PROPERTIES OF CEMENT SAND BRICK CONTAINING PALM OIL CLINKER AS PARTIAL SAND REPLACEMENT

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PROPERTIES OF CEMENT SAND BRICK CONTAINING PALM OIL CLINKER AS PARTIAL SAND REPLACEMENT

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AA 12171

A Final Year Project submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Civil Engineering (Hons)

Faculty of Civil Engineering & Earth Resources

UNIVERSITI MALAYSIA PAHANG

JANUARY 2017

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DEDICATION

"Don't read success stories, you will get only message.

Read failure stories, you will get some ideas to get success."

-A.P.J. Abdul Kalam

Dedicated to my beloved parent and my siblings

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Last but not least, to all my friends, thank you to those who have helped me, directly or indirectly, both in my study and in my personal life. I wish you all the best in your future undertakings.

ABSTRACT

Palm oil clinker is a by-product of palm oil industry, which normally being dumped abundantly as waste that can caused undesirable effects to our environment sustainability. The amount of waste are expected to increase due to rapid growth of palm oil industry in Malaysia. Due to growth of construction industry in Malaysia, demand toward construction material like sand will also increase. Increase in sand usage will lead to increase in river sand mining activity that can cause ecological imbalance such as channel substrate removal, river bank erosion and sediment suspension. All of this problem has lead researcher to find a possible material replacement for sand and this research focused about palm oil clinker as possible sand replacement material. This research studied the effect of palm oil clinker on properties of cement sand brick that are compressive strength test, flexural strength test and moisture absorption test. The percentage of sand replacement are 10%, 20%, 30% and 40%. All the results were compared with control brick. The testing age are set to specific days, which are 7, 14 and 28 days. All the test were conducted according to ASTM standard for brick. Finding shows that cement sand brick containing 10% of palm oil clinker (POC) replacement provides the best results in terms of compressive strength and flexural strength. However, for water absorption test, plain brick shows a better result.

ABSTRAK

Klinker kelapa sawit adalah produk daripada industry kelapa sawit, yang kebiasaanya dianggap sebagai bahan buagan dan mampu memberikan kesan negatif kepada alam sekitar. Jumlah klinker dijangka akan bertambah kerana industri kelapa sawit diangka akan berkembang pesat di masa hadapan. Industri pembinaan di Malaysia juga dijangka akan berkembang pesat dan hal ini akan meningkatkan jumlah penggunaan bahan asas seperti pasir. Peningkatan penggunaan pasir bakal meningkatkan aktiviti perlombogan pasir yang akan mengakibatkan ketidakseimbagan ekosistem seperti hakisan tebing, pencemaran/kelodakan air dan sebagainya. Kesungguhan untuk megatasi masalah ini telah mnjadi pemangkin kepada para penyelidik untuk mencari bahan yg sesuai digunakan untuk mengantikan pasir and penyelidikan ini menumpukan tentang klinker kelapa sawit sebagai pengganti separa pasir. Penyelidikan ini menkaji kesan penggantian klinker kelapa sawit di dalam bata terhadap kekuatan mampatan, kekuatan lenturan dan juga peratusan penyerapan air. Peratusan penggantian klinker kelapa sawit di dalam bata adalah 10%, 20%, 30% dan 40% daripada jumlah pasir. Kesemua keputusan ujian akan di bandingkan dengan keputusan bata kontrol. Tempoh ujikaji bata dilakukan pada hari ke 7, 14 dan 28. Procedur ujikaji bata dilakukan berdasarkan ASTM standard untuk bata. Berdasarkan keputusan ujikaji, bata yang mempunyai 10% klinker kelapa sawit mempunyai kekuantan mampatan dan kekuatan lenturan tertinggi. Sementara itu, bata kontrol menunjukkan keputusan terbaik pada ujukaji penyerapan air.

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LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
POC	Palm oil clinker
MPOB	Malaysian palm oil board
SiO_2	Silicon oxide
K_2O	Potassium Oxide
CaO	Calcium Oxide
P_2O_5	Phosphorus pentoxide
MgO	Magnesium Oxide
Fe_2O_3	Ferric Oxide
Al_2O_3	Aluminium Oxide
SO_3	Sulphur trioxide
Na_2O	Sodium Oxide
TiO_2	Titanium dioxide
Cr_2O_3	Chromium(III) oxide
OPC	Ordinary portland cement

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Nowadays, world organization are getting more concerned about environmental management and construction industry are also not an exception to this. Waste is one of the biggest treat to environment and if it does not been manage wisely, it may cause negative impact in the future. Waste can come from many sources and the largest waste come from industrial waste. Malaysia is an industrial country and one of the biggest industry in Malaysia is palm oil industry. According Malaysia Palm Oil Board (MPOB, 2015), Malaysia palm oil industry produces about 90 million tons of palm oil in 2014. Large number production come with large number of waste. One of the waste produced is palm oil clinker (POC).

Palm oil clinker considered as a by-product waste produced from burning of palm oil fibre and oil palm shell inside the boiler under high temperature in order to generating steam engine for extracting palm oil (Abutaha et al, 2016). Physically palm oil clinker (POC) are porous, grey in color, irregular in shape and much lighter compare to normal aggregate (Kandasan and Razak, 2015). POC can be found in large quantities and have small commercial value in Malaysia. Hence, this industrial waste can be converted into potential construction material and one of the suggested material that can be replace by POC is sand. Sand is one of the material that largely used in construction industry and due to high demand of this material, the price for sand has been increases lately. Using POC as a potential sand replacement might be a positive move for construction industry since the price for POC is cheaper compare to natural sand and at the same time able to preserved the environment.

1.2 PROBLEM STATEMENT

Awareness of an environmental problem of waste disposal and high demand toward construction material like natural sand are a proof that construction industry need to find and accept partial material replacement especially from recycle material or waste material. 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. Palm oil clinker (POC) is one of the waste material that is available in Malaysia. Around 2.6 million tons of solid waste was produced annually by the palm oil industry which mostly composed of POC and palm oil shell (Basri et al., 1999). With amount of palm oil industry are expected to increase in the future, using POC as an alternative construction material is a right step to preserve the environment.

Reducing the number of natural sand used is also one of the ways to preserve the environment since natural sand is obtaining near river and it is not a renewable material. Overuse of natural sand from river can causes river channel degradation and erosion, head cutting, increased turbidity, stream bank erosion and sedimentation of riffle areas (Kondolf, 1993). Thus, study on uses of palm oil clinker (POC) as an alternative sand in brick industry with a view of effective utilization of the resources and environmental protection is necessary. In order to examine the effectiveness of POC as a partial sand replacement in cement sand brick and it applicability, few lab testing were conducted and the result will be compare with plain cement sand brick.

1.3 OBJECTIVE

This study is conducted to achieve the following objective:

i) To investigate the effect of palm oil clinker content as partial sand replacement on compressive strength of cement sand brick.

ii) To investigate the effect of palm oil clinker content as partial sand replacement on flexural strength of cement sand brick.

iii) To investigate the effect of palm oil clinker content as partial sand replacement on water absorption of cement sand brick.

1.4 SIGNIFICANCE OF RESEARCH

Study about this knowledge will enlighten the society about the use of waste materials for brick production. This study will give a further information about using palm oil clinker (POC) as partial sand replacement in the production of cement sand bricks. This study will contribute to green technology development in Malaysia. Succeeding in this research will decrease the number of sand mining activity thus as the same time preserved the environment. The information is expected to contribute to better understanding about the behavior of the brick contain POC that acts as a partial sand replacement.

1.5 SCOPE OF REASEARCH

This study concentrate on the behavior of brick that contain various percentage of palm oil clinker (POC) as the partial sand replacement. The test covered about compressive strength, flexural strength, and moisture absorption of the brick. Two types of mixes were prepared during this study and the mixes are control mix and modified mix. The control mix consist 0% of palm oil clinker with 100% used of natural sand. The modified mix consist varies percentage of palm oil clinker.

The mix or specimen must contain percentage replacement level of palm oil clinker (POC) from 10%, 20%, 30 and 40% as a partial sand replacement. Two type of curing that were used in this study are water curing and air curing. The specimen were tested at 7, 14 and 28 days. The specimen were tested to known in detail about the bricks compressive strength, flexural strength and moisture absorption. The size of the samples is fixed to 210x100x65 millimeters dimension.

1.6 LAYOUT OF THESIS

Chapter one contained introduction and problem statement of this research. The objective, significance of research and scope of research were also highlighted to describe the purpose of this research. Chapter 2 reviewed about past studies related to present research. The issues related to sand mining activity was the first issues that were discussed. Then, elaboration about the characteristics of palm oil clinker and its influence on cement sand brick. Last, examined the factor that influence compressive strength, flexural strength, moisture absorption of brick containing palm oil clinker (POC).

