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

RASYDAN BIN MOHAMAD

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

UNIVERSITI MALAYSIA PAHANG

DECLARATION OF THESIS AND COPYRIGHT

Author's Full Name : RASYDAN BIN MOHAMAD

Date of Birth : 8 MARCH 1995

Title : EXPERIMENTAL STUDY OF PROPERTIES FOR SAND BRICK WITH PALM OIL CLINKER AS PARTIAL REPLACEMENT FOR FINE AGGREGATE WITH RATIO OF 15% WITH RICE HUSK OF 10%, 20% AND 30%

Academic Session : 2017/2018

I declare that this thesis is classified as:

- ☐ CONFIDENTIAL (Contains confidential information under the Official Secret Act 1997)*
- ☐ RESTRICTED (Contains restricted information as specified by the organization where research was done)*
- ☑ OPEN ACCESS I agree that my thesis to be published as online open access (Full Text)

I acknowledge that Universiti Malaysia Pahang reserves the following rights:

1. The Thesis is the Property of Universiti Malaysia Pahang
2. The Library of Universiti Malaysia Pahang has the right to make copies of the thesis for the purpose of research only.
3. The Library has the right to make copies of the thesis for academic exchange.

Certified by:

_______________________	_______________________
(Student's Signature)	(Supervisor's Signature)
950308115111	SHARIZA BINTI MAT ARIS
New IC/Passport Number	Name of Supervisor
Date: 11 JUNE 2018	Date: 11 JUNE 2018

NOTE : * If the thesis is CONFIDENTIAL or RESTRICTED, please attach a thesis declaration letter.

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

____

(Supervisor's Signature)

Full Name : SHARIZA BINTI MAT ARIS

Position : LECTURER

Date : 11 JUNE 2018

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

____

(Student's Signature)

Full Name : RASYDAN BIN MOHAMAD

ID Number : AA14121

Date : 11 JUNE 2018

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

RASYDAN BIN MOHAMAD

Project submitted in fulfillment of the requirements
for the award of the
Bachelor Degree in Civil Engineering

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

JUNE 2018

ACKNOWLEDGEMENTS

Firstly, I am grateful to Allah S.W.T. for giving me the good health and wellbeing that were necessary to complete this book.

I would like to express my sincere gratitude to my supervisor, Madam Shariza Binti Mat Aris, for the continuous support of my thesis and related research, for her patience, motivation, and immense knowledge. Her guidance helped me in all the time of research and writing of this thesis.

My sincere thanks also goes to the FKASA lab staff who gave access to the laboratory and research facilities. Without they precious support it would not be possible to conduct this research.

I thank my fellow friends for the stimulating discussions, for the days we were working together in the laboratory, and for all the effort to help me during this research.

Last but not the least, I would like to thank my family: my parents and to my brothers and sister for supporting me spiritually throughout writing this thesis.

ABSTRAK

Peningkatan populasi pertumbuhan manusia telah membawa kepada pertambahan bahan buangan. Bahan buangan boleh menyebabkan masalah yang serius kepada alam sekitar. Bahan buangan boleh dikurangkan dengan memprosesnya dalam bahan binaan seperti bata. Bagi perlindungan alam sekitar dan pembangunan lestari, kajian menyeluruh telah dijalankan ke atas pengeluaran batu bata dari bahan buangan. Klinker minyak kelapa sawit adalah produk sampingan industri kelapa sawit yang biasanya banyak dibuang sebagai sisa yang boleh mengakibatkan kesan yang tidak diingini kepada kelestarian alam sekitar. Klinker kelapa sawit yang sangat berliang dan ringan adalah sesuai untuk digunakan sebagai pengganti agregat halus. Objektif kajian ini adalah tentang sifat-sifat bata pasir dengan klinker sebagai pengganti separa agregat halus dengan nisbah 15% klinker dengan pertambahan sekam padi sebanyak 10%, 20% dan 30%. Bata pasir dengan nisbah bancuhan 1: 6 (1 simen, 6 pasir) dibuat berdasarkan standard JKR. Jumlah keseluruhan sampel adalah 256 bata termasuk sampel kawalan. Bata tersebut menjalani pengawetan udara dan pengawetan air selama 3, 7, 14 dan 28 hari. Bata pasir kemudian diuji untuk mencari kekuatan mampatan, kekuatan lentur, ketumpatan dan penyerapan air. Daripada penemuan kedua-dua kekuatan mampatan dan lentur pada 28 hari pengawetan, sampel yang paling optimum ialah sampel dengan nisbah 15% klinker dengan 10% sekam padi. Dalam ujian penyerapan air, sampel dengan peratusan tertinggi sekam padi iaitu bata dengan 30% sekam padi mencapai peratusan penyerapan air yang tertinggi. Keputusan ini membuktikan bahawa peratusan tinggi sekam padi boleh meningkatkan penyerapan air di dalam bata. Berdasarkan analisis, kesimpulan dapat dibuat bahawa klinker dan sekam padi dapat digunakan sebagai pengganti separa untuk agregat halus dalam pembuatan batu bata. Walau bagaimanapun, kekuatan yang dicapai dari bata ini mungkin tidak sama dengan bata kawalan. Melalui kajian ini, dapat disimpulkan bahawa nisbah terbaik untuk penggantian agregat halus di dalam bata pasir ialah 10% klinker dengan 10% sekam padi. Untuk kaedah pengawetan, pengawetan udara adalah kaedah terbaik untuk digunakan.

ABSTRACT

The increasing of human growth population has led to the surge of the waste material. The waste material can cause serious problem to the environment. The waste materials can be reduced by processing them in construction materials such as brick. For environmental protection and sustainable development, extensive research has been conducted on production of bricks from waste materials. Palm oil clinker is a by-product of palm oil industry which normally being dumped abundantly as waste which caused to the undesirable effects to our environment sustainability. The oil palm clinker that is highly porous and lightweight in nature is suitable to be used as a fine aggregate replacement. The objective of this work is about the properties of sand brick with clinker as partial replacement for fine aggregate with ratio of 15% with rice husk of 10%, 20% and 30%. The sand brick with a mix ratio 1:6 (1 cement, 6 sand) were designed based from the JKR standard. The overall number of samples is 256 bricks including the control samples. The brick undergoes air curing and water curing for 3, 7, 14 and 28 days. The sand brick were tested to find its compressive strength, flexural strength, density and water absorption. From the finding of both compressive and flexural strength at the 28 days of curing, the optimum sample is the sample with ratio of 15% clinker with 10% rice husk. In the water absorption test, the sample with the highest percentage of rice husk which is the brick with 30% rice husk reached the highest water absorption. This result proved that the higher percentage of rice husk increase the water absorption in the brick. Based on the results analysis, it can be concluded that the clinker and rice husk can be used as partial replacement for fine aggregate in the making of brick. However, the strength achieved from this brick might not be same as the control brick. Through the study, it can be concluded that the best ratio for the fine aggregate replacement is 10% clinker with 10% rice husk. For the curing method, the air curing is the best method to use.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

JKR	Jabatan Kerja Raya
Kg	Kilogram
C	Celcious
MPa	Megapascal
SiO_2	Silicon dioxide
Al_2O_3	Aluminium oxide
Fe_2O_3	Ferric oxide
N	Newton
mm^2	Milimeter Square
mm	Milimeter
cm^2	Centimeter Square
OH	Hydrogen
O	Oxygen
OPC	Ordinary Portland Cement
UMP	University Malaysia Pahang
FKASA	Fakulti Kejuruteraan Awam dan Sumber Alam
MS	Malaysian Standard
POC	Palm Oil Clinker
RH	Rice Husk
ASTM	American Society for Testing and Materials
MR	Modulus of Rupture
psi	Pound-force per square inch
lbf	Pound-force
in.	inches

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Nowadays, the human population size has grown rapidly reaching about more than 7.3 billion people. As the world's population size has grown, waste generation also increased rapidly. It is important to reuse these materials and dispose of them. Waste can be used in the construction industry in two ways that is by reusing and recycling or processing waste into raw materials used in the production of building materials.

Throughout history, bricks have been used in every culture, from the Ancient Chinese to the Romans. People viewed brick as a stronger material than wood, as it was resilient to fire, rot, and pests. Brick is a building material used to make walls, pavements and other elements in masonry construction. Conventional bricks are produced from clay with high temperature kiln firing or from ordinary Portland cement (OPC) concrete. In many areas of the world, there is already a shortage of natural source material for production of the conventional bricks. Extensive research has been conducted on production of bricks from waste materials.

Palm oil clinker is a by-product of palm oil industry which normally being dumped abundantly in the landfill as a waste material. The clinker that is highly porous and lightweight in nature is suitable to be used as a fine aggregate replacement.

Rice husk is produced from the milling process of paddy. The rice husk contributes to the agricultural waste. The use of rice husk ash as a partial replacement in bricks helps to reduce waste and prevent dumping of the material.

1.2 PROBLEM STATEMENT

The construction of building and houses every year has increased both in the urban and rural areas. Therefore, there is a high demand for construction material such as sand-brick. The high production of sand brick will make the natural source become scarcer. The shortage of natural resources such as sand can be overcome by the replacement of sand with waste material in the brick production.

The waste material such as palm oil clinker and rice husk increased every year while the disposal land becomes more limited. To reduce the waste material disposal, the palm oil clinker and rice husk can be used in the making of the sand-brick as replacement for the fine aggregate. This study is conducted to find out whether the material is suitable to be used in the production of sand-brick. This study is also to compare the strength of the sand-brick mixed with the clinker and rice husk with the normal type of sand-brick.

1.3 OBJECTIVE

The aim of this research is to establish a detailed understanding of brick properties through laboratory experiments in order to determine:

I. The density of the brick.

II. The compressive strength of the brick.

III. The flexural strength of the brick.

IV. The water absorption of the brick.

1.4 SCOPE OF STUDY

The scope of this research is to make a cement sand-brick that to be used in Malaysia and followed by the specification from the JKR. This study focuses on the testing that will be made on the sand-brick based on the proportions of clinker used as the partial replacement of the fine aggregate. The clinker will be mixed with the rice husk that obtained from Bernas paddy factory in Rompin, Pahang.

1.5 SIGNIFICANCE OF STUDY

The accumulation of waste materials in the landfill increase every year. It is important to reuse this waste into the production of construction materials. The benefit gain from this research is that it can greatly reduce the disposal of the clinker into the landfills. As the sand-brick will be used in the construction, it will create a more sustainability construction to the material.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Bricks is the most common construction material that had been used in the construction around the world. In most of countries, the brick manufacturing has improved and become more innovative. Over the last few years, many researches had been done on the waste materials such as the clinker into the manufacturing of brick. The utilization of waste materials into the manufacturing of bricks not only can help to reduce the waste disposal but also increase the properties of the bricks.

2.2 PALM OIL CLINKER

As stated by (Mohd Zamin, et al., 2015), The production of palm oil clinker is quite new as it is the by-product of oil palm shell and palm oil fibre. As the palm oil industries generate electricity to run the plants, both oil palm shell and palm oil fibres in appropriate proportion (30:70) are being burnt at high temperature of about 850 C and the resulting product is christened as palm oil clinker. Once the palm oil clinker boulders are crushed into suitable sizes, it can be used as lightweight aggregate in concrete. Contemporary studies have shown that oil palm shell and palm oil clinker can be used as lightweight aggregate for producing normal strength to high strength structural concrete with compressive strengths in the range of 17–53.6 MPa.

Palm oil clinker (POC) is a blackish colored solid waste material. It is considered stable and non-biodegradable under normal environmental condition. The chemical composition of such waste material can be determined by using spectrophotometer. The observation revealed that palm oil clinker contains a mixture of SiO^2, Al^2O^3, and Fe^2O^3.

In addition, low concentrations of several transition metal and alkali oxides are also present (Mohammad Razaul, et al., 2016). Recently, a few researches have been conducted on the utilization of POC as an aggregate in different types of concrete for various application purposes. It was found that the mechanical properties of lightweight concrete can be enhanced by using POC (Mohammad Razaul, et al., 2016). In depth research and studies carried out on these waste materials could increase the chances of utilizing or recycling this material again in another industry and thereby reduce the continuous exploitation and conserve the available natural resources for use in future (Jegathish & Hashim, 2015).

Table 2.1 Chemical composition of Palm Oil Clinker (POC) and Oil Palm Shell (OPS).

Oxides	**SiO_2**	**K_2O**	**CaO**	**P_2O_5**	**MgO**	**Fe_2O_3**	**Al_2O_3**	**SO_3**	**Na_2O**	**TiO_2**	**Cr_2O_3**	**Others**
POC	59.63	11.66	8.16	5.37	5.01	4.62	3.7	0.73	0.32	0.22	-	0.58
OPS	46.61	9.88	14.76	1.95	2.91	10.19	3.33	7.84	1.15	-	1.38	-

Source: (Rasel, et al., 2015)

2.3 RICE HUSK

Rice husk is one of the most widely available agricultural wastes in many rice producing countries of the world. The waste product, rice husk, generated from the accumulation of the outer covering of rice grains during the milling process, constitutes about 20% of 300 million metric tons of rice produced annually in the world (Moayad N. & Hana A., 1984). Rice husk used as a valued added raw material for different purposes. It possess various properties that make them suitable for bioethanol production as stated (Anuradha, et al., 1992)

Rice husk biomass is made up of three polymers like cellulose, hemicelluloses and lignin. Rice husk contains 75-90 % organic matter such as cellulose, lignin etc. and rest mineral components such as silica, alkalis and trace elements. Rice husk is unusually high in ash compared to other biomass fuels in the range 10-20%. The ash is 87-97% silica, highly porous and light- weight, with a very high external surface area. Presence of high amount of silica makes it a valuable material for use in industrial application (Kumar, et al., 2013).

