STUDY ON PROPERTIES OF CLAY BRICK AND CB BRICK UNDER DIFFERENT HEATING RATES

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Discarded cigarette butts (CB) are a form of non-biodegradable litter. CB are carried as runoff from streets to drains, rivers, and ultimately to the beaches and ocean. Cigarette filters are one of the most collected items each year. This study presented the research of incorporation of CB into fired clay brick. The effects of the additional of CB material on the properties of fired clay brick were investigated. Physico-mechanical properties of fired clay bricks manufactured with 2.5% and 5.0% of CB are fired at different heating rates at 1°C/min, 3°C/min, and 5°C/min in a furnace. The properties of CB brick were tested on compressive strength, initial rate suction (IRS), dry shrinkage and dry density. The results from the study were analyzed and compared between CB brick and control brick. The properties of CB brick are presented and discussed. From the results, it shows that the values of shrinkage and IRS were slightly increased with the increasing of CB in fired clay brick manufactured. However, the shrinkage of brick was reduced by up to 50% depending on the percentage of CB incorporated into the raw material. Nevertheless, the appropriate percentage of CB addition into the mixture improved the compressive strength value by 6.6% to 18%. On the other hand, at 3°C/min of heating rate resulted the best properties of manufactured brick compared to 1°C/min and 5°C/min. As the conclusion, in this study 2.5% CB brick fired at 3°C/min is the optimum condition in the brick manufacturing as it obtained the best physical and mechanical properties.
Puntung rokok (CB) adalah sejenis sampah yang bukan bersifat biodegrasi. CB dibawa oleh air dari jalan-jalan menuju ke parit, sungai dan akhirnya ke pantai seterusnya ke laut. Puntung rokok merupakan sampah yang paling banyak dikutip sepanjang tahun. Kajian ini membentangkan penambahan CB ke dalam bata tahan liat. Kesan penambahan CB ke atas bata tanah liat akan dikaji. Sifat fiziko-mekanikal bata yang ditambah dengan 2.5% CB dan 5.0% CB pada kadar pembakaran yang berbeza iaitu 1°C/min, 3°C/min dan 5°C/min akan diuji pada ciri-ciri kekuatan mampatan, Kadar serapan awal (IRS), Pengecutan Kering dan juga ketumpatan. Keputusan daripada kajian analisis yang dijalankan terhadap ciri-ciri bata CB dan bata kawalan dibincangkan dan dibentangkan. Daripada keputusan yang diperolehi mendapati nilai pengecutan dan nilai IRS sedikit meningkat selari dengan penambahan peratusan CB di dalam bata tanah liat. Walau bagaimanapun, kadar pengecutan bata mengurang sehingga 50% bergantung pada peratusan CB yang dimasukkan ke dalam bata. Penambahan peratusan CB yang bersesuaian menjadikan jumlah kekuatan mampatan bata bertambah manakala pada kadar pembakaran 3°C/min menghasilkan ciri-ciri bata yang lebih baik berbanding dengan bata yang dibakar pada kadar 1°C/min dan 5°C/min. Sebagai kesimpulannya, daripada kajian mendapati bata 2.5%CB yang dimasukkan ke dalam bata tanah liat dan dibakar pada kadar 3°C/min menghasilkan ciri-ciri fizikal dan mekanikal yang terbaik.
CONTENT

TITLE PAGE i
DECLARATION ii
DEDICATION iii
ACKNOWLEDGEMENT iv
ABSTRACT v
ABSTRAK vi
CONTENT vii
LIST OF TABLES x
LIST OF FIGURES xii
LIST OF SYMBOLS AND ABBREVIATIONS xv
LIST OF APPENDICES xvii

CHAPTER I INTRODUCTION
1.1 Introduction 1
1.2 Problem Statement 2
1.3 Objectives of Study 3
1.4 Scope of Study 3
1.5 Importance and Contribution of Study 3

CHAPTER II LITERATURE REVIEW
2.1 Introduction 4
2.2 Cigarette Butts (CB) 4
  2.2.1 What is Cigarette Butts 5
2.2.2 Impact of Cigarette Butts
   2.2.2.1 The Implication of Cigarette Butts on Beaches
   2.2.2.2 The Implication of Cigarette Butts on Marine Life
   2.2.2.3 The Impact of Cigarette Butt Litter Towards The Food Chain

2.3 Fired Clay Brick
   2.3.1 History of Clay Brick
   2.3.2 Types of Brick
      2.3.2.1 Common Brick
      2.3.2.2 Face Brick
      2.3.2.3 Engineering brick
   2.3.3 Properties of Bricks
      2.3.3.1 Initial Rate of Suction (IRS)
      2.3.3.2 Dry Density
         2.3.3.2.1 Protected Grade (PRO)
         2.3.3.2.2 General Purpose Grade (GP)
         2.3.3.2.3 Exposure Grade (EXP)
      2.3.3.3 Compressive Strength of Bricks
   2.3.4 Overview of Waste Recycling in Clay Bricks

CHAPTER III RESEARCH METHODOLOGY

3.1 Introduction
3.2 Material
   3.2.1 Clay Soil
      3.2.1.1 Properties of Soil
      3.2.1.2 Chemical Properties of Soil
   3.2.2 CB
      3.2.2.1 Properties of CB
      3.2.2.2 Chemical Properties of CB
3.3 Manufacturing Process of Clay Brick
   3.3.1 Control Brick
   3.3.2 CB Brick
3.4 Testing Method
   3.4.1 Dry Shrinkage
   3.4.2 Dry Density
   3.4.3 Initial Rate of Suction (IRS)
   3.4.4 Compressive Strength