Chapter three described about the experimental details and methodology. Methodology begins with elaboration on the preparation of material such as POC and then followed by the cement sand brick preparation according to brick mix design. This chapter was ended with discussion on the testing method used for this research.

Result obtain from the experiment conduct were discussed in chapter four. This chapter discusses about the compressive strength, flexural strength and water absorption of the specimen. Physical changes appeared during and after tests are also highlighted in this chapter. Finally, Chapter 5 presents the conclusion of the present study. This final chapter ends with recommendations for future study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Bricks are one of the oldest known building materials around the world. It was first found in southern Turkey and around Jericho back in 7000BC (ET Clay Products Ltd, 2011). The first bricks were sun dried mud bricks. Fired bricks were later to be developed and it was found to be more resistant to harsher weather conditions. This found shows that it is made them a much more reliable brick for use in permanent buildings, where mud bricks would not have been sufficient. Fired brick were also useful for absorbing any heat generated throughout the day, then releasing it at night.

As time goes by, bricks industry started to revolutionize from material used, type of brick, colour and shape. With modern machinery, earth moving equipment, powerful electric motors and modern tunnel kilns, making bricks has become much more productive and efficient (ET Clay Products Ltd, 2011). Bricks can be made from variety of materials and one of the most common type of brick is cement brick. Cement brick are made from mixing of ordinary Portland cement, natural sand and batch water. Natural sand normally have the highest amount of material used in the making of brick compared to cement and water. This shows that large amount natural sand needed in construction industry, thus increasing natural sand mining activity to fill up the demand and it does affect the environment because natural sand is non-renewable material.

This has lead researchers to find an alternative material to replace natural sand and one of the material is palm oil clinker (POC). POC is a waste by-product from the incineration process of oil palm shells and fibers (Abutaha et al, 2016). Palm oil clinker can be easily be found in bundle due to large palm oil industry in Malaysia. Uses of waste in construction industry can reduce the cost of the project and at same time preserved the environment by reducing sand mining activity.

2.2 TYPE OF BRICK

Bricks are the most common material in construction world. Brick served as a function of filling the gap or hole between building structure and to divide one area from another. Brick are commonly used for wall construction involving not just building but also used in retaining wall structure. There are many type of brick that exists nowadays. They are difference from shape, colour, materials used and resistance ability.

2.2.1 Cement sand brick

Cement-sand brick or also known as concrete brick is a masonry unit made from Portland cement, water, and suitable aggregates with or without addition of other materials (General Shale, Technical Bulletin, 2015). Cement sand brick may not physically look good because of it visually porous looking, but it have many benefits that make it a good choice for construction industry. According to cement.org website, concrete brick deaden exterior noise, providing a buffer from traffic noise, airplanes flying overhead and other various disruptions, fire protection and brick wall can improve the thermal mass qualities of exterior walls, thus reducing energy bills. The compressive strength of the brick is 7.5 N/mm^2 with a weight of single brick around 2.5 to 2.7 kg (Kartini et al, 2012).

Concrete brick is manufactured in various option of colors and patterns. The type of finishing is even an option whether smooth, sandblasted, stone pattern and others. The type of material used to produce bricks can be anything from regular aggregate concrete to various mixtures of lightweight aggregates. They are usually colored with iron oxide pigment at the surface, or the pigment is present throughout the mixture. The production of cement sand brick is rather simple compare to others, where it does not need a high tech machine or need to go through a burning process. Cement sand brick need to undergo curing process to ensure proper hydration process take place. The minimum days for curing are 7 days to ensure hydration of the cement and development of optimum strength of the brick (Cement & Concrete Institute, 2006). Figure 2.1 show an example of cement sand brick.

Figure 2.1: Cement sand brick

Souce: S. S. Industries

2.2.2 Clay brick

Clay type of brick can be divided into two category which are unfired-clay brick and fired-clay brick. Unfired-clay bricks were first used back on 8000BC, and fired-clay bricks were later produced on 4500BC (Zhang, 2013). According to greenspec website, unfired-clay brick are difference from fired-clay brick in term of drying method. Unfired-clay brick was dried by using air dry. It is done to reduce shrinkage. The strength of unfired-clay is complicated and no single value can be assigned. The strength of it highly dependent on the properties of the material, the dimensions of the wall and the water content.

Fired-bricks are produced by firing the brick at about 900–1025 °C raw clays mainly composed of illite-chlorite, quartz, calcite and dolomite, sodium and potassium feldspars, and iron oxides/hydroxides (Viani et al., 2016). The firing process could affect the physical and mechanical properties, colours and appearance of the manufactured brick. There are around 1500 billion of clay brick been produced annually (Weyant et al., 2014). This is a proved that are a lot of demand toward using of clay type of brick in construction industry.

Figure 2.2: Fired-clay brick

Source: Argilus 2016

Figure 2.3: Fired-clay brick

Source: Lowe's 2012

2.3 NATURAL SAND MINING

Sand mining is the activity of removing sand from their natural configuration (Ashraf et al., 2011). Sand is widely used in construction industry from projects like land reclamations, the construction of artificial islands and coastline stabilization. According to Jabatan Pengaliran dan Saliran Malaysia (JPS), there are several method that can be used in obtaining natural sand from mining activity that had been approved by Malaysia government. Firstly through pump and pontoon method. This is the most recommended method because it does reduce damage to riverbank. However the position of pump, pontoon, anchor wire and pipe must not disturb the activity at the river. Secondly through dragging method. This method is not really been suggested, although it is one of the most common methods used in Malaysia, because it does increase erosion in the riverbank. Dragging methods are done by using hydraulic and dragline machine. Thirdly through uses of dredger ship. Dredger ship normally use in wide type of river and in estuary. This method collect highest amount of sand. Lastly, through manual method which are by using man labour.

From statistic shown by Jabatan Mineral dan Geosains Malaysia, as much as 37,339,082 billion tons of sand and gravel been mined from all around Malaysia in 2011 and this statistic are the highest from year 2009 until 2013. Even though the statistic decreasing in 2012 but the number increase back in 2013 and the pattern are expected to increase in the future due to rapid growth of construction industry in Malaysia. Full statistic are shown in table 2.1.

Table 2.1: Statistic of Raw Sand Produce

Year	Total weight (tons)
2009	17,382,050
2010	30,698,267
2011	37,339,082
2012	28,592,007
2013	35,577,567

Sources: (Jabatan Mineral dan Geosains Malaysia)

Figure 2.4: Sand mining activity

Source: Civil society 2015

2.4 IMPACT OF SAND MINING TO ENVIROMENT

Sand mining is one the most importance industry in Malaysian. Even though sand mining does have many positive impact to Malaysia economy but negative impact of sand mining can counter back the weight of positive impact. Kondolf reported that in stream mining resulted in channel degradation and erosion, head cutting, increased turbidity, stream bank erosion and sedimentation of riffle areas (Kondolf, 1993). This not only destroy our river where our source of fresh water, but it will also affect the aquatic life inside the river. It should be known that the processes of prospecting, extracting, concentrating, refining and transporting minerals have great potential for disrupting the natural environment (Rabie et al., 1994).

The impact to the biological resources can be clearly saw, including removal of infauna, epifauna, and some benthic fishes and alteration of the available substrate (Ashraf et al., 2010). Impact that can be saw due to this effect are, vegetation around river will be destroy, erosion, water sources will be polluted and reduce the diversity of animals supported by nearby woodlands habitats (Byrnes and Hiland, 1995). Sand mining activity not only effecting ecosystem near a river, it also can cause deforestation for the purpose of road construction to mining area.

Figure 2.5: Impact of sand mining activity

Source: Google 2012

2.5 USES OF WASTE IN INDUSTRY

Waste is unwanted material or substance leftover either from manufacturing process of industry or from community or from household. The waste can be divided into three condition which are solid, liquid and gas, which each of it have a difference effect on the environment. Number of waste that been produce by Malaysian per days in 2005 are 19,000 and expected to increase to 30,000 per days in 2020 (Kosmo, 2016). This waste statistic only include the waste from household and does not include the waste from industry. Industrial waste is a waste produced by an industrial activity during manufacturing process. Due to a lot of waste been produced worldwide, researcher found out a way to reduce it by recycling the waste and reuse it in daily life application. According to united state environmental protection agency, nearly all industrial process from manufacturing, consume goods to generating energy and able to produces different types of by-products which mainly are usable materials.

