EXPERIMENTAL STUDY FOR SAND BRICKS WITH CLINKER AS PARTIAL REPLACEMENT FOR FINE AGGREGATE WITH RATIO OF 15% WITH RICE HUSK OF 10% , 20 % AND 30%

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ABSTRAK

Kajian ini bertujuan untuk mengkaji batu bata pasir dengan klinker sebagai pengganti separa agregat halus dengan nisbah 15% dengan sekam padi sebanyak 10%, 20% dan 30%. RH adalah bahan buangan yang dihasilkan selepas menuai padi dan dibuang sementara POC adalah produk sampingan dari peringkat pemprosesan barangan kelapa sawit. Dengan berkaitan dengan kajian ini, POC dan RH mentah mempunyai tekstur dan fizikal yang sama seperti pasir biasa. Bidang kajian merangkumi parameter penting dalam menentukan kekuatan mampatan, keupayaan penyerapan air lenturan dan ketumpatan. Sejumlah 216 batu bata pasir dengan dimensi panjang 225mm, 113 lebar dan kedalaman 75mm disediakan dan dibahagikan kepada empat kumpulan mengikut jenis ujian yang berlainan. Ujian mampatan menggunakan 120 batu bata dan ujian lenturan menggunakan 72 bata manakala ujian penyerapan air dan ujian kepadatan sama dengan 24 bata. Semua sampel batu pasir di setiap ujian mempunyai empat penggantian RH yang berbeza. Terdapat 10%, 20%, 30% dan campuran kawalan. Semua sampel dibahagikan sama rata dan dirawat dengan pengawetan udara dan air selama 28, 60 dan 90 hari sebelum ujian. Sampel pada 60 hari pengawetan dengan RH 10% menunjukkan campuran terbaik untuk kedua-dua jenis pengawetan. Keputusan akhir menunjukkan bahawa semua sampel dicapai kekuatan mampatan dan lenturan minimum. Kajian akhirnya menunjukkan bahawa bata pasir simen dengan klinker dan RH sebagai pengganti separa untuk agregat halus mendapat hasil yang lebih baik.

ABSTRACT

This research has aims to study for sand bricks with clinker as partial replacement for fine aggregate with ratio of 15% with rice husk of 10%, 20% and 30%. RH is a waste material that produce after harvesting the paddy and being disposed while POC is a by-product from the processing stages of palm oil goods. By relating to this study, the POC and raw RH have the same texture and physical as normal sand. The field of studies covers crucial parameters in determining the compressive strength, flexural strength water absorption ability and density. A total 216 sand bricks with dimension of 225mm length, 113 width and 75mm depth were prepared and been divided into four groups according to different type of testing. The compression test used 120 bricks and flexural test used 72 bricks while water absorption test and density test are same with 24 bricks. All the sand bricks samples in each of the test had four different replacement of RH percentages. There were 10%, 20%, 30% and the control mixture. All sample are divided equally and cured in air and water curing for 28, 60 and 90 days before testing. The samples at 60 days of curing with RH 10% are shows the best mixture for both type of curing. The final result indicate that all sample are achieved the minimum compressive and flexural strength. The study finally demonstrated that cement sand brick with clinker and RH as partial replacement for fine aggregate get better result.

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W	Water absorption
Wi	Weight after water absorption
Wd	Weight before water absorption

LIST OF ABBREVIATIONS

RH	Rice Husk
POC	Palm Oil Clinker
MS	Malaysia Standard
OPC	Ordinary Portland Cement
BS	British Standard
JKR	Jabatan Kerja Raya
CTMS	Center for Technology Management and Services

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The world of construction industry are rapidly growth nowadays as its always aiming to becomes better cheaper and greener along the goals to archive environmental friendly to the world. The increase of construction industry are always depends on demands for people in a population to fulfil their needs. As many construction are develop, the more building materials are required and this causes the building materials become shortage, thus intervention into looking the material alternative are needed. Malaysia is overburden with waste materials and mostly dump these materials to landfill and required more spaces or area. Therefore the only way to overcome the problems is by recycling these materials into renewable building materials. Waste materials such as rice husk (RH) can be used as a replacement of sands in concrete. RH have a properties such as its low bulk density, toughness, abrasive in nature, resistance to weathering to name a few, therefore it can be used as an in filled material that do not really need to have the strength of an engineering bricks which the strength 7.5 N/mm² 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 produced 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 based products also generates an almost similar quantity of by-products, which have to be handled 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

Paddy residue consists of paddy straw and rice husk. Both of these residues are still not fully utilized in Malaysia. Malaysia is distinctive of the prominent producers of paddy. It has gained 0.48 Million tonne of rice husk (UNDP, 2002) with 3, 176, 593.2 tonnes production of rice straw in a year (Malaysia Economics Statistics, 2011) due to the emerging technological development in agro-industry. Malaysia's agriculture department is targeting to expand the output of the paddy sector as of the recent harvest from 3 to 5 tonnes per hectare to about 8 tonnes per hectare in 2012 and 9 to 10 tonnes per hectare in 2020 (NCER, 2007). If the target is achieved with 10 tonnes per hectare, the output of paddy will be increased to 6, 575, 474.8 tonnes per year. According to national news agency (BERNAMA, 2013), 200,000 ha idle land in Malaysia will be used for paddy plantation. This will increase to about 30% of paddy production.

In Malaysia, most common brick in construction industry is cement sand brick due to its price are cheaper. Unluckily, the cement sand bricks are lower values of compressive strength, fire resistance and chemical-attack resistance but higher value of water absorption and initial rate of section compared to fire-clay brick. The conventional fire-clay brick still has a lot of room for development. 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 palm oil clinker 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 Research

In this study 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 15% 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 7 days and 28 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

Brick is one of the widely used construction materials in Malaysia. Bricks also one of the oldest building materials and durable material since there are brick walls, foundations, pillars and road surfaces constructed many years ago and still intact. In the past, rudimentary brick making techniques used available natural materials such as clay and sand. With industrial revolution, economic growth and overall increase in population, tremendous demand is exerted on natural resources for creating new infrastructure. The increasing demand for the construction materials especially bricks are exploiting natural resource to the large extent. Nowadays, the main challenges facing the building sector are focused on the improvement of its energy efficiency and the reduction of its environmental impact. In this context, eco-friendly materials using renewable and local resources are in full development. Over the last years, a significant increase of various research activities about eco-materials using vegetable resources has been reported. Example raw rice husk and clinker.

This study area was conducted involving the use of agricultural waste such as rice husk and palm oil clinker as to replace fine aggregate in making a sand brick. This study will involve experimenting the bricks capability which is in density, compressive strength, flexural strength and water absorption rate. In this chapter, classification of the bricks will be explain clearly and also the percentage of material for sand brick such as palm oil clinker and rice husk and the test to be conducted will be describe clearly. Besides that, the raw material characteristics and its properties will be describe in this chapter. Therefor this study will lead to discussion of the process, problems and the potential of rice husk in a brick manufacturing.

2.2 General

2.2.1 Sand Brick

Bricks is defined as one of the important building material used in making walls, pavements and masonry construction. In the form of rectangle and made of inorganic material, bricks are hard and tough material in among materials in construction. Bricks are produced in many classes, type, materials and sizes which is vary with region and time period and are produce in bulk quantities. In Malaysia standard, 1982, it serves as a well unit with a size not exceeding 337.5mm long, 225 mm wide and 112.5 mm in height.

Figure 2.1 Sand Bricks

The bricks are both based on study of Tan Boon Tong (2000) are as follows:

i. Have a fixed shape
ii. Have a uniform size and texture
iii. Rectangular and smooth surface
iv. Have an average weight of 2.3kg a up to a brick 3.3kg
v. Absorption rate does not exceed 15% of its own weight

The size of sand bricks are following the JKR Standard is shown at the table 2.1

Table 2.1 Size of sand brick followed JKR standard

Length (mm)	**Width (mm)**	**Depth (mm)**
225 ± 3.2	11.3 ± 1.6	75 ± 1.6

2.2.2 Palm Oil Clinker

Malaysia, being one of the largest producer and manufacturer of palm oil products. Palm oil planted area in 2017 reached 5.81 million hectares, an increase of 1.3% as against 5.74 million hectares the previous year. Sarawak overtook Sabah as the largest oil palm planted state, with 1.56 million hectares or 26.8% of the total Malaysian oil palm planted area, followed by Sabah with 1.55 million hectares or 26.6% and Peninsular Malaysia with 2.70 million hectares or 46.6%, generates large amount of palm oil by-products, which can be recycled into Palm Oil Clinker (POC).In Malaysia, POC can be found in abundance and have little or no commercial value. As a result, it is one of the main contributors to the pollution problem of the nation. However, various studies have shown that this agro waste can serve as potential construction materials. POC is generally porous, irregularly shaped with good lightweight characteristics and is obtained in large chunks (Fig. 2.2.a) during incineration process of oil palm shell and the fibre. It serves as an ideal alternative aggregate when crushed and sieved into suitable sizes as seen in Fig. 2.2.b

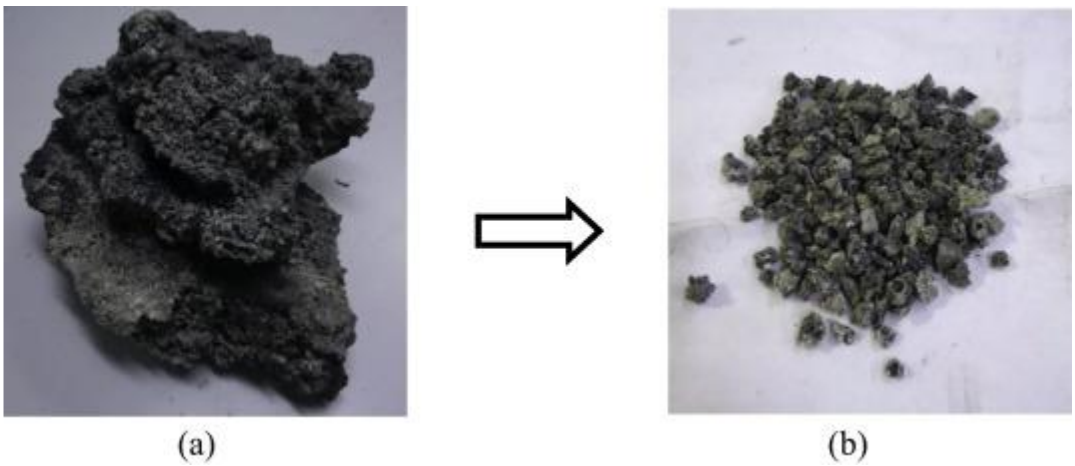

Figure 2.2 Crushed Palm Oil Clinker

2.2.3 Rice Husk

Rice husk (or rice hulls) are the hard protecting coverings of grains of rice. In addition to protecting rice during the growing season, rice husk can be put to use as building material, fertilizer, insulation material, or fuel or gasoline. Malaysia is one of the leading producers of paddy. It has gained 0.48 Million tonnes of rice husk with 3,176,593.2 tonnes production of rice straw in a year due to the emerging technological development in Agra-industry. Malaysia’s agriculture department is targeting to improve the productivity of the paddy sector from the current yield from 3 to 5 tonnes per hectare to around 8 tonnes per hectare in 2012 and 9 to 10 tonnes per hectare by 2020. If the target is achieved with 10 tonnes per hectare, the output of paddy will be increased to 6,575,474.8 tonnes per year. According to national news agency 200,000 ha idle land in Malaysia will be used for paddy plantation. This will increase to about 30% of paddy production. Parallel, to these the production of paddy residue also increases. Malaysia will face the problem regarding the paddy residue or waste management in the future.

Figure 2.3 Rice Husk

2.3 Type of Brick

2.3.1 Common Brick

Common bricks normally do not have a high aesthetic value compared to the other bricks. Commonly it can be seen where bricks has no specific packaging over it surface. Common brick also used in the construction process where it used to carried out plastering the brick above. It a common that this brick are used to make a wall partition or for the other uses such as a surface is not so important.