CHAPTER IV RESULT AND DISCUSSION
4.1 Introduction
4.2 Testing Program
   4.2.1 Soil Properties
   4.2.2 Dry Shrinkage
   4.2.3 Dry Density
   4.2.4 Initial Rate of Suction (IRS)
   4.2.5 Compressive Strength
   4.2.6 Physical and Mechanical Properties of Control Brick
   4.2.7 Sample
   4.2.8 Physical and Mechanical Properties of 2.5% CB Brick
   4.2.9 Sample

CHAPTER V CONCLUSION AND RECOMMENDATION
5.1 Introduction
5.2 Conclusion
5.3 Recommendations
LIST OF TABLES

2.1 Chemical in CB
2.2 Properties of the fired and unfired sample PWT
3.1 Classification of soil according to plasticity
3.2 The chemical in clay brick
3.3 The chemical compound found in CB
3.4 Ratio of CB, Clay Soil and Water
3.5 Aspect ratio factor
4.1 Chemical composition of the soil used
4.2 Dry shrinkage percentage of bricks fired at 1°C/min
4.3 Dry shrinkage percentage of bricks fired at 3°C/min
4.4 Dry shrinkage percentage of bricks fired at 5°C/min
4.5 Dry density for the control bricks, 2.5% CB bricks and 5.0% CB bricks at heating rates 1.0°C/min, 3.0°C/min and 5.0°C/min.
4.6 The Initial rate of suction fired at 1°C/min
4.7 The Initial rate of suction fired at 3°C/min
4.8 The Initial rate of suction fired at 5°C/min
4.9 The compressive strength of control brick and CB brick fired at 1°C/min
4.10 The compressive strength of control brick and CB brick fired at 3°C/min
4.11 The compressive strength of control brick and CB brick fired at 5°C/min
4.12 Physical and mechanical properties of control brick sample firing at different heating rates
4.13 Physical and mechanical properties of 2.5% CB brick
LIST OF FIGURES

2.1 CB littering
2.2 Fired Clay Brick
2.3 Typical Types of Clay Brick
2.4 Correlative between bulk density and porosity
3.1 Flow Chart of Methodology
3.2 The soil & CB used to make a brick before mixed with Hobart Mechanical Mixer
3.3 An Amount of Water Ware Added Into the Mixture by Stages during the Process. The mixture process was takes around 30 minute to complete
3.4 The mixture of CB, Clay Soil and Water after 30-minute mixture process
3.5 The sample ware pressed into the moulds according to the desire and compacted by layer.
3.6 To ensure that the compaction rate is uniform the moulds were compacted using a hand operated soil compactor, then the top surface was flattened before allowed it to dry naturally in room temperature in 24 hours and 24 hours in the oven at temperature 105°C
3.7 After the drying process was completed, the bricks are then input into the furnace and were baked at prescribed temperature such as 1.0°C/min, 3.0°C/min and 5.0°C/min.
3.8 Measuring the length of the sample
3.9 Apparatus for measuring the initial rate of suction (IRS)
4.1 Sequence of testing
CHAPTER I

INTRODUCTION

1.1 Introduction

Smokers discard billion of cigarette butts (CB) yearly, tossing the waste directly to the environment. It knows that CB will degrade overtime due to the action of weathering element such as sun, wind, rain and mechanical action. However, the degradation process can take months or maybe year depending on the environment condition. CB can take up to 12 months to break down in fresh water and up to 5 years to break down in seawater.

Smoking cigarettes is hazardous to their health, but a new study shows that cigarette butts can be just as dangerous for the environment. CB have the effects on the marine life and the chemical from one-filtered CB had the ability to kill fish living in a one-litter bucket of water (Jacob, 2009). CB waste problem also have the effects on the environment because of the filters that end up on beach. According to annual Ocean Conservancy’s International Cleanup 2007 report that CB is a most single littered item collected at beach. Furthermore, 1.69 billion pounds (845,000 tons) of butts wind up as litter worldwide per year. (Novotny et. al., 2009)

Reuse, reduce and recycle are the system that has been used to overcome most of waste issues. Recycling CB by itself is not easy as it deals with separation and entrapped chemicals as well as an efficient procedure of recycling. Combining the CB in material such as fired bricks is a good alternative to sustain composite building materials. (A Kadir and Mohejerani, 2010)

Brick is one of accommodating units as a building material due to its properties. From the previous research, shows attempts have made to incorporate waste in the production of brick for example limestone powder waster dust (LPW)
and wood sawdust (WSW), (Paki Turgut and Halil Murat Algin, 2006), process waste tea (PWT), (Ismail Demir, 2005), incinerator fly ash slag (MSWI) (Kae Long Lin, 2006) and kraft pulp (Ismail Demir et. al., 2004) have proven that adding the incorporated waste not just environmentally advantageous but it also increase the performance of brick properties. This paper will investigate fired clay brick and CB Brick performance at different heating rates. The physical and mechanical properties of CB Brick will be discussed. If CB waste could improve the properties of fired clay brick, it would increase the value of the waste. Moreover, instead of neglecting this littering issue, recycle the CB could be beneficial in brick industry.

