EXPERIMENTAL STUDY OF PROPERTIES FOR SAND BRICKS WITH PALM OIL CLINKER AS PARTIAL REPLACEMENT FOR FINE AGGREGATE WITH RATIO OF 5% WITH RICE HUSK 10%, 20% AND 30%

MOHAMAD SAFWAN BIN PAUZI

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

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MOHAMAD SAFWAN BIN PAUZI

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ABSTRAK

Bata telah digunakan secara meluas di dalam pembinaan dan sebagai bahan untuk bangunan di seluruh pelusuk dunia. Kajian ini bertujuan untuk menentukan bahan sisa kekuatan mampatan, kekuatan lenturan, ketumpatan dan penyerapan air seperti klinker minyak sawit dengan sekam padi sebagai pengganti agregat halus (pasir) untuk membuat bata pasir. Dari bahan buangan tersebut ianya boleh dijadikan sebagai bata yang mesra ekonomi yang memberikan banyak manfaat untuk kita semua sebagai contoh boleh menjimatkan kos dan boleh mengurangkan pelupusan sampah yang terbiar. Nisbah yang digunakan sebagai pengganti batu halus iaitu pasir adalah 5% klinker minyak kelapa sawit dengan 10%, 20% dan 30% sekam padi. Nisbah mortar pula adalah 1:6 yang bermaksud satu (1) adalah bahagian simen untuk enam (6) adalah bahagian pasir mengikut Jabatan Kerja Raya (JKR) spesifikasi di dalam seksysen E (kerja bata) dalam fasal 3.1. Saiz bata pasir yang mengikut JKR specifikasi adalah 225 mm x 113 mm x 75mm untuk satu bata. Sampel hasilnya pada empat pengujian yang merupakan kekuatan mampatan, kekuatan lentur, ketumpatan dan penyerapan air. Prosedur ujian mengikut piawaian ASTM dan JKR. Tujuan penyelidikan ini adalah untuk mencari nisbah terbaik untuk membuat kualiti bata pasir yang berkualiti berdasarkan piawaian JKR. Umur pengawetan sampel untuk eksperimen ini adalah 3 hari, 7 hari, 14 hari dan 28 hari. Setiap hari mengubati menggunakan 64 sampel bata pasir untuk setiap ujian tetapi hanya sampel pada umur sembuh selama 28 hari digunakan untuk ketumpatan ujian dan penyerapan air. Kekuatan mampatan tertinggi bagi nisbah yang menggantikan agregat halus yang pasir ialah pengawetan udara 5% klinker dan sekam padi 10% iaitu 8.02 MPa, kekuatan lenturan tertinggi untuk nisbah yang menggantikan agregat halus yang pasir adalah air menyembuhkan klinker 5% dan sekam padi 10% iaitu 0.265 MPa, kepadatan tertinggi bagi nisbah yang menggantikan agregat halus iaitu pasir yang menyembuhkan klinker 5% dan sekam padi 10% iaitu 17.95 kN/m^3 dan penyerapan air terendah untuk nisbah yang menggantikan agregat halus yang pasir adalah pengawetan udara 5% klinker dan sekam padi 10% yang 4,65%. Oleh itu, kesimpulannya adalah klinker 5% dengan sekam padi 10% adalah nisbah terbaik dari bata pasir ini yang menggantikan agregat halus (pasir) dengan klinker dan sekam padi. Jumlah sampel untuk eksperimen ini termasuk sampel kawalan ialah 256 unit.

ABSTRACT

Brick are widely used in construction and building material around the world. This research is to determine compressive strength, flexural strength, density and water absorption waste material such as palm oil clinker with rice husk as a replacement of fine aggregate (sand) for making a sand brick. From that waste material can be used to produce eco- friendly brick will give many benefit to all of us for example can reduce cost, can reduce from disposal to the land and idle. The ratio that used for replace fine aggregate which is sand are 5% palm oil clinker with 10%, 20% and 30% of rice husk. The ratio of the mortar is 1:6 which is consist of one (1) part of cement to six (6) parts of sand according to Jabatan Kerja Raya (JKR) of Standard Specification at section E (brickworks) in clause 3.1. The size of the sand brick according to the JKR specification is 225 mm x 113 mm x 75mm for one brick. In this process of curing there are two type of curing process that used for this experiment which is air curing and water curing. The sample the result on four testing which is compressive strength, flexural strength, density and water absorption. The testing procedure as per ASTM and JKR standard. The purpose of this research is to find the best ratio for making a good quality of sand brick based on JKR standard. The sample curing ages for this experiment are 3 days, 7 days, 14 days and 28 days. Each of curing ages days used 64 sand brick samples for the every testing but only the sample at curing age for 28 days used for testing density and water absorption. The highest compressive strength for the ratio that replace fine aggregate which is sand is air curing 5% clinker and 10% rice husk which is 8.02 MPa, the highest flexural strength for the ratio that replace fine aggregate which is sand is water curing 5% clinker and 10% rice husk which is 0.265 MPa, the highest density for the ratio that replace fine aggregate which is sand is air curing 5% clinker and 10% rice husk which is 17.95 kN/m^3 and the lowest water absorption for the ratio that replace fine aggregate which is sand is air curing 5% clinker and 10% rice husk which is 4.65%. So, the conclusion is 5% clinker with 10% rice husk was the best ratio of this sand brick that replace fine aggregate (sand) with clinker and rice husk. The total of sample for this experiment including a control sample is 256 units.

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LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
OPC	Ordinary Portland Cement
POC	Palm Oil Clinker
RH	Rice Husk
W_s	Weight of saturated
W_i	Weight of immersed
mm^2	Millimetre square
mm	millimetre
Kg	kilogram
L	Length
W	Width
H	Height
JKR	Jabatan Kerja Raya
MS	Malaysian Standard
μm	micrometre
MPa	Mega Pascal
N	Newton
MR	Modulus Rupture

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Nowadays, so many industries had been built because of the rapidly growing world population especially in urban area. So from that, industries must increasing their product because consumers increasing. For example the industries of palm oil and agriculture such as rice husk from increasing their total number of product. Consequently, will produced more by product which is wasted material and normally being dumped abundantly as waste. Malaysia is one of the primary producers of palm oil in Asia. It is the second largest palm oil-producing country in the world, producing more than half of world's palm oil annually. Malaysia generates about 3.13 million tons of palm shell as waste, which has been projected to grow because of the ongoing global consumption demand for palm oil.

For In the construction, the demand materials has been on the rise in order to sustain the fast growing global population. Nowadays, because of increasing in population has caused increasing in development. So many construction has been built in urban and rural area. Consequently, so many natural resources used for construction such as sand, gravel, trees and so on. Because of that, the use of abundant natural resources will cause the material to be limited. This interest is a result of various factors such as the ever increasing cost of raw materials and the continuous depletion of natural resources resulting in the shortage of building materials to meet the demand of the rapidly growing world population. Recently, utilization of solid waste and its by-products in construction has gained the attention of many researchers.

1.2 PROBLEM STATEMENT

Rapidly population has caused increasing in number of product and by product produced from factory such as palm oil clinker and rice husk. So it will become unbalanced between production of product and by product. The highest number of product has cause the highest number of by product. Increasing of by product has become problem in dumping issue. Therefore, the usage by product such as used in the construction is good alternative that can reduced too many idle disposal and dump site.

Rapidly of development in urban and rural area will caused so many construction are ongoing. Therefore, the uses of sand brick was highly demand through a lot of variety type of brick from brick production. So the natural resources such as sand has been usage not in control. Because of that, replacing another material to be replaced sand in production of brick as an alternative can reduced the usage of natural resources such as sand.

1.3 MAIN OBJECTIVES

In the construction, brick are the one part for construction material. Different type of brick has different strength, density and water absorption. Therefore, the presence of wasted material such as palm oil clinker and rice husk as a replacement of natural resources such as sand in the used of sand brick in effort to solve the problem. To determine the compressive strength, flexural strength, density and water absorption of sand brick that consist clinker and rice husk as a partial replacement of fine aggregate (sand) and also to determine the best ratio of sand brick mixed with this material.

1.4 SCOPE OF WORK

This research wants to find the best ratio and to know the quality of brick mix with clinker and rice husk. Making the mould with dimension are 110mm x 220mm x 65mm that follow JKR standard. Then the moulds were stored safely in the laboratory concrete until the day of casting. There are three ratio of sample which is 5% clinker with 10% rice husk, 5% clinker with 20% rice husk and 5% clinker with 30% rice husk that will mix together for making these brick. Then, the brick samples were tested on compressive strength test, flexural strength test, density test and water absorption test. The experiment were run and analysed at the concrete laboratory FKASA, University Malaysia Pahang. This sample will be test after curing. There are two type of curing will be used which is air curing and water curing. The curing period of these sample are used is 3 days, 7 days, 14 days and 28 days. The tests will be conducted on every curing period which is on 3 days, 7 days, 14 days and 28 days.

1.5 RESEARCH OF SIGNIFICANT

Making a good quality based on the ratio of materials when mixed it together. This research is to making a brick consist with clinker and rice husk as partial replacement of fine aggregate (sand). The clinker contains particles of various sizes from 3mm to 25mm. The clinker must sieve through 5mm sieve to eliminate unsuitable material and particles larger than 5mm size particle. The rice husk must filter to remove the dust and dried in oven about 20 minutes. The brick samples will be tested for compressive strength test, density test, flexural strength test, water absorption test and density test. Compressive strength is relevant to a structural engineer calculating structural brickwork strengths in accordance with the recommendations of the Structural Masonry Codes of Practice. Water absorption is a measure of available pore space and is expressed as a percentage of the dry brick weight. Flexural strength is an indirect measure of the tensile strength of concrete. It is a measure of the maximum stress on the tension face of an unreinforced concrete. Making a good quality of brick depend on the ratio of mixes cement, sand and water. When this experiment success can reduce the pollution and can save the earth reduced the waste materials.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Nowadays so many waste material which is getting more and more discarded to the land. This is because palm oil clinker nowadays used as utilizing waste material in the construction industry is an effective way to protect the environment and minimize construction cost. The use of waste material as sand replacement for producing brick can save the world from producing more waste material that disposal to the land and idle. The concept of sand brick refers to a units of construction material, made from mortar with a bonding agent comprising of cement, sand, and water. Mortar is mixture of cement and sand that is usually used to build brick or block walls. Brick was used as a construction material more than 5,000 years ago. There are many brick produced with contain the waste material such as palm oil clinker, rice husk and so on. The production and application from waste materials nowadays can make high demand to the world and reduce the waste material from idle. Therefore, this chapter discuss the types of brick that use in construction, brick properties and method that used for brick testing.

2.2 GENERAL

2.2.1 Sand Brick

Bricks are used for construction material such as for making building and pavement. The brick is usually laid flat and is usually bound to form the structure to improve its stability and strength. Brick can divided by 2 categories which is fired and non-fired bricks. Sand brick is made up from the mixture of sand, cement and water. This usually used for making cement brick and must follow the ratio of mixture according to the desired strength.

2.2.2 Palm Oil Clinker (POC)

Palm oil clinker (POC) is a waste by-product gathered after the complete incineration process of oil palm shell and fibre. Physically they are porous, grey in colour, irregular in shape and much lighter which may be used as a potential lightweight aggregate for concrete when crushed. Using them as a cover for the potholes on the roads within the vicinity of the plantation areas. 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. It consists of various calcium silicates including alite and belite. This can be very efficient way to avoid pollution environmental and also benefiting the construction industry as an aggregate replacement (Abutaha, et al., 2015). Efficient materials and environmental friendly need to be introduced to reduce the pollution of environmental increased from the high carbon footprint of cement in its stages of production. It was crushed and sieved to the desired particle sizes. The particles less than 5 mm are considered as fine aggregate and particles in the range of 5–14 mm are considered as coarse aggregate (Mohammed, et al., 2014). (Ibrahim & Razak, 2015) Stated that compressive strength was highest due to the least porosity. The previous studies have shown that POC is a suitable lightweight aggregate replacement in concrete because of one benefit is can reduced dead load by as much as 35% and still provide the structural strength of concrete structures without much loss in the strength of the structure and also can reduces the cost and energy usage and lowers carbon emission (Abutaha, et al., 2015). Figure 2.1 show the sieve analysis grading curve for river sand, fine POC, Granite coarse and POC coarse that were utilized in this study.

The aggregates satisfied the parameters and fell within the range of well-graded aggregate.

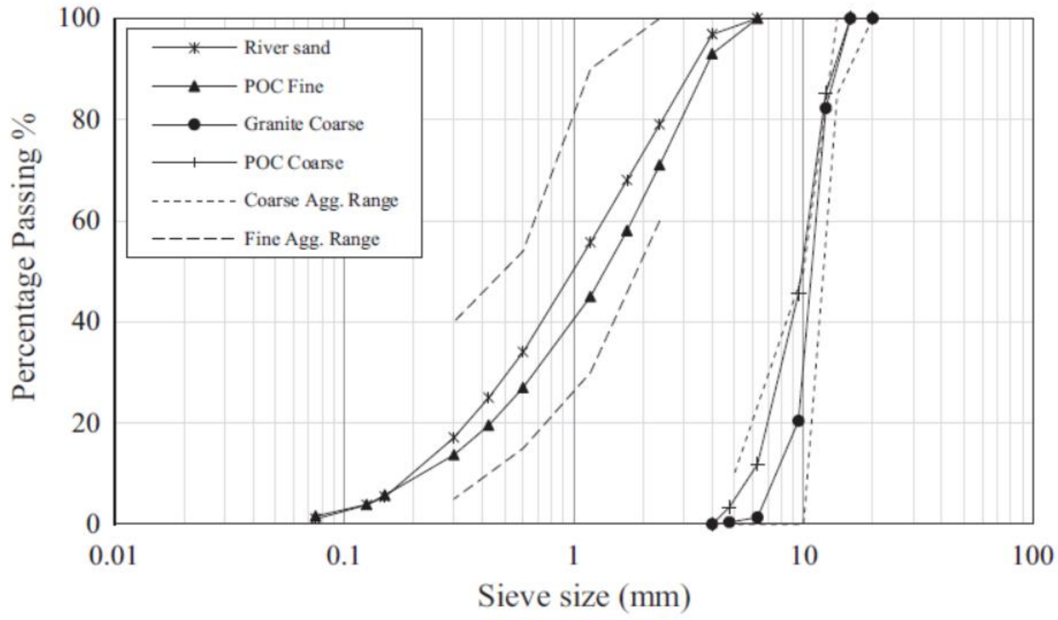

Figure 2.1: Sieve analysis grading

Source: Abutaha et al, (2015)

(Abutaha, et al., 2015) Stated that the unit weight of the POC aggregate is approximately 25% lighter than river sand and 48% lighter than crushed granite stone. The water absorption of POC is higher than the natural aggregate. This result indicates that this waste material is suitable for replacing natural aggregates for structural application. Mohammed et al, (2013) stated that the test results for compressive strength ranges from 25.5 to 42.56 N/mm^2. Lightweight concrete normally has density less than 2000 kg/m^3 and the air dry density for POC ranges from 1818.24 to 1845.62 kg/m^3, which is less than 2000 kg/m^3 and approximately 16% lighter than normal concrete (2200 kg/m^3). (Ibrahim & Razak, 2015) Found that substitution of natural aggregate with POC decreased the compressive strength and density while increasing its porosity and coefficient of permeability.

2.2.3 Rice Husk (RH)

Rice husk (RH) are the hardened coverings that are protecting a grains of rice and also protect the rice during the growing season since it is hard materials that including opaline silica and lignin (He, et al., 2015). The husk is mostly indigestible to humans so that it are one of the waste material. In addition, rice husk can be a raw material that use as building material, fertilizer, insulation material, or fuel. The rice husk can be formed into rice husk ash after combustion. The rice husk ash is used efficiently as a pozzolanic material because it rich in amorphous silica. For this experiment, rice husk ash are not needed because this experiment need rice husk as a raw material.

