A STUDY ON BRICK USING FINE COCONUT SHELL

SITI ZUL NORAIN BINTI MUHAMAD

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

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SITI ZUL NORAIN BINTI MUHAMAD

Thesis submitted in fulfillment of the requirements
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ABSTRAK

Dalam industri pembinaan, peningkatan kos bahan binaan merupakan salah satu impak yang besar kepada masyarakat. Oleh yang demikian, penggunaan bahan baru dalam penggantian pasir untuk menghasilkan bata yang lebih mesra alam sekitar dengan menggunakan bahan buangan telah dijalankan. Sisa kelapa seperti tempurung kelapa adalah salah satu bahan buangan yang dihasilkan dari proses pertanian. Perkara ini secara tidak langsung menimbulkan cabaran kepada pihak yang terlibat dalam menangani pelupusan serta pengurusan alam sekitar. Kajian ini dijalankan untuk mengkaji kesan bata pasir terhadap penggunaan tempurung kelapa halus yang terdiri daripada 0%, 2.5% dan 7.5%. Bata kawalan piawai yang mengandungi 0% tempurung kelapa digunakan untuk membandingkan data yang diperolehi dengan sampel data yang mengandungi tempurung kelapa halus. 40 biji bata yang mengandungi tempurung kelapa halus dan 20 biji bata tanpa tempurung kelapa halus sebagai bata kawalan piawai dihasilkan dalam kajian ini. Saiz bata yang digunakan ialah 225 mm x 115 mm x 75 mm dan nisbah penggunaan simen dan pasir 1:6. Bancuhan bata diawet dengan menggunakan kaedah pengawetan air untuk 7 dan 28 hari. Sifat- sifat bata simen yang mengandungi campuran tempurung kelapa halus ditentukan dengan menjalani dua ujikaji. Pertama, ujian kekuatan mampatan, dan yang kedua ialah ujian kadar penyerapan air yang dilaksanakan pada hari ke-7 dan ke-28. Berdasarkan hasil ujikaji, kekuatan bata simen tempurung kelapa halus menurun apabila peratusan penggunaan tempurung kelapa halus meningkat. Kemudian, kadar penyerapan air juga meningkat apabila peratus penggunaan tempurung kelapa halus meningkat. Oleh itu, keputusan keseluruhan ujikaji ini menunjukkan bahawa nilai optimum peratus campuran tempurung kelapa halus sebagai bahan pengganti pasir adalah 2.5%, yang mana ia menunjukkan sifat terbaik berbanding dengan 7.5%. Kajian ini membuktikan bahawa penggunaan kelapa sebagai bahan pengganti pasir dalam bata simen pasir dapat membantu mengurangkan kos pembinaan serta dapat mengurangkan sisa di tapak pelupusan.

ABSTRACT

The rising cost of building materials in the construction industry nowadays, has a major impact on the society. Therefore, the use of new materials in the replacement of sand to produce more environmental-friendly bricks using by products were carried out. Coconut shell is one of the waste materials produced from the agricultural process. This matter indirectly poses a challenge to the parties involved in dealing with the disposal as well as the environmental management. This study was conducted to investigate the bricks properties effect of using fine coconut shell which comprised of 0%, 2.5% and 7.5% as replacement for sand. The 0% replacement of fine coconut shell are used to compare the data with a sample that contains fine coconut shell. 40 bricks that composed of fine coconut shell and 20 bricks with nil content of the fine coconut shell were tested in this study. The size of the bricks is 225 mm x 115 mm x 75 mm with a standard mixture of cement: sand, with the ratio of 1:6 were used in this study. The mixture of bricks were treated with water curing methods for 7th and 28th days. The properties of the samples were determined by two tests, which are compressive strength test and water absorption test and were implemented at 7th and 28th days. Based on the results of the test, the strength of the samples were decreased when the percentage usage of fine coconut shell was increased. Then, the water absorption rate was increasing as the percentage usage of fine coconut shell increases. Thus, the overall result of this tests shows that the optimum value of brick using fine coconut shell as a sand replacement is 2.5%, which is it performs the best properties compared with 7.5%. This study proves that the use of coconut shell as replacement for sand in sand brick helps in reducing the construction costs as well as can reduce the wastes at the landfill sites.

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LIST OF SYMBOLS

%	Percentage
˚C	Degree Celsius
M	Meter
mm^2	Millimetre square
N/mm^2	Newton/millimetre square
kg	Kilogram
kN	Kilo newton
mm	Millimetre
MPa	Mega Pascal
min	Minute

LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
BS	British Standard
OPC	Ordinary Portland Cement
L	Length
W	Width
H	Height

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Brick are widely used in construction and buildings material around the worlds. Cement bricks industry is considered one of the biggest natural resource consumers (Sadek, 2012). Brick has been used for at least 10, 000 years in a variety of a structure, including homes, private buildings and public buildings. There are varieties of brick, which are common brick, usually it is for general building work, secondly facing brick, and it is for attractive appearance or aesthetical view when it is used without rendering or plaster, and lastly engineering bricks, the bricks are more dense and strong, and it is to defined limits for absorption and strength. A brick can be composed of clay bearing soil, sand and lime, or concrete materials. Bricks are produce in numerous classes, types, materials, and sizes, which vary with region and time period, and are produced in bulk quantities. Sand brick is a type of brick made from a mixture cement and sand and molded under pressure. The cementation process involves the introduction of bacteria and nutrients to sand, and through bacterial processes calcite precipitation binds particles together, ultimately creating a sandstone material (Bernardi et al., 2014).

Coconut is develop in excess of 86 centuries. Wherein, Sri Lanka is the fifth greatest, having development of around 2,513,000 metric tons amounts of coconut every year. The cultivation of coconut sums up to about 12 million hectares of land and production is meant of livelihood for approximately 10 million farmers and their families around the world. However, it is the contributor to the nation’s pollution problem as a solid waste in the form of waste coconut shells (Jain & Apeksha, 2017). After the coconut scratched out from the shell, the shell is typically disposed as wastes. Besides that, the texture of coconut shell surface, which is rough on the outside and quite smooth inside the shell. A coconut shell can be utilize for development material application; it would gainful towards nature, but can be favourable for low salary families as, it can be utilized for the development of minimal effort houses. Hence, the usage of coconut shell as partial sand replacement give the positive effect to world, which is the waste material at waste disposal plant can be reduce from time to time.

1.2 Problem Statement

There is spectacular growth of the construction industry and every river in our country has made a major contribution to it through the supply of sand today. Sand was used extensively in the preparation of concrete in building industry. Based on cement usage and engineering computations (i.e. cement consumption and the ratio of cement to sand for various construction purposes), sand demand for 2007 was estimated to be 17.37 million metre cubes (Navaratnarajah & De Zoysab, 2018). The continuous mining of sand will cause problems in future since sand is also essential to the river itself other than it plays a vital role in the construction industry. To overcome this problem, a replacement material is required to replace the usage of river sand in the brick production. One of the replacement material that is available is coconut shell.

Coconut is a major plantation crop of Sri Lanka and coconut millers are striving to add value to coconut shells being generated as an agricultural waste material (Chinthani et al., 2015). The coconut shell is a natural material that is available abundantly in Malaysia. Therefore, the utilization of this material as sand replacement in construction will be a crucial step to improve sustainability and eco-friendly construction. In addition to that, it will help to reduce self-weight of concrete structures. Reused of coconut shell will indirectly reducing environmental pollution since the waste disposal process usually had some negative impacts towards the environment. For instance, the combustion process will increase carbon dioxide level into the air as well as increasing the environmental temperature. By adding these agricultural wastes into brick mixture it might help reduce the cost of construction as the supply of sand river is getting harder. Thus, the use of coconut shells as a partial river sand replacement can be a very effective solution to overcome the short supply of sand at present.

1.3 Objective

The main objectives of this study are:

i. To obtain the optimum percentage of fine coconut shells in sand brick.
ii. To determine the properties of sand bricks using fine coconut shell as partial replacement of sand based on compressive strength and water absorption.

1.4 Scope of Study

This research generally using coconut shell as sand replacement. Based on the objective of this research is to obtain the optimum percentage and determine the properties of fine coconut shells compared with brick did not use coconut shell. The nominal size of sand brick are, the length is 225 mm (± 3.2), width is 115 mm (± 1.6) and depth is 75mm ± (1.6). The ratio used for the brick mixture is 1 ratio 6 (1:6) which are according to cement sand brick ratio. Normally, they prefer to use sand brick in construction industry because the manufacturing process of sand brick is quite easy compare to clay brick. Besides that, the sand brick is a cheaper compare to other bricks in construction.