2.3.1 Utilization of Rice husk

Rice husk used for different applications depending upon their physical and chemical properties like ash content and silica content. Rice husk can be used to generate electric power, but that will release a large number of greenhouse gases, and the emission of rice husk ash into the ecosystem has attracted huge criticisms and complaints (Ying, et al., 2011). It is also used as a raw material for making some compounds like silica and silicon compounds. Rice husk have various application in different industries and domestic fields (Kumar, et al., 2013).

2.4 BRICK

Brick is one of the building material used in the masonry construction. A brick can be composed of clay-bearing soil, sand and lime or concrete materials. Based on the size of the structure for which construction they would be applied, the bricks are usually produced and used in bulk. The bricks is considered as the strongest and longest lasting building material that was used throughout the history.

2.4.1 Burnt Clay bricks

As stated by (Bernard K., et al., 2014), burnt clay bricks are man-made materials that are widely used in building, civil engineering work, and landscape design. They are made out of regular clay and formed by using moulds in which clay is filled and dried and then baked or fired in the kiln. Burnt bricks are usually do not have any attractive appearance, so they need an application of plaster when used in walls. The bricks can withstand extreme heat and therefore use in construction projects involving thermal, chemical, and mechanical stress.

Figure 2.1 Burnt clay bricks

2.4.2 Sand Lime bricks

Sand lime bricks are made by mixing hydrated lime and sand instead of cement. The mixture are treated in the high pressure steam autoclave after being pressed in the moulds. These bricks are in smooth gray color and have aesthetic advantage. Sand lime bricks are used in construction industries such as ornamental works in buildings and masonry works.

Figure 2.2 Sand lime bricks

2.4.3 Concrete bricks

Concrete bricks are produced by using solid aggregate concrete. They are pressed in the mould and treated by steam. These bricks are made under lower pressure steam. Most concrete bricks have one or more hollow cavities, and their sides may be cast smooth or with a design. The concrete bricks are primarily used as a building material in the construction of facades, fences, basement walls and foundation walls.

Figure 2.3 Concrete bricks

2.4.4 Engineer bricks

The characteristic of engineer bricks are usually thicker and stronger. These type bricks are produced under high temperature. They have the lowest risk of water absorption. Engineering bricks are most suited for ground-works, manholes and sewers, retaining walls and other situations where strength and resistance to frost attack and water are the most important factor (Sanghera, 2014).

Figure 2.4 Engineer bricks

2.5 PROPERTIES OF BRICK

Brick has many good properties which make it most popular building material in the industry.

2.5.1 Compressive strength

The Compressive Strength is the stress (load divided by area) of a brick specimen at failure, or the average stress at failure of a group of brick specimens, when tested under the procedure. The specimen is tested in the "flatwise orientation" so that the bed face of the brick is the lower loaded surface. (Bernard K., et al., 2014) stated that compressive strength depends on the raw materials used, the manufacturing process, and the shape and size of the brick. The crushing resistance varies from about 3.5 N/mm^2 for soft facing bricks to 140 N/mm^2 for engineering bricks when tested in the dry state. Generally, compressive strength decreases with increasing porosity, but strength is also influenced by clay composition and firing. According to (Matysek & Witkowski, 2015), tensile strength and modulus of elasticity of bricks are in close statistical relations with compressive strength.

2.5.2 Water Absorption

Brick strength are largely dependent on its water absorption capacity. Brick water absorption is due to the presence of voids in the bricks. When the brick has more voids it will absorb more water and reduces the load carrying capacity.

Based on (Badorul Hisham & Brook, 2015), water absorption results in a reduction of the water/cement ratio which can lead to a poor mortar quality. The behaviour resulting from the transfer of water from the mortar to the brick can be likened to that caused by absorption of water by the aggregate in concrete because the masonry only consists of brick and mortar. Therefore, the modulus of elasticity is not only dependent on the properties of the mortar and the masonry unit but probably also on the effect of unit water absorption through an equivalent transition zone.

2.5.3 Flexural Strength

Flexural strength is the measure of the tensile strength of concrete beams or slabs. Flexural strength identifies the amount of stress and force the concrete slab, beam or other structure can withstand such that it resists any bending failures.

The flexural strength increases occur when volume dosage rate recycled fine aggregate increases at 55% and achieved strength of 1.58 N/mm^2. But it is gradually decreased when it has more than 55% of volume dosage rate recycled fine aggregate because brick is too porous. This will lead to aggregates that are bound not tightly, creating porous and reducing the strength of the brick (Faisal, et al., 2017).

2.5.4 Density Test

By dividing the weight of specimens with the volume, the density of the specimens can be obtained. Figure 2.5 shows the average density of sand cement brick with recycled concrete aggregate. From the result, it was shown that the average of the density for sand brick with recycled fine aggregate are lower when compared to control brick.

From the result, the lowest density can be seen in bricks with 75% of recycled fine aggregate which reduce the density 4.9% for 7 days sample and 5.4% for 28 days sample compared to control bricks (Faisal, et al., 2017).

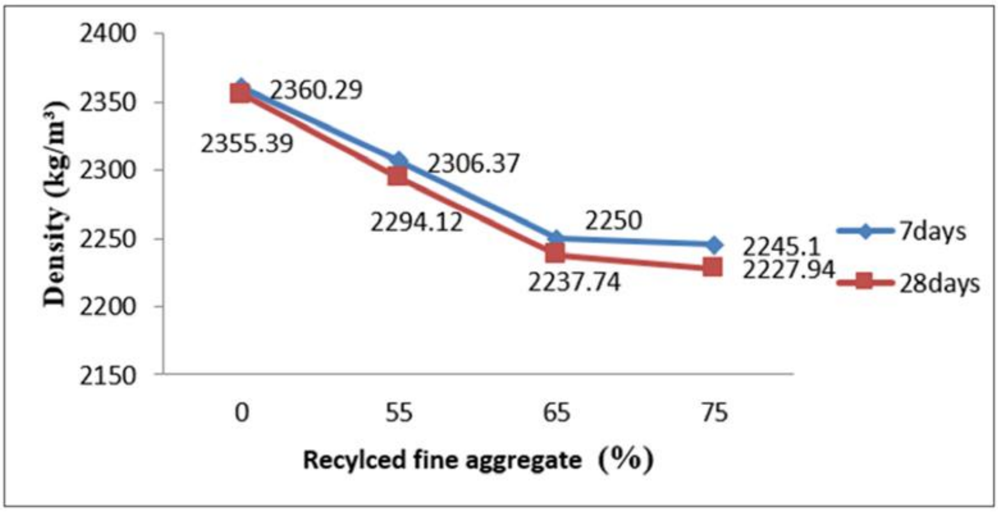

Figure 2.5 The average density of sand cement brick with recycled fine aggregate
Source: (Faisal, et al., 2017)

2.6 CURING METHOD

Curing is the process which controls the loss of moisture from concrete after it is placed in position, or in the manufacture of concrete products, thereby giving time for the hydration of the cement to occur. Because of the hydration of cement takes several days or weeks, rather than hours, curing must be done for a certain period of time if the concrete is to achieve its potential strength and durability. Curing may also include the control of concrete temperature since this affects the rate at which cement hydrates.

The maximum strength of bricks formed under 3000 psi pressure and cured in water for four weeks followed by one week in air was found are 877.36 kg/cm^2. The bricks that were cured in water for four weeks followed by one week in air instead of five weeks in air shown that, the stronger inter-molecular OH-O bond became dominant over the weaker intra-molecular OH bond (Banu, et al., 2013)

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

The preparation and test method that are used in this experiment will be more discussed on this chapter. This study will begin with the flow of methodology which is the summary of methodology for this project. The methodology is based on the testing and experiments to investigate the compressive strength, flexural strength, density and water absorption of the brick. The sand brick will be produced with the ratio of 1:6 by partially replacing the fine aggregate with ratio of 15% clinker with 10%, 20% and 30% of rice husk. Then, continued with the preparation of materials, where the lists of materials are cement, water, sand as fine aggregate, clinker with rice husk as fine aggregate as partial sand replacement.

3.2 METHODOLOGY FLOW CHART

The methodology flowchart was shown in Figure 3.1. The laboratory work that involved in this study are material preparation, concrete mixing process, curing process and testing. The result obtained from the test will be analysed. Hence, the methodology process is very important to know the percentage of clinker with rice husk effectiveness to be use as partially replacement of fine aggregate in sand brick.

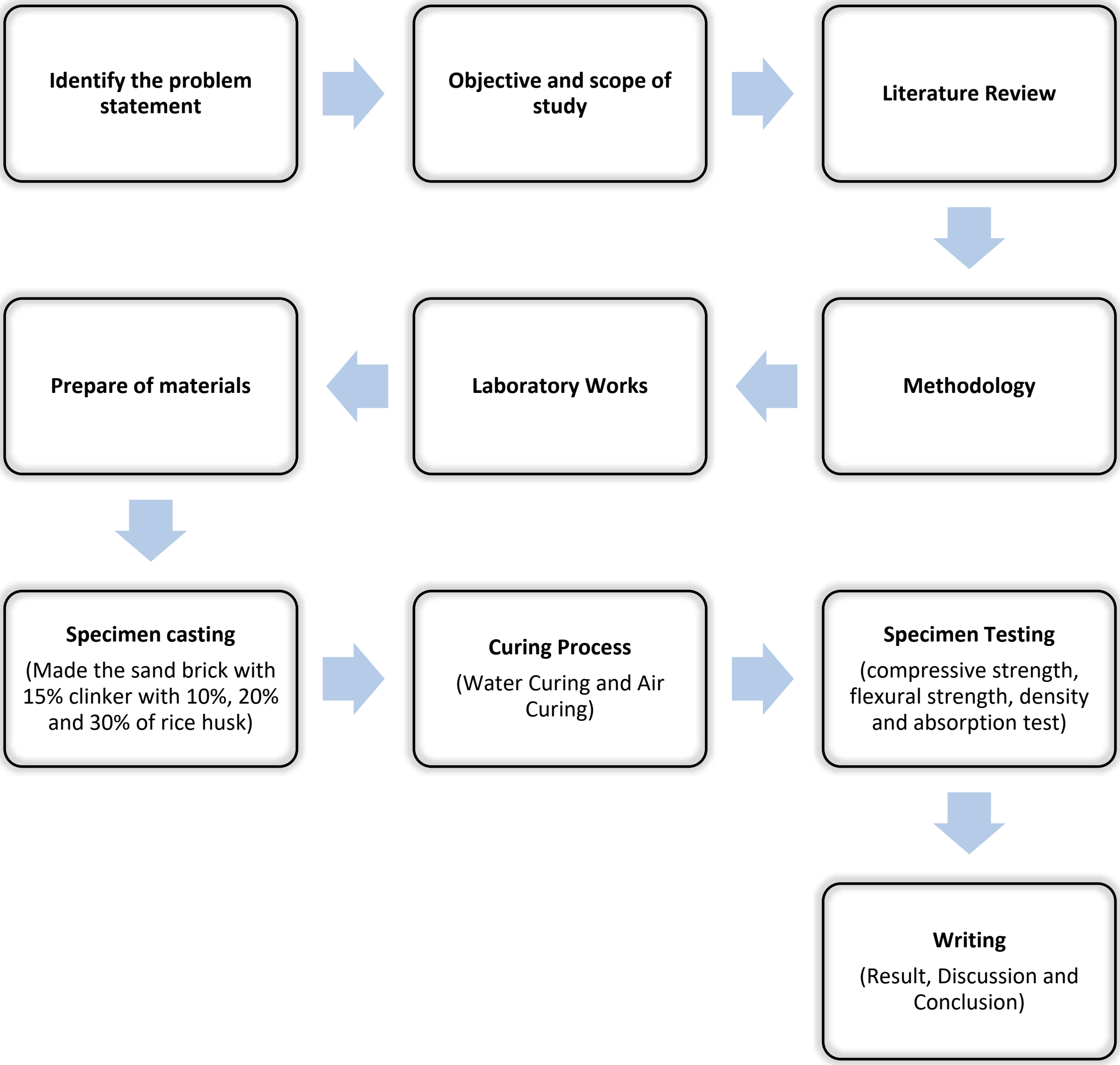

Figure 3.1 Methodology Flowchart

3.3 DESIGN BRICK MIX

3.3.1 Cement

The cement acts as a binder in the mix because it binds water and aggregate together. There are two categories of cement that is hydraulic and non-hydraulic cement. The non-hydraulic cement such as slaked lime, becomes harden by carbonation in the presence of carbon dioxide which is naturally present in the air. For the hydraulic cement such as the Portland cement, becomes adhesive due to a chemical reactions between the cement and water. The process occur is known as hydration process.