1.2 Problem Statement

CB are undoubtedly one of the environmental problem that cause blight on beaches, street, sidewalks, waterways and public spaces. Area with a high number of littered CB look dirty, which attracts more littering of other rubbish items. If CB are simply dropped, it can smoulder for up to 3 hours. Cigarette smoke contain up to 4000 chemicals so each second the butt is left alight, dangerous toxins are released into the environment. CB also presents a threat to wildlife. CB have been found in the stomachs of fish, birds, whales and other marine creatures who mistake them for food. Recycle CB into fired clay brick might be worth to be considered because managing CB littering is a critical issue to be taken care of.

CB not only a smoking issue but also litter issue in the environment. Cigarette manufacturers cannot control a smoker's behaviour when it comes to the disposal of cigarette butts. To ensure the earth free from littering from CB, we need to take an active and responsible role in educating smokers about this issue and devote resources to the cleanup of cigarette litter.

Recycle CB in fired clay brick could be an alternative disposal method for CBs waste and solve the littering problem.
1.3 Objectives of Study

The purpose of this study is to recycle CB in fired clay brick. The objectives of the study are as follows:

i. To propose an alternative disposal method for CB waste.
ii. To determine the possibility of incorporating CB in clay brick.
iii. To compare the property's value between fired clay brick and CB brick at different heating rates.

1.4 Scope of Study

The CB will be collecting around UTHM Campus and Parit Raja, Batu Pahat. The tests will be performed at Research Centre for Soft Soil (RECESS) and Structural Laboratory, Department of Civil Engineering at UTHM. The scope will be focused to observe the potential of CB waste to substitute in clay brick manufacturing. The experiment will be conducted to observe the properties of fired clay brick and CB brick that will be fired at different heating rates 1°C/min, 3°C/min and 5°C/min. The properties such as dry shrinkage, dry density, initial rates of suction (IRS) and compressive strength of CB brick will be tasted.

1.5 Importance and Contribution of Study

From this study, the properties of CB in clay brick can be obtained from the test. If the new composition manages to get the strength required, it can help to increase the value of CB waste. Instead of watching this waste dispose without any utilization, reuse of the waste may open up people eyes. People can broaden their knowledge that disposal items can be useful for such issue. The idea might be worth to be considered because the CB can be found everywhere, not just in our country.
CHAPTER II

LITERATURE REVIEW

2.1 Introduction

This chapter will reviewed on literature of CB, its toxicity and will narrow down to recycling CB into fired clay brick.

2.2 Cigarette Butts (CB)

Smoker discards billion of CBs yearly Figure 2.1, tossing the waste directly into the environment. It is known that CB will degrade overtime due to the action of weathering element such as sun, wind, rain and mechanical action. However, the degradation process can take months or maybe year depending on the environment condition. For an example, CB can take up to 12 months to break down in fresh water and up to 5 years to break down in seawater.

According to the World Health Organization (2006), world population hover around six billion people and out of this number, there are 1.1 billion people in the world that smoke, that is one-third of all the people on earth over the age of 15. For example, the 470 billion cigarettes smoked in the US translate to a total of 176250000 pounds (79945660.5 kg) of CB in one year alone. The filters from 5.608 trillion, approximate world production, would weigh more than 2.1 billion pounds (0.953 billion kg).
There is lots of misinformation out there regarding cigarette butt litter. The biggest myth is that cigarette filters are biodegradable. In fact, CB are not biodegradable in the sense that most people think of it. The acetate (plastic) filters can take many years to decomposed. Smokers may not realize that their actions have such a lasting, negative impact on the environment.

Area that has high composition of CB will look dirty and indirectly attracts the littering of other rubbish items. If butts are simply drop, it can smoulder for up to 3 hours. Cigarette smoke contain up to 4000 chemicals so each second the butt is left alight, dangerous toxins are released into the environment. CB also presents a threat to wildlife. CB have been founded in the stomachs of fish, birds, whales and other marine creatures which mistaken them as food. (Register 2002)

2.2.1 What is Cigarette Butts

The remnant tobacco portion of a cigarette, a filter that is not cotton and 165 toxic chemicals contain in the CB. 95% of cigarette filters are made of cellulose acetate that is slow to degrade in the environment CB filters trap the dangerous by-products of smoking by accumulating particulate smoke components and 165 toxic chemicals. Table 2.1 below shows the chemicals substance that can leach into the environment from the CB. (California Waste Management Bulletin 2003)
Table 2.1: Chemical in CB