In Malaysia, we are lucky because we have a lot natural fiber like rice husk, bamboo leaf ash and waste from palm oil industry that can be used in construction industry. This shows that Malaysia have a lot of source that can be used to create a more environmental friendly building thus decreasing number of waste at the same time. There are a lot of advantage in using waste material in construction industry. According to united state environmental protection agency, the performance of the concrete can increase by using some of the industry waste like fly ash and slag cement. The cost of construction project can also be reduce by using waste as construction material.

2.6 PALM OIL CLINKER

The utilization of waste materials from the palm oil industry provides immense benefit to various sectors of the construction industry (Kanadasan and Razak, 2015). There are a lot of by-product that had been produced in palm oil industry and palm oil clinker is one of it. Palm oil clinker (POC) is a waste by-product from the incineration process of oil palm shells and fibers. It can be classified as artificial aggregate. Palm oil clinker considered as a by-product waste produced from burning of palm oil fibre and oil palm shell inside the boiler under high temperature in order to generating steam engine for extracting palm oil (Abutaha et al, 2016). Palm oil clinker are originally in a form of big chuck, as shown in figure 2.6. Detail palm oil mill process are further demonstrate in figure 2.7.

Figure 2.6: Palm oil clinker

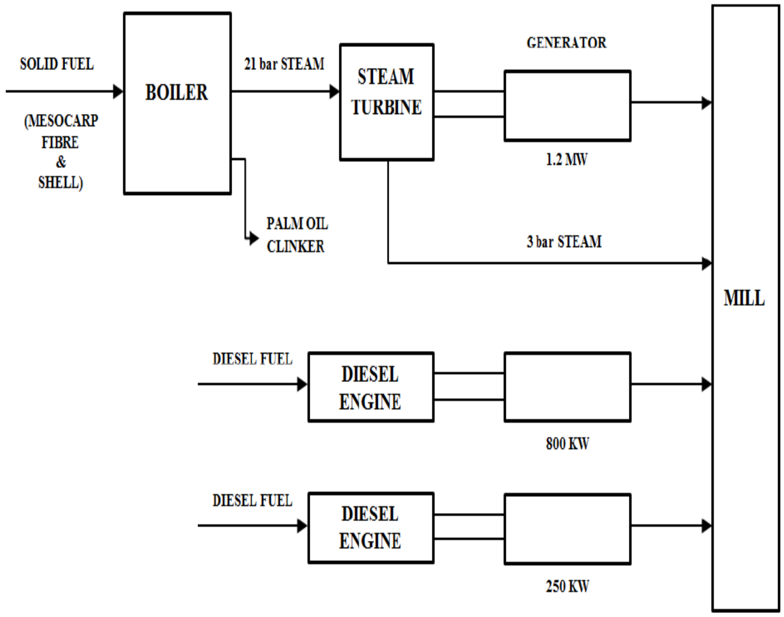


Figure 2.7: Schematic diagram of a typical power house in palm oil mill

Source: Yusof 2006

2.6.1 Properties of palm oil clinker

Palm oil clinker (POC) physically look more toward stone like material and POC is grey in colour. The clinker that been produced are lightweight, porous and irregular in shape (Kanadasan and Razak, 2015). This means palm oil clinker has a potential to be classified as lightweight aggregate help in achieved lightweight concrete. Palm oil clinker concrete has been classified as a structural lightweight concrete in accordance with the requirements of the ASTM:C330 and BS8110 (1997). There are various range of particle size, which is from fine gravel to fine sand. Palm oil clinker that had been crush to fit the size of fine and coarse aggregate, has a unit weight of 1119 kg/m^3 and 781 kg/m^3 (Mohammed et al, 2013), which are approximately 25% lighter compared to the conventional river fine sand (Delsye et al, 2006) and 48% lighter compared to the crushed granite stone (Teo et al, 2006). This can help to reduce the self-weight of the structure and able to cut cost with sacrificing too much of the structure strength. Full physical and chemical properties of palm oil clinker are shown in table 2.2 and table 2.3.

Table 2.2: Physical properties of palm oil clinker

Properties	**Fine palm oil clinker**	**Coarse palm oil clinker**
Aggregate size (mm)	<5	5-14
Bulk density (kg/m^3)	1118.86	781.08
Specific gravity (SSD)	2.01	1.82
Moisture content	0.11	0.07
Water absorption (24 h)	26.45	4.35
Fineness modulus	3.31	6.75
Los angeles abrasion value (%)	-	27.09
Aggregate impact value (%)	-	25.36
Aggregate crushing value (%)	-	18.08

Sources: (Mohammed et al, 2012)

Table 2.3: Chemical composition of palm oil clinker

Oxides	**Palm oil clinker**
SiO_2	59.63
K_2O	11.66
CaO	8.16
P_2O_5	5.37
MgO	5.01
Fe_2O_3	4.62
Al_2O_3	3.7
SO_3	0.73
Na_2O	0.32
TiO_2	0.22
Cr_2O_3	-
Others	0.58

Sources: (Ahmmad et al., 2014)

In general, most of lightweight aggregate will have a high water absorption ability compare to natural sand and palm oil clinker (POC) is not an exception to this. Even though POC have a high water absorption ability, it can be beneficial to hardening of the concrete. Previous report shows that lightweight concretes with porous aggregate (high water absorption) are less sensitive to poor curing as compared to normal weight concrete especially in the early ages due to the internal water supply stored in the porous lightweight aggregate (Al-Khaiat, 1998). Palm oil clinker not only has an effect on concrete but it also has an effect to mortar. Based on previous feasibility study that had been done on palm oil clinker aggregates, the result confirms that the ability of palm oil clinker to reduce the density of the mortar by 7% and able to produce structural efficiency between 0.035 and 0.05 MPa/kg m^3 (Kanadasan et al., 2015). Figure 2.8 and 2.9 shows pictures of POC.

Figure 2.8: Course palm oil clinker

Figure 2.9: Fine palm oil clinker

2.6.2 Availability around Malaysia

Malaysia is one of the primary producer of palm oil in the world and in fact Malaysia is the second largest palm oil-producing country in the world. Malaysia have been supplying more than half of world’s palm oil annually. Malaysia generates about 3.13 million tons of palm shell as waste, which has been projected to grow because of the ongoing global consumption demand for palm oil (Basri et al., 1999). This show that Malaysia have a lot of sources of palm oil and it can be easily available to use in when needed. A lot of sources come with a lot of waste. Around 2.6 million tons of solid waste was produced annually by the palm oil industry which mostly composed of palm oil clinker (POC) and palm oil shell (Basri et al., 1999). Compare with number of sand mining in 2011 based on souces from Jabatan Mineral dan Geosains Malaysia which is approximately 37000000, we should be able to reduce about 7% of number of sand mining in that year. According to Kementerian Komunikasi dan Multimedia Malaysia, there are about 4.7 million hector of size of palm oil farm and about 416 number of palm oil mill around Malaysia. This show that there are a lot of sources for clinker that can be obtained from various location around Malaysia.

2.7 USES OF PALM OIL CLINKER

Palm oil clinker possess a good properties that allowed it to be used in various application, condition and environment. Palm oil clinker is suitable to be used as an aggregate replacement in making of lightweight concrete (Ibrahim and Razak, 2016). This statement been proved by previous research which said that palm oil clinker are approximately 25% lighter compared to the conventional river fine sand (Delsye et al, 2006) and 48% lighter compared to the crushed granite stone (Teo et al, 2006). Besides that, Palm oil clinker powder can be used as partial cement replace in concrete. Palm oil clinker powder performance are good and managed to produce about 70% of the strength when compared to control specimens even the replacement level are up to 50% (Kanadasan and Razak, 2015). This show that it is suitable to be used in medium strength structure application. Other than that, palm oil clinker is suitable to be used in self compacting concrete. Study from Kanadasan and Razak state that self-compacting concrete (SCC) efficiency and quality has been improved with additional of palm oil clinker without effecting the durability of the concrete. However, no study discussed about the performance of brick containing POC as partial sand replacement.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter describe about the experimental program and method to determine the effect of palm oil clinker on cement sand brick. Compression test, flexural test and water absorption test ware the test used to determine the objectives of this research. All the testing and laboratory work been done according to existing standards. Figure 3.1 describe the experimental process flow in a simpler form which is flow chart.

