A STUDY ON SAND BRICK USING WOOD DUST AS SAND REPLACEMENT

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ABSTRAK

Sejak kebelakangan ini, pembinaan adalah salah satu industri yang sedang membangun, oleh yang demikian permintaan sumber asli untuk menghasilkan campuran dan bahan adalah tinggi. Oleh kerana kekurangan sumber dan kesulitan dalam pembuatan, ia mengakibatkan kekangan dan secara langsung meningkatkan harga bahan untuk kerja-kerja pembinaan. Selain itu, isu alam sekitar yang berkait dengan pencemaran yang disebabkan oleh produk sisa dari industri. Peningkatan penggunaan pasir mengakibatkan aktiviti perlombongan yang menyebabkan ketidaksamaan ekologi seperti degradasi dan hakisan tebing. Fokus kajian ini adalah untuk menentukan habuk kayu yang optimum sebagai bahan gantian pasir untuk penghasilan bata pasir serta untuk mengkaji kekuatan mampatan dan kadar penyerapan air. Kajian ini telah dijalankan dalam tiga peratusan yang berbeza iaitu 2.5%, 5.0% dan 7.5% habuk kayu sebagai gantian pasir. Sampel kawalan dengan tanpa gantian (0%) digunakan untuk membandingkan dengan peratusan yang lain. Nisbah campuran yang digunakan untuk setiap campuran adalah 1:6 dan menjalani proses pengawetan selama 7 hari dan 28 hari sebelum ujian dapat dilakukan. 80 unit bilangan bata pasir disediakan dengan saiz 225 mm x 115 mm x 75 mm dan agihan sampel setiap ujian dan peratusan bagi 7 hari dan 28 hari adalah 5 sampel. Keputusan menunjukkan bahawa kekuatan berkurang apabila peratusan gantian habuk kayu meningkat serta secara langsung kadar penyerapan air juga meningkat. Penemuan juga menunjukkan bahawa sampel dengan 2.5% habuk kayu menyumbang kekuatan mampatan yang lebih tinggi dan kadar penyerapan air paling rendah berbanding sampel lain.

ABSTRACT

Recently, construction is one of the developing industry, thus the demand for the natural resources in order to produce the mixtures and material is getting high. Due to the limitation of sources and difficulties in production it is lead to the shortage and increasing of price of materials for construction works. Besides that, deal with environmental issues that related to the pollution that cause by the waste product from the industries. Increase in sand usage lead to mining activities that cause the ecological inequality such as degradation and corrosion of river bank. This research focused in term to determine the optimum wood dust as sand replacement material for sand brick production and to examine the compressive strength and water absorption rate. The study has been conducted in three different percentages which is 2.5%, 5.0% and 7.5% of wood dust replacement. Control samples with 0% replacement is use to compare with the other percentages. The mix ratio used for every mixtures is 1:6 and undergo 7 days and 28 days of curing process before the tested can be conducted. Total 80 numbers of brick were prepared with size 225 mm x 115 mm x 75 mm. The distribution of samples was 5 samples for each testing for both 7 days and 28 days for every percentage. The results show that the strength was reduce directly when the percentages of wood dust replacement increase as well as the water absorption rate also increase. The findings also show that the samples with 2.5% of wood dust are higher in compressive strength and lowest water absorption among the other samples.

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LIST OF SYMBOLS

%	Percentage
mm^2	Milimeter square
^oC	Degree Celcius
N/mm^2	Newton/milimeter square
kg	Kilogram
kN	Kilo Newton
mm	Milimeter
MPa	Mega Pascal
min	Minute
kg/m^3	Kilogram/meter cube

LIST OF ABBREVIATIONS

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

CHAPTER 1

INTRODUCTION

1.1 Introduction

In this era of globalization, Malaysia is one of country that rapidly developing in term of economy, technology and population. Economic growth can be one of the remark to determine the development of the country. Construction industry in residential and commercial has been increased from time to time due to the investment from the foreign and local developer. In order to fulfil the requirement for the construction, it may lead to high demand of natural resources exploration in order to produce the mixtures or material that been using in construction works, for example the used of river sand for a production of sand brick.

Brick is one of the important materials that needed in the construction works especially for building and pavement constructions. Other than that, bricks also can be used as decoration material on a surface since nowadays there is a lot of brick type. In addition, brick is high in durability and good insulator which is it can maintain and regulate the temperature inside the building. Moreover, brick also good in load-bearing properties and production of brick require less cost. Brick commonly used for produce walls, pavements and because recently there a lot brick which is have aesthetic value and it can be used for garden wall and cladding. In Malaysia, there is two types of bricks that commonly use in building construction which is clay brick and sand brick. Characteristic and properties of the brick is depending on the type of brick.

Most of industries will produces a lot of waste and may cause negative impact to environment and community. In sequence, many research has been conducted to find the suitable material to replace those natural resources that is use in construction. Hence, recycle and reuse of waste materials for other construction purposes is one of the solution to cater those problems and produce the renewal product. Recycling waste materials by incorporating them into building materials is a practical solution for pollution problems. These waste materials can be divided into three categories which is construction and demolition waste, industrial waste and agricultural waste (Sabai et al., 2013)

Wood dust is one of waste product from wood processes and in order to control and manage these waste, utilization of wood dust as replacement of sand is one of the alternative method to overcome the problem. It is medium sized of material made by cutting or chipping of wood in producing wood products or furniture. High demand of processed wood may increase the production of wood waste and without the proper management of the waste is may harm the environment. Therefore, study of the engineering properties of the brick with sand replacement is important to ensure the wood dust may give the best result indirectly minimizing the environmental problems.

1.2 Problem Statement

Nowadays, the building construction especially commercial and residential are rapidly construct due to the increasing of population. Generally, in Malaysia, clay brick and sand brick were used for construct masonry wall of a building and also for pavement construction. Usage of clay brick was popular before but due to the limitation of sources and the difficulties in manufacturing process lead to use of sand brick. In addition, sand brick was used in construction because it is more cheap regard of the material used for the production only require cement and sand.

Due to the speedy growth of construction industry, river sand is one of the material that highly demand in production of sand brick (David et al., 2016). Besides that, the usage of river sand may lead to corrosion and degradation of river bank also it may cause a flood during heavy rain. Hence, sand mining activities may occur aggressively since it is a non-renewable natural resources and it is the only source the industry rely on. In other hand, cost of material for producing brick has been increase from time to time. Other than that, uncontrolled illegal sand mining activities can cause bad impact to the river and the environment. Thus, alternative way should be found to cope with this demand in the future.

Based on the observations, a lot of studies had been made to find out an alternative to replace river sand in a brick production. Mostly, waste material had been used as the replacement of river sand such as the coconut shell, rice husk, rice straw and many more.

