EFFECTS OF SPECIMEN SIZE AND SHAPE ON COMPRESSIVE STRENGTH OF FOAMED CONCRETE CONTAINING SPENT BLEACHING EARTH AND KENAF FIBER

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ABSTRAK

Penyelidikan ini mengkaji kesan saiz dan bentuk spesimen pada kekuatan mampatan konkrit berbuih yang mengandungi Processed Spent Bleaching Earth (PSBE) dan Kenaf Fiber. Terdapat dua campuran yang disediakan iaitu PFC (30% daripada PSBE sebagai penggantian simen separa simen dan PKF (30% PSBE + 0.5% Kenaf Fiber). Ketumpatan campuran direka sebagai 1600 kg / m^3 Semua spesimen telah diuji untuk menentukan kebolehkerjaan dengan mengukur aliran campuran dan ujian mampatan untuk menentukan kekuatan mampatan konkrit berbuih. Kajian ini difokuskan untuk menentukan kesan saiz dan bentuk pada kekuatan mampatan konkrit berbuih pada 7 hari, 14 hari dan 28 hari. Saiz dan bentuk spesimen yang digunakan untuk kekuatan mampatan ialah saiz 150x150x150mm, 100x100x100mm dan 50x50x50mm dan silinder 150 x 300 mm dan 100 x 200 mm. Dari hasil eksperimen, kedua-dua campuran menunjukkan kekuatan mampatan untuk semua saiz dan bentuk daripada spesimen dari 7 hari hingga 28 hari. Campuran PFC memberikan kekuatan mampatan tertinggi mencapai 17.0 MPa dalam saiz kiub 100x100x100mm dan 150x150x150mm pada 28 hari, dan dalam campuran PKF, mencapai 11.0 MPa dalam saiz kiub 100x100x100mm dan 150x150x150mm pada 28 hari. Sebaliknya, kekuatan mampatan saiz silinder 100x200 mm diameter adalah 21% lebih besar daripada diameter 150x300 mm yang mencapai 19.0 MPa dan 15 MPa dalam PFC. Juga, kekuatan mampatan saiz silinder 100x200 mm diameter adalah 30% lebih besar daripada diameter 150x300 mm yang mencapai 20 MPa dan 14 MPa dalam PKF.

ABSTRACT

Present research studies the effects of specimen size and shape on compressive strength of foamed concrete containing Processed Spent Bleaching Earth (PSBE) and Kenaf Fiber. There are two mixtures were prepared which namely PFC (30% of PSBE as partial cement replacement of cement and PKF (30% PSBE + 0.5% Kenaf fiber). The mix density was design as 1600 kg/m^3. All specimens were tested to determine the workability by measure the flow table of the mixtures and compression test to determine the compressive strength of foamed concrete. This study was focused to determine the effect of size and shape on compressive strength of foamed concrete at 7 days, 14 days and 28 days. The size and shape of specimens used for compressive strength were cubes of size 150x150x150mm, 100x100x100mm and 50x50x50mm and cylinders of 150 x 300 mm and 100 x 200 mm. From the experimental results, both mixtures showed increase in the compressive strength for all sizes and shape of specimens from 7days to 28 days. As compared to PFC mix, the highest compressive strength achieved 17.0 MPa in cubes size 100x100x100mm and 150x150x150mm at 28 days, and in PKF mix, the highest compressive strength achieved 11.0 MPa in cube size 100x100x100mm and 150x150x150mm at 28 days. In other hand the compressive strength of cylinders size 100x200 mm diameter was 21% greater than 150x300 mm diameter which achieved 19.0 MPa and 15 MPa in PFC. Also, the compressive strength of cylinders size 100x200 mm diameter was 30% greater than 150x300 mm diameter which achieved 20 MPa and 14 MPa in PKF.

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LIST OF ABBREVIATIONS

PSBE	Processed Spent Bleaching Powder
FC	Foamed Concrete
LFC	Lightweight foamed concrete
OPC	Ordinary Portland cement
ASTM	American Society for Testing and Materials
FKASA	Fakulti Kejuruteraan Awam dan Sumber Alam
UTM	Universal Testing Machine
UMP	Universiti Malaysia Pahang
US	United State
w/c	Water-Cement ratio
s/c	Sand-Cement ratio
MgO	Magnesium Oxide
SO_3	Sulphur Trioxide
CO_2	Carbon Dioxide
CH	Calcium Hydroxide
CSH	Calcium Silicate Hydrate
C_3S	Tricalcium Silicate
CaO	Calcium Oxide
SiO_2	Silicon Dioxide
Al_2OH_3	Aluminium Trioxide
Fe_2O_3	Ferric Oxide
Kg/m^3	Kilogram per meter cube
Mpa	Mega Pascal
lbs	Pound
pints	Unit of Volume
L	Litre
mm	Milimeter
h	Hour
cm^2/g	Centimeter square per gram
kN	kilo Newton
kN/s	kilo Newton per second
kPa	kilo Pascal
℃	Degree Celcius
%	Percentage