In this research, brick containing coconut shell as sand replacement in percentage of 2.5 and 7.5 used in the brick mixture. The practical size of fine coconut shells range are less than 20 mm. There are three different percentage used of fine coconut shell for brick mixture included normal sand brick. Normal sand brick of coconut shells in construction use as a standard control while for other percentage of coconut shells have ten samples of each sand brick. Each of sand brick will test to check whether it can be get better result in strength and compared to normal bricks in construction. In order to determine the best optimum percentage of coconut shell in brick, water absorption rate and compressive strength will be defined by undergoing necessary testing and analysis. All testing are being done in the concrete laboratory. The result will be analysed and come out with significant conclusion after testing the sand brick containing fine coconut shell.

1.5 Significant of Study

At the end of this research, data and results of optimum percentage of brick mixture and properties of fine coconut shell are gaining from this experimental study. Based on this data and results, the sand brick containing coconut shell is sustainable and environmental friendly brick made using waste material. This study will become a helpful especially for the government, which is by turn these waste materials into a potential material, automatically the environmental issue can be solve. Since, by using these waste materials material, and at the same time these waste materials will be dispose and reduces dumping spaces and helps to maintain a clean environment. Malaysia should take the advantages by having an abundant of waste material such as coconut shell, and turn this waste into a potential material that will benefit the people also the environment. Lastly, this research study will spread the knowledge about turning these waste materials into a potential material that can benefit people and helps in maintain a clean environment.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In construction, the term of brick can be characterize as rectangular block of hard material manufactured form clay, sand and concrete that was used for building walls. Brick has been used as materials in construction for 5000 years and it was first made in Middle East near Tigris and Euphrates River.

2.2 Types of Brick

There are a few types of bricks commonly used in the construction works. The bricks differentiate due to the materials used, method of manufacturing and the curing method applied during the manufacturing.

2.2.1 Sand Brick

Sand brick is a type of brick made from a mixture of cement and sand. It is moulded under pressure and cured under steam at 93°C. Usually it is use as backing brick and where there is no danger of attack from acid or alkaline conditions. The typical size of the brick is 225 mm x 113 mm x 75 mm (L x W x D). Meanwhile, the average weight of this type of brick is 2.6 kg with 7 N/mm^2 as its compressive strength.

2.2.2 Clay Brick

A clay brick is widely used in construction industry. It is made from clays that are molded into shape and fired in the oven. The clay will transform the clay to have high compressive strength and good in weathering qualities during the firing process. Clay bricks have variety of natural colors and the colors remain stable without need rendering or painting works. Furthermore, clay bricks have high compressive strength that can support relatively high load.

Clay bricks have to satisfy many different requirements in terms of thermal and acoustic properties, load-bearing capacity as well as ecological impact (Mariarosa, 2009). Clay bricks has high thermal mass. It is able to maintain stable level of heat energy for extended period in heating and cooling because bricks absorb and releases heat slowly. Clay bricks also an excellent in fire resistance and sound insulation due to their high mass.

2.2.3 Fire Brick

It also known as refractory bricks is a block of refractory ceramic that is build with ability to withstand high heat but having low thermal conductivity for great energy saving. The applications of dense firebricks are in application with extreme chemical, mechanical or high thermal stress. For example, it is use inside wood-fired kiln which subject to high temperature. It also designs to have low thermal conductivity to make the environment of the operating process safe. The application of firebricks is depending on the dense and porous.

2.2.4 Sand Lime Brick

It is also known as Calcium Silicate bricks. Raw materials including lime, quartz, crushed siliceous rock and fly ash mixed together with mineral colorants during wet mixing. The mix is molded under pressure forming the bricks.

Bricks are made by mixing are chemically bonded bricks and have advantages compared to clay bricks such as lighter in weight, can be produced on desired color and required no plastering because the appearance are uniform in shape and smooth.

2.3 Factor Influence Strength of Sand Brick

Generally, a good sand brick must be hard, well burnt, uniform throughout, excellent in texture and colour. Sand brick must effective in shape, size and dimension. If these factors are achieve, sand brick should not break easily when stuck against another brick or dropped from a height of about one meter. In using sand brick for construction, certain desirable properties should be target. Among these desirable properties are compressive strength, density, thermal stability, porosity, sound insulation, fire resistance, durability, and so forth.

2.4 Durability of Sand Brick

Sand brick is a durable material. The durability of the brick is ensure by careful supervision of the selection of materials, its design and strict quality control during mixing and curing processes. The mix proportions of materials and the water/cement ratio for a particular application can increase the durability of the brick. The design of mix should prioritize the reduction of interconnected porosity that caused from high water/cement ratio. Curing compounds can be used to restrict the rate of water lost by evaporation from the surface of the brick and thus, adequate curing of the brick can be achieved. All of these factors should be considered to make a highly durable cement sand brick.

2.5 Size of Sand Brick

Bricks can be made in multiple shapes and size depending on the application. The size of bricks is made for convenient to handle and light enough for lifting and placing with hand.

According to British Standard, BS3921:1985, the size for one unit of brick must have dimension at least 215 mm long, 102.5 mm width and 65 mm height. The proposed size of the bricks for this research is in the Table 2.1 below:

Table 2.1 Size of sand brick

Size of bricks	**Length (mm)**	**Width (mm)**	**Height (mm)**
Coordinating size	225	112.5	75
Work size	225	115	75

2.6 Material Properties

In this study, the materials that will be used for making sand bricks are cement, sand, water and fine coconut shell.

2.6.1 Cement

Cement is one of the important materials in the sand brick. It can be defined as the bonding material having cohesive and adhesive properties, which makes it capable to unite the different construction materials. The cement used in this study is Ordinary Portland Cement (OPC). OPC is a type of powder material that is widely used in the building construction. It is kept in a sealed container and stored in the humidity controlled room to avoid exposure to moisture.

2.6.2 Sand

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. . Influence of sand grading and its fineness modulus on various properties was examined by reconstituting the natural sand having particles finer than 4.75, 1.18 and 0.5 mm. Sand can also refer to a textural class of soil or soil type. In the making of sand brick, sand is added alongside other materials in a mold to shape the brick and complete the mixture. The sand that was used in this study was river sand supplied by a local supplier that was available at Concrete Laboratory Faculty of Civil Engineering and Earth Resources, Universiti Malaysia Pahang (UMP). It was air-dried before being kept in a container to protect it from getting wet due to excessive moisture condition or rain from the surroundings. The size of the sand used was less than 2.36 mm sieve.

2.6.3 Water

Water is one of the most important elements in construction but people still ignore quality aspect of this element. The water is required for preparation of mortar, mixing of cement concrete and for curing work such as during construction work. The quality and quantity of water has much effect on the strength of mortar and cement concrete in construction work. The water used for mixing and curing should be clean and free from injurious quantities of alkalis, acid, oils, salt, sugar, organic materials, vegetable growth and other substances that may be deleterious to bricks, stone, concrete or steel. Potable water generally considered satisfactory for mixing. The pH value of water should be in the right value, not less than 6. Water must be cleaned from impurities. Therefore, clean tap water was used in this research because impure water could have adverse effect on the strength and durability of the concrete.

2.6.4 Coconut Shell

Coconut shell is an agricultural waste, mainly generated from edible coconut milk processing. Coconut shell which has been cleansed were left air dried for a week to obtain approximately a saturated surface-dry condition. Then, the surface texture of the shells was fairly smooth in the inside and rough on the outside. Coconut shells also have a high capacity of moisture retaining and water absorbing.

Based on (Gunasekaran et al., 2015) a coconut shells has better workability and the pore structure in coconut shells behave like a reservoir. Coconut shells represent more than 60 % of the domestic wastes, it was abundantly available agricultural waste. Based on (Mohammad & Pawade, 2014) coconut is a versatile product, since it has multiple uses. Almost all the parts of a freshly grown coconut are eatable or otherwise are used in some or other manner. The size of coconut shell used was less than 20mm.

The potential candidate for the development of new composites material are coconut shell, it is because of their high strength and modulus properties. Coconut shells possess a composite of high strength and it is suitable to be used in the broad range of application such as building materials. Figure 2.1 below shows the coconut shell used as a sand replacement and size of coconut shell used in this study.