Wood process activities had produced a lot of waste such as sawdust and wood chip. Normally, these kind of waste will be disposed through landfilling or incineration. Moreover, the environment can be harm and polluted through the incineration and produce a lot of carbon emissions which pollutes the environment (Akshay et al., 2018) that may affect the human being and also the plants and river. By burning the wood waste, it may produce the smoke and harmful gases such as carbon dioxide and carbon monoxide which are hazardous to human health especially it may cause a lung problem. (Anette, 2009)

1.3 Objective

This study was conducted to achieve the following objectives:

i. To determine the optimum percentage of wood dust as sand replacement of sand brick.
ii. To determine the compressive strength of sand brick with wood dust.
iii. To examine the water absorption rate of sand brick with wood dust.

1.4 Scope of Study

In this research wood dust is used to replace river sand in the sand brick production. This study focus on the laboratory testing by following the standard requirements where to determine the compressive strength and to investigate of water absorption rate of sand brick with and indirectly to determine the optimum percentage of wood dust as sand replacement in sand brick. The wood dust used for this research is collected from the sawmill waste in Gambang, Pahang area. The collected wood dust was sieved to obtained size of smaller than 2.36 mm as it were mix into the mixtures of river sand and cement.

The mixture was having three range of percentage of wood dust that will be added which is 2.5%, 5.0% and 7.5%. The dimension of brick is 225 mm length, 115 mm width and 75 mm height. The conventional sand brick will be the control sample which means the sand brick with wood dust sample will be compared with the control sample and will be determined as it will fulfill all the requirements according to Standard Specification for Buildings Works, Malaysian Public Work Department.

1.5 Significant of Study

Along with the modernization, there is need a replacement or improvement of materials in construction industry to other economical and sustainable materials. Other than that, increasing of population also may lead to the increasing of building construction so that there is need to provide economical place to people to live in. Hence, this study will be significant if this study is success where the result obtain is comply all the standard requirement.

In addition, the cost of construction can reduce since it is use the waste material where it can be easily to obtain indirectly more low cost housing also can be construct and it may give the benefit for the lower income family to have proper lifestyle. Other than that, by using waste material as wood dust it can reduce the quantity of waste material and it can replace conventional dispose method so that a sustain and clean environment can be maintain for the next generations.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Bricks in one of the important material that has been used in building construction in worldwide since the oldest time. The demand of brick is increase rapidly from time to time indirectly increase the demand of natural resources since it requires the large quantity of natural resources materials especially sand in order to produce a brick. Hence, because of continuously harvest activities of natural resources, it may cause a pollution towards the environment such as the river may become polluted because of the sand mining activities.

Plenty of research have been done to determine the suitable material that can be used in the construction industries to replace and improve the conventional materials that available in the market. Normally, the research is using the waste product because it may solve the general problems related with the waste materials such as the disposal method and also the effect of the waste product to the environment and society. The use of waste and recycled materials has many economic and environmental benefits to the society (Thandavamoorthy, 2015).

2.2 Sand Brick

In construction world, bricks are the most common material that has been used. It used to form a partition and to divided one area from another area within the building structure. Nowadays, there are many types of bricks due to the modern technology and system but it is difference in shape, size, colour, materials used and the strength. One of the popular brick that has been used in the construction industry nowadays is cement sand brick.

Cement sand bricks also known as concrete bricks and sandcrete because it is made from sand, water and cement. Solid concrete units commonly called concrete bricks, whereas hollow units are known as concrete block, cinder blocks or hollow blocks (Ettu et al., 2013).

In addition, cement sand brick may not physically good because of the rough and porous surface and the colour of the cement sand brick is grey and it offer a good strength as a load-bearing member. Normally, it is used for interior wall for a building rather than being used for exterior wall of high rise building because of this restraint conditions. The production of cement sand brick can consider as simple and easy because it not required any difficult and complicated process. The cement sand brick also required to undergo curing process for 7 days and 28 days to let the hydration process take place and to obtain the optimum strength of the brick. Figure 2.1 shows the example of sand brick.

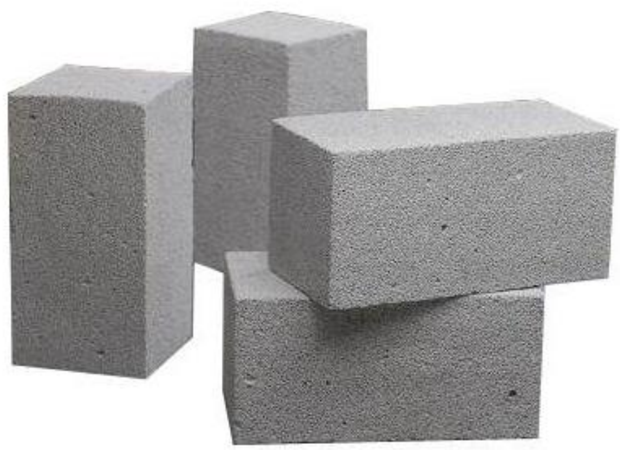

Figure 2.1 Sand brick

2.2.1 Properties of Sand Brick

Good brick must be hard, well burnt, uniform throughout, sound in texture and colour, and sharp in shape and dimension and should not break easily when stuck against another brick or dropped from a height of about one meter (Bernard et al., 2014). Furthermore, density is one of the properties for cement sand brick which is the ratio between the dry brick weight and the volume of the cement sand brick. It also used to determine the particles that found in the volume. Besides that, based on the basic knowledge that the higher the value, then the denser the brick is. Normally, the density ranges from 1200 kg/m^3 to 1900 kg/m^3.

Besides that, brick is good as thermal insulator substantial compare with the other building materials such as concrete. Because of the condition of the brick that is not in solid condition so that the thermal insulation can be improve at certain state. The moisture content of brick helps to main the temperature inside the building structure. The thermal conductivity of brick is measured at various water content and densities that shown the thermal conductivity for denser brick is higher than less dense brick.

Other than that, porosity is determine as ratio between volume of void including the pores and crack and the total volume of the specimen. It is the important parameter due it influences the properties such as, mechanical strength, chemical reactivity, durability and common quality of brick.

2.2.2 Durability of Sand Brick

Sand brick can be classified as durable material. The durability of the brick can be obtained by the quality of the materials selection, design of mixtures and the control and management of the process during mixing and curing procedures. The process should follow the standard of procedure and require full supervision. The suitable and accurate mix proportion and design with the water cement ratio of brick will increase the durability of the brick. The design mixtures should prioritize so that the porosity condition can be reduced. Curing process also helps to maintain the durability of the brick. The durability of the brick will be affected by these factor and it should be considered during the production.

2.2.3 Size of Sand Brick

Based on the (Anon. 2014) Standard Specification for Building Works, Malaysian Public Work Department, to produce a good cement sand brick it should comply with MS 27 while for size for all cement sand bricks and hollow bricks shall be as Table 2.1:

Table 2.1 Standard size of brick

Length, L (mm)	**Width, W (mm)**	**Depth, H (mm)**
225 ± 3.2	113 ± 1.6	75 ± 1.6

Furthermore, it is consist of uniform mixture of sand and cement where it should be mixed according to the ratio 1:6, 1 bag of cement and 6 parts of sand. Minimum average of compressive strength should be 5.2 N/mm^2 for the cement sand brick.