The physical properties for rice husk in term of a moisture content and particle size distribution. Unique physical and chemical properties of RH, like high ash content, silica content, it can be effectively used in domestic and industrial processing (Babaso & Sharanagouda, 2017). Firstly about moisture content of rice husk are substantially affects its quality as a fuel source. It also increase in moisture content and decreases its heating value which in reduces the conversion efficiency and performance of the system because a large amount of energy would be used for vaporization of the fuel moisture during conversion. (Mansaray & Ghaly, 1996) observed that for the particle size of rice husk is when particle size is too large can cause secondary reactions to occur within the particles that may lead to the formation of undesired products such as char and tars but when particle size is too small can cause the feedstock may not be retained in the reaction zone long enough for complete conversion, thereby resulting in low conversion efficiencies.

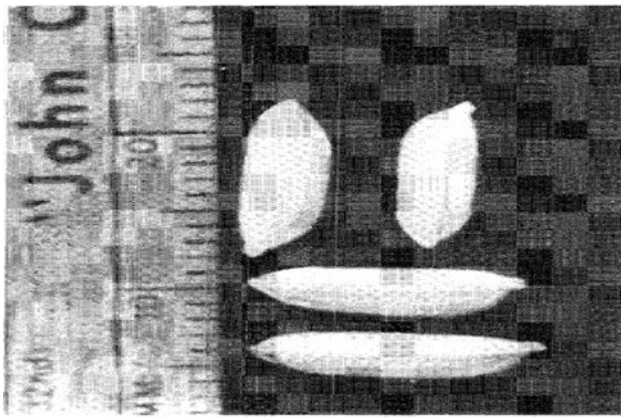

Figure 2.2: measurement of rice husk using ruler
Source: Mansaray & Ghaly (1996)

The Figure 2.2 shows measurement of rice husk using ruler in millilitres. The measurements were select based on a 100 single rice husk particles that had both husk parts and about 55% of the particles size of rice husk in ranged of 6.2 to 10.0 mm of length and in ranged of 1.7 to 2.4 mm of width. In addition, the results of the weight, length, and width distribution of rice husk are presented in Table 2.1.

Table 2.1 results of the weight, length, and width distribution of rice husk

Sieve number	**Mesh number**	**Weight (%)**	**Length (mm)**		**Width (mm)**	
			Range	**Average**	**Range**	**Average**
1	7	2.06	11.6-12.4	12.0	2.8-4.0	3.4
2	8	14.22	10.2-11.4	10.8	2.4-2.8	2.6
3	10	23.60	8.8-10.0	9.4	2.0-2.4	2.2
4	12	31.34	6.2-8.0	7.1	1.7-2.0	1.9
5	14	18.72	4.0-6.0	5.0	1.4-1.7	1.6
6	18	7.37	3.2-4.0	3.6	1.0-1.4	1.2
7	20	1.17	1.5-2.4	2.0	0.8-1.0	0.9
8	25	0.67	0.8-1.2	1.0	0.7-0.9	0.8
pan		0.85	dust	dust	dust	dust

Source: Mansaray & Ghaly (1996) (Lynch, 1994)

2.3 Type of Brick

Brick is very important materials in construction such as to make walls, pavements and another elements in construction. (Lynch, 1994) Stated that the definition of brick is generally a rectangular prism size that can be carried with one hand conveniently. Bricks are produced in so many classes, types, materials and also sizes which vary with region and time period, and are produced in bulk quantities. Besides, the brick classification is depend on the method and materials used in producing the brick. The type of brick that usually used in the construction are clay bricks, sand-lime bricks and concrete bricks but for this experiment that used is sand bricks. Another equally important style is the caption. All captions for figures, tables and equations are formatted using their respective styles prepared in this template.

2.3.1 Clay Brick

Clay brick is a very famous materials used in the construction of industrial, commercial and residential structures. (Lourenc¸o, et al., 2010) Stated that the clay brick is make by a clay mixed with water and an aggregate which is sand. From this mixture can prevent shrinkage and provide bulk. It was easily produced, lighter than stone, easy to mould, and formed a wall that was fire resistant and durable. Clay brick is a brick dough product which is consists of clayey soil and water and naturally dried, formed primitively and fired it in the kilns at the workshop cited by (Dalkılıç & Nabikoğlu, 2016). Mud function for relatively thick consistency and become a form that are pressed into forms of brick. It is fired in a kiln at high of temperatures that is 1,000 degrees Celsius. The imperial standard size is 222mm long x 106mm wide x 73mm high and the mass is between 3.0kg to 3.5kg. Furthermore, clay brick has the ability to absorb and release the heat during the day and night. Then, it also has the ability to reduce the need for heating of artificial in winter and cooling in summer season. In addition, clay brick has the ability to maintain its original beauty and lasts more than 100 years in form of colour, form and texture. Clay brick structures require less maintenance and has high compressive strengths. Clay brick walls has achieve maximum fire ratings and withstand the fires longer than other building materials. There are three main type of brick which are facing bricks, engineering bricks and common bricks.

Figure 2.3: Clay bricks

2.3.2 Facing Brick

Facing bricks are the most popular type of brick and have been the artificial material choice for thousands of years and especially in the housing market price. It mostly used for the external walls of a building construction and generally chosen for their qualities of aesthetic. Artificial material has the huge impact on the external aesthetics of a building along the design and the most important is the decision must selecting the right material. It also must be weather resistant because their aesthetic qualities. All types of project for facing brick from traditional to ultra-modern. Other than that, facing bricks also produce by using different techniques of manufacturing so they are available in a number of different types including so stock bricks and wirecut.

2.3.3 Engineering Brick

Engineering bricks are a type of brick used where strength, low water porosity or acid which is flue gas resistance are needed and can be used for damp-proof courses. Engineering bricks also have higher compressive strength and low water absorption. In traditionally, it used in civil engineering and very suitable for applications in strength and resistance are also important to frost attack and water. For examples of engineering bricks is commonly used consists of ground-works, bridges, manholes, sewers and retaining walls. The British Standard (BS: 3921, 1985) that categorized compressive strength. Engineering bricks are rated as Class A or Class B that mean the Class A being the strongest and the Class B are the most common than Class. Therefore, engineering bricks also are commonly in smooth red colour although blue engineering bricks also nowadays available.

2.3.4 Common Brick

Common bricks are actually the one of least common type of brick in UK. It tend to be low compressive strength than facing bricks or engineering bricks. Common bricks are generally as lower quality. There is also less concentration given to a consistent appearance on common bricks. Common bricks should not be used underground and usually used for internal brickwork only.

2.3.5 Sand-Lime Brick

Sand lime bricks are popularly known as calcium silicate bricks. (Dachowski & Nowek, 2016) Stated that sand-lime bricks are generally made from natural raw materials which is sand, lime and water that no additives. Sand lime bricks are mostly made by mixing sand, fly ash and lime followed by a chemical process during wet mixing. The mix is put into the moulded and pressed to form the brick. (Dachowski & Nowek, 2016) Stated that approximately 90% of the weight of the product is sand, limestone is about 7% and about 3% constitutes water. These bricks have advantages over than clay bricks such as it colour appearance is look like gray instead of the regular reddish colour. It shape is uniform and presents a smoother finish that not require plastering. Therefore, these bricks have a higher strength as a load-bearing member. A firm white building material is produced by high pressing the mixture and autoclaving. Sand lime bricks are the main parameters for architects and has a good acoustic insulation, good heat & humidity accumulation as well as very good fire resistance for building construction. The cost of construction will reduced up to 40% of total cost which is follow this factors are calcium silicate products of wastage is very less, the quantity of mortar that needed is less and will reduced the thickness of wall when constructed using sand lime bricks because this bricks is very high compressive strength.

Figure 2.4: Sand lime Bricks

Sand lime bricks are designated by BS 187:1978 according to their compressive strength and appearance into the classes shown in Table 2.

Table 2.2 Classes of Sand lime bricks

class	Minimum mean Compressive strength (wet) Of ten bricks N/mm^2	Minimum predicted Lower limit of Compressive strength N/mm^2
7	48.5	40.5
6	41.5	34.5
5	34.5	28.0
4	27.5	21.5
3	20.5	15.5

Source: Lynch (1994)

2.4 BRICK PROPERTIES

2.4.1 Compressive Strength

Compressive strength of brick is very important to brick strength as a result must meet the requirement in brickwork design. (Lynch, 1994) Found that compressive strength is related to a structural engineer that calculating structural brickwork strengths in according to the recommendations of the Structural Masonry Codes of Practice. By mixing the suitable materials, compacting and curing can obtained the maximum strength. Compressive strength or known as crushing strength of bricks are very variable and can change from 3 N/mm^2 to 40 N/mm^2 depend on the raw materials that used for making brick according to the manufacturing process, size and shape of brick. Compression testing machine is used to find compressive strength. This machine can describe that the compression plate of which shall have ball seating in the form of portion of a sphere center of which coincides with the centre of the plate.

According to the MS 76 1972 or to adhere to building regulations. The compressive strength for bricks is 5.2 MN/m^2 and blocks is 2.8 MN/m^2 refer in Clauses 12, 17 and 22 also can be load bearing that used in one- and two-storey houses, the 5.2 MN/m^2 of brick is unlimited to non-load bearing uses. Comply with requirements to the Clause should be checked the methods stated in Clauses 39 and 40. If the works of manufacturer for a quality control system including the strength testing and the result tests quality control are making the base of acceptance. (Yuxia, et al., 2014) Found that the compressive strength of the concrete is higher with the particle size of raw materials is smaller.

The brickwork of load bearing is uncalculated and only the strength requirements of this standard are stated in Clauses 12, 16 and 20. Except for a higher strength is agreed in accordance stated in Clause 10 that the bricks compressive strength of normal quality shall tested in accordance stated in Clause 39 and not less than 5.2 MN/m^2 and also the blocks of normal quality not less than 2.8 MN/m^2. These minimum strengths is acceptable by brick and blocks are satisfying in other respects (MS 76, 1972).

2.4.2 Flexural Strength

Flexural strength is known as modulus of rupture or bend strength or transverse rupture strength because it is material property before it yields in a flexure test. The most commonly used transverse bending tests which are specimens that have either cross-sectional or rectangular cross- sectional fractures or results using a three-point straight test technique. The flexural strength is the highest stress experienced within the material at its moment of yield. It is measured by stress with the symbol is sigma. (Ahmed, et al., 2014) Stated that the behaviour concrete structure of deflection and cracking are depend on the flexural tensile strength of concrete. It also increase of age and strength of concrete. The proportional increase in the flexural tensile strength at same age of concrete goes on decreasing with increase of level of concrete strength. The tensile strength of concrete is one of the measure of flexural strength. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. (Costigan & Pavía, 2009) Found that the compressive and flexural strength of a EN 459-2 standard mortar increases by 60-65% in between 28 days and 56 days while its flexural bond strength also increases by 80%.

2.4.3 Density

The density of concrete is a measurement of unit weight. A normal concrete weight is 2400 kg per cubic meter or 145 lbs per cubic foot (3915 lbs per cubic yard). The density of concrete is depend on the aggregate amount and density, the amount of entrapped air and also the content of water and cement. (ydon, 1987) Stated that concretes produced by crushed rocks and gravels a density changes arise from changes in the amount of air in the mortar phase that effect the strength but the quality are change depends on the air whether it is purposely introduced as widely recognised. The fully compacted lower density concrete is produced by lower density aggregates and necessity of these aggregates are of higher porosity and this does not necessarily reduce the concrete quality. Vice versa, good quality structural concrete produced by manufactured aggregates of relative density about 1.5. It is at least as good as- and seems to be intrinsically better than similar concrete made with normal weight aggregates.

2.4.4 Water Absorption

The strength of a brick depend on its water absorption capacity. Water absorption in the bricks presence of voids that will allow passage of water. The pores of the bricks will absorb the content of water from mortar that put on the bricks. The water absorption also affect the mortars properties and the bonding of mortar between the bricks. (Lynch, 1994) Found that water absorption is measurement of available pore space that expressed as a percentage of the dry brick weight and the classification is used for calculated the flexural strength of masonry walls for example their resistance to bending because it is related to mortar bonding. (Zhang & Zong, 2014) Stated that water absorption is measured the increase in mass by measuring the percentage of dry mass. Surface water absorption is higher than internal water absorption and this is caused by rapidly loss of water at the cover concrete when curing. The higher water absorption the higher penetration height. The initial rate of absorption (IRA) by the clay bricks is supposed to be fall by the range between of 0.25 and 2.05 kg/min/m^2 in order to form the strength of bond between mortar and bricks. If the IRA of the Clay bricks is less than 0.25 kg/min/m^2 does not absorb too much water from the mortar and the water may float on the mortar. If the IRA value is too high and too much moisture is pulled from the mortar and the mortar will dried and harden faster than the brick bonds. The bonding between mortar and bricks will not enough strong even the mortar has hardened.

2.5 METHOD

2.5.1 Curing

The process when a chemical reaction such as polymerization or physical action such as evaporation are takes place the resulting in a harder, tougher or more stable linkage for example an adhesive bond of the substance such as concrete. The some curing processes need a maintenance for certain temperature and humidity level. (Raheem, 2013) Stated that curing is the primarily of designed that to keep the concrete moisture with preventing the rate of the loss of moisture and starting gained the strength from it during the period. The objective of curing process for the concrete is giving the concrete what it needs to gain strength properly. The important aspect of curing is temperature of the concrete must not be too cold or too hot. When fresh concrete temperature is cooler below about 50 F, the reaction hydration are getting slows down a lot and if the reaction hydration below about 40 F, it virtually stops. (Akinwumi & Gbadamosi, 2014) Stated that curing ensures that concrete experience continued hydration, leading to its continued strength gain.

(Zhang & Zong, 2014) Found that the temperature of curing and the duration of moist curing are the most important for proper pore structure. So is one of the method that so important for the fresh concrete to maintain the moisture content and temperature in freshly cast concrete for a definite timeframe that immediately following placement. There are two major purposes of the curing process which is to prevent the loss of moisture from the concrete and another one is to maintain the temperature for hydration to occur for a certain period of time. Ponding was the most effective method of curing. It produced the highest level in compressive strength and cube densities. (Obam & Ogah, 2016) Found that the mean compressive strength realized from ponding method is 9.8 and 16.8 percent higher than the strengths gained from wetting and polythene methods respectively and this implies that the traditional curing by immersion appeared to be the best method to achieve desired concrete strength.

(Akinwumi & Gbadamosi, 2014) Stated that curing the concrete function is to maximise its strength for example increase the structural integrity and reduce cracks of concrete. Water curing some techniques such as ponding, immersion, fogging and wet covering of curing. Ponding curing is to cure flat surfaces where water easily ponded. This method is the best practice that concrete is cure shortly after the reaction of chemical has getting started allowing the concrete to harden. The Curing conditions must maintained during the first 24 hours or until the final setting time of cement has passed. Immersion curing is done in concrete testing for specimen of curing concrete. Then, fogging curing is used during hot weather, so this method can reduce the temperature of concrete by maintaining the moisture inside the body of concrete. Lastly, wet Covering is used to conserving water on the surface of the concrete with completely covering the surface quickly after the concrete has set with water fabrics of absorbent.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In this chapter will be discuss on preparation and test method used in this experiment. On this experiment, it will start with flow of methodology for making a sand bricks. This experiment will be conducted based on testing the sand bricks to determine the compressive strength, density, flexural strength and water absorption of sand brick that consist palm oil clinker and rice husk. The ratio of 5% palm oil clinker as partial replacement of fine aggregate with 10%, 20% and 30% of rice husk that will produced the sand bricks shall be mixed in the ratio of 1:6. Therefore, preparation materials was needed before conducted the experiment. The list of materials such as cement, sand, water, oil palm clinker, rice husk as for making the sand bricks.