Figure 2.1 Coconut shell

2.7 The Principles Parameter Used

In this study, there are two principles parameter that will be used to obtain the optimum percentage and properties of sand brick containing fine coconut shell.

2.7.1 Compressive Strength Test

All of the samples undergo the compressive strength after water curing for specific period of time. This test aims to determine the compressive strength of the bricks. The apparatus that will be used is compressive testing machine. The bricks need to undergo test according to the standard practice of compression test. Five samples were prepared for each test. Firstly, place the sample with flat faces horizontal facing upwards between plates of the testing machine. Then, apply load axially at a uniform rate of 1.25 mm/min until failure occurs and note maximum load at failure. The load at failure is the maximum load at which the sample fails to produce any further increase in the indicator reading on the testing machine. Lastly, the last reading will be taken. Compressive strength of each sample was calculated in MPa (N/mm^2). Figure 2.2 shows visuals of the compressive strength test machine.

Calculation of compressive strength was done according to the following equation 2.1 below:

$$C = W / A \qquad 2.1$$

Where:

C = Compressive Strength, MPa

W = Maximum Load, N indicated by the compression test machine

A = Area of upper and lower bearing surfaces of the sample, cm^2

Figure 2.2 Compressive strength test machine

2.7.2 Water Absorption Test

Water absorption used to determine the amount of water absorbed under specified conditions. Factors affecting water absorption include: type of plastic, additives used, temperature and length of exposure. The data sheds light on the performance of the materials in water or humid environments. Moisture content is very critical as the mixture must be wet enough to bind together when compacted (Vinay et al., 2017).

For the water absorption test, the samples are dried in an oven as shown in Figure 2.3 for a specified time and temperature and then placed in a desiccator to cool. The samples will be dried in a ventilated oven for at least 24 hours. The weight of the samples will then be recorded. After drying, the samples will be cooled in a drying room with relative humidity around 70%. The samples will then be submerged in clean water at 30°C for 24 hours. The water on the sample surface will be wiped with a damp cloth and the weight of the samples will weighed again and recorded after removing the samples from the submerged condition. The water absorption of each samples in percentage was computed.

The boiling water absorption of each samples was calculated to the nearest 0.1 % as follows in Equation 2.2 below:

$$Water\ Absorption, \% = 100\ [(Ws - Wd)/Wd] \qquad 2.2$$

Where:

Wd = dry weight of the samples

Ws = saturated weight of the samples after submersion in boiling water

Figure 2.3 Ventilated oven

2.8 Table of Previous Research

No	Researcher	Year	Parameter	Material (additive / replacement)	Result
1	**Siti Nur Amiera Jeffry, Ramadhansyah Putra Jaya, Norhidayah Abdul Hassan, Haryati Yaacob & Mohd Khairul Idham Mohd Satar.** - Mechanical performance of asphalt mixture containing nano-charcoal coconut shell ash	2018	Mechanical performance of asphalt mixture	Nano-charcoal ash from coconut shell	The performance of nano-charcoal coconut ash asphalt mixtures were enhanced compared with the control asphalt mixture which is 1.5%, 6% and 7%.
2	**Olga Kizinievic, Viktor Kizinieva, Ina Pundiene & Dainius Molotokas.** - Eco-friendly fired clay brick manufactured with agricultural solid waste	2018	Physical and mechanical properties and porosity.	Oat husk, barley husk and middlings,	Additives of barley husk and middlings produce higher strength with optimum percentages 5% but absorp more water compare with oat husk.
3	**Navaratnarajah Sathiparana & De Zoysab, H. T. S. M.** - The effects of using agricultural waste as partial substitute for sand in cement blocks	2018	Density Strength (Tensile and Flexural) Durability	Rice husk, sawdust, peanut shell, rice straw and coconut shell	Optimum ratio 1:5:1

No	Researcher	Year	Parameter	Material (additive / replacement)	Result
4	**Apeksha Kanojia & Sarvesh Jain, K.** - Performance of coconut shell as coarse aggregate in concrete	2017	Strength and density	Coconut shell	Replacement of conventional aggregate by waste coconut shell results into decrease in compressive strength.
5	**Valeria Corinaldesi, Alida Mazzoli & Rafat Siddique** -Characterization of Lightweight Mortars Containing Wood Processing by-products Waste	2016	Mechanical performances, strength, and shrinkage	Wood processing-by-products	Mortar with sawdust perform better with optimum 2.5% and higher than 5 MPa. Shrinkage and water absorption when present of wood waste.
6	**Jaya Prithika, A. & Sekar, S. K.** -Mechanical and fracture characteristics of Eco-friendly concrete produced using coconut shell, ground granulated blast furnace slag and manufactured sand	2015	Mechanical properties of concrete	Coconut shell, ground granulated blast furnace slag and manufactured sand	Compressive strength decreased by 8%, 7% and 14% for 25% replacement of cement by ground granulated blast furnace slag for water cured, steam cured and conceal cured coconut shell cement.
7	**Davamoorth Thany, T.** - Wood Waste as Coarse Aggregate in The Production of Concrete	2015	Workability, strength and durability,	Wood aggregate	Optimum percentage is 15%.

No	Researcher	Year	Parameter	Material (additive / replacement)	Result
8	**Gunasekaran, K., Annadurai, R. & Kumar, P. S.** -Long term study on compressive and bond strength of coconut shell aggregate concrete	2012	Workability, density and strength	Coconut shell	Flexural strength (17.53%) Splitting tensile strength (10.11%)
9	**Gunasekaran, K., Kumar, P. S. & Lakshmipathy, M.** -Mechanical and bond properties of coconut shell concrete	2011	Mechanical properties of concrete	Coconut shell concrete	Optimum Ratio 1:1.82:0.55
10	**Kulak, F. S.** -Enhancing of Wood Chipping Concrete Properties by Adding Waste Fibre	2008	Strength and density	Wood Chipping and Waste Fibre	Optimum percentage for: Compressive – 15% Tension – 20%

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, the laboratory experiments has been conducted to identify the effects of using coconut shell as sand replacement material in high strength sand brick. It is include all the material properties needed and casting of the sand bricks. Several experiments were conducted to investigate the effect of fine coconut shell as a sand replacement towards sand brick. All the testing conducted were in accordance to ASTM standard.

3.2 Conceptual Framework of Research

Conceptual framework in Figure 3.1 gives an overview the overall about the research progress. The first stages in methodology are briefing and discussed about the title for the project selected. After a suitable title was selected, make a reviewed about all information based on the project from the internet, journals, books, articles, newspapers etc. Based on the literature review that has been conducted, appropriate testing methods to conduct lab work are decided. Then, the next stage is analysing all the information gathered from the experiments. After that, a draft report are prepared and submitted. Finally, the findings obtained in the study conducted was presented to fulfil the requirement of Final Year Project. The experimental are conducted in the concrete laboratory at Universiti Malaysia Pahang.