2.3 Advantages of using Sand Brick in Construction

Generally, brick is used to form wall structure in building such as commercial and residential building, high rise building and others. Other than that, brick also can be used as retaining wall and pavement. Nowadays, the usage of cement sand brick in construction industry become popular since it brings a lot of advantages to the environment and also the variation on its application.

First and foremost, cement sand brick is more cheap than the clay brick. This is because it goes through a simpler production process compare to the other. Compare with the clay brick, cement sand brick not require the burning process where it can save up more time and cost. Furthermore, the material used such as fine aggregate or sand contribute the strength to the brick where it makes the brick more durable. Besides that, there are two type of cement sand brick in market which is solid and hollow where the usage of it depends on the purpose of the construction. Another advantages of the cement sand brick are availability in various shape that suit the purpose for it to be used that make the brick versatile. The rough texture and porous surface makes the brick more unique and provide the aesthetic value to the structure.

2.4 Materials

2.4.1 Cement

Cement is the most important materials in concrete production. It acted as a binder to bind all other materials and to make the concrete hard. It is in a powdery form with adhesive and cohesive properties. Besides that, there are two types of cement that commonly used in the industry which is the hydraulic cement and non-hydraulic cement. The difference between both types of cements are it produce solid materials in contact with water due to the hydration process which is for the hydraulic cement, and for the non-hydraulic cement it does not require water to be harden.

Recently, the most common cement that been used in the construction industry is the hydraulic-type portland cement. Based on the (Anon. 2009) Cement and Concrete Association of Malaysia., this type of cement is powdery cementitious material that produces by heating up the lime, alumina, iron oxide, magnesia and silica where it is mixed together in a kiln before it been pulverized. Concrete can be produce when it is mix with aggregates and absent of water.

2.4.2 Sand

Sand is one of the natural resources materials which obtained by natural weathering of rocks such as harvest and mining activities. Sand also can be classified as fine aggregate and it is used in concrete production. Moreover, sand is loose granular materials and it is normally yellowish brown in colour. Fine sand normally passing through a screen with clear opening of 1.5875 mm, it is generally used for masonry works. Gravely sand is passing through a screen with clear openings of 7.62 mm, it is commonly used for plastering works. Other than that, coarse sand is known as sand passing through a screen with clear opening of 3.175 mm, it is generally used for masonry work.

Besides that, for a better mixture, sand should in a clean condition and hard. In this study, river sand was used. The river sand was obtained from the river beds which is consists of fine rounded grains. According to (Anon. 2014) Standard Specification for Building Works, Malaysian Public Work Department, the sand gradation for cement sand brick has to meet the terms with MS 29.

Sand can act to reduce the shrinkage problem which is occur during setting and drying directly will reduce the cracking and also can fill the void as it is in small size particles. This condition can contribute to improve the strength of the sample.

2.4.3 Water

Most of surface on earth covered by water. Pure water is colourless, odourless and tasteless and it is most important thing that we need in our daily life. other than that, water also required in brick production. It is used to mix and bind cement together with sand. The presence of water can cause the process of hydration in cement which it is acted as the chemical reaction agent directly harden the mixture. The water used should be fulfil the requirement and free from any impurities or particles. Generally, for this research, tap water was used because it is clean and free from other organic materials and no testing was needed to the water sample.

2.4.4 Wood Dust

Generally, sawmill will produce industrial waste materials in various shape and size. It is product of cutting, grinding, sanding or other activities and because of these daily activities it may increase the amount of production of wood waste. About 136 million tonnes of wood wastes are produced every year in the world and this wastes are a huge threat to the environment which is it that may lead to damage the land and surrounding because it is dumped (Thandavamoorthy, 2015). It commonly known as wood chip, sawdust and others. Wood dust is one of the wood waste that can be found in wood industry. The physical and chemical properties of wood dust vary significantly depending on many factors such as geographical location and industrial processes. Hardwoods usually produce more dust than softwoods, and the bark and leaves generally produce more wood dust than the inner wood parts of the tree (Siva Kumar, 2018). Besides that, it can be used as burner material or it can be reprocessed into other materials. Environmental problem such as treatment and disposal are arise due to the continuity production of this wood waste material.

In consequence, wood dust can be used to create a sustainable construction and environmental friendly product directly it can solve problem in term of reducing the cost of construction materials since the wood dust is already waste (Dilip et al., 2014), saving the natural resources materials and protect our environment. Besides that, replace or adding wood wastes such as wood dust in concrete or brick can contributes to reduce the heat of the building. Wood wastes also good in sound insulator where it is suitable to use in area that occur noise problem. It is used in theatres and cinema while it also used for roads and express ways construction as a barrier to ease the noise pollution in the neighbourhood area (Thandavamoorthy, 2015). By producing the environmental sand brick, it can reduce the construction problems such as cost and time. Figure 2.2 and Figure 2.3 below shows the wood dust that had been used in this study.

Figure 2.2 Wood waste from sawmill

Figure 2.3 Wood dust

2.5 Compressive Strength of Brick

Compressive test is the most common parameter that used to identified the performance of the brick or concrete materials. Mixing the suitable materials, compacting method and procedure and also the curing process may contribute to the maximum strength of brick. Compressive strength of brick is important because it can act as non-load bearing wall and the strength is used for brickwork design. Sturdier brick can contribute to the superior brickwork design. According to (Anon. 2014) Standard Specification for Building Works, Malaysian Public Work Department, the minimum allowable average compressive strength shall be 5.2 N/mm^2. The compressive strength of brick can vary from 3 N/mm^2 to 40 N/mm^2 depending on raw materials used for making brick, manufacturing process and size and shape of brick. Compressive strength can be obtained when the load is subjected to the material until it reach the limit and it is crushed.

2.6 Water Absorption of Brick

The water absorption test is to determine the percentage of water absorption of the brick. This condition also can help to determine the amount of water that can be absorbed by the brick. Water absorption of the brick is depending on the variable of raw materials used for the production of brick. Generally, the amount of water absorption is influenced by the bond between the brick and green materials which is high in void percentage.

2.7 Previous Research Outcomes

Table 2.3 Summary of related research

No.	Research Title	Year	Parameter	Material (additive / replacement)	Result
1.	**Navaratnarajah Sathiparan, De Zoysa, H.T.S.M.** **-** The Effects of Using Agricultural Waste As Partial Sunstitute For Sand In Cement Blocks	2018	Density, strength, Durability, acid and alkaline resistance	Rice husk, sawdust, peanut shell, rice straw and coconut shell	Satisfied the strength requirement especially coconut shell and peanut shell and can be used for construction material.
2.	**Maggi Madrid, Aimar Orbe, Helena Carre, Yokasta Garcia** **-** Thermal Performance of Sawdust and Lime-mud Concrete Masonry Units	2018	Density, absorption, capillary suction, strength, thermal properties, economic benefits	Crushed natural-limestone, and sawdust	Replacement of limestone by sawdust decrease the strength.
3.	**Olga Kizinievic, Viktor Kizinievic, Ina Pundiene and 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 absorb more water compare with oat husk.