3.2 METHODOLOGY FLOW CHART

In figure 3.1 was showed about methodology flow chart that included all about material preparation, process of mixing sand bricks, process of curing and testing the bricks. The result of the testing that will conducted on compressive strength, density, flexural strength and water absorption will be collected and analyses. So, methodology process is one part that to know the effectiveness of oil palm clinker with rice husk as a partial replacement of fine aggregate to produce sand bricks.

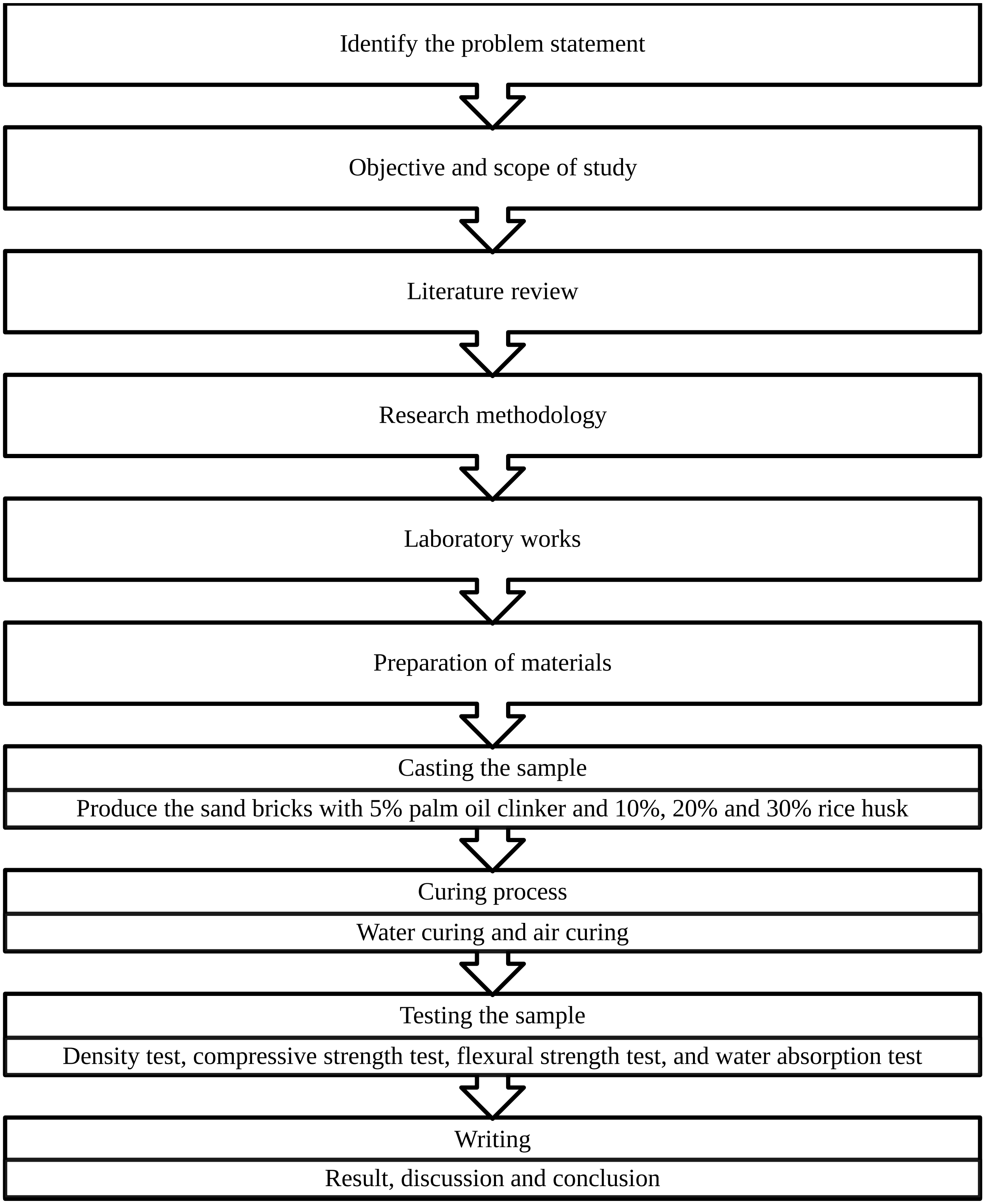

Figure 3.1: Methodology flowchart

3.3 DESIGN BRICK MIX

3.3.1 Cement

The function of cement as a binder because it used to bind raw material such as aggregate and water are mix together. Cement can be categorized as hydraulic and non-hydraulic cement. Non-Hydraulic cement can be describes as cement dries reacts by carbon dioxide in the air and prevent from chemical attack after setting. Hydraulic cement such as ordinary Portland cement (OPC) is react with water due to chemical reaction that are very strong in water and prevent from chemical attack. This process known as hydration process. Cement has so many type of production such as ordinary Portland cement, sulphate resisting cement, low heat cement, rapid hardening Portland cement, Portland pozzolana cement, high alumina cement and white ordinary Portland cement. For this experiment used OPC because it usually used in all type of construction works. This type of cement is manufactured by limestone or chalk that mixing together with shale or clay to form clinker and crushed it to become a grey colour powder. Besides that, this cement need to keep the packages properly because to prevent the cement harden on its own. University Malaysia Pahang Concrete Laboratory also provides ordinary Portland cement (Cap Orang Kuat) will be used for this experiment. This experiment must refer to the Jabatan Kerja Raya (JKR) of Standard Specification at section E (brickworks) in clause 1.1 stated that the cement must be ordinary Portland cement comply by MS 29 under section D (concrete works).

Figure 3.2: Ordinary Portland cement (Cap Orang Kuat)

3.3.2 Water

Water is the key materials for the cement reaction with aggregate and other material. Without water the all material such as cement and aggregates will not mixed and combined together. Water is a transparent, almost colourless chemical that is a major element of Earth. The chemical formula is H2O, which means that each molecule contains one oxygen and two hydrogen atoms connected by covalent bonds. For this experiment, water usage can get from University Malaysia Pahang Concrete laboratory. This experiment must refer to the Jabatan Kerja Raya (JKR) of Standard Specification at section D (concrete work) in clause 2.3 complying with MS 28.

Figure 3.3: Tap water

3.3.3 Fine Aggregate

Sand is a natural granular material composed of fine stones and fine mineral particles. The size particle are smaller and also known as fine aggregate because passing the sieve of 4.75 mm and retained on sieve 75 µm or 63 µm. The sand was got from river that must pure sand with free from the loam, clay, dirt, chemical and other organics material. University Malaysia Pahang Concrete Laboratory also provides pure sand will be used in this experiment. The sand must according to the Jabatan Kerja Raya (JKR) of Standard Specification at section E (brickworks) in clause 2.1 stated that sand used for mortar must complying with MS 29 under section D (concrete work).

Figure 3.4: Fine aggregate

3.3.4 Palm Oil Clinker (POC)

The Palm Oil Clinker (POC) got from Kilang Sawit Lepar Hilir 3 Gambang Pahang. POC is a light, solid, and fibrous material and must crushed it before use as replacement of fine aggregates. Particles size need that need to crush in the range less than 5mm before used it are considered as fine aggregate. So, this experiment used POC as a raw material to replace the fine aggregates (sand) with ratio of 5%.

Figure 3.5: Palm Oil Clinker

3.3.5 Rice Husk (RH)

The rice husk (RH) got from Kilang Padi Bernas at Rompin Pahang. It is hardened coverings to protect a grains of rice and also protect the rice during the growth season. It is one of waste material that can be used in construction materials. The average particle size is 6 mm. For this experiment, RH that used no need to sieve and just cleaned the dust at the RH only. Used the pure RH in this experiment. Then, dried the RH in the oven about 20 minutes before used. This experiment also used rice husk as a raw material to replace the fine aggregates (sand) with ratio of 10%, 20% and 30%.

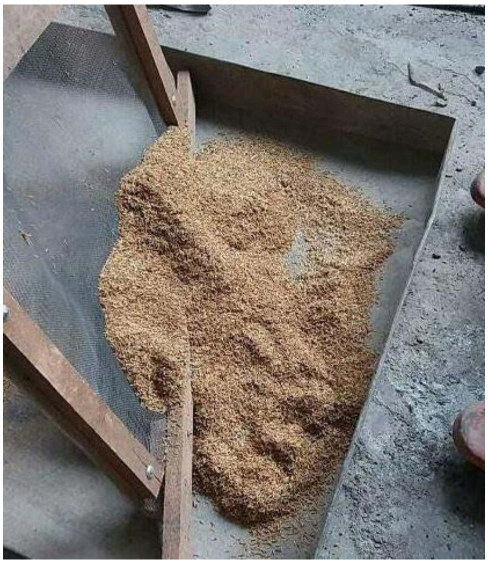

Figure 3.6: Rice Husk

3.4 PARAMETER USED FOR TESTING

3.4.1 Machine Prepared Sample

- Crushed machine – crushed the Palm Oil Clinker (POC)
- Sieve shaker machine – sieve the sand, Palm Oil Clinker (POC) and rice husk (RH) passing 4.75mm
- Mixer machine- mix all the materials
- Weighing scale- weight the materials and sample

Figure 3.7: Sieve shaker machine

Figure 3.8: Sieve set

3.5 DIMENSION ANALYSIS

The sample of each ratio the used for testing are 64 bricks. This samples are used for density test, compressive test, flexural test and absorption test. The experiment used Palm Oil Clinker as partial replacement of fine aggregate (sand) with ratio of 5% with rice husk of 10%, 20% and 30%. The ratio of the mortar is 1:6 which is consist of one (1) part of cement to six (6) parts of sand according to Jabatan Kerja Raya (JKR) of Standard Specification at section E (brickworks) in clause 3.1. The total sample of bricks for this experiment are 256 units. The size of sand bricks in Table 3.1 according to the JKR of Standard Specification comply in cause 4.3.2.

Table 3.1 Size of sand bricks

Test 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	20	68
		5% POC			
10% RH	16	16	16	20	68
20% RH	16	16	16	20	68
30% RH	16	16	16	20	68
Total					272

Table 3.3 Type of curing process

Type of curing	Ratio	3 days	7 days	14 days	28 days
Water curing	Standard	8	8	8	10
	5% POC with 10% RH	8	8	8	10
	5% POC with 20% RH	8	8	8	10
	5% POC with 30% RH	8	8	8	10
Air curing	Standard	8	8	8	10
	5% POC with 10% RH	8	8	8	10
	5% POC with 20% RH	8	8	8	10
	5% POC with 30% RH	8	8	8	10

On this experiment, the sample was needed are 272 units with differences ratio of mixed of sand bricks and curing ages. The standard of sand bricks was 68 units are needed but another 204 units for different ratio of mixed with POC and RH. The sample curing ages are 3 days, 7 days, 14 days and 28 days with two type of method curing which is air curing and water curing. After that, the test will be conducted on density test, water absorption and destructive test which is compressive and flexural test.

3.5.2 Analysis Sample

Sand brick ratio is 1:6 (which is 1 part of cement and 6 part of sand Size of sand brick used according JKR specification is 225 mm x 113 mm x 75mm 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

The weight of one unit of sand bricks is 4.59 kg

3.6 PROCEDURE OF WORK

3.6.1 Mould

Mould is the important thing for casting the fresh of sand brick after mixed all the materials. The mould of the perimeter must according the size of sand bricks which is 225 mm x 113 mm x 75 mm. University Malaysia Pahang Concrete Laboratory only provide the plywood and need to make own mould.

3.6.1.1 The Procedure to Form the Mould

To make the mould, 9 pieces of plywood size is height 75 mm and width 912 mm and also 9 pieces of plywood size is 1824 mm for width and 75±1.6 mm for height. Overall, the total one formwork can obtained for 64 samples. So, from that can easier to divide every 64 samples from different ratio of mixture.

i) Marked the plywood according to the dimension of bricks

ii) Cutting the plywood by the wood cutter machine.

3.6.1.2 The Preparation Material

For this experiment, the materials used are sand, cement, water, oil palm clinker and rice husk. The coal bottom ash must passing 4.75 mm sieve as partial replacement of sand. Oil palm clinker and rice husk must dried in oven before used. All material weighed are listed in analysis sample.

3.6.1.3 Process of Work

The casting process started casting of the sample and followed by the sand bricks ratio of material that already set for this experiment.

i. The plywood must brushed with oil before casting the sample because to avoid the sample from sticking to the mould and easier to remove the sample from the mould.
ii. The material that already prepared according to the ratio are put into the mixer machine part by part until material was blended in 5 to 10 minutes.
iii. Place the material that was blended into the mould and used the rod to

compress the mixture to remove the air void.

iv. Wet sacks was placed on the mould samples and left up to 24 hours.

v. After 24 hours, remove the sample from the mould and proceed to the air curing and water curing process for 3 days, 7 days, 14 days and 28 days shown in figure 3.7 and figure 3.8.

vi. Weighed the sample before testing the sample.

vii. Repeated the step 1 until 6 by another ratio of the POC and RH as fine aggregate.

Figure 3.9: Air curing

Figure 3.10: Water curing

3.7 CURING

The most important of curing process is for giving the brick to gain strength properly. There are two major purposes which is to prevent the loss of moisture from the brick and maintain the temperature for hydration to occur for a certain period of time. Another function of curing is to reduce the cracks of the brick. For this experiment, the function of curing that used was same with the brick. There are two type of curing process that used for this experiment which is air curing and water curing. This curing must according to Jabatan Kerja Raya (JKR) of Standard Specification at section D (concrete works) in clause 5.8.1.

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-hr.

   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 its mass was first determined, place it in the oven for a second drying treatment of 24-hr 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-hr 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-hr 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:

3.9.1 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).

3.9.2 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 2h 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 3.11: Compressive testing machine

3.10.2 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.

3.10.3 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 3.12: 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.

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

ix. 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.

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

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

Where:

r: loading rate, lb/min (MN/min)

S: rate of increase of extreme fiber, psi/min (MPa/min)

b: average specimen width, in. (mm)

d: average specimen depth, in. (mm)

L: span length, in (mm)

viii. Finally, measure the cross section of the tested specimen at each end and at centre 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, MPa

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

L = span length, mm

b = average width of specimen, mm, at the fracture

d = average depth of specimen, mm, at the fracture

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

The experiment has been test for 256 sample for the each ratio including control sample. It has 4 types of ratio which is control sample, 5% clinker with 10% rice husk, 5% clinker with 20% rice husk and 5% clinker with 30% rice husk. Each of ratio has 64 samples of sand brick. The result was collected from testing the sample trough compressive strength, flexural strength, density and water absorption test based on the method of air curing and water curing for 3 days, 7 days, 14 days and 28 days. Overall, all the sample was successful to collect the data from this experiment. All the data are represented by table and graph.