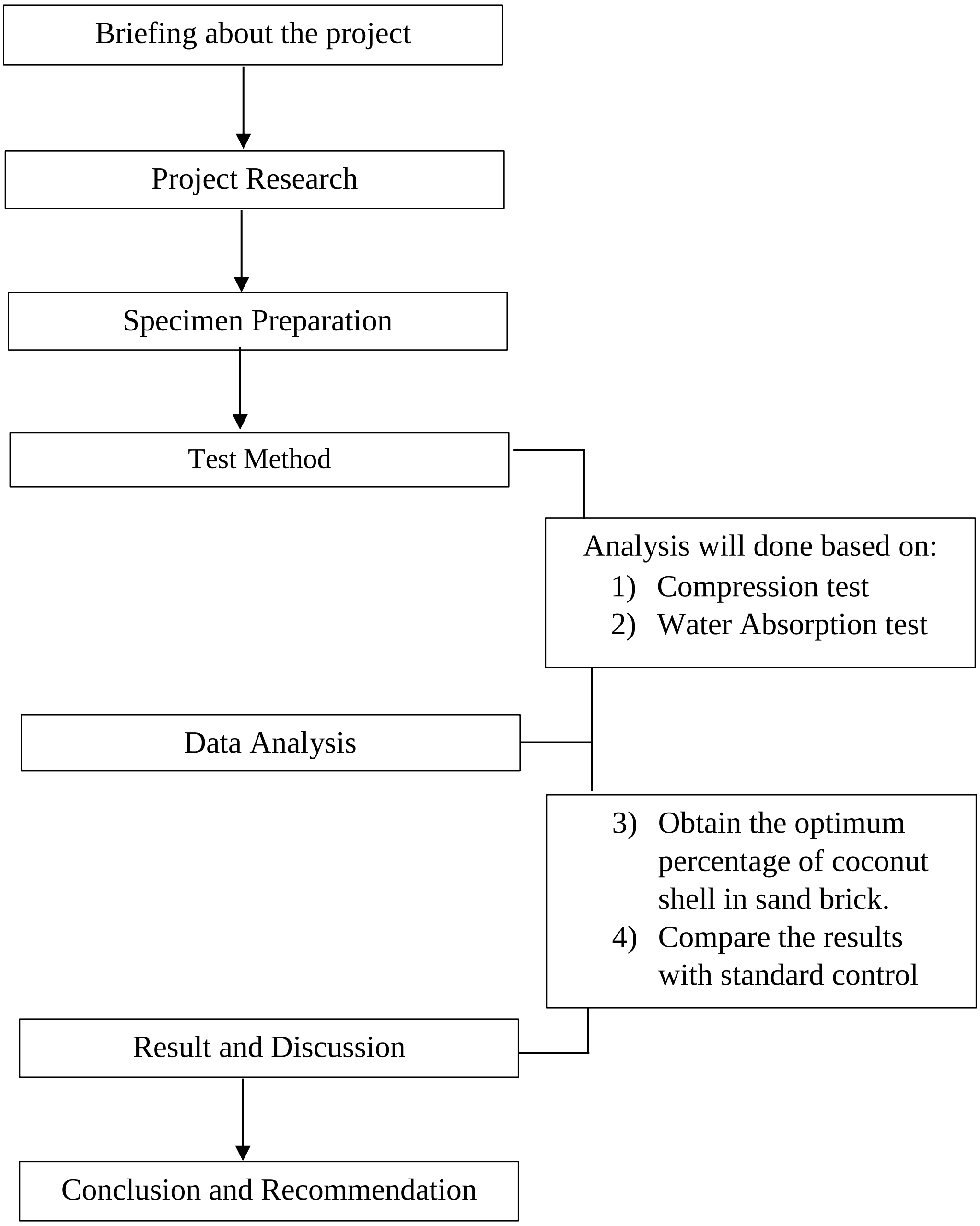

Figure 3.1 Conceptual framework of research

3.3 Sand Brick Design

In this study, the dimension of the sand brick based on Public Work Department, Standard Specification for Buildings Works, 2014, it stated that all sand brick shall comply with Malaysia Standard. The dimension of sand brick were designed 225 (Length) x 115 (Width) x 75 (Height) mm as shown in Figure 3.2 below.

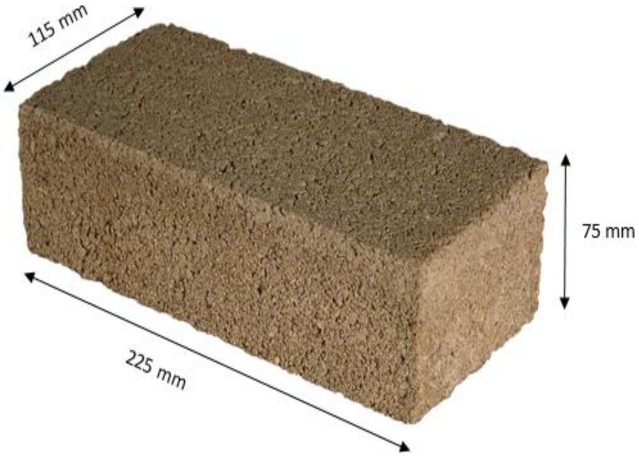

Figure 3.2 Sand brick dimension

3.4 Mix Design of Sand Brick

The material properties used for casting the sand brick are cement, sand, water and fine coconut shell as sand replacement. The standard mixture of cement: sand, with the ratio of 1: 6 were used and every each percentage replacement have 20 samples of sand brick All the mix proportion and sand distribution used for sand bricks can be classified as shown in Table 3.1 and 3.2 below:

Volume of brick = 0.225 m x 0.115 m x 0.075 m

= 0.00194 m

Density of cement = 1440 kg/m^3

Density of sand = 1920 kg/m^3

Table 3.1 Mix proportion for sand brick

Sample (%)	Cement (kg)	Sand (kg)	Coconut Shell (kg)	Water (kg)
0	7.8	52.2	0	5.46
2.5	7.8	50.90	1.31	5.46
7.5	7.8	48.28	3.92	5.46

Table 3.2 Sample distribution

Type of test	Sample (%)	7 days of water curing	28 days of water curing	Total samples
Compressive Strength	0	5 Samples	5 Samples	30 Samples
	2.5	5 Samples	5 Samples	
	7.5	5 Samples	5 Samples	
Water Absorption	0	5 Samples	5 Samples	30 Samples
	2.5	5 Samples	5 Samples	
	7.5	5 Samples	5 Samples	

3.5 Preparations of Material

The materials used in the sand bricks manufacturing are ordinary Portland cement, sand, water and fine coconut shell. The preparation of the materials were done and handled properly to ensure the bricks produce followed the study research.

3.5.1 Cement

This Ordinary Portland Cement (OPC) is suitable for brick production because specially formulated for high early age strength. It is ideal for high strength concrete applications where time is of the essence. Orang Kuat is suitable for concrete structure, precast, brick making and all general applications, where high strength is needed to improve productivity. During preparation of the materials, the cement that had been weighted was kept in airtight container to avoid the effect to the cement reaction with air and vapor. Figure 3.3 below shows the OPC brand name Orang Kuat used in this study.

Figure 3.3 Ordinary Portland Cement

3.5.2 Sand

Sand is an important material used in the manufacturing of sand brick. The sand was prepared by filtering it to remove the unwanted impurities and any bigger of aggregate. For this study, the river sand as shown in Figure 3.4 selected for casting of brick and the size used in this study was obtained using sieve method with 2.36 mm passing.

Figure 3.4 Sand

3.5.3 Water

The water–cement ratio is the ratio of the weight of water to the weight of cement used and has an important influence on the quality of brick produced. A lower water-cement ratio leads to higher strength and durability, but may make the mix more difficult to place. For this study, the water – cement ratio is 0.7.

3.5.4 Coconut Shell

Coconut shell (CS) are naturally occurring structural composites which form a protective chamber for coconut and its juice (Sefiu et al., 2015). Coconut shells were used as a sand replacement in a brick mixture. The coconut shells were collected from the local shops selling of coconut milks and were cleaned form the fiber and husk. Coconut shell were allowed through the drying process of sundry in 24 hours approximately after cleaning process. The next process are crushing coconut shells by using roller machine and manually by hammer into small chips size. The materials used was less than 20 mm to replace sand. Figure 3.5 to Figure 3.7 shows the process of preparation coconut shell, respectively.

Figure 3.5 Coconut shell

Figure 3.6 Process of crushing coconut shell using roller machine

Figure 3.7 Process of crushing coconut shell using hammer

Figure 3.8 shows the size of fine coconut shell less than 20 mm for sand replacement.

Figure 3.8 Size of fine coconut shells used

3.6 Sand Brick Manufacturing Process

In this research, the samples of sand brick were prepared in a fixed 225 mm x 115 mm x 75 mm dimensions for all bricks. Sand brick manufacturing making by brick formworks and the materials used was plywood. The first process are marked the size of sand brick that will produced using marker. The next process are cutting the plywood according to marked markings. Lastly, nailing process, the pieces from plywood are nailed together to form a brick formwork as shows in Figure 3.9. Then, poured the mix of brick mixture into the formwork. After 24 hours, the formwork be opened and the bricks were to be dried according to the curing time.

Figure 3.9 Brick formwork

3.7 Brick Casting and Curing Process

Coconut shell brick was produced by adding coconut shells in different percentage that are 0%, 2.5% and 7.5%. The ingredients such as cement, sand and coconut shell were mixed together in dry condition in a mixer for a 2 minutes, water was mixed after the materials was blended into the machine. Finally, all the ingredients were allowed to mix in the machine for a period of at approximately 5 minutes. Extra cares taken to avoid segregation of brick mixture. Figures 3.10 show the process of brick mixing, respectively.

