EXPERIMENTAL STUDY OF PROPERTIES FOR SAND BRICKS WITH CLINKER AS PARTIAL REPLACEMENT FOR FINE AGGREGATE WITH RATIO OF 10% WITH RICE HUSK OF 10% , 20 % AND 30%

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ABSTRAK

Penggunaan bahan buangan dalam industri pembinaan adalah cara yang berkesan untuk melindungi alam sekitar dan meminimumkan kos pembinaan. Dalam kaedah ini, komposisi kelapa sawit (POC) dan sekam padi digunakan sebagai pengganti komposisi pasir dalam pengeluaran bata pasir. Oleh itu, eksperimen telah dijalankan untuk menyiasat kesan kandungan POC dan sekam padi sebagai pengganti pasir pada sifat bata. Sejumlah tiga campuran yang mengandungi pelbagai peratusan sekam padi, iaitu 10%, 20%, 30% dengan 10% POC malar telah disediakan. Separuh spesimen diletakkan dalam “water curing” dan separuh lagi diletakkan dalam “air curing” yang dibiarkan sehingga tarikh ujian. Ujian kekuatan mampatan dan kekuatan lenturan dilakukan pada 28, 60 dan 90 hari. Ujian penyerapan air dan ujian ketumpatan dilakukan pada 28 hari. Penemuan menunjukkan bahawa lebih banyak peratusan sekam padi akan mengurangkan kedua-dua kekuatan mampatan dan kekuatan lenturan bata.

ABSTRACT

Utilizing waste material in the construction industry is an effective way to protect the environment and minimize construction cost. In this paper, palm oil clinker (POC) aggregates and rice husk were used as fine aggregate replacement in sand brick production. Thus, experimental work has been conducted to investigate the effect of POC content and rice husk as partial sand replacement on the properties of brick. A total of three mixes containing various percentage of rice husk, which are 10%, 20%, 30% with constant 10% POC have been prepared. Half of specimens were water cured and another half were air cured until the testing date. The compressive strength test and flexural strength test was conducted at 28, 60 and 90 days. The water absorption test and density test was conducted at 28 days. The findings show that the more percentage of rice husk will reduce both compressive strength and flexural strength of the brick.

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LIST OF SYMBOLS

W	Water absorption
W_i	Weight after absorption
W_d	Weight before water absorption
ρ	Density

LIST OF ABBREVIATIONS

RH	Rice Husk
FFB	Fresh fruit bunch
OPS	Oil palm shell
OPF	Oil palm fibre
POC	Palm oil clinker
PWD	Public work department

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The growths of the construction industry in Malaysia are in line with the increased of population for people to fulfill their living needs. However, the shortage of building material especially sand will hinder the development, thus intervention into looking for alternatives should be emphasize. Malaysia is overburden with waste materials and to dump these materials to landfill, there are no spaces or areas available. So, the only way to overcome the problem is by recycling these material into renewable building materials. Waste material that can be use as sand replacement in concrete or mortar is rice husk (RH), i.e. an agricultural waste. RH have properties such as low bulk density, toughness, abrasive in nature, resistance to weathering to name a few, therefore it seems to suit to be used as replacement of sand in making bricks itself. Knowing that bricks can be use as an in-filled material, therefore it does not really need to have the strength of an engineering bricks thus, strength of 7.5 N/mm^2 as stipulated in BS EN 771-3:2003[6] would be good enough.

The agricultural industry in Malaysia has progressed rapidly over the past few decades with the palm oil industry showing significant dominance. Statistics show that the total plantation area of oil palm in 2014 was 5.39 million hectares, which increased by 3.1% compared to 2013 (MPOB, 2014). In addition, as of the third quarter of 2015, almost 16.91 million tonnes of crude palm oil were produce in Malaysia (MPOB, 2014). As of October 2015, there were 442 fresh fruit bunch (FFB) mills in Malaysia, which processed about 82.74 million tonnes of FFB (MPOB, 2015). The mass production of palm oil clinker based products also generates an almost similar quantity of by-products, which have to be handle appropriately. Such by-products include oil palm shell (OPS), oil palm fibre (OPF) and palm oil clinker (POC). The incineration of OPS and OPF in a boiler at high temperature generates palm oil clinker (POC). One of the current trends reported by Vijaya et al. (2008) is that some of the mills make use of POC to fill the potholes on the roads leading to the plantation estates. Thus, considering the continuous depletion of conventional materials from natural resources for manufacture of mortar and sand brick, it would be a novel and indeed innovative method to channel this waste as an alternative. Although a few studies have been conducted on the use of POC as aggregate, it should be noted that none focused on the use of POC fine as a replacement for sand. This study is expected to create a breakthrough for the incorporation of POC fine.

1.2 Problem Statement

A market study carried out by Bronzeoak Ltd. (2003) shows that approximately 600 million tonnes of rice paddy is produced each year. On average, 20% of the rice paddy is husk, which gives an annual total production of 120 million tonnes. In a majority of rice producing countries, much of the husk produced from the processing of rice is either burnt or dumped as waste (Paya et. Al, 2000). Rice husk is a waste product of agricultural activity in most countries in Asia, including Malaysia. Rice husk has created a major problem of disposal to the rice milling industry in Malaysia and elsewhere in the world (Farook et. Al., 1989). The Department of Statistics, Malaysia (2016), reported that the production of paddy amounted to 2,599,382 tonnes in the year 2016.

In Malaysia, the most common brick used in the construction industry is cement sand brick due to its cheaper price. Unfortunately, the cement sand brick has lower values of compressive strength, fire resistance and chemical-attack resistance, but higher values of water absorption and initial rate of section compared to fire-clay brick. The conventional fired-clay brick still has a lot of room for improvement. Some fires-clay bricks have high values of compressive strength but are high in water absorption, and are really heavy. In order to improve the performance of engineering properties of cement sand brick in terms of compressive strength, water absorption, density and flexural strength other materials can be considered to partially replace fine aggregate with rice husk.

1.3 Objective of Study

The objectives of this study are:

i. To investigate the optimum ratio of rice husk in cement sand brick.
ii. To determine the characteristic of cement sand brick:

- ➢ Density
- ➢ Water absorption rate
- ➢ Compressive strength
- ➢ Flexural strength

1.4 Scope of Project

In this research palm oil clinker (POC) are used as the waste materials. Based on the objective of this research is to study the optimum percentages of palm oil clinker used in the cement sand brick. The dimensions of the brick are according to the Public Work Department (PWD) Standard Specification for Buildings Works, 2005, it stated that, all cement sand brick shall comply with MS 27. The nominal size of cement sand brick is, the length is 210 mm (± 3.2), width is 100 mm (± 1.6) and depth is 71mm ± (1.6). The ratio used for the brick mixture is 1 ratio 6 (1:6) which are according to cement sand brick ratio.

In this research there are the percent of replacement for fine aggregate with ratio of 10% with rice husk of 10%,20% and 30%. This ratio used to determine which the best ratio are there have 60 samples. Each ratio will undergo a testing and analysis, and based on the testing and analysis result, the best optimum percentages of palm oil clinker are determined.

The laboratory testing are for properties at 28 days, 60 days and 90 days. For compressive strength and flexural strength test were conducted at 28 days, 60 days and 90 days. Water absorption test were conducted at 28 days. All this test were conducted in according to ASTM C55 (2015).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Sand bricks are created with a combination of aggregates and cement that contains constant hydraulic pressure, as well as simultaneous vibration. In the history of professional construction practices, brick is one of the oldest of all building materials. It is also arguably the most durable, since there are brick walls, foundations, pillars, and road surfaces constructed thousands of years ago that are still intact. Today, bricks are most often used for wall construction, especially as an ornamental outer wall surface. Officially, the term brick is used to denote a building unit made of shaped clay, but in modern times it is used to refer to any stone or clay-based building unit that is joined with cementitious mortar when used in construction. Typically, bricks are about 4 inches wide, 8 inches long, with a variety of thicknesses. Larger stone- or clay-based building units of the type used in foundations are usually called blocks.

This study was conducted involving the use agricultural waste such as clinker palm oil and rice husk to replace fine aggregate in making sand bricks. To experimented the bricks capability in term of density, water absorption rate, compressive strength, and flexural strength compare to normal sand bricks. In this chapter, the content and percent of the material in the sand brick, clinker palm oil and rice husk use and laboratory tests carried out on the brick will also be described. Chapter 2 deliberates and discusses usage of waste materials in brick production published by previous researchers. This chapter also discusses the potential of rice husk in brick manufacturing and the process of manufacturing brick, including the problems that arise during the operation process. In addition, characteristics of the raw materials used and the basic properties of brick are also discussed at the end of this chapter.

2.2 General

2.2.1 Sand Brick

In the past, the material that used to build a wall is bricks. Until today, the bricks are still the most common material in Malaysia's construction sector. Clay brick and sand brick are the common brick that can found in market. It serves as a wall unit with a size not exceeding 337.5 mm long, 225 mm wide and 112.5 mm in height (Standard Malaysia, 1982).

Figure 2.1 Sand Bricks

A bricks is a building material used to make walls, pavements and other elements in masonry construction. Traditionally, the term brick referred to unit composed of clay, but it is now used to denote any rectangular units lain 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. Cement sand brick is a type of brick made from a mixture cement and sand and molded under pressure (McGraw-Hill Dictionary of Scientific & Technical Term, 2003).

Based on the study of Tan Boon Tong(2000) the brick have a fixed shape, have a uniform size and texture, rectangular and smooth surface, have an average weight of 2.3 kg up to a brick 3.3 kg, and absorption rate does not exceed 15% of its own weight.The size of sand bricks were follow the JKR Standard is shown at the Table 2.1

Table 2.1 Size of sand brick follows the JKR standard

Length (mm)	Width (mm)	Depth (mm)
225 ± 3.2	113 ± 1.6	75 ± 1.6

Source: Rahman (2007)

2.2.2 Palm Oil Clinker

Malaysia is one of the primary producers of palm oil in Asia. It is the second largest palm oil-producing country in the word, producing more than half of word'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. However, the palm oil industry is also a major contributor to the pollution problem occurring in the country, with an estimated 2.6 million tons of solid waste produced annually (F.Abutaha et al, 2016). The high amount of waste generated is mostly composed of palm oil clinker (POC) and palm oil shell. POC is abundant and have small commercial value in Malaysia; hence, this industrial waste can be converted into potential construction materials.

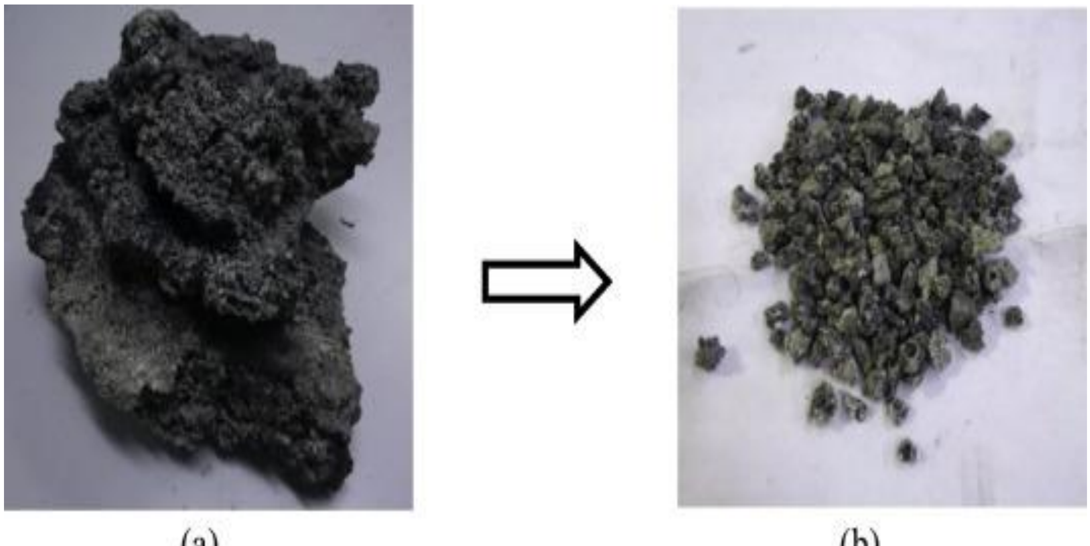

Figure 2.2 Palm Oil Clinker (a), Crushed Palm Oil Clinker (b)

2.2.3 Rice Husk

The rice plant covers 1% of the earth's surface and is a primary source of food for billions of people. Globally, approximately 600 million tonnes of rice paddy is produced each year. On average, 20% of the rice paddy is husk, giving an annual total production of 120 million tonnes. In the majority of rice producing countries, much of the husk produced from the processing of rice is either burnt or dumped as waste (Bronzeoak Ltd., 2003). This ash is treated as a waste material usually dumped at the backyard causing unforeseen environmental hazards. Table 2.2 shows the production of paddy in Malaysia until 2016. The husk generated from this paddy is 20% by weight, amounting to 450,477.6 tonnes for the year 2016.

