PROPERTIES OF CEMENT SAND BRICK CONTAINING FLY ASH AS PARTIAL CEMENT REPLACEMENT

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RROPERTIES OF CEMENT SAND BRICK CONTAINING
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Thesis submitted in fulfillment of the requirements
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ABSTRACT

Fly ash can be found in large quantities because our country has several power plant stations. The waste disposal of fly ash effects to the environment surroundings. The cement production also causes air pollution, water pollution, and others. By using fly ash as an alternative construction material is a right step to preserve the environment. Hence, this study conducted to investigate the properties of cement sand brick containing fly ash as partial cement replacement. There are several tests conducted to investigate the effect of fly ash as partial cement replacement on compressive strength, flexural strength, and water absorption of cement sand brick. The test of brick specimens with replacement ratios of 0%, 10%, 20%, 30% and 40%, are measured and are compared with those of the bricks specimens without fly ash at the same ages. The water absorption measured at 28 days after the bricks undergo water curing. The type of curing used in the experiment is water curing in aged of 7 and 28 days. All experimented works are follow the standard of ASTM. Furthermore, the observation of strength behaviors are analyzed and discussing in terms of the properties of cement sand brick. In term of compressive strength, the higher the percentages of fly ash used, the lower the compressive strength of brick. With regard to flexural strength, the higher the percentages of fly ash, the lower the flexural strength of brick. Based on water absorption, the higher the percentages of fly ash, the higher the water absorption. Conclusively, the brick contain fly ash can be used for non-load bearing application.

ABSTRAK

Abu-abu terbang boleh ditemui dalam kuantiti yang besar kerana negara kita mempunyai beberapa stesen janakuasa. Pelupusan sisa abu terbang memberi kesan kepada persekitaran. Pengeluaran simen juga menyebabkan pencemaran udara, pencemaran air, perubahan klimaks dan lain-lain. Dengan menggunakan abu terbang sebagai bahan binaan alternatif adalah langkah yang tepat untuk memelihara alam sekitar. Oleh itu, kajian ini dijalankan untuk mengkaji sifat-sifat bata pasir simen yang mengandungi abu terbang sebagai pengganti kepada simen. Terdapat beberapa ujian dijalankan untuk menyiasat kesan abu terbang sebagai pengganti simen pada kekuatan mampatan, kekuatan lenturan, dan penyerapan air Ujian spesimen bata dengan nisbah gantian sebanyak 0%, 10%, 20%, 30% dan 40%, dan umur 7 dan 28 hari diukur dan dibandingkan dengan spesimen batu bata tanpa abu terbang pada umur yang sama . Jenis pengawetan yang digunakan dalam eksperimen ialah pengawetan air. Semua eksperimen mengikuti standard ASTM. Tambahan pula, kelakuan kekuatan pemerhatian dianalisis dan dibincangkan dari segi sifat-sifat bata pasir simen. Penyerapan air adalah28 hari selepas batu bata menjalani pengawetan air. Dari segi kekuatan mampatan,semakin tinggi persentase abu terbang yang digunakan, semakin rendah kekuatan mampatan bata. Berkenaan dengan kekuatan lenturan, semakin tinggi peratusan abu terbang semakin rendah kekuatan lenturan bata. Berdasarkan penyerapan air, semakin tinggi peratusan abu terbang, semakin tinggi penyerapan air. Walau bagaimanapun, bata mengandungi abu terbang yang boleh digunakan untuk aplikasi tanpa galas.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Nowadays, the environmental management and construction industry are of great importance. The main factor of this problem here is waste production. Waste is the biggest treat to environment and it will give a negative impact in our future. So, we have to manage it wisely. Waste can be produce in many sources for example from coal power plant industry. Malaysia have many place that generate coal power plant for electricity. From that industry it produces about million tons of waste that called fly ash.

Fly ash is one of the waste product from the coal combustion process with temperature reach approximately 2800°F. Fly ash is a fine grained materials consisting mostly of spherical, glassy particles. Fly ash can be found in large quantities and small commercial value in Malaysia. Hence, the waste products have a potential to be used in construction industry. The suggestion is to use the fly ash as cement replacement. Cement is the main product that has high demand in construction industry in Malaysia. By using fly ash as a potential cement replacement it will might give a benefit for our construction industry. In addition, the price of fly ash is more effective compared to the price of cement.

1.2 Problem Statement

Awareness of environmental problem due to waste disposal and high demand of construction material like natural sand and cement are needed so that construction industry find and accept partial material replacement especially from recycle material or waste material. Fly ash will also affect the environment surrounding. From the combustion of coal, it will causes bad pollution to the environment. For example it will causes of air pollution. Human can easily having a disease from the low quality of environment. In addition, using a waste material in construction industry is one of the right ways to ensure that waste material been manage correctly and it does reduce the area to dispose waste material. Fly ash is one of the waste material that is available in Malaysia. There are six coal power electricity plant station for long time being for example in Manjung power station, Perak. Normally, the growth in power plant that use coal as the source of fuel has produced a million tons of ash every day (Abdullah, 2016). With amount of coal industry are expected to increase in the future, using fly ash as an alternative construction material is a right step to preserve the environment.

Production of cement can cause soil erosion, air pollution, water pollution, urban heat and flooding (Banthia, 2014). It is because factory that produce cement will release carbon dioxide gases. The carbon dioxide gases will effect to the environment and also human health. Noise emissions occur throughout the whole cement manufacturing process from preparing and processing raw materials, from the clinker burning and cement production process, from material storage as well as from the dispatch and shipping of the final products. The heavy machinery and large fans used in various parts of the cement manufacturing process can give rise to noise and/or vibration emissions. Reducing the number of cement used is also one of the ways to preserve the environment since cement is obtaining from the factory. Thus, study on uses of fly ash as an alternative sand in brick industry with a view of effective utilization of the resources and environmental protection is necessary.

1.3 Objective

This research is conducted to achieve the following objective:

i. To investigate the effect of fly ash as partial cement replacement on compressive strength of cement sand brick.
ii. To investigate the effect of fly ash as partial cement replacement on flexural strength of cement sand brick.
iii. To investigate the effect of fly ash as partial cement replacement on water absorption of cement sand brick.

1.4 SIGNIFICANT OF STUDY

This study enlighten the society about the use of waste materials for brick production. The study will give a further information about using fly ash as partial sand replacement in the production of cement sand bricks. This work will contribute to green technology development in Malaysia. Succeeding in this research will decrease the number of cement production activity thus as the same time preserved the environment. The information is expected to contribute to better understanding about the behaviour of the brick contain fly ash that acts as a partial cement replacement.

1.5 LAYOUT OF THESIS

In chapter one is the introduction. It explains about overall of the thesis. The first sub topic explain about the background of the study and the problems statement in this research. This chapter also point out the objective and the significance of the study in this research. Chapter two elaborates about the information of the brick and type of brick. Besides that, explaining about industrial waste and the effect of industrial waste to the environment. In addition, this chapter also contains information about fly ash and its properties more details. Chapter two ended with the information of cement, cement industry and the effect of cement production on the environment.