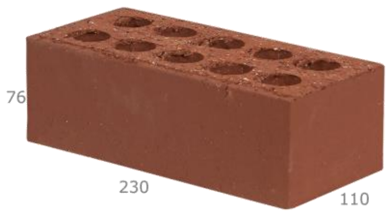

Figure 2.4 Common Brick

2.3.2 Facing Brick

Facing brick has a high quality and the price is more expensive than ordinary bricks. There is bottled in either a texture surface, smooth or sandy. While the colour is uniform and can be colourful. Bricks work on the wall create interesting effects are tied due to the smooth surface. Brick is also not required rendering on plaster on it.

Figure 2.5 Facing Bricks

2.3.3 Engineering Brick

Engineering brick is a solid brick and used for construction must support the weight of large load and does not absorb water. It is also used to work-work underground, which bear high loads and are exposed to different weather and temperature.

Between the building using bricks construction engineering are:

- Retaining wall
- Wall or wall that bear the brunt
- Sewerage bricks
- Forms of other walls that may be exposed to the action of acids and corrosion

2.3.4 Clay Brick

Clay bricks are produced depends on the needs and demand for building materials at construction sites. The selection is depends on the use of bricks in the construction and the selection was made based on feature-produced bricks. Classification of clay bricks can be specify into 3 group which is common brick, facing bricks and engineering bricks.

Figure 2.6 Clay Brick

2.4 Material

2.4.1 Cement

Two kinds of an ordinary Portland cement were employed, i.e., PC30 and PC40, which conform to Vietnamese standard TCVN 2682:1999. The cements originated from one clinker source but were pulverized to different degree of fineness. The physical properties of the cements are listed in Table 2.2.

Table 2.2 Properties of the cements

No	Properties	Test results		Standard TCVN 2682:1999	
		PC30	PC40	PC30	PC40
1	Normal consistency (%)	26	29	–	–
2	Setting time (minute)				
	(a) initial	95	85	⩾ 45	⩾ 45
	(b) final	190	175	⩽ 375	⩽ 375
3	Volumetric density (g/cm^3)	3.14	3.15	–	–
4	Residue on 75 µm sieve (%)	10	4	<15	<12
5	Blaine specific surface area (cm^2/g)	2700	3750	–	–
6	Compressive strength (MPa)[a]				
	(a) 3 days	16.2	22.6	>16	>21
	(b) 7 days	27.1	35.6	–	–
	(c) 28 days	38.5	47.7	>30	>40

2.4.2 Water

In this study, the water source used in making the bricks are tap water and the water need to be clean water. The percentage of the volume water mixed is based on the weight of sand used. In brick construction we use the 1:6 cement sand ratio -that means 1 cement bag should be mixed with 6 bags of sands and the water cement ratio is normally taken as the half of cement (Safeer Ali Khan, 2016). Selection of volume quantities of water to be used is important because water will cause a failure in which the mixture will become flaccid and less use of lead bricks from becoming too dry. (Zakaria, 1986)

2.4.3 Sand

Sand is a main element in making the sand brick to give the brick to have a good strength. In this test, sand will be collected in Kuantan, Pahang. Sand should be clean from excess elements such as clay, silts, and matter chemicals salt and coated grains.

2.4.4 Rice Husk

Rice is a major food crop in many regions of the world. Global rice production in 2007 was approximately 638 million tonnes and Malaysia's contribution was 2.2 million tonnes. Due to global demand, rice production is expected to grow from year to year. Rice husk (RH) is the outer covering of the rice grain and is obtained during the milling process. RH constitutes 20% of the total rice produced. As a renewable material, the use of RH can eliminate waste disposal and support environmental protection.

The reasons behind the use of RH in the construction industry are its high availability, low bulk density (90-150kg/m3), toughness, abrasive in nature, resistance to weathering and unique composition. The main components in RH are silica, cellulose and lignin. The composition of RH as a percentage of weight is shown in Table 1. RH contains high concentration of silica in amorphous and crystalline (quartz) forms.

The presence of amorphous silica determines the pozzolanic effect of RH. Pozzolanic effect exhibits cementitious properties that increase the rate at which the material gains strength. The extent of the strength development depends upon the chemical composition of alumina and silica in the material. The external surface of the husk contains high concentration of amorphous silica which decreases inwards and is practically non-existent within the husk. The elemental composition of the surface and interior of the husk is summarized in Table 2.3.

Table 2.3 Main Composition of RH

Composite	Wt%
SiO_2	18.80 – 22.30
Lignin	9 – 20
Cellulose	28 – 38
Protein	1.90 – 3.0
Fat	0.30 – 0.80
Other nutrients	9.30 – 9.50

Table 2.4 Elemental Composition at Different Regions in A RH

Elemental Composition	External Husk Surface Wt %	Husk Interior Wt %	Internal Husk Surface Wt %
C	6.91	62.54	30.20
O	47.93	35.19	42.53
Si	45.16	2.27	27.27

2.4.5 Palm Oil Clinker

The raw POC (Figure 2.7) which is a by-product through incineration of OPS in the palm oil industry for generating heat, was crushed and sieved through 5 mm sieve. The particles between 5 mm to 300 µm of crushed POC were used as fine aggregate. Figure 2.8 shows the surface texture of POC < 4 mm. The end product of quarry dust as known as M-sand were dried and sieved before using as fine aggregate as shown in figure 2.9. Figure 2.8 and figure 2.10 represent the particle shape of POC sand and M-sand. It was noticed that POC sand had sharp angular edge and M-sand had rounded shape due to its centrifugal processing through VSI crusher. POC sand particles contained a lot of porous space with grayish texture. The specific gravity of POC sand is lower than M-sand and this attributes in the development of lighter concrete. The water absorption rate of POC sand is 1.76 times higher than M-sand.

Figure 2.7   POC < 4mm

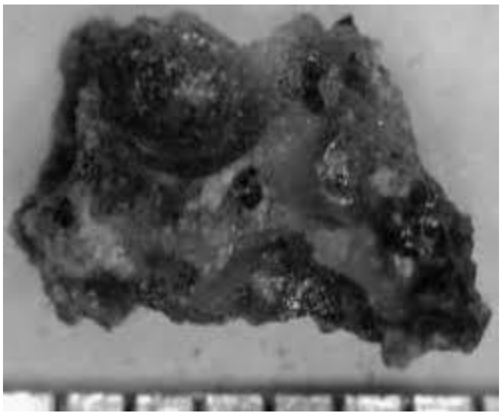

Figure 2.8   Surface texture of POC < 4mm

Figure 2.9   POC.M-sand

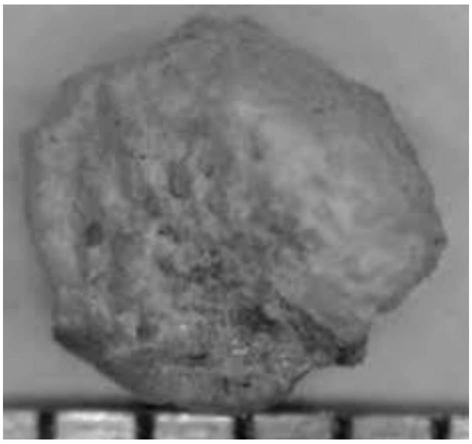

Figure 2.10 Surface texture of M-sand

CHAPTER 3

METHODOLOGY

3.1 Introduction

The issue on environment preservation and sustainability has leads to a new finding on new material that has been generates by product from industrial sector. Many waste materials have been used as the replacement in construction material such as in production of cement san brick. As the world seek for alternative materials in production of brick this study will identify the properties of sand brick with 15% of clinker as replacement of fine aggregate with rice husk of 10%, 20% and 30% in terms of compressive strength, water absorption, density and flexural strength. In this chapter will explain the parameter and testing conducted to as a lead to archive the objective of this research and simultaneously clarify the mixing ratio including clinker and rice husk.

In this chapter also will ensure the objective of this study are conducted properly according to the standard procedure of testing. Testing and the method that used in this study are very important and affecting to the data obtained and the data will be evaluated to the performance of the alternate material studies and received a percentage of the corresponding replacement material to produce a maximum strength of bricks. Therefore, the comparison are made between control sample and the sand bricks with 15% of clinker and various percentage of rice husk 10%, 20% and 30%.

3.2 Research Design

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

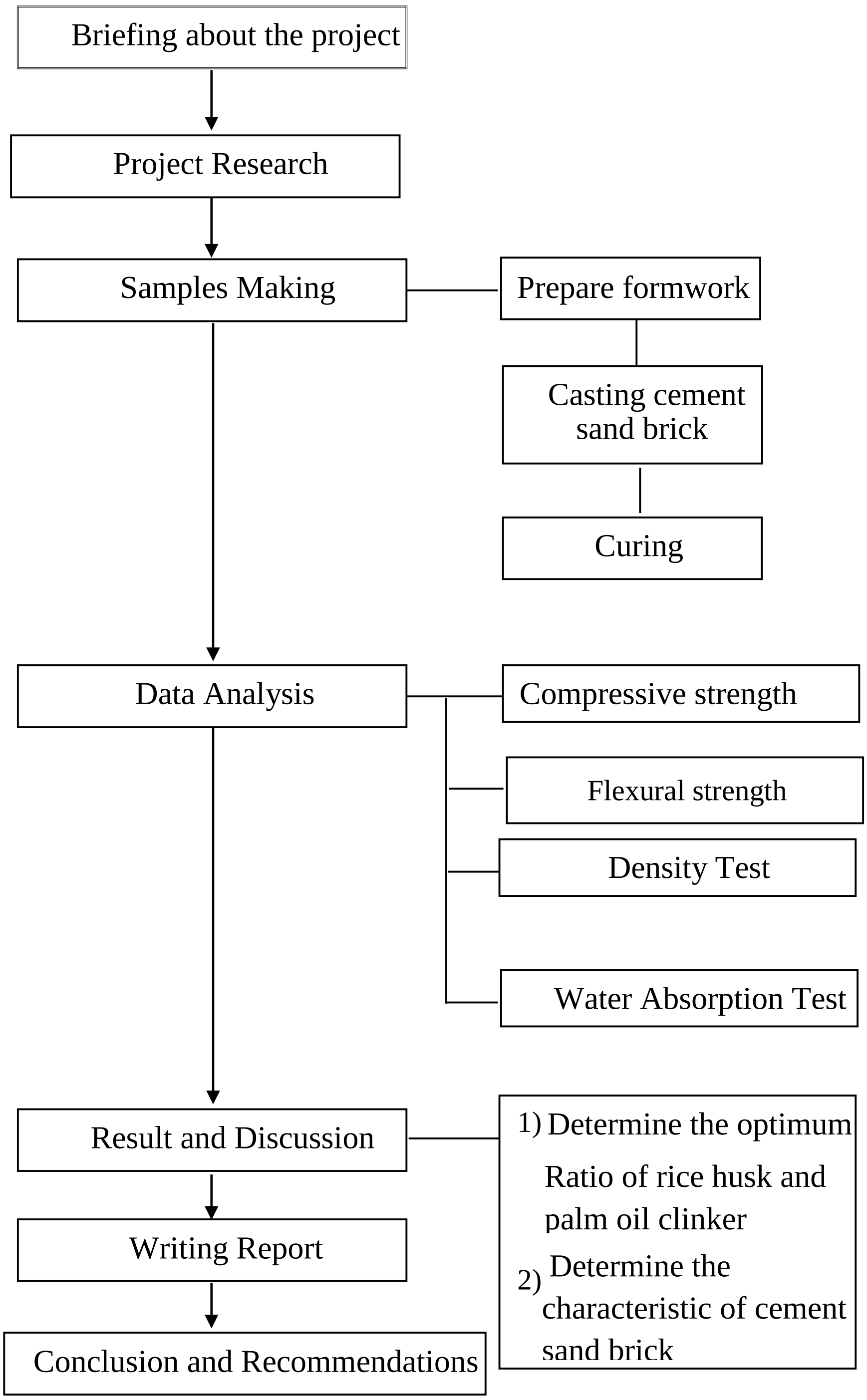

Figure 3.1 The Study Flow Chart

3.3 Preparation of Materials

Preparation of material is very crucial in making cement sand bricks as in order to perform a good strength of a brick will always depend on the type of materials used in brick making and perform with right ratio in mixing as the bricks will be compared to the control sand brick. The most important materials is sand, cement and water.