4.2 COMPRESSIVE STRENGTH

4.2.1 The Average Compressive Strength for Control Sample

Table 4.1 Average Compressive Strength of Control Sample

Days	Compressive Strength (MPa)	
	Air Curing	Water Curing
3	5.30	4.50
7	4.64	5.49
14	6.85	5.94
28	8.85	8.47

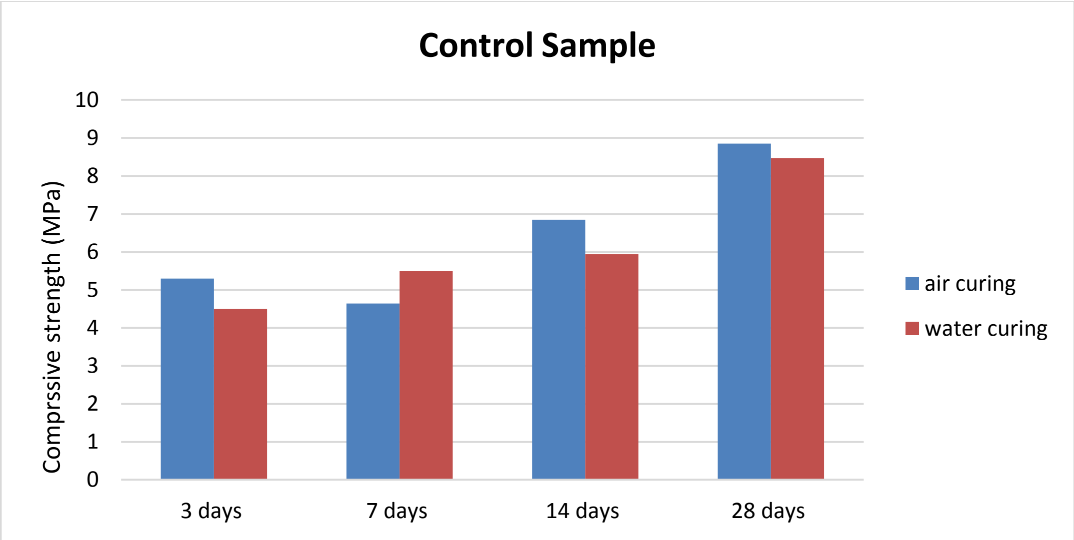

Figure 4.1: Graph Compressive Strength of Control Sample

The bar graph shows the different result of compressive strength compared by air and water curing period. At the beginning during 3 days, air curing is 5.3 MPa higher then water curing is 4.5 MPa. Then, at 7 days show the compressive strength of water curing is 5.49 MPa suddenly increase more than air curing is 4.64 MPa. After that, at 14 days, air curing has drastically increased from 4.64 MPa to 6.85 MPa more than water curing but the water curing increased slightly from 5.49 MPa to 5.94 MPa. Overall, during 28 days, the air curing is highest compressive strength which is 8.85 MPa compared to water curing which is 8.47 MPa. So, the result shows the highest compressive strength for control sample is air curing.

4.2.2 The Average Compressive Strength for 5% Clinker with 10% Rice Husk

Table 4.2 Average Compressive Strength of 5% Clinker with 10% Rice Husk

Days	Compressive Strength (MPa)	
	Air Curing	Water Curing
3	4.70	3.89
7	6.24	5.67
14	6.62	6.38
28	8.02	6.66

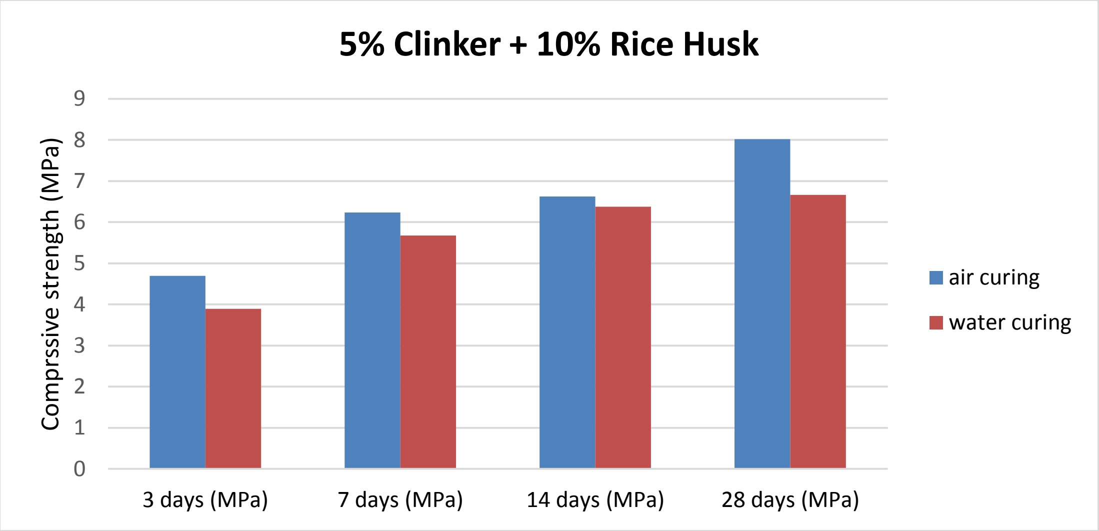

Figure 4.2: Graph Compressive Strength of 5% Clinker with 10% Rice Husk

The bar graph at figure 4.2 shows the average compressive strength for 5% Clinker with 10% Rice Husk replacement of fine aggregate for air curing and water curing. At 3 days, air curing is 4.70 MPa higher than water curing is 3.89 MPa. Then, both type of curing was drastically increased at 7 days. For air curing increased from 4.70 MPa to 6.24 MPa and water curing increased from 3.90 MPa to 5.67 MPa. After that, both type of curing was increased slightly at 14 days. For air curing increased from 6.24 MPa to 6.62 MPa and water curing increased from 5.67 MPa to 6.38 MPa. Then, air curing suddenly increased drastically again from 6.62 MPa to 8.02 MPa at 28 days but water curing suddenly increased slightly from 6.38 MPa to 6.66 MPa at 28 days. Overall, the result for this ratio shows the highest compressive strength compared the type of curing is air curing.

4.2.3 The Average Compressive Strength for 5% Clinker with 20% Rice Husk

Table 4.3 Average Compressive Strength of 5% Clinker with 20% Rice Husk

Days	Compressive Strength (MPa)	
	Air Curing	Water Curing
3	3.28	2.44
7	6.95	6.46
14	7.45	6.57
28	7.83	6.96

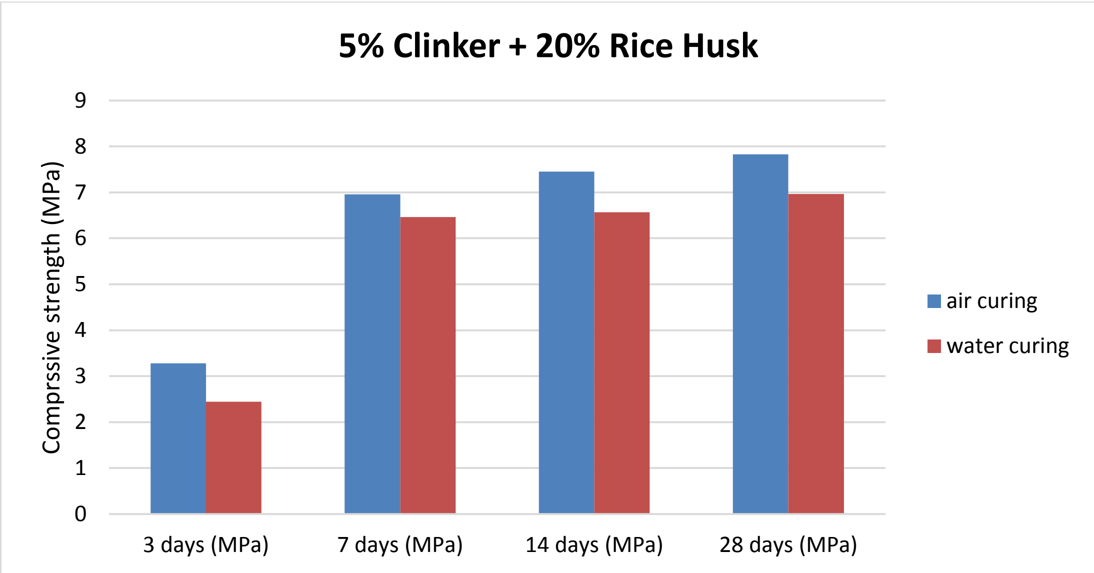

Figure 4.3: Graph Compressive Strength of 5% Clinker with 20% Rice Husk

The bar graph shows in figure 4.3 was the average compressive strength of ratio 5% Clinker with 20% Rice Husk that are compared between air and water curing. During 3 days, the compressive strength shows air curing result is 3.28 MPa higher than water curing result is 2.44 MPa. Then, result for air curing for 7 days increased rapidly to 6.95 MPa. Water curing also increased rapidly to 6.46 MPa at 7 days. During 14 days, air curing result rose to 7.45 MPa but the water curing increased slightly from 6.46 MPa to 6.57 MPa. At 28 days, both type of curing increased slightly. For air curing increased from 7.45 MPa to 7.83 MPa and the water curing increased from 6.57 MPa to 6.96 MPa. The result shows the overall highest average compressive strength of ratio 5% Clinker with 20% Rice Husk is air curing.

4.2.4 The Average Compressive Strength for 5% Clinker with 30% Rice Husk

Table 4.4 Average Compressive Strength of 5% Clinker with 30% Rice Husk

Days	Compressive Strength (MPa)	
	Air Curing	Water Curing
3	3.23	3.07
7	6.20	6.11
14	6.39	6.22
28	6.48	6.33

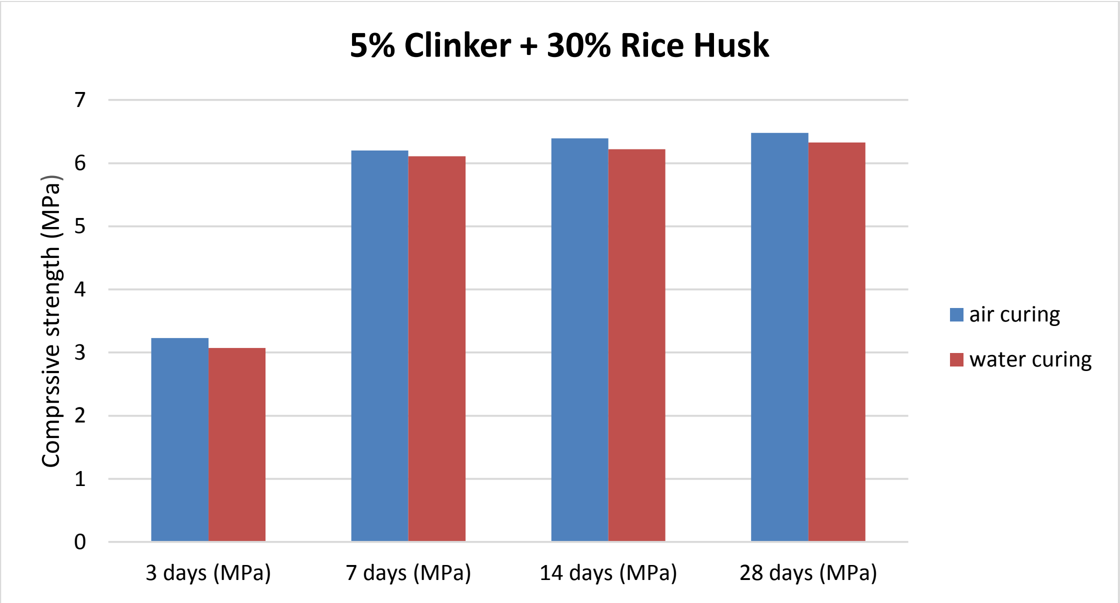

Figure 4.4: Graph Compressive Strength of 5% Clinker with 30% Rice Husk

The bar graph in figure 4.4 shows the different result compressive strength of 5% Clinker with 30% Rice Husk between types of curing. At the beginning during 3 days, the result of air and water curing is slightly different which is for air curing result is 3.23 MPa and water curing result is 3.07 MPa. Then, both type of curing at 7 days increased drastically but the different between air and water curing are very slightly which means air curing result is 6.20 MPa and water curing result is 6.11 MPa. From 7 days to 14 days, the compressive strength is slightly different because the result for air curing from 6.20 MPa to 6.39 MPa and water curing from 6.11 MPa to 6.22 MPa. During 28 days, both type curing still increased slightly. For the air curing result rose from 6.39 MPa to 6.48 MPa and water curing result rose from 6.22 MPa to 6.33 MPa. At the conclusion, the highest compressive for this ratio is air curing.

4.2.5 Average Compressive Strength for Air Curing Every Ratio

Table 4.5 Average Compressive Strength for Air Curing

Days	Compressive Strength (MPa)			
	Control sample	5% Clinker + 10% Rice Husk	5% Clinker + 20% Rice Husk	5% Clinker + 30% Rice Husk
3	5.30	4.70	3.28	3.23
7	4.64	6.24	6.95	6.20
14	6.85	6.62	7.45	6.39
28	8.85	8.02	7.83	6.48

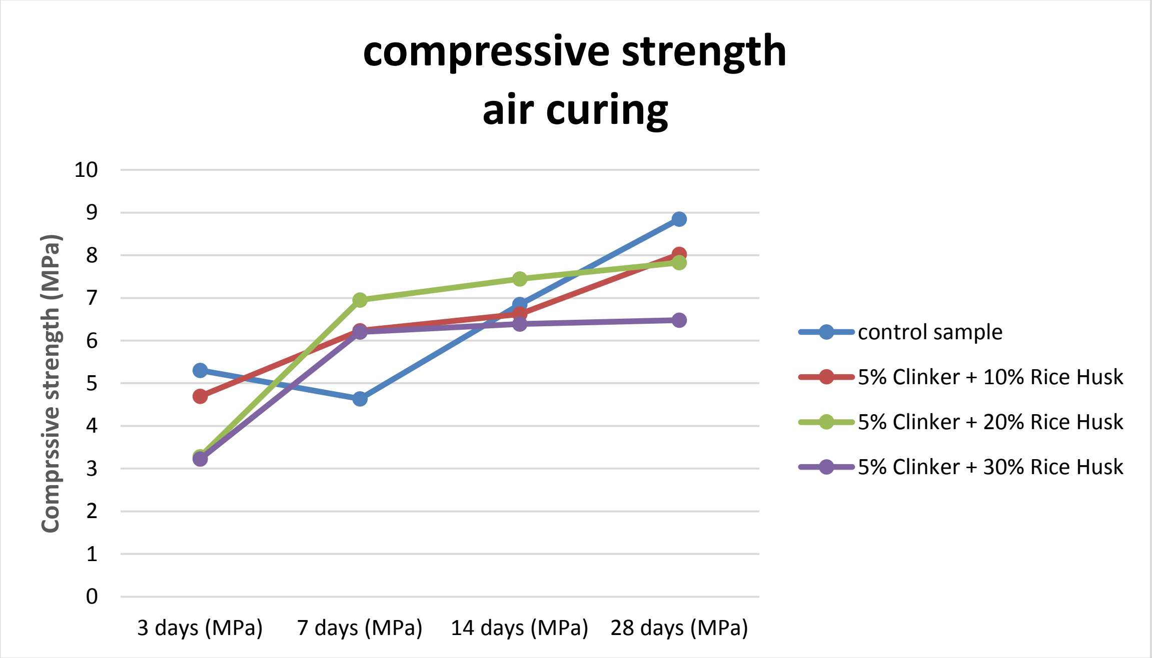

Figure 4.5: Graph Compressive Strength of Air Curing

Table 4.5 and figure 4.5 of graph shows changes of the compressive strength of air curing with 4 different type of ratio which is control sample, 5% clinker with 10% rice husk, 5% clinker with 20% rice husk and 5% clinker with 30% rice husk replacement as fine aggregate for 3, 7, 14 and 28 days. In 3 days, compressive strength for the control sample is 5.30 MPa are highest from 5% Clinker with 10% Rice Husk is 4.70 MPa, 5% Clinker with 20% Rice Husk is 3.28 MPa and 5% Clinker with 30% Rice Husk is 3.23 MPa which is rapidly decrease of strength. However, at 7 days for control sample is 4.64 MPa are lowest from 5% Clinker with 10% Rice Husk is 6.24 MPa, 5% Clinker with 20% Rice Husk is 6.95 MPa which is rapidly increase of strength and dropped slightly at ratio

5% clinker with 30% rice husk is 6.20 MPa. At 14 days, the highest ratio of compressive strength is 5% clinker with 20% rice husk which is 7.45 MPa but the lowest ratio of compressive strength is 5% clinker with 30% rice husk which is 6.39 MPa. Lastly during 28 days, the highest ratio of compressive strength is control sample which is 8.85 MPa but the lowest ratio is 5% clinker with 30% rice husk which is 6.48 MPa.