Figure 3.10 Process of mix the materials into mixing machine

After the machine mixing was stopped, ensured that the mixed was well blended and no segregation process was occurring. The fresh brick mixture was placed in the formwork by trowels. It ensured that the representative volume was filled evenly with all the samples to avoid the segregation. Brick mixture was placed in formwork into 3 layers. Each layer was compacted manually using rod. The compaction process was conducted to remove entrapped air or void in the brick mixture. Figures 3.11 shows the process of brick casting.

Figure 3.11 Process of placing brick mixture into formwork

The mixture were worked using a trowel to give uniform surface. After finished, the surface was trimmed using a tool for achieving good surface finish. The bricks are marked with a label after the initial drying. The formwork was remoulded after 24 hours of casting and immediately stored for curing. Figures 3.12 shows the process of brick casting already done.

Figure 3.12 Brick casting already done

Sand brick was designed for control and fine coconut shell replacement of 0%, 2.5% and 7.5% are cured in the curing tank for 7 and 28 days. Figure 3.13 shows the curing process of sand brick.

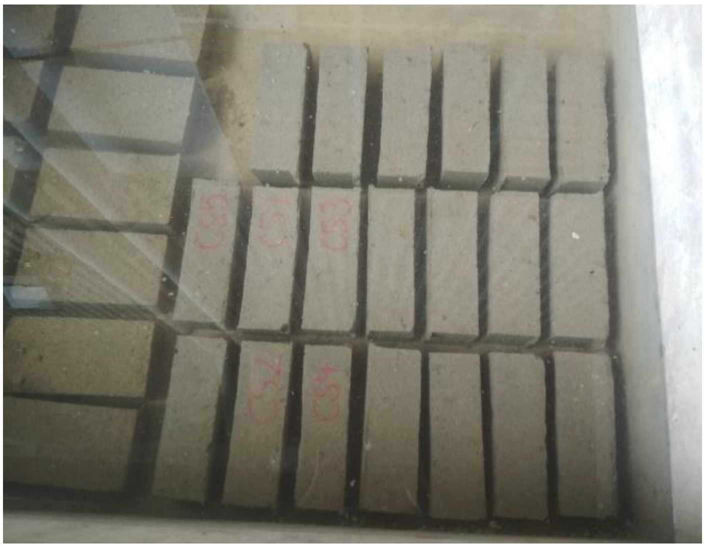

Figure 3.13 Curing process of sand brick

3.8 Laboratory Testing

Compressive testing was carried out on a compressive testing machine (CTM) of capacity 2000 kN with standard ASTM C39/C39M. Water absorption test were carried out on ventilation oven with 105˚C. 30 of sand bricks are tested for compressive strength test and other samples for water absorption test at 7 and 28 days.

3.8.1 Compressive Strength Test

A sand brick compression test was performed on standard control brick of and coconut shell sand brick with partial replacement 0%, 2.5% and 7.5% of size 225 (length) x 115 (width) x 75 (height) mm after 7 and 28 days of immersion in water for curing. The compressive strength was defined as resistance of concrete to axial loading. The brick was placed in a compressive testing machine, and load was applied. Figure 3.14 shows the samples of brick was conducted on the compression strength test. The strength was recorded and the average was calculated.

Figure 3.14 Sample of sand brick used for compression test

Figure 3.15 shows the process of compression test based on curing day. The brick was placed into the machine and the load was applied to the brick. The brick failed and cracked occurred because of the pressure load applied.

Figure 3.15 Process of compression test

After the compression test was done, the strength was obtained and results were recorded. The crack patterns will appear on all the side of the sand brick because of the compression process. Figure 3.16 shows the example cracked pattern of sand brick.

Figure 3.16 Cracked pattern of sand brick

3.8.2 Water Absorption Test

Water absorption rate test to determine the proportion of water absorbed by brick, it is a guide to the effects of exposure to water or humid conditions. The bricks had been dried in a ventilated oven for 24 hours. Figure 3.17 shows the samples place in oven.

Figure 3.17 Samples place in oven

After the drying process for 24 hours, the brick had been cooled in a drying room with relative humidity around 70%. Then the bricks was submerged in a clean water for 24 hours. Figure 3.18 shows the water curing process.

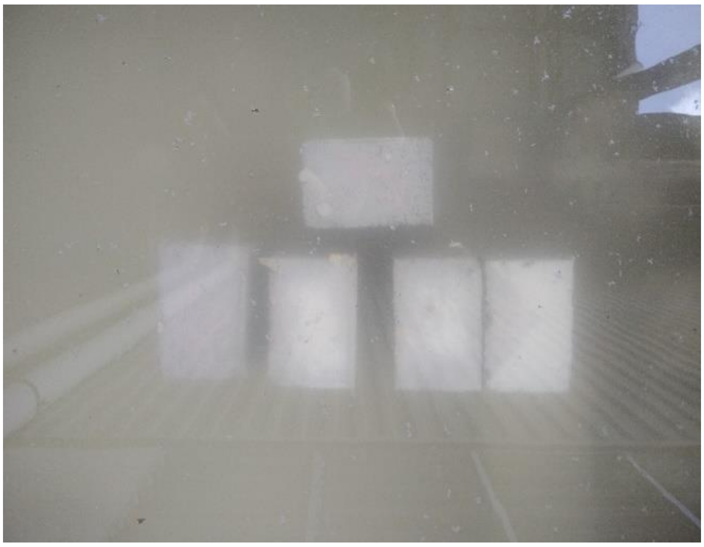

Figure 3.18 Water curing process

After the submerged process were done for 24 hours, wiped the surface water of the brick with a damp cloth and weight of bricks was weighed again. Figure 3.19 shows the weighting of sand brick.

Figure 3.19 Weighting of sand brick

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter, the results in terms of compression strength and water absorption testing resulted was presented.

In this chapter, the experimental data were analysed for each sample of testing. The data was illustrated in tables and graphs for observation and comparison of percentage of coconut shells as part of sand replacement in sand brick with respect to its strength and water absorption rate.

The study is important to test whether the coconut shells are waste material which can be used or not as part of construction material for future benefits and to determine the optimum ratio of coconut shells for sand bricks. The data based on criteria that was specified in chapter 3.

4.2 Compressive Strength

Compression test was conducted on sand brick of 0% as a standard control and fine coconut shell with replacement of 2.5% and 7.5%. The compression test carried out at 7 days and 28 days. Table 4.1 below shows a summary result of compressive strength test of coconut shell as sand replacement.

Table 4.1 Compressive strength of sand brick

Percentage of Coconut Shell (%)	**Compressive Strength (Mpa)**	
	7 day	**28 day**
0	4.27	5.42
2.5	3.10	4.00
7.5	2.86	3.59