Chapter three is about the methodology to conduct the experiment. Started with introduction followed by flowchart of this research. It elaborates on the preparation of materials for making cement sand brick. The manufacture of this brick according to cement sand brick mix design are also discussed. The type of materials and mix proportion are also stated in this chapter. This chapter l ended with discussion on the testing method adopted in order to investigate the performance of the brick due to its compressive, flexural strength, and water absorption. In the chapter four, it discussed about the experimental result that obtained after conducting the experiment. This chapter also will explain about the properties of brick such as compressive strength, flexural strength, and water absorption after subjected to several testing. For chapter five, presents the conclusion and recommendation for the future study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, discussion on various topics and reading materials which can help to study the properties of cement sand brick containing fly ash as partial cement replacement. The topics describe about the brick, type of brick and their properties. Besides that, it will explain about the waste material in Malaysia. In addition, this section also will review fly ash literature and the properties of fly ash described in more detail. For the last, this chapter discussed generally on the production of cement in Malaysia and its effect towards the environment.

2.2 HISTORY OF BRICK

A brick is building material used to make walls, pavements and other elements in masonry construction. Traditionally, the term brick referred to a unit composed of clay, but it is now used to denote any rectangular units laid in mortar. A brick can be composed of clay-bearing soil, sand, and lime, or concrete materials. Bricks are produced in numerous classes, types, materials, and sizes which vary with region and time period, and are produced in bulk quantities.

Good quality bricks have a major advantage over stone as they are reliable, weather resistant and can tolerate acids, pollution and fire. Bricks can be made to any specification in color, size and shape which makes bricks easier to build with than stone.

Air-dried bricks, also known as mud bricks, have a history older than fired bricks, and have an additional ingredient of a mechanical binder such as straw.

Bricks are laid in courses and numerous patterns known as bonds, collectively known as brickwork, and may be laid in various kinds of mortar to hold the bricks together to make a durable structure. Brickwork is also much cheaper than cut stone work. However there are some bricks which are more porous and therefore more susceptible to dampness when exposed to water. For best results in any construction work, the correct brick must be chosen in accordance with the job specifications.

2.3 TYPES OF BRICK

2.3.1 Common Burnt Clay Bricks

Common burnt clay bricks are formed by pressing in molds. Then these bricks are dried and fired in a kiln. Common burnt clay bricks are used in general work with no special attractive appearances as shown in figure2.1. When these bricks are used in walls, they require plastering or rendering.

Figure 2.1 Common Burnt Clay Bricks

Sources: (SafeerAbbas, 2017)

2.3.2 Sand Lime Bricks

Sand lime bricks are made by mixing sand, fly ash and lime followed by a chemical process during wet mixing. The mix is then molded under pressure forming the brick. These bricks can offer advantages over clay bricks such as: Their color appearance is gray instead of the regular reddish color, the shape is uniform and presents a smoother finish that doesn't require plastering as shown in Figure 2.2. These bricks offer excellent strength as a load-bearing member.

Figure 2.2 Sand Lime Bricks

Sources: (Organo, 2011)

2.3.3 Concrete Bricks

Concrete bricks are made from solid concrete and are very common among homebuilders as shown in Figure 2.3. Concrete bricks are usually placed in facades, fences, and provide an excellent aesthetic presence. These bricks can be manufactured to provide different colors as pigmented during its production. The benefit of using the concrete bricks is it available in a variety of shapes- not limited to rectangular, exceptional in durability and also offers a wider color variety than clay.

Figure 2.3. Cement bricks

Sources: (Organo, 2011)

2.4 INDUSTRIAL WASTE

Industrial waste is defined as waste generated by manufacturing or industrial processes. The types of industrial waste generated include cafeteria garbage, dirt and gravel, masonry and concrete, scrap metals, trash, oil, solvents, chemicals, weed grass and trees, wood and scrap lumber, and similar wastes. Hazardous waste may result from manufacturing or other industrial processes. Certain commercial products such as cleaning fluids, paints or pesticides discarded by commercial establishments or individuals can also be defined as hazardous waste. If improperly managed, this waste can pose dangerous health and environmental.

2.4.1 Types of Industrial Waste

Industrial waste is the waste produced by industrial activity which includes any material that is rendered useless during a manufacturing process such as that of factories, industries, mills, and mining operations. Industrial waste can be categorized into biodegradable and non-biodegradable. Biodegradable is industrial wastes which can be decomposed into the non-poisonous matter by the action of certain microorganisms are the biodegradable wastes. They are even comparable to house wastes. These kinds of waste are generated from food processing industries, dairy, textile mills, slaughterhouses, etc. Some examples are paper, leather, wool, animal bones, wheat, etc. They are not toxic in nature and they do not require special treatment either as shown in Figure 2.5. Their treatment processes include combustion, composting, gasification, bio-methanation, etc. (Towonsing, 2017)

Non-biodegradable is industrial wastes which cannot be decomposed into non-poisonous substances are the non-biodegradable wastes. Examples are plastics, fly ash, synthetic fibers, gypsum, silver foil, glass objects, radioactive wastes, etc. These wastes cannot be broken down easily and made less harmful. Hence, they pollute the environment and cause threat to living organisms. Figure 2.4 and figure 2.5 shows an example of non-biodegradable waste.

Figure 2.4 Wood

Sources: (Chiew, 2003)

Figure 2.5 Synthetic Fiber

Sources: (Massenger, 2017)

Figure 2.6 Fly ash

Sources: (The Master Builder, 2017)

2.4.2 Industrial Waste and Environment

The economic growth and urbanization experienced in many parts of the Asian and Pacific Region over the past 10-15 years, has significantly escalated the quantities of MSW being generated in many cities, including Bangkok, Beijing, Mumbai, Calcutta, Colombo, Dhaka, Hanoi, Jakarta, Kuala Lumpur, Manila and Shanghai (United Nations 1995, Koe and Aziz 1995). Uncontrolled, open dumping on the peripheries of many of the region's cities has resulting in the degradation of valuable land resources and the creation of long-term environmental and human health problems. Throughout the region, indiscriminate dumping has led to the contamination of surface and groundwater supplies, whilst open burning of waste contributes significantly to urban air pollution as illustrate in Figure 2.7 and figure 2.8. At a global level, the uncontrolled release of methane, which is produced as a by-product of the decomposition of organic wastes, represents a significant proportion of the region's contribution to the greenhouse effect.