4.2.6 Average Compressive Strength for Water Curing Every Ratio

Table 4.6 Average Compressive Strength for Water Curing

Days	Compressive Strength (MPa)			
	Control sample	**5% Clinker + 10% Rice Husk**	**5% Clinker + 20% Rice Husk**	**5% Clinker + 30% Rice Husk**
3	4.50	3.89	2.44	3.07
7	5.49	5.67	6.46	6.11
14	5.94	6.38	6.57	6.22
28	8.47	6.66	6.96	6.33

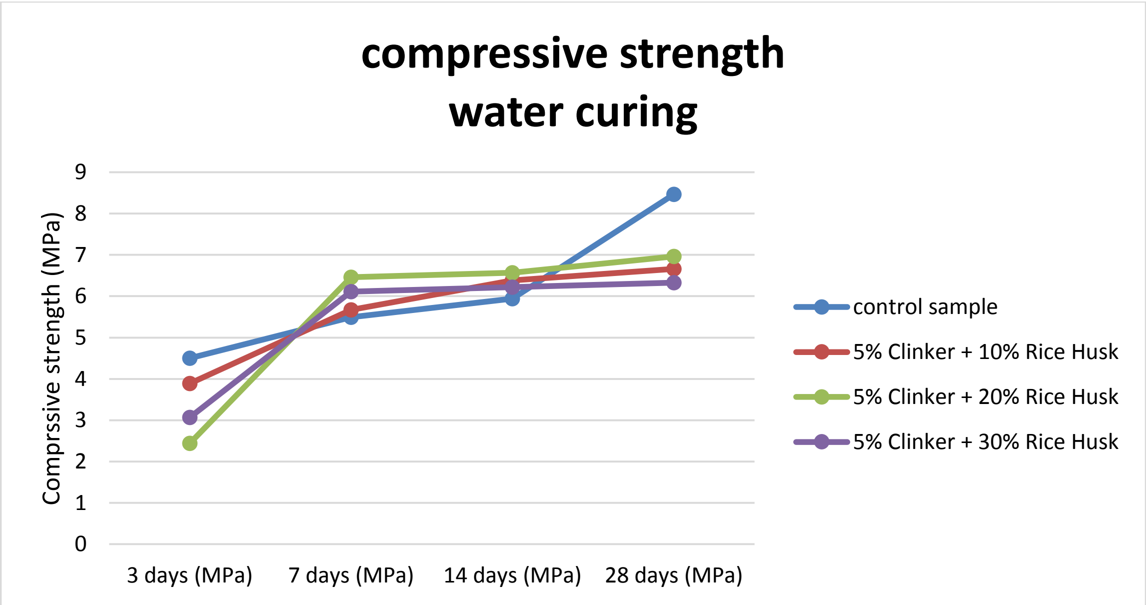

Figure 4.6: Graph Compressive Strength of Water Curing

Table 4.6 and figure 4.6 of graph shows changes of the compressive strength of water curing with 4 different type of ratio which is control sample, 5% clinker with 10% rice husk, 5% clinker with 20% rice husk and 5% clinker with 30% rice husk replacement as fine aggregate for 3, 7, 14 and 28 days. During 3 days, the compressive strength of control sample was 4.50 MPa, then dropped gradually at ratio 5% clinker with 10% rice husk and 5% clinker with 20% rice husk which is 3.89 MPa and 2.44 MPa then, increased slightly at ratio 5% clinker with 30% rice husk which is 3.07 MPa. At 7 days, the ratio of 5% clinker with 20% rice husk is rapidly increased becomes the highest compressive strength which is 6.46 MPa but the lowest ratio is the control sample which is 5.49 MPa. After that during 14 days, the ratio of the ratio of 5% clinker with 20% rice husk still the highest compressive strength which is 6.57 MPa and the lowest ratio still control sample which is 5.94 MPa. Lastly at 28 days, the ratio of control sample suddenly increased become the highest compressive strength which is 8.47 MPa and the lowest ratio is 5% clinker with 30% rice husk which is 6.33 MPa.

4.3 FLEXURAL STRENGTH

4.3.1 The Average Flexural Strength for Control Sample

Table 4.7 Average Flexural Strength of Control Sample

Days	Flexural Strength (MPa)	
	Air Curing	Water Curing
3	0.159	0.170
7	0.170	0.168
14	0.179	0.210
28	0.209	0.267

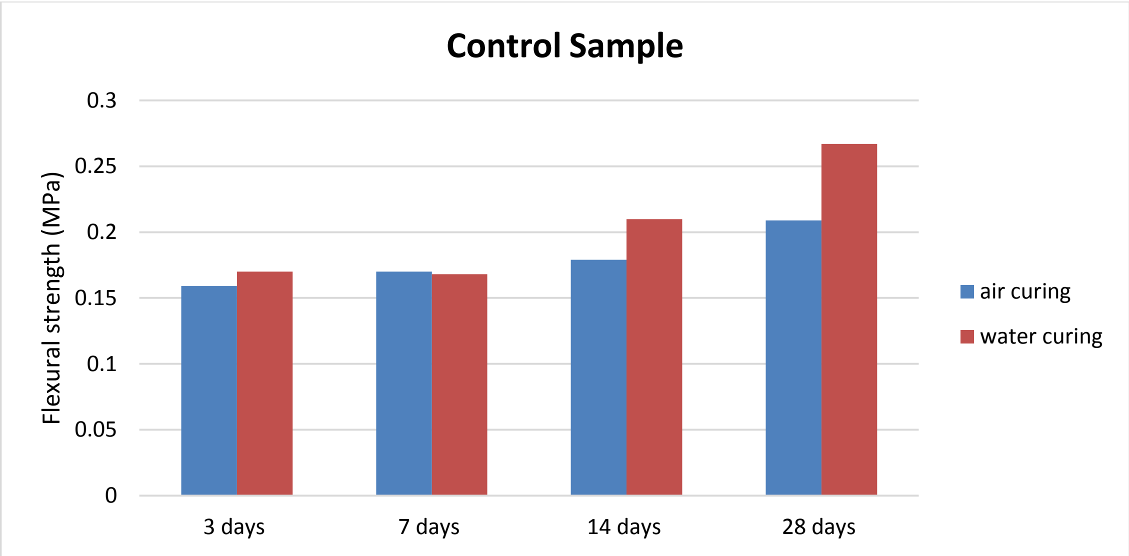

Figure 4.7: Graph Flexural Strength of Control Sample

The bar graph at figure 4.7 shows the result of the average flexural strength for control sample compared by air curing and water curing. During at 3 days, the result of air curing is 0.159 MPa lower than water curing is 0.170 MPa. Then at 7 days, the air curing result is 0.17 MPa suddenly slightly higher than water curing is 0.168 MPa. For water curing 7 days was decreased from 3 days. During 14 days, water curing result is 0.210 MPa drastically increased from 7 days but air curing result 0.179 MPa is slightly increased from 7 days. Lastly at 28 days, water curing result 0.267 MPa is increased drastically again higher than air curing result is 0.209 MPa. At the conclusion, the highest flexural strength control sample is water curing at 28 days.

4.3.2 The Average Flexural Strength for 5% Clinker with 10% Rice Husk

Table 4.8 Average Flexural Strength of 5% Clinker with 10% Rice Husk

Days	Flexural Strength (MPa)	
	Air Curing	Water Curing
3	0.188	0.141
7	0.195	0.211
14	0.219	0.265
28	0.259	0.265

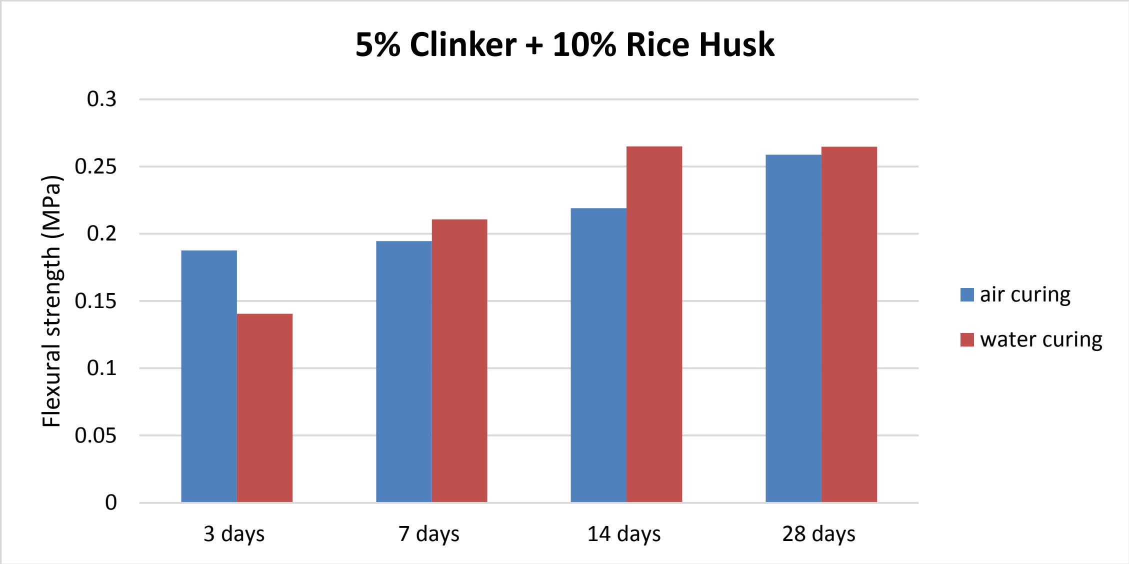

Figure 4.8: Graph Flexural Strength of 5% Clinker with 10% Rice Husk

The bar graph at figure 4.8 shows the average flexural strength for 5% Clinker with 10% Rice Husk replacement of fine aggregate for air curing and water curing. During 3 days, the air curing result is 0.188 MPa higher than water curing 0.141 MPa. During the 7 days, the result of is air curing 0.195 MPa lower than water curing is 0.211 MPa. Then at 14 days, water curing 0.265 MPa is suddenly increased higher than air curing result is 0.219 MPa. Lastly during 28 days, the result for water curing was maintain is 0.265 MPa but for the air curing increased from 0.219 MPa to 0.259 MPa. Overall, the highest flexural strength is water curing at 28 days.

4.3.3 The Average Flexural Strength for 5% Clinker with 20% Rice Husk

Table 4.9 Average Flexural Strength of 5% Clinker with 20% Rice Husk

Days	Flexural Strength (MPa)	
	Air Curing	Water Curing
3	0.148	0.117
7	0.186	0.208
14	0.209	0.213
28	0.219	0.227

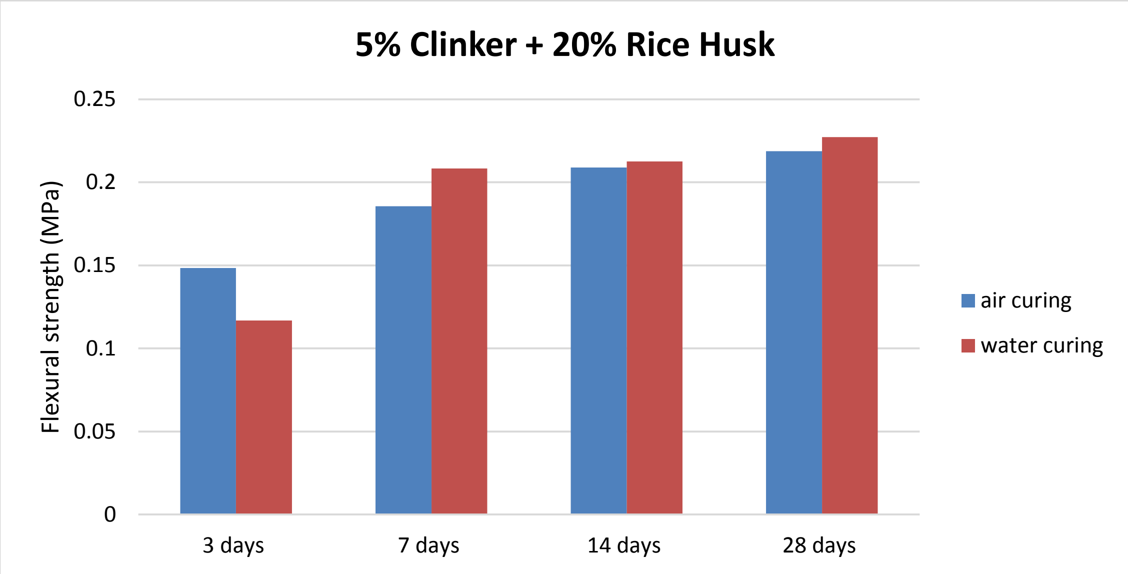

Figure 4.9: Graph Flexural Strength of 5% Clinker with 20% Rice Husk

The bar graph at figure 4.9 shows the average flexural strength for 5% Clinker with 20% Rice Husk replacement of fine aggregate for air curing and water curing. During 3 days, air curing is 0.148 MPa highest than water curing is 0.117 MPa. After that at 7 days, both of curing increased which is air curing increased from 0.148 MPa to 0.186 MPa and water curing increased from 0.117 MPa to 0.208 MPa. Suddenly at 14 days, water curing result 0.213 MPa increased slightly and air curing rose from 0.186 MPa to 0.209 MPa. Lastly during 28 days, the highest result is waeng which is 0.227 MPa but air curing result is less than water curing which is 0.219 MPa.

4.3.4 The Average Flexural Strength for 5% Clinker with 30% Rice Husk

Table 4.10 Average Flexural Strength of 5% Clinker with 30% Rice Husk

Days	Flexural Strength (MPa)	
	Air Curing	Water Curing
3	0.148	0.117
7	0.186	0.208
14	0.209	0.213
28	0.219	0.227

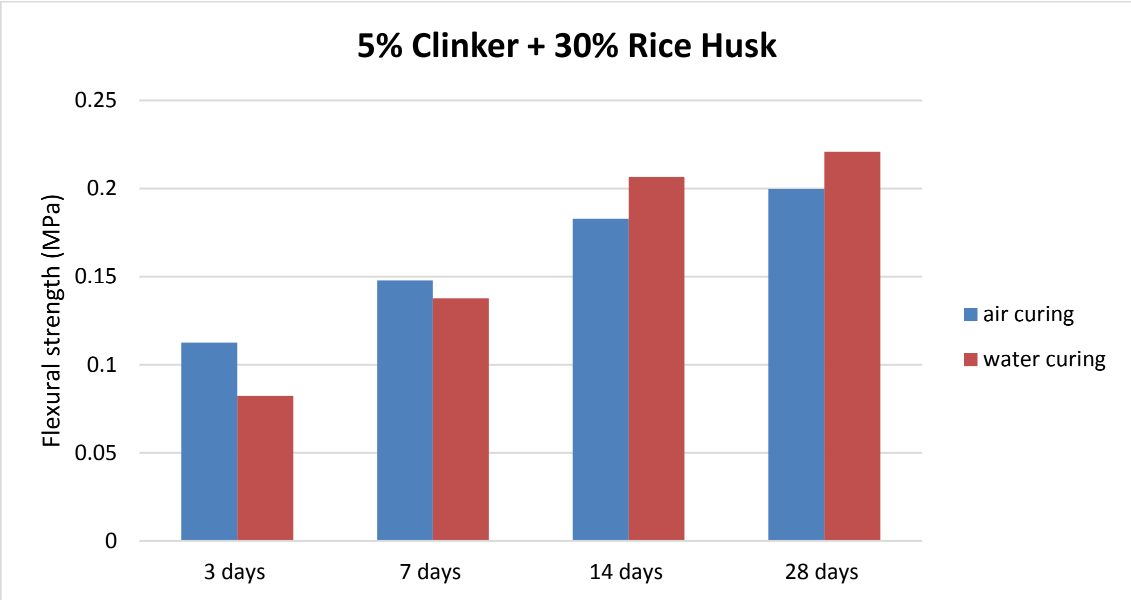

Figure 4.10: Graph Flexural Strength of 5% Clinker with 30% Rice Husk

The bar graph in figure 4.10 shows the different result flexural strength of 5% Clinker with 30% Rice Husk between types of curing. During 3 days, the highest flexural strength is air curing which is 0.112 MPa but water curing is 0.082 MPa lower than air curing. Then at 7 days, air curing still highest than water curing which is air curing result is 0.148 MPa but water curing result is 0.138 MPa. After that during 14 days, both of curing is increased drastically but air curing result 0.183 MPa is suddenly lowest than water curing 0.207 MPa. During 28 days, the highest flexural strength is water curing which is 0.221 MPa and water curing result is 0.120 MPa.