3.2 EXPERIMENTAL PROCESS FLOW

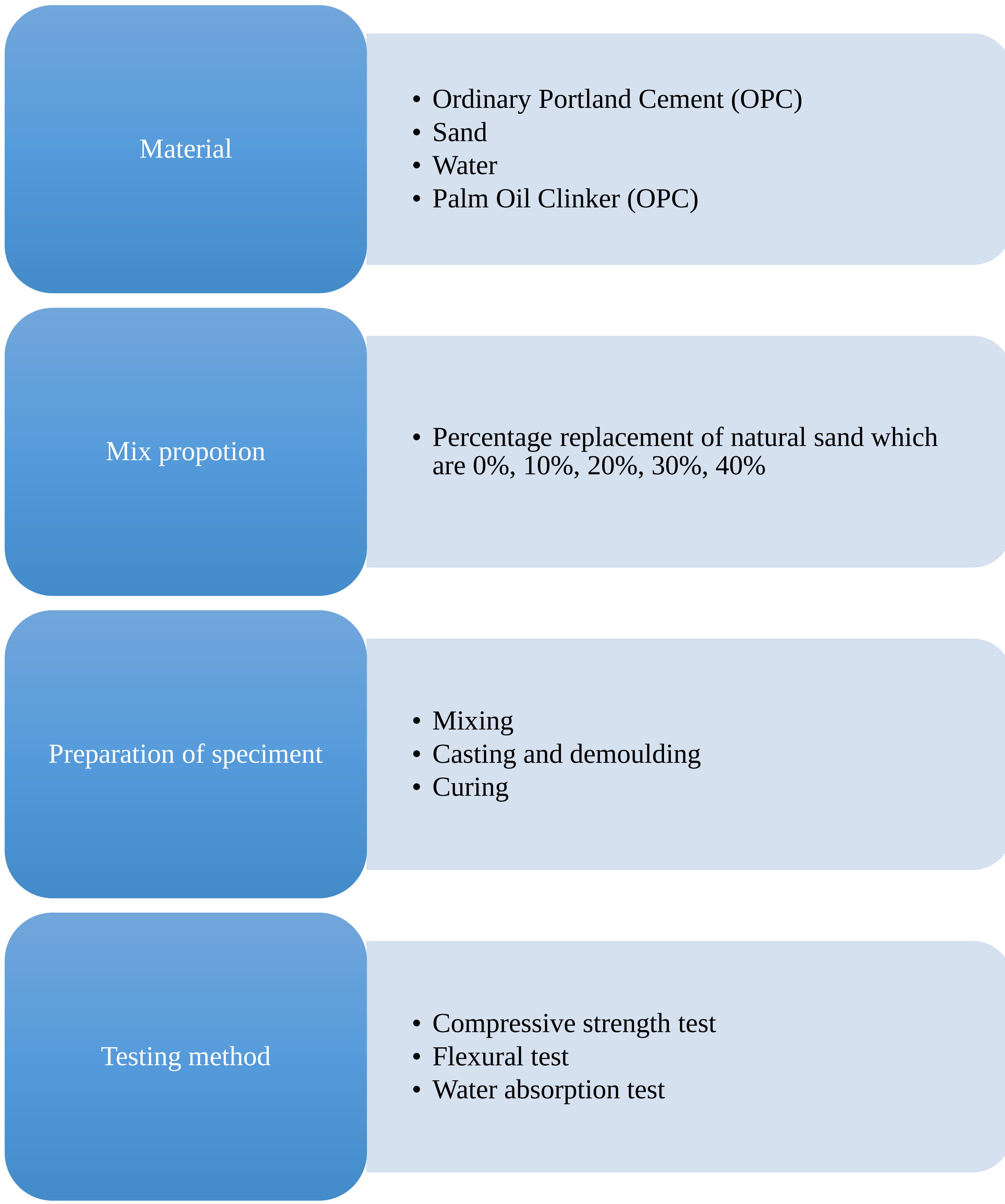


Figure 3.1: Experimental process flow

3.3 MATERIAL USED

The main material used in this experiment were ordinary Portland Cement (OPC), natural sand, water and palm oil clinker. Palm oil clinker acts as a partial sand replacement in cement-sand brick.

3.3.1 Cement

The type of cement used in this research was Ordinary Portland Cement (OPC) as shown in figure 3.2 below. This cement was produced by company name YTL Cement Marketing Sdn Bhd. This type of cement follows the Malaysian Standard MS 522: Part 1: 2007 for Portland cement specification. Ordinary Portland Cement (OPC) need to be keep out from open air and store in closed package inside the laboratory. The purpose was to prevent the cement to reacts with water and become hardened before use.

Figure 3.2: Orang kuat Ordinary Portland Cement

3.3.2 Natural sand

The type of sand used in the research was a common river sand. The sand was placed in the roofed area at the laboratory to make sure the sand is not wet and in fact the sand must be in oven dry condition to ensure there was no excessive amount of water inside the sand. Excessive amount of water can affect the result of the specimen. The figure below shows a clearer image of the sand used in this research.

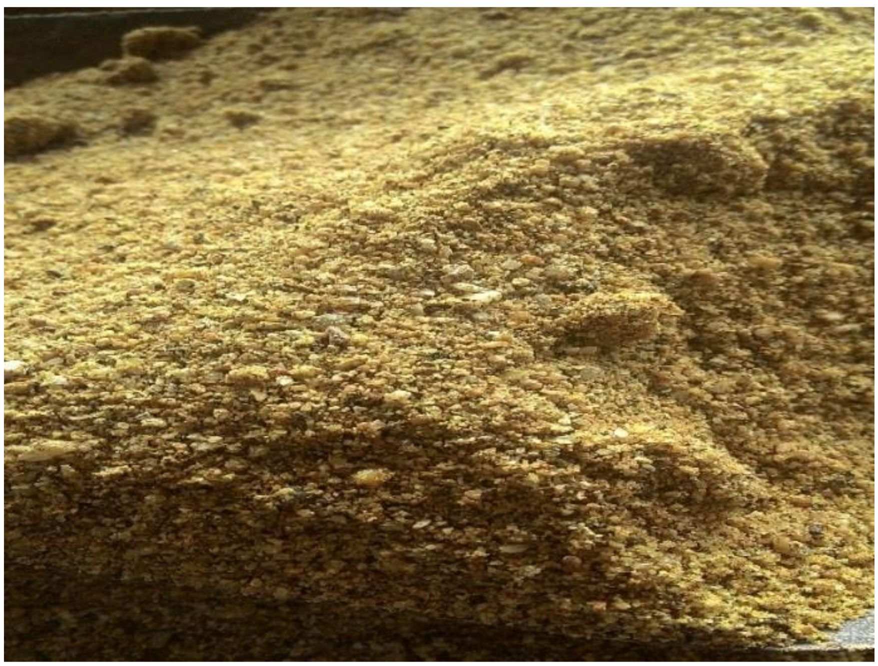


Figure 3.3: Sand

3.3.3 Water

The type of water used in this experiment was tap water. This type of water was used during the mixing process of the ingredient and during water curing process. Water plays an important role in hydration process and workability improvement of the specimen. Water used need to be clean and free from impurities that can affect the specimen result. The amount of water used in this experiment depends on the mix design.

Figure 3.4: Tap water

3.3.4 Palm oil clinker

Palm oil clinker (POC) was used in this research to replace natural sand inside the brick. POC was obtained in palm oil mill near lepar hilir in kuantan. POC was mixes with other material and need to be choose manually with hand. POC was collected and been places inside a gunny bag to be transfer to FKASA laboratory. At the laboratory, POC that were collected need to be cleaned to remove all dirt and mud. After cleaning process was done POC was left to dry inside the oven at 105±5 ^{o}C for 24 hours. POC was originally in the form of big chunks and need to be manually crush to make it smaller and easier for next stage procedure. Normally, hammer was used for this process. After that, palm oil clinker were further crush by using jaw crush machine to reduce the size until it reach sand like size. Next, the POC size were properly selected by choosing the size smaller than 1.18mm through sieving process. Only the amount of POC that passing the sieve size 1.18mm were used in this research. The remaining POC that retain in sieve size 1.18mm were again being crush by using jaw crushing machine. After the crushing process was done, palm oil clinker were being sieve once again and the amount of POC that pass size 1.18mm were collected. The steps were repeated until the amount of POC that were needed for this research were obtained. All the picture related to POC are shown below, start from obtaining POC at palm oil mill until finished sieving process, which are from figure 3.5 until figure 3.11.

Figure 3.5: Obtaining POC from palm oil mill

Figure 3.6: Raw palm oil clinker

Figure 3.7: Cleaning POC

Figure 3.8: Crushing POC by hammer

Figure 3.9: Crushing POC by using jaw crusher

Figure 3.10: Sieving POC

Figure 3.11: Fine POC

3.4 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. All fine palm oil clinker (POC) were used as a partial sand replacement in this research. The amount of replacement were 0%, 10%, 20%, 30% and 40% by the weight of the sand. A total of 3 mix were used in this experiment. The cement sand ratio used for this research was 1:5 by weight of the material and water to cement ratio was 0.7. This ratios were fixed for all specimen. The normal weight of a brick was 2.7kg. Table 3.1 shows in detail the mix proportion of the specimen used in this research. Table 3.2 represent the mix proportion in percentage and table 3.3 show the total specimen for each test. The volume of one brick specimen is $1.365x10^{-3}$ m^3.