Figure 2.7 Gas Emissions from the factory

Sources: (Rosenthal, 2007)

Figure 2.8 Waste water from factory

Sources: (Knutgget, 2012)

2.5 COAL INDUSTRY AND FLY ASH

The fly ash produced from the burning of pulverized coal in a coal-fired boiler is a fine-grained, powdery particulate material that is carried off in the flue gas and usually collected from the flue gas by means of electrostatic precipitators, baghouses, or mechanical collection devices such as cyclones. In general, there are three types of coal-fired boiler furnaces used in the electric utility industry. They are referred to as dry-bottom boilers, wet-bottom boilers, and cyclone furnaces. The most common type of coal burning furnace is the dry-bottom furnace.

When pulverized coal is combusted in a dry-ash, dry-bottom boiler, about 80 percent of all the ash leaves the furnace as fly ash, entrained in the flue gas. When pulverized coal is combusted in a wet-bottom (or slag-tap) furnace, as much as 50 percent of the ash is retained in the furnace, with the other 50 percent being entrained in the flue gas. In a cyclone furnace, where crushed coal is used as a fuel, 70 to 80 percent of the ash is retained as boiler slag and only 20 to 30 percent leaves the furnace as dry ash in the flue gas.

Figure 2.9 Pile of coal in Selantik, Pantu, Sarawak

Sources: (Precast Magazine, 2009 - 2010)

2.5.1 Physical Properties of Fly Ash

Fly ash is a fine grained material consisting mostly of spherical, glassy particles. Some ashes also containing irregular or angular particles. Fly ash is the pulverized fuel ash extracted from the fuel gases by any suitable process like cyclone separation or electrostatic precipitation (Zain, 2012). The size of particles varies depending on the sources. Some ashes may be finer or coarser than Portland cement particles. Fly ash consists of silt sized particles which are generally spherical, typically ranging in size between 10 to 100 micron (Sabnis, 2016). Figure 2.13 shows the scanning electron microscope (SEM) micrographs of polished sections of sub-bituminous and a secondary electron SEM image of bituminous of fly ash particles. Some of these particles appear to be solid, whereas other larger particles appear to be portions of thin, hollow spheres containing many smaller particles.

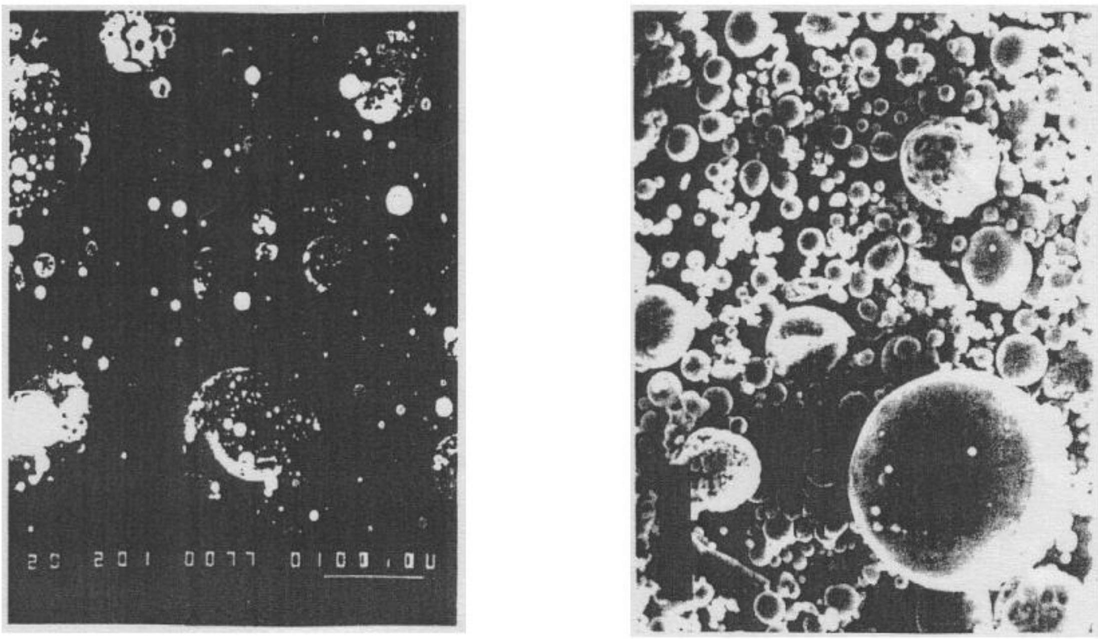


Figure 2.10 SEM micrograph of sub-bituminous ash and bituminous ash

Sources: (Zain, 2012)

Fly ash can be tan to dark gray, depending on its chemical and mineral constituents. Figure 2.11 shows the typical of ash colors. Tan and light colors are typically associated with high lime content. A brownish color is typically associated with the iron content. A dark gray to black color is typically attributed to an elevated unburned content. Fly ash color is usually very consistent for each power plant and coal source. The specific gravity of different fly ashes varies over a wide range. The specific gravity ranged from a low value of 1.90 for a sub-bituminous ash to a high value of 2.96 for an iron-rich bituminous ash

Figure 2.11 Typical ash colors
Sources: (Aakash Dwivedi, 2014)

In general, the physical characteristics of fly ashes vary over a significant range, corresponding to their source. Fineness is probably influenced more by factors such as coal combustion and ash collection and classification than by the nature of the coal itself. Similarly, the type of fly ash showed no apparent influence on the specific surface as measured by the Blaine technique.

2.5.2 Chemical Properties of Fly Ash

The most common fly ash derives from bituminous coal, is mainly siliceous, and is known as class F fly ash. It has constant fineness and constant carbon content. The carbon content is assumed to be equal to the loss on ignition, although the latter includes also any combined water or fixed CO_2 present. The fly ash may affect the color of the resulting concrete, the carbon in the ash making it darker. This may be importance from the standpoint of appearance, especially when concretes with or without fly ash are placed side by side. The figure 2.12 shows the classification of fly ash.Sub-bituminous coal and lignite results in high-lime ash, known as class C fly ash. Class C fly ash is high-lime ash originating from lignite coal. High-lime ash has some cementations properties of its own but, because its lime will combine with the silica and alumina portions of the ash, there will be less of these compounds to react with the lime. (Neville, 1988)

a) A Class C Fly Ash b) A Class F Fly Ash

Figure 2.12. Classification of fly ash

2.5.2 Use of Fly Ash in Construction

All precast concrete producers can now use a group of materials called “fly ash” to improve the quality and durability of their products (Precast Magazine, 2009 - 2010). Fly ash improves concrete’s workability, pump ability, cohesiveness, finish, ultimate strength, and durability as well as solves many problems experienced with concrete today–and all for less cost. Fly ash, however, must be used with care. Without adequate knowledge of its use and taking proper precautions, problems can result in mixing, setting time, strength development, and durability**.**

Fly ash can be used as prime material in blocks, paving or bricks; however, one the most important applications is PCC pavement. PCC pavements use a large amount of concrete and substituting fly ash provides significant economic benefits. Fly ash has also been used for paving roads and as embankment and mine fills, and its gaining acceptance by the Federal government, specifically the Federal Highway Administration.