CHAPTER 1

INTRODUCTION

1.1 Background of study

The cylinder specimen of concrete (150mm diameter and 300mm height) is a standard specimen to test the compressive strength in United States. While in Britain and Europe, the standard specimen for testing the compressive strength is a cube specimen of concrete by size 150 × 150 × 150 mm (Abdullah, Mohd Mustafa et al 2012). The cubes are smaller compared with the cylinder specimen of concrete, and the advantages of cylinders do not depend on the quality and condition of the mould and that their density can be more readily and accurately established by weighing and measuring (Jignesh, Kerai 2015).

Foamed concrete is one of the most important building materials. It has wide range of applications. It can be cast in-place for a unit low cost terrace houses and bungalow and also high-rise building. Other applications are it can be used for lightweight brick or block, panels and partition walls of various dimensions either precast or poured in place, insulation works, cavity walls, roofing, ceiling panels, road a sidewalk and other. In addition, foamed concrete can be used in building construction, low cost house, highway construction, blinding, void filing, footing, tunnel lining, trench reinstatement, roof insulation and light weight purposes. The application of foamed concrete depends on the density of the foam concrete itself (Narayanan, N 2000).

Kenaf Fiber 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, inclusion 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 Fiber need to undergo some treatment to reduce high water absorption characteristic of the Fiber. One of the treatments recommended is 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 Fiber as compared to untreated Kenaf Fiber (ASTM C1202 2012).

Pre-treatment of crude palm oil (CPO) during a refining process which involves degumming and bleaching, generates plentiful of spent bleaching earth (SBE). Bleaching earth is a very fine powder and its main component is silicon dioxide (∼57% and more depending on the type). It is prepared by treating montmorillonite clay (represented by Al2O3 4SiO2 nH2O) with mineral acids and by eluting basic components such as aluminium, iron and magnesium. SBE is a discarded palm oil refinery (POR) waste containing a high percentage of residual oil. PSBE has been incinerated for cement manufacturing but there is difficult in maintaining good cement quality due to the high concentration of oil in PSBE (Chem. Soc 1983).

Presently, this research is to investigate the effect of specimen size and shape on compressive strength of foamed concrete containing Kenaf Fiber and Processed Spent Bleaching Earth (PSBE) and use it as a partial cement replacement in foamed concrete in term of strength.

1.2 Problem statement

Nowadays, speedy development in our country makes the excessive uses of normal cement (OPC). OPC produces around one tone of carbonic acid gas per tons created according to Mahachi J, Golinger A M & Wagenaar F, (2004), raising vital environmental considerations. Because the OPC isn't noticeably economical friendly, several researches are done to exchange the utilization of OPC, as Associate in nursing example the combination is replaced with foam. Thus, makes the concrete lighter. It’s found that the compressive strength of foamed concrete is principally influenced by density according E. P. Kearsley & H. F. Mostert, (2005). So, the scale and form of specimen becomes a very important parameter for the compressive strength of foamed concrete according Sarıdemir (2013).

1.3 Objectives of study

The goal of this study is to investigate the effect of specimen size and shape on compressive strength of foamed concrete containing Processed spent bleaching earth and Kenaf Fiber. The specific objectives of this study are:

i. To determine the effect of size on compressive strength of foamed concrete.
ii. To determine the effect of shape on 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 with containing spent bleaching earth and Kenaf Fiber in foamed concrete properties. The materials were mixed according to ratio of 30% of PSBE and 0.5% of Kenaf fiber with foamed concrete. It is focused on the influence of specimen on the workability and compressive strength. The compressive strength tests were done at 7, 14 and 28 days. All of the materials and specimen preparation is based on standard code practice requirement of ASTM. The data from the result were analyzed to determine the effect the specimen size and shape on the compressive strength of foamed concrete.

1.5 Significant of Study

The significant of this study is to provide more knowledge on the performance of foamed concrete containing PSBE and Kenaf Fiber. The advantage of using spent bleaching earth that can use as replacement as cement. Also, Kenaf Fiber increasing the compressive strength of foamed concrete.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discussed the studies related to the effect of PSBE and Kenaf Fiber in foamed concrete. Also, discussed about the materials, production and effect of using PSBE and 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 aluminum powder with calcium hydroxide and other alkalis released by cement.