There are several types of cements which are available in the markets. The example of cements are ordinary Portland cement (OPC), rapid hardening cement, low heat cement, sulfate resisting cement, white cement, Portland pozzolana cement, hydrophobic cement, colored cement, waterproof Portland cement, Portland blast furnace cement, air entraining cement, high alumina cement and expansive cement. The cement that are used in this experiment is the ordinary Portland cement (OPC). The cement was kept in an air tight packages to ensure that the cement will not exposed to the moisture which can hardened the cement. For this experiment, the Concrete Laboratory of University Malaysia Pahang (UMP) has provided us the ordinary Portland cement (cap orang kuat) that are to be used in the making of the sand brick.

Figure 3.2 Ordinary Portland Cement (OPC)

3.3.2 Water

Water is the vital parts in the hydration process of cement in binding the aggregate and other materials together. The water used must be a portable water, fresh, colourless, odourless, tasteless and free from any organic substances. This is to prevent any side reactions that would occur which may interfere with the result of the experiment. The water used in this experiment is from the Concrete Laboratory of University Malaysia Pahang (UMP).

Figure 3.3 Tap water

3.3.3 Fine Aggregates

Aggregates are chemically inert, solid bodies that held together by the cement. There are various shapes, sizes and materials of aggregate ranging from fine particles of sand to a large coarse rocks. Usually, the fine aggregate that are passing 4.75mm sieve are used to design brick mix.

The aggregates used should be clean, hard and strong. The aggregates needs to be washed to remove any dust, silt, clay, organic matter or other impurities that would interfere with the bonding reaction in the cement paste. The aggregates used in this experiment is obtained by sieving in order to fulfil the requirement of 100% passing through the 4.75mm sieve. The sand that are being used as the fine aggregates was provided by Concrete Laboratory of University Malaysia Pahang (UMP).

Figure 3.4 Fine aggregate

3.3.4 Palm Oil Clinker

The clinker used in this experiment was obtained from Kilang Kelapa Sawit Lepar Hilir 3 in Gambang, Pahang. Firstly, the clinker need to be dried with oven to remove the moisture. Then, the clinker particles were sieved and the size passing 4.75mm sieve was used in this study. This experiment used clinker as a partial replacement of the fine aggregate with the ratio of 15% to make the sand brick.

3.3.5 Rice Husk

The rice husk used in this experiment is as a partial replacement with the ratio of 10%, 20% and 30% from the fine aggregate. The rice husk needs to be oven dried before can be used in the experiment. The dried rice husk does not have to be sieved as the usage of the rice husk in this experiment were as a raw material. The rice husk used was obtained from the Bernas paddy factory in Rompin, Pahang.

3.4 PARAMETER USED FOR TESTING

3.4.1 Machine prepared sample

I. Crushed machine – to crush the clinker and rice husk
II. Sieve shaker machine – to sieve crush clinker and rice husk
III. Mixer machine – to mix the material
IV. Weighing scale – to weight material and sample

3.5 DIMENSION ANALYSIS

The number of bricks that were tested in each ratio are 64 bricks. For the each of the ratio, the bricks are used to test compressive strength, flexural strength, density and water absorption. This experiment used clinker with ratio of 15% and rice husk with ratio of 10%, 20% and 30% as the partial replacement of the fine aggregate. The making of sand brick with ratio 1:6 (1 cement, 6 sand) is based on the JKR Standard according to section E (brickworks) in clause 3.1. The total sample that are used in this experiment is 160 bricks. The size of samples is shown in Table 3.1 according MS 27 in JKR Standard clause 4.3.

Table 3.1 Dimension of Brick

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

3.5.1 List prepared sample

Table 3.2 Total no of sample of sand bricks (unit)

Days Ratio	3	7	14	28	Total
Standard	16	16	16	16	64
		15% POC			
10% RH	16	16	16	16	64
20% RH	16	16	16	16	64
30% RH	16	16	16	16	64
Total					256

Table 3.3 Type of curing process

Type of Curing	Ratio	3 days	7 days	14 days	28 days
	Standard	8	8	8	8
	15% POC with 10% RH	8	8	8	8
Air	15% POC with 20% RH	8	8	8	8
	15% POC with 30% RH	8	8	8	8
	Standard	8	8	8	8
	15% POC with 10% RH	8	8	8	8
Water	15% POC with 20% RH	8	8	8	8
	15% POC with 30% RH	8	8	8	8

3.5.2 Analysis sample

Size of sand brick

225 x 113 x 75 mm

Total volume for one brick

0.225 x 0.113 x 0.075

= 0.001907 m^3

Ratio for sand brick 1:6

Cement = 1 /7 x 0.001907 = 0.0002724 m^3

Sand = 6/7 x 0.001907 = 0.001635 m^3

Total cement and sand used:

1 m^3 = 2406.53 kg

Cement = 0.0002724 m^3 = 0.66 kg

Sand = 0.001635 m^3 = 3.93 kg

3.6 PROCEDURE OF WORK

3.6.1 Mould

Mould are used in casting the sand brick to meet the required size and dimension respectively. The mould are built by using the plywood that had been supplied by the Concrete Laboratory of University Malaysia Pahang. The size and dimension of the mould should be the same as the size and dimension of brick which is 225x113x75 mm.

3.6.1.1 The procedure to form the mould

To build the mould, 5 pieces of plywood with the size of 75mm in width times by 113mm in height and another 11 pieces of plywood size of 225mm in width times by 113mm in height were needed. In overall, the mould could form about 40 samples of brick. This will make the process of casting to be easier.

3.6.1.2 The preparation material

The materials that are used in this experiment was cement, sand, water, clinker and rice husk. The clinker and rice husk are needed to crush and sieve by passing 4.75mm as a fine aggregate. All the material weighed are listed in analysis sample.

3.6.1.3 Process of work

The process of casting started with the casting of the control sample brick. Then, the casting is followed by the brick with 10%, 20% and 30% of rice husk.

I. The plywood must be brushed with oil to prevent the mix sticks to the plywood and also to ease the mould opening work.

II. The materials that had already prepared is put into the mixer machine part by part until the material blended in for 5 – 10 minutes.

III. The material are placed into the mould and by using rod, compress the mix.

IV. Wet sacks are placed on the specimens mould and leave for 24 hours.

V. After reached 24 hours, the mould are opened for the water curing and air curing process for 3 days, 7 days, 14 days and 28 days.

Figure 3.5 Air curing process

Figure 3.6 Water curing process

VI. The sample is weighed before testing the sample.

VII. Step 1 – 6 is repeated by using another ratio sample.

3.7 CURING

Curing is the process or operation which controls the loss of moisture from concrete. Curing must be undertaken for some specified period of time if the concrete is to achieve its potential strength and durability. There are three basic ways of curing. The first involves by keeping the surface of the concrete moist such as ponding, sprinkling and damp sand. The second is by preventing the loss of moisture from the concrete by covering with polythene sheeting or leaving the formwork in place. The third involves the use of spray or roller applied curing compounds.

For this experiment, the ponding method is used because it is an effective method for preventing loss of moisture from the brick. This method also effective to maintain a uniform temperature.

3.8 DENSITY TEST

3.8.1 Objective

This test method to determine of density, percent absorption and percent voids in sand brick. Testing procedures based in ASTM 04.02 C 642-97 (page 338) which is Standard Test Method for Density Absorption and Voids in Hardened

3.8.2 Procedure

1. *Oven-Dry Mass*

   I. The mass of the portions is determined.

   II. Dry the specimens in an oven at a temperature of 100-110˚C for not less than 24-hour.

   III. After removing each specimen from the oven, cool in dry air (preferably in a desiccator) to a temperature of 20-25 ˚C. Then determine the mass.

IV. If the specimen is comparatively dry when its mass was first determined, and the second mass closely agrees with the first, consider it dry.

V. If the specimen is wet when it's mass was first determined, place it in the oven for a second drying treatment of 24-hour and again determine the mass.

VI. If the third value checks the second, consider the specimen dry.

VII. In case of any doubt, redry the specimen for 24-hour periods until check values of mass are obtained.

VIII. If the difference between values are obtained from two successive values of mass exceed 0.5% of the lesser value, return the specimens to the oven for an additional 24-hour drying period.

IX. Repeat the procedure until the difference between any two successive values is less than 0.5% of the lowest value is obtained.

Designate this last value A.

3.9 WATER ABSORPTION TEST

This test method used for determining the relative water absorption properties over time of sand brick. This is because the samples are made under laboratory conditions. The test was conducted at FKASA concrete laboratory. There are 5 samples of bricks for each ratio required for this test. Meanwhile, this specimen need to dry for a 3 days, 7 days, 14 days and 28 days. According to ASTM Standard C 140 - 03 there are two main procedures of absorption testing:

Saturation

I. Immerse the test specimens in water at a temperature of 15.6 °C - 26.7°C for 24 hours.
II. Weigh the specimen while suspended by a metal wire and completely submerged in water.
III. Record the weight of immersed specimen as Wi (immersed weight).
IV. Then, remove it from the water and allow to drain for 1 min by placing them on a 9.5 mm or coarser wire mesh.
V. Remove visible surface water with a damp cloth, weight and record as Ws (saturated weight).

Drying

I. Subsequent to saturation, dry all specimens in a ventilated at 100°C to 115°C for not less than 24 h and until two successive weighings at intervals of 2 hour shows an increment of loss not greater than 0.2 % of the last previously determined weight of specimen.
II. Record weight of dried specimen as Wd (Oven-dry weight)

In conclusion, from this test the water absorbed can be obtained between the weights recorded. The quality of brick are determined by the percentages of water absorbed. If the less water absorbed the brick can be classified as good quality brick.

3.10 COMPRESSIVE STRENGTH TEST

The compressive strength test known as compressive test was used to measure the performance of the brick sample compared to standard sand brick. The brick considered strong if they can resist the crushing load better than the standard through maximum load achieved. The size of sample which is complying with ASTM C67-03a is 225mm X 113mm X 75mm was tested on 3, 7, 14 and 28 days curing age. The sample was test immediately after the removal of sample from curing tank. The sample was put into a compressive testing machine with thick plates placed above and below each sample to distribute load equally.

3.10.1 Objective

The main objective of this testing is to determine the compressive strength of sand brick. Based on Malaysian Standard (MS27), the minimum permissible average compressive strength is about 5.2 N/mm^2 per 10 samples.

Figure 3.7 Compressive testing machine

3.10.2 No of sample used

Table 3.4 Total no of sample used for this testing is 256 samples.

Days / Ratio	3	7	14	28	Total
Standard	16	16	16	16	64
		15% POC			
10% RH	16	16	16	16	64
20% RH	16	16	16	16	64
30% RH	16	16	16	16	64
Total					256

3.10.3 Procedures

The testing procedures based on ASTM C 67

I. The sample was taken out from the curing tank then surface of sample was dried out using the cloth.
II. The dimension and weight of the sample were measured and recorded.
III. The sample then placed in flatwise position at the center of bearing plate so that the load applied in the direction of depth of the sample.
IV. The sample was capped with the bottom and upper flat steel for the equal load distribution.
V. After that, the load was applied in uniform rate until the sample reached the failure state where the sample fail to produce any increase indicator reading on testing machine.
VI. The reading was recorded.
VII. Step (II) to (VI) was repeated on other sample for control sample, 10%, 20% and 30% rice husk at 3, 7, 14 and 28 days for water curing and air curing.

3.10.4 Calculation

Calculation of compressive strength of each sample as below:

$$C = W / A$$

Where:

C= Compressive strength of the sample (N/mm^2 or MPa)

W= Maximum load indicated by testing machine (N)

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

3.11 FLEXURAL STRENGTH TEST

Flexural test evaluates the tensile strength of sand brick indirectly. It tests the ability of sand brick to withstand failure in bending. The results of flexural test on sand brick expressed as a modulus of rupture which denotes as (MR) in MPa or psi. The flexural strength is theoretically derived from the elastic beam theory, where stress-strain relation is assumed to be linear. Therefore, modulus of rupture is commonly presenting an overestimate value of brick tensile strength. The flexural test on sand brick can be conducted using the center-point loading test (ASTM C293).

3.11.1 Objective

To determine the flexural strength and flexural modulus of concrete.

3.11.2 Apparatus

Figure 3.8 Flexural strength testing machine

3.11.3 Procedure

I. The flexural test should be conducted on the specimen immediately after taken out of the curing condition so as to prevent surface drying which decline flexural strength.

II. Placed the specimen on the loading points. The hand finished surface of the specimen should not be in contact with loading points. This will ensure an acceptable contact between the specimen and loading points.

III. Centered the loading system in relation to the applied force.

IV. Bring the block applying force in contact with the specimen surface at the loading points.

V. Applied loads between 3 to 6 percent of the computed ultimate load.

VI. Employing 0.10 mm and 0.38 mm leaf-type feeler gages, specify whether any space between the specimen and the load-applying or support blocks is greater or less than each of the gages over a length of 25 mm or more.

VII. Eliminate any gap greater than 0.10mm using leather shims (6.4mm thick and 25 to 50mm long) and it should extend the full width of the specimen.

VIII. Capping or grinding should be considered to remove gaps in excess of 0.38mm.

IX. Load the specimen continuously without shock till the point of failure at a constant rate to the breaking point.

X. Applied the load at a rate that constantly increase the extreme fiber stress between 125 and 175 psi/min (0.86 and 1.21 MPa/min) until rupture occurs.