4.3.5 Average Flexural Strength for Air Curing Every Ratio

Table 4.11 Average Flexural Strength for Air Curing

Days	Compressive Strength (MPa)			
	Control sample	5% Clinker + 10% Rice Husk	5% Clinker + 20% Rice Husk	5% Clinker + 30% Rice Husk
3	0.159	0.188	0.148	0.112
7	0.170	0.195	0.186	0.148
14	0.179	0.219	0.209	0.183
28	0.209	0.259	0.219	0.120

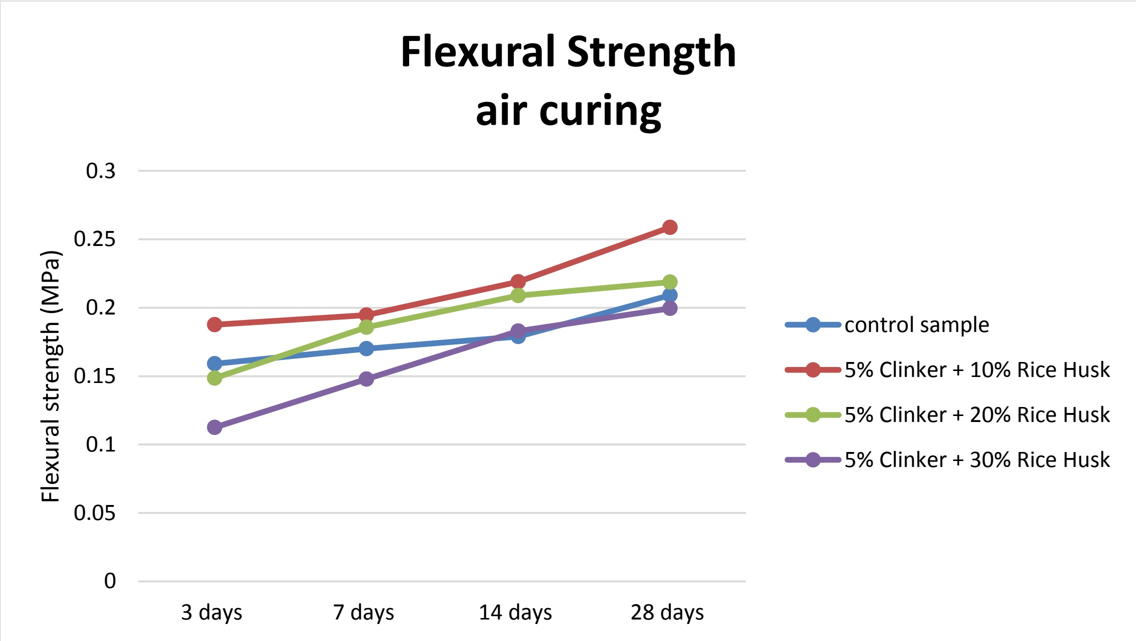

Figure 4.11: Graph Flexural Strength of Air Curing

Table 4.11 and figure 4.11 of graph shows changes of the flexural strength of air curing with 4 different type of ratio which is control sample, 5% clinker with 10% rice husk, 5% clinker with 20% rice husk and 5% clinker with 30% rice husk replacement as fine aggregate for 3, 7, 14 and 28 days. During 3 days, the highest ratio for flexural strength is 5% clinker with 10% rice husk with 0.188 MPa. At 7 days also the ratio 5% clinker with 10% rice husk is the highest ratio which is 0.195 MPa. After that during 14 days, ratio 5% clinker with 10% rice husk still the highest which is 0.219 MPa but suddenly ratio 5% clinker with 30% rice husk 0.183 MPa is higher than control sample which is 0.179 MPa. Lastly at 28 days, the highest still ratio 5% clinker with 10% rice husk with drastically increased which is 0.259 MPa but the lowest ratio 5% clinker with

30% rice husk which is 0.120 MPa. At the conclusion, the highest flexural strength for the air curing is ratio 5% clinker with 10% rice husk.

4.3.6 Average Flexural Strength for Water Curing Every Ratio

Table 4.12 Average Flexural Strength for Water Curing

Days	Compressive Strength (MPa)			
	Control sample	5% Clinker + 10% Rice Husk	5% Clinker + 20% Rice Husk	5% Clinker + 30% Rice Husk
3	0.170	0.141	0.117	0.082
7	0.168	0.211	0.208	0.138
14	0.210	0.265	0.213	0.207
28	0.267	0.265	0.227	0.221

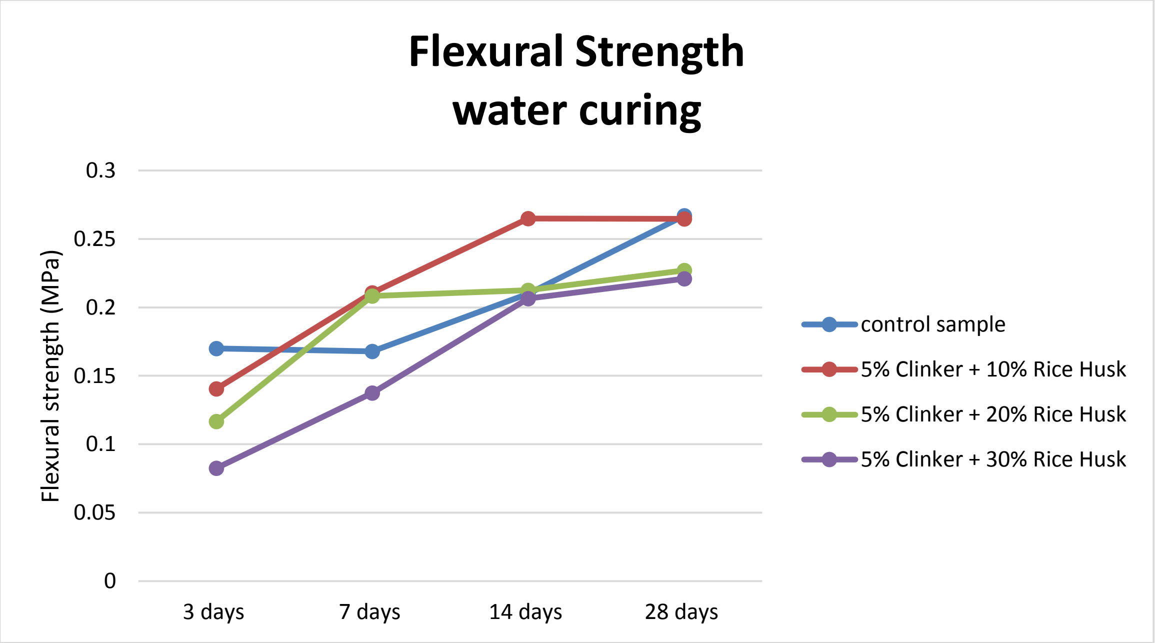

Figure 4.12: Graph Flexural Strength of Water Curing

Table 4.12 and figure 4.12 of graph shows changes of the flexural strength of water curing with 4 different type of ratio which is control sample, 5% clinker with 10% rice husk, 5% clinker with 20% rice husk and 5% clinker with 30% rice husk replacement as fine aggregate for 3, 7, 14 and 28 days. During 3 days, the highest flexural strength for water curing is control sample 0.170 MPa and the lowest is ratio 5% clinker with 30% rice husk 0.082 MPa. Then during 7 days, control sample suddenly dropped lower than ratio 5% clinker with 10% rice husk and 5% clinker with 20% rice husk which is 0.168 MPa. So, the highest ratio of the flexural strength during 7 days is ratio 5% clinker with 10% rice husk which is 0.211 MPa and the lowest still ratio 5% clinker with 30% rice husk is 0.138 MPa. At 14 days, the ratio 5% clinker with 10% rice husk rose from 0.211 MPa to 0.265 MPa. After that during 28 days, ratio 5% clinker with 10% rice husk maintain the flexural strength which is 0.265 MPa but the highest result is control sample which is 0.267 MPa and the lowest still ratio 5% clinker with 30% rice husk which is 0.221 MPa.

4.4 DENSITY

4.4.1 The Average Density for Air Curing

Table 4.13 Average Density for Air Curing

Ratio	Density (kN/m^3) Air curing
Control Sample	15.82
5% Clinker + 10% Rice Husk	17.95
5% Clinker + 20% Rice Husk	18.16
5% Clinker + 30% Rice Husk	15.79

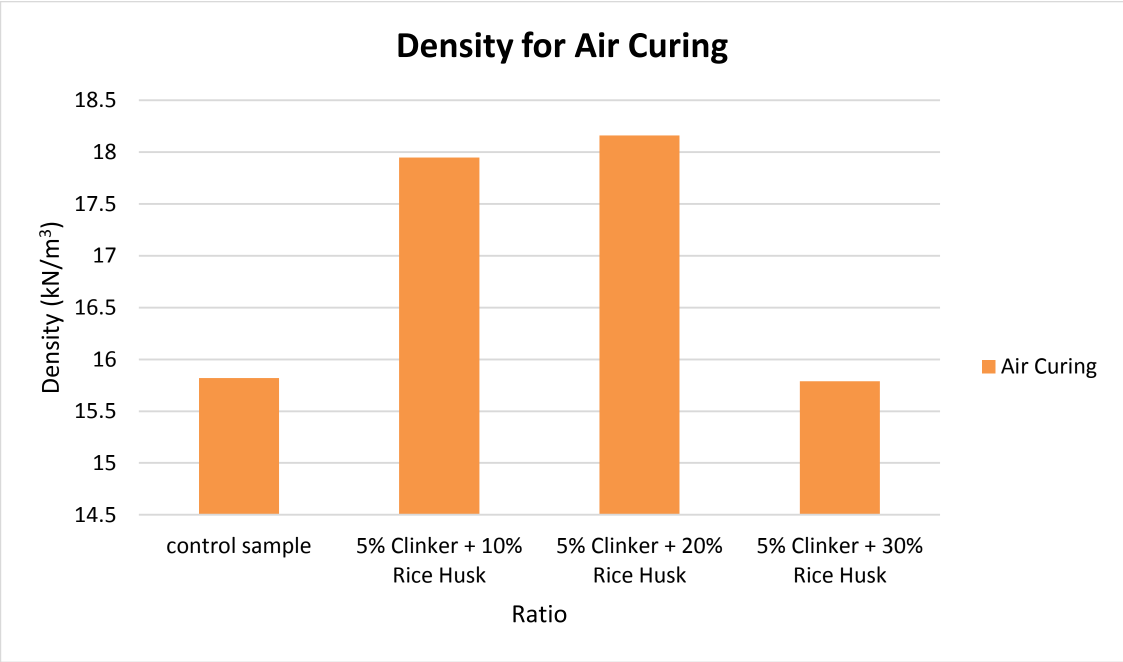

Figure 4.13: Graph Density for Air Curing

The bar graph in figure 4.13 shows the result density of every ratio which is control sample, 5% Clinker with 10% rice husk, 5% clinker with 20% rice husk and 5% clinker with 30% rice husk for air curing for 28 days. The highest density is ratio 5% clinker with 20% rice husk which is 18.16 kN/m^3 but the lowest density for this type of curing is ratio 5% clinker with 30% rice husk which is 15.79 kN/m^3.

4.4.2 The Average Density for Water Curing

Table 4.14 Average Density for Water Curing

Ratio	Density (kN/m^3)
	Water curing
Control Sample	19.17
5% Clinker + 10% Rice Husk	17.84
5% Clinker + 20% Rice Husk	16.57
5% Clinker + 30% Rice Husk	16.17

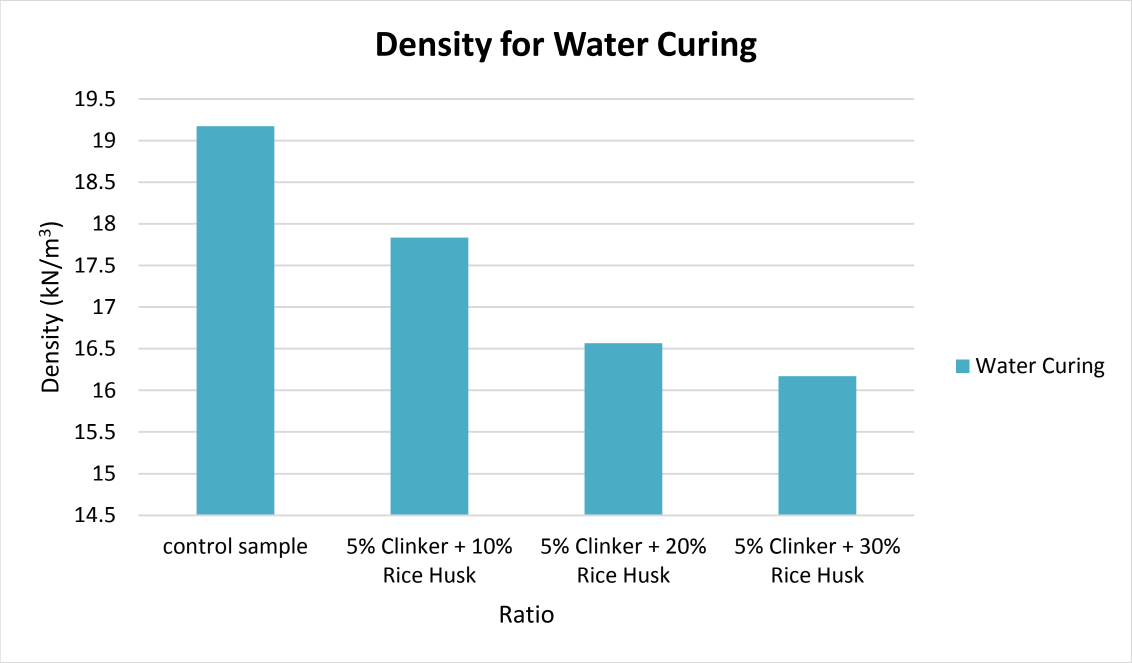

Figure 4.14: Graph Density for Water Curing

The bar graph in figure 4.14 shows the result density of every ratio which is control sample, 5% Clinker with 10% rice husk, 5% clinker with 20% rice husk and 5% clinker with 30% rice husk for water curing for 28 days. The highest density for the water curing is control sample which is 19.17 kN/m^3 and dropped gradually for another ratio but the lowest density is ratio 5% clinker with 30% rice husk which is 16.17 kN/m^3.

