Retrieved (http://dx.doi.org/10.1016/j.conbuildmat.2015.10.112).

Memon, Shazim Ali, Rao Arsalan, Sardar Khan, and Tommy Yiu Lo. 2012. “Utilization of Pakistani Bentonite as Partial Replacement of Cement in Concrete.” *Construction and Building Materials* 30:237–42.

Amran, Y. H. Mugahed, Nima Farzadnia, and A. A. Abang Ali. 2015. “Properties and Applications of Foamed Concrete; A Review.” *Construction and Building Materials* 101:990–1005. Retrieved (http://dx.doi.org/10.1016/j.conbuildmat.2015.10.112)

APPENDIX A

LABORATORY TESTING RESULT

Workability test

	Flow Diameter	Flow values	Description
			LOW
FC	181 mm	24%	20-40%
			High
KFC	200 mm	60%	60-80%

Compressive Test Result

The average of compressive strength of FC mixture

	Size (mm)	Height (mm)	Weight (kg)	Compressive Strength N/mm^2		
				7 days	14 days	28 days
Cube	50x50x50 mm	50	0.21	4.4	4.7	5.1
	100x100x100mm	100	1.79	4.5	4.9	5.8
	150x150x150mm	150	5.93	4.8	5.3	6.01
Cylinder	100x200mm diameter	200	2.79	2.3	2.5	2.8
	150x300mm diameter	300	9.67	3.0	3.3	6.4

The average of compressive strength of KFC mixture

	Size (mm)	Height (mm)	Weigh (kg)	Compressive Strength N/mm^2		
				7 days	14 days	28 days
Cube	50x50x50 mm	50	0.23	8	9.42	9.8
	100x100x100mm	100	1.82	8.9	10.5	11
	150x150x150mm	150	5.99	9.5	10.9	12
Cylinder	100x200mm diameters	200	2.88	6.43	6.5	7.5
	150x300mm diameters	300	9.76	6.97	8.75	10