XI. The loading rate as per ASTM standard can be computed based on the following equation:

XII. $$r = \frac{2Sbd^2}{3L}$$

a. Where:

b. *r*: loading rate, lb/min (MN/min)
c. *S*: rate of increase of extreme fiber, psi/min (MPa/min)
d. *b*: average specimen width, in. (mm)
e. *d*: average specimen depth, in. (mm)
f. *L*: span length, in (mm)

XIII. Finally, measure the cross section of the tested specimen at each end and at center to calculate average depth and height.

3.11.4 Calculation

Calculate the modulus of rupture as follows:

$$R = \frac{3PL}{2bd^2}$$

Where:

R = modulus of rupture, psi, or MPa

P = maximum applied load indicated by the testing machine, lbf, or N

L = span length, in., or mm

b = average width of specimen, in., or mm, at the fracture

d = average depth of specimen, in., or mm, at the fracture

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

The experiment has been done for 240 samples of sand brick. There are 4 types of sample that are used in this experiment that are control sample, 15% clinker with 10% rice husk, 15% clinker with 20% rice husk and 15% clinker with 30% rice husk. Each of the ratio have 64 of bricks respectively. The samples are cured both using water and air curing method for 3, 7, 14 and 28 days. The result analysed are based on the compressive strength test, flexural strength test, water absorption test and density test that had been done on the brick. Overall, all the data collected are represented by table and graph.

4.2 COMPRESSIVE STRENGTH

4.2.1 Average Compressive Strength for Control Sample

Table 4.1 Average Compressive Strength of Control Sample

Days	Compressive Strength (N/mm^2)	
	Air Curing	Water Curing
3	5.31	4.50
7	4.64	6.46
14	6.85	5.49
28	8.85	8.47

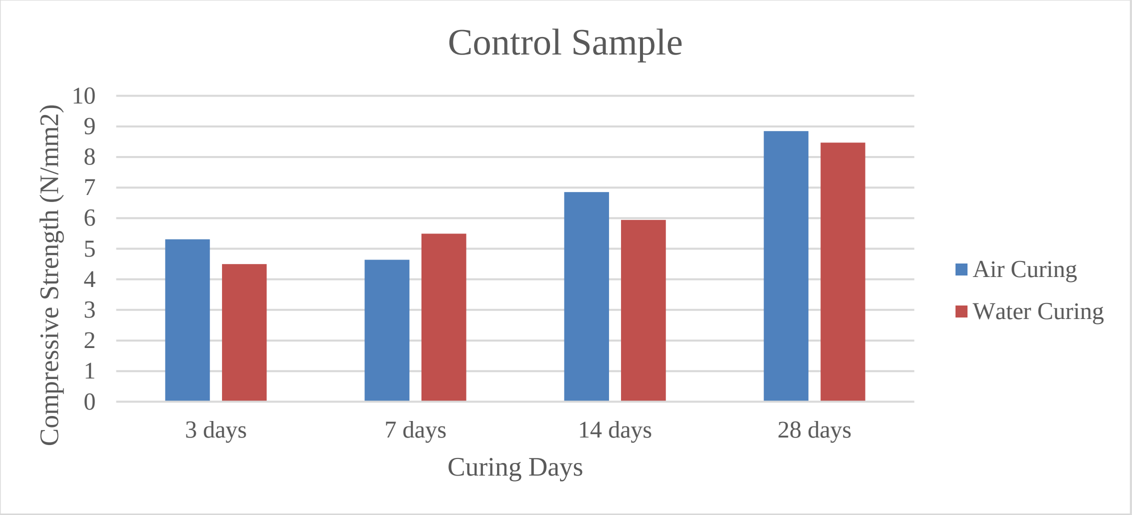

Figure 4.1 Compressive Strength Graph of Control Sample

The graph in Figure 4.1 compares the compressive strength of the control sample for different number of curing days and the method of curing. In the air curing method, the value of compressive strength decrease at 7 days and increase from 14 to 28 days. The compressive strength from the water curing method shows a linear increase. The highest compressive strength is from the air curing method which is at 8.845 N/mm2 at the 28 days of curing.

4.2.2 Average Compressive Strength for 15% Clinker with 10% Rice Husk Sample

Table 4.2 Average Compressive Strength of 15% Clinker with 10% Rice Husk Sample

Days	Compressive Strength (N/mm^2)	
	Air Curing	Water Curing
3	4.93	4.00
7	6.75	6.35
14	8.02	6.85
28	8.42	6.92

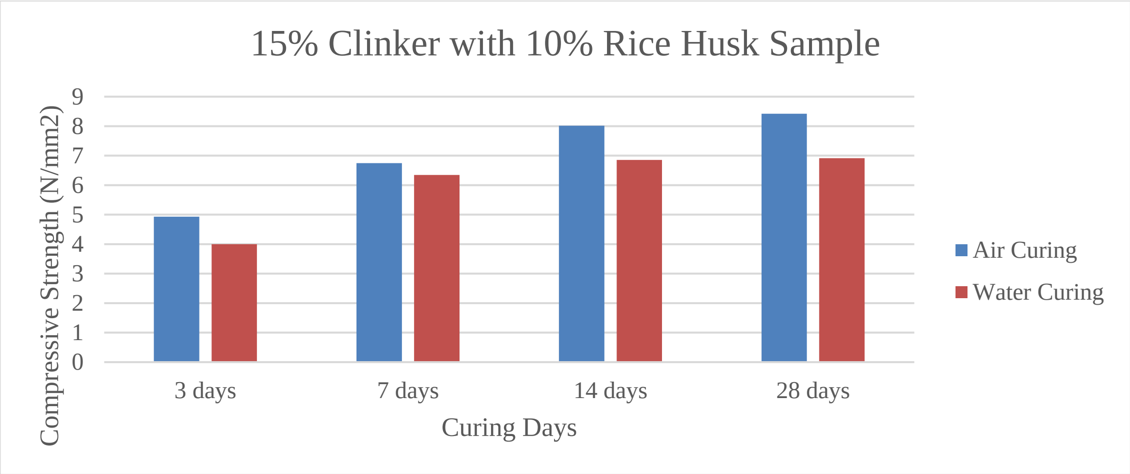

Figure 4.2 Compressive Strength Graph of 15% Clinker with 10% Rice Husk Sample

From the graph of the sample with 15% clinker with 10% rice husk in Figure 4.2, it can be seen that the compressive strength from both air and water curing method was increasing uniformly with the highest strength were at 28 curing days. The graph shows that the strength from the air curing is higher than the water curing. The highest compressive strength achieved from the sample of 15% clinker with 10% rice husk is 8.42 N/mm2.

4.2.3 Average Compressive Strength for 15% Clinker with 20% Rice Husk Sample

Table 4.3 Average Compressive Strength of 15% Clinker with 20% Rice Husk Sample

Days	Compressive Strength (N/mm^2)	
	Air Curing	Water Curing
3	5.50	3.28
7	6.96	6.84
14	7.10	6.95
28	7.75	7.63

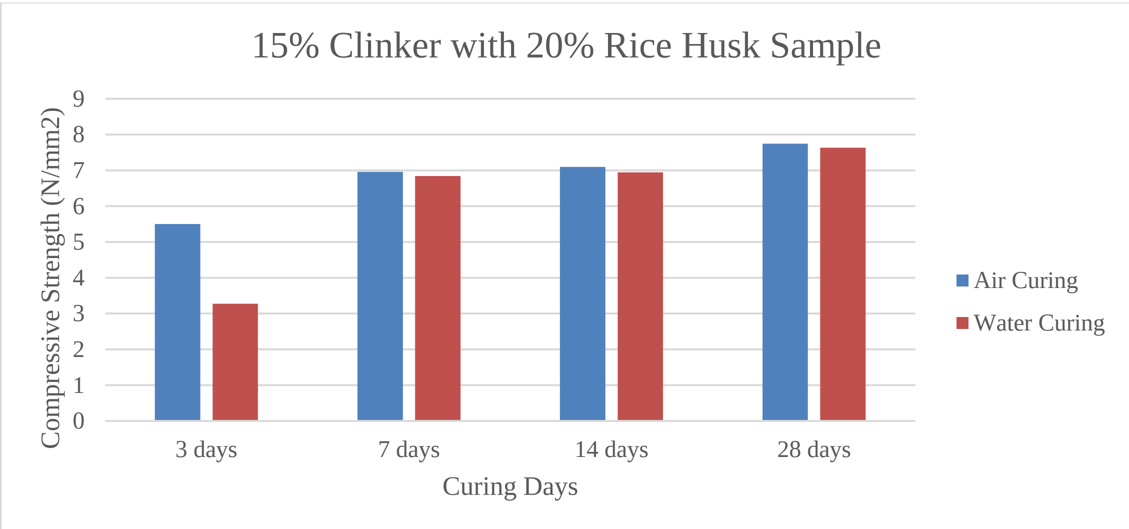

Figure 4.3 Compressive Strength Graph of 15% Clinker with 20% Rice Husk Sample

From Figure 4.3, the sample of 15% clinker with 20% rice husk shows a high difference of compressive strength at 3 days of curing between the both curing methods. However, at the 7, 14 and 28 days of curing there is only minimal difference of strength between the water and the air curing. The highest compressive strength achieved is 7.75 N/mm2 from air curing method at 28 days of curing.

4.2.4 Average Compressive Strength for 15% Clinker with 30% Rice Husk Sample

Table 4.4 Average Compressive Strength of 15% Clinker with 30% Rice Husk Sample

Days	Compressive Strength (N/mm^2)	
	Air Curing	Water Curing
3	5.08	4.88
7	5.27	5.05
14	5.84	5.63
28	6.51	5.80

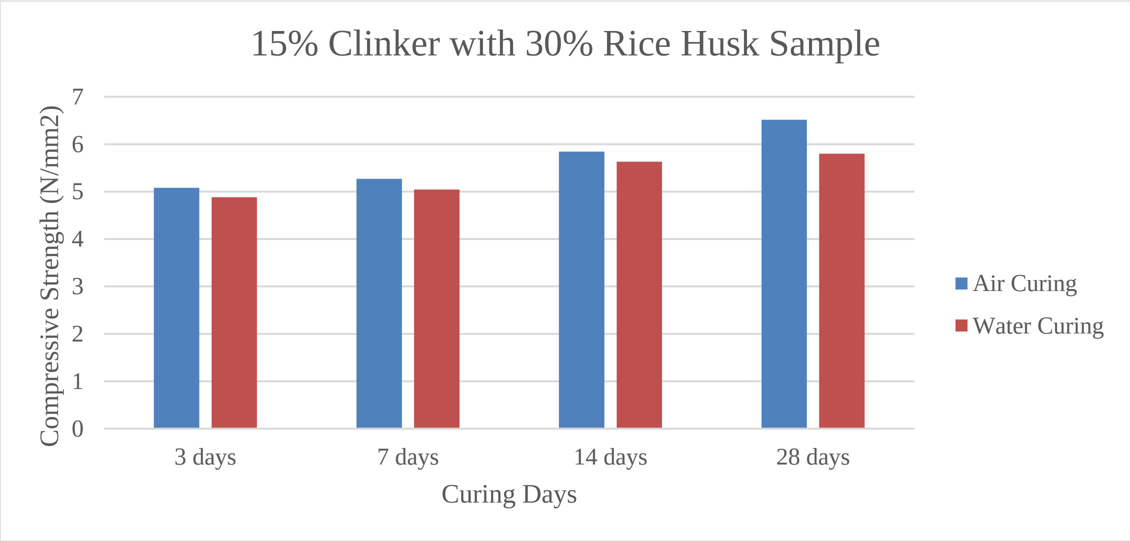

Figure 4.4 Compressive Strength Graph of 15% Clinker with 30% Rice Husk Sample

The bar graph from Figure 4.4 shows the compressive strength of sample with the 15% clinker and 30% rice husk. The compressive strength shows a linear increase from 3 days until 28 days of curing. It can be seen that the value of compressive strength of the air curing are higher than the water curing method. Result shows the highest compressive strength from this sample is 6.51 N/mm2.