Table 3.1: Mix proportion by weight per volume

Samples	**Cement (kg/m^3)**	**Sand (kg/m^3)**	**Palm oil clinker (%)**	**Palm oil clinker (kg/m^3)**	**Water (kg/m^3)**
A	329.7	1648.4	0	0	230.7
B	329.7	1483.5	10	164.8	
C	329.7	1318.7	30	329.7	
D	329.7	1153.8	30	494.5	
E	329.7	989.0	40	659.3	

Table 3.2: Mix proportion by percentage

Sample	**Cement (%)**	**Sand (%)**	**Palm oil clinker (%)**	**Water**
A	17	83	0	0.7
B	17	73	10	
C	17	63	20	
D	17	53	30	
E	17	43	40	
Total	-	-	-	

Table 3.3: Number of specimen for water curing and air curing

Type of testing	Percentage replacement (%)	No of sample by curing days			Total samples
		7 Days	14 days	28 days	
Compressive strength test	0%	6	6	6	90
	10%	6	6	6	
	20%	6	6	6	
	30%	6	6	6	
	40%	6	6	6	
Flexural strength test	0%	6	6	6	90
	10%	6	6	6	
	20%	6	6	6	
	30%	6	6	6	
	40%	6	6	6	
Water absorption test	0%	6	6	6	90
	10%	6	6	6	
	20%	6	6	6	
	30%	6	6	6	
	40%	6	6	6	

3.5 SPECIMEN PREPARATION

The preparation of the specimen start by preparing palm oil clinker which involve crushing and sieving processed. Then other material such as cement, sand and water was prepared for the cement-sand brick making process. The flow of the specimen’s preparation is shown in Figure 3.12.

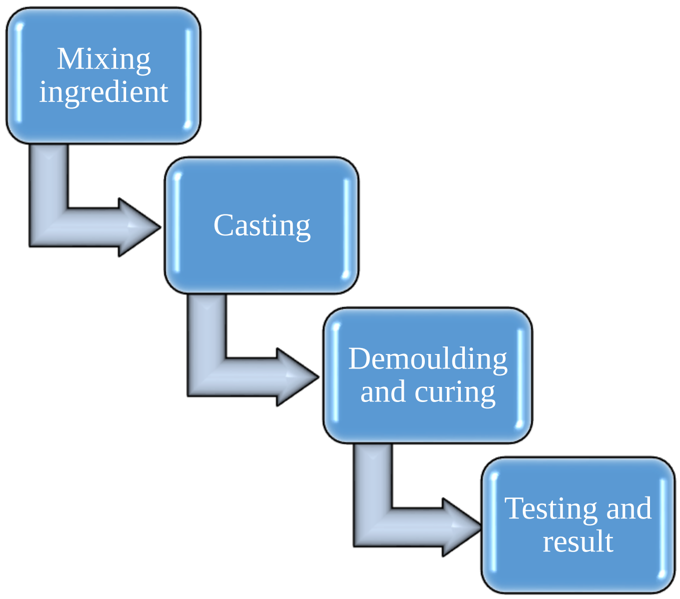


Figure 3.12: Specimen preparation flow

3.5.1 Mixing and casting

The size of each specimens were fixed to 210mm x 100mm x 65mm to follow the standard size for brick in industry. 3 sample of each specimen were prepared for each mix proportion. Electric mixer machine was used for mixing process to ensure all materials were mixed properly. Figure 3.13 show in detail the type of casting machine used. The mix were then being pour into wood mould and compacted manually by hand. The mould was built manually by hand because the mould for brick was not provided for this research.

Figure 3.15 shows the actual picture of the mould used. The surface of the mould need to be flatted to bring out the rectangular shape of the brick. It is important to check the mould condition before mixing because any damage to the mould can affect the testing result of brick. It was important to ensure handmade mould was coated with grease for easy demoulding process and to avoid loss water from the mixture.

Figure 3.13: Electric powered mixer

Figure 3.14: Placing mix inside mould

Figure 3.15: Mould

3.5.2 Sample curing

The curing process for the specimen start 24 hours after mixing process were done. The mould was remove from the specimen and then immediately being cured according to type of curing for this research. The curing method that involve were air curing and water curing. The specimens were tested at age of 7, 14 and 28 days.

Figure 3.16: Specimen subjected to water curing

Figure 3.17: Specimen subjected to air curing

3.6 TESTING METHOD

There were 3 type of testing involve in studying the effect of palm oil clinker in cement sand brick. The type of testing were compressive strength test, flexural test and water absorption test. All the test were conducted according to existing standard.

3.6.1 Compressive strength test

Compressive strength test was conducted by using compressive test machine. The test was conducted accordance to method suggested by ASTM C55 (2011). The compressive strength of the specimen were tested at 7, 14 and 28 days. The purpose of this test is to determine the maximum load that each of the specimen can hold before it fail. The result of the specimen was taken after a constant loading rate of 1.25 mm/min was applied to the specimen until it failed. The compressive strength of the specimen was calculated by dividing the maximum load that the specimen can hold by specific surface area of the specimen. Compressive strength of each specimen was calculated in MPa (N/ mm^2). Figure 3.18 shows the compressive test machine.

Calculation of compressive strength,

$C = W / A$

Where:

C = compressive strength of the specimen, kg/m^2.

W = maximum load, N (or kgf) indicated by the testing machine

A = average of the gross areas of the upper and lower bearing surfaces of the specimen, in^2 (or cm^2)

Figure 3.18: Compressive strength machine

3.6.2 Flexural strength test

The flexural strength test was conducted to determine the ability of the specimen to resist the stress. The test was conducted based on ASTM C55 (2011). The specimens were cured by water and air for 7, 14 and 28 days before the flexural strength test were conducted. A constant loading rate of 1.27 mm/min was set to the testing machine. The test was conducted by locating the brick at the support and centering the brick to point where loading is applied. The loading must be applied without shock to ensure a much accurate result. Figure 3.19 shows a flexural strength test machine. The calculation result were calculated as follows:

$p = P/w$

Where :

p = the breaking load per width

P = the transverse breaking load obtained from the machine

w = the width of the masonry

Figure 3.19: Flexural strength test machine

3.6.3 Water absorption test

For water absorption test, specimen was dried inside an oven at 110°C for 24 hour to obtain the dry weight. The dry weight of the specimen was recorded as W_d. Then, specimen will be submerged inside clean water tank for 24 hours. Both dry and saturated weight of the specimen were recorded. The surface of the specimen need to be wipe out completely to get a much accurate result. The result was taken to the nearest 0.1% of cold-water absorption. This test followed procedures as described in ASTM C55 (2011). Figure 3.20 shows type of oven used for this type of testing.

Calculation

Absorption, % = $100 (W_s – W_d) / W_d$

Where:

W_d = dry weight of the specimen, and

W_s = saturated weight of the specimen after submersion in cold water.

Figure 3.20: Oven

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

In this research, five mixes were prepared, with one mix for control brick and others four mixes for brick contain various percentages of palm oil clinker (POC). The results for control bricks were used as a benchmark for brick containing percentages of POC for performance estimation. All of the specimens were tested and observed for compressive strength, flexural strength and water absorption test. Half of the specimens were subjected to water curing and another half were subjected to air curing. A total of 270 bricks were prepared and cured in different curing times, namely, 7, 14 and 28 days. This chapter presents the results obtained from the current study and discusses the results.