<table>
<thead>
<tr>
<th></th>
<th>Chemical in CB</th>
<th>Used in rat poison</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Arsenic</td>
<td>Used in rat poison</td>
</tr>
<tr>
<td>2</td>
<td>Acetone</td>
<td>Main ingredient in paint thinner and nail polish remover</td>
</tr>
<tr>
<td>3</td>
<td>Benzene</td>
<td>Found in rubber cement</td>
</tr>
<tr>
<td>4</td>
<td>Cadmium</td>
<td>Found in batteries and artist’s oil paints</td>
</tr>
<tr>
<td>5</td>
<td>DDT/Dieldrin</td>
<td>Insecticides</td>
</tr>
<tr>
<td>6</td>
<td>Hexamine</td>
<td>In barbecue lighter fluid</td>
</tr>
<tr>
<td>7</td>
<td>Hydrogen Cyanide</td>
<td>Used as a poison in gas chambers</td>
</tr>
<tr>
<td>8</td>
<td>Naphthalenes</td>
<td>Used in explosives and moth ball</td>
</tr>
<tr>
<td>9</td>
<td>Phenol</td>
<td>Used in disinfectants and plastics</td>
</tr>
<tr>
<td>10</td>
<td>Stearic acid</td>
<td>Found in candle wax</td>
</tr>
<tr>
<td>11</td>
<td>Acetic acid</td>
<td>In hair dye and photo developing fluid</td>
</tr>
<tr>
<td>12</td>
<td>Ammonia</td>
<td>A typical household cleaning fluid</td>
</tr>
<tr>
<td>13</td>
<td>Butane</td>
<td>Cigarette lighter fluid</td>
</tr>
<tr>
<td>14</td>
<td>Carbon Monoxide</td>
<td>A poisonous gas found un car exhaust</td>
</tr>
<tr>
<td>15</td>
<td>Formaldehyde</td>
<td>Used to embalm dead bodies</td>
</tr>
<tr>
<td>16</td>
<td>Hydrazine</td>
<td>Used in jet and rocket fuels</td>
</tr>
<tr>
<td>17</td>
<td>Lead</td>
<td>A highly poisonous metal</td>
</tr>
<tr>
<td>18</td>
<td>Nitrobenzene</td>
<td>A gasoline additive</td>
</tr>
<tr>
<td>19</td>
<td>Polonium – 210</td>
<td>A highly radioactive element</td>
</tr>
</tbody>
</table>

2.2.2 Impact of Cigarette Butts

2.2.2.1 The Implication of Cigarette Butts on Beaches

CB have ranged as the one littered item collected from the shores for more than 15 consecutive years beginning from 2003 during item during California’s Coastal Cleanup Day. Many coastal-dependent species including some of the 23 endangered species depend on sand beaches as it natural habitat. Shorebirds, feed on microscopic creatures, diatoms and bacteria found in grains of sand. CB pollution in Hawaii causes tumours’ in the turtle that return to beaches in order to lay eggs in the sand. Sea lions, elephant seals and harbour seals haul out daily on the sandy beaches to absorb the heat from the sun, give birth and feed their newborn pups. Crabs, clams, starfish and sea urchins are rottenly found on beaches, 177 species of marine animals and tobacco litter causing unnecessary malnutrition, starvation, affects 111 species of
shorebirds and death based on the UN International Maritime Organization. (California Coastal Commission and International Maritime organization, 2003)

2.2.2.2 The Implication of Cigarette Butts on Marine Life

The CB just not implicate the human health but it also effect on marine life. CB lying in our streets and gutters are carrying via storm water during rain directly into our harbours, beaches and rivers. The chemical contained in these butts and the butts themselves will affect water quality and can causes death towards the marine life. Storm water not treated well caused the litter and cigarette butts carried by storm water are dump directly into these waterways. CB can take up to 12 months to be decompose in fresh water and increase to 5 years to break down in seawater. Birds and marine life can expect the butts as food, resulting in serious digestive problems that may lead to seriously inner injuries and sometimes can lead to death. CB have found in the stomachs of young birds, sea turtles and other aquatic creatures. Lead and cadmium that contained in the butts of cigarette filter can leach out in water. The chemicals begin to leach into the aquatic environment and threaten the wellbeing of marine life within one hour of contact with water. (Register, 2006)

2.2.2.3 The Impact of Cigarette Butt Litter Towards The Food Chain.

Ingestion of plastic cigarette filters is a serious threat to wildlife. Field biologists and wildlife rehabilitators who routinely find CB in the intestines, stomachs, and X-rays of dead or sick marine life make a clear consequence of the effect of CB litter on the food chain. Seabirds that forage for food near dunes have been observing ingesting CB. Biologists suspect even trace amounts of chemicals may have harmful effects at the origins of the food web. In particular, tiny invertebrates, such as coquina clams can be groggy, reducing their reaction time and more apt to becoming prey for predators because of nicotine poisoning. The coquina clam is important food for pompano fish. In the bodies of larger animals, higher concentrations of toxins can accumulate as they move up the food chain. By comparison, most cases of nicotine poisoning among children result from their ingestion of cigarettes (University of Central Florida, American Association of Poison Control Canter, 2005)
2.3 Fired Clay Brick

A small, rectangular block made of fired clay is a simple description of clay brick Figure 2.2. From one place to another, the clay brick production varies widely in composition. Silica (grains of sand), alumina, lime, iron, manganese, sulphur and phosphates, with different proportions are composing mainly in the clays. Grinding or crushing the clay in mills and mixing it with water to make it plastic are the steps to manufactured bricks. Then, the plastic clay is moulded, textured, dried and fired. Bricks are manufacture with variety colours, such as dark red, brown and gray base on the firing temperature of the clay during manufacturing. The firing temperature for brick manufacturing varies from $900^\circ$C-$1200^\circ$C. Clay brick have an average density of $2 \text{ Mg/m}^3$. (Mamlouk and Zaniewski, 1999) (Hendry 1983)

![Fired Clay Brick](image)