4.	**Li, M., Khelifa, M. and Ganaoui, M. Ei.** - Mechanical Characterization of Concrete Containing Wood Shavings As Aggregates	2017	Mechanical Properties	Wood Shaving	Ratio between flexural and compressive strength is 47% and water absorption rate is below 30%.
5.	**Thandavamoorthy, T. S.** - Wood Waste as Coarse Aggregate in The Production of Concrete	2015	Workability, strength and durability,	Wood aggregate	Optimum percentage is 15%.
6.	**Gengying Li, Xiaoyang Xu, E. Chen, Jie Fan, Guangjing Xiong** **-** Properties of Cement-based bricks with oyster-shells ash.	2014	Strength and durability	Oyster shells	Addition of oyster shells give an improvement to the strength but excessive of it may decreases the result.
7.	**Bashar S. Mohammed, Abdullahi, M., & Hoong, C. K.** **-** Statistical Model for Concrete Containing Wood Chipping as Partial Replacement to Fine Aggregate	2014	Workability, mechanical properties,	Wood Chipping	Slump increased when wood chipping is increased, concrete strength decreased when ad wood chipping. Optimum percentage is 10%

8.	**Sadek, D. M.** **-** Physico-mechanical Properties of Solid Cement Bricks Containing Recycled Aggregates	2011	Strength, unit weight and water absorption	Recycled aggregates (clay brick)	Recycled aggregates higher water absorption and strength when replaced the fine aggregate only.
9.	**Bederina, M., Laidoudi, B., Goullieux, A., Khenfer, M. M., Bali, A. & Queneudec, M.** **-** Effect of The Treatment of wood shaving on the physico-mechanical Characteristic of Wood Sand Concrete	2009	Density, Strength, insulation and shrinkage	Treated wood shaving	The result given is positive and improved.
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

The purpose of this study is to determine the compressive strength and to determine the water absorption rate and to determine the optimum percentage of wood shredded as sand replacement in sand brick. In this chapter, it will discuss in detail about the material used and how the material will be prepared and also the testing method that will be conducted regarding the study. Moreover, the testing will be conduct in Heavy Structural Laboratory, Universiti Malaysia Pahang. All the materials will be collect and prepare after all the detailed was finalized. Then, proceed with the mixing and production sand brick sample and follow by the conduct the testing. The results of the testing will be collect and discuss.

3.2 Framework of Research

Figure 3.1 gives an overview of the overall research progress. This study involved laboratory work which is material preparation, mixing process, curing process and testing. The result will be recorded and analysed to fulfil the requirement of Final Year Project.

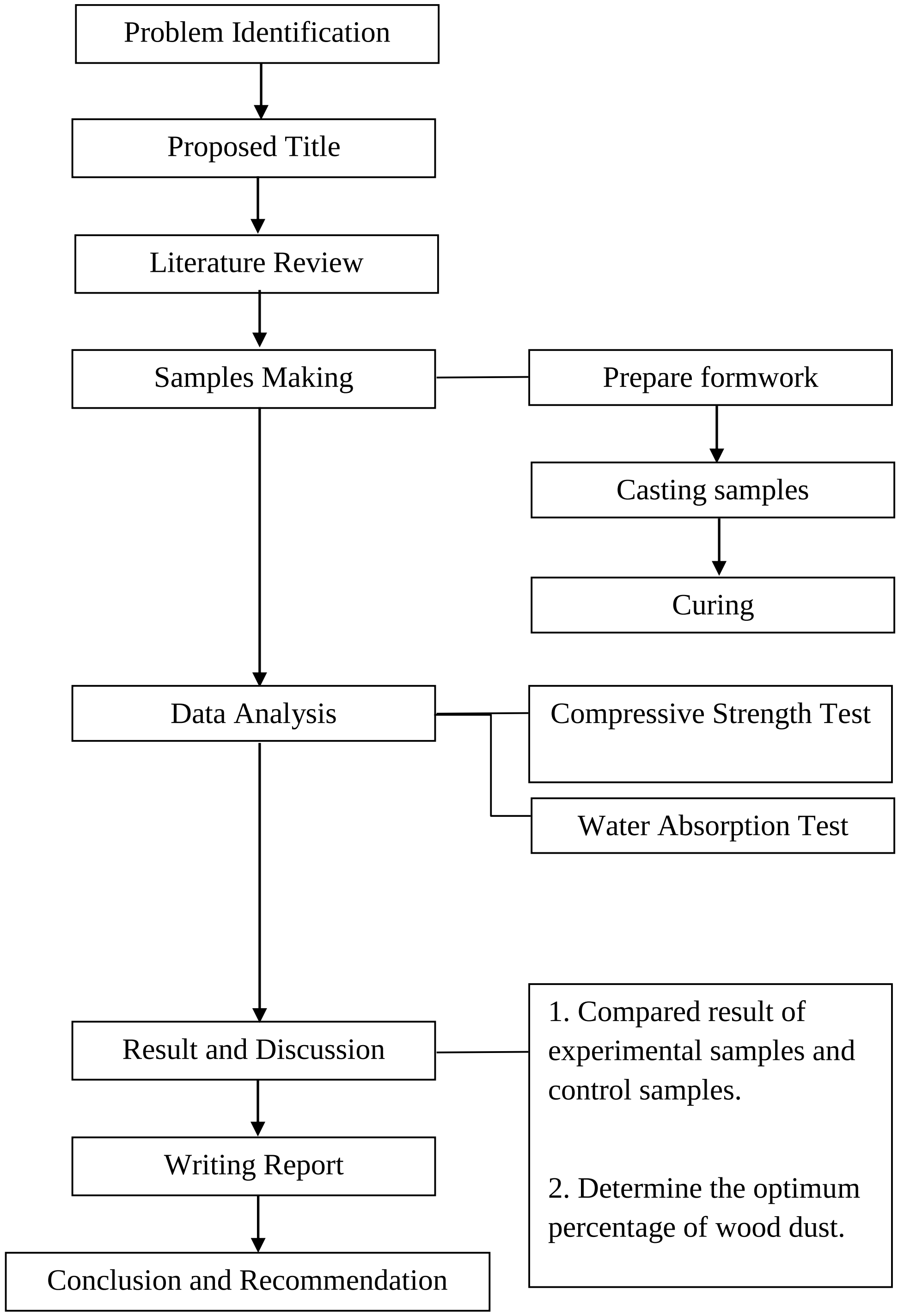

Figure 3.1 Framework of research

3.3 Design Brick Mixture

3.3.1 Ordinary Portland Cement (OPC)

Cement is known as a binder when it mixed together with water and aggregate. A chemical process may occur when the cement reacts with water and the process is known as hydration process. In this study, the Ordinary Portland Cement (OPC) is use as it is the general cement type that being used in most construction. The cement should be stored in a dry condition and kept in air tight so that it will prevent from any moist condition so that it does not harden before usage. Figure 3.2 shows the Ordinary Portland Cement brand name Orang Kuat was used in this study.