4.2.1 Compressive Strength at Seven Days

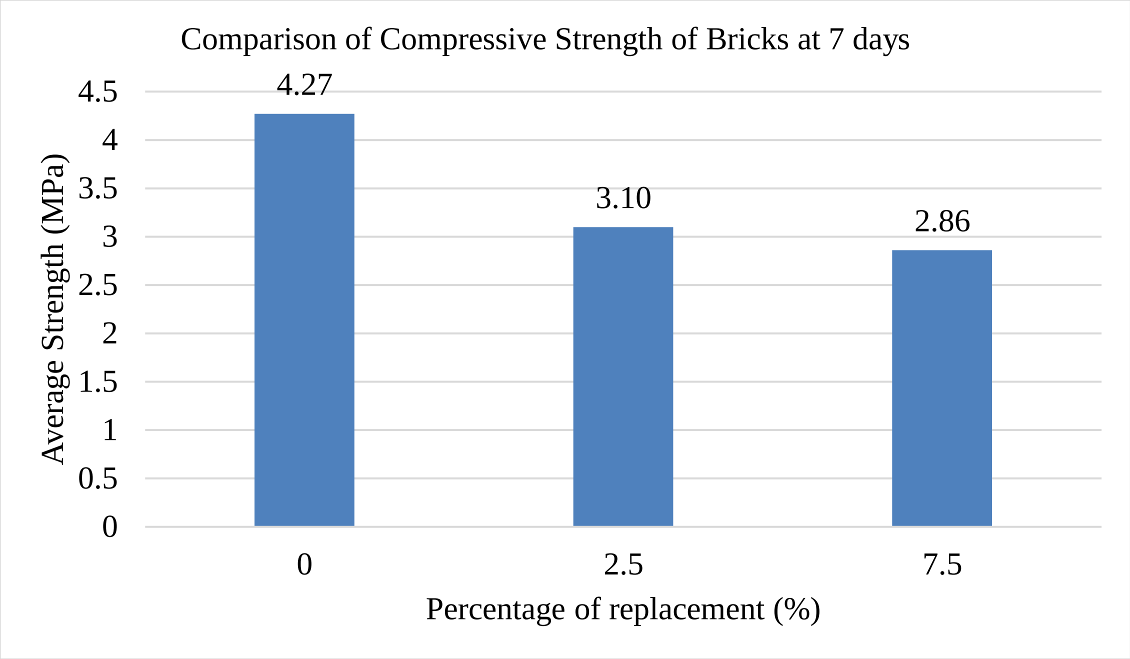

Figure 4.1 Compressive strength result at seven days

Figure 4.1 shows the strength of standard 0%, 2.5% and 7.5% replacement of fine coconut shell for seven days curing. Ordinarily, at the age of seven days, cement sand brick should achieve 75 % of its strength. The compressive strength for standard control, which is 0% replacement at seven days is 4.27 MPa. For the 2.5% replacement, the compressive strength at seven days is 3.10 MPa. Lastly, the 7.5% replacement recorded the value of compressive strength at seven days is 2.86 MPa. The result of compressive strength at seven days shows that the 7.5% replacement of coconut shell have the lowest strength with 1.41 MPa differ from the standard control brick compared with 2.5% replacement have 1.17 MPa from the standard control brick.

4.2.2 Compressive Strength at Twenty-Eight Days

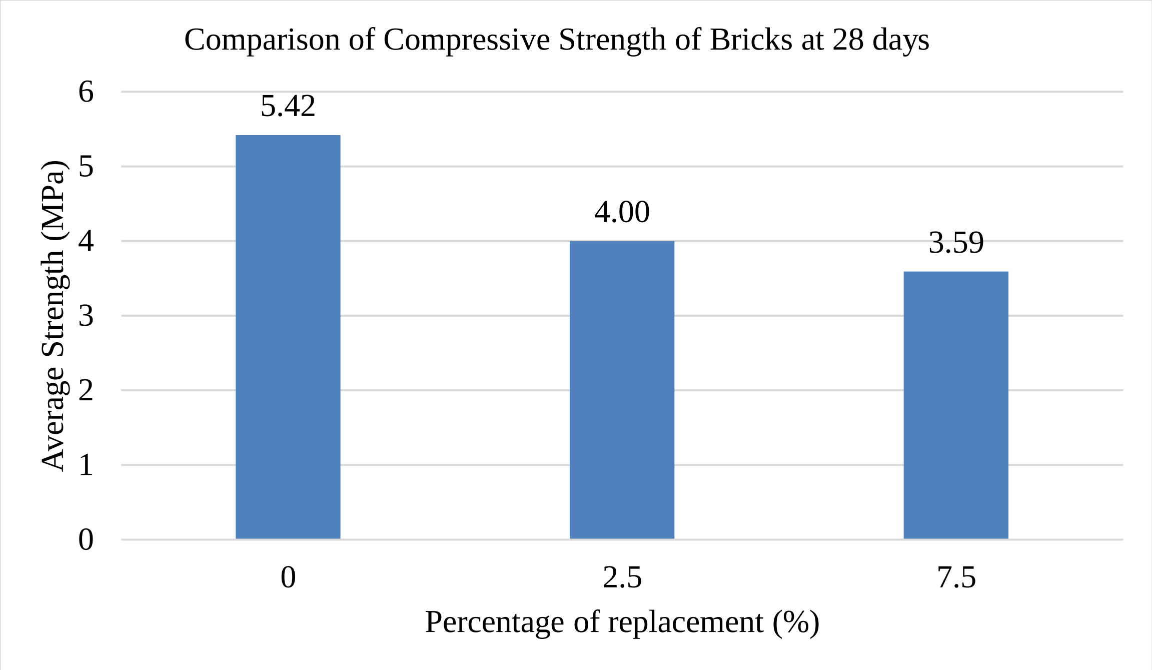

Figure 4.2 Compressive strength result at twenty-eight days

The Figure 4.2 shows the compressive strength at twenty-eight days curing. Ordinarily, at twenty-eight days brick should achieve 99% to 100% of its strength. The compressive strength of 0% replacement of fine coconut shell at twenty-eight days is 5.42 MPa. For the 2.5% replacement, the compressive strength is 4.00 MPa and 7.5% replacement is 3.59 MPa. Based on the result, it shows that the value of compressive test for 2.5% replacement have a higher strength with 1.42 MPa differ to standard control brick compared at 7.5% replacement with 1.83 MPa differ to standard control brick.

4.2.3 Comparison of Compressive Strength of Bricks

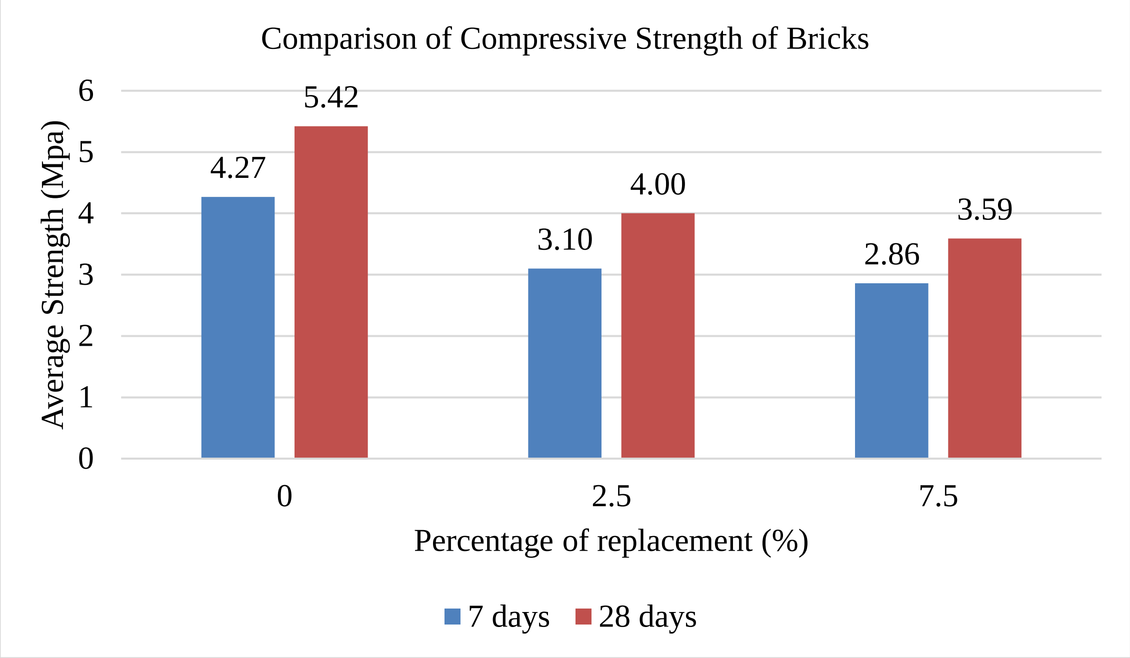

Figure 4.3 Comparison of compressive strength for both 7 and 28 days

Based on the Figure 4.3 shows the comparison of compressive strength of sand bricks for 0%, 2.5 % and 7.5% of fine coconut shell as replacement of sand. The minimum permissible average compressive strength shall be 5.2 N/mm and above (Standard Specification for Building Works, 2014). From the data obtained, it show that the average strength of standard control bricks which is 0% at 7 days is 4.27 MPa and grew to 5.42 MPa at 28 days. The replacement for 2.5% at 7 days is 3.1 MPa and slightly increased to 4.00 MPa at 28 days. While for replacement of 7.5% at 7 and 28 days are 2.86 MPa and went up to 3.59 MPa.

The percentage replacement of 2.5% and 7.5% shows that the strength of the sand brick was decreased when the percentage usage of fine coconut shell was increased. Compressive strength were identified with the cement substance, it is because of the difficulties to decide how much water mixture was absorbed by fine coconut shell, in this manner not accessible for response between coconut shells and cement, may add to the strength decrease.