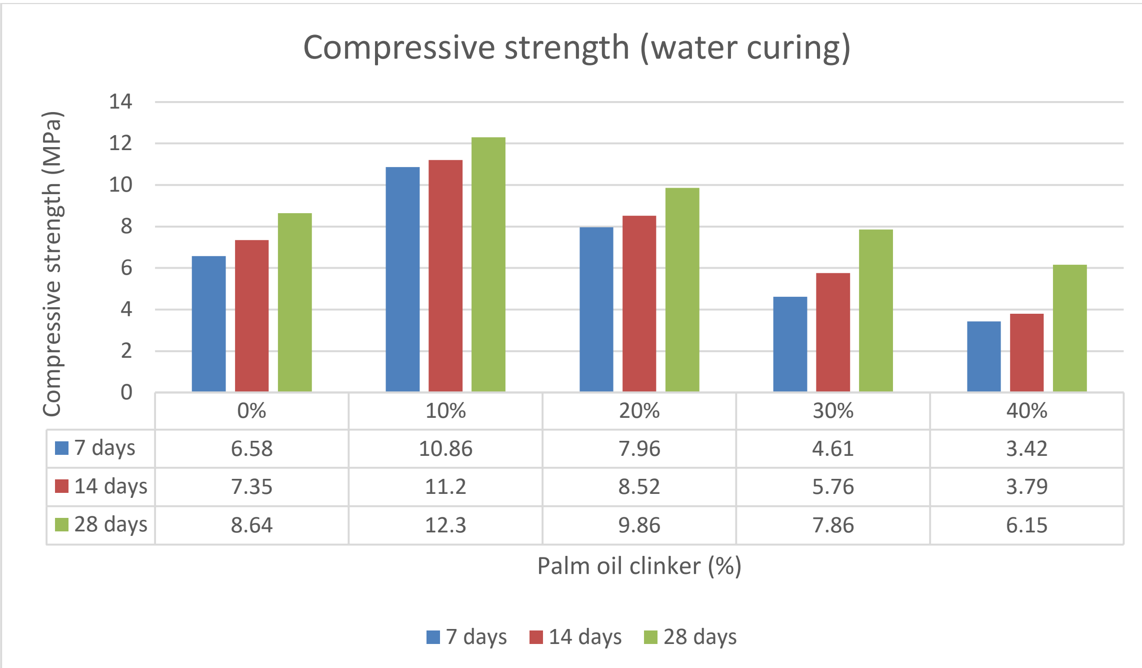
4.2 COMPRESSIVE STRENGTH TEST

Figure 4.1 and figure 4.2 shows the result of compressive strength of specimens subjected to water curing and air curing respectively. Based on both figures, the strength recorded at 10% replacement of palm oil clinker (POC) shows the highest result of compressive strength regardless result from water curing or air curing. The graphs also indicated that the strength were affected by many factors such as the POC replacement percentage, the curing method and the curing age.

It can be observed that, the compressive strength of the specimen only increase at specimen containing 10% POC and start to drop for Specimens that contain 20%, 30% and 40% of POC. The strength of the specimen increase due to ability of POC to fill the void inside the specimen. The logical reason to this is due to particle size of POC was smaller than sand even both of this material was sieve through size 1.18mm. This will make the specimen to become more dense and stronger. However, the replacement percentage has a limit, and in this case, it was from 20% until 40% replacement level. Start from 20% replacement, it can be conclude that the strength of the brick decrease with increase in percentage of POC. The value drop due to increase in porosity of the specimen. Porosity of the specimen increase due to porous structure of POC particle. Porous structure of POC will make the structure to become less rigid and less dense. This will lead to a lower strength of the specimen with increased number of POC inside the specimen. Although the strength of specimen contain 20% of POC lower than specimen contain 10% POC, it strength can still be accepted because the specimen still has a higher strength compare to plain specimen.

Based on the curing method, it was observed that water curing results were slightly stronger that results from air curing. The reason for this is due to rate of hydration process for specimens submerged inside water is higher. Higher hydration process will cause more calcium oxide to reacts with water to produce calcium silicate hydrate gel (C-S-H gel) which will results in higher strength. The highest results recorded were 12.3 MPa and 11.82 MPa for water curing and air curing respectively. Water curing results are 4.06% higher compare to air curing result.

It was observed that all specimens increasing in compressive strength value as the curing period became longer. The theory behind this is also related to production of C-S-H gel inside the specimens. The older the age of specimen the higher the number of C-S-H gel produce inside specimens, which will result in increased number of specimen strength.



	0%	10%	20%	30%	40%
7 days	6.58	10.86	7.96	4.61	3.42
14 days	7.35	11.2	8.52	5.76	3.79
28 days	8.64	12.3	9.86	7.86	6.15

Figure 4.1: Compressive strength of specimen subjected to water curing

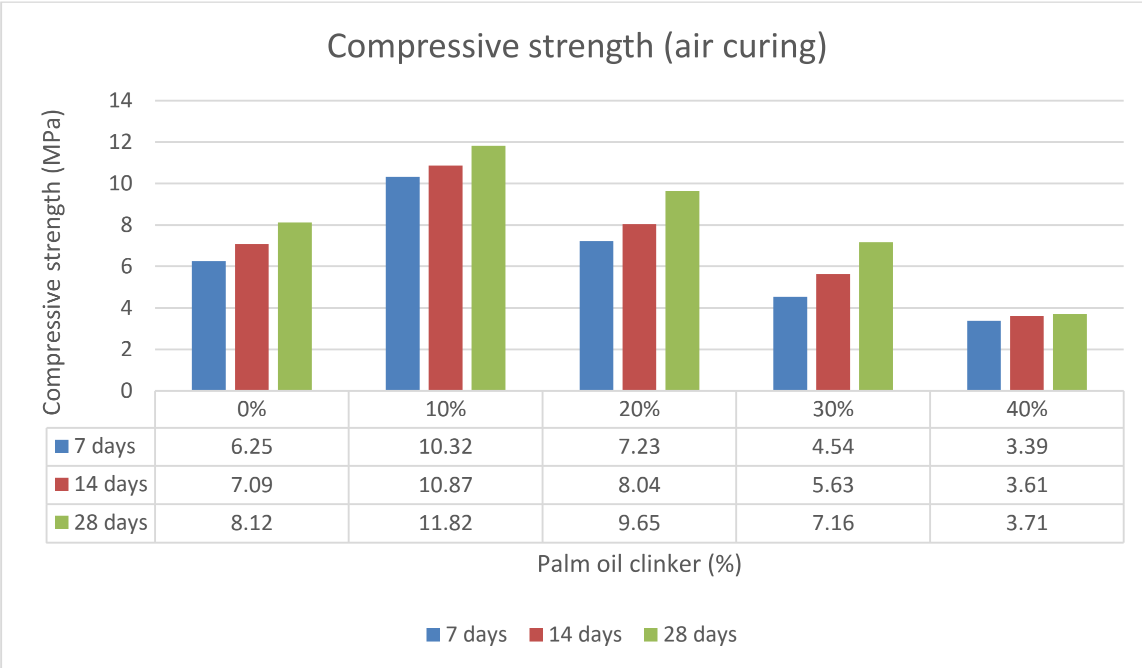


Figure 4.2: Compressive strength of specimen subjected to air curing

4.3 FLEXURAL STRENGTH TEST

In this part, the result from flexural strength will be presented. Figure 4.3 and figure 4.4 shows the result of specimen flexural strength subjected to water curing and air curing respectively. Both of result from water curing and air curing indicates that, specimen containing 10% of palm oil clinker (POC) has the highest flexural strength. The graphs also point out that the strength were affected by many factors such as the POC replacement percentage, the curing method and the curing age.

It can be observed that, the flexural strength of the specimen only increase at specimen containing 10% POC and start to drop for Specimens that contain 20%, 30% and 40% of POC. The strength of the specimen increase due to ability of POC to fill the void inside the specimen. In general, POC particle size is smaller than particle size of sand. So, at certain amount of replacement, in this case which is 10%, the POC particle can fill the void inside the specimen. This will cause the specimen to become more dense and stronger. However, the replacement percentage of POC has its own limit which is 20% and above. The flexural strength of the specimen start to drop from this point. The reason that cause the reduction is because the porosity of POC particle is higher than sand particle. This will cause the specimen porosity to increase and become less dense. Therefore, when the specimen become less compact, the flexural strength of specimen will drop. The highest flexural strength recorded was 0.294 MPa.

It was noticed that the strength of specimen subjected to water curing had a higher flexural strength than specimen subjected to air curing. The reason behind this is because of rate of hydration. Specimen subjected to water curing will has a higher rate of hydration due to presence of water. This will cause more calcium oxide (CaO) to react with water and produce more calcium silicate hydrate gel (C-S-H gel) to be produce and increase the strength of specimen. The presence of water during curing period will fully maximize the potential of the specimen.

In addition, the flexural strength of the specimen does getting better with age. Specimen at 28 days shows the highest strength regardless percentage of replacement or curing method. This is probably due to fact that cement hydration rate is almost finished at 28 days. This is a proved that specimen will reach its target strength in 28 days. This can also be related to number of C-S-H gel produce. The longer the period of time, the higher number of C-S-H gel produced.