3.3.1 Sand

Sand in construction of sand brick is very important. Sand characteristics affect the flow and body mortar needs in its plastic state. As the paste hardens, sand particles become cemented together and contribute to the structural properties of hardened mortar. Sand reduces shrinkage that occurs in setting and drying; thus it helps minimize cracks. Well-graded sand features a well-distributed mix of particles of varying sizes, which minimizes voids. Sand that is too fine has more surface area to coat. Coarser sand particles result in larger voids to fill. As a result, mortar made with sand that is too fine or too coarse contains more water per unit volume, which decreases the mortar's strength. Excessively fine sand also makes mortar less workable

3.3.2 Water

A clean water and free of impurities were used because water contains impurities such as organic and sulphate could affect the 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 not to weaken the bonding structure in the brick.

3.3.3 Cement

Cement were used in this test is Portland Composite Cement. This cement was prepared by the technician staff at the concrete laboratory. Total volume for one brick is 0.00191 m^3. So, the ratio of brick is 1:3 that’s mean, one part is cement and 3 part is sand. In this test, total brick was produced is 100 brick. This calculation total volume of cement was used:

Ratio for sand brick is 1:3

Cement: 1= 0.000637 m^3

Sand: 3 m^3

Total cement and sand was used:

Cement: 0.000637 x 1000 x 100 = 63.7 kg

Sand: 0.00127 x 1000 x 100 = 127 kg

3.3.4 Palm Oil Clinker

Palm oil clinker had been used as one of the admixture in this test for produce cement 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 cleaned to remove the dirt of the particles to make sure the organic content in the POC had remove because if not it will make fungus live at the brick. Then POC is crushed into smaller size and clinker is sieved is taken.

Figure 3.2 Collection of Palm Oil Clinker in Progress

3.3.5 Rice Husk

Figure 3.3 Collection of Palm Oil Clinker in Progress

Figure 3.4 Process Crushing Palm Oil Clinker

Figure 3.5 Process Clinker Is Sieve

3.3.5 Rice Husk

Rice husk is use to this test with three different percentage to three different sample. Which is 10%, 20% and 30% ratio of rice husk

Figure 3.6 Process Sieve Rice Husk from Other Materials

3.4 Brick Design

3.4.1 Size of Cement Sand Brick

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

Table 3.1 Standard Specification for Building Work 2005

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

3.4.2 Size of Formwork

In order to produce 100 samples of cement sand brick with 15% of clinker and three different ratio of rice husk, the following size of formwork has been proposed. Formworks are made from plywood with 12 mm thickness and complying with MS 228.

Figure 3.7 Formwork and Moulded Cement Sand Brick In the Formwork

3.5 Specimen Preparation

The sample preparation was conducted in the FKASA concrete laboratory in University Malaysia Pahang. Palm oil clinker was cleaned and crushed and placed and stored in a dry place. The ratio of POC is 15% was prepared to mixture the portions of cement and sand with different ratio of rice husk 10%, 20% and 30%. Each mixture proportion contains 48 brick of sample for testing 60, 90, 180 days and 75 brick sample for testing 28 days. Sample with 0% of POC and rice husk were used as the control sample. The design of the mixture was measured to be mixed to produce a mixture of brick. Table 3.1 below shows the mix design for each ingredient in the production of cement sand brick.

Table 3.2 Ratio of Mix Design Cement Sand Brick

mixture	**Ratio Mixture**		
	Sand (%)	Clinker (%)	Rice Husk (%)
0	100	0	0
1	75	15	10
2	65	15	20
3	55	15	30

3.6 Method of Testing

3.6.1 Curing Process

Curing is an important process of maintaining satisfactory moisture content and temperature in brick 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 of 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. This test was conducted at the CTMS concrete laboratory.

Table 3.3 Ratio of Palm Oil Clinker and Rice Husk in the Brick and Type of Test.

Days	Curing	Type Of Test			
		Compressive Strength	Flexural Strength	Density	Water Absorption Rate
28	Water	15	9	3	9
	Air	15	9	3	9
60	Water	15	9		
	Air	15	9		
90	Water	15	9		
	Air	15	9		

Figure 3.8 Process Placing the Sample for Air Curing

3.6.2 Compressive Strength Test

Compression strength is an important ingredient in assessing the ability of a brick structure. According to the technical notes of the Brick Industry Association, the U.S. generally, the increase in compressive strength of brick units will lead to increased compressive strength and elastic modulus of a brick bonding structure. The compressive strength are carried out the load carrying capacity of bricks under compression with help of compression testing machine.

In addition, compressive strength of bricks is very variable and can vary from 30 kg/cm^2 to 150 kg/cm^2. The minimum compressive strength of bricks are common building is 35 kg/cm^2 second class bricks is 70 kg/cm^2 and first class bricks is 105 kg/cm^2 and compressive strength of bricks not less than 140 kg/cm^2 are graded as AA class.

There are procedure of compressive strength that was conducted at the concrete lab:

i. Take a sample of brick and measure its dimension.
ii. After the dimension of bricks, calculate cross-sectional area of bricks.
iii. Then, place the sample of bricks between the jaws of compressive testing machine.
iv. The load will be applied gradually on the bricks until the brick cracks.
v. When cracks are observed on bricks stop the machine and measure applied load and jot down it.
vi. Repeat the procedure for different samples of bricks.

Figure 3.9 Process Compressive Strength Testing

Figure 3.10 Process pacing the sample in the compressive machine

3.6.3 Water Absorption

Objective of this test is to determine the water absorption capacity of bricks. The test was conducted at CTMS concrete laboratory. The water absorption of bricks is not related to the porosity owing to the nature of pores themselves. Some of pores may be through pores which permit air to escape in absorption test and allow free passage of water in absorption test, but other are completely seated and inaccessible to water under ordinary conditions.

There are procedure of water absorption test:

i. Take 2 sample of bricks for each ratio.
ii. Dry the specimen in 28 days.
iii. Remove the bricks from the air curing and water curing method.
iv. Remove the specimen and wipe out any trace of water with a absorbed cloth and weight the specimen within three minutes after remove the brick from water.
v. Take the weight of brick in wet condition

3.6.4 Flexural Test

The flexural strength testing are done to measure the tensile strength of a cement sand bricks. It test the brick to withstand failure in banding. The flexural test on this studies are conducted using centre point load test. The configuration of testing is shown in figure 3.11

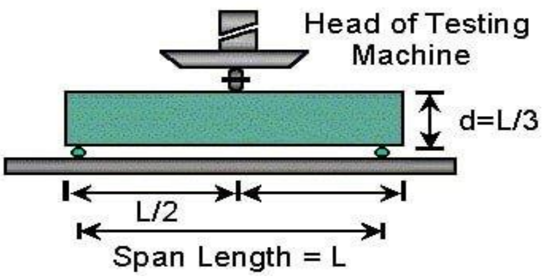

Table 3.11 Machine Flexural Strength

Figure 3.12 Machine Flexural Strength

3.6.5 Density

The density of the different mixture of brick with rice husk ratio and fixed clinker ratio are compared to the control sample. This is aim to identify the in situ density of natural or compacted soils using sand pouring cylinder.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter we 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 three ratios there 10%, 20% and 30%. In addition, this process by using two curing method which are air curing and water curing for 28 days, 60 days and 90 days. In this chapter the result will be shown for compressive strength, flexural strength, density and water absorption test and compression between different ratios with control sample. The result of the compressive strength, flexural strength and water absorption test for 28 days, 60days and 90 days samples were taken for an average brick and were compared with the control brick sample. From the test results obtained, the data were described in the table and graph using Microsoft excel to support and display the data more clearly.

4.2 Sand Brick Tests

There are four test were conducted on the sand brick which are compressive strength, flexural strength test, density and water absorption test. These test are conducted by following PWD standard according to MS JKR 2005 and the these test is carried out for 28 days, 60 days, and 90 days. As to archive the objective of this studies, testing are required to be done.

4.2.1 Compressive Strength Test

Compressive strength test were conducted using Compression Machine at concrete laboratory has been designed to get the compressive strength of the brick. Through this test, the sample brick for 10 units including air curing and water curing of each percentage ratio was tested after the bricks reached the maturity at 28 days, 60 days and 90 days. The value of its strength. Figure 4.1 shows the compressive strength of control sample against 28, 60 and 90 days.

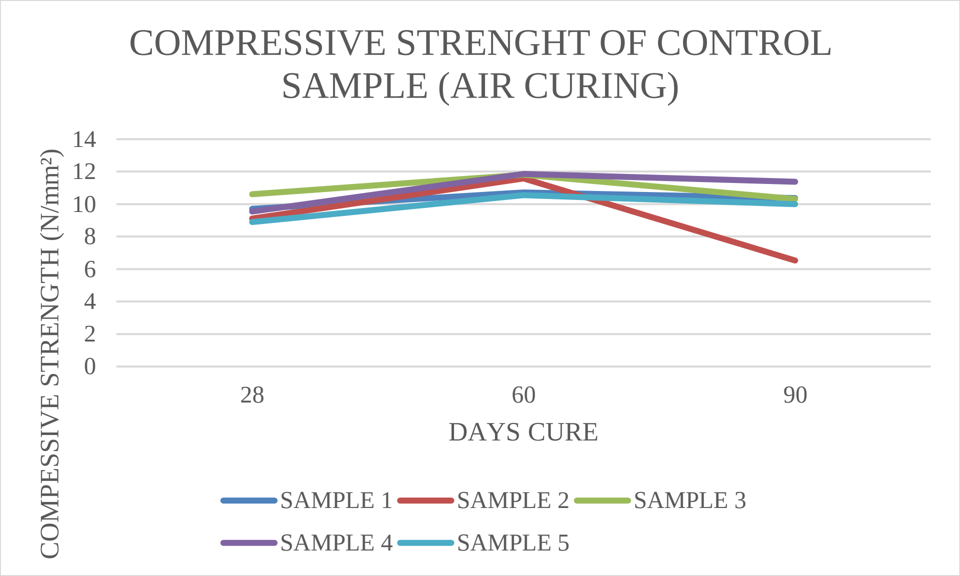

Figure 4.1 Control Sample for Air Curing

In figure 4.1 shows the graph control sample for air curing against days. At 28 days, the result shows to have an increasing in compressive strength as reaching the 60 days curing with the highest strength at 11.86 N/mm^2. As the sample continue to cure until day 90 the compressive strength in air curing are shows dropping up to the 9.99 N/mm^2.

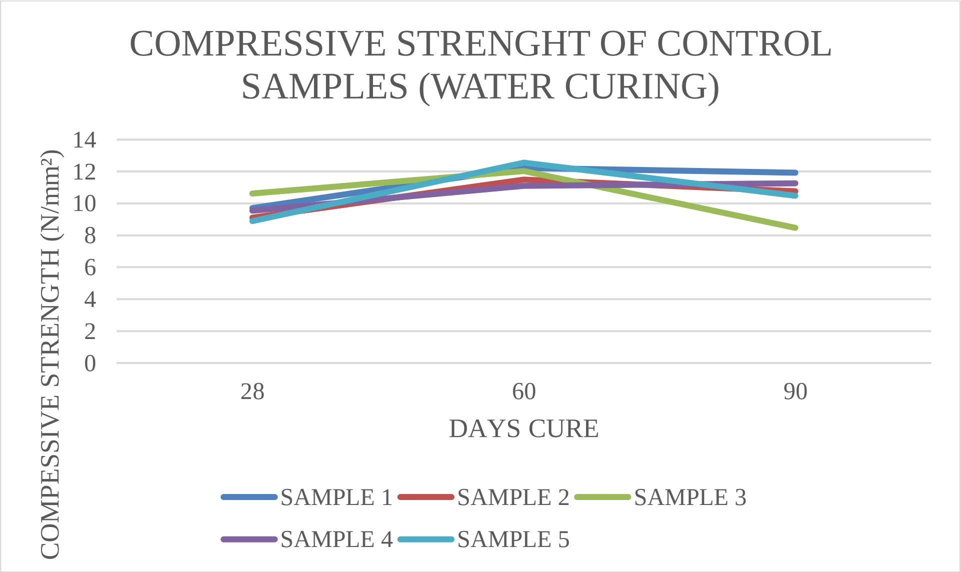

Figure 4.2 Control Sample for Water Curing

The graph above shows the compressive strength of control samples in water curing. From the experiment, the control sample also share almost the same data result where the graph shows at 28 days curing, the strength are increasing as the sample are continue to cure up to day 60 where it shows the highest at 12.55 N/mm² and slightly drop their strength as at 90 days with the lowest 8.47 N/mm².