Besides that, the surface of coconut shell have a porous space, which weaken the bonds between the cement, sand and fine coconut shell. Despite the fact that a compaction were done properly during the casting process, since coconut shell is irregular shape, the void or porous space may create during casting process. Other than that, the correct technique in curing process of bricks also important to produce a good strength of brick. Curing process is a technique by which the brick was secured against loss of moisture required for hydration and kept inside the prescribed temperature run. Curing will increase the strength and decrease the permeability of hardened brick. In addition, it helps is additionally in mitigating thermal and plastic cracks, which can severely impact durability of bricks. The compressive strength of fine coconut shell is develops in early stages, and compressive strength continues to increase with age through curing process.

Therefore, the result obtained from this experiment shows that the sand brick which containing fine coconut shell has lowest compressive strength compared to the sand brick without fine coconut shell replacement.

4.3 Water Absorption Test

The main purpose of water absorption test was to determine the rate of water absorption into sand brick. The procedure was carried out at 7 and 28 days using five samples of brick for each percentage. After completion of curing process, each brick samples were dried in the oven at 105°C for 24 hours. The dry weight of brick was obtained and recorded. Then, bricks samples were immersed in clean water for 24 hours. After 24 hours, the bricks were removed from water and wiped the surface of the brick with a damp cloth and the weight of the bricks was weighed again. Table 4.2 below shows the summary result of water absorption rate of bricks for 7 and 28 days curing.

Table 4.2 Water absorption rate of sand brick

Percentage of Coconut Shell (%)	**Compressive Strength (Mpa)**	
	7 day	**28 day**
0	11.52	9.50
2.5	13.78	10.14
7.5	14.01	11.97

4.3.1 Water Absorption Rate at Seven Days

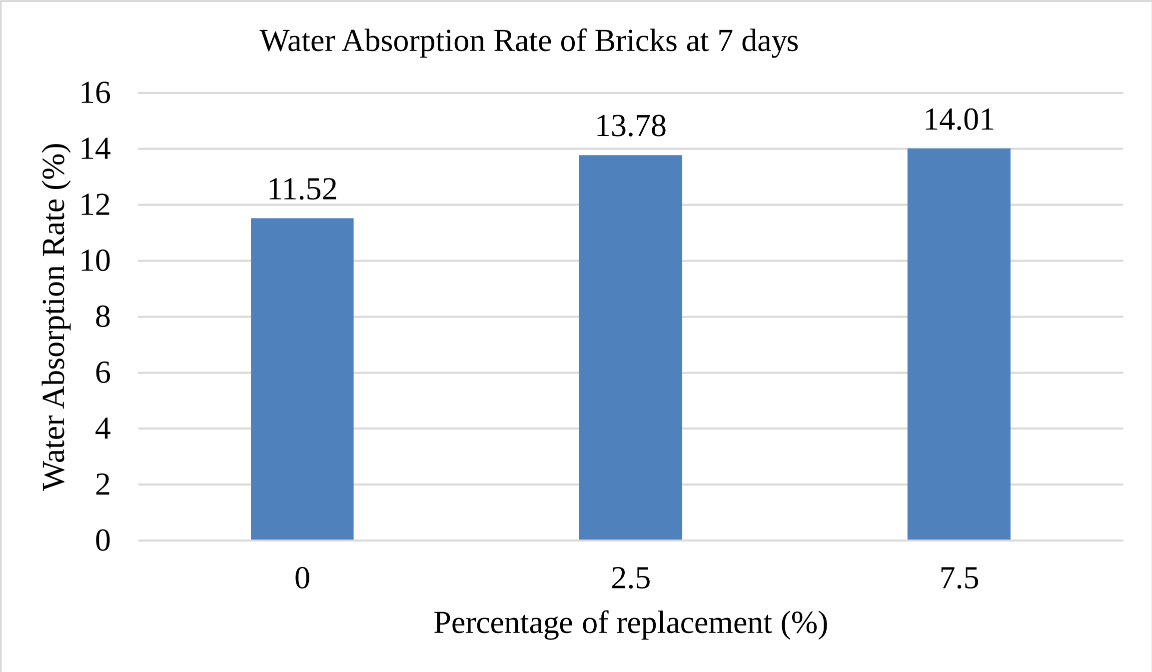

Figure 4.4 Water absorption rate at seven days

Based on the Figure 4.4 shows the percentage of water absorption rate for bricks at 7 days curing. The water absorption rate for 0% replacement is 11.52 %. For the 2.5% replacement, the water absorption rate is 13.78% and 14.01% for 7.5% replacement of fine coconut shell. The result shows that 7.5% replacement have the highest water absorption rate with 2.49% differ from the standard control brick compared with 2.5% replacement have 2.26% from the standard control brick.

4.3.2 Water Absorption Rate at Twenty-Eight Days

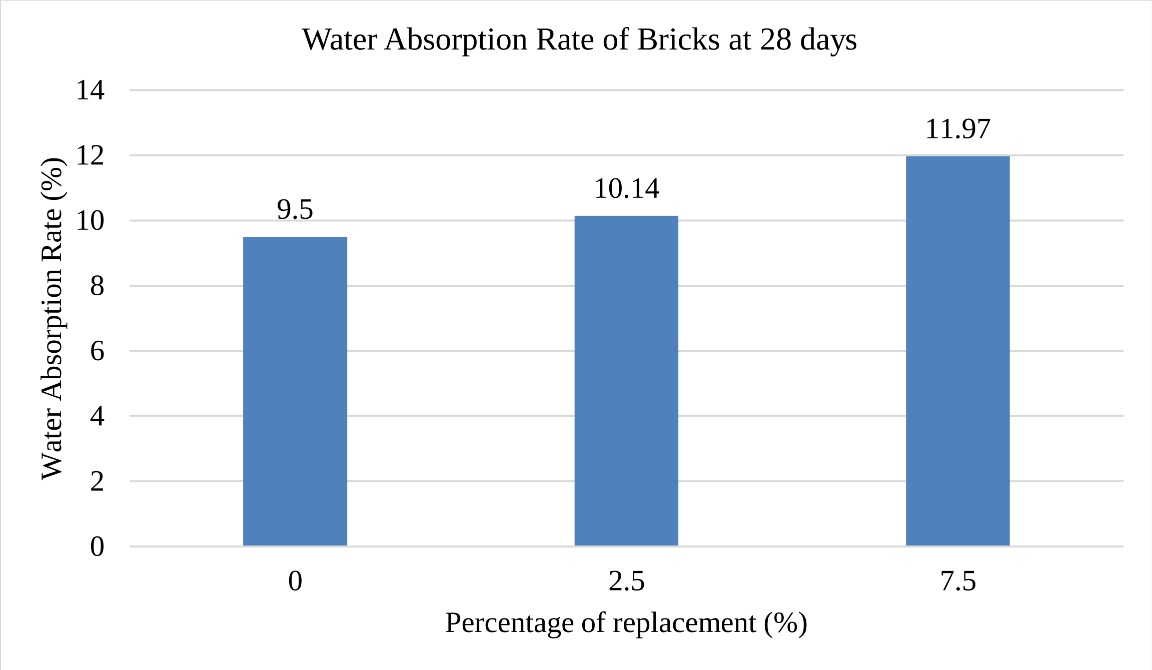

Figure 4.5 Water absorption rate at twenty-eight days

The Figure 4.5 shows the percentage of water absorption rate at twenty-eight days curing. The water absorption rate of 0% replacement of fine coconut shell at twenty-eight days is 9.50%. For the 2.5% replacement, the water absorption rate is 10.14%. Lastly, the 7.5% replacement recorded the value of water absorption rate is 11.97%. Based on the result shows that 7.5% replacement have the highest water absorption rate with 2.47% differ from the standard control brick compared with 2.5% replacement have 0.64% from the standard control brick.