2.6 CEMENT IN CONTRUCTION

The history of cementing material is as old as the history of engineering construction, Egyptians, Romans and Indians used some kind of cementing materials in their ancient constructions. It is believed that the early Egyptians mostly used cementing materials, obtained by burning gypsum. The process mixed and ground hard limestone and finely divided clay in the form of slurry and calcined it in a furnace similar to lime kiln till the CO_2 was expelled. The mixture so calcined was then grounded to a fine powder. Perhaps, the process used a temperature lower than the clinkering temperature.

Cement is a powdered material with water forms a paste that hardens slowly. It is made by sintering a mixture of various raw materials. The main raw material composed in the mixture is calcium carbonates as limestone and other alumina, silicates as clay or shale. The cement industry plays a vital role in the growth and development of a country as it provides required infrastructure for economic development of the country.

Ordinary Portland Cement (OPC) is the most common cement used in general concrete construction when there is no exposure to sulphate in the soil or groundwater. The most common use for Portland cement is in the production of concrete as shown in Figure 2.13. Concrete is a composite material consisting of aggregate (gravel and sand), cement, and water. As a construction material, concrete can be cast in almost any shape desired, and once hardened, can become a structural (load bearing) element. Figure 2.14 shows that the cement is use in constructions work.

Figure 2.13. Ordinary Portland cement
Sources: (Blount, 1904)

Figure 2.14 The Uses of Cement in Construction

Sources: (Mingas, 2012)

2.6.1 Cement Production Method

The raw materials required for manufacturing of Portland cement, are calcareous materials such as limestone or chalk and argillaceous materials such as shale or clay. The process of manufacture of cement consists of grinding the raw materials, mixing them intimately incertain proportions depending upon their purity and composition and burning at temperature of about 1300 to 1500o C. , at which temperature material sinters and partially fuses to form nodular shaped clinker (Rosenthal, 2011). The product formed by using this procedure is Portland cement. There are two process known as wet processes as shown in Figure 2.15 and dry processes as shown in Figure 2.16. It depending upon whether the mixing and grinding of raw materials is done in wet or dry conditions.

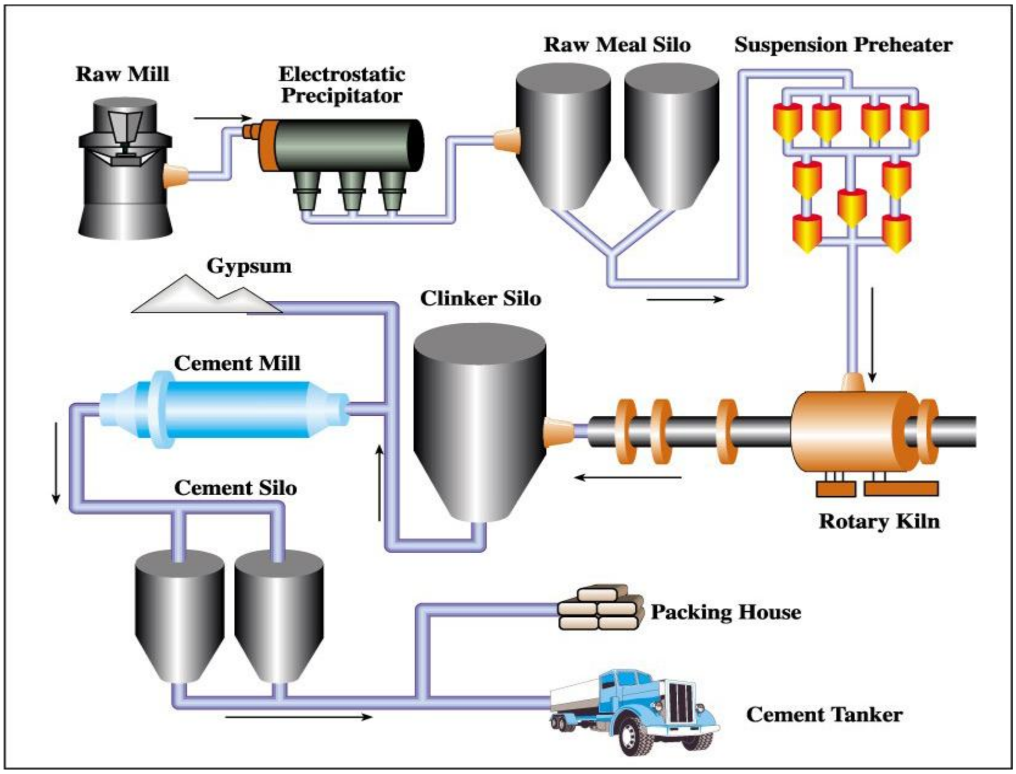


Figure 2.15. Wet process

Sources: (Talal, 2015)

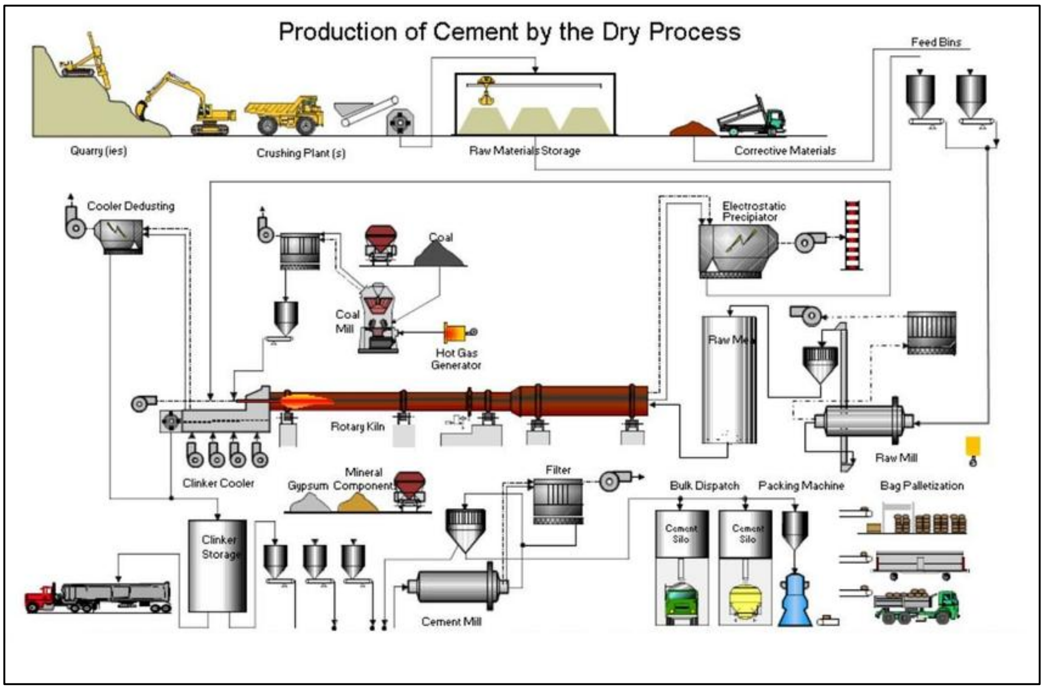


Figure 2.16. Dry process

Sources: (University, 2015)

2.6.2 Cement Industry and Environment

The increasing number of cement production is lead to number of environmental concerns. Cement has been produces and use for hundreds of year in all parts of the world. Cement is the most widely used in construction materials with annual consumption estimates between 20 to 30 billion tonnes. The production of cement give many effect to the environmental. The production of cement involves the consumption of large quantities of raw materials, energy, and heat. Cement production also results in the release of a significant amount of solid waste materials and gaseous emissions (Ing. Miroslav Stajanča, 2012). In addition, noise emissions occur throughout the whole cement manufacturing process from preparing and processing raw materials, from the clinker burning and cement production process, from material storage as well as from the dispatch and shipping of the final products. The heavy machinery and large fans used in various parts of the cement manufacturing process can give rise to noise pollution.