Figure 3.2 Ordinary Portland Cement

3.3.2 River Sand

River sand also can be classified as fine aggregate. It is the important material in production of sand brick. Usually, the size of fine aggregate that use is not more than 5 mm. Figure 3.3 below shows the river sand that had been used and it was filtered or sieved if needed so that it was follow the requirement and it can remove any unwanted impurities and it should free from clay, loam and dirt. The river sand should be in dry condition before being used.

Figure 3.3 River sand

3.3.3 Water

Water is important in order to allow the hydration process of the cement and without water it does not allow the cement to bind all the materials. Type of water used for the production of sand brick is ordinary tap water. It should be clean, colourless, odourless and free from any organic substances. Figure 3.4 below shows the tap water used in this study.

Figure 3.4 Water

3.3.4 Wood Dust

Wood dust was used in this study to replace natural sand inside the sand brick. The wood dust was obtained from the sawmill factories at Gambang area. It is waste from wood production processed such as grinding, cutting, sanding and other activities. Wood dust was collected and been placed in a large plastic bag and stored in FKASA laboratory before it been prepared and used. Besides that, wood dust need to be dry in room temperature straight after it being collected so that any moisture within the wood dust can be removed. This is because the wood dust was damp because of the humidity and the changes of weather and it is put at an open area before it be disposed. If the wood dust in damp condition it may affect the quality and the condition of wood dust before it being used.

Originally the wood dust that collected from the sawmill was varies in sizes and shapes in order to obtain the require size for this study the wood dust was sieved and the process were continuously until the amount of wood dust that were needed for the research were obtained. The sizes of wood dust used need to pass sieve no 2.36 mm. Later, the wood dust was weighted according to the amount for each percentages depends on the calculation. After that, before the wood dust was used, it must be soaked in water for at least 24 hours in room temperature and it is tightly sealed. These process were let the wood dust absorb water and make the wood dust in saturated condition. This process to avoid the wood dust from absorb water during the casting and curing process that may affect the hydration process of the cement. Figure 3.5 to Figure 3.7 below shows the processed of preparing wood dust material.

Figure 3.5 Sieve process of wood dust

Figure 3.6 Wood dust soaked with water

Figure 3.7 Soaked wood dust was filtered

3.4 Brick Dimension and Mix Proportions

The dimension used in this research were designed as shown in Figure 3.8. The dimension of the brick is based on the (Anon. 2014) Standard Specification for Buildings Works, Malaysian Public Work Department. Figure 3.8 below shows the detail dimension of the brick.

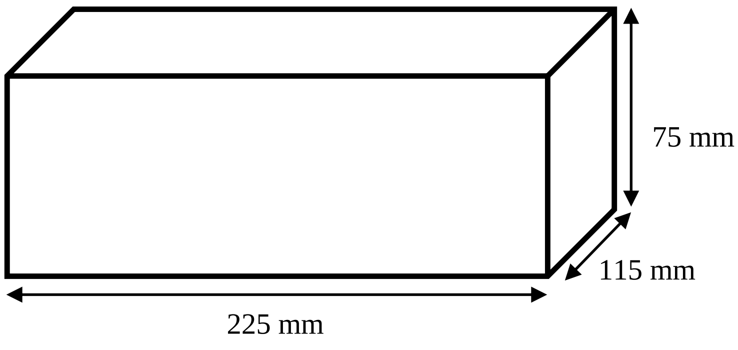

Figure 3.8 Dimension of brick

The test that had been conducted on the brick was compressive strength test and water absorption for all the sample including control sample, 2.5%, 5.0% and 7.5% of replacement wood dust with standard ratio 1:6 which is 1 for cement, 6 for sand. All percentages that replaced with wood dust were prepared 10 samples for compressive strength test while 10 samples for water absorption test. The samples were undergo water curing process for 7 days and 28 days before compressive strength test and water absorption test can be conducted. Total quantities for samples production for this study are 80 samples.

Table 3.1 below shows the sample distribution for both testing that used for various percentages of brick containing wood dust and also for the control samples. The average value was obtained from the total results of the test conducted.

Table 3.1 Samples distribution

	Percentages Replacement (%)	**Water Curing**		**Total Samples**
		7 days	28 days	
Compressive Strength Test	0	5 samples	5 samples	40
	2.5	5 samples	5 samples	
	5.0	5 samples	5 samples	
	7.5	5 samples	5 samples	
Water Absorption Test	0	5 samples	5 samples	40
	2.5	5 samples	5 samples	
	5.0	5 samples	5 samples	
	7.5	5 samples	5 samples	

The cement sand ratio mixtures were followed the 1:6 ratio. The amount of wood dust replaced for 2.5%, 5.0%, and 7.5% was based on the amount of sand that obtained from the cement sand ratio.

Table 3.2 below shows the outline of the quantities of materials used for this study.

Table 3.2 Mix quantities of materials

Materials		
Cement (%)	**Sand (%)**	**Shredded Wood (%)**
100	100	0
100	97.5	2.5
100	95.0	5.0
100	92.5	7.5

Table 3.3 Mix quantities of materials by weight (kg)

Percentages Replacement (%)	Materials			Water (kg)
	Cement (kg)	Sand (kg)	Wood Dust (kg)	
0	7.8	52.20	0	5.46
2.5	7.8	50.90	2.5	5.46
5.0	7.8	95.00	5.0	5.46
7.5	7.8	48.28	7.5	5.46

3.5 Manufacturing and Mixing Procedure

The preparation of the samples started by prepared the formwork for the sand brick samples follow by prepared the wood dust which was involved the sieved process. Then, other materials such as cement, sand and water was prepared for the sand brick production.

Figure 3.9 Samples preparation flow

3.5.1 Formwork Preparation

In this study, the brick production require formwork for casting the sand brick. The samples were poured into the formwork where the formwork were followed the measurements of the sample brick. The formwork was made of plywood. The manufacturing of formwork was followed the general procedure to prepare formwork. Besides that, the plywood was sealed using strapping tape and grease need to be applied onto the formwork surface so that it was be easy when removing the brick sample from the formwork later and to avoid any of the sample from stick onto the formwork. Figure 3.10 and Figure 3.11 shows the formwork of the brick.