2.2.1 Evolution of foamed concrete

It was first developed in Stockholm, Sweden known as Cellular concrete in the early 1900’s. This technology was quickly spread to different country around the world after the Second World War. The applications were for economical large-size structural panel units and were used in low-rise structures and site reconstruction. In the United

States of America, the applications were for floor, wall and roof units with low compression strength which limit this product to fills and insulation only. New researches were done in 1970's and 1980's that led to commercial use of foamed concrete in construction.

2.3 Application of foamed concrete

Application of foamed concrete has become popular worldwide, especially at the regions suffering from housing shortages or subjected to adverse weather, hurricanes and earthquakes. In North America, the overall demand was more from the southern US and to be equal to the actual production. But, in Canada, cement-based foam has been widespread used for tunnel annulus grouting, flowable fills and in geotechnical applications. This growing interest seems to be partially due to a significant increase in the costs of other lightweight building materials such as dry wall and wood and in part to the environmental issues. Besides, an additional feature of foamed concrete encouraged it as to be appropriate for large volumes of supplementary cementing admixtures because of the manufacturing and environmental cost associated with cement production.

Other typical usage of foamed concrete are used under concrete paving, to prevent frost heave in roads, to insulate shallow foundation systems and placements, to prevent frost heave under pile cap sand frost jacking of shallow piles, to use as a grout to fill abandoned pipes and as backfill under buried oil field modules, to decrease the temperature under hot oil tanks and the tank support and to fill voids under slabs and to reduce the thermal stress and the thermal gradient in hot concrete pits and thus insulate shallow according to S. Mindess (2014).

2.4 Materials used in foamed concrete

2.4.1 Cement

Cement is an important part to bind the sand to form a foamed concrete. According to 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. according Davidson, (1977) stated that cement will become harder once it is near water. based on 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.

2.4.2 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 according to Nambiar, Ramamurthy, and Asce (2008). Other components may include aluminum, 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.

2.4.3 Water

The amount of water to be added to the blend relies on the moisture content of the sand, yet as a normal figure, 40-45 liters 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. To avoid unneeded shrinkage in the mould 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.

2.4.4 Foaming agent

Acoording to 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, saponin and hydrolyzed 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. Aluminum powder as foaming agent gives a high degree of thermal insulation and considerable savings in material due to the porous structure based on Narayanan and Ramamurthy (2000).

2.5 Production of foamed concrete

Foamed concrete is a combination of cement paste and fine sand with a multitude micro/macroscopic discrete air cells uniformly distributed throughout the mixture to produce a lightweight concrete. It is commonly done in two different methods. Method 1, mixing of preformed foam into the cement and water slurry and as the concrete hardens, the bubbles disintegrate leaving air voids of similar sizes. Method 2 was known as Autoclaved Aerated Concrete (AAC) which consists of a mix of cement, water, sand, lime and an expansion agent. Expansion agent was added to make the bubble and poured into the mix during the mixing process. A chemical reaction that produce gas, either hydrogen or oxygen to form a gas-bubble structure within the concrete was created. Zeolite powders, high carbon ash and recycles aluminum are the extra mechanical structures suitable in the production of cellular lightweight concrete. Lcc (2003).

2.6 Properties of foamed concrete

2.6.1 Density

The density is a unit for measuring the weight of the foamed concrete that could be identified from the fresh state and hardened state of foamed concrete. The foamed concrete ought to have flow ability and self-compact ability as it cannot be subjected to compaction or vibration. These two properties are assessed regarding consistency and stability of the foamed concrete. 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 bentonite, caused the fresh and dry density to decrease. The bentonite 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 amount of bentonite increase, the oven dry density decreased due to specific gravity of the cement which is higher than bentonite. Research from Memon et al. (2012) stated hat control specimen that produced by 100% of cement have higher density than concrete mixed with pozzolan materials.

2.6.2 Workability

Water-cement ratio controls the workability of fresh concrete. Generally, flow table test is used to measure the workability. Study from Yetgin and Çavdar (2006) reported that as the natural pozzolan addition ratio increased, the workability of natural pozzolan also increased for a density of 1400kg/m^3. It means that the workability of cement mortar containing natural pozzolan decreased as increase in the percentage of natural pozzolan in the mix. Small particle size and high surface area of pozzolan particles have less workability compared to 100% cement concrete.(Çolak 2003).