4.4.3 The Differences Average Density between Types of Curing

Table 4.15 Differences Average Density

Ratio	Density (kN/m^3)	
	Air curing	Water curing
Control Sample	15.82	19.17
5% Clinker + 10% Rice Husk	17.95	17.84
5% Clinker + 20% Rice Husk	18.16	16.57
5% Clinker + 30% Rice Husk	15.79	16.17

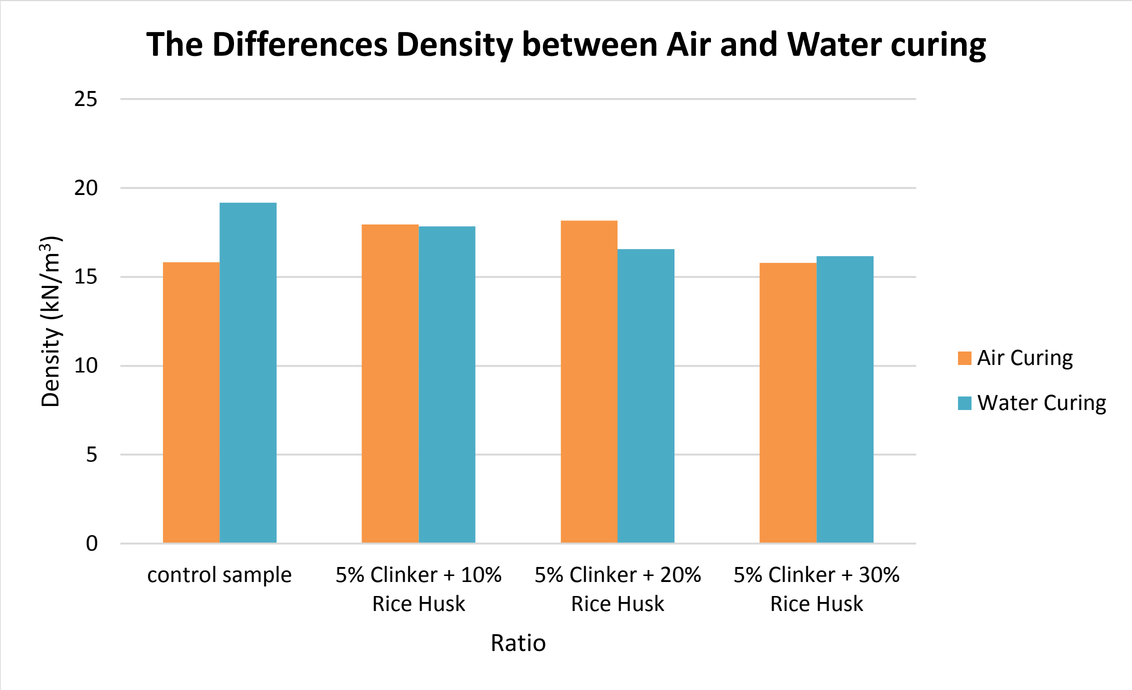

Figure 4.15: Graph Differences Density between Types of Curing

Table 4.15 and figure 4.15 of bar graph shows differences density between air curing and water curing with 4 different type of ratio which is control sample, 5% clinker with 10% rice husk, 5% clinker with 20% rice husk and 5% clinker with 30% rice husk replacement as fine aggregate for 28 days. For the control sample, water curing result is 19.17 kN/m^3 highest than air curing is 15.82 kN/m^3. For the ratio 5% clinker with 10% rice husk, air curing is 17.95 kN/m^3 slightly higher than water curing is 17.84 kN/m^3. Then, for the ratio 5% clinker with 20% rice husk air curing is 18.16 kN/m^3 increased more than water curing which is 16.57 kN/m^3. For the ratio 5% clinker with 30% rice husk, water curing is 15.79 kN/m^3 less than water curing which is 16.17 kN/m^3. At the conclusion, the highest density is control sample of the water curing.

4.5 WATER ABSORPTION

4.5.1 The Average Water Absorption for Air Curing

Table 4.16 Average Water Absorption for Air Curing

Ratio	Water Absorption (%)
	Air curing
Control Sample	11.22
5% Clinker + 10% Rice Husk	4.65
5% Clinker + 20% Rice Husk	4.95
5% Clinker + 30% Rice Husk	5.79

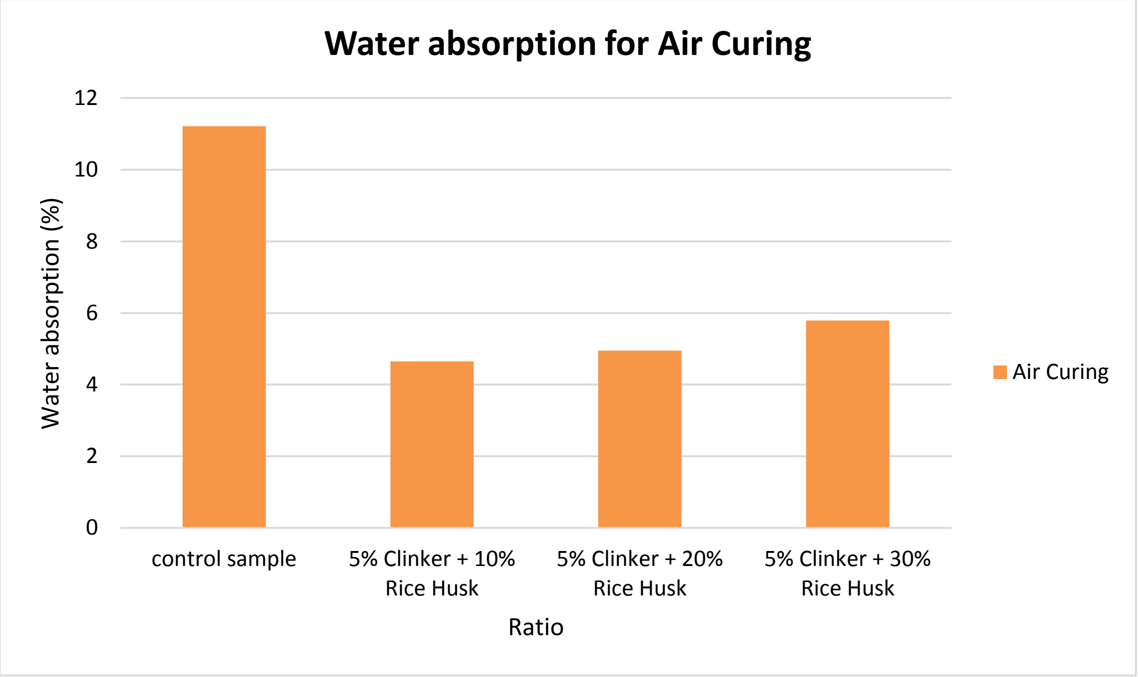

Figure 4.16: Graph Water Absorption for Air Curing

The bar graph in figure 4.16 shows the result water absorption of every ratio which is control sample, 5% Clinker with 10% rice husk, 5% clinker with 20% rice husk and 5% clinker with 30% rice husk for air curing for 28 days. The highest water absorption result for the air curing is control sample which is 11.22% but the lowest result is 5% Clinker with 10% rice husk which is 4.65%.

4.5.2 The Average Water Absorption for Water Curing

Table 4.17 Average Water Absorption for Water Curing

Ratio	Water Absorption (%)
	Water curing
Control Sample	11.88
5% Clinker + 10% Rice Husk	10.63
5% Clinker + 20% Rice Husk	13.10
5% Clinker + 30% Rice Husk	13.12

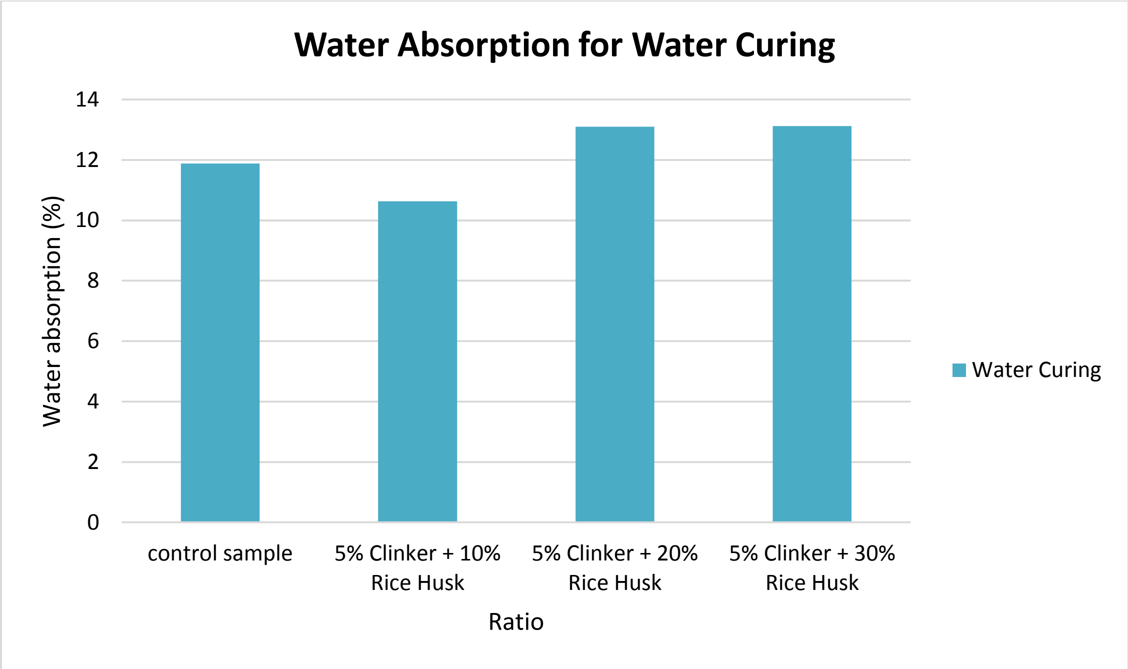

Figure 4.17: Graph Water Absorption for Water Curing

The bar graph in figure 4.17 shows the result water absorption of every ratio which is control sample, 5% Clinker with 10% rice husk, 5% clinker with 20% rice husk and 5% clinker with 30% rice husk for water curing for 28 days. The highest result for the water curing is ratio 5% clinker with 30% rice husk which is 13.12% and the lowest result for the water curing is ratio 5% Clinker with 10% rice husk which is 10.63%.

4.5.3 The Differences Average Water Absorption between Air and Water Curing

Table 4.18 Differences Average Water Absorption

Ratio	Water Absorption (%)	
	Air curing	Water curing
Control Sample	11.22	11.88
5% Clinker + 10% Rice Husk	4.65	10.63
5% Clinker + 20% Rice Husk	4.95	13.10
5% Clinker + 30% Rice Husk	5.79	13.12

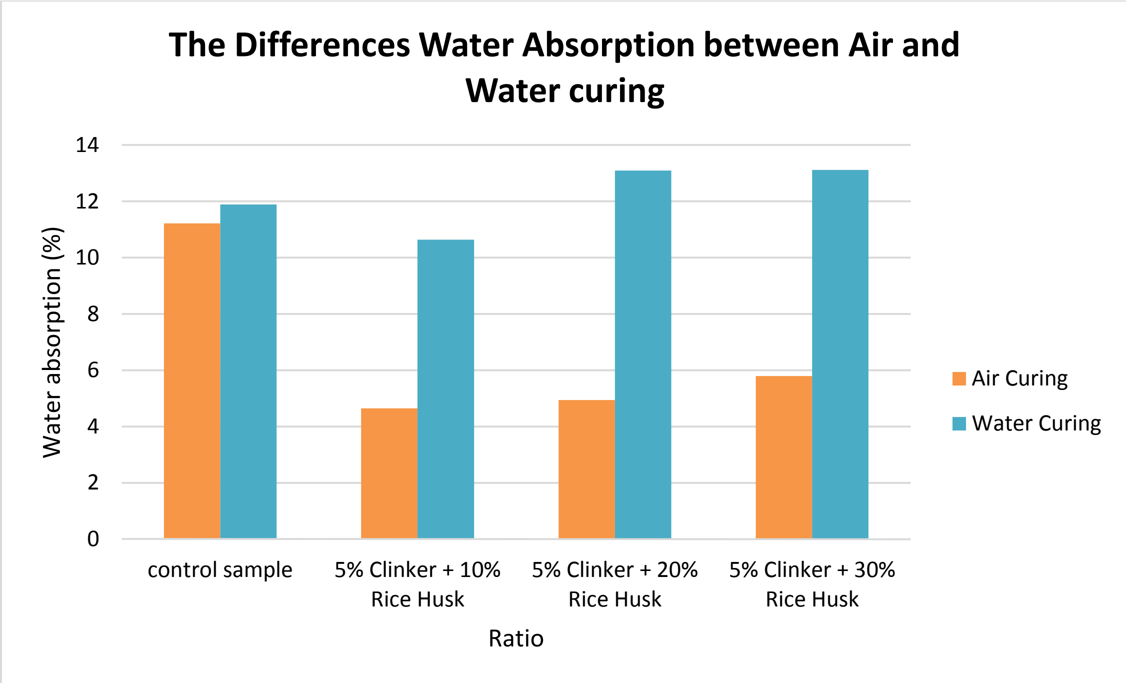

Figure 4.18: Graph Differences Water Absorption between Types of Curing

Table 4.18 and figure 4.18 of bar graph shows differences density between air curing and water curing with 4 different type of ratio which is control sample, 5% clinker with 10% rice husk, 5% clinker with 20% rice husk and 5% clinker with 30% rice husk replacement as fine aggregate for 28 days. For all ratio, the result of water curing is higher than air curing. For control sample is 11.88% slightly increased than air curing which is 11.22% but for the another ratio the drastically different between air and water curing such as for the ratio 5% clinker with 10% rice husk for air curing is 4.65% but for the water curing is 10.63%. For the ratio 5% clinker with 20% rice husk water curing 13.10% is highest drastically than air curing 4.95%. Lastly for the ratio 5% clinker with 30% rice husk water curing 13.12% is also drastically increased than air curing is 5.79%.

4.6 DISCUSSION

From the result that had been discuss, the result of the compressive strength, flexural strength, density and water absorption for 4 different types of ratio which is control sample, 5% clinker with 10% rice husk, 5% clinker with 20% rice husk and 5% clinker with 30% rice husk replacement as fine aggregate. The compressive strength for the shown the highest ratio is control sample for air curing which is 8.85 MPa during 28 days. The optimum of compressive strength for the mixed ratio is air curing 5% clinker with 10% rice husk which is 8.02 MPa and the lowest compressive strength for the mixed ratio is water curing 5% clinker with 30% rice husk which is 6.33 MPa during 28 days. Then, the highest flexural strength is control sample of water curing which is 0.267 MPa. The optimum for mixed ratio is water curing 5% clinker with 10% rice husk which is 0.265 MPa and the lowest ratio is air curing 5% clinker with 30% rice husk which is 0.120 MPa during 28 days. Furthermore, the highest result 28 days for density is control sample of water curing which is 19.17 kN/m^3. The highest density for mixed ratio is air curing 5% clinker with 10% rice husk which is 17.95 kN/m^3 and the lowest for density is air curing 5% clinker with 30% rice husk 15.79 kN/m^3. Lastly, the optimum result 28 days for water absorption is ratio 5% clinker with 30% rice husk of water curing which is 13.12% and the lowest water absorption is air curing 5% clinker with 10% rice husk which is 4.65%. So from the result above, usage 5% clinker with 10%, 20% and 30% rice husk as a partial replacement of fine aggregate will reduce the strength of the brick. Wasted material rice husk good in absorb water, so it will affect the strength of brick. From this result the higher usage of material clinker with rice husk the lower the density so it will affected the strength of brick. So, from the result shown the compressive strength and flexural strength depend on materials the used for make this brick. From this waste materials which is clinker with rice husk can conclude that when higher the usage of this material the lower the compressive, flexural strength and density. Higher usage of material, the density decreased, the sand brick become lighter but it depend on the compressive strength when the higher density provides higher strength and fewer amount of voids and porosity. The strength of brick depends upon its water absorption capacity, higher the water absorption, higher usage wastes materials, lower the strength of sand brick. The water absorption is due to the presence of voids in the brick so the pores of the bricks will absorb the content of water from mortar that put on the bricks and can cause highly porosity. It can concluded that rice husk has higher capability in water absorb.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 GENERAL

In general, this study focus on the compressive strength, flexural strength, density and water absorption for the 4 different type of ratio which is control sample, 5% clinker with 10% rice husk, 5% clinker with 20% rice husk and 5% clinker with 30% rice husk replacement as fine aggregate. Nowadays, highly demand for the industry needed this eco brick in usage for the construction such as housing and also reducing the dumping disposal of natural waste. In addition, have this eco brick can produce more conventional production for construction industry and can reduce cost for the construction materials.