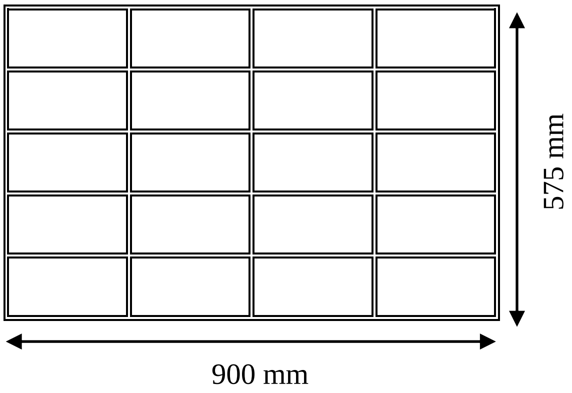

Figure 3.10 Plan view of formwork

Figure 3.11 Brick formwork

3.5.2 Mixing and Casting Procedure

Figure 3.12 Mixing procedure

Figure 3.12 above shows the sequences of the materials added in order to prepare the mixtures. Each of the materials is weighted separately according to the Table 3.2. Cement, sand and wood dust was poured carefully and mixed together into the concrete mixer machine. Quantity of water was added regularly until the total amount of water was poured. The mixture was mixed and stirred thoroughly until it is mix up and blended together. After that, the mixtures were ready to pour into the formwork and it was poured consistently and evenly in the formwork to form a smooth brick sample. Next, the sample was compacted using the steel rod continuously so that the brick was compacted enough and may get rid the air void inside the samples. Then, the sample were ready and left 24 hours to let it harden before it was taken out from the formwork and undergo curing process. Figure 3.13 to Figure 3.15 shown the process of sand brick manufacturing.

Figure 3.13 Sample was compacted using steel rod

Figure 3.14 Complete brick casting process

Figure 3.15 Final sample production

3.5.3 Curing Process

After the sample was harden and taken out from the formwork, it will undergo a curing process. Curing is important to control the moisture content and temperature in the brick for a specific period of time and to foster the strength and durability of the brick. Moreover, a proper curing process can assist the hydration process of the cement and directly increased the strength of the brick.

There are many method of curing process, for this study water curing was chosen. Based on the Table 3.1 the samples were cured into the water curing tank. All the samples were cured for 7 days and 28 days before the laboratory testing can be conducted on it as shown in the Figure 3.16 below.

Figure 3.16 Water curing process

3.6 Testing Method

3.6.1 Compressive Strength Test

The purpose of the compressive strength test is to determine the maximum stress and load that the brick can sustain when applied the load gradually until the brick totally failed. Compressive strength test also known as crushing strength of the brick which is the ability of the brick to resist the load until it crush and it was carried out according to standard ASTM C55. Compressive strength test was conducted by using the compression testing machine as in the Figure 3.17. The test was conducted on the samples at 7 days and 28 days curing age. The load was applied on the sample by using the machine until the sample totally crushed and the result was recorded and the average value was taken from the recorded data.

Before the testing was conducted, the plate bearing and the samples need to be wiped and cleaned. Then, flat plywood was placed on top and bottom of the samples surface so that the load will distributed evenly. The sample was placed at the centre of the bearing plate and positioned properly as in the Figure 3.18. Then, the load was applied axially at uniform rate continuously until the sample was failed. The sample was failed when the maximum load was applied on it. The data of the maximum load applied on the machine was recorded and the processes were repeated for all samples.

The compressive strength calculated for each sample using the equation:

$$P = F / A \qquad 3.1$$

Where:-

P = Compressive Strength, MPa

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

A = Area of upper surface of the sample, mm^2

Figure 3.17 Compressive strength machine

Figure 3.18 Sample placed on the testing machine

3.6.2 Water Absorption Test

Water absorption test had been conducted according to ASTM C55. The purpose of the water absorption test to determine the moisture content of the sand bricks directly to the effects of exposure to water or humidity of the surrounding. Other than that, water absorption is the main factor which can affect the durability of the bricks.

For water absorption test, the samples were dries in the ventilated oven as Figure 3.19 for at least 24 hours with temperature 105°C as in the Figure 3.20 below. After the samples were took out from the ventilated oven, the weight of the dry samples was recorded as w_d. After drying, the specimen will be cooled in a drying room with relative humidity around 70%. Next, the samples were submerged in clean water for another 24 hours. Then, after it had been submerged, the surface of the sample was wiped with a damp cloth and it was weighted again. The data was recorded and all the samples will undergo the same processes.

The water absorption rate calculated for each sample using the equation

$$Water\ Absorption, \% = \frac{(w_s - w_d)}{w_d}\ x\ 100 \qquad 3.2$$

Where:-

w_d = Dry weight of the specimen

w_s = Saturated weight of the samples after submersion in water.

Figure 3.19 Ventilation oven

Figure 3.20 Sample placed in oven

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

The samples were classified in six different group which is the control and three samples of various percentages of 2.5%, 5.0% and 7.5% of wood dust. The control samples where contain 0% of wood dust acted as a role of control sand brick. Besides that, for overall samples including the control and replacement percentage were made in similar proportion which is 1:6. Every samples were labelled with number and replacement percentages in order to make it more easy for the data recorded processes. All samples were undergo water curing process. A total 80 bricks were casted depends on the curing times which is 40 numbers for 7 days and another 40 numbers for 28 days.

This chapter present the results and data by two testing that was conducted. It is compressive strength test and water absorption test. The testing was conducted by following the ASTM. Discussion about the outcomes by analysing it with previous research. For both testing, the results obtained for the replacement samples were compared with the control samples as the reference of engineering properties. The outcomes of the testing were interpreted into table and graph to show the comparison and for better understanding.

4.2 Compressive Strength of Sand Brick

A compressive strength test was conducted to determine strength and the behaviour of materials under the crushing loads. The samples were compressed and the maximum load was recorded. In this research, the samples were tested after 7 days and 28 days of curing process. 5 number of samples were tested for each percentages of sand replacement and the average data was obtained from it.

Table 4.1 Compressive strength for 7 and 28 days

Percentages of wood dust (%)	**Compressive Strength (MPa)**	
	7 days	28 days
0 (control)	4.27	5.42
2.5	1.70	2.90
5.0	1.24	1.44
7.5	1.05	1.28