2.6.3 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. A study from Jones and McCarthy (2005) reported that the compressive strength of 30% fly ash as fine aggregates as cement replacement foamed concrete with 1600kg/m^3 at age of 28 days is 28MPa.

2.7 Introduction to Spent Bleaching Earth

For the past few years, there are many types of solid waste had been tested and suggested to be a cement replacement such as fly ash, palm oil fuel ash, silica fumes and spent bleaching earth Alsubari, Shafigh, and Jumaat (2015). Malaysia is one of the biggest national that produces spent bleaching earth (SBE). Index Mundi. (2015) stated that Malaysia produced about 20,500 per 1,000 metric tons of SBE. There are about 600,000 metric tons of SBE per 60 million tons of palm oils worldwide of SBE disposed at landfills (Malaysia) Park et al (2004).

2.8 Properties of Processed Spent Bleaching Earth

According to Loh et al.(2013) bleaching earth is montmorillonite and bentonite-based natural clay that have similar characteristics as zeolite, thus makes it mimics zeolite in many ways. SBE contains Silica in Silicon Dioxide ($Si0_2$) with about 60.4%. In Hydration process, cement reacted with water (H_2O) produced C-S-H gel and

Calcium Hydroxide. The silica then reacted with Calcium Hydroxide and water to produce secondary C-S-H gel in pozzolanic reaction.

Hydration Process

$$\text{Cement} + H_2O = \text{C-S-H Gel} + Ca(OH)_2$$

Pozzolanic Reaction

$$SiO_2 + Ca(OH)_2 + H_2O = \text{C-S-H Gel}$$

2.9 Introduction to Kenaf Fiber

Kenaf fiber comes from a plant named ‘Kenaf’ which is a plant in the Malvaceae family, is in the genus Hibiscus and is probably native to southern Asia although its exact natural origin is unknown. Kenaf denoted as industrial Kenaf due to of its great interest for the production of industrial raw materials Kenaf is comparatively commercially available and economically cheap amongst other natural fiber reinforcing material. Kenaf has been studied as a potential replacement for the diminishing tobacco farming industry in the south-eastern United States. Kenaf is a hardy, strong and tough plant with a fibrous stalk, resistant to insect damage and requires relatively fewer amount of or no pesticides. Kenaf fiber consisting of following properties which includes its density is 1320 kg/m^3, Tensile strength is 260 N/mm^2 and moist absorption is 10-12%, with the average diameter of fiber is 67.6l m. The Kenaf plant can grow to heights of 3.5– 4.5 m within 4–5 months with annual fiber yields of 6 to 10 tons of dry fiber/acre, which is approximately four times greater than that of southern pine trees.

Kenaf filaments consist of discrete individual fibers, generally 2–6 mm long. Because of its high stiffness, strength values and also has higher aspect ratios which made it suitable to be used as reinforcement in polymer composites. It has a best fiber which contains 75% cellulose and 15% lignin which offers the advantages of being biodegradable and environmentally safe material for producing structural concrete. The treatments of Kenaf Fiber is recommended 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 based on Saba, N.; Paridah, (2015)