4.3.3 Comparison of Water Absorption Rate of Bricks

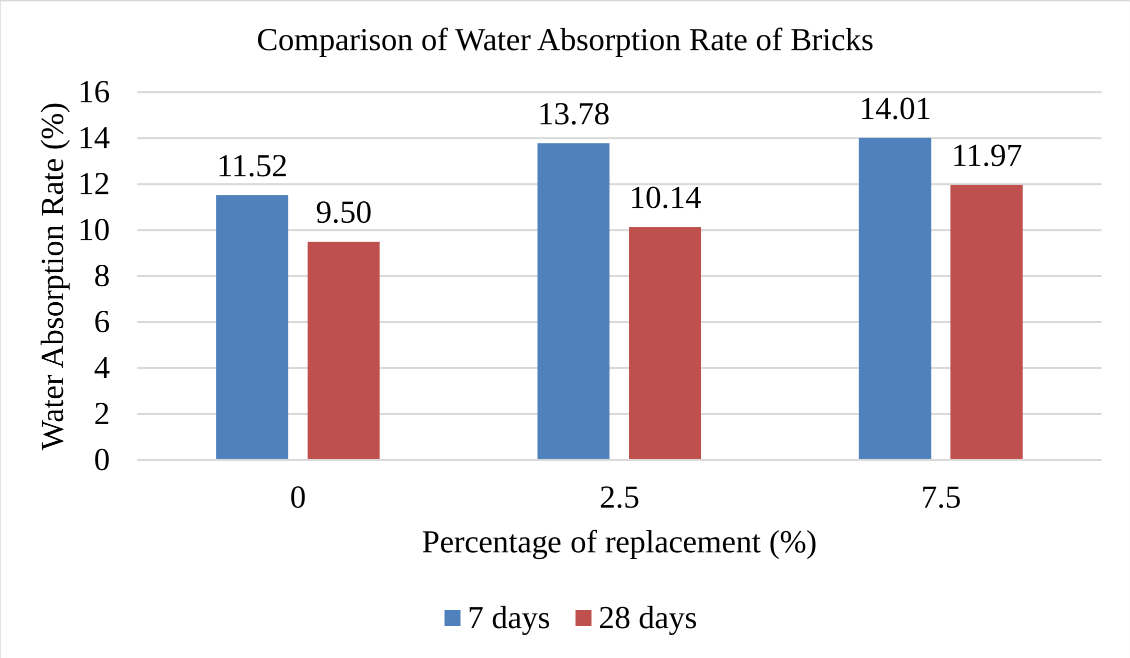

Figure 4.6 Comparison of water absorption rate for both 7 and 28 days

Figure 4.6 above shows the comparison of water absorption rate of sand bricks for 0%, 2.5 % and 7.5% of fine coconut shell as replacement of sand. From the data obtained, it show that the average of water absorption rate for standard control bricks which is 0% at 7 days is 11.52% and slightly decreased to 9.50% at 28 days. The replacement for 2.5% at 7 days is 13.78% and declined to 10.14% at 28 days. While for replacement of 7.5% at 7 and 28 days are 14.01% and slightly dropped to 11.97%. The result shows the percentage of water absorption rate were increased with the increasing of fine coconut shell as a sand replacement.

The increasing of the water absorption may be related to the characteristic of the coconut shell that absorbs water. The water can get through the porous area in brick, since coconut shell is fibrous, making it easier to absorb water. According to Mohammad and Pawade, (2014), a coconut shells is porous and fibrous and it holds the moisture by provide a barrier for moisture to move towards the surface, it is due to the fibrous nature that provide high absorbing ability. In addition, it is supported by Gunasekaran and Laskhmipathy, (2012), the pore structure in coconut shells behave like a reservoir and the water absorbed by the coconut shells during submerged is stored and the pore structures in the coconut shells acts as a reservoir.

The highest percentage of water absorption rate for this experiment, which at 7.5% replacement, since it is the highest percentage use of fine coconut shell as a sand replacement. The sand bricks with 0% fine coconut shell replacement showing the best percentage compared with sand bricks containing fine coconut shell.

CHAPTER 5

CONCLUSION

5.1 Introduction

This study was conducted to determine the strength and properties of the sand bricks with fine coconut shell as replacement for sand and the different percentage replacement which are 0%, 2.5 and 7.5%.

5.2 Conclusion

From the results obtained, the following conclusion can be drawn based on the objectives. The first objective for this study is to obtain the optimum percentage of fine coconut shell as a sand replacement. Based on the result, it can concluded the compressive strength for 2.5 % replacement at 28 days was chosen as an optimum percentage for this project. The replacement of 2.5% is 4.00 MPa was the highest compressive strength and have the least water absorption rate which are 13.78% at 7 days and 10.14% at 28 days compared to other percentage replacement.

The second objective is to determine the properties of sand bricks based on compressive strength and water absorption test. From the results obtained, it can concluded that the compressive strength of sand bricks was decreased with increasing percentages use of fine coconut shell as a sand replacement. The average strength of sand bricks containing fine coconut shell not achieved the minimum permissible average compressive strength of Standard Specification for Building Works, 2014 which is 5.2 N/mm^2. Lastly, in water absorption rate, it can concluded that the sand bricks containing fine coconut shell tend to increase with the increasing of percentage of replacement. The entire average of water absorption rate does not exceed the general limit of water absorption rate. This may be due to characteristic of coconut shell if fibrous and easy to absorb water.

Therefore, the use of waste material consisting of fine coconut shell as a replacement for sand in this study produces sand bricks that does not reached the specification of sand bricks in the market. Hence, it cannot be used in main structural components as load bearing wall in construction field but maybe can be used for non-bearing structure components likes temporary partition wall and pathway.

5.3 Recommendations

Throughout this project, there are things that need to be analysed and reviewed to make this project become more reliable and referenced in the future. Therefore, some recommendations are made to improve the results obtained in the study and analysis for future review. The recommendations base on objective and are as follows:

i. It is recommended to modify the size of materials to increase the compressive strength and reduce the water absorption.
ii. Alternatively, it would be beneficial for further study to continue by analysing the results of this study and come up with more efficient and economical to reduce the cost.
iii. Based on first objective from this study, for future studies can be conducted with the use of different percentage of replacement. The use of different percentage of replacement is to observe the effects of 0%, 2.5% and 7.5% replacement of sand into the bricks by implementing the same scope of this study.
iv. In addition, this study can be conducted using the coconut shell material along with other non-conventional material like palm kernel shells, coir pith, shells, rice husks, etc.

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APPENDIX A
RAW DATA OBTAINED FOR COMPRESSIVE STRENGTH

Standard Control / 0% replacement

Sample / Days	7	28
1	4.08 MPa	5.22 MPa
2	4.01 MPa	5.49 MPa
3	4.09 MPa	5.53 MPa
4	4.37 MPa	5.54 MPa
5	4.82 MPa	5.30 MPa

2.5% replacement

Sample / Days	7	28
1	3.20 MPa	4.03 MPa
2	3.72 MPa	4.80 MPa
3	2.47 MPa	3.93 MPa
4	3.00 MPa	3.89 MPa
5	3.11 MPa	3.34 MPa

7.5% replacement

Sample / Days	7	28
1	3.32 Mpa	3.19 Mpa
2	3.34 Mpa	4.22 Mpa
3	2.33 Mpa	3.08 Mpa
4	2.92 Mpa	3.72 Mpa
5	2.86 Mpa	3.73 Mpa

APPENDIX B
RAW DATA OBTAINED FOR WATER ABSORPTION RATE

Standard Control / 0% replacement

Sample	7 days		28 days	
	Dry Weight (g)	Weight after Submerged for 24 hr (g)	Dry Weight (g)	Weight after Submerged for 24 hr (g)
1	3274.1	3676.4	3771.2	4113.9
2	3450.9	3855.0	3442.6	3731.2
3	3462.8	3798.6	3482.4	3814.9
4	3321.1	3714.0	3360.3	3706.6
5	3202.1	3588.1	3460.3	3811.6

2.5% replacement

Sample	7 days		28 days	
	Dry Weight (g)	Weight after Submerged for 24 hr (g)	Dry Weight (g)	Weight after Submerged for 24 hr (g)
1	3433.3	3809.3	3311.5	3613.3
2	3386.3	3783.0	3453.6	3782.5
3	3432.0	3805.4	3429.2	3685.4
4	3423.3	3787.5	3463.1	3854.6
5	3363.5	3687.8	3480.1	3843.1

7.5% replacement

Sample	7 days		28 days	
	Dry Weight (g)	Weight after Submerged for 24 hr (g)	Dry Weight (g)	Weight after Submerged for 24 hr (g)
1	3326.2	3788.2	3233.7	3618.0
2	3285.1	3725.0	3201.8	3571.0
3	3315.7	3795.4	3283.6	3679.8
4	3247.4	3701.2	3274.3	3696.1
5	3192.1	3649.8	3290.3	3668.4