Table 2.2 Production of paddy in Malaysia

Year	**2016**	**2015**	**2014**	**2013**	**2012**
Production of Paddy (tonnes)	2,252,388	1,756,433	1,834,831	2,603,654	2,599,382

Source : Department Of Statistics Malaysia

Figure 2.3 Rice Husk

2.3 Type of Brick

2.3.1 Burnt Clay Brick

Burnt clay bricks are the classic form of brick, created by pressing wet clay into molds, then drying and firing them in kilns. This is very old building material-the type of brick found in many of the ancient structures of the word. In appearance, these bricks are solid blocks of hardened clay, usually reddish in colour.

Burnt clay bricks are typically sold in four classes, with first-class offering the best quality and most strength. These high-grade burnt clay bricks have no noticeable flaws, but they're also going to cost more. When these bricks are used in walls, they require plastering or rendering with mortar. Uses for burnt clay bricks include:

- ✓ Masonry walls
- ✓ Foundations
- ✓ Columns

Figure 2.4 Burnt Clay Brick.

1.1.2 Fly Ash Brick

Fly ash clay bricks are manufactured with clay and fly ash-a byproduct of coal burning – fired at about 1,000 degrees C. Because fly ash contains a high volume of calcium oxide, this Type of brick is sometimes described as self-cementing, since it expands when exposed to moisture. This tendency to expand, however, can also produce pop-out failure. Fly ash clay brick has the advantage of being lighter in weight than clay or concrete brick.

Typical uses for fly ash clay brick include:

- ✓ Structural walls
- ✓ Foundations
- ✓ Pillars
- ✓ Anywhere that improved fire resistance is required

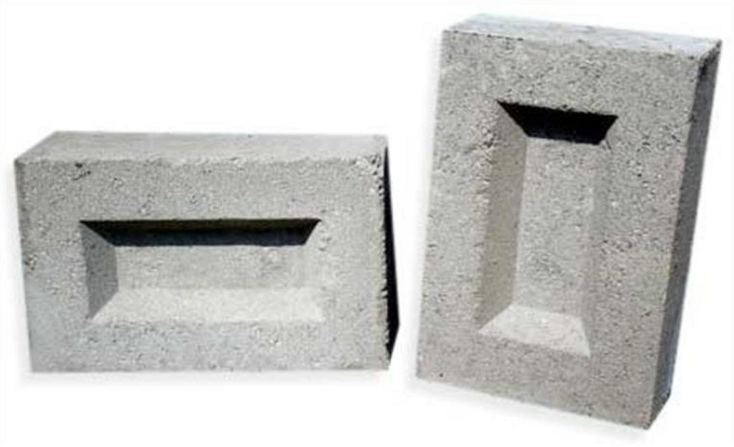

Figure 2.5 Fly Ash Brick

1.1.3 Sand Lime Brick

Sand lime bricks (also known as calcium silicate bricks) are made by mixing sand, fly ash and lime. Pigments may also be added for colour. The mixture is than molded under pressure to form bricks; the materials bond together by a chemical reaction that occurs as the wet bricks dry under heat and pressure. These bricks are not, however, fired in klins in the same manner as burnt clay bricks. Sand lime bricks can offer some advantages over clay bricks such as:

- ✓ Their colour appearance is gray instead of the regular reddish colour.
- ✓ Their shape is uniform and presents a smoother finish that does not require plastering.
- ✓ These bricks offer excellent strength for load-bearing structures.
- ✓ When pigments was added, the bricks can be used for ornamental purposes.
- ✓ Less mortar is required during construction.
- ✓ Edges are straight and precise, making construction easier.
- ✓ Bricks do not effloresce salts and minerals.

The uses for sand lime bricks include:

- ✓ Structural foundations and walls

- ✓ Exposed brick walls and pillars
- ✓ Ornamental uses (when pigments are added)

Figure 2.6 Sand Lime Brick

1.1.4 Fire Brick

Also known as refractory bricks, these are manufactured from specially formulated earth with a high aluminium oxide content. After burning, these bricks can withstand very high temperatures without their shape, size, or strength being affected.

Common used for this type of brick include:

- ✓ Lining of chimneys and furnaces
- ✓ Pizza ovens and outdoor brick barbecues

Figure 2.7 Fire Brick

1.4 Materials

1.4.2 Cement

Cement is any substance which binds together other materials by a combination of chemical processes known collectively as setting. Cements are dry powders and should not be confused with concretes or mortars, but they are an important constituent of both of these materials, in which they act as the ‘glue’ that gives strength to structures. Mortar is a mixture of cement and sand whereas concrete also includes rough aggregates; because it is a major component of both of these building materials, cement is an extremely important construction material. It is used in the production of the many structures that make up the modern world including buildings, bridges, harbors, runways and roads. It is also used for facades and other decorative features on buildings. The constant demand for all of these structures, increasingly from the developing world, means that cement is the second most consumed commodity in the world after water (Francesca, 2010).

Cements used in construction can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to set in the presence of water (Blezard, 2004). Non-hydraulic cement will not set in wet conditions or underwater; rather, it sets as it dries and reacts with carbon dioxide in the air. It can be attacked by some aggressive chemicals after setting (Blezard, 2004). Hydraulic cement (e.g, Portland cement) set and become adhesive due to a chemical reaction between the dry ingredients and water. The chemical reaction results in mineral hydrates that are not very water-soluble and so are quite durable in water and safe from chemical attack. This allows setting in wet condition or underwater and further protects the hardened material from chemical attack. The chemical process for hydraulic cement found by ancient Romans used volcanic ash (Blezard, 2004).

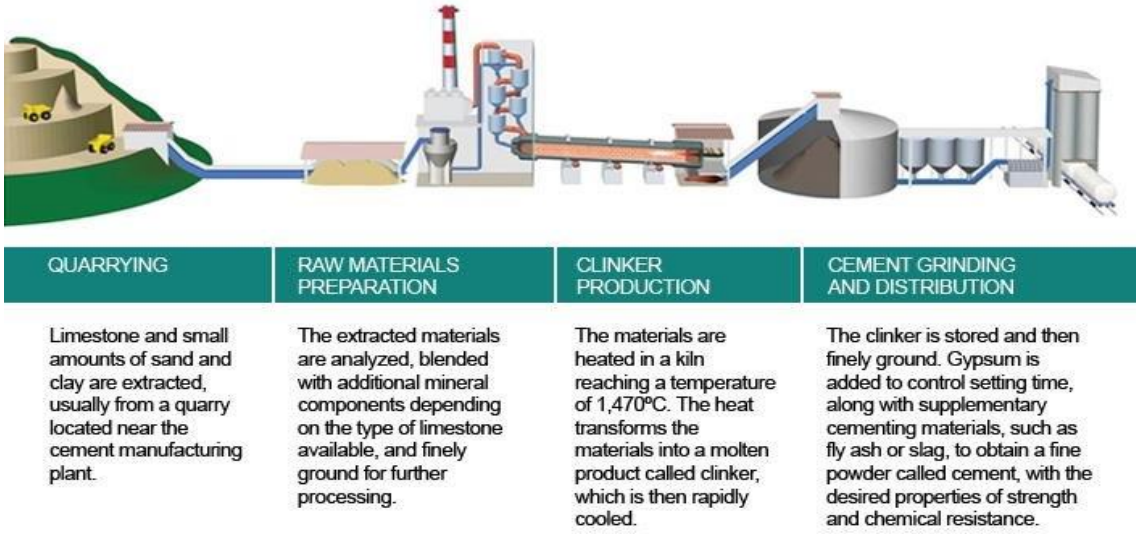

Figure 2.8 Cement raw materials processing

1.4.3 Water

Water is largely discussed from a physical or a normative perspective. From a physical perspective, discussions are usually limited only to the terrestrial part of the hydraulic cycle, comprised of blue water, green water and gray water. Much of the discussion focuses on blue water, differentiating between surface water and groundwater. Most discussions of water thus focus on less than 3% of the total water of the hydrosphere (Shiklomanov, 1993). Yet, while these discussions are couched in technical terms, they reflect deeper societal issues, pertaining to values and norms. Hence, it should not be surprising that in these discussions different actors espouse different views of water (Linton, 2010). Many view water as a natural resource (Falkenmark & Lindh, 1974; Clarke, 1993; Glieck, 1993; Postel, 1997, for example). Others (mostly economists) argue that it should be viewed as a commodity or a factor of production (Winpenny, 1994; Rogers et al., 2002). However, water is first and foremost a source of life. Thus it has been argued that water should be considered as a basic need, and therefore it constitutes a right to which people are entitled (Glieck, 1998). Proponents of bio-centric approaches have argued that similar entitlements should also be extended to other species (Merchant, 1997; Breckenbridge, 2005).

1.4.3 Sand

Sand is a granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; i.e., a soil containing more than 85 percent sand-sized particles by mass. Sand is an important element in the making of sand brick to give the strength to the brick. The sand that used for this brick must clean from excess element that can be effect the texture of brick such as clay and silt.

1.4.4 Palm Oil Clinker (POC)

For this study, palm oil clinker is use about 10% to all 3 sample of sand brick. Palm oil clinker is use to replace the sand only 10% to test whether brick with clinker have different strength in term of density, water absorption rate, compressive strength and flexural strength.

Table 2.3 Chemical composition of POC powder. (Jegathish Kanadasan and Hashim Abdul Razak ,2015)

Oxides	**POC Powder**
CaO	6.37
Al_2O_3	5.37
K_2O	15.10
MgO	3.13
SO_3	2.60
Na_2O	0.24
P_2O_5	0.07
SiO_2	59.90
Fe_2O_3	6.93
Mn_2O_3	0.12
TiO_2	0.12

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1.5 METHODS

2.5.1 Compressive Strength Test

MS 4.3.5:2005 states that the minimum permissible average compressive strength shall be 5.2 N/mm^2 for bricks. Minimum strength accepted although no emphasis on other aspects. According to Jackson & Ravindra (1996), generally the compressive strength decrease as the hollow or porous growing but strength was also influenced by the composition of the sand.

2.5.2 Flexural Strength Test

Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a brick just before it yields in a flexural test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of yield. It is measured in term of stress.

2.5.3 Water Absorption Rate Test

Raw materials used during the production process effects the water absorption property of the bricks (Koroth et al., 1998). In Indian Standard (1992) specifies that the water absorption of brick should be less than 20% of the brick’s weight.

Deboucha et al. (2011) in their studies found that the water absorption bricks decrease from 68% to 14% for increasing cement from 20% to 30%. They reported a negative relation between total water absorption between total water absorption and the compressive strength. In addition, the total water absorption of bricks decreases with the increasing dry density and increasing curing periods.