CHAPTER 3

METHODOLOGY

3.0 INRODUCTION

An experiment has been conducted to determine the effects of fly ash as a partial cement replacement in terms of compressive strength, flexural strength, water absorption and efflorescence. In this chapter, material and the experiment method will be explain specifically. This will includes all the materials required and casting of the specimen. All the specimen need to be tested in order to analyse and present data. All the testing was conducted in accordance to ASTM standard. Figure 3.1 show the flow of the experimental work.

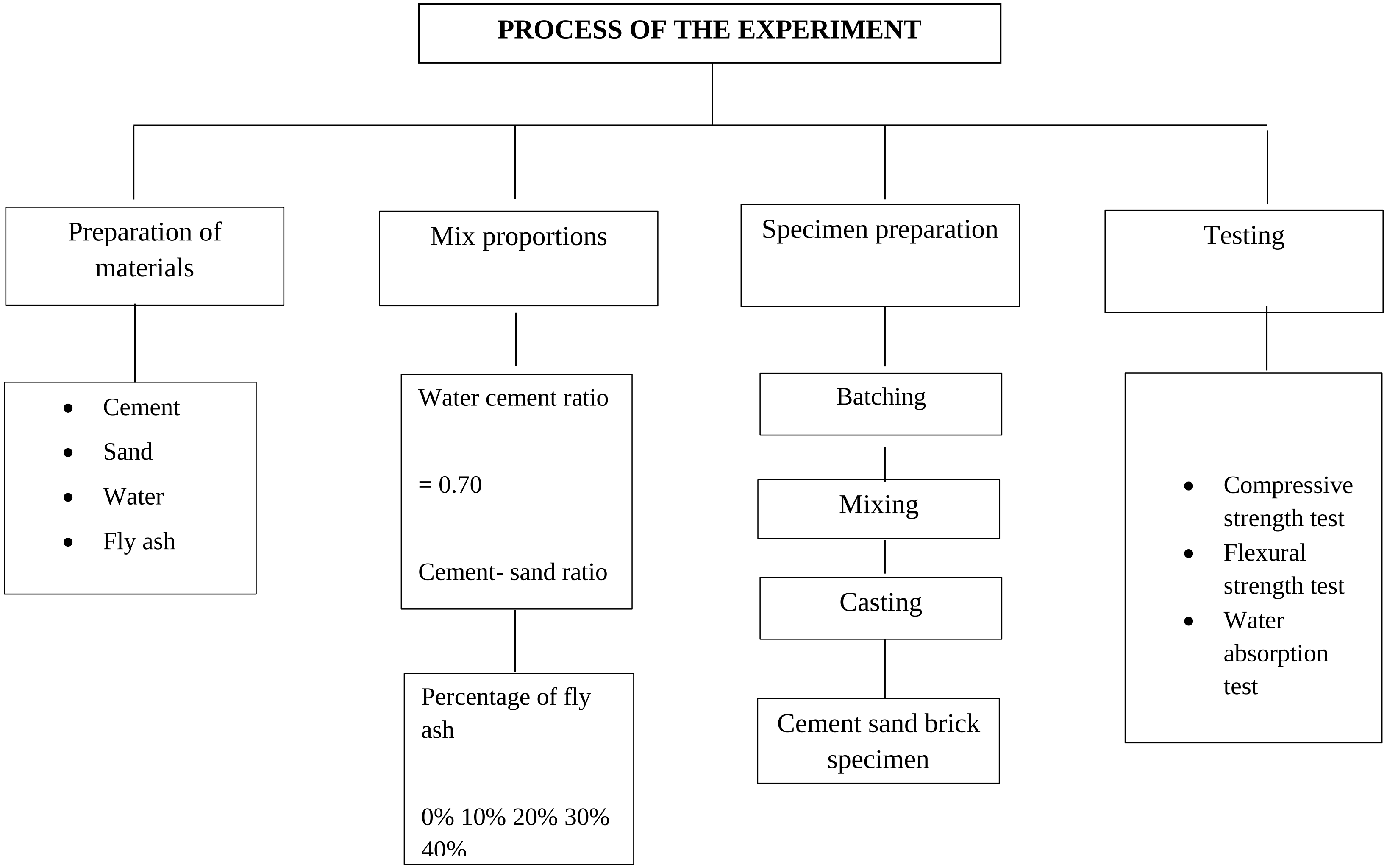


Figure 3.1 Flowchart of experiment work

3.2 MATERIALS

In this research, the materials that will be used in the making of cement sand bricks are cement, sand, water, and fly ash.

3.2.1 SAND

Sand is naturally occurring granular material composed of finely divided rock and mineral particles. Sand is classify by size which is finer than gravel and coarser than silt. Sand is also refer to a textural class of soil or soil type. Soils are consist more than 85% sand-sized particles by mass. For the making of cement sand brick, sand in the figure 3.2 is added along together with others materials which are cement and water in the mold to cast the brick and complete the mixture.

Figure 3.2 Air Dry River sand

3.2.2 WATER

Water is one of the most important element in the whole construction process as shown in figure 3.3. It becomes necessary to check the quality of water which is being used. Water to be used for construction purpose should be clean and clear. The water cement ration that be used in this experiment is 0.70.

Figure 3.3 Tap water

3.2.3 CEMENT

Cement is a fine mineral powder manufactured with very precise processes. Mixed with water, this powder transforms into a paste that binds and hardens when submerged in water. Because the composition and fineness of the powder may vary, cement has different properties depending upon its makeup. Cement is the main component of concrete. It's an economical, high-quality construction material used in construction projects worldwide. For this experiment, the cement will bind together with fly ash and sand with the present of water. Cement that will used in this experiment is Ordinary Portland Cement brand Orang Kuat as shown in figure 3.4.