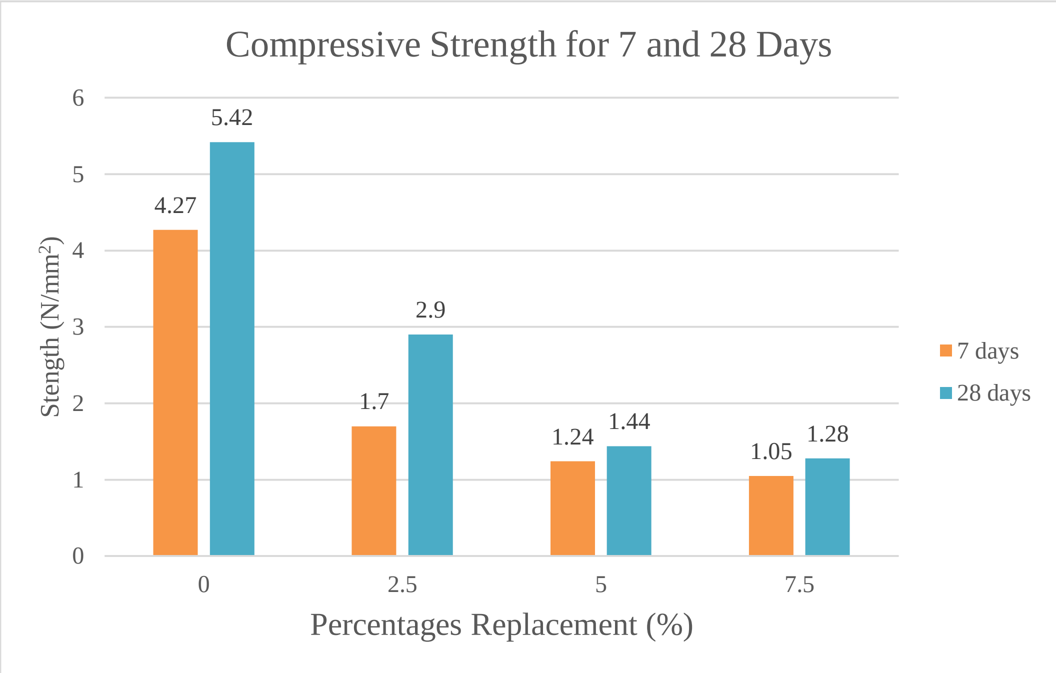

Figure 4.1 Compressive strength result for 7 and 28 days

Based on Table 4.1 and Figure 4.1 it shows the results of the brick for 7 days and 28 days after curing process. Normally on 7 days, the brick should achieve 75% from its ultimate strength. For control sample which is contain 0% of wood dust the compressive strength value is increased steadily which is 4.27 MPa. Meanwhile, for the 2.5% of wood dust achieve the maximum strength compared with the other samples that contain wood dust but the compressive strength decreased dramatically to 1.70 MPa and the second percentage which is 5.0% was 1.24 MPa and followed by 7.5% of wood dust the result obtain is 1.05 MPa and it was decreased from the control value. The strength value for mixtures that replaced with wood dust were lesser than the control value. The results show that there is slightly differ between the samples containing wood dust and the control samples. Moreover, the different of compressive strength value between the 2.5%

and 7.5% of wood dust samples and control samples is 2.57 MPa and 3.22 MPa respectively.

Basically, brick will achieve 99% to 100% of its ultimate strength at 28 days. The outcomes shown that there were an increment regarding the compressive strength value. The control samples with 0% of wood dust significantly increased by 5.42 MPa of compressive strength. While, for 2.5% of wood dust the results shown it steadily decrease until 2.90 MPa. Regardless, it is the maximum strength compare to the 5.0% and 7.5% of wood dust replacement. Furthermore, for 5% of samples it slightly drops by 1.44 MPa and for 7.5% of wood dust replacement it obtained 1.28 MPa. The value obtained is compared with the control sample which is for the 2.5% of sand replacement, the different is 2.52 MPa. Besides that, for 5% and 7.5% of sand replacement the different between the value of compressive strength with the control samples is 3.98 MPa and 4.14 MPa respectively. The amount of wood dust also gives a big impact to the results obtained.

In short, the outcomes expressed that the control samples which contain 0% of wood dust achieved the highest compressive strength compared between the samples that contain wood dust. Generally, the results shown that there were decreasing of compressive strength when the percentage of wood dust replacement was increased as the amount of wood dust was higher. The overall decreasing of compressive strength of the brick was due to several reasons that may lead to the results obtained. The most adequate reasons were high content of voids in the bricks mixtures that lead to decreasing the strength when the wood dust content was increased. It also makes the bonding between the cement and other materials in the mixtures loose and apart from each other where this condition may contribute to lower the strength and difficulties to obtain a better result. Other than that, the water content within the samples also lead to the outcomes. The wood dust which was in saturated condition and also the amount of water that being used for the research lead to the excessive water quantity in the mixtures directly affect the hydration process of cement. This condition causes the lower strength of the brick.

4.3 Water Absorption Rate of Sand Brick

A water absorption test was conducted to determine the degree of water absorption by the brick samples. The testing was conducted after 7 days and 28 days of curing. 5 samples were prepared for each percentage for both 7 days and 28 days. The result from every brick was recorded and average value was obtained.

Table 4.2 Water absorption for 7 and 28 days

Percentages of Wood Dust (%)	Water Absorption (%)	
	7 days	28 days
0 (control)	11.59	9.50
2.5	16.56	12.19
5.0	19.29	15.88
7.5	19.88	16.28

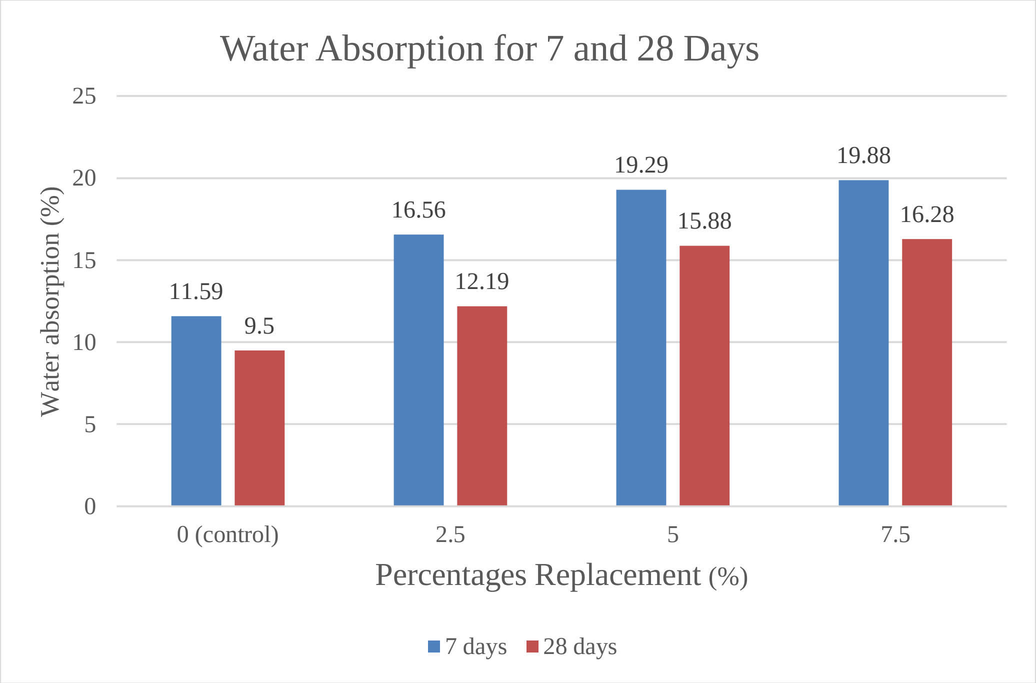

Figure 4.2 Water absorption result for 7 and 28 days

Based on Table 4.2. and Figure 4.2 it shows that the outcomes from the testing for control and sand replacement samples for both 7 days and 28 days. Generally, higher water absorption rate is considered unsuitable for load bearing materials. All the samples produced high degree of water absorption. For the sample tested at 7 days, the water absorption was higher compared with the samples tested at 28 days. For the control sample the water absorption is 11.59% it is the lowest water absorption compare to the others. Besides that, for the 2.5% of wood dust the water absorption drastically increase to 16.56%. and continuously increase for 5.0% and 7.5% of wood dust which is 19.29% and 19.88% respectively. Meanwhile, the different of water absorption between the control and the samples that contain wood dust quite large for the lowest and highest water absorption. For control and 2.5% containing wood dust the difference was 4.97% while it is 8.29% between control and 7.5% of wood dust. It shown that the incremental of water absorption rate as the quantity of wood dust also increase.