1.5.4 Density Test

The bricks density influences the weight of walls and variations in weight have implications on structural, thermal design and acoustical properties of the wall. Raw materials of brick and manufacturing process govern the density of bricks. Construction industry favors using a low-density bricks (lightweight brick) due to their benefits such as, lower structural dead-load, easy to handle, lower transportation costs, better thermal insulation and increase the percentage of brick production per unit of raw material (Raut et al., 2011; Wu and Sun, 200).

According to Kadir et al. (2010) lower density bricks can replace conventional bricks except when greater strength is needed. Adam and Agib (2001) present density value of some common masonry wall materials that summarized in Table 2.4.

Table 2.4 Density of common wall materials

Property	**Density (kg / m^3)**
Compressed stabilised earth blocks	1700 – 2200
Lightweight concrete blocks	600 – 1600
Dense concrete blocks	1700 – 2100
Calcium silicate bricks	1600 – 2100
Aerated concrete blocks	400 – 950
Fired clay bricks	1400 – 2400

Source : Adam and Agib (2001)

CHAPTER 3

METHODOLOGY

3.1 Introduction

The purpose of this research was to study the properties of the sand brick being added with 10% of clinker as replacement of fine aggregate with rice husk of 10%, 20%, and 30% in term of compressive strength, water absorption, density and flexural strength. There were three motives of this chapter which are to outline the research methodology of this study, clarify the calculations of the rice husk ratios, and explaining the parameter and testing conducted to achieve the objectives of this research.

This chapter is an approach in order to ensure the project to achieve the objectives outlined earlier. It will also can assure the research to be conduct correctly according to the procedures of the testing. When the research being execute according to standard of the procedure, the result outcome is highly believed to be correct and trusted. Therefore, by preparing research methodology in thesis, any issues or technical problems that can affect the final results of this research can be avoided in the future. The arrangement of this chapter will cover from the first step on executing the research until the final phase of the study. This will guarantee the exact way of the research to be lead to and can be complete within the timeframe given.

3.2 Project Design

The flow chart shows the flow of work done from start until final of the study, as shown in Figure 3.1. With the study of the flow chart, the entire review process can be seen easily. Each section contained in the flow chart will be described in more detail in each chapter in this study.

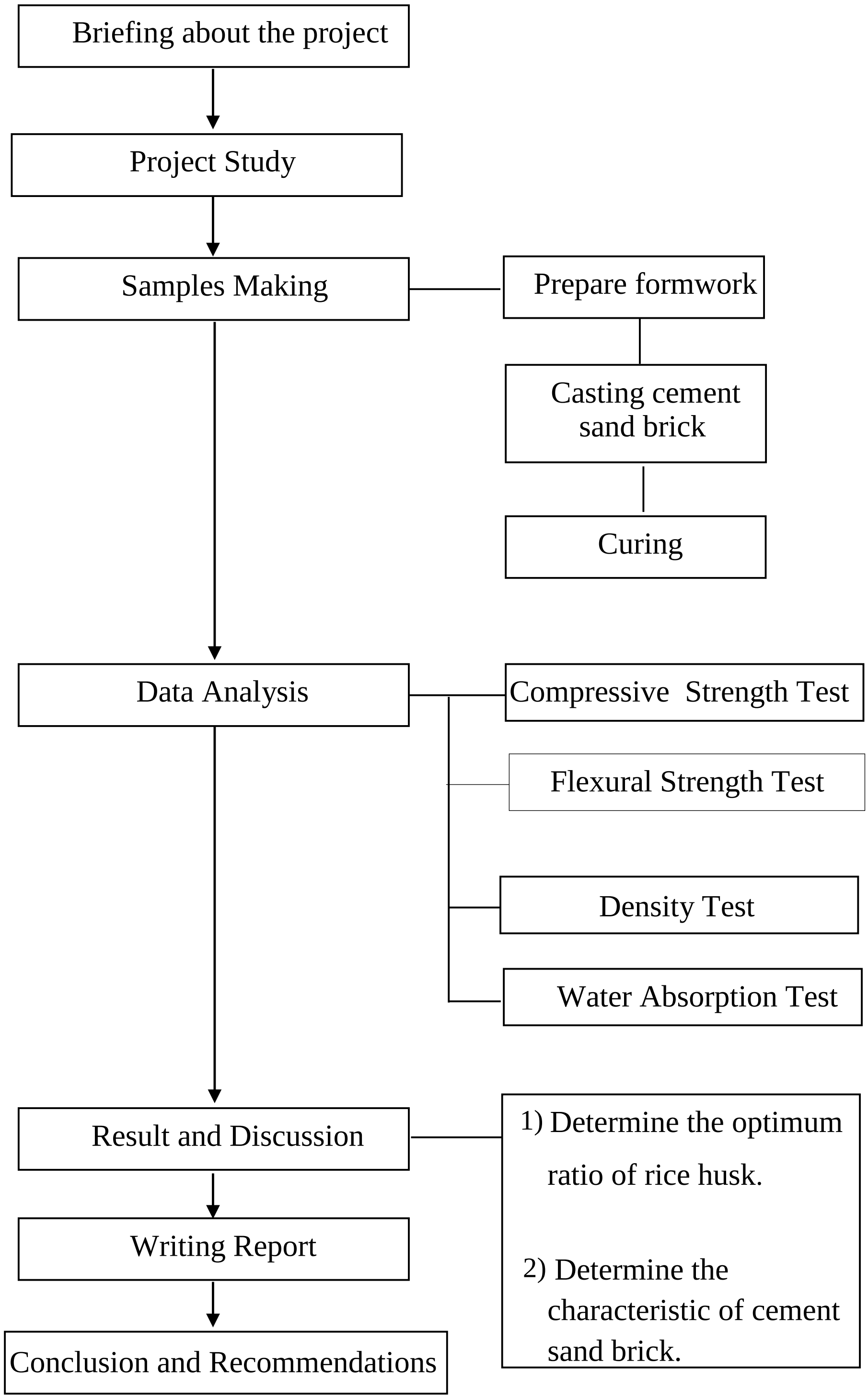

Figure 3.1 Conceptual framework of project

1.3 Brick Design

Brick design was important since the brick is the main character in this research. The following sub-section will explain the details of the proposed cement sand brick used.

3.1.1 Size of Cement and Brick

Design of a cement sand brick will follow the standard nominal sizes provided by Public Work Department (PWD) in (Standard Specification for Building Works 2005)

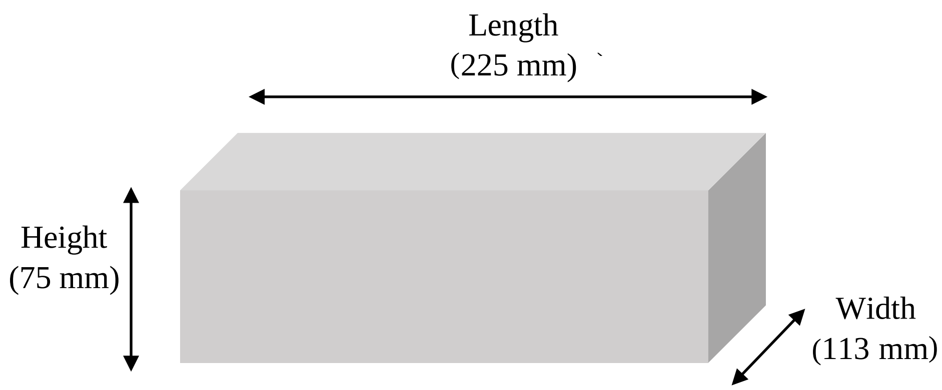

Figure 3.2 Size of a propose cement sand brick

3.1.2 Size of Formwork

In order to produced 216 samples of cement sand brick added with three ratio of rice husk with constant ratio of clinker, the following size of formwork has been proposed. Formworks are made from plywood with 12 mm thickness and complying with MS 228.

3.2 Preparation of Materials

In order to make these sand bricks, the preparation of materials is very important to make sure the bricks have follow the right requirement. The most important materials is sand, cement, and water. The other material that want to add to these brick are Palm oil clinker and rice husk. These all material is used to this project to compared with the normal or control sand brick in term of compressive stress, flexural stress, density and water absorbtion.

3.2.1 Sand

Sand (silica) in important in construction of sand brick. Silica prevents raw bricks from cracking, shrinking and warping. The higher the proportion of sand, the more and shapely and uniform in texture will be the brick. Although, excess silica destroys cohesion between the brick brick particles and makes brick brittle and weak. We must make sure the sand is free from the other properties that will disturb the strength of brick such as clay materials.

Figure 3.3 Sands

3.2.2 Water

Clean water and free of impurities were used because water contains impurities such as organic and sulfate could affect cement hydration in the brick structure. This can cause unwanted effects occur on the properties of brick masonry, especially when it has hardened. To get clean water, tap water was used for the mixing process. Mixture of the water in the mixing rate should be appropriate so as not to weaken the bonding structure in brick.

Figure 3.4 Tap Water

3.2.3 Cement

Cement were used in this test is Portland Composite Cement. This cement was prepared by technical staff at the concrete laboratory. Total volume for one brick is 0.00191 m^3. So, the ratio of brick is 1:6, that's mean, one part was cement and six parts was sand. In this test, total brick was produced is 216 bricks. This is calculation total volume of cement was used:

Ratio for sand brick is 1:6

Cement: 1= 0.000637 m^3

Sand: 6 = 0.00382 m^3

Total cement and sand was used:

Cement = 0.000637 x 1000 x 216 = 137.6 kg

Sand = 0.00382 x 1000 x 216 = 825.1 kg

Figure 3.5 Portland Cement

3.2.4 Palm Oil Clinker

Palm oil clinker had been used as an admixture in this test for produce sand brick. Palm oil clinker were taken at the factory of palm oil at Lepar Hilir, Pahang. After took the palm oil clinker, it should be crashed to small particle and sieved it.

Figure 3.6 Taking Palm Oil Clinker at factory of palm oil

Figure 3.7 Crushing the large palm oil clinker

Figure 3.8 Sieve palm oil clinker passing 4.75 mm

3.2.5 Rice Husk

Rice husk is use to this test with three different percentage to three different sample. The rice husk were took at Kuala Rompin, Pahang. Rice husk also needed to sieve to get passing 4.75 mm.

Figure 3.9 Sieve rice husk to get passing 4.75 mm

3.3 Specimen Preparation

The sample preparation was conducted in UMP CTMS concrete laboratory in University Malaysia Pahang. The ratio of rice husk is 10%, 20%, and 30% and constant ratio of 10% palm oil clinker was prepared to mixture the proportions of cement and sand.

Table 3.1 Ratio of Mix Design Sand Brick

Mixture	**Ratio of Mixture**		
	Sand (%)	Rice Husk (%)	Palm Oil Clinker (%)
0	100	0	0
1	80	10	10
2	70	20	10
3	60	30	10

Figure 3.10 Cut the plywood following the right size to make formwork

Figure 3.11 Demoulded the brick from the formwork

3.4 Method of Testing

3.61 Curing Process

Curing was an important process of maintaining satisfactory moisture content and temperature in bricks for a definite period of time immediately following placement. Usually, cured bricks have an adequate amount of moisture for continued hydration and development of strength, and volume stability. There are three main methods of curing; maintaining mixing water in brick during the early hardening process, reducing the loss of mixing water from the surface of the concrete, and accelerating strength gain using heat and additional moisture.

Figure 3.12 Process of water curing

3.6.2 Compressive Strength Test

For the compressive strength test, 10 specimens of sand brick was tested for every ratio of rice husk. 5 specimens from air curing while another 5 specimens from water curing. On the testing day, the sand brick was carefully centred on the compression machine. Load was applied onto the specimen without shock until failure occurred.

Compressive strength of specimen calculated using following equation,

$$Compressive\ Strength\ \left(\frac{N}{mm^2}\right) = \frac{Applied\ Load\ (N)}{Cross\ Sectional\ Area\ (mm^2)}$$

Figure 3.13 Process of compressive strength test

3.6.3 Density Test

To know the density of the different ratio mixture of brick and make comparison with control sample. The objective is to determine the in situ density of natural or compacted soils using sand pouring cylinder. To determine density test, 3 specimens were oven about 24 hours. Then, after one day oven, weight the specimens and calculated the average weight of specimens.