Figure 2.2: Fired Clay Brick

2.3.1 History of Clay Brick

In the Middle East date 10,000 years ago, archaeologists have found bricks. Mud left after the rivers in that area flooded makes these bricks. Scientists suggested this idea. The bricks were moulded by bare hand. Then, the bricks were left under the sun in order to make it dry. Layering the bricks using mud and tar as mortar is the way to
build the structure of the bricks. Around 4,000 B.C, the ancient city of Ur (modern Iraq) was built with mud bricks. Clay dug from the earth, mixed with straw, and baked in crude ovens or burned in a fire were the technique used to make these bricks. Great Wall of China and remnants of Roman buildings are some example of many ancient structures that made of bricks and still standing today. The Romans further developed kiln-baked bricks and spread the art of brick making throughout Europe. Adobe brick that made up from adobe soil, comprised of clay, quartz, and other minerals, and baked in the sun is the oldest type of brick in the Western Hemisphere. In dry regions throughout the world, most notably in Central America, Mexico, and the southwestern United States are the venues where adobe soil can be found.

Aztecs in the fifteenth century built The Pyramid of the Sun using the adobe bricks and it is still standing. Bricks were used as early as the seventeenth century in North America. During the Industrial Revolution, bricks were used extensively for building new factories and homes. Until the nineteenth century, raw materials for bricks were mined and mixed, and bricks were formed, by manual labour. The first brick making machines were steam powered, and the bricks were fired with wood or coal as fuel. Modern brick making equipment is powered by gas and electricity. Some manufacturers still produce bricks by old method, but the majorities are using the modern method. (Campbell 2003)

2.3.2 Types of Brick

2.3.2.1 Common Brick

This type of brick does not have a specific package on the surface, and is usually use for the walls of the restrictions that will be cover with a layer of plaster, or for other uses where the appearance of the surface is not so important.
2.3.2.2 Face Brick

This type of brick has a finish on the surface, either smooth or sandy texture. Jigger colour is uniform or colourful. Brick is use to make the surface of the wall to look pretty and be robust nature of the weather.

2.3.2.3 Engineering brick

Engineering brick is a solid brick construction and is used for retaining wall, resistant to brunt, bridge foundation, sewerage and wall form, and erosion. Figure 2.3 shows the typical types of brick

- Modular
- Engineer
- Economy
- Double
- Roman
- Norman
- Norwegian
- King Norman
- Triple
- SCR
- SCR

Figure 2.3: Typical Types of Clay Brick

2.3.3 Properties of Bricks

The properties of clay bricks affect appearance and quality of masonry construction. In order to achieve the designated of durability, quality and strength, emphasis on the properties of units such as dry shrinkage, dry density, initial rate of suction (IRS) and compressive strengths (CS) will be calculate.
2.3.3.1 Initial Rate of Suction (IRS)

The amount of water absorbed in one minute through the bed face of the brick is known as the initial rate of suction (IRS). It is a measure of the brick's 'suction' and can be used as a factor in the design of mortars that will bond strongly with units. As mortars other than the 'deemed to comply' mortars are rarely used, the impact of the IRS is primarily on the bricklayer. Bricklayers, through practical experience, adjust the mortar, the height of a wall built in a day and the length of time before ironing the joints, according to the suction.

The capacity of the brick to absorb water and the ability of the mortar to retain the water that is needed for the proper hydration of cement will largely influenced the bond between the masonry unit and mortar. The next course would not be properly bedded if the brick sucks the water too quickly from the mortar. The units tend to float on the mortar bed if the mortar retains too much water and making it difficult to lay plumb walls at a reasonable rate. In either case, there will be poor bond. The optimum value of IRS is considered to be between 0.5kg/m$^2$.min and 1.5kg/m$^2$.min. However, IRS can exceed these limits. The mortar's water retentively should be matched to the brick type where good bond strength is critical. (Brick & Pavers technical Manual – Boral, 2002).

2.3.3.2 Dry Density

Clay composition that varies from about 2250kg/m$^3$ to about 2800kg/m$^3$ but most commonly lying close to 2600kg/m$^3$ is the factor that determines the solid density $\rho_s$ of brick ceramic. For an individual brick material, the bulk density $\rho = \rho_s(1-n)$ exactly, where $n$ is the porosity. Figure 2.4 show the general inverse correlation between bulk density and porosity for a diverse sample of different clay brick, among which $\rho_s$ is varies. Since $n$ varies widely among brick of different kind and since frogs and perforations may be present, standard from brick, vary greatly in weight from about 1.8kg to 3.8kg. (Jackson and Dhir 1996)
According to AS/NZS4456.10 Resistance to Salt Attack, brick are assesses and class into three grades. In summary, the three grades of brick that can be use are as follows:

2.3.3.2.1 Protected Grade (PRO)

Suitable for use in elements above the damp-proof course in non-marine exterior environments. Elements above the damp-proof course in all exterior environments, with a waterproof coating, properly flashed junctions with other building elements and a top covering (roof or coping) protect the masonry.
2.3.3.2 General Purpose Grade (GP)

Suitable for use in an external wall, excluding walls in severe marine environments or in contact with aggressive soils and environments. General-purpose grade bricks can also be used in PRO applications.

2.3.3.2.3 Exposure Grade (EXP)

Suitable for use in external walls exposed to severe marine environments, for example up to one kilometre from a surf coast or up to 100 metres from a non-surf coast or in contact with aggressive soils and environments. The distances are specimen from mean high water mark. Exposure grade bricks can also be used in PRO and GP applications. Bricks are classier as either EXP or GP.