Figure 3.4 Orang Kuat Ordinary Portland cement

3.2.4 FLY ASH

Fly ash is one of the naturally-occurring products from the coal combustion process as shown in figure 3.5. It is a material that is nearly the same as volcanic ash. The most common use of fly ash is as a partial replacement for Portland cement used in producing brick. For this study, replacement rates is 0%, 5%, 10%, 15% 20% and 25%, but can be higher. Fly ash reacts as a pozzolan with the lime in cement as it hydrates, creating more of the durable binder that holds concrete together.

Figure 3.5 fly ash

3.3 MIX PROPORTION

Mixing process of the brick was done by using standard brick making procedure. The brick was mix by using mechanical mixer. All the specimen were weighted according to the mix design before mixing. Fly ash were used as partial cement replacement in this study. The amount of replacement were 0%, 10%, 20%, 30%, and 40% by the weight of the cement. A total of three mix used in this experiment. Water cement ratio 0.7 is use. Cement sand ratio that have been used is 1:6. Besides that, the size of the cement sand brick is 100mm × 65mm × 210mm (W×H×L). The volume of one brick specimen is 1.365 × 10^{-3} m^3. The normal weight of a brick was 2.7 kg. Table below show the details of the mix proportion of the specimen used in this study. Table 3.1 represent the total specimen for each test.

Table 3.1 Total specimen for each test

Type of testing	**% of replacement**	**No of sample curing days**			**Total samples**
		7 day	**14 day**	**28 day**	
Compressive strength	0	3	3	3	54
	10	3	3	3	
	20	3	3	3	
	30	3	3	3	
	40	3	3	3	
	0	3	3	3	
	10	3	3	3	

Flexural strength	20	3	3	3	54
	30	3	3	3	
	40	3	3	3	
Water absorption	0	-	-	3	54
	10	-	-	3	
	20	-	-	3	
	30	-	-	3	
	40	-	-	3	

3.4 SPECIMEN PREPERATION

The preparation of the specimen starting by preparing the fly ash sample. Next, the others material such as cement, sand, and water was prepared for the process to make the cement sand brick. The targeted strength of brick is 3.45 MPa. For mixing process electric mixer machine was used to ensure all the material were mixed properly. Figure below show the detail in the type of casting machine used. The mix were then being poured into the handmade would mould compacted manually by hand. The specimen were covered with wet gunny sacks and left for one night. The specimen will be unmould for the next days and the sample was cured using air curing. The surface of mould need to be oiled to make easier when removing it and to avoid the wood absorb the water from the specimen. It is important to check the condition of the mould that can affect the testing

Figure 3.6 The mechanical mixer was use to mix the ingredients

Figure 3.7 The mix was pour into the wood mould

Figure 3.8 Manually compacted by hand

Figure 3.9 All the specimen were covered with wet gunny sack and left overnight

Figure 3.10 All the specimens after demoulded were immersed in
water tank until the testing age.

3.5 TESTING PROCEDURE

According to the ASTM standard there are several type of testing for brick. In this study. There are four type of test have been focus which is compressive, flexural strength, water absorption and efflorescence test. This testing method started with the compressive strength and flexural strength testing once the brick reached the required age, at 7 and 28 days. The water absorption rate was obtained for brick at 28 days.

3.5.1 Compressive Test

Compressive strength test was carried out using compressive machine as shown in the figure. The test was carried out using Compressive Testing Machine as shown in figure 3.6. The test was carried out in the UMP concrete laboratory according to the standard of compressive strength test ASTM C55 (2011). The compressive strength of the brick was measured at 7 and 28 days. The apparatus that will be used is compressive testing machine by MATEST. Three sample were prepared for each test. The brick specimen were placed so that the load applied perpendicular to the surface bed of the brick. Then, apply the load axially at a uniform rate of 1.25 mm/min till failure occurs and note the maximum load at failure. The failure load for the specimen was recorded and all the pertinent details regarding to the failure were observed. The load at failure is the maximum load at which the sample fails to produce any further increase in the indicator reading on the testing machine. The last reading will be taken.

The compression strength, C can be given as

$$C = \frac{P}{A}$$

Where,

C = compressive strength of brick sample (N / mm^2 or MPa)

P = maximum load carried by the sample during test (N)

A = average cross sectional area of the sample (mm^2)

Figure 3.11 Universal Testing Machine (UTM)

3.5.2 Flexural Test

Flexural test was carried to determine the ability of the specimen to resist the stress. The test was carried out in the UMP concrete laboratory according to the standard of compressive strength test ASTM C55 (2011). The compressive strength of the brick was measured at 7 and 28 days. The apparatus that will be used is using Flexural Testing Machine where a constant loading rate of 1.27 mm/min was set to the testing machine as shows in figure 3.7. The failure load for the specimen was recorded and all the pertinent details regarding to the failure were observed.

$$R = \frac{PL}{bd^2}$$

Where,

R = modulus of rupture ($\frac{N}{mm^2}$ or MPa)

P = maximum load carried by the sample during testing (N)

L = brick length (mm)

b = average width of sample at the fracture (mm)

d = average depth of the specimen at the fracture (mm)

Figure 3.12 Flexural Testing machine

3.5.3 Water Absorption Test

Moisture absorption rate used to measure the amount of water absorbed under specified condition. This test follow the procedures as described in ASTM C55 (2011). Figure show the brick under water absorption. For the test, the brick specimen were weight and recorded. The specimen was dried at 110°C for at least 24 hours. The weight of dry was recorded as Wd. After drying, the specimen was cooled in a drying room at 25 with relative humidity was around 70%. The specimen were then stored to be free from air draft and were un-stacked and separately place for 4 hours until the surface temperature was approximately at 28. Which equal to the drying room. The surface water of the specimen was wiped off with a damp cloth and the weight ware recorded.

The water absorption of the brick was calculated by using this formula,

$$\text{Water Absorption (\%)} = \frac{ws-wd}{wd} \times 100\%$$

Where,

Ws = saturated weight of the sample (kg)

Wd = dry weight of the sample (kg)

Figure 3.13 Sample has been dried up to 24 hours

Figure 3.14 Sample was submerged in water for 24 hours after has been dried up in the oven

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In the research, five mixes were prepared with one mix control brick and others four mixes for bricks contain various percentages of fly ash. The control sample contains 0% of fly ash was casted as common cement sand brick to compared the performance of the brick. In this chapter, the results and discussion of the test is reviewed. The results obtained from the experimental testing has been presented according to the method that has been discussed in the previous chapter. The results of the test included the mechanical properties test which is compressive strength test, flexural strength test, and water absorption test. The total of 105 bricks were prepared and cured in different curing ages for 7 days and 28 days.

4.2 Compressive strength of cement sand brick

Figure 4.1 show the results on compressive strength of the cement sand brick specimens subjected to water curing with 7 and 28 days of curing period. According to the compressive test, the strength at 0% replacement of fly ash which is the controlled mix shows the highest results of compressive strength. The graph also indicated that the strength were effected by many factors such as the fly ash replacement percentage and the curing age. It can be observed that, the compressive strength of the bricks started to decrease at the percentages of 10% to 40%.