Density test of specimen calculated using following equation,

$$Density, \rho = \frac{Mass}{Volume}$$

3.6.4 Water Absorption Test

Objective to this test was to determined the water absorption capacity of brick. The test was conducted at UMP CTMS concrete laboratory. Water absorption is used to determine the amount of water absorbed under specified conditions. Factors affecting water absorption include: type of plastic, additives used, temperature and length of exposure. To determine water absorption of specimens, weight the specimen for specimen after oven and after immersed. Also used 3 specimen for this test.

Water absorption of specimen calculated using following equation,

$$\% \, Water \; Absorption = \frac{W_i - W_d}{W_d} \times 100$$

3.6.5 Flexural Strength Test

The objective to make flexural test was to measure flexural strength and flexural modulus. Flexural strength is defined as the maximum stress at the outermost fiber on either the compression or tension side of sand bricks. For flexural strength test, 6 specimens were used for every ratio of testing. 3 specimen from air curing while another 3 specimens from water curing. The specimen was carefully centred on the flexure machine. Load was applied onto the specimen without shock until the specimen break into half.

Flexural strength of specimen calculated using following equation,

$$Flexural \; Strength \; \left(\frac{N}{mm^2}\right) = \frac{Applied \; Load \; (N)}{Cross \; Sectional \; Area \; (mm^2)}$$

Figure 3.14 Process of flexural strength test

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter will discuss the result of laboratory test conducted on control samples and different ratios. A total of sand brick was conducted in concrete lab is 216. This total had been added for four ratio of rice husk there are 10%, 20% and 30%. In addition, in this process by using two curing method which are air curing and water curing for 28, 60 and 90 days. In this chapter, the results will be shown for compressive strength, flexural strength, water absorption test and density test and comparison between different ratios with control samples. From the test results obtained, the data were described in the tables and graphs using Microsoft Excel to support and display the data more clearly.

4.2 Sand Brick Test

There are four tests were conducted on the sand bricks which are compressive strength, flexural strength, water absorption test and density test. These tests following JKR standard according to MS JRK: 2005 and these tests carried out for 28, 60 and 90 days. These tests are done to achieve the objectives for this study.

4.2.1 Compressive Strength Result

Compressive strength tests were conducted using Compression Machine at concrete laboratory has been designed to get the compression strength of the brick. Through this test, the sample brick for 5 units of each percentage ratio was tested after this brick reached the maturity at 28, 60 and 90 days. The value of the brick sample were recorded based on the average value of its strength. Figure 4.1 shows, the compressive strength of control samples against 28, 60 and 90 days.

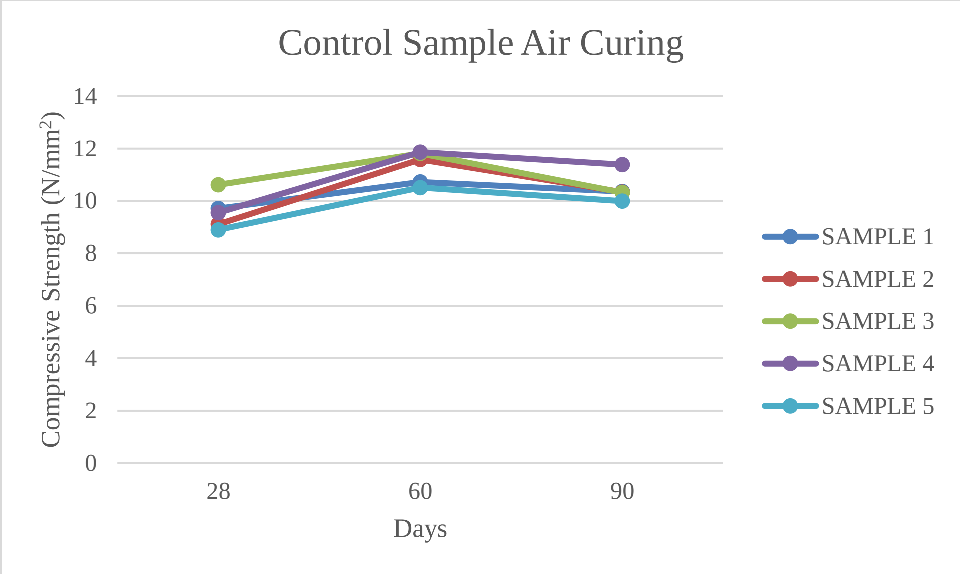

Figure 4.1 Control sample for air curing

In figure 4.1 shows the graph of control sample for air curing against the days. At 60 days, the highest result for this control sample is 11.86 N/mm^2 compare to the other samples. The graphs show 28 days and 60 days, the graph increase steadily while at 90 days decrease steadily. The lowest result for this control sample is 9.99 N/mm^2.

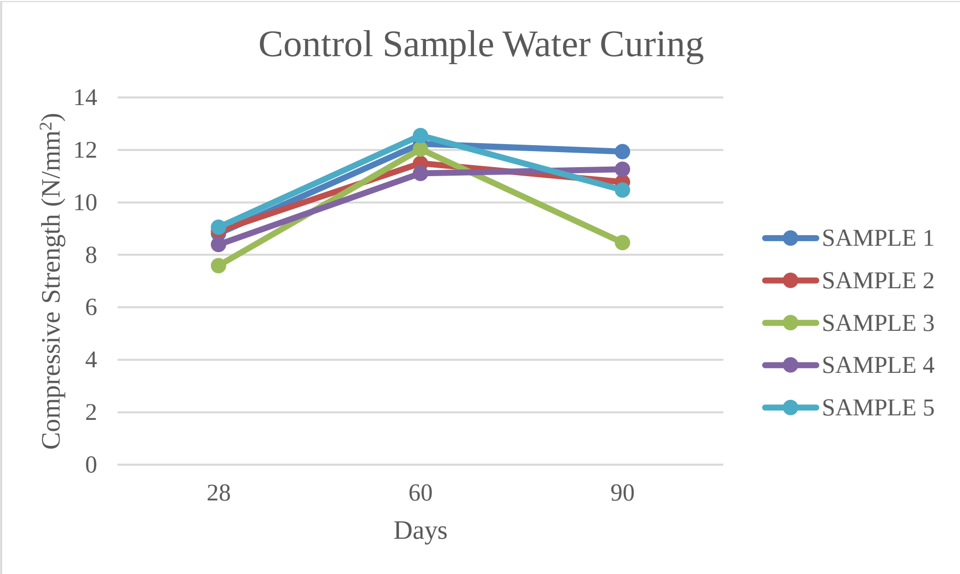

Figure 4.2 Control sample for water curing

The line graph above show the changes in compressive strength and days for control sample of water curing. The highest result for compressive strength is at 60 days which is 12.55 N/mm^2. The graph shows that at 28 days and at 60 days the compressive strength increase steadily for 5 sample of sand brick and decrease steadily at 90 days. The lowest result for compressive strength is at 28 days which is 7.59 N/mm^2.

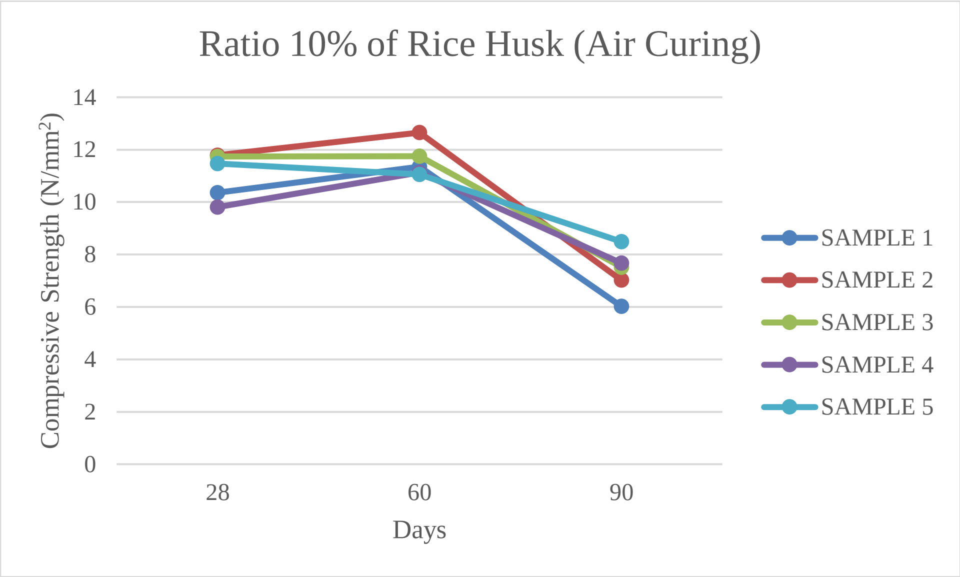

Figure 4.3 10% of RH for air curing

In figure 4.3 shows the line graph of palm oil clinker for air curing about the changes in compressive strength against days. At 60 days, the highest result for this graph is 12.65 N/mm^2 compare to another sample of brick. The lowest result for this graph is 6.02 N/mm^2 at 90 days of curing.

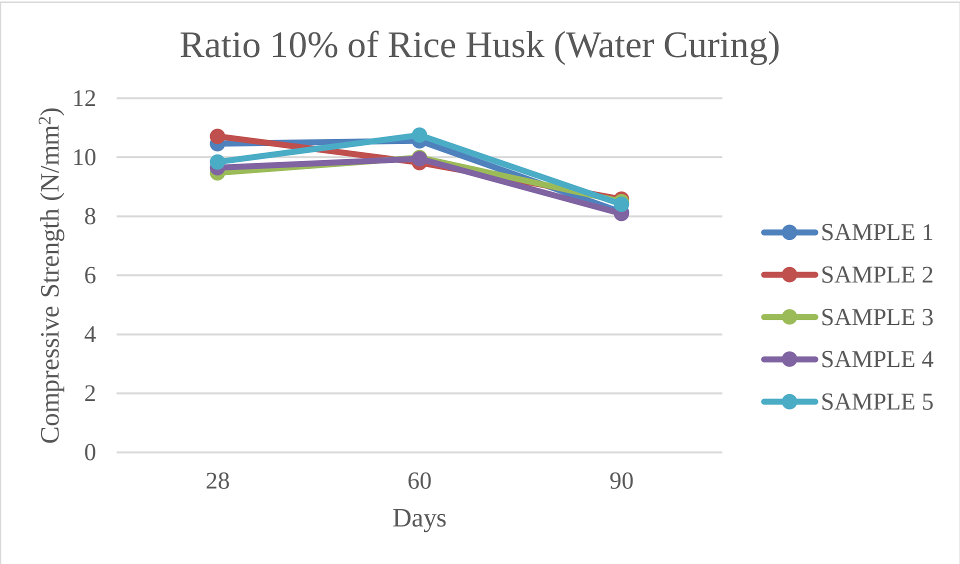

Figure 4.4 10% of RH for water curing

In figure 4.4 shows the line graph of palm oil clinker for air curing about the changes in compressive strength against days. At 60 days, the highest result for this graph is 10.75 N/mm^2 compare to another sample of brick. The lowest result for this graph is 8.09 N/mm^2 at 90 days of curing.