4.2.5 Average Compressive Strength for Air Curing

Table 4.5 Average Compressive Strength of Air Curing

Days	Compressive Strength (N/mm^2)			
	Control sample	15% Clinker + 10% Rice Husk	15% Clinker + 20% Rice Husk	15% Clinker + 30% Rice Husk
3	5.31	4.93	5.50	5.08
7	4.64	6.75	6.96	5.27
14	6.85	8.02	7.10	5.84
28	8.85	8.42	7.75	6.51

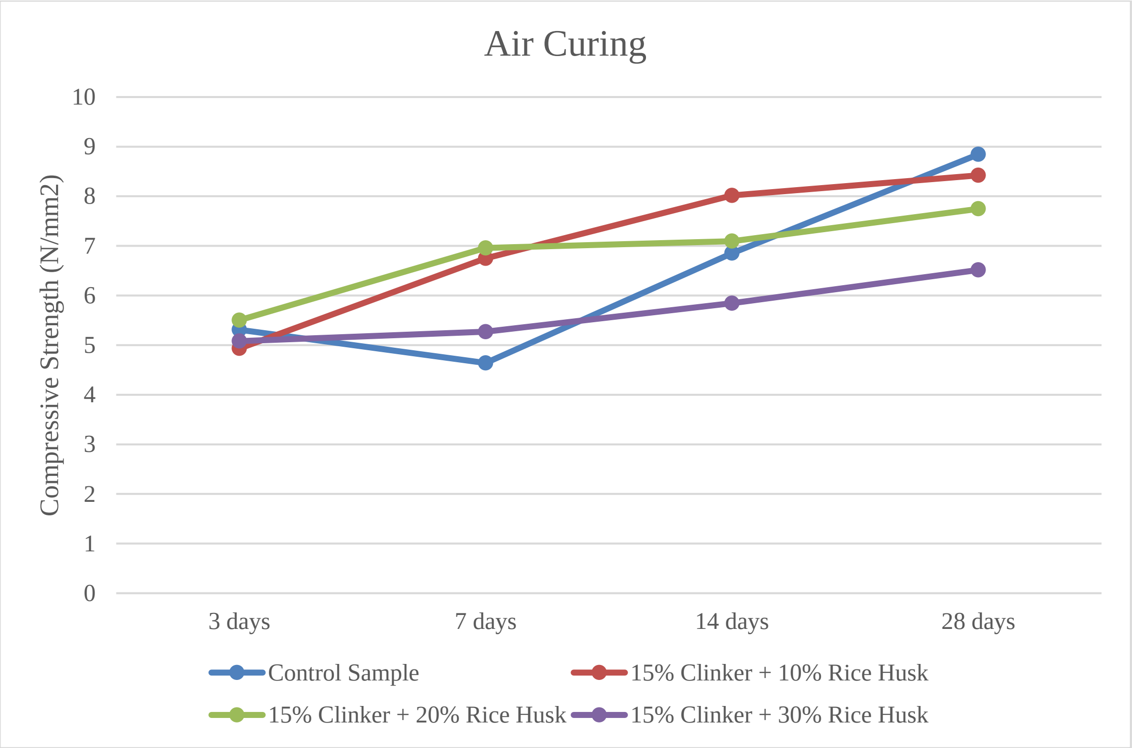

Figure 4.5 Compressive Strength Graph for Air Curing

Based on Figure 4.5, all the sample mixed with clinker and rice husk have higher compressive strength than the control sample at the 7 days of curing. However, at the 28 days of curing, the compressive strength of control sample is higher than the other sample. The sample with ratio of 15% clinker and 10% rice husk shows the highest strength among the other ratio which is 8.42 N/mm^2.

4.2.6 Average Compressive Strength for Water Curing

Table 4.6 Average Compressive Strength of Water Curing

Days	Compressive Strength (N/mm^2)			
	Control sample	15% Clinker + 10% Rice Husk	15% Clinker + 20% Rice Husk	15% Clinker + 30% Rice Husk
3	4.50	4.00	3.28	4.88
7	5.49	6.35	6.84	5.05
14	5.94	6.85	6.95	5.63
28	8.45	6.92	7.63	5.80

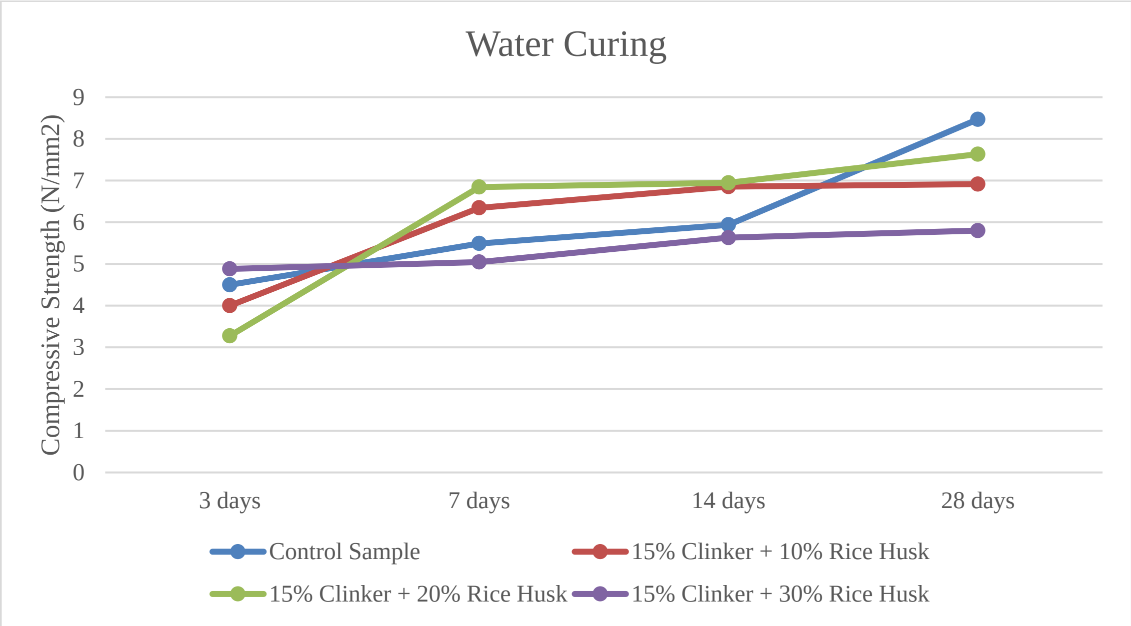

Figure 4.6 Compressive Strength Graph for Water Curing

The Table 4.6 and Figure 4.6 shows the average compressive strength for water curing. The brick with ratio of 15% clinker and 20% shows the highest compressive strength among the other ratio at the 7, 14 and 28 days of curing. The brick with ratio of 15% clinker and 30% rice husk shows only high strength at the 3 day of curing but not at the 7,14 and 28 days.

4.3 FLEXURAL STRENGTH

4.3.1 Average Flexural Strength for Control Sample

Table 4.7 Average Flexural Strength of Control Sample

Days	Flexural Strength (N/mm^2)	
	Air Curing	**Water Curing**
3	0.159	0.171
7	0.170	0.168
14	0.179	0.210
28	0.209	0.267

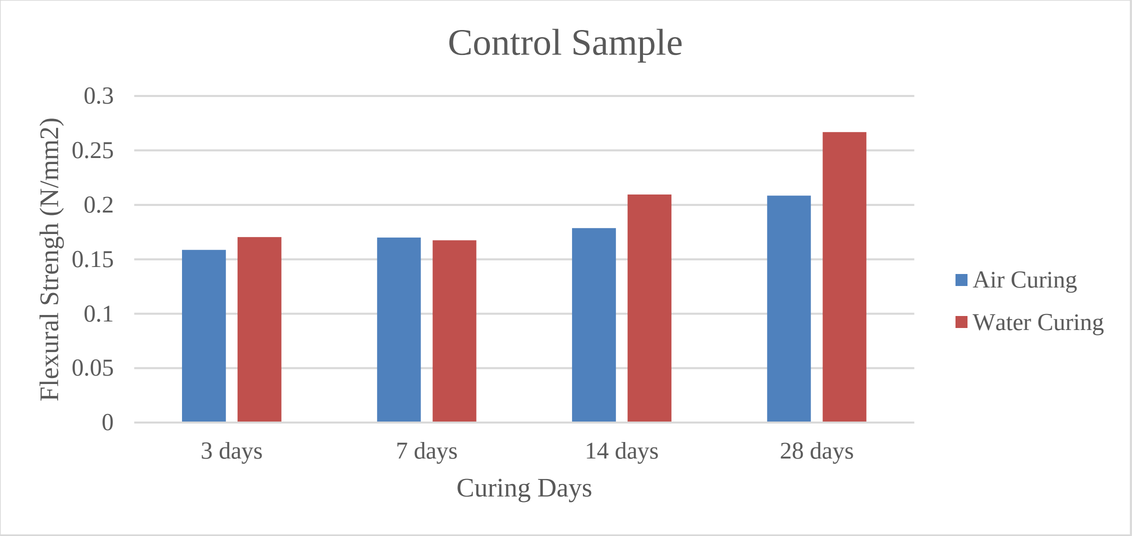

Figure 4.7 Flexural Strength Graph of Control Sample

The Table 4.7 and Figure 4.7 shows the result of the flexural strength of control sample. According to the graph, the highest flexural strength achieved is 0.267 N/mm2 with water curing method at 28 days of curing. In overall, the water curing method shows a higher flexural strength than the air curing method.

4.3.2 Average Flexural Strength for 15% Clinker with 10% Rice Husk Sample

Table 4.8 Average Flexural Strength of 15% Clinker with 10% Rice Husk Sample

Days	Flexural Strength (N/mm^2)	
	Air Curing	Water Curing
3	0.134	0.138
7	0.179	0.162
14	0.184	0.189
28	0.233	0.249

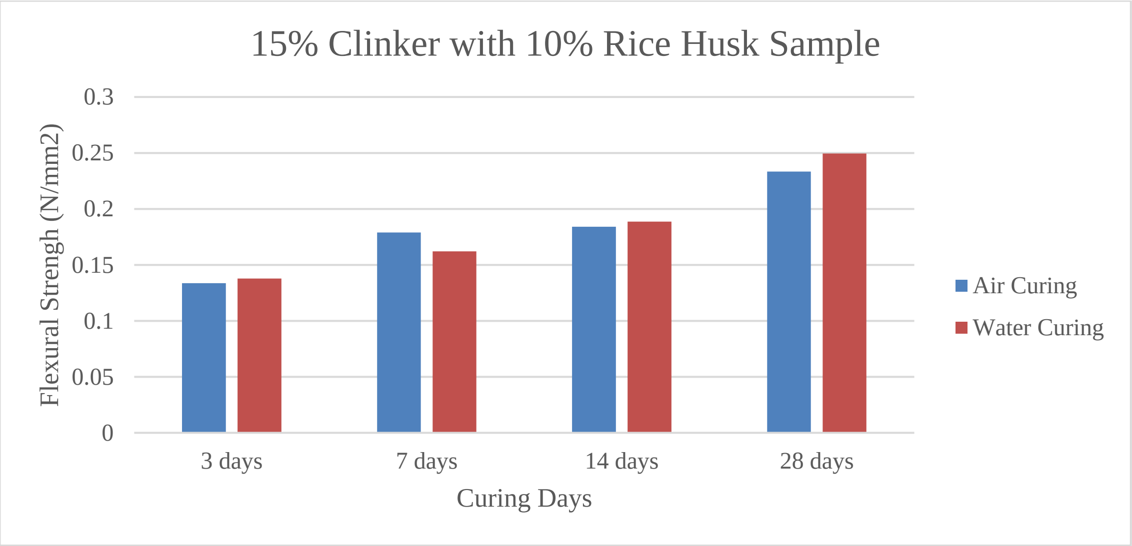

Figure 4.8 Flexural Strength Graph of 15% Clinker with 10% Rice Husk Sample

The bar graph from Figure 4.8 shows the flexural strength of 15% clinker with 10% rice husk sample. At the 3 days of curing the flexural strength achieved only 0.134 N/mm2 for air curing and 0.138 N/mm2 for water curing. The strength gradually increases until the 28 days of curing achieving the highest strength which is 0.233 N/mm2 for air curing and 0.249 N/mm2 for water curing. In overall, the flexural strength from water curing method shows a higher result compared to air curing method.

4.3.3 Average Flexural Strength for 15% Clinker with 20% Rice Husk Sample

Table 4.9 Average Flexural Strength of 15% Clinker with 20% Rice Husk Sample

Days	Flexural Strength (N/mm^2)	
	Air Curing	**Water Curing**
3	0.183	0.168
7	0.187	0.178
14	0.190	0.188
28	0.207	0.208

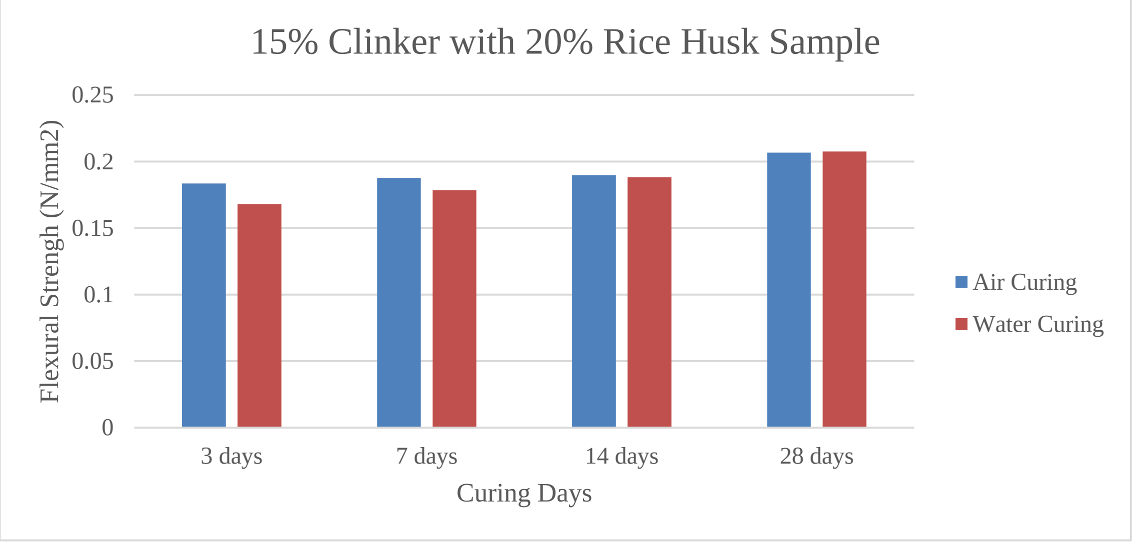

Figure 4.9 Flexural Strength Graph of 15% Clinker with 20% Rice Husk Sample

The graph in Figure 4.9 shows the flexural strength for sample of 15% clinker with 20% rice husk changes with the number of curing days. At the 3 days until 28 days of curing, the flexural strength shows only small increase of value over time. Both curing method also shows only minimal differences at each respective curing days. The highest flexural strength is at 0.208 N/mm2 from water curing with difference only 0.001 N/mm2 to air curing.