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 Programmer

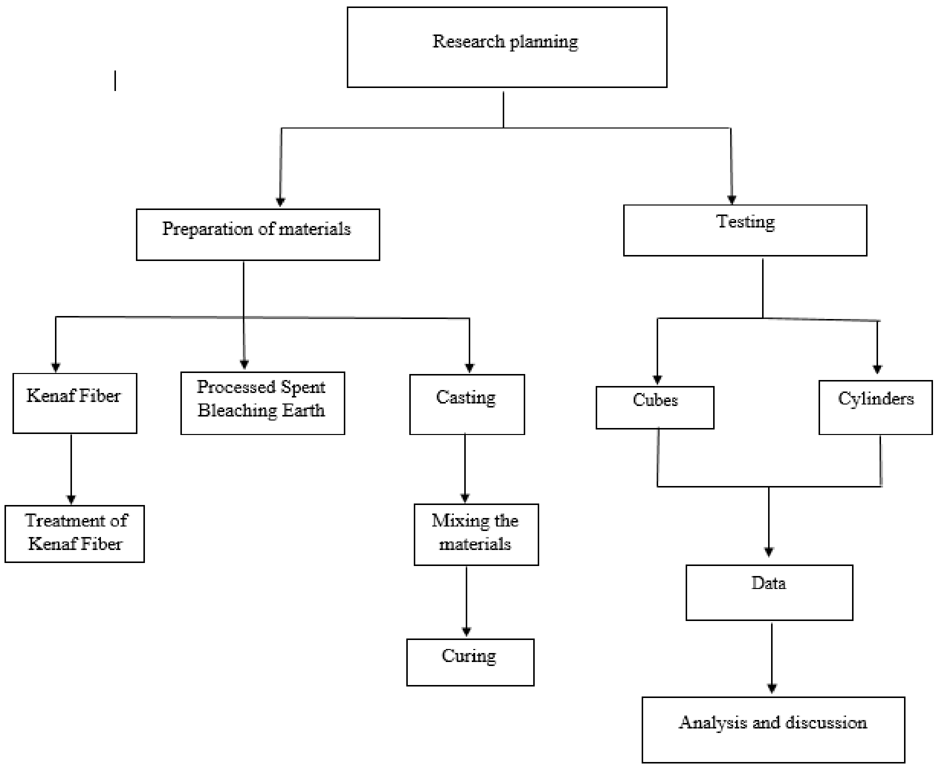


Figure 3.1: Research planning

3.3 Materials of famed concrete

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 3.2below showed the type of cement used in this study.

Figure 3.2**:** Ordinary Portland cement

3.3.2 Processed of Spent Bleaching Earth

Spent Bleaching Earth used in this research was supplied by Eco Innovation Sdn Bhd. PSBE was classified as Class N Natural Pozzolan in accordance with ASTM C618-12 (2012). In this study, PSBE was sun dried for 2 days and sieved passing size 300µm to achieve finer particle before mixing.

Figure 3.3: Processed Spent Bleaching Earth

3.3.3 Processed of 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 3.4: Kenaf Fiber

3.3.4 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.

3.3.5 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 tap water used was clean and free from any dirt.

3.3.6 Foaming Agent

All of the procedure and preparation for preformed foam was following the LCM guideline. 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 3.5: Foaming Agent

3.4 Mix proportion of foamed concrete

In this study, there are two mixtures were prepared which namely PFC (30% of PSBE as partial cement replacement of cement) and PKF (30% PSBE + 0.5% Kenaf Fiber). The mix density was design as 1600 kg/m^3.

Table 3.1: Mix proportion of foamed concrete

Mixture	**kg/m ^{3}**	**s/c**	**w/c**	**Cement**	**Sand**	**Foam**	**%PSBE**	**% Kenaf Fiber**
PFC (30%PSBE)	1600	1.5	0.5	16.1	24.1	0.75	4.8	**-**
PKF (30% PSBE + 0.5% Kenaf)	1600	1.5	0.5	16.1	24.1	0.75	4.8	0.8

3.5 Production of foamed concrete

In this study, foamed concrete was prepared by mixing cement, PSBE, Kenef Fiber, silica sand, water and preformed foam according to ASTM C796.F preformed foam has been prepared by diluting 1 liter of foaming agent with 25 liters 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 liter 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 cured in water for duration of 24 hours.

Greasing the specimens cubes and cylinders

Mixing the materials by using mixture

Foamed agent production by machine

Filling up the specimens

Weight the specimens after drying

Curing the Specimens for7, 14 and 28 days

Figure 3.6**:** Preparation of PFC and PKF Mixing

3.6 Testing

3.6.1 Workability

In this study, the workability of the foamed concrete has been determined by conducting flow table test. The flow table test measures the horizontal spread of a concrete cone specimen after being subjected to jolting. The apparatus consists of a 700 mm square wooden top plate lined with a thin metal sheet, as shown in Figure 3.7 The plate is hinged on one end to a base, while on the other end, clips allow the plate to be lifted a vertical distance of 40mm.Etched into the metal sheet are two perpendicular lines that cross in the center of the plate and a 200 mm circle concentric with the center of the plate. The frustum of a cone used to mold the concrete is shorter than the slump cone, with a top diameter of 130 mm and with a bottom diameter and height of 200 mm. To perform the test, the cone mold is placed in the center of the plate and filled in two layers, each of which is compacted with a tamping rod. The plate is lifted with the attached handle a distance of 40mm and then dropped a total of 15 times. The horizontal spread of the concrete is measured. The test is applicable to a wide range of concrete workability and is especially appropriate for highly fluid mixes that exhibit a collapsed slump. The flow table test for foamed concrete should be in the range 180-200mm for 0.55 water cement ratio. The percentage of flow table test to measure the workability was calculated from the diameter obtained through the famed concrete by using this equation 3.1