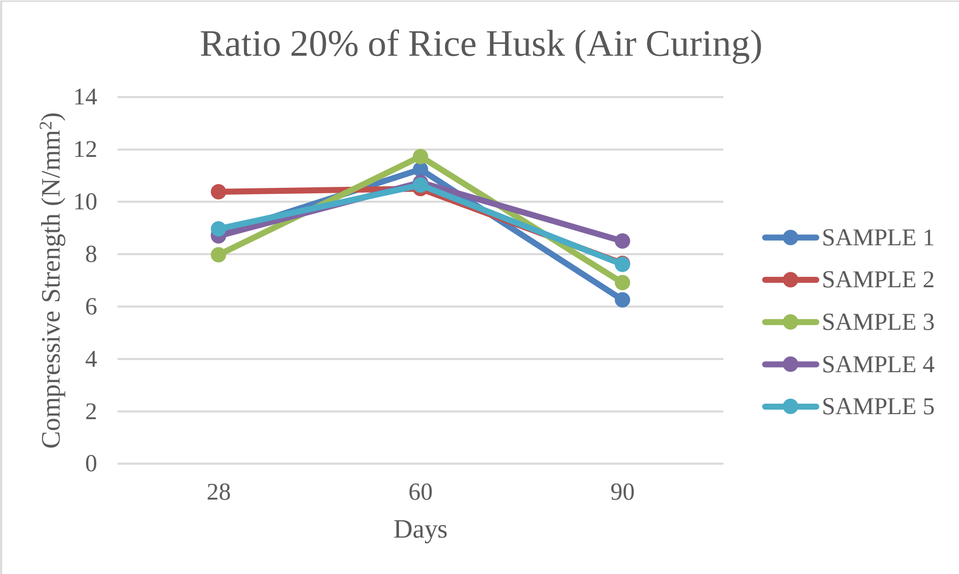

Figure 4.5 20% of RH for air curing

The line graph above show the changes in compressive strength and days for control sample of water curing. The highest result for compressive strength is at 60 days which is 11.73 N/mm^2. The graph shows that at 28 days and at 60 days the compressive strength increase steadily for 5 sample of sand brick and decrease steadily at 90 days. The lowest result for compressive strength is at 28 days which is 6.26 N/mm^2.

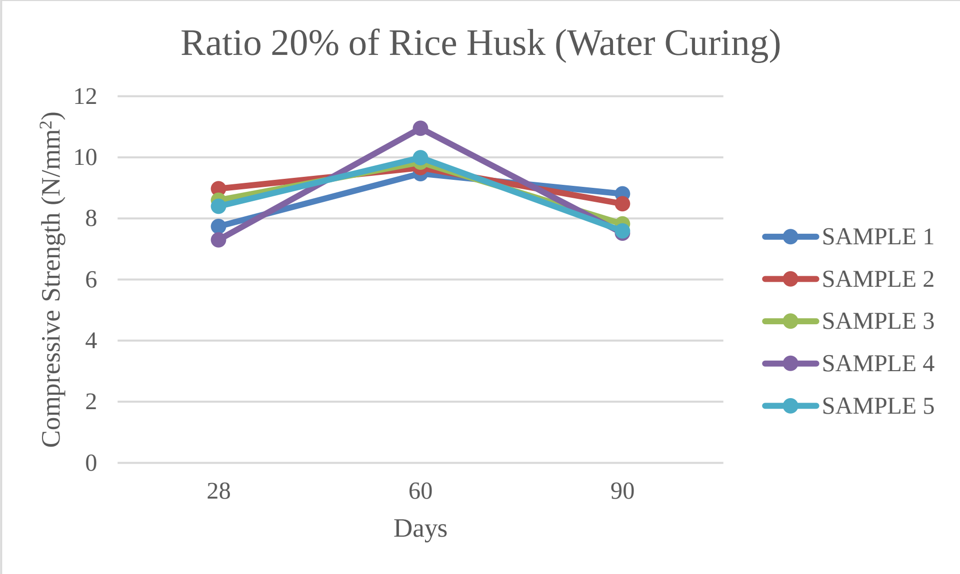

Figure 4.6 20% of RH for water curing

In figure 4.6 shows the line graph of palm oil clinker for air curing about the changes in compressive strength against days. At 60 days, the highest result for this graph is 10.95 N/mm^2 compare to another sample of brick. The lowest result for this graph is 7.52 N/mm^2 at 90 days of curing.

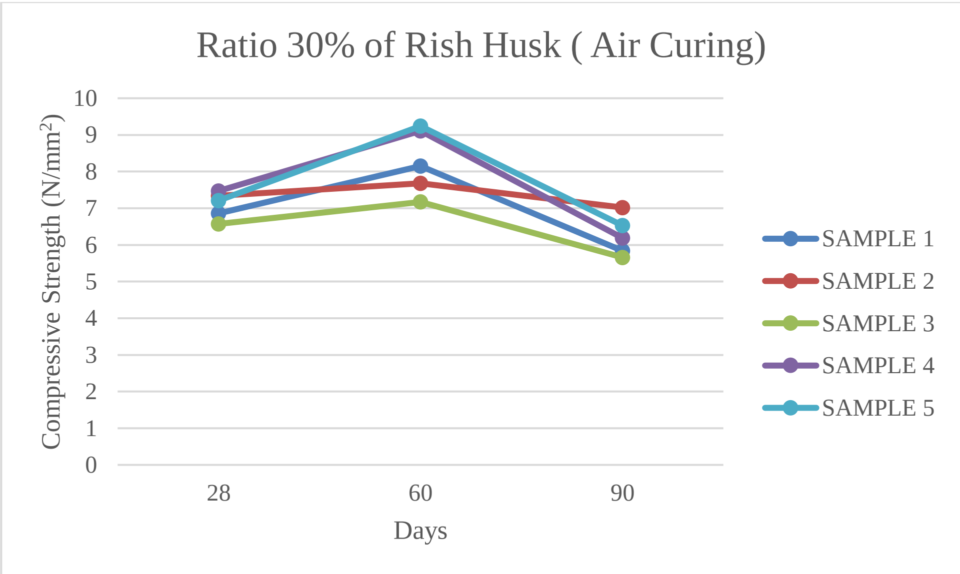

Figure 4.7 30% of RH for air curing

The line graph above show the changes in compressive strength and days for control sample of water curing. The highest result for compressive strength is at 60 days which is 9.24 N/mm^2. The graph shows that at 28 days and at 60 days the compressive strength increase steadily for 5 sample of sand brick and decrease steadily at 90 days. The lowest result for compressive strength is at 28 days which is 5.66 N/mm^2.

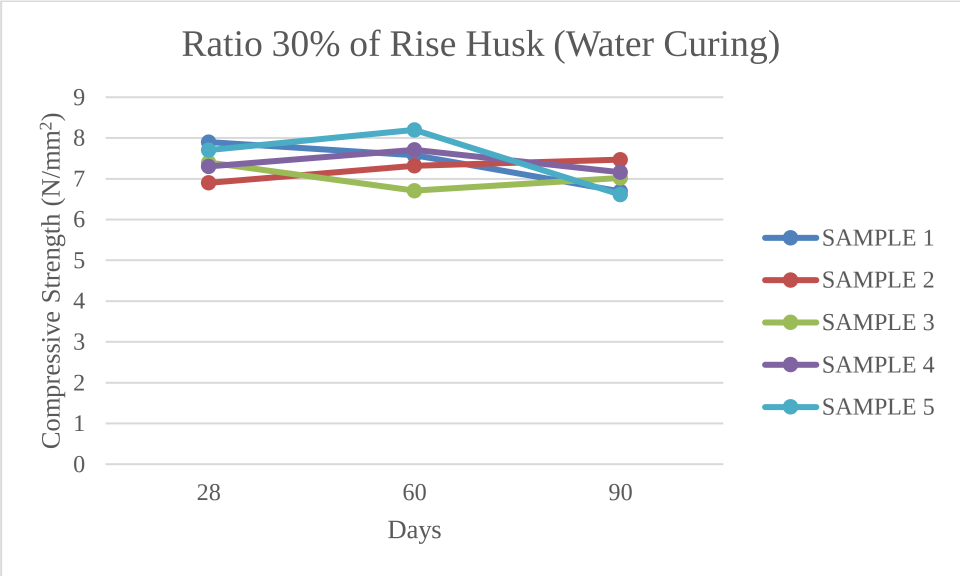

Figure 4.8 30% of RH for water curing

In figure 4.8 shows the line graph of palm oil clinker for air curing about the changes in compressive strength against days. At 60 days, the highest result for this graph is 8.20 N/mm^2 compare to another sample of brick. The lowest result for this graph is 6.61 N/mm^2 at 90 days of curing.

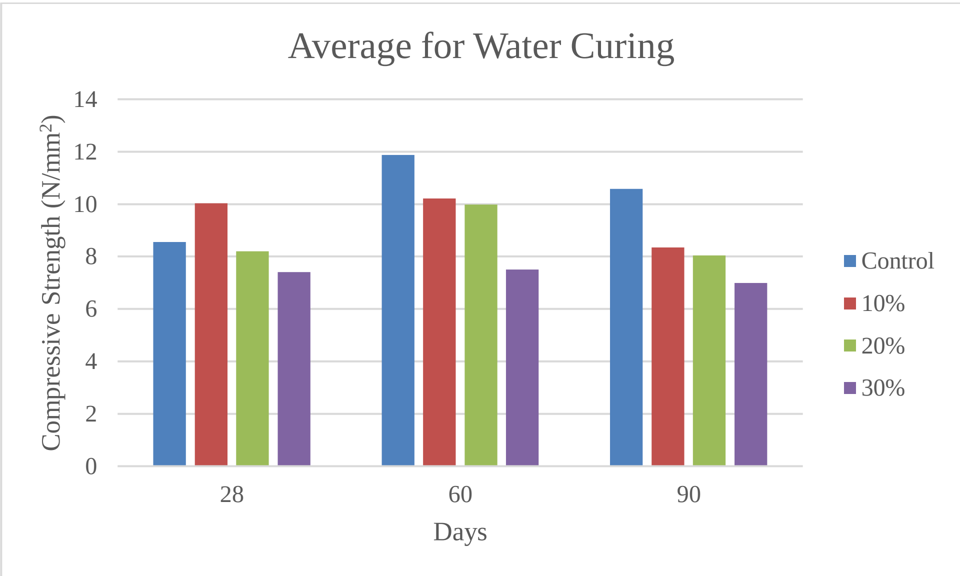

Figure 4.9 Compressive Strength against Days for Water Curing

The bar chart indicates the changes in the compressive strength of four different ratios of sand brick for water curing. After 60 days, the controlled brick has the highest strength which is 11.88 N/mm^2 compare to the other brick. The compressive strength for both 60 and 90 days decrease suddently from control sample to the 10% but from ratio 10% the graph dropped steadily to the ratio 20%.

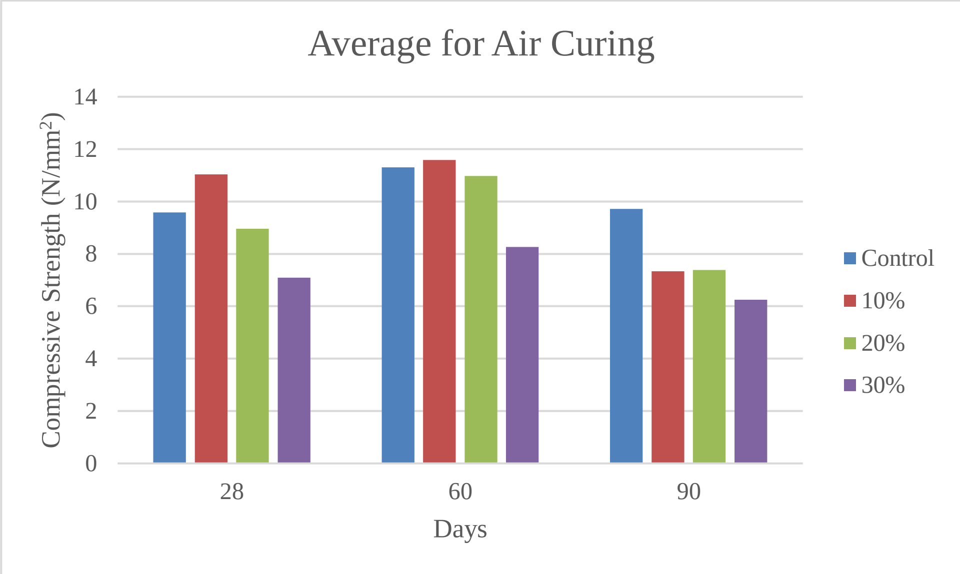

Figure 4.10 Compressive Strength against Days for Air Curing

The bar chart indicates the changes in the compressive strength of four different ratios of sand brick for water curing. After 60 days, the 10% ratio brick has the highest strength which is 10.21 N/mm^2 compare to the other brick. The compressive strength 90 days decrease suddently from control sample to the 10% but from ratio 10% the graph dropped steadily to the ratio 20%. The lowest result in air curing is ratio 30% in 90 days which is 6.248 N/mm^2.