For the results tested at 28 days, the value was slightly decreased compared with the sample tested at 7 days. For control samples the water absorption value obtained was 9.5% and it is the lowest value compared with the others. Next, for the samples containing 2.5% wood dust show that it absorbs less water compared with the 5.0% and 7.5% of wood dust samples. The water absorption rate was 12.19%. Furthermore, the value for water absorption of 5% of wood dust was significantly increase to 15.88% and continuously increase to 16.28% for 7.5% samples containing wood dust. The difference for the lowest and highest water absorption rate between the control samples and wood dust replacement samples was 2.69% and 6.78% for the 2.5% and 7.5% wood dust replacement respectively.

In conclusion, the control sample showed lowest water absorption compared with the samples containing wood dust. The results proved that the sample with 2.5% of wood dust had the lowest water absorption rate while for 7.5% of wood dust had the highest water absorption compared to other mixes. It showed that, the water absorption rate is increase proportionally with the quantity of wood dust. From the data obtained, the physical characteristic of the wood dust which act like a sponge that easily absorb water. Other than that, the chemical properties, size and shape of the wood dust would affect the water absorption and also the strength of the brick.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study was conducted to investigate the compressive strength and water absorption rate of the sand brick with wood dust as sand replacement with different percentage which is 2.5%, 5.0% and 7.5% in order to overcome the issues regarding the highly demand of brick material in construction industry and also to reduce the problem of management and disposal of natural waste. The following conclusion can be drawn based on the results obtained.

The compressive strength was decreased with the increasing of wood dust which is the highest strength for 28 days of curing process the strength obtained was 2.90 MPa with 2.5% of wood dust replacement while the minimum strength was 1.28 MPa with wood dust contained by 7.5%. Both outcomes did not meet the requirement based on the standard specification whereas the minimum strength is 5.2 MPa.

Wood dust as sand replacement in sand brick production would affect the water absorption rate. The percentage of water absorption rate were directly proportional to the percentages of sand replacement. The study proved that, the lowest water absorption rate for 28 days was 12.19% compare to the other percentages. Sand brick that contain less water absorption rate was better and suitable to be used for commercial and construction industry.

Based on the results obtained, it can conclude that the 2.5% replacement of wood dust was the optimum percentage since it has the highest compressive strength among the other mixtures that containing wood dust. The compressive strength was 2.90 MPa with 28 days of curing. Regardless, the strength of wood dust bricks did not meet the standard specification of minimum strength which is 5.2 MPa. Besides that, 2.5% of wood dust replacement also achieved the lowest value of minimum water absorption rate which is 12.19%.

In recent construction industries, the usage of sand brick contained wood dust did not suitable as load bearing wall due to the lower compressive strength. Meanwhile, it is suitable to be used as heat insulator since it is high in water absorption rate. Besides that, it also can be used as non-load bearing wall or decoration materials such as the brick pathway, indoor brick floor or brick archway because of the aesthetic value but it need to concern on the weather factor. Lastly, the sand brick containing wood dust can be used as sound insulator as it can be placed at the existing wall in order to reduce the sound volume.

5.2 Recommendations

Based on the study that had been made, a few recommendations can be made to improve the outcomes in future. Hence, the following recommendations are made:

i. Details study about the chemical composition and physical properties of the wood dust should be carried out to determine the reaction between the other materials.

ii. A study on the quantity of water that should be used with addition of wood dust should be made so that it will not affect the hydration process of cement.

iii. Thermal conductivity test should be carried out to investigate the performance of the normal sand brick and sand brick containing wood dust.

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APPENDIX A

RAW DATA OF COMPRESSIVE STRENGTH TEST

Control sample (0%)

	Compressive Strength (MPa)	
Days / Sample	7	28
1	4.08	5.22
2	4.01	5.49
3	4.09	5.53
4	4.37	5.54
5	4.82	5.3

Percentages 1 – 2.5%

	Compressive Strength (MPa)	
Days / Sample	7	28
1	1.34	2.84
2	1.95	2.98
3	2.19	2.85
4	1.62	2.98
5	1.39	2.85

Percentages 2 – 5.0%

	Compressive Strength (MPa)	
Days / Sample	7	28
1	0.97	1.58
2	1.24	1.32
3	1.57	1.41
4	1.1	1.46
5	1.08	1.43

Percentages 3 – 7.5%

	Compressive Strength (MPa)	
Days / Sample	7	28
1	1.08	1.12
2	0.96	1.14
3	1.22	1.3
4	1.26	1.48
5	0.71	1.36

APPENDIX B

RAW DATA OF WATER ABSORPTION TEST

CONTROL SAMPLE (0%)

	Oven (Kg)	Submerged 24 hr (Kg)	Oven (Kg)	Submerged 24 hr (Kg)
Days / Sample	7	28	7	28
1	3274.1	3676.4	3771.2	4113.9
2	3450.9	3855	3442.6	3731.2
3	3462.8	3798.6	3482.4	3814.9
4	3321.1	3714	3360.3	3706.6
5	3202.1	3588	3460.3	3811.6

Percentages 1 – 2.5%

	Oven (Kg)	Submerged 24 hr (Kg)	Oven (Kg)	Submerged 24 hr (Kg)
Days / Sample	7	28	7	28
1	3179.8	3796.5	3247.3	3638.4
2	3188.5	3728	3393.3	3773.3
3	3131.5	3642.5	3211.5	3640.1
4	3063.5	3579.5	3153.9	3523.8
5	3180.8	3695.9	3363.1	3788.5

Percentages 2 – 5.0%

	Oven (Kg)	Submerged 24 hr (Kg)	Oven (Kg)	Submerged 24 hr (Kg)
Days / Sample	7	28	7	28
1	2752.1	3267.8	2767.2	3184.4
2	2952.6	3440.7	2771	3175.6
3	2840.7	3324.7	2805.5	3250.5
4	2547.3	3146.7	2879.6	3345.6
5	2515.9	3034.8	2829.2	3329.5

Percentages 3 – 7.5%

	Oven (Kg)	Submerged 24 hr (Kg)	Oven (Kg)	Submerged 24 hr (Kg)
Days / Sample	7	28	7	28
1	2775.9	3338.1	2950.7	3400.7
2	2722.3	3237.9	3069	3609.8
3	2684.8	3262.7	2789.3	3217.4
4	2891.2	3416.4	3016.5	3507.1
5	2797.2	3342.7	2988.4	3493.2