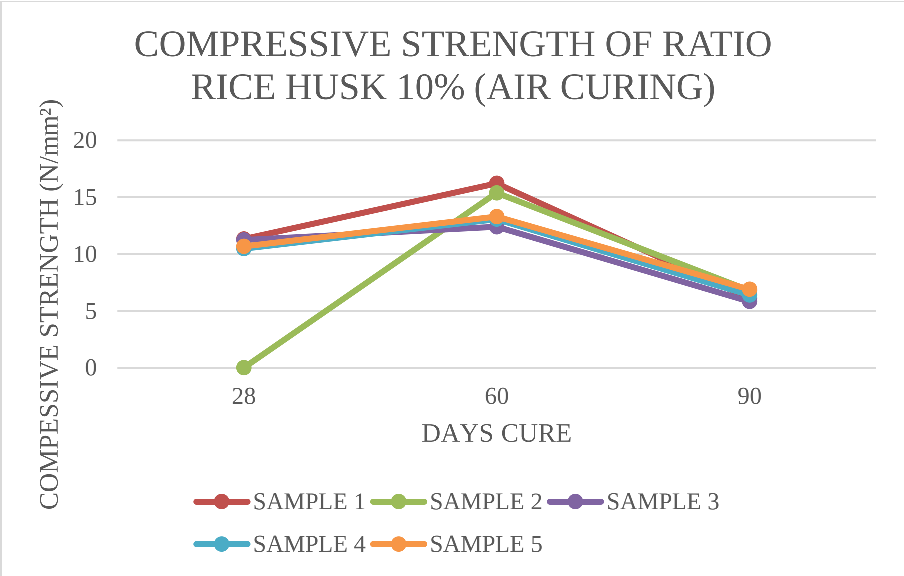

Figure 4.3 Compressive Strength Of 10% RH (Air Curing)

In figure 4.3 shown the line graph of 10% of rice husk for air curing about the changes in compressive strength against days. At day 28 the highest result for this graph is sample 2 with 11.93 N/mm². Compare to other sample of brick. While at 60 days, the highest of the strength are sample 1 and shows the line graph is increasing and reach its maximum compression at 16.21 N/mm² and drop significantly as the sample at 90 days with the lowest strength at 5.82 N/mm².

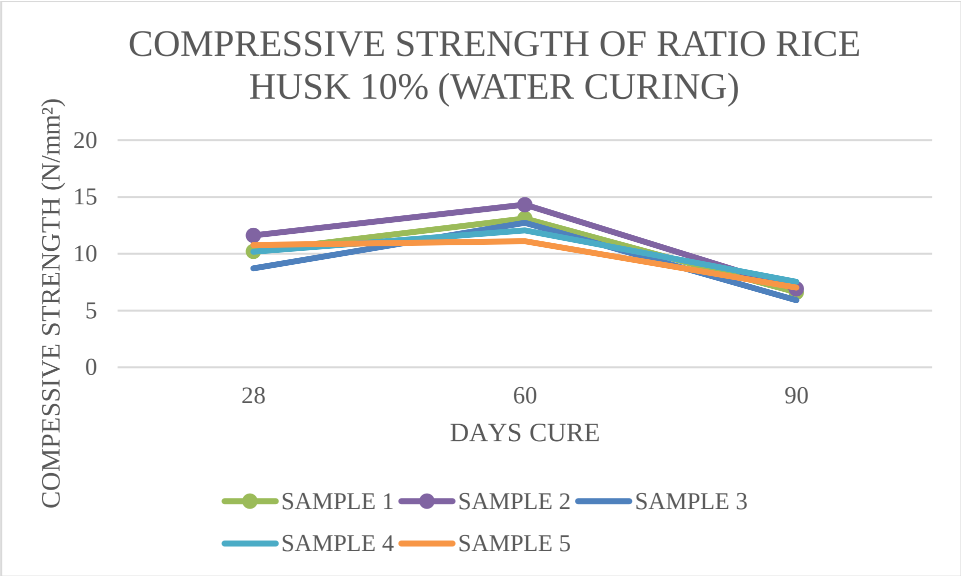

Figure 4.4 Compressive Strength Of 10% RH (Water Curing)

In figure 4.4 shown the line graph of 10% of rice husk for water curing about the changes in compressive strength against days. The graph show the same curve as the compressive strength of 10% RH (air curing) which shows at day 28 the result are increasing its strength as they are cure at day 60 long with highest among the other sample, it reach 14.32 N/mm². For this graph with 5.91 N/mm² shows the lowest strength at the 90 days curing prove that the strength of the sample are dropping as long cure process.

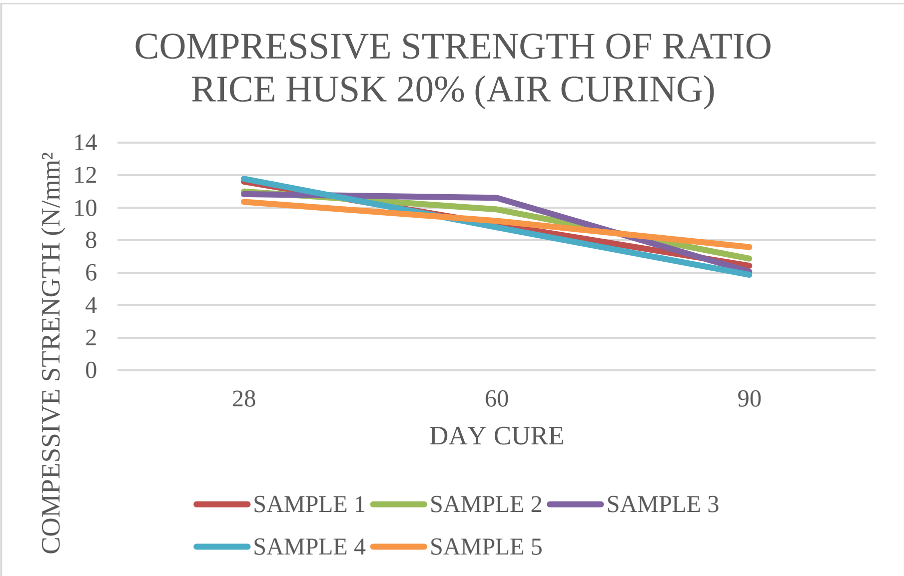

Figure 4.5 Compressive Strength Of 20% RH (Air Curing)

The figure 4.5line graph shows curves differently compared to 10% RH. Compressive strength of 20% RH in air curing shows almost steadily decreasing its strength as at 28 days, the highest strength with 11.60 N/mm² and to the lowest strength at 90 days of cure with 5.87 N/mm².While sample 3 shows a very little drop of strength from day 28 to 60 days with difference 0.23 N/mm² and then steadily drop its strength at 90 days with 6.06 N/mm².

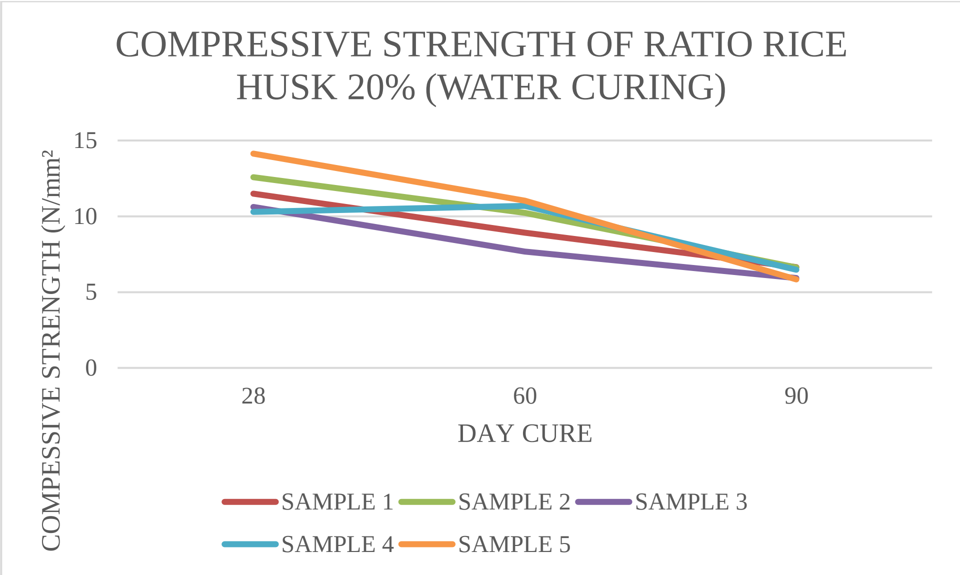

Figure 4.6 Compressive Strength of 20% RH (Water Curing)

The line graph shows the changes in compressive strength and days for 20% RH at water curing. From the data of this experiment, the compressive strength of the sand brick are also shows dropping as the time of curing increasing. At 28 days, the highest of the strength are 12.57 N/mm² and drop it strength at 60 days at 7.67 N/mm² and continue to low its strength at 90 days of cure with the lowest strength at 5.84 N/mm². However, for sample 4 only shows strength of sample at 28 days are increasing at 60 days from 10.28 N/mm² to 10.68 N/mm² at 60 days. Then drop its strength with reading 6.47 N/mm².

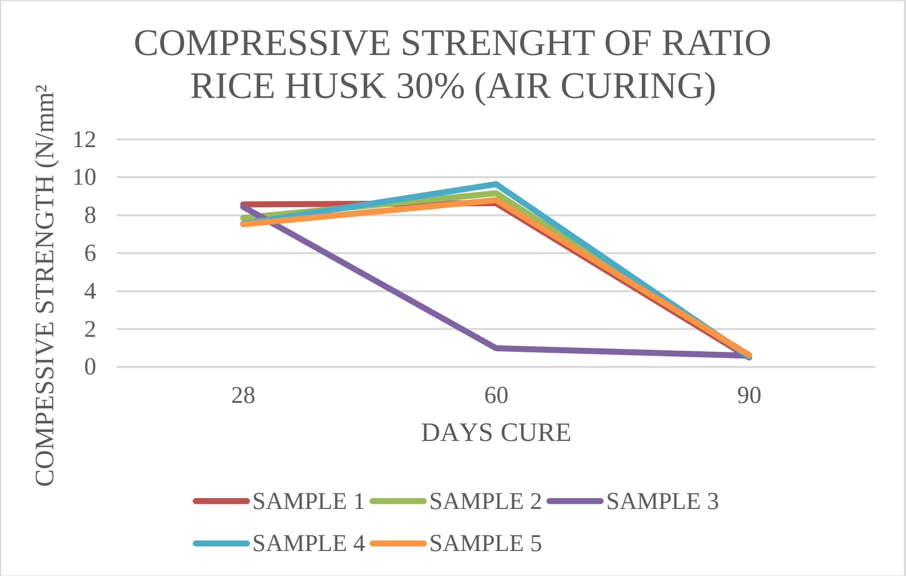

Figure 4.7 Compressive Strength Of 30% RH (Air Curing)

In figure 4.7 shown the line graph of 30% of RH for air curing about the changes in compressive strength against days for air curing. At day 28 the sample shows increasing its compressive strength a little form 7.51N/mm² the lowest at 28 days to the highest at 60 days with 9.16 N/mm². From the experiment the compressive strength are drop drastically to the lowest of its strength 0.49 N/mm². However, for sample 3 data of its compressive strength are shows differently from 28 days the strength at 8.44N/mm² drastically drops to 0.99 N/mm² at 60 days of curing shows the huge different compare to other samples as the sample may have construct improperly or may have some other defect during the experiment.