4.2.2 Flexural Strength Result

Flexural strength tests were conducted using Flexural Machine at concrete laboratory has been design to get the flexural strength of the brick. Through this test, the sample brick for 5 units of each percentage ratio was tested after this brick reached the maturity at 28, 60 and 90 days. The value of the brick sample were recorded based on the average value of its strength. Figure 4.11 shows, the average flexural strength for water curing against 28, 60 and 90 days. Figure 4.12 shows, the average flexural strength for air curing against 28, 60 and 90 days.

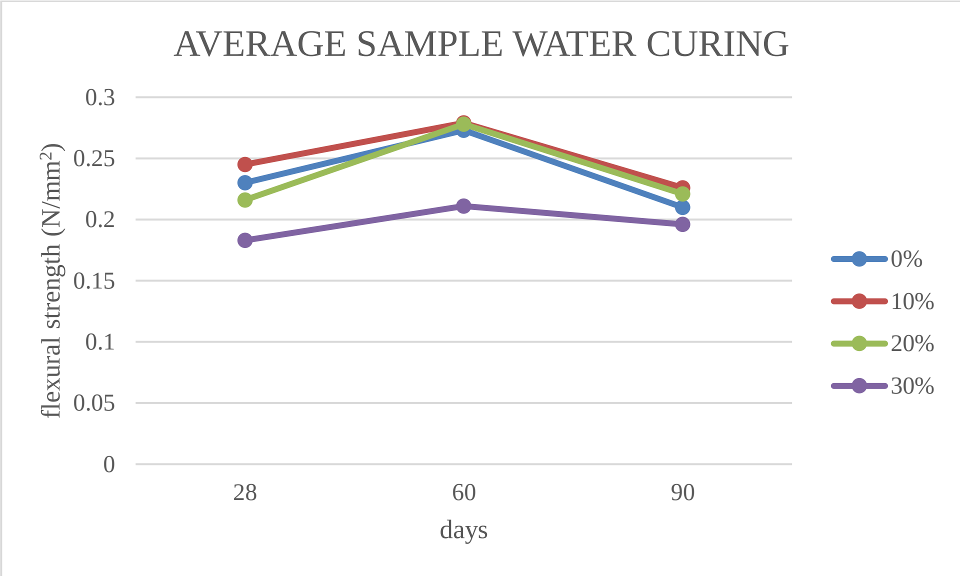

Figure 4.11 Average Flexural Strength for water curing

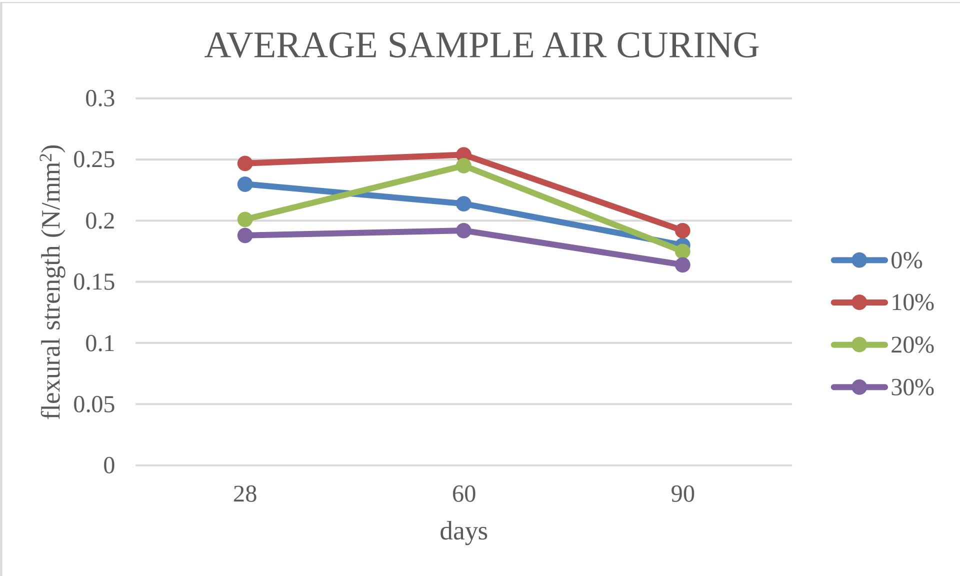

Figure 4.12 Average Flexural Strength for air curing

4.2.3 Water Absorption Result

Water absorption test were conducted after 28 days casting the samples. On the other hand to get the result of the samples, the samples should be weighted before and after to calculate the result. Result for water absorption can get after enter the weight of sand brick into the formula of water absorption.

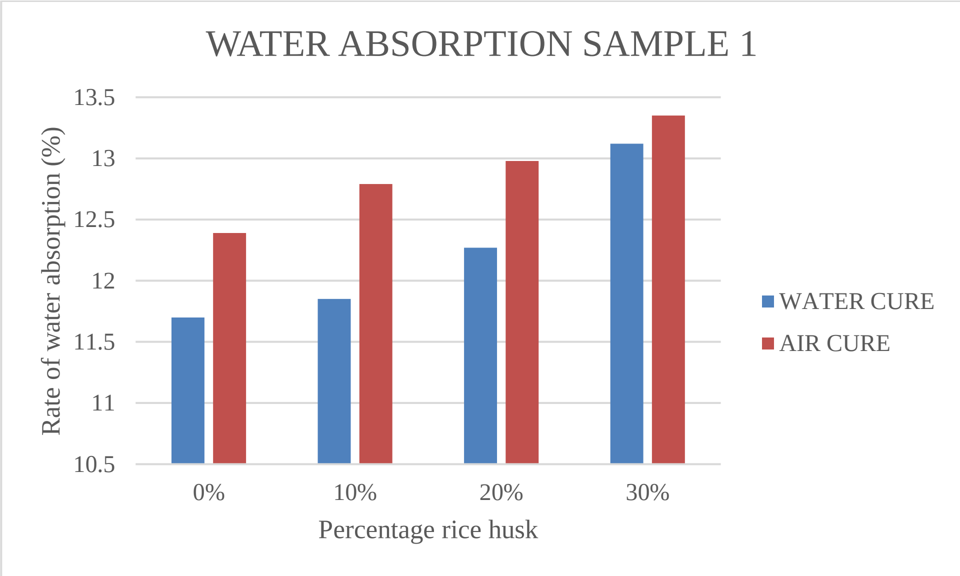

Figure 4.13 Average water absorption

The bar chart indicates the changes in the water absorption due to change ratio of rice husk. The water absorption pattern increase as more rice husk was added as partial sand replacement. This cause rice husk absorp a lot of water and this reduce the degree of compaction of the fresh mix resulting in presents of void and non-uniform distribution of raw rice husk.

4.2.4 Density Result

The density test were conducted after 28 days casting the sample. On the other hand to get the result of the samples, the samples should be dry at oven to get weight after oven. Result for density test can get after enter the average weight after oven into the formula of density.

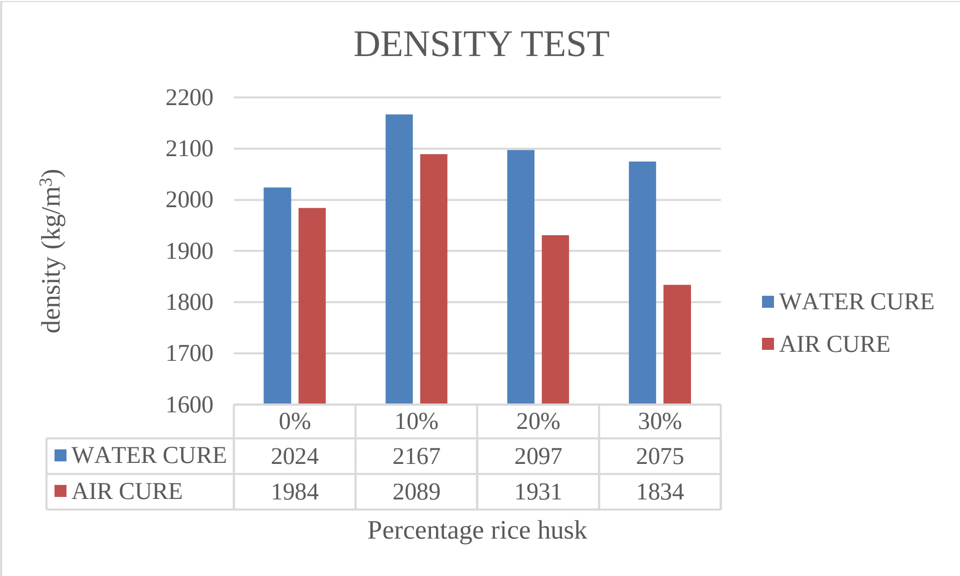

Figure 4.14 Density test

The bar chart indicates the changes in the density due to change ratio of rice husk. From the control to 10% ratio density of brick rapidly increase and then decrease steadily when ratio goes 20% and 30%.

4.3 Discussion

The laboratory test result data of compressive strength and flexural strength for all sand brick were analysed for two types of curing which are air curing and water curing on 28, 60 and 90 days. Same goes to water absorption test and density test but only test at 28 days. From this study there are four tests will be discussed based on the objectives this study which are compressive strength test, flexural strength test, water absorption test and density test.

The best compressive strength is 10% of rice husk with constant 10% of palm oil clinker at 60 days. This is because more rice husk into the brick make the strength will dropped.

CHAPTER 5

CONCLUSION

5.1 Introduction

In this chapter, the conclusion will be concluded by a summary from the overall the projects. This conclusion covers all the process of projects from prepares the raw materials until data analysis to achieve the objectives. On the other hand, in this chapter will be discussed about the recommendations to improve the next project based on observation from this project.

5.2 Conclusion

In the conclusion, bricks are commonly used in the construction in the construction industry or highly demand in this era. So, this country grow rapidly to achieve the objective which means more grow the country, the bricks will more high demand. Overall, the objective of this study was achieved based on BS EN 771-3:2003[6] stated that, the strength of engineering brick shall be 7.5 N/mm^2 even though the compressive strength obtained still cannot reach the compressive strength of control brick, but palm oil clinker and rice husk has the potential to be used in the manufacture of bricks due to the compression strength showed a good result.

The outcome of these results is to compare the compressive strength, flexural strength, water absorption and density of sand brick are replaced with palm oil clinker with rice husk and control samples. From the average of compressive strength for air curing is increase from 9.58 N/mm^2 to 11.03 N/mm^2 for 10% ratio then decrease to 7.09 N/mm^2 at 28 days. At 60 days the result increase from 11.30 N/mm^2 to 11.59 N/mm^2 for 10% ratio then decrease to 8.27 N/mm^2. At 90 days the result decrease from 9.72 N/mm^2

to 6.25 N/mm^2. While using water curing method also increase from 8.55 N/mm^2 to 10.03 N/mm^2 for 10% ratio then decrease to 7.4 N/mm^2 at 28 days and same pattern like air curing for 60 days and 90 days. Then, the average for flexural strength by using air curing is increase from 0.23 N/mm^2 to 0.25 N/mm^2 for 10% ratio then decrease to 0.19 N/mm^2 at 28 days. At 60 days the result increase from 0.21 N/mm^2 to 0.25 N/mm^2 for 10% ratio then decrease to 0.19 N/mm^2. At 90 days the result increase from 0.18 N/mm^2 to 0.19 N/mm^2 for 10% ratio then decrease to 0.16 N/mm^2. While using water curing method also increase from 0.23 N/mm^2 to 0.25 N/mm^2 for 10% ratio then decrease to 18 N/mm^2 at 28 days and same pattern like air curing for 60 days and 90 days. Then, the sample 1 for water absorption by using air curing is increase from 11.7% until 13.12% at 28 days while by using water curing also increase from 12.39% until 13.35% at 28 days. Finally, the average for density by using air curing is increase from 1984 kg/m^3 to 2089 kg/m^3 for 10% ratio then decrease to 1834 kg/m^3 while by using water curing also increase from 2024 kg/m^3 to 2167 kg/m^3 for 10% ratio then decrease to 2075 kg/m3 at 28 days.