The logical reasons to this due to particle size of the cement is smaller. This will make the specimen to become more dense and stronger. The value drop due to increase in porosity of the specimen. Porosity of the specimen increase due to porous structure of fly ash particles. The porous of the fly ash will make the structure to become less rigid and less dense. This will lead to the lower strength of the specimen with increased number of fly ash inside the specimen. The strength of the specimen contains 30% of fly ash lower than specimen contain 10% fly ash, it strength cannot be accepted because of the specimen has s lower strength compare to control specimen.

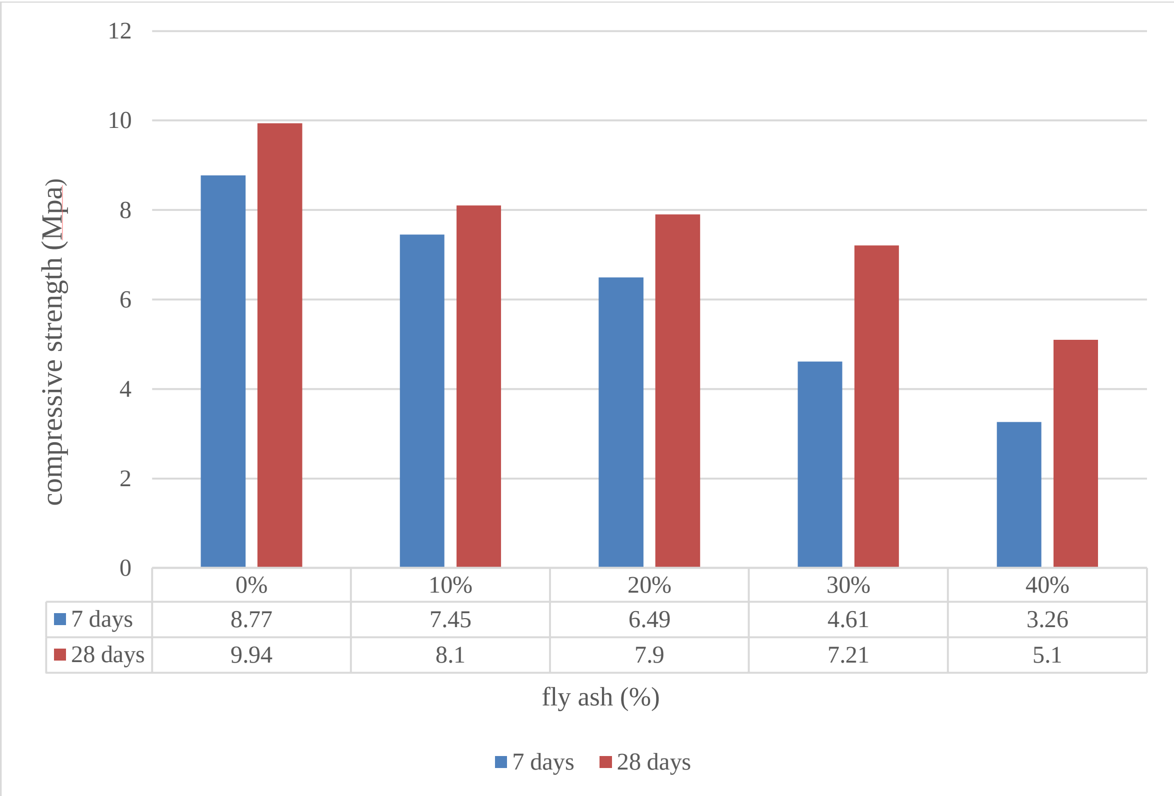
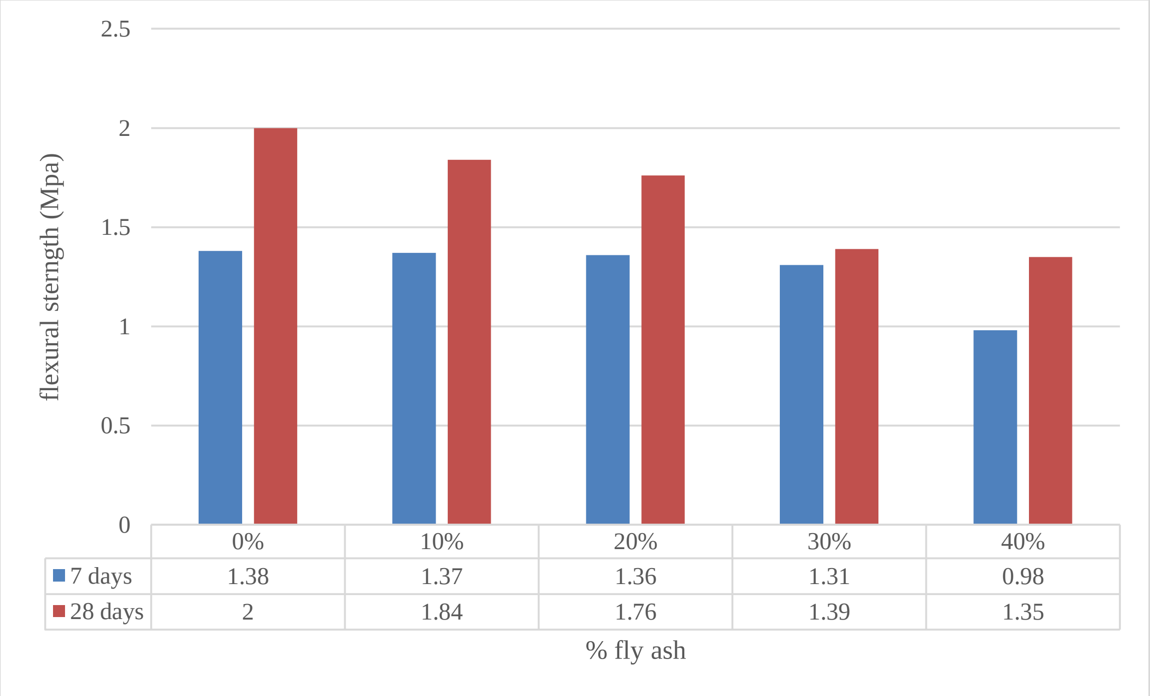


Figure 4.1 Compressive strength at 7 and 28 days

4.3 Flexural Strength of Cement Sand Brick

Figure 4.2 shows the results on flexural strength of cement sand brick with respect to 7 and 28 days of curing period. In this section, the flexural test was conducted on the samples are presented. The average reading from the flexural test result of three samples of each type of sample are taken to increase the accuracy of the reading. Five type of the samples were prepared, just like the compressive strength test, the samples are control sample with no fly ash and the four others samples which contains 10%, 20%, 30% and 40% of fly ash. The samples was casted and label the through 7 and 28 days of water curing before being tested. The results indicates that, specimen containing of 0% of fly ash has the highest flexural strength.