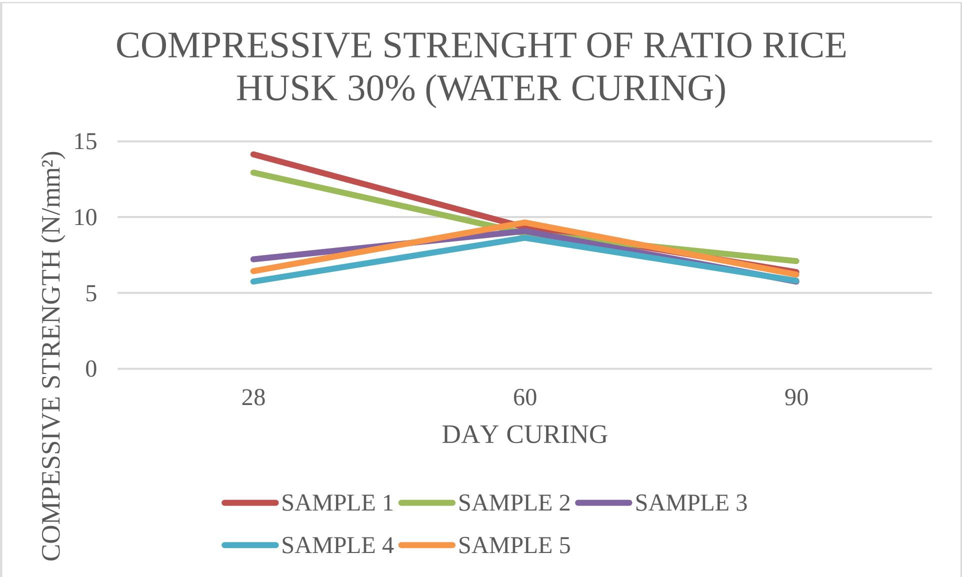

Figure 4.8 Compressive Strength Of 30% RH (Water Curing)

In figure 4.8 shows the line graph of compressive sand brick with 30% RH for water curing about the changes in compressive strength against days. At 28 days, the highest result for this graph is 14.15 N/mm^2 and followed by sample 2 with 12.94 N/mm^2 and continue decrease in strength to the lowest 5.75 N/mm$^{2.}$

Table 4.1 Average of Control Sample

Days	Compressive Strength (N/mm²)					
	Air Curing			Water Curing		
	10	20	30	10	20	30
28	11.13	11.11	7.98	10.29	11.82	9.3
60	14.07	9.49	7.44	12.66	9.7	9.13
90	6.4	6.56	0.56	6.79	6.32	6.25

Table 4.2 Average of Control Sample for Control Sample

Day	Compressive Strength (N/mm²)	
	Air Curing	Water Curing
28	9.576	9.576
60	10.875	11.88
90	9.716	10.582

4.2.2 Flexural Strength Test

The specimen period of the sample 28 days, 60 days and 90 days are conducted flexural strength test. There are 6 units of samples tested for the flexural strength test which divided 3 units for air curing and 3 units water sample. The figure 4.9 shows the average control sample for air curing against days of curing 28, 60, and 90 days and figure 4.10 shows the control sample for water curing against days of curing 28, 60 and 90 days.

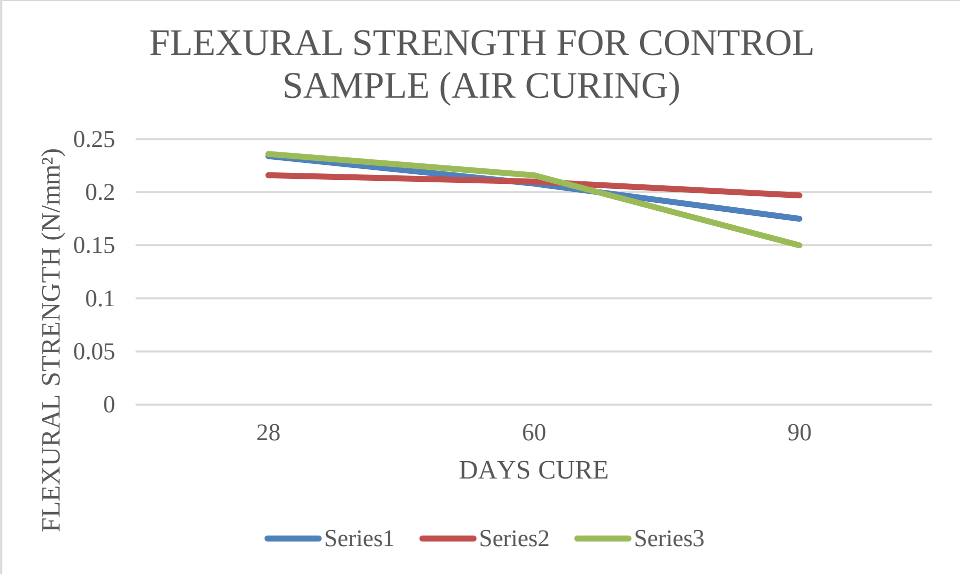

Figure 4.9 Flexural Strength of Control Sample Air Curing

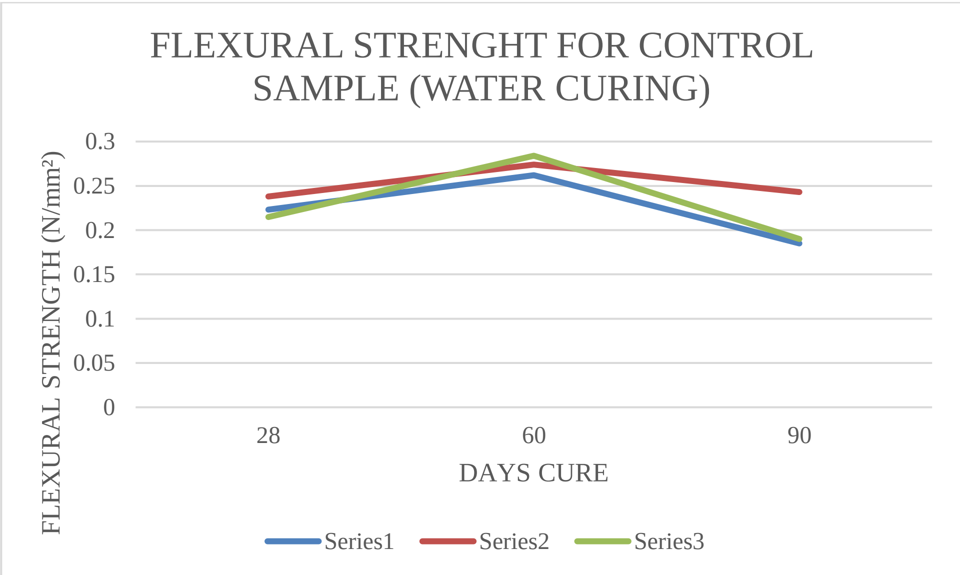

Figure 4.10 Flexural Strength of Control Sample in Water Curing.

Flexural strength of the control brick is 0.2252 N/mm^2 for 28 days 0.2735 N/mm^2 for sample 60 days and 0.2059 N/mm^2 for sample 90 days for the water curing while from the air curing is 0.2283 N/mm^2 for 28 days, 0.2114 N/mm^2 for 60 days and 0.1742 N/mm^2 for 90 days curing.

From the result, the flexural strength for the air curing is increases at 60 days curing and achieved strength of 0.2938 N/mm^2. But it is gradually decreased when it long days of curing while for the water curing side also giving the same shape of curve as in air curing results with the highest flexural strength at 60 days with 3.663 N/mm² . This study shows that the higher percentage rate rice husk give the less strength to the brick because brick is too porous. It is lead to aggregates are bound not tightly, creating porous and reducing the strength of the brick.

Figure. 4.11 shows, the average flexural strength for air curing against 28, 60 and 90 days. Figure 4.12 shows, the average flexural strength for water curing against 28, 60 and 90 days.

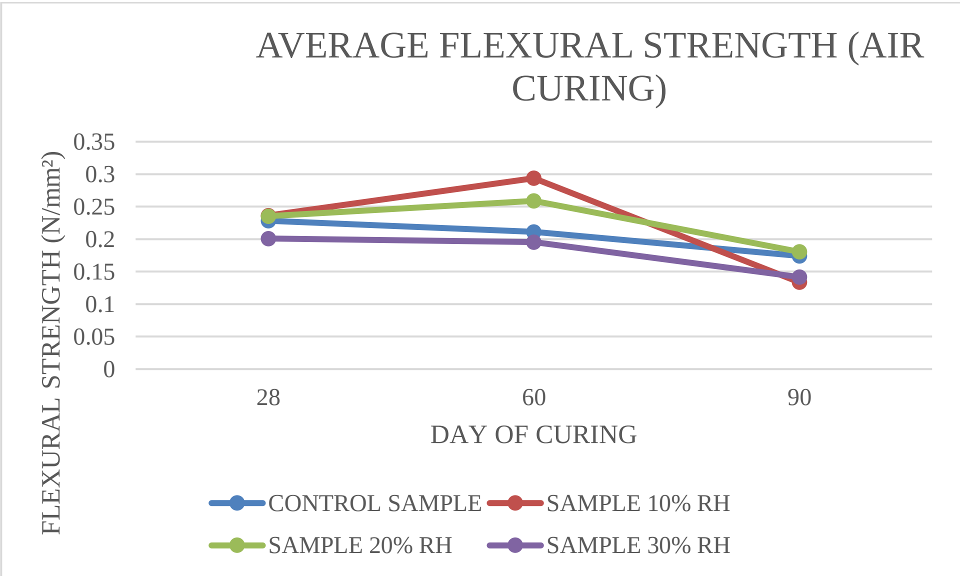

Figure 4.11 Average Flexural Strength of Air Curing

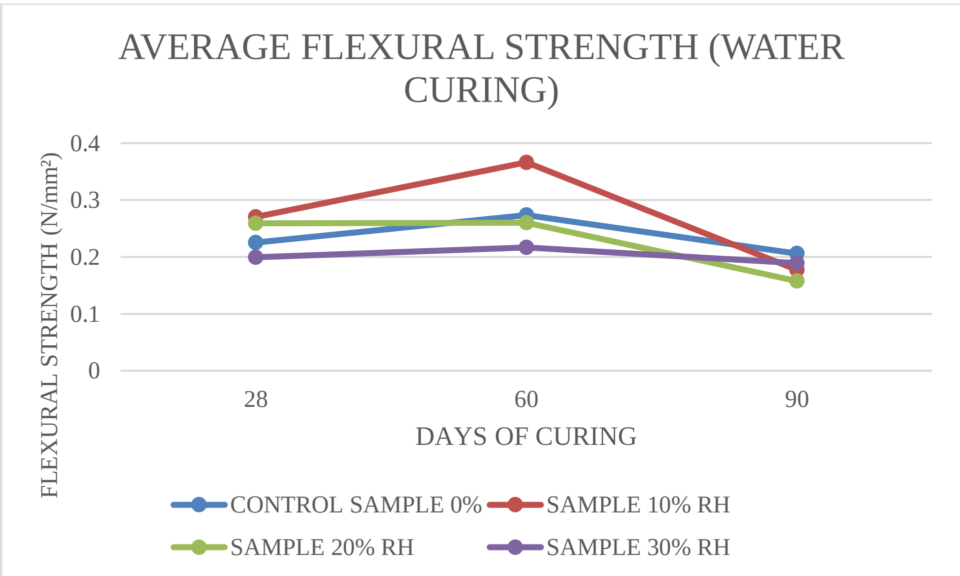

Figure 4.12 Average Flexural Strength of Water Curing

4.2.3 Water Absorption Test

Water absorption test were conducted after 28 days casting the sample. Specimen for water absorption test are weighted before and after to calculate the results. The result for water absorption can be identify by the percentage of the difference weight of brick before and after and divided by before weight as in the formula below:

Water absorption

$$W = \frac{Wi - Wd}{Wd} \times 100 \qquad 4.1$$

Wi = Sample weight after water absorption

Wd = Sample weight before water absorption

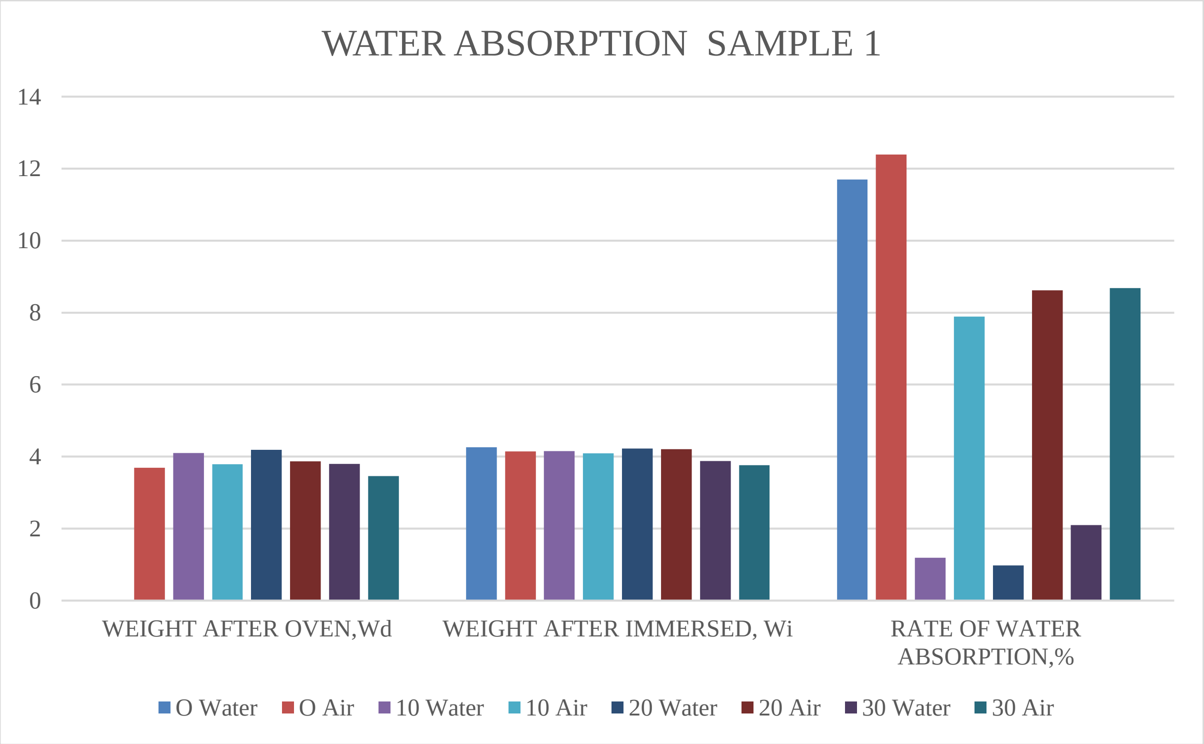

Figure 4.13 Water Absorption of Sample 1

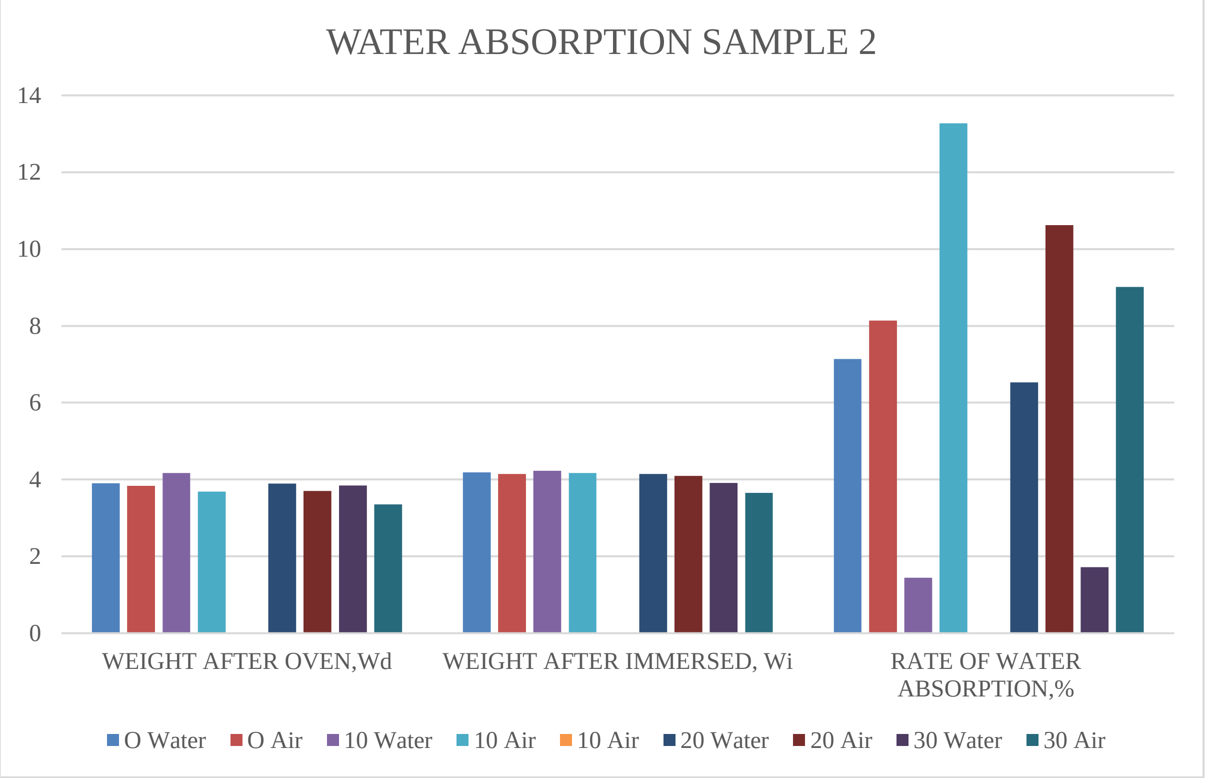

Figure 4.14 Water Absorption of Sample 2

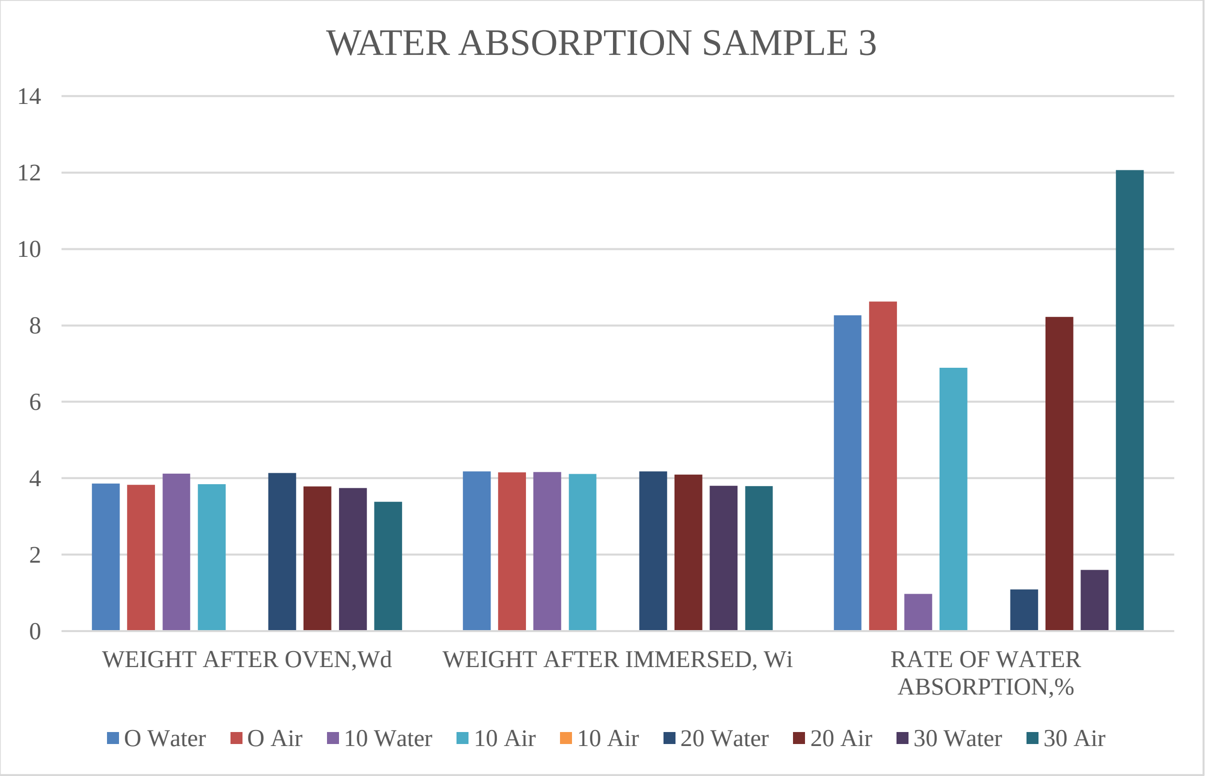

Figure 4.15 Water Absorption of Sample 3

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 absorb 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

Brick density is an important parameter. Density indicates the weight of the brickwork, cores, cells, and frogs decrease the density and in turn, decrease the material cost. Density test are obtained by dividing the mass of the brick with the volume of the brick. As shown below is the formula of density test.

Density

$$Density\ test = \frac{Mass}{Volume} \quad (4.2)$$

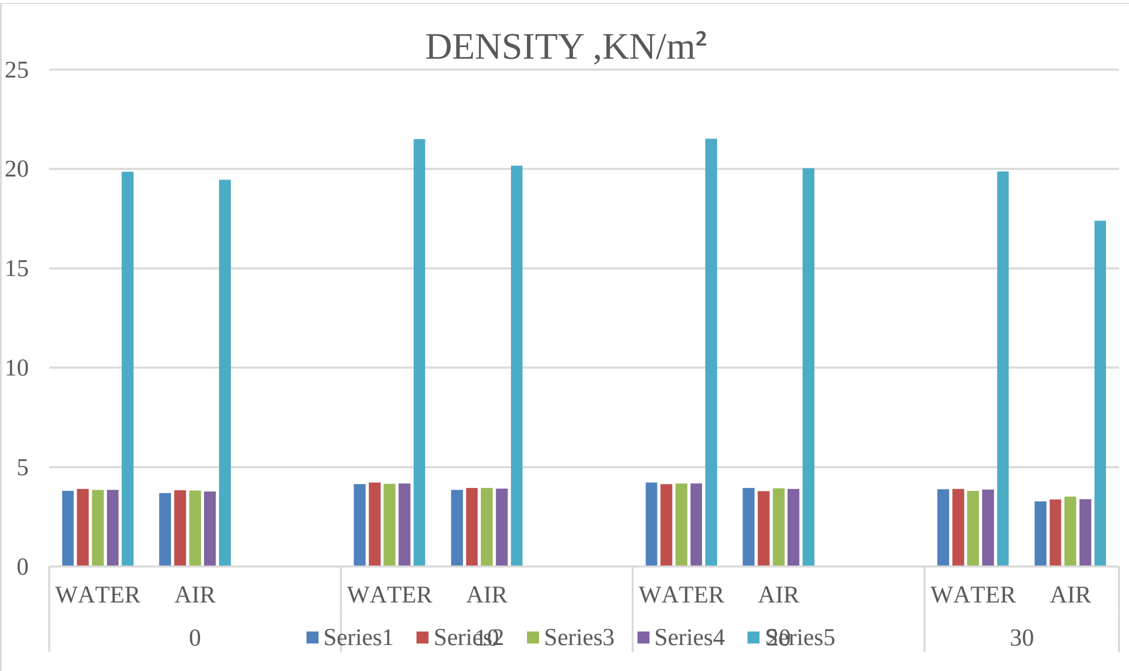

Figure 4.16 Density.