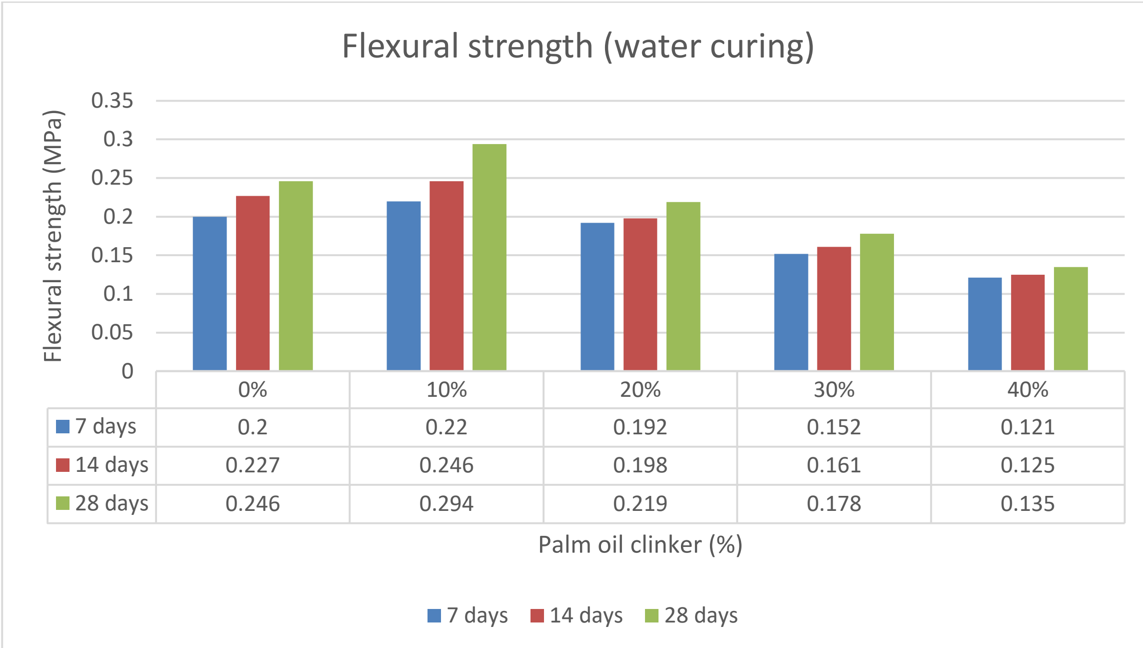


Figure 4.3: Flexural strength of specimen subjected to water curing

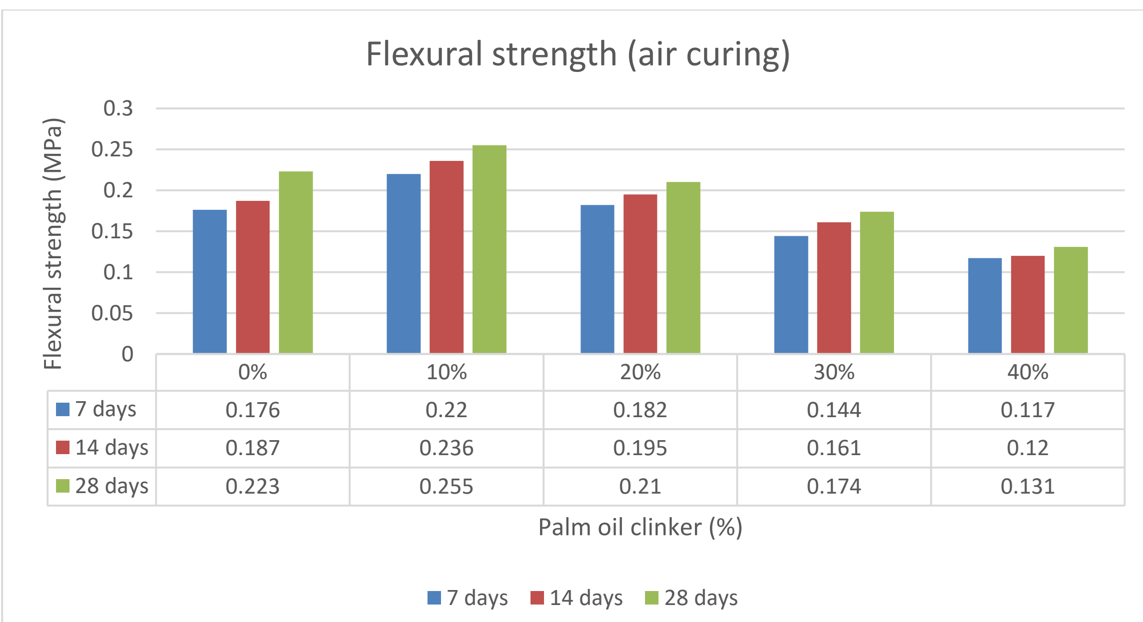


Figure 4.4: Flexural strength of specimen subjected to air curing

4.4 WATER ABSORPTION TEST

Water absorption test was conducted to determine the ability of specimen to absorb water. Basically, bricks are not suitable to be used when it can absorb high percentage of water. Figure 4.5 and figure 4.6 shows in detail the percentage of water absorption for each mixes. Three bricks were tested for each sample proportions and the average was calculated. The results obtained showed that all of the brick samples produced lower absorption of water at the age of 28 days. This probably due to compactness of specimen increase with time. The older the age of the specimen, the more compact the specimen will be. The compactness of specimen increase because of increased number of calcium silicate hydrate gel (C-S-H gel) content inside the specimen. Increase number of C-S-H gel content will increase the compactness of the specimen.

According to data's, plain brick show the lowest percentage of water absorption for both water curing and air curing result. For water curing, the percentage of water absorption was 11.7%, while for air curing the percentage was 12.1%. The water absorption pattern increase with increase percentage of palm oil clinker (POC) replacement. This probably due to porous structure of the POC particle. Porous structure of POC particle will act as a storage place for water. At the same time, Increase percentage of POC replacement will cause increase percentage of specimen porosity. Increase in specimen porosity will lead to more water to be absorption by the specimen and increase the percentage of water absorption. So increase in POC content will increase the absorption of water by the specimen.

It was also noticed that water curing result show less percentage of water absorption compare to air curing result. This can be related to rate of hydration process that occur inside the specimen. Water curing specimen had a much better rate of hydration due to submersion of specimen inside water. Better rate of hydration will cause more number of C-S-H gel been produced thus make the specimen become more compact.