The best compressive strength is 10% of rice husk with 10% constant palm oil clinker for air curing which is 11.59 N/mm^2 at 60 days. Then, the best flexural strength is 10% of rice husk which is 0.254 N/mm^2 at 60 days. For water absorption for all samples is not exceeds 20% from its dry weight but for the best water absorption is 30% of rice husk which is 13.35%. Lastly the best value for density at 10% rice husk which is 2075 kg/m^3.

In addition, the devaluation of the compressive strength and flexural strength of the bricks sample may also due to an error of the laboratory equipment. On the other hand, brick mould has a loose problem at the side of the mould due to the continued use the same mould for the next bricks. This problem make the result not uniformed and evenly but still get best result.

Last but not least, the result still acceptable and can be used for the future in industry because the compressive strength and flexural strength result were higher than the control sample result.

5.3 Recommendations

Based on studies that have been conducted, there are some suggestions that have been identified can be taken as an enhancement for a future study. Below are some suggestions that can be used to reinforce data analysis, study and achieve the objectives;

i. From this study, the strength of the brick increase at the ratio 10% of rice husk with constant 10% of palm oil clinker then decrease when increase ratio of rice husk. The increasing of strength cause by existing of palm oil clinker. Therefore, detail further study is required to figure out the optimum ratio of constant palm oil clinker. Maybe can add with 15% and 20% of palm oil clinker.
ii. According to this study, the result shows that the strength of brick slightly decrease when add ratio 20% and 30% of rice husk. Therefore, for further study these ratio cannot be use anymore. To know the exact optimum ratio of rice husk, further study can use 5%, 7.5% and 12.5% ratio of rice husk. It will make more accurate optimum ratio of rice husk.
iii. In carrying out the study in the future, the curing day need to be change. Due to this study, the strength of brick decrease from 60 days to 90 days. So, curing for 90 days not valid to test the strength of brick. Further study can use 1 days, 7 days and 28 days to know the best day for curing to get the highest strength of brick.

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APPENDIX A

Compressive Strength test result at 28 Days Air Curing

RATIO CLINKER 10% RATIO
RICE HUSK: 10%

CHARACTERISTICS	AIR CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.701	3.829	3.888	3.93	4.08
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	263.5	299.7	298.4	249.3	291.7
COMPESSIVE STRENGTH (N/mm²)	10.36	11.79	11.74	9.81	11.47
AVERAGE (N/mm²)	11.034				

RATIO CLINKER 10% RATIO
RICE HUSK: 20%

CHARACTERISTICS	AIR CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.847	3.759	3.815	3.585	3.791
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	222.4	263.9	203	221.2	228
COMPESSIVE STRENGTH (N/mm²)	8.75	10.38	7.98	8.7	8.97
AVERAGE (N/mm²)	8.956				

RATIO CLINKER 10% RATIO
RICE HUSK: 30%

CHARACTERISTICS	AIR CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.706	3.481	3.53	3.518	3.791
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	175.5	186.6	167	189.8	183.4
COMPESSIVE STRENGTH (N/mm²)	6.86	7.34	6.57	7.47	7.21
AVERAGE (N/mm²)	7.09				

APPENDIX B

Compressive Strength test result at 28 Days Water Curing

RATIO CLINKER 10% RATIO
RICE HUSK: 10%

CHARACTERISTICS	WATER CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	4.008	4.139	4.115	4	4.077
AREA (mm²)	254252	25425	25425	25425	25425
MAXIMUM LOAD (N)	265.9	272.3	240.9	245.4	250.3
COMPESSIVE STRENGTH (N/mm²)	10.458	10.71	9.47	9.65	9.84
AVERAGE (N/mm²)	10.0256				

RATIO CLINKER 10% RATIO
RICE HUSK: 20%

CHARACTERISTICS	WATER CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.999	4.053	3.948	3.913	4.029
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	196.8	228.1	219.6	185.2	213.8
COMPESSIVE STRENGTH (N/mm²)	7.74	8.97	8.6	7.3	8.4
AVERAGE (N/mm²)	8.202				

RATIO CLINKER 10% RATIO
RICE HUSK: 30%

CHARACTERISTICS	WATER CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.775	3.977	3.93	3.874	3.836
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	200.9	174	187.1	185.7	195.8
COMPESSIVE STRENGTH (N/mm²)	7.9	6.9	7.4	7.3	7.7
AVERAGE (N/mm²)	7.44				

APPENDIX C

Compressive Strength test result at 60 Days Air Curing

RATIO CLINKER 10% RATIO
RICE HUSK: 10%

CHARACTERISTICS	AIR CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.904	3.855	3.786	3.998	3.838
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	288.5	321.5	298.8	282.9	281
COMPESSIVE STRENGTH (N/mm²)	11.35	12.65	11.75	11.13	11.05
AVERAGE (N/mm²)	11.586				

RATIO CLINKER 10% RATIO
RICE HUSK: 20%

CHARACTERISTICS	AIR CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.814	3.719	3.635	3.743	3.729
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	285.7	266.9	298.3	273.1	270.5
COMPESSIVE STRENGTH (N/mm²)	11.24	10.5	11.73	10.74	10.64
AVERAGE (N/mm²)	10.97				

RATIO CLINKER 10% RATIO
RICE HUSK: 30%

CHARACTERISTICS	AIR CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.643	3.396	3.377	3.558	3.617
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	207.2	195.3	182.3	231.5	234.8
COMPESSIVE STRENGTH (N/mm²)	8.15	7.67	7.17	9.11	9.24
AVERAGE (N/mm²)	8.268				

APPENDIX D

Compressive Strength test result at 60 Days Water Curing

RATIO CLINKER 10% RATIO
RICE HUSK: 10%

CHARACTERISTICS	WATER CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	4.353	4.249	4.205	4.292	4.074
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	268.4	249.8	253.9	253	273.2
COMPESSIVE STRENGTH (N/mm²)	10.56	9.82	9.99	9.95	10.75
AVERAGE (N/mm²)	10.214				

RATIO CLINKER 10% RATIO
RICE HUSK: 20%

CHARACTERISTICS	WATER CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	4.219	4.227	4.251	3.99	4.033
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	240.7	245.7	250.3	278.4	254
COMPESSIVE STRENGTH (N/mm²)	9.47	9.66	9.84	10.95	9.99
AVERAGE (N/mm²)	9.982				

RATIO CLINKER 10% RATIO
RICE HUSK: 30%

CHARACTERISTICS	WATER CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.836	3.757	3.979	4.055	4.016
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	192.8	186.2	170.7	196	208.5
COMPESSIVE STRENGTH (N/mm²)	7.58	7.32	6.71	7.7100	8.2
AVERAGE (N/mm²)	7.504				

APPENDIX E

Compressive Strength test result at 90 Days Air Curing

RATIO CLINKER 10% RATIO
RICE HUSK: 10%

CHARACTERISTICS	AIR CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.377	3.622	3.692	3.631	3.616
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	153.3	178.6	191.1	194.9	215.8
COMPESSIVE STRENGTH (N/mm²)	6.02	7.02	7.52	7.67	8.49
AVERAGE (N/mm²)	7.344				

RATIO CLINKER 10% RATIO
RICE HUSK: 20%

CHARACTERISTICS	AIR CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.894	3.777	3.91	3.895	3.642
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	151.1	194.4	175.7	216.1	193.4
COMPESSIVE STRENGTH (N/mm²)	6.26	7.65	6.91	8.5	7.61
AVERAGE (N/mm²)	7.386				

RATIO CLINKER 10% RATIO
RICE HUSK: 30%

CHARACTERISTICS	AIR CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.568	3.799	3.69	3.694	3.728
AREA (mm²)	254225	254225	254225	254225	254225
MAXIMUM LOAD (N)	148.4	178.4	143.8	157.3	166
COMPESSIVE STRENGTH (N/mm²)	5.84	7.02	5.66	6.19	6.53
AVERAGE (N/mm²)	6.248				

APPENDIX F

Compressive Strength test result at 90 Days Water Curing

RATIO CLINKER 10% RATIO
RICE HUSK: 10%

CHARACTERISTICS	WATER CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	4.095	4.117	4.254	4.133	4.202
AREA (mm^2)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	207	218.1	216.2	205.6	213.9
COMPESSIVE STRENGTH (N/mm^2)	8.14	8.58	8.5	8.09	8.41
AVERAGE (N/mm^2)	8.344				

RATIO CLINKER 10% RATIO
RICE HUSK: 20%

CHARACTERISTICS	WATER CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	4.108	4.278	4.521	3.943	4.206
AREA (mm^2)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	224.1	215.7	198.9	191.1	193
COMPESSIVE STRENGTH (N/mm^2)	8.81	8.48	7.82	7.52	7.59
AVERAGE (N/mm^2)	8.044				

RATIO CLINKER 10% RATIO
RICE HUSK: 30%

CHARACTERISTICS	WATER CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.118	3.457	3.229	3.271	3.238
AREA (mm^2)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	170	190	178.4	182.1	168.1
COMPESSIVE STRENGTH (N/mm^2)	6.69	7.47	7.02	7.16	6.61
AVERAGE (N/mm^2)	6.99				

APPENDIX G

Flexural Strength test result at 28 Days Air Curing

RATIO CLINKER: 10% RATIO RICE HUSK: 10%

CHARACTERISTICS	AIR CURING		
SAMPLES	1	2	3
WEIGHT (KG)	4.007	3.899	3.769
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	6.87	6.21	5.77
COMPESSIVE STRENGTH (N/mm²)	0.27	0.244	0.227
AVERAGE (N/mm²)	0.247		

RATIO CLINKER: 10% RATIO RICE HUSK: 20%

CHARACTERISTICS	AIR CURING		
SAMPLES	1	2	3
WEIGHT (KG)	3.69	3.636	3.517
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	5.64	4.86	4.84
COMPESSIVE STRENGTH (N/mm²)	0.222	0.191	0.19
AVERAGE (N/mm²)	0.201		

RATIO CLINKER: 10% RATIO RICE HUSK: 30%

CHARACTERISTICS	AIR CURING		
SAMPLES	1	2	3
WEIGHT (KG)	3.577	3.526	3.798
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	4.96	4.08	5.29
COMPESSIVE STRENGTH (N/mm²)	0.195	0.16	0.208
AVERAGE (N/mm²)	0.187666667		

APPENDIX H

Flexural Strength test result at 28 Days Water Curing

RATIO CLINKER: 10% RATIO RICE
HUSK: 10%

CHARACTERISTICS	WATER CURING		
SAMPLES	1	2	3
WEIGHT (KG)	4.22	4.321	4.08
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	6.22	5.79	6.66
COMPESSIVE STRENGTH (N/mm²)	0.245	0.228	0.262
AVERAGE (N/mm²)	0.245		

RATIO CLINKER: 10% RATIO RICE
HUSK: 20%

CHARACTERISTICS	WATER CURING		
SAMPLES	1	2	3
WEIGHT (KG)	4.104	4.104	3.948
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	5.8	5.7	5.02
COMPESSIVE STRENGTH (N/mm²)	0.228	0.224	0.197
AVERAGE (N/mm²)	0.216333333		