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

From this experimental, the laboratory test result are consist of compressive strength and flexural strength for all sand brick which were analysed from two method of curing, air curing and water curing on 28, 60 and 90 days. While for the water absorption and density test result are only at 28 days. From the result of this experiment study compressive strength test, flexural strength, water absorption test and density test are discussed as to archive the objective of this study.

The graph of compressive strength and flexural strength as in 4.2 shows that 10% of rice husk with constant 15% palm oil clinker at 60 days shows the best compressive strength and flexural strength. This is because as the higher percentage rate rice husk give the less strength to the brick because brick is too porous which give lead to the strength dropped.

The water absorption from all sample the best water absorption is 10% of rice husk with constant 15% palm oil clinker and the best density from this study is 10% of rice husk with constant 15% palm oil clinker. This cause rice husk absorb 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.

Overall, this study is accepted but the ratio of percentage of rice husk and clinker need to be decrease to get the best result for sand bricks.

CHAPTER 5

CONCLUSION

5.1 Introduction

In this chapter, the conclusion will be concluded by am summary from the overall the projects. This conclusion covers all the process of process of projects from the raw materials until data analysis to achieve the objective. Besides, this chapter will discuss some recommendations to improve the next project based on observation from this project.

5.2 Conclusion

In conclusion, bricks are materials that are commonly used in construction industry and highly demand in this new era of construction. As a country desire to grow rapidly it require more development that can give more profit to the country to grow. Therefore, more development in a country will soon require high demand on brick for construction. All-purpose 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 and from this study shows that the compressive strength obtained reach and exceed the compressive strength of control brick, this shows that the rice husk and palm oil clinker has potential in the manufacture of bricks due to the good result shows in the experiment.

The control sample construct with purpose to compare the compressive strength, flexural strength, water absorption and density of sand brick are replaced with rice husk and palm oil clinker. From the average of compressive strength for air curing is increase from 9.58 N/mm^2 to 11.13 N/mm^2 for 10% ratio rice husk then decrease to 7.98 N/mm^2 for 30% rice husk at 28 days. At 60 days the result increase from 10.87 N/mm^2 to 14.07 N/mm^2 for 10% ratio then decrease to 7.45 N/mm^2 for 30% rice husk. At 90 days the result decrease from 9.72 N/mm^2 to 6.41 N/mm^2. While using water curing method also increase from 9.57 N/mm^2 to 10.29 N/mm^2 for 10% ratio then decrease to 9.30 N/mm^2

for 30% at 28 days and same pattern following 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 0.24 N/mm^2 for 10% ratio then decrease to 0.20 N/mm^2 for 30% rice husk at 28 days. At 60 days the result increase from 0.21 N/mm^2 to 0.29 N/mm^2 for 10% ratio then decrease to 0.19 N/mm^2. At 90 days the result decrease from 0.17 N/mm^2 to 0.13 N/mm^2 for 10% ratio. While using water curing method also increase from 0.23 N/mm^2 to 0.27 N/mm^2 for 10% ratio then decrease to 0.19 N/mm^2 for 30% rice husk 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 decrease from 11.7% until 7.89% at 28 days while by using water curing also decrease from 12.39% until 1.19% at 28 days. Finally, the average for density by using air curing is increase from 19.46 kN/m^3 until 20.16 kN/m^3 for 10% ratio then decrease to 17.39kN/m^3 while by using water curing also increase from 19.86 kN/m^3 until 21.50 kN/m^3 for 10% ratio then decrease to 19.87 kN/m^3 at 28 days.

The best compressive strength is 10% of rice husk with 15% constant palm oil clinker for air curing which is 14.07 N/mm^2 at 60 days. Then, the best flexural strength is 10% of rice husk which is 0.29 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. Lastly the best value for density at 20% rice husk which is 21.52 kN/m^3.

Besides that, the devaluation of the compressive strength and flexural strength of the bricks sample may also due to an error of the laboratory equipment or improper construct of the bricks due to the loose side of the mould after being used continuously. This problem cause the result not uniformed and evenly but still may give the good result.

In conclusion, the result is still acceptable and can be used for future manufacture in brick industry because the compression strength and flexural strength result were higher than the control sample result.

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APPENDIX A

Compressive Control Sample for Air Curing At 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
Compressive Strength (N/mm²)	9.7109144 5	9.1091445 4	10.615535 9	9.5457227 1	8.8967551 6
Average (N/mm²)	9.575614553				

Compressive Control Sample for Water Curing At 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
Compressive Strength (N/mm²)	9.7109144 5	9.1091445 4	10.615535 9	9.5457227 1	8.8967551 6
Average (N/mm²)	9.575614553				

Flexural Control Sample for Air Curing At 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
Flexural Strength (N/mm²)	0.233628319	0.21553589	0.235594887
Average (N/mm²)	0.228253032		

Flexural Control Sample for Water Curing At 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
Flexural Strength (N/mm²)	0.22300885	0.237561455	0.215142576
Average (N/mm²)	0.225237627		

Compressive Control Sample for Air Curing At 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	301.5	268.3
Compressive Strength (N/mm²)	10.7177974	11.5830875	11.8112094	9.711	10.5526057
Average (N/mm²)	10.87514002				

Compressive Control Sample for Water Curing At 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
Compressive Strength (N/mm²)	12.2281219	11.4926254	12.0314651	11.0953786	12.5545723
Average (N/mm²)	11.88043265				

Flexural Control Sample for Air Curing At 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
Flexural Strength (N/mm²)	0.208849558	0.210029499	0.21553589
Average (N/mm²)	0.211471649		

Flexural Control Sample for Water Curing At 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
Flexural Strength (N/mm²)	0.262340216	0.273746313	0.284365782
Average (N/mm²)	0.273484104		

Compressive Control Sample for Air Curing At 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
Compressive Strength (N/mm²)	10.3638151	6.52900688	10.3166175	11.3824975	9.99016716
Average (N/mm²)	9.716420846				

Compressive Control Sample for Water Curing At 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
Compressive Strength (N/mm²)	11.9292035	10.7689282	8.4719764	11.2645034	10.473943
Average (N/mm²)	10.58171091				

APPENDIX B

Water Absorption Rate at 28 Days

Ratio,%	Type Of Curing	Rate Of Water Absorption,%
O	Water	11.7
	Air	12.39
10	Water	1.19
	Air	7.89
20	Water	0.98
	Air	8.62
30	Water	2.1
	Air	8.68

Ratio,%	Type Of Curing	Rate Of Water Absorption,%
O	Water	7.14
	Air	8.14
10	Water	1.44
	Air	13.27
20	Water	6.53
	Air	10.62
30	Water	1.72
	Air	9.01

Ratio,%	Type Of Curing	Rate Of Water Absorption,%
O	Water	8.26
	Air	8.62
10	Water	0.97
	Air	6.89
20	Water	1.09
	Air	8.22
30	Water	1.6
	Air	12.06

APPENDIX C

Density at 28 days

Ratio	Type Of Curing	Density, Kn/M²
0	Water	19.85286811
	Air	19.45515933
10	Water	21.50027389
	Air	20.16143527
20	Water	21.52255929
	Air	20.03800841
30	Water	19.87001073
	Air	17.3997592

Compressive For Air Curing at 28 Days Curing

Ratio Clinker 15% Ratio Rice Husk: 10%

Characteristics	**Air Curing**				
Samples	1	2	3	4	5
Weight (Kg)	3.885	3.919	3.819	3.934	4
Area (mm^2)	25425	25425	25425	25425	25425
Maximum Load (N)	287.6	303.4	286	266.4	271.7
Compressive Strength (N/mm^2)	11.3117011	11.9331367	11.2487709	10.4778761	10.6863324
Average (N/mm^2)			11.13156342		

Ratio Clinker 15% Ratio Rice Husk: 20%

Characteristics			**Air Curing**		
Samples	1	2	3	4	5
Weight (Kg)	3.89	3.687	3.851	3.661	3.781
Area (mm²)	25425	25425	25425	25425	25425
Maximum Load (N)	295	279.5	275.4	299.4	263.3
Compressive Strength (N/mm²)	11.6027532	10.993117	10.8318584	11.7758112	10.3559489
Average (N/mm²)			11.11189774		

Ratio Clinker 15% Ratio Rice Husk: 30%

Characteristics			**Air Curing**		
Samples	1	2	3	4	5
Weight (Kg)	3.462	3.588	3.66	3.517	3.498
Area (mm²)	25425	25425	25425	25425	25425
Maximum Load (N)	217.9	199.7	214.7	192	191.1
Compressive Strength (N/mm²)	8.57030482	7.85447394	8.44444444	7.55162242	7.51622419
Average (N/mm²)			7.987413963		

Compressive For Water Curing at 28 Days Curing

Ratio Clinker 15% Ratio Rice Husk: 10%

Characteristics			**Water Curing**		
Samples	1	2	3	4	5
Weight (Kg)	4.193	4.185	4.292	4	4.249
Area (mm²)	254252	25425	25425	25425	25425
Maximum Load (N)	259.7	294.9	221.4	259	273.5
Compressive Strength (N/mm²)	10.2142756	11.5988201	8.7079646	10.186824	10.7571288
Average (N/mm²)			10.29300261		

Ratio Clinker 15%
Ratio Rice Husk: 20%

Characteristics	Water Curing				
Samples	1	2	3	4	5
Weight (Kg)	4.188	4.236	4.046	4.245	4.005
Area (mm^2)	25425	25425	25425	25425	25425
Maximum Load (N)	292.2	319.8	269.9	261.6	359.3
Compressive Strength (N/mm^2)	11.4926254	12.5781711	10.6155359	10.2890855	14.1317601
Average (N/mm^2)	11.82143559				

Ratio Clinker 15%
Ratio Rice Husk: 30%

Characteristics	Water Curing				
Samples	1	2	3	4	5
Weight (Kg)	3.871	3.8	3.94	3.775	3.833
Area (mm^2)	25425	25425	25425	25425	25425
Maximum Load (N)	359.7	329.1	183.5	146.3	163.8
Compressive Strength (N/mm^2)	14.1474926	12.9439528	7.2173058	5.75417896	6.44247788
Average (N/mm^2)	9.301081613				

Compressive For Air Curing At 60 Days Curing

Ratio Clinker 15%
Ratio Rice Husk: 10%

Characteristics	Air Curing				
Samples	1	2	3	4	5
Weight (Kg)	3.918	3.983	4.148	4.013	4.143
Area (mm^2)	25425	25425	25425	25425	25425
Maximum Load (N)	412.3	391.2	315.3	332.2	338.1
Compressive Strength (N/mm^2)	16.2163225	15.3864307	12.4011799	13.06588	13.2979351
Average (N/mm^2)	14.07354966				

Ratio Clinker 15%
Ratio Rice Husk:
20%

Characteristics	Air Curing				
Samples	1	2	3	4	5
Weight (Kg)	3.975	3.882	3.656	3.681	3.995
Area (mm²)	25425	25425	25425	25425	25425
Maximum Load (N)	228	251.7	269.7	223.7	233.3
Compressive Strength (N/mm²)	8.96755162	9.89970501	10.6076696	8.79842675	9.17600787
Average (N/mm²)	9.489872173				

Ratio Clinker 15%
Ratio Rice Husk:
30%

Characteristics	Air Curing				
Samples	1	2	3	4	5
Weight (Kg)	3.502	3.466	3.485	3.725	3.445
Area (mm²)	25425	25425	25425	25425	25425
Maximum Load (N)	219.6	232.9	25.2	245.1	223.7
Compressive Strength (N/mm²)	8.63716814	9.16027532	0.99115044	9.64011799	8.79842675
Average (N/mm²)	7.445427729				