2.3.3.3 Compressive Strength of Bricks

The compressive strength of clay brick is an important mechanical property that control their load-carrying capacity and durability, it depends on the composition of the clay, method of brick manufacturing and degree of firing. The compressive strength was determine by capping and tasting at the half unit “flatwise” (load applied in the direction of the height of the unit) and calculating the dividing of load at failure by using cross-section area (ASTM C67). The net or gross cross section area are used to determines the compressive strength. However the net cross-area only used if the net cross-section less than 75% of the gross cross-section. If the capacity of the testing machine not large enough to test half brick, a quarter of brick can be test. (Mamlouk and Paniewski 1999) (W.G Curtin et. al., 2006)

2.3.3.3.1 Characteristic Unconfined Compressive Strength (f'uc)

In the design of masonry to calculate the strength of a wall, the engineers will use the characteristic unconfined compressive strength. Bricks in any one batch have a range of strengths that would usually follow a normal distribution. The different strength of bricks will contribute to the strength of the wall while the weakest brick will not be the determiner of the wall's strength. Characteristic unconfined compressive strength
has been use in engineering practice as the safety precaution. Characteristic unconfined compressive strengths of the bricks usually have the range between 15MPa to 35 MPa.

Calculated number based on the compressive strength is the definition for the unconfined compressive strength. Steel plates are use on top and below in order to measure the compressive strength of a brick. A shorter brick will have a high compressive strength compare to a tall brick if this constrains the surface and where all other factors are equal. The compressive strength is multiply by a factor, which varies with the height of the brick as the method to remove this test effect. There salting number is called the unconfined compressive strength and reflects the performance of the brick in a wall. Theoretically, the equal unconfined compressive strength will be produce if the bricks are identical except for their height.

2.3.4 Overview of Waste Recycling in Clay Bricks

From the previous research, shows attempts have made to incorporate waste in the production of brick for example limestone powder waster dust (LPW) and wood sawdust (WSW), (Turgut and Algin, 2006), process waste tea (PWT), (Demir, 2005), incinerator fly ash slag (MSWI) (Lin, 2006) and kraft pulp (Demir et. al. 2004) have proven that adding the incorporate waste not just environmentally advantageous but it also increase the performance of brick properties.

Therefore, by added the CB in clay brick might show the same result or better result as other additional component in clay brick properties. Table 2.2 below shows the result obtained from previous experiments that will be used as the reference and will be compared with CB brick properties. This table is using for make a comparison between normal brick and normal brick with added component
Based on the experimental by Demir (2005) shows that mixture 5% PWT waste additives can be use in brick production. The compressive strength value for both types of brick was increase with increasing the amount of PTW. The waste additive also increased the open porosity and these effects decrease the bulk density and improve the properties of thermal insulating. By using the PWT also help the protection of the environment and most economical because the firing temperature was determined as 900°C.

Based on experiment by Lin, (2006) show using the solid waste incinerator fly ash slag in clay brick production. The compressive strength of the brick & MSWI slag clay with follow the CNS 1127-R3042 standard: 150 kg/cm² first class and 100 kg/cm² for second-class brick. When the heating temperature increase to 800°C and 900°C, the compressive strength of brick gradually increased, and at heating temperature the compressive strength of brick sample met the criteria for first class brick. The additional MSWI slag clay also makes the brick less infiltrates, greater durability and resistance to natural environment expected.

The test result from Turgut and Algin (2006) shows that the WSW & LPW combination provides result which are of potential to be used in production of lighter and economical new brick material because the unit weight of WSW & LPW brick produce a comparatively lighter composite which about 65% lighter than conventional concrete brick.

Based on Demir and Orhan (2004) experiment shows that the kraft pulp residue addition in clay brick increases the required water content for plasticity, as
well it increases dry bending strength of clay sample up to 5% residue. The result demonstrated is useful to decrease the number of crack due to the handling problem of unfired brick. The brick also make a positive contribution to the heat input of the kiln. Even if the compressive strength of the brick is reducing, the value is still higher they require strength value of TS705. The additional kulp pulp can be use as pore-performing additive in clay body because it not affects the other brick manufacturing parameters.

Referring to the previous experiment, the successful of waste recycling in clay brick motivate and encourage the usage of CB as the added material in clay brick. It is apparent that recycling different. CB in fired clay brick could be considered an important step to be one of the alternative disposal method for CB waste disposal and solve its littering problem.
CHAPTER III

RESEARCH METHODOLOGY

3.1 Introduction

This chapter will review and discussed about the material, equipment, and the experiment held to find the physical properties of the bricks. In this investigation, control and fired brick sample with 2.5% and 5% of CB content were prepared. Brick sample were manufactured in cube according to minimum requirement of testing. The brick sample will be dried for 24 hours in the oven at 105°C. The entire brick sample will be fired from room temperature to 105°C by using the different rate of temperature. All manufactured sample will be tested for shrinkage, density, water absorption, compressive strength and thermal conductivity. This research was conducted in several stages to achieve the objective of the study, as shown in Figure 3.1.
Figure 3.1: Flow Chart of Methodology
3.2 Material

3.2.1 Clay Soil

The soil that used in this study is clay soil, which is available in Hoe Guan Brick Sdn. Bhd. ½ miles, Jalan Kluang, 86100 Air Hitam, Johor. To make sure no impurities mixture in the clay soil, the soil were sieved first.