4.3.4 Average Flexural Strength for 15% Clinker with 30% Rice Husk Sample

Table 4.10 Average Flexural Strength of 15% Clinker with 30% Rice Husk Sample

Days	Flexural Strength (N/mm^2)	
	Air Curing	Water Curing
3	0.126	0.122
7	0.132	0.127
14	0.140	0.167
28	0.216	0.239

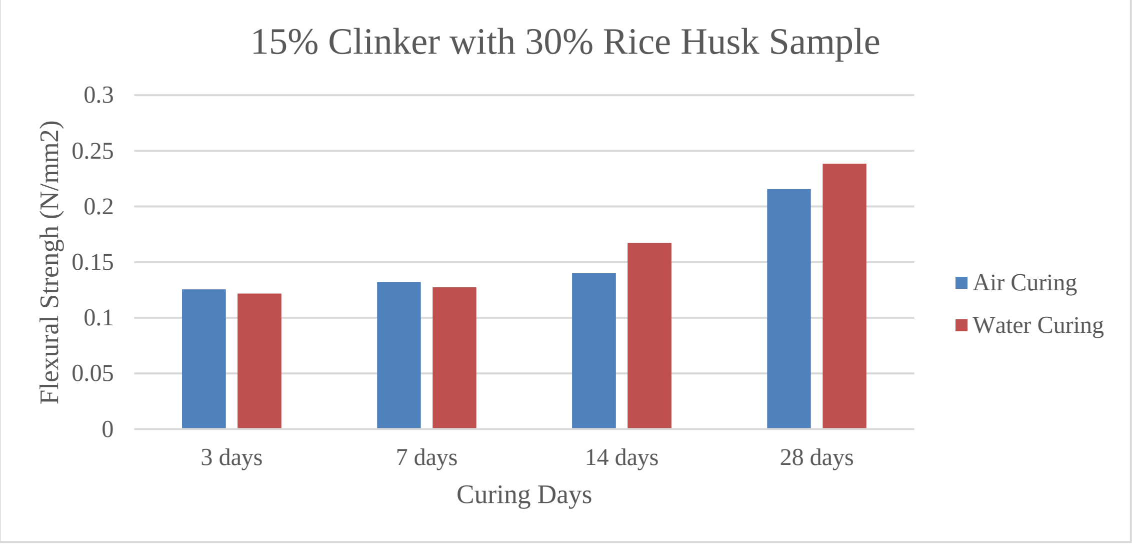

Figure 4.10 Flexural Strength Graph of 15% Clinker with 30% Rice Husk Sample

Table 4.10 and Figure 4.10 shows the flexural strength of sample consists of 15% clinker with 30% rice husk. The flexural strength shows only a slight increase at the 3 and 7 days of curing. However, the flexural strength increase drastically from the 14 until 28 days of curing. The highest flexural strength achieved is 0.239 N/mm2 by the water curing method.

4.3.5 Average Flexural Strength for Air Curing

Table 4.11 Average Flexural Strength of Air curing

Days	Flexural Strength (N/mm^2)			
	Control sample	**15% Clinker + 10% Rice Husk**	**15% Clinker + 20% Rice Husk**	**15% Clinker + 30% Rice Husk**
3	0.159	0.134	0.183	0.126
7	0.170	0.179	0.188	0.132
14	0.179	0.184	0.190	0.140
28	0.209	0.233	0.207	0.216

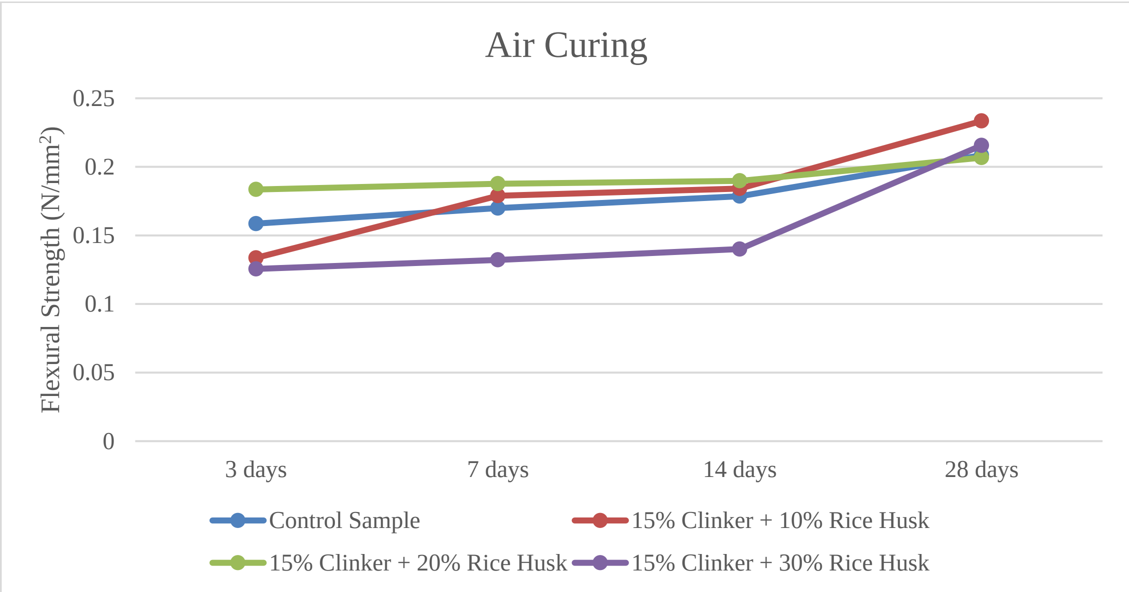

Figure 4.11 Flexural Strength Graph for Air curing

From the flexural graph, the sample of 15% clinker with 20% rice husk shows the highest flexural strength at the 3, 7 and 14 days but the strength drop at the 28 days. Sample of 15% clinker with 10% rice husk achieved 0.233 N/mm^2 at the 28 days which is higher than other sample.

4.3.6 Average Flexural Strength for Water Curing

Table 4.12 Average Flexural Strength of Water Curing

Days	Flexural Strength (N/mm^2)			
	Control sample	**15% Clinker + 10% Rice Husk**	**15% Clinker + 20% Rice Husk**	**15% Clinker + 30% Rice Husk**
3	0.170	0.138	0.168	0.122
7	0.168	0.162	0.178	0.127
14	0.210	0.189	0.188	0.167
28	0.267	0.249	0.208	0.239

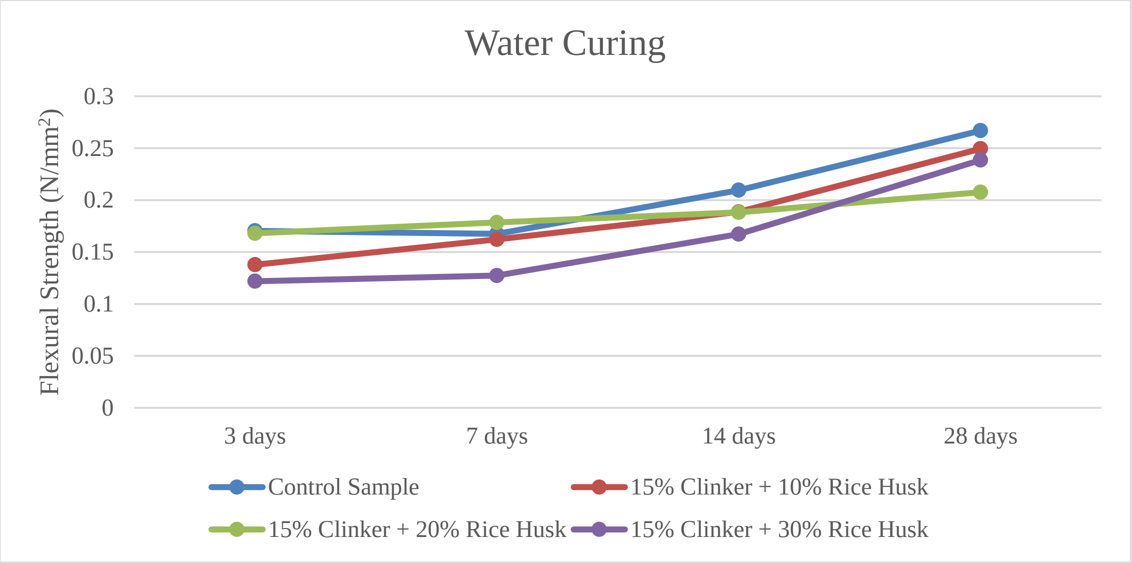

Figure 4.12 Flexural Strength Graph for Water Curing

Based on Figure 4.12, at the 3 days of curing the control sample have the highest strength followed by the sample of 15% clinker with 20% rice husk with only 0.002 N/mm^2 difference. However, at the 28 days, the sample with 15% clinker and 10% rice husk achieved the highest strength after the control sample.

4.4 DENSITY

4.4.1 Density at 28 Days

Table 4.13 Density of Samples at 28 Days

Ratio	Density (kN/m3)	
	Air curing	Water curing
Control Sample	19.06	19.17
15% Clinker + 10% Rice Husk	19.35	20.17
15% Clinker + 20% Rice Husk	18.03	18.14
15% Clinker + 30% Rice Husk	18.64	17.83

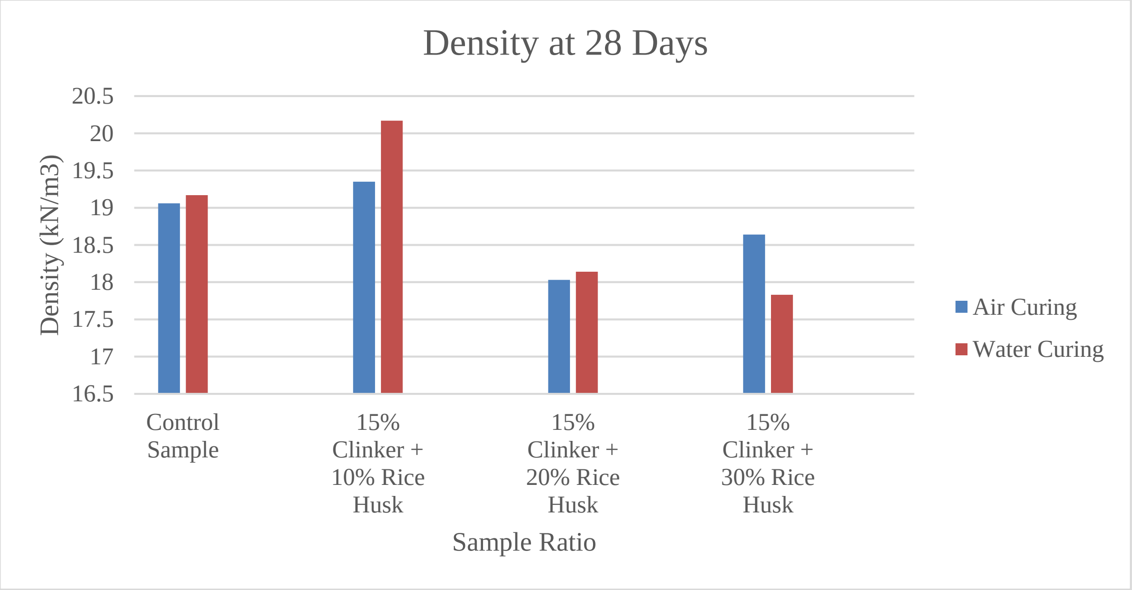

Figure 4.13 Density Graph of Samples at 28 Days

The Figure 4.13 shows the relationship of density with the sample ratio along with curing method at 28 days. The density is at the highest at the 15% clinker with 10% rice husk sample higher than the control sample. However, with the increase percentage of rice husk, the density values become lower. The water curing method shows an effective method to get a high density value.