Compressive For Water Curing At 60 Days Curing

Ratio Clinker
15% Ratio Rice
Husk: 10%

Characteristics	Water Curing				
Samples	1	2	3	4	5
Weight (Kg)	4.618	4.535	4.676	4.677	4.544
Area (mm²)	25425	25425	25425	25425	25425
Maximum Load (N)	333.1	364.2	323.5	306.5	282.3
Compressive Strength (N/mm²)	13.1012783	14.3244838	12.7236971	12.0550639	11.1032448
Average (N/mm²)	12.66155359				

Ratio Clinker 15% Ratio Rice Husk: 20%

Characteristics	Water Curing				
Samples	1	2	3	4	5
Weight (Kg)	4.31	4.122	4.221	4.353	4.036
Area (mm²)	25425	25425	25425	25425	25425
Maximum Load (N)	226.6	259.9	195.2	271.7	280.2
Compressive Strength (N/mm²)	8.91248771	10.2222222	7.67748279	10.6863324	11.020649
Average (N/mm²)	9.703834808				

Ratio Clinker 15% Ratio Rice Husk: 30%

Characteristics	Water Curing				
Samples	1	2	3	4	5
Weight (Kg)	3.373	3.729	3.71	3.881	3.874
Area (mm²)	25425	25425	25425	25425	25425
Maximum Load (N)	237.6	227	231	219.7	245.4
Compressive Strength (N/mm²)	9.34513274	8.92822026	9.08554572	8.64110128	9.6519174
Average (N/mm²)	9.130383481				

Compressive For Air Curing At 90 Days Curing

Ratio Clinker 15% Ratio Rice Husk: 10%

Characteristics	Air Curing				
Samples	1	2	3	4	5
Weight (Kg)	3.47	3.59	3.877	3.566	3.44
Area (mm²)	25425	25425	25425	25425	25425
Maximum Load (N)	155.3	172.7	148.1	162.6	175.1
Compressive Strength (N/mm²)	6.10816126	6.79252704	5.82497542	6.39528024	6.88692232
Average (N/mm²)	6.401573255				

Ratio Clinker 15%
Ratio Rice Husk:
20%

Characteristics			Air Curing		
Samples	1	2	3	4	5
Weight (Kg)	3.451	3.438	3.457	3.519	3.577
Area (mm²)	25425	25425	25425	25425	25425
Maximum Load (N)	163.4	174.6	154.2	149.3	192.6
Compressive Strength (N/mm²)	6.42674533	6.86725664	6.06489676	5.87217306	7.57522124
Average (N/mm²)			6.561258604		

Ratio Clinker 15%
Ratio Rice Husk:
30%

Characteristics			Air Curing		
Samples	1	2	3	4	5
Weight (Kg)	3.26	3.509	3.332	3.326	3.401
Area (mm²)	254225	254225	254225	254225	254225
Maximum Load (N)	126.2	145.7	150.6	138.1	161.6
Compressive Strength (N/mm²)	0.49641066	0.57311437	0.59238863	0.54321959	0.63565739
Average (N/mm²)			0.568158128		

Compressive For Water Curing At 90 Days Curing

Ratio Clinker
15% Ratio Rice
Husk: 10%

Characteristics			Water Curing		
Samples	1	2	3	4	5
Weight (Kg)	4.181	3.946	3.911	4.016	4.137
Area (mm²)	25425	25425	25425	25425	25425
Maximum Load (N)	168	175.5	150.2	191.4	178.5
Compressive Strength (N/mm²)	6.60766962	6.90265487	5.90757129	7.5280236	7.02064897
Average (N/mm²)			6.793313668		

Ratio Clinker 15% Ratio Rice Husk: 20%

Characteristics	**Water Curing**				
Samples	1	2	3	4	5
Weight (Kg)	3.971	3.954	3.81	3.897	3.935
Area (mm²)	25425	25425	25425	25425	25425
Maximum Load (N)	169	171	150.7	164.6	148.4
Compressive Strength (N/mm²)	6.64700098	6.72566372	5.92723697	6.47394297	5.83677483
Average (N/mm²)			6.322123894		

Ratio Clinker 15% Ratio Rice Husk: 30%

Characteristics	**Water Curing**				
Samples	1	2	3	4	5
Weight (Kg)	3.889	3.88	3.646	3.795	3.869
Area (mm²)	25425	25425	25425	25425	25425
Maximum Load (N)	162.2	180.6	146.2	147.7	158
Compressive Strength (N/mm²)	6.37954769	7.10324484	5.75024582	5.80924287	6.21435595
Average (N/mm²)			6.251327434		

APPENDIX D

Flexural For Air Curing At 28 Days

Ratio Clinker: 15% Ratio Rice Husk: 10%

Characteristics		Air Curing	
Samples	1	2	3
Weight (Kg)	3.963	4.126	3.919
Area (mm²)	25425	25425	25425
Maximum Load (N)	6.3	6.26	5.48
Flexural Strength (N/mm²)	0.247787611	0.246214356	0.21553589
Average (N/mm²)		0.236512619	

Ratio Clinker: 15% Ratio Rice Husk: 20%

Characteristics		Air Curing	
Samples	1	2	3
Weight (Kg)	3.877	3.829	3.931
Area (mm²)	25425	25425	25425
Maximum Load (N)	5	7.19	5.76
Flexural Strength (N/mm²)	0.196656834	0.282792527	0.226548673
Average (N/mm²)		0.235332678	

Ratio Clinker: 15% Ratio Rice Husk: 30%

Characteristics		Air Curing	
Samples	1	2	3
Weight (Kg)	3.607	3.876	7.454
Area (mm²)	25425	25425	25425
Maximum Load (N)	5.98	5.02	4.33
Flexural Strength (N/mm²)	0.235201573	0.197443461	0.170304818
Average (N/mm²)		0.200983284	

Flexural For Water Curing At 60 Days

Ratio Clinker: 15% Ratio Rice Husk: 10%

Characteristics	**Water Curing**		
Samples	1	2	3
Weight (Kg)	4.233	4.164	4.234
Area (mm²)	25425	25425	25425
Maximum Load (N)	7.34	6.75	6.51
Flexural Strength (N/mm²)	0.288692232	0.265486726	0.256047198
Average (N/mm²)		0.270075385	

Ratio Clinker: 15% Ratio Rice Husk: 20%

Characteristics	**Water Curing**		
Samples	1	2	3
Weight (Kg)	4.233	4.226	4.188
Area (mm²)	25425	25425	25425
Maximum Load (N)	6.77	6.35	6.63
Flexural Strength (N/mm²)	0.266273353	0.249754179	0.260766962
Average (N/mm²)		0.258931498	

Ratio Clinker: 15% Ratio Rice Husk: 30%

Characteristics	**Water Curing**		
Samples	1	2	3
Weight (Kg)	3.845	3.94	3.871
Area (mm²)	25425	25425	25425
Maximum Load (N)	4.65	5.39	5.17
Flexural Strength (N/mm²)	0.182890855	0.211996067	0.203343166
Average (N/mm²)		0.199410029	

Flexural For Air Curing At 60 Days

Ratio Clinker: 15% Ratio Rice Husk: 10%

Characteristics	**Air Curing**		
Samples	1	2	3
Weight (Kg)	3.85	4.192	3.97
Area (mm²)	25425	25425	25425
Maximum Load (N)	7.49	7.65	7.27
Flexural Strength (N/mm²)	0.294591937	0.300884956	0.285939036
Average (N/mm²)		0.29380531	

Ratio Clinker: 15% Ratio Rice Husk: 20%

Characteristics	**Air Curing**		
Samples	1	2	3
Weight (Kg)	4.062	4.005	4.008
Area (mm²)	25425	25425	25425
Maximum Load (N)	6.81	5.95	6.99
Flexural Strength (N/mm²)	0.267846608	0.234021632	0.274926254
Average (N/mm²)		0.258931498	

Ratio Clinker: 15% Ratio Rice Husk: 30%

Characteristics	**Air Curing**		
Samples	1	2	3
Weight (Kg)	3.228	3.296	3.275
Area (mm²)	25425	25425	25425
Maximum Load (N)	5.16	4.47	5.3
Flexural Strength (N/mm²)	0.202949853	0.175811209	0.208456244
Average (N/mm²)		0.195739102	

Flexural For Water Curing At 60 Days

Ratio Clinker: 15% Ratio Rice Husk: 10%

Characteristics	**Water Curing**		
Samples	1	2	3
Weight (Kg)	4.693	4.476	4.89
Area (mm²)	25425	25425	25425
Maximum Load (N)	9.61	8.69	9.64
Flexural Strength (N/mm²)	0.377974435	0.341789577	0.379154376
Average (N/mm²)		0.366306129	

Ratio Clinker: 15% Ratio Rice Husk: 20%

Characteristics	Water Curing		
Samples	1	2	3
Weight (Kg)	4.079	4.268	4.628
Area (mm²)	25425	25425	25425
Maximum Load (N)	5.91	6.73	7.2
Flexural Strength (N/mm²)	0.232448378	0.264700098	0.283185841
Average (N/mm²)		0.260111439	

Ratio Clinker: 15% Ratio Rice Husk: 30%

Characteristics	Water Curing		
Samples	1	2	3
Weight (Kg)	3.688	3.924	3.866
Area (mm²)	25425	25425	25425
Maximum Load (N)	4.82	6.15	5.55
Flexural Strength (N/mm²)	0.189577188	0.241887906	0.218289086
Average (N/mm²)		0.216584726	

Flexural For Air Curing At 90 Days

Ratio Clinker: 15% Ratio Rice Husk: 10%

Characteristics	Air Curing		
Samples	1	2	3
Weight (Kg)	3.511	3.364	3.337
Area (mm²)	25425	25425	25425
Maximum Load (N)	3.45	3.9	2.85
Flexural Strength (N/mm²)	0.135693215	0.15339233	0.112094395
Average (N/mm²)		0.133726647	

Ratio Clinker: 15% Ratio Rice Husk: 20%

Characteristics	Air Curing		
Samples	1	2	3
Weight (Kg)	3.67	3.501	3.284
Area (mm²)	25425	25425	25425
Maximum Load (N)	5.65	4.94	3.18
Flexural Strength (N/mm²)	0.222222222	0.194296952	0.125073746
Average (N/mm²)		0.180530973	

Ratio Clinker: 15% Ratio Rice Husk:
30%

Characteristics	Air Curing		
Samples	1	2	3
Weight (Kg)	3.44	3.263	3.338
Area (mm²)	25425	25425	25425
Maximum Load (N)	4.25	3.6	2.95
Flexural Strength (N/mm²)	0.167158309	0.14159292	0.116027532
Average (N/mm²)		0.14159292	

Flexural For Water Curing At 90 Days

Ratio Clinker: 15% Ratio Rice Husk:
10%

Characteristics	Water Curing		
Samples	1	2	3
Weight (Kg)	4.083	3.952	4.054
Area (mm²)	25425	25425	25425
Maximum Load (N)	4.2	4.59	4.73
Flexural Strength (N/mm²)	0.16519174	0.180530973	0.186037365
Average (N/mm²)		0.17725336	

Ratio Clinker: 15% Ratio Rice Husk:
20%

Characteristics	Water Curing		
Samples	1	2	3
Weight (Kg)	3.537	3.812	3.869
Area (mm²)	25425	25425	25425
Maximum Load (N)	3.94	3.62	4.46
Flexural Strength (N/mm²)	0.154965585	0.142379548	0.175417896
Average (N/mm²)		0.157587676	

Ratio Clinker: 15% Ratio Rice Husk:
30%

Characteristics	Water Curing		
Samples	1	2	3
Weight (Kg)	3.748	3.69	3.705
Area (mm²)	25425	25425	25425
Maximum Load (N)	4.59	5.52	4.31
Flexural Strength (N/mm²)	0.180530973	0.217109145	0.169518191
Average (N/mm²)		0.18905277	