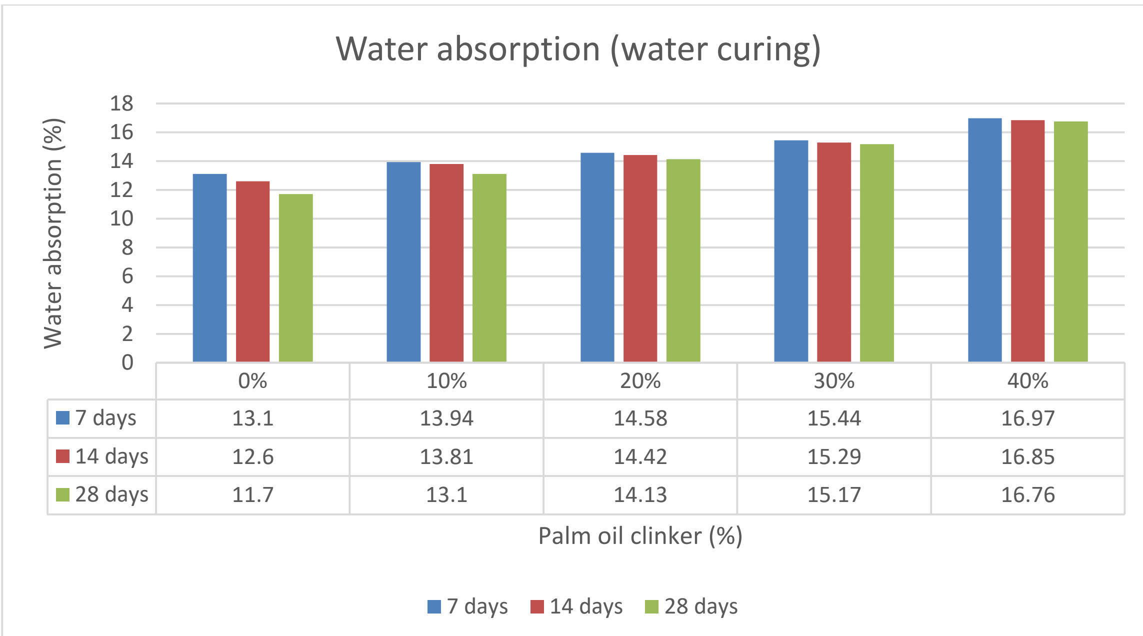


Figure 4.5: Water absorption of specimen subjected to water curing

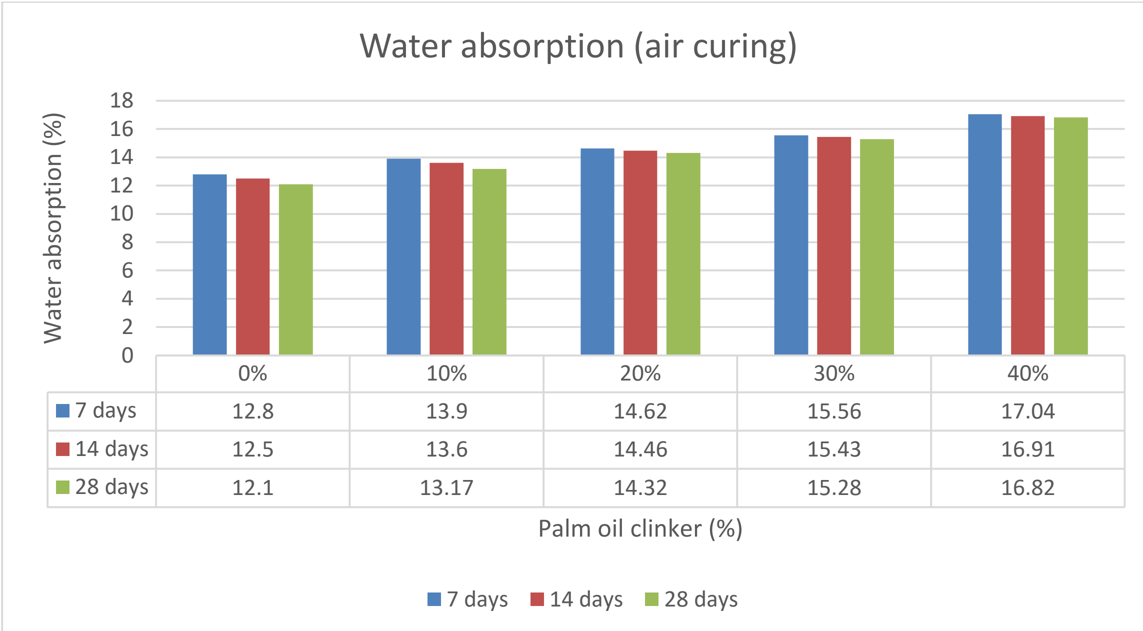


Figure 4.6: Water absorption of specimen subjected to air curing

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The main objective of this study was to determine the compressive strength, flexural strength and water absorption of brick containing palm oil clinker as partial sand replacement. The following conclusions can be drawn from the results obtained.

i) With regard to compressive strength, brick produced from 10% palm oil clinker as partial sand replacement recorded the highest strength compared plain cement-sand brick because palm oil clinker (POC) particles are smaller than river sand particle. Therefore, POC particle would act as filler effect to fill the void inside the brick and make the brick to become more dense and stronger.

ii) In term of flexural strength, brick containing 10% of POC shows the highest flexural strength. This probably due to small particle size of POC compare to natural river sand which can fill the void inside the brick thus make the brick more dense and stronger.

iii) The present of POC in brick would affect the water absorption percentage. Brick containing POC show an increase value of water absorption compare to plain cement sand brick. This can be related to the structure of POC particle. The structure of POC is more porous than Natural River sand thus increase the porosity of the brick and increase the brick water absorption value.

iv) The brick curing type and also brick curing period does had an effect on brick mechanical properties. The brick strength does getting stronger with longer time of curing period. This probably related to calcium silicate hydrate gel (C-S-H gel) content inside the specimen, where it increase with time and with presence of water.

v) This study shows that POC could be a prospective potential as a partial sand replacement material

5.2 RECOMMENDATION

There are several recommendation that had been identified for future development of palm oil clinker (POC) as a replacing material in brick industry. Hence, the following recommendations are:

i) Investigate the performance of the brick containing POC by conducting various tests such as Fire Resistance test and Efflorescence test.

ii) Find out the durability of brick containing POC in real world application such as effect of the brick from the change of natural weather and environment for at least one year.

REFERENCE

This guide is prepared based on the following references:

Abutaha, F., Razak, H. A., Kanadasan, j. (2016). Effect of palm oil clinker (POC) aggregates on fresh and hardened properties of concrete. Construction and Building Materials 112: 416–423.

Ahmmad, R., Jumaat, M.Z., Bahri, S., Islam, A.B.M.S. (2014). Ductility performance of lightweight concrete element containing massive palm shell clinker. Constr.Build. Mater. 63: 234-241.

Al-Khaiat H and Haque MN (1998). Effect of initial curing in early strength and physical properties of a lightweight concrete. Cem Concr Res 28(6): 859–66.

Ashraf, M. A., Yusoff, M. J. M. I., Mahmood, A. W. K. (2011). Sand mining effects, causes and concerns. Scientific Research and Essays Vol. 6(6): 1216-1231.

ASTM Standard C55, 2011. Standard Specification for Concrete Building Brick. ASTM International.

Azam, N. A. Z. 2011. Kitar semula sisa pepejal. Kosmo. 30 November

Basri, H. Mannan, M.,Zain, M. (1999). Concrete using waste oil palm shells as aggregate. Cem. Concr. Res. 29 (4): 619–622.

Bhushan, C., Yadav, Basu,N. K., Kumar, R. (2016), National Brick Mission.

BS 8110: Part 1: 1997. Structural use of concrete. Part 1. Code of practice for design and construction. London: British Standards Institution.

Byrnes MR and Hiland MW (1995). Large-scale sediment transport patterns on the continental shelf and influence on shoreline response. Large-Scale Coastal Behavior. 126: 19-43.

Cement & Concrete Institute. (2006). How To Make Concrete Bricks And Blocks. Cement & Concrete Institute, Midrand, 1996, reprinted 1997, 1999, 2003, 2006.

Delsye CL, Manna MA, Kurian JV (2006). Flexural behavior of reinforced lightweight concrete beams made with oil palm shell (OPS). J Adv Concr Technol 4(3): 1–10.

ET Clay Products Ltd (2011). The History of Bricks and Brickmaking. http://www.etbricks.co.uk/index.php?p=articles-the-history-of-bricks

General Shale (2015). Brick specification. https://generalshale.com/resources/file/2f26b032-fa24-4e1a-91e1-f770b39a9716.pdf

Greenspec (2016). Unfired clay brick. http://www.greenspec.co.uk/building-design/unfired-clay-bricks/

H. A. Ibrahim and H. A. Razak (2016). Effect of palm oil clinker incorporation on properties of pervious concrete. Construction and Building Materials 115: 70-77.

Jabatan Minerals dan Geosains Malaysia (2006). http://malaysianminerals.com/index.php?option=com_content&task=view&id=31&Itemid=54

Kanadasan, J. and Razak, H. A. (2015). Utilization of Palm Oil Clinker as Cement Replacement Material, material 8: 8817-8838.

Kanadasan, J., Fauzi, A. F. A., Razak, H. A., Selliah, P., Subramaniam, V., Yusoff, S. (2015). Feasibility studies of palm oil mill waste aggregates for the construction industry. Materials 8 (9): 5319.

Kartini, K., Norul Ernida, Z. A., Noor Fazilla, B., Ahmad Farhan, H. (2012). Development Of Lightweight Sand-Cement Brick Using Quarry Dust, Rice Husk And Kenaf Powder For Sustainability. International Journal of Civil & Environmental Engineering IJCEE-IJENS Vol:12 No:06.

Kondolf, G.M. and Swanson, M.L (1993). Channel adjustments to reservoir construction and gravel extraction along stony creek. Environmental Geology and Water Science, 21: 256-269.

Kondolf G.M. (1994). Geomorphic and environmental effects of in stream gravel mining. Landscape and Urban Planning 28: 225-243.

Kementerian Komunikasi dan Multimedia Malaysia. 2009. Bab 9 kelapa sawit.

Malaysian Palm Oil Board (2016). Economic and industry development division. http://bepi.mpob.gov.my/index.php/statistics/production.html

Ministry of Natural Resources and Environment Department of Irrigation and Drainage Malaysia. 2009. River Sand Mining Management Guideline.

Mohammeda, B. S., Foo W.L., Hossain, K.M.A., Abdullahi, M. (2013). Shear strength of palm oil clinker concrete beams. Materials and Design 46: 270–276.

Malaysian Standard MS 522: Part 1: 2007 for Portland cement specification

Portland Cement Association (2016). Brick. http://www.cement.org/concrete-basics/concrete-homes/building-systems-for-every-need/brick

Rabie MA, Blignaut PE, Fatti LP (1994). Environmental Management in South Africa. South Africa, Juta. pp. 823.

Teo DCL, Mannan MA, Kurian VJ (2006). Structural concrete using oil palm shell (OPS) as lightweight aggregate. Turkish J Eng Environ Sci 30: 1–7.

United State environmental protection agency (2008). Using Recycled Industrial Materials in Building.
https://www.epa.gov/

ZHANG, L. (2013). Production of bricks from waste materials –A review. Construction and Building Materials. 47: 643-655.