Equation 3.1

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

Figure 3.7**:** Measuring the Diameter of Mixing

3.6.2 Compressive Strength Test

In this study, the Compressive strength of the foamed concrete was determined on cube and cylinder specimens that were cured in water curing and tested for 7, 14 and 28 days as per ASTM C39M-18. All the specimens for compressive strength test have been stored in the curing tank until the testing day. 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 was 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. Figure 3.8 show the testing set up below. The value of Compressive strength was calculated from the maximum loading acting on cross sectional area of cubes and cylinder by using this equation 3.2.

$$\text{Compressive Strength } \sigma = \frac{P}{A} \qquad \text{Equation 3.2}$$

Where:

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

Figure 3.8**:** Compressive Strength Machine

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

The goal of this study is to investigate the effects of specimen size and shape of foamed concrete containing Spent Bleaching Earth and Kenaf Fiber. The workability, and compressive strength, had been investigated and the details results are presented as follow.

4.2 Chemical Composition of PSBE

The chemical composition of Processed Spent Bleaching Earth (PSBE) is to determine either the suitability of the chemical component as replacement of cement. The laboratory test conducted to identify chemical composition is X-Ray fluorescence test. From the chemical test, the chemical composition will be compared with the cement chemical composition. Besides that, the type of pozzolan can be identifying based on the chemical composition provided.

Table 4.1: Chemical composition of Processed Spent Bleaching Earth

Parameters	OPC	PSBE
CaO %	55.49	6.6
SiO_2%	26.49	55.82
Al_2O_3%	9.81	13.48
Fe_2O_3%	3.9	8.24
MgO%	0.8	5.94
SO_3%	4.72	1.05
Loss on Ignition %	0.88	0.18

Table 4.1 show the chemical composition present in PSBE. It is shown the chemical composition which present in cement are available in PSBE. It proved the ability of the PSBE function as partial replacement for cement. Moreover, classification type of pozzolan for Processed Spent Bleaching Earth based on ASTM C-618. From the chemical composition provided, it resulted that PSBE is classified as siliceous type (ASTM C618-12 Type N) which contain 55% reactive silica and reactive calcium oxide less than 10% and possess no hydraulic properties.

4.3 Workability of foamed concrete

Table 4.2 present the workability of PFC and PKF. It is clear that the foamed concrete has low workability to 40% in PFC mixing containing PSBE and the flow diameter obtained 350 mm. Therefore, PKF mixing containing PSBE and Kenaf Fiber has high workability to 72%- and 430-mm flow diameter.

Table 4.2: Flow Table of PFC and PKF

Mixing	Flow Diameter	Flow values	Description
PFC	350 mm	40%	LOW 20-40%
PKF	430 mm	72%	High 60-80%

Table 4.3**:** The average of compressive strength for cubes and cylinder of PFC mixing

Shape	Size mm	Height mm	Weight Kg	Compressive strength MPa		
				7 days	14 days	28 days
Cube	50x50x50	50	0.214	13	12	11
	100x100x100	100	1.70	9	15	17
	150x150x150	150	5.65	10	16	17
Cylinder	150diameter	300	9.80	7	13	15
	100diameter	200	12.9	9	11	19

Table 4.3 show the average of compressive strength for cubes and cylinder of PFC mixing during 7 days, 14 days and 28 day. The higher value for compressive strength of cubes were recorded by 17 MPa in 28 days in cube size 100 mm x 100 mm x 100 mm and 150 mm x 150 mm x 150 mm. Also, cylinder size 100 mm x 200 mm recorded the higher value for compressive strength in 28 days by 19 MPa.

Table 4.4**:** The average of compressive strength of cubes and cylinder of PKF mixing

Shape	**Size mm**	**Height mm**	**Weight Kg**	**Compressive strength MPa**		
				7 days	**14 days**	**28 days**
Cube	50x50x50	50	0.193	6	10	9
	100x100x100	100	1.471	8	11	11
	150x150x150	150	5.0	8	10	11
Cylinder	150 diameters	300	9.00	6	9	14
	100 diameters	200	13.72	6	9	20

Table 4.4 show the average of compressive strength for cubes and cylinder of PKF mixing during 7 days, 14 days and 28 day. The higher value for compressive strength of cubes were recorded by 11 MPa in 28 days in cube size 100 mm x 100 mm x 100 mm and 150 mm x 150 mm x 150 mm. Also, cylinder size 100 mm x 200 mm recorded the higher value for compressive strength in 28 days by 20 MPa.