4.5 WATER ABSORPTION

4.5.1 Water Absorption Percentage at 28 Days

Table 4.14 Water Absorption Percentage Samples at 28 Days

Ratio	**Water Absorption (%)**	
	Air curing	**Water curing**
Control Sample	11.22	11.88
15% Clinker + 10% Rice Husk	10.24	9.84
15% Clinker + 20% Rice Husk	13.42	9.69
15% Clinker + 30% Rice Husk	14.24	10.99

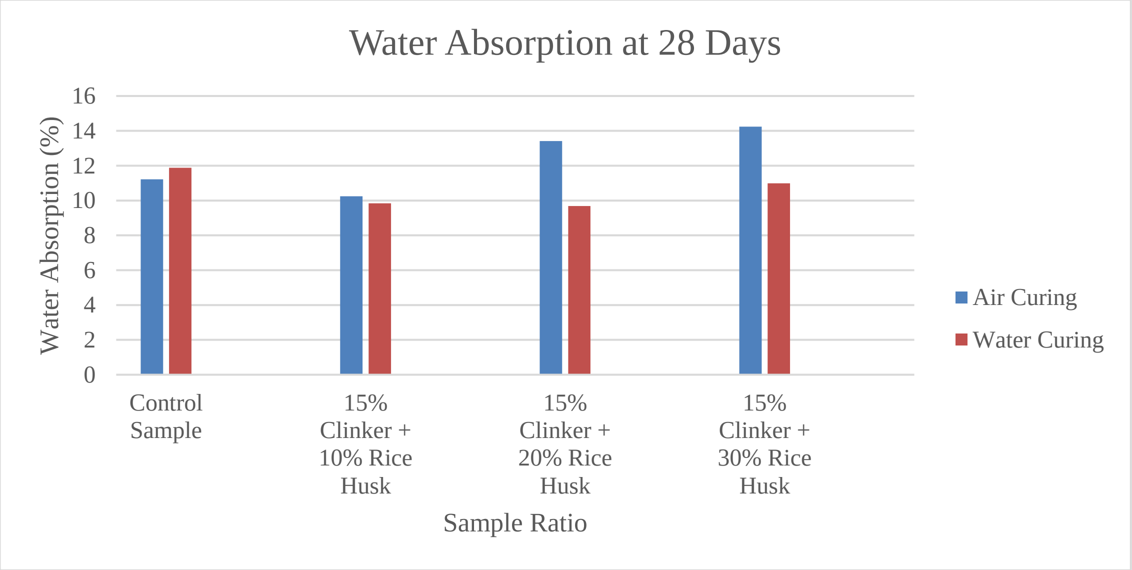

Figure 4.14 Water Absorption Percentage Graph at 28 Days

Table 4.14 and Figure 4.14 graph shows the water absorption percentage changes with the ratio of clinker and rice husk present in the sample based on type of curing at 28 days. The sample using the air curing method shows a higher percentage of water absorption compared to the water curing method. The highest percentage of water absorption achieved is 14.24% from the sample of 15% clinker with 30% rice husk.

4.6 DISCUSSION

From the result shown above, all the sample ratio affecting the compressive strength, flexural strength, density and water absorption has been discussed. From the finding of compressive strength, the optimum sample is the sample with ratio of 15% clinker with 10% rice husk achieving 8.42 N/mm^2 using the air curing method at 28 days. For the flexural strength, the most optimum sample is also the sample with ratio of 15% clinker with 10% rice husk at 0.249 N/mm^2 using the water curing method at 28 days. In the density also, the highest density which is 20.17 kN/m^3 comes from the sample of 15% clinker with 10% rice husk. Apart from that, in the water absorption, the sample with the highest percentage of rice husk reached the highest water absorption which is at 14.24% at the 28 days. This result proved that the higher percentage of rice husk increase the water absorption in the brick.

CHAPTER 5

CONCLUSION

5.1 GENERAL

This study focus to determine the strength of the brick with the clinker as partial replacement for fine aggregate with ratio of 15% with rice husk of 10%, 20% and 30%. The results are compared with standard brick to find out whether it is suitable to use in construction. The production of the brick will reduce the waste material disposal and help to improve the properties of sand brick.

5.2 CONCLUSION

The compressive strength and flexural strength of the bricks are depends on the percentage and type of materials used. From this experiment, the compressive strength and the flexural strength of the brick is lower than the control sample brick. This is because the present of the rice husk in the brick will reduce the strength of brick.

In the density test, only the brick with ratio of 15% clinker and 10% rice husk shows a higher density than the control brick. Whereas, other sample shows a lower density than the control sample brick. It shows that the higher percentage of rice husk will reduce more density. From the water absorption results, the brick with high percentage of rice husk absorbs more water.

In conclusion, the clinker and rice husk can be used as partial replacement for fine aggregate in the making of brick. However, the strength achieved from this brick might not be same as the control brick. Through the study, it can be concluded that the best ratio for the replacement is 10% clinker and 10% rice husk. For the curing method, the air curing is the best method to use.

5.3 RECOMMENDATION

The following recommendations are offered based on the findings and conclusion of the study.

I. It is recommended that the percentage ratio of clinker and rice husk should be reduce to get a higher compressive and flexural strength.

II. It is also recommended to reduce both the size of clinker and rice husk as it will be used as partial replacement for fine aggregate.

III. Construct a better mould using steel to produce a more accurate size of brick.

IV. Handle the testing machine properly to get a more accurate results.

REFERENCES

Mohd Zamin, J. et al., 2015. Characteristics of palm oil clinker as replacement for oil palm shell in lightweight concrete subjected to elevated temperature. *Construction and Building Materials*, pp. 942-951.

Jabatan Kerja Raya (2005). In: *Standard Specifications for Building Works*. MS 20800.

Anuradha, G., Prem, D. G. & P. V. Ramachandra, l., 1992. Combustion and gasification characteristics of rice husk. *FUEL*, Volume 71.

Badorul Hisham, A. B. & Brook, J. J., 2015. INFLUENCE OF UNIT WATER ABSORPTION ON DEFORMATION OF MASONRY. *Canada Masonry Design Centre.*

Banu, T., Md. Muktadir, B., Gulshan, F. & Kurny, A., 2013. Experimental Studies on Fly Ash-Sand-Lime Bricks with Gypsum Addition. *American Journal of Materials Engineering and Technology*, Volume I, pp. 35-40.

Bernard K., B., Kofi, A. & Joseph K., J. K. O.-K., 2014. Perceptions on Barriers to the Use of Burnt Clay Bricks for Housing Construction. *Journal of Construction Engineering*, Volume 2014.

Faisal, S. K., Herman Shah, H., Nurul Bazilah, A. & Mohd Irwan, J., 2017. Sand Cement Brick Containing Recycled Concrete Aggregate as Fine-Aggregate Replacement. *MATEC Web of Conferences*, Volume 103.

Jegathish, K. & Hashim, A. R., 2015. Utilization of Palm Oil Clinker as Cement Replacement Material. *Materials*, 8(12), pp. 8817-8838.

Kumar, S., Sangwan, P., Dhankhar R., M. V. & Bidra, S., 2013. Utilization of Rice Husk and Their Ash: A Review. *Research Journal of Chemical and Environmental Sciences*, I(5), pp. 126-129.

Matysek, P. & Witkowski, M., 2015. A Comparative Study on the Compressive Strength of Bricks from Different Historical Periods. *International Journal of Architectural Heritage.*

Moayad N., A.-K. & Hana A., Y., 1984. Use of rice husk ash in concrete. *The International Journal of Cement Composites and Lightweight Concrete*, 6(4).

Mohammad Razaul, K., Huzaifa, H. & Hashim, A. R., 2016. Assessment of pozzolanic activity of palm oil clinker powder. *Construction and Building Materials*, pp. 335-343.

Mohammad Razaul, K., Huzaifa, H., Hashim, A. R. & Sumiani, Y., 2016. Characterization of palm oil clinker powder for utilization in cement-based applications. *Construction and Building Materials,* pp. 21-29.

Rasel, A. et al., 2015. Performance evaluation of palm oil clinker as coarse aggregate in high strength lightweight concrete. *Journal of Cleaner Production*, pp. 1-9.

Sanghera, K., 2014. *George Lines.* [Online]
Available at: https://www.georgelines.co.uk/building-materials-2/engineering-brick/
[Accessed 12 December 2017].

Ying, L. et al., 2011. A new method of comprehensive utilization of rice husk. *Journal of Hazardous Materials*, pp. 2151-2156.

APPENDIX A

Control sample of for air curing 3 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm^2)	Flexural strength (N/mm2)
1	3.915	0.025425	127.7	-	5.02	-
2	3.867	0.025425	128.7	-	5.06	-
3	3.907	0.025425	138.5	-	5.46	-
4	3.967	0.025425	145.0	-	5.70	-
5	4.037	0.025425	-	4.36	-	0.171
6	3.899	0.025425	-	3.23	-	0.127
7	4.020	0.025425	-	4.51	-	0.177
8	-	-	-		-	-
	Average				5.31	0.158

Control sample of for water curing 3 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	4.075	0.025425	146.6	-	4.54	-
2	3.977	0.025425	114.1	-	3.85	-
3	4.164	0.025425	161.0	-	4.72	-
4	4.161	0.025425	152.6	-	4.88	-
5	4.223	0.025425	-	4.91	-	0.193
6	4.200	0.025425	-	4.52	-	0.178
7	4.095	0.025425	-	4.31	-	0.170
8	4.073	0.025425	-	3.59	-	0.141
	Average				4.50	0.170

Control sample of for air curing 7 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.758	0.025425	113.1	-	4.45	-
2	3.634	0.025425	102.1	-	4.21	-
3	3.677	0.025425	108.3	-	4.26	-
4	3.830	0.025425	143.1	-	5.63	-
5	3.583	0.025425	-	3.74	-	0.147
6	3.840	0.025425	-	4.07	-	0.160
7	3.913	0.025425	-	5.15	-	0.203
8	3.663	0.025425	-	-	-	-
	Average				4.64	0.170

Control sample of for water curing 7 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.968	0.025425	146.6	-	5.77	-
2	4.108	0.025425	114.1	-	3.85	-
3	4.069	0.025425	161.0	-	6.33	-
4	4.054	0.025425	152.6	-	6.00	-
5	3.804	0.025425	-	3.56	-	0.140
6	3.994	0.025425	-	5.42	-	0.213
7	3.684	0.025425	-	2.73	-	0.107
8	4.077	0.025425	-	5.32	-	0.209
	Average				5.49	0.168

Control sample of for air curing 14 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.728	0.025425	181.0	-	7.12	-
2	3.685	0.025425	176.8	-	6.95	-
3	3.727	0.025425	164.8	-	6.48	-
4	-	0.025425	-	-	-	-
5	3.646	0.025425	-	5.24	-	0.206
6	3.681	0.025425	-	4.35	-	0.171
7	3.316	0.025425	-	4.03	-	0.159
8	-	0.025425	-	-	-	-
	Average				6.85	0.179

Control sample of for water curing 14 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	4.061	0.025425	177.8	-	7.00	-
2	3.920	0.025425	157.3	-	6.19	-
3	4.005	0.025425	118.0	-	4.64	-
4	-	0.025425	-	-	-	-
5	3.841	0.025425	-	5.30	-	0.209
6	4.039	0.025425	-	6.01	-	0.236
7	3.883	0.025425	-	4.67	-	0.184
8	-	0.025425	-	-	-	-
	Average				5.94	0.210

Control sample of for air curing 28 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.846	0.025425	228.5	-	8.99	-
2	3.805	0.025425	199.2	-	7.84	-
3	3.890	0.025425	219.4	-	8.61	-
4	3.954	0.025425	252.4	-	-	-
5	3.942	0.025425	-	5.07	-	0.199
6	3.928	0.025425	-	5.14	-	0.276
7	3.885	0.025425	-	5.69	-	0.248
8	-	0.025425	-	-	-	-
	Average				8.85	0.267

Control sample of for water curing 28 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	4.263	0.025425	245.9	-	9.67	-
2	4.292	0.025425	214.1	-	8.42	-
3	4.212	0.025425	192.5	-	7.57	-
4	4.293	0.025425	208.8	-	8.21	-
5	4.212	0.025425	-	7.04	-	0.277
6	4.339	0.025425	-	7.01	-	0.276
7	4.257	0.025425	-	6.31	-	0.248
8	4.222	0.025425	-	6.18	-	0.267
	Average				8.47	0.267

APPENDIX B

Sample of 15% Clinker with 10% Rice Husk for air curing at 3 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.616	0.025425	104.7	-	4.12	-
2	3.591	0.025425	134.7	-	5.30	-
3	3.584	0.025425	132.4	-	5.21	-
4	3.594	0.025425	129.8	-	5.11	-
5	3.575	0.025425	-	3.03	-	0.119
6	3.512	0.025425	-	3.55	-	0.140
7	3.554	0.025425	-	3.52	-	0.138
8	3.642	0.025425	-	3.49	-	0.137
	Average				4.93	0.134

Sample of 15% Clinker with 10% Rice Husk for water curing at 3 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.882	0.025425	71.1	-	2.80	-
2	3.916	0.025425	113.5	-	4.46	-
3	3.904	0.025425	112.7	-	4.43	-
4	3.911	0.025425	109.5	-	4.31	-
5	3.944	0.025425	-	3.53	-	0.139
6	3.967	0.025425	-	3.48	-	0.137
7	3.971	0.025425	-	3.52	-	0.138
8	3.947	0.025425	-	3.48	-	0.137
	Average				4.00	0.138

Sample of 15% Clinker with 20% Rice Husk for air curing at 3 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.769	0.025425	146.6	-	5.77	-
2	3.911	0.025425	131.6	-	5.18	-
3	3.910	0.025425	144.2	-	5.67	-
4	3.866	0.025425	137.2	-	5.40	-
5	4.010	0.025425	-	5.26	-	0.207
6	3.731	0.025425	-	4.35	-	0.171
7	3.842	0.025425	-	4.63	-	0.182
8	3.857	0.025425	-	4.42	-	0.174
	Average				5.50	0.183