3.2.1.1 Properties of Soil

To determine the properties of soil, the plastic limit (PL) test and Liquid Limit (LL) test would be testing on clay soil.

As the preparation for LL test, specimens were selected to adjust the water content of the sample by adding distilled water and mixing on a glass plate with spatula. The sample will be place in a container. Place a portion of the prepared sample in the cup of the liquid limit device at the point where the cup rests on the base and spread it so that it is 10mm deep at its deepest point. Form a horizontal surface over the soil. The air bubbles from the soil specimen were eliminated. Keep the unused portion of the specimen in the storage container. Form a groove in the soil by drawing the grooving tool, bevelled edge forward, through the soil from the top of the cup to the bottom of the cup. When forming the groove, hold the tip of the grooving tool against the surface of the cup and keep the tool perpendicular to the surface of the cup. Lift and drop the cup at a rate of 2 drops per second. Continue cranking until the two halves of the soil specimen meet each other at the bottom of the groove. The two halves must meet along a distance of 13mm (½ inch). Record the number of drops required to close the groove. Remove a slice of soil and determined its water content, the process will be repeated depending on the sample of soil at slightly higher or lower water content. Whether water should be added or removed depends on the number of blows required to close the grove in the previous sample.

To determine the PL of soil, make a sample Preparation Procedure for Plastic Limit. Select 20g specimen of the same sample used for the preparation of the liquid limit test. This sample should be dry enough so that it will not be sticky. Place this sample in the same container and on top of the wetter specimen. From the 20 gram of
sample, select a 1.5-2.0 gram specimen for testing. Roll the test specimen between the palm and fingers on the ground glass plate to form a thread with uniform diameter. Continued rolling the thread until it reached a uniform diameter of 3.2mm or 1/8 inch. When the thread becomes a diameter of 1/8 inch, reform it into a ball.

Knead the soil for a few minutes to reduce its water content slightly. When the soil reached the point, where it will crumble, and when the thread is a uniform diameter of 1/8 inch, it is at its plastic limit. Determine the water content of the soil. Repeat this procedure three times to compute an average plastic limit for the sample.

The value of Plastic Index (PI) can be calculated from the value of LL and PL by using the equation below and Table 3.1 shows the classification of soil according to the plasticity index value.

\[
PI = LL - PL
\]

Where

- \(PI\) = Plastic Index
- \(LL\) = Liquid Limit
- \(PL\) = Plastic Limit

Table 3.1: Classification of soil according to plasticity

<table>
<thead>
<tr>
<th>Plasticity Index (I_p or PI)</th>
<th>Degree of Plasticity</th>
<th>Type of Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Non-Plastic</td>
<td>Sand</td>
</tr>
<tr>
<td>&lt; 7</td>
<td>Low-Plastic</td>
<td>Silt</td>
</tr>
<tr>
<td>7-17</td>
<td>Medium Plastic</td>
<td>Silty clay or clayey silt</td>
</tr>
<tr>
<td>&gt;17</td>
<td>Highly</td>
<td>Plastic clay</td>
</tr>
</tbody>
</table>

### 3.2.1.2 Chemical Properties of Soil

According to the book, Comprehensive Basic Engineering, the normal chemical properties of clay show in Table 3.2 below. (Punmia et. al. 2003)
Table 3.2: The chemical in clay brick

<table>
<thead>
<tr>
<th>Compound Formula</th>
<th>Formula</th>
<th>Content %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>SiO₂</td>
<td>Not less than 60</td>
</tr>
<tr>
<td>Alumina</td>
<td>Al₂O₃</td>
<td>Not less than 15</td>
</tr>
<tr>
<td>Ferric Oxide</td>
<td>Fe₂O₃</td>
<td>Not less than 3</td>
</tr>
<tr>
<td>Lime</td>
<td>CaO or CaCO₃</td>
<td>Not less than 3</td>
</tr>
<tr>
<td>Magnesia</td>
<td>MgO or MgCO₃</td>
<td>Not less than 3</td>
</tr>
<tr>
<td>Alkalies</td>
<td>K₂O + Na₂O</td>
<td>Not less than 4</td>
</tr>
<tr>
<td>Total Water Solutes</td>
<td></td>
<td>Not less than 1</td>
</tr>
<tr>
<td>Loss of ignition</td>
<td></td>
<td>Not less than 7</td>
</tr>
</tbody>
</table>

3.2.2 CB

The CB was collected around the UTHM Campus and Parit Raja, Batu Pahat. After the collection, the CB was disinfecting by heating at temperature 105°C for 24 hours and seal in plastic bag.