4.4 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 form 7 days to 28 days. The highest of compressive strength of PFC for cube of size 50mm was found to have 13.0 MPa, following by size 100 mm was 17.0 MPa and size 150 mm at 28 days respectively. Hence, the increases in cube size increased the compressive strength. The compressive strength of PKF was decreased according to the Kenaf fiber. The increase is more in 100mm cubes and 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)

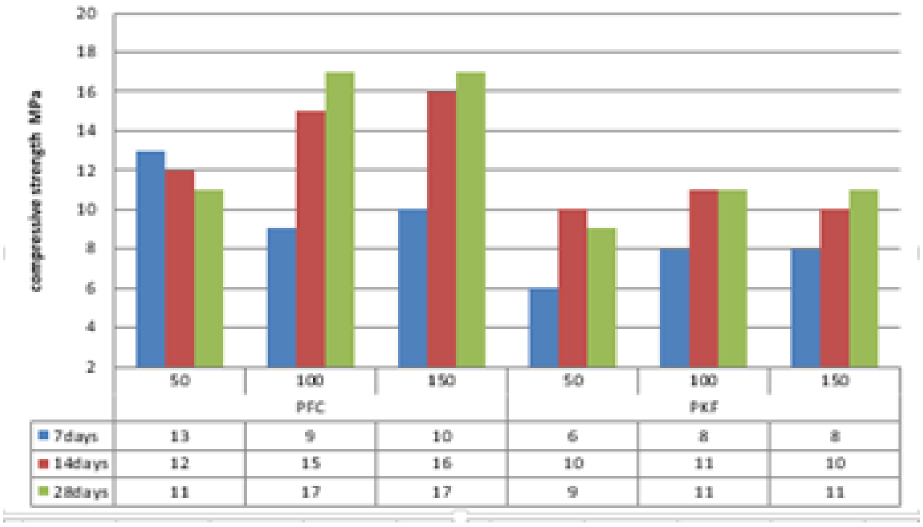
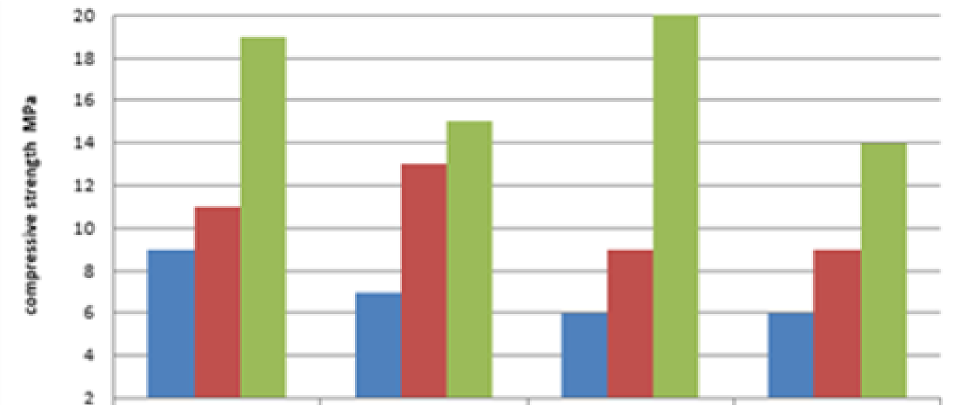


Figure 4.1: Development of compressive strength of foamed concrete due to size of cubes

4.5 **Influence of specimen size of cylinders on compressive strength**

Figure4.2 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 highest compressive strength of 100 mm diameter recorded as 19.0 MPa and 150 mm diameter was 15.0 MPa in PFC which mean that 100 mm diameter cylinder was 21% greater than 150 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)



	100x200	150x300	100x200	150x300
	PFC		PKF	
7days	9	7	6	6
14days	11	13	9	9
28days	19	15	20	14

Figure 4.2**:** Development of compressive strength of foamed concrete due to size of cylinders

4.6 Influence of shape on compressive strength

Figure 4.3 shows the graph comparing the compressive strength between 100 mm cube and 100 mm diameter of cylinders for PFC and PKF. The highest values were 17.0 MPa given by cube 100 mm at 28 days in PFC. It was 10.5 % smaller than 100 mm diameter of cylinder. 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).