Sample of 15% Clinker with 20% Rice Husk for water curing at 3 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.960	0.025425	86.7	-	3.41	-
2	4.071	0.025425	77.3	-	3.04	-
3	3.904	0.025425	85.8	-	3.37	-
4	4.005	0.025425	83.3	-	3.28	-
5	4.199	0.025425	-	4.56	-	0.179
6	4.135	0.025425	-	3.85	-	0.151
7	4.177	0.025425	-	4.41	-	0.173
8	3.981	0.025425	-	4.27	-	0.168
	Average				3.28	0.168

Sample of 15% Clinker with 30% Rice Husk for air curing at 3 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.459	0.025425	138.7	-	5.46	-
2	3.363	0.025425	124.1	-	4.88	-
3	3.450	0.025425	122.5	-	4.82	-
4	3.476	0.025425	131.4	-	5.17	-
5	3.397	0.025425	-	3.43	-	0.135
6	3.226	0.025425	-	2.75	-	0.108
7	3.214	0.025425	-	3.42	-	0.135
8	3.363	0.025425	-	3.17	-	0.125
	Average				5.08	0.126

Sample of 15% Clinker with 30% Rice Husk for water curing at 3 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.645	0.025425	128.4	-	5.05	-
2	3.444	0.025425	114.9	-	4.52	-
3	3.574	0.025425	126.3	-	4.97	-
4	3.421	0.025425	126.8	-	4.99	-
5	3.189	0.025425	-	3.30	-	0.130
6	3.451	0.025425	-	2.78	-	0.109
7	3.433	0.025425	-	3.27	-	0.129
8	3.453	0.025425	-	3.04	-	0.120
	Average				4.88	0.122

APPENDIX C

Sample of 15% Clinker with 10% Rice Husk for air curing at 7 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.658	0.025425	173.1	-	6.81	-
2	3.574	0.025425	183.8	-	7.23	-
3	3.738	0.025425	183.9	-	7.23	-
4	3.451	0.025425	145.5	-	5.72	-
5	3.822	0.025425	-	4.56	-	0.179
6	3.496	0.025425	-	3.57	-	0.140
7	3.797	0.025425	-	4.53	-	0.178
8	3.814	0.025425	-	5.54	-	0.218
	Average				6.75	0.179

Sample of 15% Clinker with 10% Rice Husk for water curing at 7 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.810	0.025425	156.6	-	6.16	-
2	3.907	0.025425	158.2	-	6.22	-
3	3.746	0.025425	134.7	-	5.30	-
4	3.857	0.025425	195.8	-	7.70	-
5	3.890	0.025425	-	4.38	-	0.172
6	3.986	0.025425	-	4.58	-	0.180
7	3.727	0.025425	-	4.03	-	0.159
8	3.940	0.025425	-	3.50	-	0.138
	Average				6.35	0.162

Sample of 15% Clinker with 20% Rice Husk for air curing at 7 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.466	0.025425	195.7	-	7.70	-
2	3.628	0.025425	167.9	-	6.60	-
3	3.500	0.025425	180.5	-	7.10	-
4	3.376	0.025425	163.6	-	6.43	-
5	3.758	0.025425	-	3.97	-	0.156
6	3.828	0.025425	-	5.57	-	0.219
7	3.684	0.025425	-	4.51	-	0.177
8	3.591	0.025425	-	5.04	-	0.198
	Average				6.96	0.188

Sample of 15% Clinker with 20% Rice Husk for water curing at 7 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.697	0.025425	162.3	-	6.38	-
2	3.695	0.025425	191.7	-	7.54	-
3	3.711	0.025425	195.1	-	7.67	-
4	3.712	0.025425	146.9	-	5.78	-
5	3.621	0.025425	-	4.62	-	0.182
6	3.717	0.025425	-	4.65	-	0.183
7	3.834	0.025425	-	4.21	-	0.166
8	3.621	0.025425	-	4.67	-	0.184
	Average					0.178

Sample of 15% Clinker with 30% Rice Husk for air curing at 7 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.314	0.025425	139.8	-	5.50	-
2	3.341	0.025425	138.9	-	5.46	-
3	3.166	0.025425	134.8	-	5.30	-
4	3.151	0.025425	122.4	-	4.81	-
5	3.373	0.025425	-	3.46	-	0.136
6	3.406	0.025425	-	3.42	-	0.135
7	3.129	0.025425	-	3.21	-	0.126
8	2.991	0.025425	-	3.35	-	0.132
	Average				5.27	0.132

Sample of 15% Clinker with 30% Rice Husk for water curing at 7 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.491	0.025425	144.0	-	5.66	-
2	3.544	0.025425	133.2	-	5.24	-
3	3.568	0.025425	119.6	-	4.70	-
4	3.532	0.025425	116.3	-	4.57	-
5	3.543	0.025425	-	2.78	-	0.109
6	3.500	0.025425	-	3.82	-	0.150
7	3.460	0.025425	-	3.46	-	0.136
8	3.611	0.025425	-	2.89	-	0.114
	Average				5.05	0.127

APPENDIX D

Sample of 15% Clinker with 10% Rice Husk for air curing at 14 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.658	0.025425	208.1	-	8.18	-
2	3.564	0.025425	178.0	-	7.00	-
3	3.832	0.025425	213.4	-	8.39	-
4	3.788	0.025425	215.8	-	8.49	-
5	3.516	0.025425	-	3.90	-	0.153
6	3.541	0.025425	-	5.75	-	0.226
7	3.529	0.025425	-	4.39	-	0.173
8	3.671	0.025425	-	4.69	-	0.184
	Average				8.02	0.184

Sample of 15% Clinker with 10% Rice Husk for water curing at 14 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	4.065	0.025425	158.1	-	6.22	-
2	3.788	0.025425	170.7	-	6.71	-
3	3.878	0.025425	176.4	-	6.94	-
4	3.864	0.025425	191.9	-	7.55	-
5	3.625	0.025425	-	4.67	-	0.184
6	4.133	0.025425	-	5.84	-	0.230
7	3.695	0.025425	-	4.11	-	0.162
8	3.832	0.025425	-	4.57	-	0.180
	Average				6.85	0.189

Sample of 15% Clinker with 20% Rice Husk for air curing at 14 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.475	0.025425	176.6	-	6.95	-
2	3.358	0.025425	183.4	-	7.21	-
3	3.380	0.025425	181.2	-	7.13	-
4	3.362	0.025425	180.4	-	7.10	-
5	3.400	0.025425	-	4.49	-	0.177
6	3.550	0.025425	-	4.65	-	0.183
7	3.581	0.025425	-	4.42	-	0.174
8	3.440	0.025425	-	5.74	-	0.226
	Average				7.10	0.190

Sample of 15% Clinker with 20% Rice Husk for water curing at 14 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.670	0.025425	172.4	-	6.78	-
2	3.780	0.025425	163.1	-	6.41	-
3	3.858	0.025425	173.7	-	6.83	-
4	3.744	0.025425	197.2	-	7.76	-
5	3.679	0.025425	-	5.10	-	0.201
6	3.810	0.025425	-	4.37	-	0.172
7	3.882	0.025425	-	5.01	-	0.197
8	3.836	0.025425	-	4.66	-	0.183
	Average					0.188

Sample of 15% Clinker with 30% Rice Husk for air curing at 14 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.244	0.025425	152.1	-	5.98	-
2	3.254	0.025425	125.3	-	4.93	-
3	3.271	0.025425	139.3	-	5.48	-
4	3.349	0.025425	177.6	-	6.99	-
5	3.150	0.025425	-	3.53	-	0.139
6	3.093	0.025425	-	3.74	-	0.147
7	3.059	0.025425	-	3.46	-	0.136
8	2.823	0.025425	-	3.51	-	0.138
	Average				5.84	0.140

Sample of 15% Clinker with 30% Rice Husk for water curing at 14 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.513	0.025425	152.4	-	5.99	-
2	3.594	0.025425	113.1	-	4.45	-
3	3.587	0.025425	161.1	-	6.34	-
4	3.696	0.025425	146.0	-	5.74	-
5	3.323	0.025425	-	3.68	-	0.145
6	3.543	0.025425	-	4.45	-	0.175
7	3.385	0.025425	-	4.35	-	0.171
8	3.663	0.025425	-	4.53	-	0.178
	Average				5.63	0.167

APPENDIX E

Sample of 15% Clinker with 10% Rice Husk for air curing at 28 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.676	0.025425	174.5	-	6.86	-
2	3.749	0.025425	224.7	-	8.84	-
3	3.553	0.025425	236.5	-	9.30	-
4	3.334	0.025425	220.8	-	8.68	-
5	3.631	0.025425	-	6.30	-	0.248
6	3.656	0.025425	-	6.64	-	0.261
7	3.511	0.025425	-	5.70	-	0.224
8	3.461	0.025425	-	5.10	-	0.201
	Average				8.42	0.233

Sample of 15% Clinker with 10% Rice Husk for water curing at 28 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.876	0.025425	181.3	-	7.13	-
2	3.980	0.025425	164.2	-	6.46	-
3	3.827	0.025425	178.6	-	7.02	-
4	3.922	0.025425	179.2	-	7.05	-
5	3.658	0.025425	-	6.56	-	0.270
6	3.753	0.025425	-	6.06	-	0.238
7	3.856	0.025425	-	5.62	-	0.221
8	3.774	0.025425	-	6.83	-	0.269
	Average				6.92	0.249

Sample of 15% Clinker with 20% Rice Husk for air curing at 28 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.278	0.025425	172.2	-	6.77	-
2	3.418	0.025425	229.5	-	9.03	-
3	3.558	0.025425	167.2	-	6.58	-
4	3.251	0.025425	218.9	-	8.61	-
5	3.097	0.025425	-	5.67	-	0.223
6	3.380	0.025425	-	4.73	-	0.186
7	3.142	0.025425	-	5.17	-	0.203
8	3.211	0.025425	-	5.45	-	0.214
	Average				7.75	0.207

Sample of 15% Clinker with 20% Rice Husk for water curing at 28 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.518	0.025425	210.1	-	8.26	-
2	3.503	0.025425	173.0	-	6.80	-
3	3.527	0.025425	223.9	-	8.81	-
4	3.514	0.025425	169.3	-	6.66	-
5	3.545	0.025425	-	4.70	-	0.185
6	3.614	0.025425	-	5.10	-	0.201
7	3.529	0.025425	-	5.79	-	0.228
8	3.574	0.025425	-	5.52	-	0.217
	Average				7.63	0.208

Sample of 15% Clinker with 30% Rice Husk for air curing at 28 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.586	0.025425	165.7	-	6.51	-
2	3.299	0.025425	189.8	-	7.47	-
3	3.016	0.025425	132.4	-	5.21	-
4	3.124	0.025425	174.6	-	6.87	-
5	3.525	0.025425	-	6.05	-	0.238
6	3.216	0.025425	-	4.69	-	0.184
7	3.093	0.025425	-	5.27	-	0.207
8	3.321	0.025425	-	5.92	-	0.233
	Average				6.51	0.216

Sample of 15% Clinker with 30% Rice Husk for water curing at 28 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (N/mm2)	Flexural strength (N/mm2)
1	3.837	0.025425	151.1	-	5.94	-
2	3.716	0.025425	131.8	-	5.18	-
3	3.900	0.025425	154.3	-	6.07	-
4	3.880	0.025425	152.7	-	6.01	-
5	3.950	0.025425	-	5.66	-	0.223
6	3.632	0.025425	-	6.12	-	0.241
7	3.802	0.025425	-	6.31	-	0.248
8	3.741	0.025425	-	6.17	-	0.243
	Average				5.80	0.239

APPENDIX F

Density Test Result at 28 Days

Ratio	Types of Curing	Area (m^2)	Weight after oven (kg)	Density (kg/m^3)	Density (kN/m^3)
Control	Air	0.025425	3.705	1942.97	19.06
Sample	Water	0.025425	3.727	1954.51	19.17
15% Clinker +	Air	0.025425	3.398	1972.86	19.35
10% Rice Husk	Water	0.025425	3.599	2056.77	20.17
15% Clinker +	Air	0.025425	3.151	1838.61	18.03
20% Rice Husk	Water	0.025425	3.275	1849.62	18.14
15% Clinker +	Air	0.025425	3.171	1900.49	18.64
30% Rice Husk	Water	0.025425	3.187	1818.16	17.83

APPENDIX G

Water Absorption Test Result at 28 Days

Ratio	Types of Curing	Area (m^2)	Weight after oven (kg)	Weight after immersed (kg)	Water absorption (%)
Control	Air	0.025425	3.592	3.995	11.22
Sample	Water	0.025425	3.593	4.020	11.88
15% Clinker +	Air	0.025425	3.594	3.962	10.24
10% Rice Husk	Water	0.025425	3.497	3.841	9.84
15% Clinker +	Air	0.025425	3.205	3.635	13.42
20% Rice Husk	Water	0.025425	3.314	3.635	9.69
15% Clinker +	Air	0.025425	3.259	3.723	14.24
30% Rice Husk	Water	0.025425	3.476	3.858	10.99