The result for flexural strength is almost similar to the compressive strength. The brick started to decrease at the early replacement until replacement percentage of 10%, until 40% replacement. The higher flexural strength was recorded at 28 days of the curing age for 0% fly ash replacement. The strength was 1.48(MPa). The higher the replacement of fly ash, the lower the strength of the brick. The strength of the specimen increase due to ability of cement to fill the voids inside the specimen. So, at certain amount of replacement in cause the specimen to become less dense.



	0%	10%	20%	30%	40%
7 days	1.38	1.37	1.36	1.31	0.98
28 days	2	1.84	1.76	1.39	1.35

Figure 4.2 Flexural strength at 7 and 28 days

4.4 Water Absorption of Cement Sand Brick

Water absorption test is used to test the ability of the brick to absorb water at specific time. According to Castrol et al. (2011), the water absorption test is an important laboratory analysis or important factor in determining the durability of cementations systems. This test is only conducted on concrete of 28 days. The result of rate of water absorption of the brick with different percentage of fly ash is tabulated in Table 4.3. In general, bricks are considered as unsuitable when they have high percentage of water absorption. In this section, the results on water absorption of cement sand brick are presented.

Based on the result, water absorption starting to increase from the replacement percentage of 10% until 40% of replacement. The results show that the sample containing 0% of fly ash had the lowest water absorption compared to that of the mixes. The water absorption percentage for the 28 days of water curing age is 0%. The higher percentage of fly ash partial replacement of cement will increase the percentage of water absorption. Cement is functioned as filler to fill the void in the brick, making the brick mush denser. Thus, the brick void could be reduced and the brick would absorb less water. It can be said that the size and the chemical composition of cement would be influence the density, strength and water absorption.

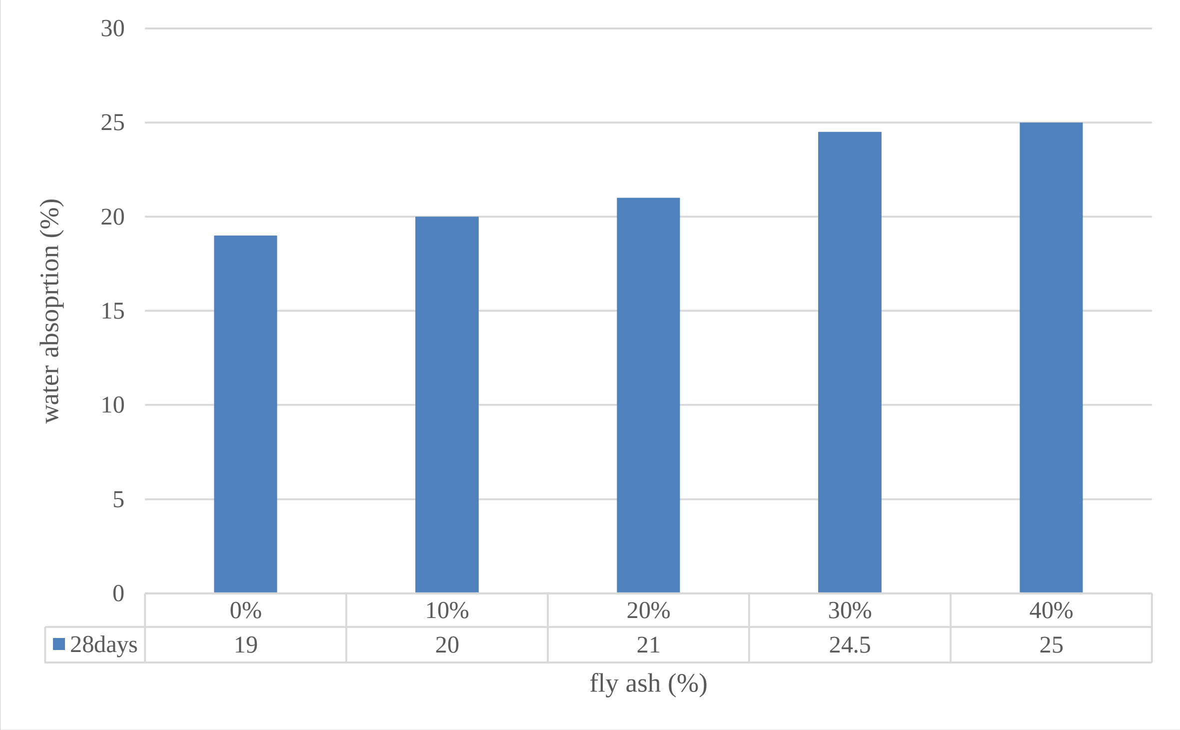


Figure 4.3 water absorption test result

4.5 Conclusion

The experimental work carried out shows that fly ash is not very suitable to be used as a partial cement replacement in cement sand brick. Integration starting of 10% of fly ash replacement will decrease the compressive strength and flexural strength. While the 0% of fly ash which is controlled mix show the higher in compressive and flexural strength. Inclusion of finely cement causes the cement brick become more compact. This is due to the filler effect of the fine particles of cement which filled the void inside the brick. As a result, cement sand brick containing 0% of fly ash exhibits lower water absorption. Conclusively, the higher the replacement of fly ash, the lower the strength of the cement sand brick.

CHAPTER 5

CONLUSION AND RECOMMENDATION

5.1 Introduction

This chapter present the conclusion of this research based on the objectives which have been set at the beginning stage of the research. The objectives of this research is to study the properties of cement sand brick containing fly ash as partial cement replacement in terms of compressive, flexural and water absorption. 5 mixes has been use to replace cement in different percentage of fly ash which is 0%,10%,20%,30% and ,40%.

5.2 Conclusion

This research had been demonstrated the utilization fly ash as partial cement replacement for cement sand brick. From the result and discussion made, it can be conclude that the objective of the study were achieved. Based on the analysis and result in chapter 4, several conclusion can be drawn:

i. With regard to compressive strength, brick produced from 0% fly ash as partial cement replacement display that the higher strength compared to cement sand brick that containing various percentage of fly ash. Cement particles would act as filler effect to fill the void inside the brick and make the brick to become denser and stronger.
ii. In term of flexural strength, brick containing 0% of fly ash show the higher flexural strength. This probably due to small particles size of cement compare

to fly ash which can fill the void inside the brick thus make the brick denser and stronger.

iii. The present of fly ash in brick would affect the water absorption percentage. The higher the percentage of fly ash, the higher of water absorption.

5.3 Recommendation

There are several recommendation that had been identified for future development of fly ash as replacing material in brick industry. Hence, the following recommendations are:

1. Investigate performance of the brick with fly ash under diff curing method
2. Study on the durability of cement sand brick such as chemical attack resistance, fine resistance and thermal conductivity.
3. Determine performance of brick containing fly ash in real world application such as effects of the brick from the change of natural weather and environment for at least one year

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