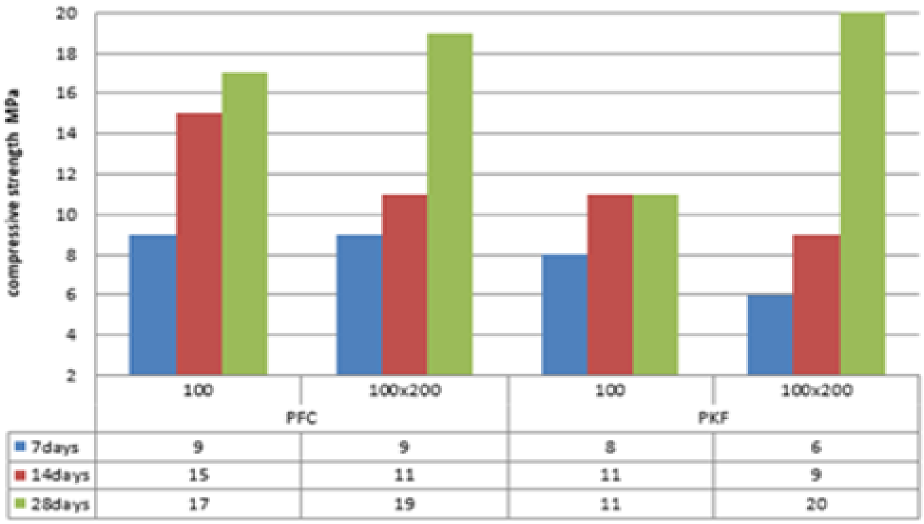


Figure 4.3**:** Development of compressive strength of foamed concrete due to size of cubes and cylinders

Figure 4.4 shows the graph comparing the compressive strength between 150 mm cube and 150 mm diameter of cylinders for PFC and PKF. The highest values were 17.0 MPa given by cube 150 mm at 28 days in PFC. It was 11.76 % greater than 150 mm diameter of cylinder.

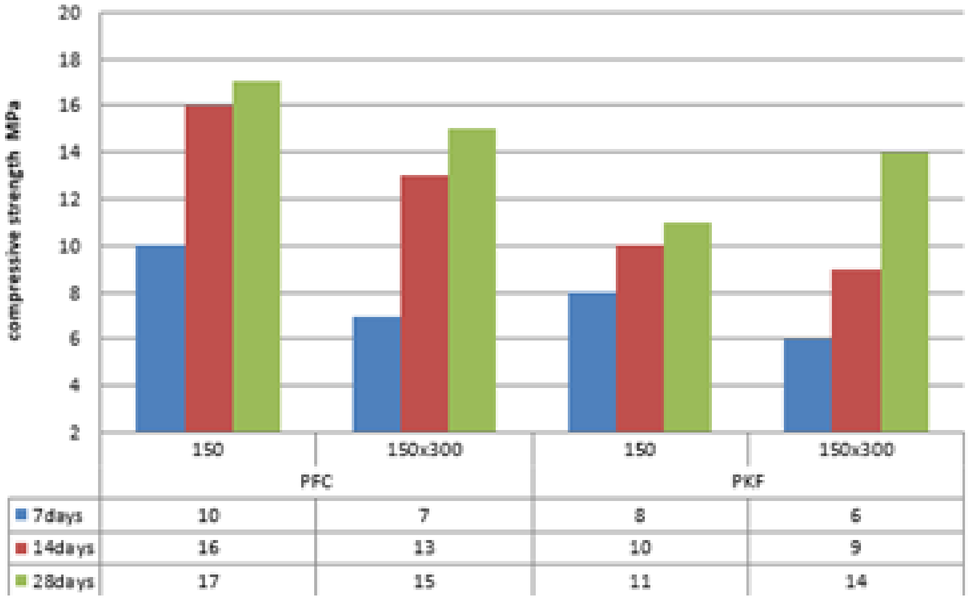


Figure 4.4**:** Development of compressive strength of foamed concrete due to size of cubes and cylinders

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

From the laboratory test conducted, the performance of Processed Spent Bleaching Earth (PSBE) as cement replacement in foamed concrete application showed a positive result. This indicates that PSBE can be recommended to be used as a new mineral admixture for greener 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 PSBE as cement replacement in foamed concrete.

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 PKF mix, the PFC mix generate higher compressive strength about 17.0 MPa in cube size 100mm at 28 day and achieved 15.0 MPa at 28 day in cylinders size 150mm diameter.
ii. Cubes could carry a higher load than cylinder in PFC compared to PKF which the cubes carry lowest compressive strength.
iii. The compressive strength of 100mm cubes produced 10.5 % smaller than 100 mm diameter of cylinder in PFC.
iv. By comparing, the compressive strength of 150mm cubes produced 11.76 % greater than 150 mm diameter of cylinder in PFC.

5.3 RECOMMENDATION

Based on the study, it is recommended to use PSBE as one of the construction materials as it can reduce the carbon dioxide emission and act as cement replacement. With low density and high compressive strength properties, it was shown that PSBE as cement replacement in foamed concrete will gives out a better result on the performance of the foamed concrete. However, further study should be conducted to improve Kenaf Fiber properties recommended as follow:

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.

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