RATIO CLINKER: 10% RATIO RICE
HUSK: 30%

CHARACTERISTICS	WATER CURING		
SAMPLES	1	2	3
WEIGHT (KG)	3.74	3.894	3.909
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	4.31	4.55	5.07
COMPESSIVE STRENGTH (N/mm²)	0.17	0.179	0.199
AVERAGE (N/mm²)	0.182666667		

APPENDIX I

Flexural Strength test result at 60 Days Air Curing

RATIO CLINKER: 10% RATIO RICE HUSK: 10%

CHARACTERISTICS	AIR CURING		
SAMPLES	1	2	3
WEIGHT (KG)	3.905	3.843	4.042
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	7.04	6.15	6.21
COMPESSIVE STRENGTH (N/mm²)	0.277	0.242	0.244
AVERAGE (N/mm²)	0.254333333		

RATIO CLINKER: 10% RATIO RICE HUSK: 20%

CHARACTERISTICS	AIR CURING		
SAMPLES	1	2	3
WEIGHT (KG)	3.703	3.762	3.709
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	6.24	5.75	6.73
COMPESSIVE STRENGTH (N/mm²)	0.245	0.226	0.265
AVERAGE (N/mm²)	0.245333333		

RATIO CLINKER: 10% RATIO RICE HUSK: 30%

CHARACTERISTICS	AIR CURING		
SAMPLES	1	2	3
WEIGHT (KG)	3.488	3.599	3.539
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	5.17	4.91	6.6
COMPESSIVE STRENGTH (N/mm²)	0.203	0.193	0.181
AVERAGE (N/mm²)	0.192333333		

APPENDIX J

Flexural Strength test result at 60 Days Water Curing

RATIO CLINKER: 10% RATIO RICE HUSK: 10%

CHARACTERISTICS	WATER CURING		
SAMPLES	1	2	3
WEIGHT (KG)	4.22	4.321	4.08
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	6.22	5.79	6.66
COMPESSIVE STRENGTH (N/mm²)	0.245	0.228	0.262
AVERAGE (N/mm²)	0.245		

RATIO CLINKER: 10% RATIO RICE HUSK: 20%

CHARACTERISTICS	WATER CURING		
SAMPLES	1	2	3
WEIGHT (KG)	4.104	4.104	3.948
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	5.8	5.7	5.02
COMPESSIVE STRENGTH (N/mm²)	0.228	0.224	0.197
AVERAGE (N/mm²)	0.216333333		

RATIO CLINKER: 10% RATIO RICE HUSK: 30%

CHARACTERISTICS	WATER CURING		
SAMPLES	1	2	3
WEIGHT (KG)	3.74	3.894	3.909
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	4.31	4.55	5.07
COMPESSIVE STRENGTH (N/mm²)	0.17	0.179	0.199
AVERAGE (N/mm²)	0.182666667		

APPENDIX K

Flexural Strength test result at 90 Days Air Curing

RATIO CLINKER: 10% RATIO RICE HUSK: 10%

CHARACTERISTICS	AIR CURING		
SAMPLES	1	2	3
WEIGHT (KG)	3.905	3.843	4.042
AREA (mm^2)	25425	25425	25425
MAXIMUM LOAD (N)	7.04	6.15	6.21
COMPESSIVE STRENGTH (N/mm^2)	0.277	0.242	0.244
AVERAGE (N/mm^2)	0.254333333		

RATIO CLINKER: 10% RATIO RICE HUSK: 20%

CHARACTERISTICS	AIR CURING		
SAMPLES	1	2	3
WEIGHT (KG)	3.703	3.762	3.709
AREA (mm^2)	25425	25425	25425
MAXIMUM LOAD (N)	6.24	5.75	6.73
COMPESSIVE STRENGTH (N/mm^2)	0.245	0.226	0.265
AVERAGE (N/mm^2)	0.245333333		

RATIO CLINKER: 10% RATIO RICE HUSK: 30%

CHARACTERISTICS	AIR CURING		
SAMPLES	1	2	3
WEIGHT (KG)	3.488	3.599	3.539
AREA (mm^2)	25425	25425	25425
MAXIMUM LOAD (N)	5.17	4.91	6.6
COMPESSIVE STRENGTH (N/mm^2)	0.203	0.193	0.181
AVERAGE (N/mm^2)	0.192333333		

APPENDIX L

Flexural Strength test result at 90 Days Water Curing

RATIO CLINKER: 10% RATIO RICE HUSK: 10%

CHARACTERISTICS	WATER CURING		
SAMPLES	1	2	3
WEIGHT (KG)	4.232	4.04	4.348
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	5.64	5.6	5.97
COMPESSIVE STRENGTH (N/mm²)	0.222	0.22	0.235
AVERAGE (N/mm²)	0.225666667		

RATIO CLINKER: 10% RATIO RICE HUSK: 20%

CHARACTERISTICS	WATER CURING		
SAMPLES	1	2	3
WEIGHT (KG)	4.188	3.901	4.021
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	5.6	5.32	5.95
COMPESSIVE STRENGTH (N/mm²)	0.22	0.209	0.234
AVERAGE (N/mm²)	0.221		

RATIO CLINKER: 10% RATIO RICE HUSK: 30%

CHARACTERISTICS	WATER CURING		
SAMPLES	1	2	3
WEIGHT (KG)	3.596	3.987	3.806
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	4.18	4.71	6.04
COMPESSIVE STRENGTH (N/mm²)	0.164	0.185	0.238
AVERAGE (N/mm²)	0.195666667		

APPENDIX M

Water Absorption Test result

SAMPLE 1

RATIO, %	TYPE OF CURING	WEIGHT AFTER OVEN,Wd	WEIGHT AFTER IMMERSED, Wi	RATE OF WATER ABSORPTION,%
O	Water	3.8.13	4.259	11.7
	Air	3.688	4.145	12.39
10	Water	3.74	4.192	11.85
	Air	3.58	4.038	12.79
20	Water	3.512	3.943	12.27
	Air	3.435	3.881	12.98
30	Water	3.498	3.957	12.12
	Air	3.319	3.762	13.35

SAMPLE 2

RATIO, %	TYPE OF CURING	WEIGHT AFTER OVEN,Wd	WEIGHT AFTER IMMERSED, Wi	RATE OF WATER ABSORPTION,%
O	Water	3.905	4.184	7.14
	Air	3.834	4.146	8.14
10	Water	4.042	4.111	1.71
	Air	3.727	4.086	9.63
20	Water	3.812	4.006	5.09
	Air	3.501	3.957	13.02
30	Water	3.975	4.04	1.64
	Air	3.366	3.793	12.69

APPENDIX N

Water Absorption Test Result

SAMPLE 3

RATIO,%	TYPE OF CURING	WEIGHT AFTER OVEN,Wd	WEIGHT AFTER IMMERSED, Wi	RATE OF WATER ABSORPTION,%
O	Water	3.861	4.18	8.26
	Air	3.827	4.157	8.62
10	Water	3.975	4.096	3.04
	Air	4.079	4.203	3.04
20	Water	3.641	4.045	11.096
	Air	3.352	3.828	14.2
30	Water	3.874	3.874	2.51
	Air	3.461	3.85	11.24

APPENDIX O

Density Test Result

RATIO	TYPE OF CURING	WEIGHT AFTER OVEN, Wd			AVERAGE WEIGHT, KG	DENSITY, Kg/m²
		1	2	3		
0	WATER	3.815	3.905	3.861	3.860	2024
	AIR	3.688	3.834	3.827	3.783	1984
10	WATER	4.192	4.111	4.096	4.133	2167
	AIR	3.899	3.966	4.087	3.984	2089
20	WATER	3.943	4.006	4.045	3.998	2097
	AIR	3.696	3.785	3.565	3.682	1931
30	WATER	3.957	4.04	3.874	3.957	2075
	AIR	3.425	3.477	3.588	3.496	1834

APPENDIX P

Compressive Strength test result of control sample Water Curing

28 Days

CHARACTERISTICS	WATER CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.736	3.72	3.868	3.828	3.801
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	246.9	231.6	269.9	242.7	226.2
COMPESSIVE STRENGTH (N/mm²)	9.71091	9.10914	10.6155	9.54572	8.89676
AVERAGE (N/mm²)	9.575614553				

60 Days

CHARACTERISTICS	WATER CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	4.018	4.91	4.147	4.216	4.02
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	310.9	292.2	305.9	282.1	319.2
COMPESSIVE STRENGTH (N/mm²)	12.23	11.49	12.03	11.1	12.55
AVERAGE (N/mm²)	11.88				

90 Days

CHARACTERISTICS	WATER CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	4.364	4.214	3.784	4.156	3.9
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	303.3	273.8	215.4	286.4	266.3
COMPESSIVE STRENGTH (N/mm²)	11.93	10.77	8.74	11.26	10.47
AVERAGE (N/mm²)	10.634				

APPENDIX Q

Compressive Strength test result of control sample Air Curing

28 Days

CHARACTERISTICS	AIR CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.736	3.72	3.868	3.828	3.801
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	246.9	231.6	269.9	242.7	226.2
COMPESSIVE STRENGTH (N/mm²)	9.71	9.10`	10.62	9.55	8.90
AVERAGE (N/mm²)	9.58				

60 Days

CHARACTERISTICS	AIR CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.843	3.911	3.817	4.01	3.835
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	272.5	294.5	300.3	3015	268.3
COMPESSIVE STRENGTH (N/mm²)	10.72	11.58	11.81	11.86	10.55
AVERAGE (N/mm²)	11.304				

90 Days

CHARACTERISTICS	AIR CURING				
SAMPLES	1	2	3	4	5
WEIGHT (KG)	3.844	3.655	3.857	3.903	3917
AREA (mm²)	25425	25425	25425	25425	25425
MAXIMUM LOAD (N)	263.5	166	262.3	289.4	254
COMPESSIVE STRENGTH (N/mm²)	10.36	6.53	10.32	11.38	9.99
AVERAGE (N/mm²)	9.716				

APPENDIX R

Flexural Strength test result of control sample Water Curing

28 Days

CHARACTERISTICS	WATER CURING		
SAMPLES	1	2	3
WEIGHT (KG)	4.135	4.174	4.139
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	5.67	6.04	5.47
COMPESSIVE STRENGTH (N/mm²)	0.22	0.24	0.22
AVERAGE (N/mm²)	0.226666667		

60 Days

CHARACTERISTICS	WATER CURING		
SAMPLES	1	2	3
WEIGHT (KG)	4.164	4.18	4.147
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	6.67	6.96	7.23
COMPESSIVE STRENGTH (N/mm²)	0.26	0.27	0.28
AVERAGE (N/mm²)	0.27		

90 Days

CHARACTERISTICS	WATER CURING		
SAMPLES	1	2	3
WEIGHT (KG)	3.787	4.255	3.912
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	4.71	6.17	4.83
COMPESSIVE STRENGTH (N/mm²)	0.19	0.24	0.19
AVERAGE (N/mm²)	0.206666667		

APPENDIX S

Flexural Strength test result of control sample Air Curing

28 Days

CHARACTERISTICS	AIR CURING		
SAMPLES	1	2	3
WEIGHT (KG)	3.827	3.873	4.056
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	5.94	5.48	5.99
COMPESSIVE STRENGTH (N/mm²)	0.23	0.22	0.24
AVERAGE (N/mm²)	0.23		

60 Days

CHARACTERISTICS	AIR CURING		
SAMPLES	1	2	3
WEIGHT (KG)	5.903	3.809	3.892
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	5.31	5.34	5.48
COMPESSIVE STRENGTH (N/mm²)	0.22	0.21	0.22
AVERAGE (N/mm²)	0.216666667		

90 Days

CHARACTERISTICS	AIR CURING		
SAMPLES	1	2	3
WEIGHT (KG)	3.796	3.763	3.425
AREA (mm²)	25425	25425	25425
MAXIMUM LOAD (N)	4.45	5.02	3.82
COMPESSIVE STRENGTH (N/mm²)	0.18	0.2	0.15
AVERAGE (N/mm²)	0.176666667		