3.2.2.1 Properties of CB

CB filter has the purpose to reduce the amount of smoke, tar, and fine particles inhaled during the combustion of cigarette. CB may look like cotton but actually it is made of cellulose acetate. Beside that CB also made from paper wrapper (plug wrap) used to wrap the acetate cellulose and polyvinyl acetate emulsion is used as a glue to attach the plug to the wrapper. (Cleanup Australian Limited, 2009)

3.2.2.2 Chemical properties of CB

According to the U.S Department of Health & Human Services. Table 3.3 below shown the chemical compound found in cigarette.
Table 3.3: The chemical compound found in CB.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Amount (per cigarette)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetaldehyde</td>
<td>980 micrograms to 1.37 milligrams</td>
</tr>
<tr>
<td>Acrylonitrile</td>
<td>Formerly 1 to 2 milligrams</td>
</tr>
<tr>
<td>4-Aminobiphenyl</td>
<td>0.2 to 23 nano grams per cigarette</td>
</tr>
<tr>
<td>o-Anisidine hydrochloride</td>
<td>unknown</td>
</tr>
<tr>
<td>Arsenic</td>
<td>unknown</td>
</tr>
<tr>
<td>Benzene</td>
<td>5.9 to 75 micrograms</td>
</tr>
<tr>
<td>Beryllium</td>
<td>0.5 nano grams</td>
</tr>
<tr>
<td>1,3-Butadiene</td>
<td>152 to 400 micro grams</td>
</tr>
<tr>
<td>Cadmium</td>
<td>1.7 micrograms</td>
</tr>
<tr>
<td>Ethylene oxide</td>
<td>unknown</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>unknown</td>
</tr>
<tr>
<td>Hydrazine</td>
<td>32 micrograms</td>
</tr>
<tr>
<td>Isoprene</td>
<td>3.1 milligrams</td>
</tr>
<tr>
<td>2-Naphthylamine</td>
<td>1.5 to 35 nanograms</td>
</tr>
<tr>
<td>Nitromethane</td>
<td>unknown</td>
</tr>
<tr>
<td>N-Nitrosodi-n-butylamine</td>
<td>3 nanograms</td>
</tr>
<tr>
<td>N-Nitrosodi ethanolamine</td>
<td>24 to 36 nanograms</td>
</tr>
<tr>
<td>N-Nitrosodi ethylamine</td>
<td>up to 8.3 nanograms</td>
</tr>
<tr>
<td>N-Nitrosodi methylamine</td>
<td>5.7 to 43 nanograms</td>
</tr>
<tr>
<td>N-Nitrosodi-n-propylamine</td>
<td>1 nanogram</td>
</tr>
<tr>
<td>N-Nitrosornornicotine</td>
<td>14 micrograms</td>
</tr>
<tr>
<td>N-Nitrosopyrrolidine</td>
<td>113 nanograms</td>
</tr>
<tr>
<td>N-Nitrososarcosine</td>
<td>22 to 460 nanograms</td>
</tr>
<tr>
<td>o-Toluidine</td>
<td>32 nanograms</td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td>5.6 to 27 nanograms</td>
</tr>
</tbody>
</table>

3.3 Manufacturing Process of Clay Brick

Two types of brick that have been manufacture for this study, which are CB brick and control brick. These bricks were compare with additional CB brick and normal clay brick.
3.3.1 Control Brick

The clay soil and water were mix to produce the brick. The mixed by using Hobart mechanical mixer with a 10-litre capacity for 30 minutes. The sample will be press into the moulds according to the desire shape. Raw bricks produced must be dry up before being fire. This stage is very vital because if the bricks is bake in the moist condition, the bricks may experiencing a lot of problems like bent, split and even broken that make it not suitable to be used as a wall of the building. Therefore, the brick will be dry in drying room at 105°C for 24 hours. By using the different heating rate, which are 1°C/min, 3°C/min, and 5°C/min, the bricks were baked in the furnace. The fired brick were tested for dry shrinkage, dry density, initial rate of suction (IRS) and compressive strength according to the British Standard and the result have been record and report.

3.3.2 CB Brick

The 2.5% CB and 5.0% CB, water and clay soil were mix to produce the brick by using Hobart mechanical mixer with a 10-litre capacity for 30 minutes. The sample will be press into the moulds according to the desire shape. Raw bricks produced must be dry up before being fire. This stage is very vital because if the bricks is bake in the moist condition, the bricks may experiencing a lot of problems like bent, split and even broken that make it not suitable to be used as a wall of the building so the brick will be dry in drying room at 105°C for 24 hours. By using the different rate of temperature such as 1°C/min, 3°C/min, and 5°C/min the bricks were bake in the furnace. The fired brick were tested for dry shrinkage, dry density, initial rate of suction (IRS) and compressive strength according to the British Standard and the result have been record and report. Table 3.4 below shows the ratio of CB, water and clay soil used to make a sample. Meanwhile Figure 3.2 to Figure 3.7 shows the step of manufacturing of brick by picture.
Table 3.4: Ratio of CB, Clay Soil and Water

<table>
<thead>
<tr>
<th>Percentage of CBs (%)</th>
<th>Dried Cigarette Butts (kg)</th>
<th>Clay Soil (kg)</th>
<th>Total Mass of Raw Materials (kg)</th>
<th>Amount of Water (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.0000</td>
<td>3.500</td>
<td>3.500</td>
<td>900</td>
</tr>
<tr>
<td>2.50</td>
<td>0.0873</td>
<td>3.300</td>
<td>3.3873</td>
<td>1080</td>
</tr>
<tr>
<td>5.00</td>
<td>0.1538</td>
<td>3.000</td>
<td>3.1538</td>
<td>1000</td>
</tr>
</tbody>
</table>

Figure 3.2: The soil & CB used to make a brick before mixed with Hobart Mechanical Mixer

Figure 3.3: An Amount of Water Ware Added Into the Mixture by Stages during the Process. The mixture process was takes around 30 minute to complete.
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