5.2 CONCLUSION

i. The highest compressive strength for the ratio that replace fine aggregate which is sand is air curing 5% clinker and 10% rice husk which is 8.02 MPa and the lowest is water curing 5% clinker and 30% which is 6.33 MPa during 28 days.
ii. The highest flexural strength for the ratio that replace fine aggregate which is sand is water curing 5% clinker and 10% rice husk which is 0.265 MPa and the lowest is air curing 5% clinker and 30% which is 0.120 MPa during 28 days.
iii. The highest density for the ratio that replace fine aggregate which is sand is air curing 5% clinker and 10% rice husk which is 17.95 kN/m^3 and the lowest is air curing 5% clinker and 30% which is 15.79 kN/m^3 during 28 days.
iv. The lowest water absorption for the ratio that replace fine aggregate which is sand is air curing 5% clinker and 10% rice husk which is 4.65% and the highest is water curing 5% clinker and 30% which is 13.12% during 28 days.
v. The best ratio of this sand brick that replace fine aggregate (sand) with clinker and rice husk is 5% clinker with 10% rice husk.

5.3 RECOMMENDATION

Based on the result obtained through this experiment, the following were made for the clinker with rice husk replacement as fine aggregate in sand brick. There are:

i. From the result shown from the graph, the compressive and flexural strength it can be recommended to investigate the percentage usage of the clinker and rice husk need to be reduced from percentage that used in this experiment for achieve higher compressive and flexural strength.
ii. Used smaller sizes of clinker and rice husk than are passing 4.75mm to replace sand for all sample.
iii. Try to wash the clinker and dry it before used because can avoid more water absorb.
iv. Sieve the sand passing 4.75mm before used it.
v. Try to use mould make from factory to ensure the size are all same.
vi. Recalculate the ratio of mixed because from this experiment not relevant between how many sample can get from the ratio with reality.

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APPENDICES 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 (MPa)	Flexural strength (MPa)
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 (MPa)	Flexural strength (MPa)
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 (MPa)	Flexural strength (MPa)
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 (MPa)	Flexural strength (MPa)
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 (MPa)	Flexural strength (MPa)
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 (MPa)	Flexural strength (MPa)
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 (MPa)	Flexural strength (MPa)
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 (MPa)	Flexural strength (MPa)
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

APPENDICES B

5% clinker with 10% rice husk of for air curing 3 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.835	0.025425	104.7	-	4.12	-
2	3.816	0.025425	134.7	-	5.30	-
3	3.820	0.025425	134.8	-	5.30	-
4	3.825	0.025425	103.6	-	4.07	-
5	3.835	0.025425	-	4.81	-	0.189
6	4.087	0.025425	-	4.76	-	0.187
7	3.891	0.025425	-	4.72	-	0.186
8	4.010	0.025425	-	4.79	-	0.188
	Average				4.70	0.188

5% clinker with 10% rice husk of for water curing 3 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.994	0.025425	97.4	-	3.83	-
2	3.929	0.025425	100.2	-	3.94	-
3	3.990	0.025425	98.2	-	3.86	-
4	3.952	0.025425	100.1	-	3.94	-
5	3.994	0.025425	-	3.43	-	0.135
6	3.929	0.025425	-	3.61	-	0.142
7	4.103	0.025425	-	3.63	-	0.143
8	4.020	0.025425	-	3.62	-	0.142
	Average				3.89	0.141

5% clinker with 10% rice husk of for air curing 7 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.600	0.025425	154.9	-	6.09	-
2	3.623	0.025425	161.2	-	6.34	-
3	3.773	0.025425	172.9	-	6.80	-
4	3.735	0.025425	145.2	-	5.71	-
5	3.617	0.025425	-	4.84	-	0.190
6	3.697	0.025425	-	5.04	-	0.200
7	3.763	0.025425	-	4.50	-	0.177
8	3.787	0.025425	-	5.36	-	0.211
	Average				6.24	0.195

5% clinker with 10% rice husk of for water curing 7 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	4.018	0.025425	150.8	-	5.93	-
2	3.857	0.025425	149.5	-	5.88	-
3	3.766	0.025425	118.0	-	4.64	-
4	4.168	0.025425	158.7	-	6.24	-
5	3.802	0.025425	-	5.38	-	0.212
6	4.042	0.025425	-	5.47	-	0.215
7	4.017	0.025425	-	5.36	-	0.211
8	3.986	0.025425	-	5.22	-	0.205
	Average				5.67	0.211

5% clinker with 10% rice husk of for air curing 14 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.940	0.025425	162.4	-	6.39	-
2	3.804	0.025425	161.5	-	6.35	-
3	3.348	0.025425	186.9	-	7.35	-
4	3.622	0.025425	162.7	-	6.40	-
5	3.987	0.025425	-	6.28	-	0.247
6	3.798	0.025425	-	6.04	-	0.238
7	3.374	0.025425	-	4.93	-	0.194
8	3.659	0.025425	-	5.02	-	0.197
	Average				6.62	0.219

5% clinker with 10% rice husk of for water curing 14 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.894	0.025425	176.9	-	6.96	-
2	3.983	0.025425	140.8	-	5.54	-
3	3.965	0.025425	157.1	-	6.18	-
4	3.797	0.025425	174.0	-	6.84	-
5	4.028	0.025425	-	6.86	-	0.270
6	4.005	0.025425	-	6.93	-	0.273
7	3.887	0.025425	-	6.42	-	0.253
8	4.101	0.025425	-	6.74	-	0.265
	Average				6.38	0.265

5% clinker with 10% rice husk of for air curing 28 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.517	0.025425	198.6	-	7.81	-
2	3.530	0.025425	208.9	-	8.22	-
3	3.547	0.025425	207.9	-	8.18	-
4	3.544	0.025425	200.3	-	7.88	-
5	3.566	0.025425	-	6.83	-	0.269
6	3.740	0.025425	-	6.53	-	0.257
7	3.796	0.025425	-	6.39	-	0.251
8	3.667	0.025425	-	6.56	-	0.258
	Average				8.02	0.259

5% clinker with 10% rice husk of for water curing 28 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	4.087	0.025425	126.3	-	4.97	-
2	4.003	0.025425	186.8	-	7.35	-
3	3.944	0.025425	179.1	-	7.04	-
4	4.005	0.025425	185.3	-	7.29	-
5	4.002	0.025425	-	5.69	-	0.224
6	4.094	0.025425	-	6.98	-	0.275
7	3.933	0.025425	-	7.34	-	0.289
8	4.021	0.025425	-	6.92	-	0.272
	Average				6.66	0.265

APPENDICES C

5% clinker with 20% rice husk of for air curing 3 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.618	0.025425	71.4	-	2.81	-
2	3.812	0.025425	95.0	-	3.74	-
3	3.800	0.025425	94.8	-	3.73	-
4	3.771	0.025425	72.3	-	2.84	-
5	3.636	0.025425	-	3.83	-	0.151
6	3.681	0.025425	-	3.74	-	0.147
7	3.662	0.025425	-	3.71	-	0.146
8	3.611	0.025425	-	3.82	-	0.150
	Average				3.28	0.148

5% clinker with 20% rice husk of for water curing 3 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.714	0.025425	56.4	-	2.22	-
2	3.822	0.025425	66.3	-	2.61	-
3	3.868	0.025425	66.8	-	2.63	-
4	3.810	0.025425	59.1	-	2.32	-
5	3.650	0.025425	-	3.31	-	0.130
6	3.866	0.025425	-	2.74	-	0.108
7	3.752	0.025425	-	2.83	-	0.111
8	3.788	0.025425	-	2.99	-	0.118
	Average				2.44	0.117

5% clinker with 20% rice husk of for air curing 7 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.600	0.025425	154.9	-	6.93	-
2	3.623	0.025425	161.2	-	7.08	-
3	3.773	0.025425	172.9	-	6.62	-
4	3.735	0.025425	145.2	-	7.19	-
5	3.617	0.025425	-	4.84	-	0.161
6	3.697	0.025425	-	5.09	-	0.216
7	3.763	0.025425	-	4.50	-	0.184
8	3.787	0.025425	-	5.36	-	0.182
	Average				6.95	0.186

5% clinker with 20% rice husk of for water curing 7 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.966	0.025425	165.4	-	6.51	-
2	4.067	0.025425	170.1	-	6.69	-
3	3.764	0.025425	177.2	-	6.97	-
4	3.890	0.025425	144.5	-	5.68	-
5	3.821	0.025425	-	5.66	-	0.223
6	3.905	0.025425	-	4.96	-	0.195
7	3.772	0.025425	-	5.39	-	0.212
8	4.024	0.025425	-	5.18	-	0.204
	Average				6.46	0.208

5% clinker with 20% rice husk of for air curing 14 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.648	0.025425	134.5	-	5.29	-
2	3.498	0.025425	162.3	-	6.38	-
3	3.563	0.025425	237.5	-	9.34	-
4	3.641	0.025425	223.3	-	8.78	-
5	3.706	0.025425	-	6.67	-	0.262
6	3.399	0.025425	-	4.65	-	0.183
7	3.581	0.025425	-	5.31	-	0.209
8	3.348	0.025425	-	4.62	-	0.182
	Average				7.45	0.209

5% clinker with 20% rice husk of for water curing 14 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.540	0.025425	157.9	-	6.21	-
2	3.608	0.025425	168.9	-	6.64	-
3	3.779	0.025425	172.0	-	6.76	-
4	3.710	0.025425	169.2	-	6.65	-
5	3.628	0.025425	-	5.81	-	0.229
6	3.561	0.025425	-	5.13	-	0.202
7	3.659	0.025425	-	5.42	-	0.213
8	3.435	0.025425	-	5.26	-	0.207
	Average				6.57	0.213

5% clinker with 20% rice husk of for air curing 28 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.547	0.025425	213.9	-	8.41	-
2	3.726	0.025425	180.9	-	7.12	-
3	3.550	0.025425	192.3	-	7.56	-
4	3.631	0.025425	209.2	-	8.23	-
5	3.729	0.025425	-	5.24	-	0.206
6	3.823	0.025425	-	5.73	-	0.225
7	3.813	0.025425	-	6.03	-	0.237
8	3.811	0.025425	-	5.25	-	0.206
	Average				7.83	0.219

5% clinker with 20% rice husk of for water curing 28 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.726	0.025425	153.1	-	6.02	-
2	3.737	0.025425	166.2	-	6.54	-
3	3.756	0.025425	198.8	-	7.82	-
4	3.742	0.025425	190.1	-	7.48	-
5	3.971	0.025425	-	5.78	-	0.227
6	3.957	0.025425	-	5.93	-	0.233
7	3.949	0.025425	-	5.66	-	0.223
8	3.956	0.025425	-	5.73	-	0.225
	Average				6.96	0.227

APPENDICES D

5% clinker with 30% rice husk of for air curing 3 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.700	0.025425	86.7	-	3.41	-
2	3.185	0.025425	76.5	-	3.01	-
3	3.533	0.025425	85.3	-	3.35	-
4	3.420	0.025425	80.1	-	3.15	-
5	3.567	0.025425	-	3.16	-	0.124
6	3.314	0.025425	-	2.70	-	0.106
7	3.322	0.025425	-	2.72	-	0.107
8	3.541	0.025425	-	2.86	-	0.112
	Average				3.23	0.112

5% clinker with 30% rice husk of for water curing 3 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.707	0.025425	74.8	-	2.94	-
2	3.831	0.025425	81.0	-	3.19	-
3	3.844	0.025425	79.3	-	3.12	-
4	3.801	0.025425	77.2	-	3.04	-
5	3.455	0.025425	-	2.18	-	0.085
6	3.382	0.025425	-	2.02	-	0.079
7	3.421	0.025425	-	2.11	-	0.083
8	3.399	0.025425	-	2.09	-	0.082
	Average				3.07	0.082

5% clinker with 30% rice husk of for air curing 7 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.407	0.025425	139.2	-	5.47	-
2	3.478	0.025425	153.2	-	6.04	-
3	3.470	0.025425	157.1	-	6.18	-
4	3.425	0.025425	180.8	-	7.11	-
5	3.284	0.025425	-	2.82	-	0.111
6	3.176	0.025425	-	3.94	-	0.155
7	3.096	0.025425	-	3.48	-	0.137
8	3.358	0.025425	-	4.79	-	0.188
	Average				6.20	0.148

5% clinker with 30% rice husk of for water curing 7 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.678	0.025425	148.4	-	5.84	-
2	3.594	0.025425	144.3	-	5.68	-
3	3.597	0.025425	163.3	-	6.42	-
4	3.676	0.025425	165.2	-	6.50	-
5	3.472	0.025425	-	1.05	-	0.041
6	3.620	0.025425	-	4.28	-	0.168
7	3.684	0.025425	-	4.36	-	0.171
8	3.579	0.025425	-	4.30	-	0.169
	Average				6.11	0.138

5% clinker with 30% rice husk of for air curing 14 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.142	0.025425	160.6	-	6.32	-
2	3.449	0.025425	158.6	-	6.24	-
3	3.382	0.025425	166.0	-	6.53	-
4	3.105	0.025425	164.9	-	6.49	-
5	3.199	0.025425	-	4.82	-	0.190
6	3.972	0.025425	-	3.67	-	0.144
7	3.708	0.025425	-	5.95	-	0.234
8	3.389	0.025425	-	4.15	-	0.163
	Average				6.39	0.183

5% clinker with 30% rice husk of for water curing 14 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.509	0.025425	166.3	-	6.54	-
2	3.761	0.025425	127.9	-	5.03	-
3	3.815	0.025425	180.1	-	7.08	-
4	3.668	0.025425	158.2	-	6.22	-
5	3.492	0.025425	-	4.19	-	0.165
6	3.592	0.025425	-	5.18	-	0.204
7	3.778	0.025425	-	5.96	-	0.234
8	3.826	0.025425	-	5.68	-	0.223
	Average				6.22	0.207

5% clinker with 30% rice husk of for air curing 28 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.082	0.025425	163.8	-	6.44	-
2	3.209	0.025425	166.5	-	6.55	-
3	3.361	0.025425	156.2	-	6.14	-
4	3.254	0.025425	172.5	-	6.78	-
5	3.303	0.025425	-	4.16	-	0.164
6	3.254	0.025425	-	5.27	-	0.207
7	3.271	0.025425	-	5.22	-	0.205
8	3.314	0.025425	-	5.64	-	0.222
	Average				6.48	0.200

5% clinker with 30% rice husk of for air curing 28 days

No of sample	Weight (Kg)	Area (m^2)	Maximum load (kN)	Load applied (kN)	Compressive strength (MPa)	Flexural strength (MPa)
1	3.502	0.025425	169.3	-	6.66	-
2	3.712	0.025425	160.2	-	6.30	-
3	3.608	0.025425	148.4	-	5.84	-
4	3.549	0.025425	165.7	-	6.52	-
5	3.664	0.025425	-	4.76	-	0.187
6	3.679	0.025425	-	5.84	-	0.230
7	3.614	0.025425	-	6.08	-	0.239
8	3.677	0.025425	-	5.79	-	0.228
	Average				6.33	0.221

APPENDICES E

Density

Ratio	Type of curing	Weight after oven (Kg)	Density (kN/m^3)
Control sample	Air	3.075	15.82
	Water	3.727	19.17
5% Clinker + 10% Rice Husk	Air	3.489	17.95
	Water	3.467	17.84
5% Clinker + 20% Rice Husk	Air	3.530	18.16
	Water	3.220	15.79
5% Clinker + 30% Rice Husk	Air	3.069	16.17
	Water	3.143	15.82

Water Absorption

Ratio	Type of curing	Weight after oven (Kg)	Weight after immersed (Kg)	Water Absorption (%)
Control sample	Air	3.592	3.995	15.82
	Water	3.593	4.020	19.17
5% Clinker + 10% Rice Husk	Air	3.548	3.713	17.95
	Water	3.545	3.922	17.84
5% Clinker + 20% Rice Husk	Air	3.477	3.649	18.16
	Water	3.253	3.679	15.79
5% Clinker + 30% Rice Husk	Air	3.245	3.433	16.17
	Water	3.117	3.526	15.82