UTILIZATION OF WASTE PLASTIC BOTTLE TO PLASTIC BRICK

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A Thesis Submitted to the Department of Civil Engineering, Daffodil International University in partial fulfillment of the requirements for the award of the Degree of

Bachelor of Science in Civil Engineering

Department of Civil Engineering

Daffodil International University

February 2024

CERTIFICATION

The thesis titled "UTILIZATION OF WASTE PLASTIC BOTTLE TO PLASTIC BRICK'' submitted by Asha Akter, (ID No: 193-47-1101), has been accepted as satisfactory in partial fulfillment of the requirements for the degree of Bachelor of Science in Civil Engineering.

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ABSTRACT

Plastics bottles is now a day a harmful substance to the environment, especially in large cities in Bangladesh. The excessive use of plastic has resulted in significant environmental problems, such as pollution destruction of natural habitats. Plastic takes 100 years to decompose, leading to the accumulation of waste in landfills and, oceans. It is essential to reduce the use of plastic and adopt sustainable alternatives to protect the environment. Plastic brick making from plastic bottles and sand mixture can be one of the best recycling solutions. Here plastic bottles use for binding material to produce the brick. In this research work, the possibility of making plastic brick from locally collected plastic bottles has been tested with a promising result. I had used three types of ratio in this research, they are 1:2,1:3,1:4 and comparing all the ratio then I had found that 1:2 ratio is better than the others. This advance research will be help to reduce that kind of materials. Also In This paper discusses about the comparison of various available bricks of the same dimensions in Bangladesh between plastic bricks as well as finds out their quality.

ACKNOWLEDGEMENT

The first characteristics is being ever great full and thankful to Allah for everything that you process including your wealth, and Health. Also I would like to express deep of my heart to my sincere supervisor Engr. Md. Imran Hasan Bappy Lecturer Department of Civil Engineering, Daffodil International University(DIU) Thank you for giving me this opportunity to work on unique topic. It has been an amazing journey to work under a great leader.

The project and thesis titled" **"UTILIZATION OF WASTE PLASTIC BOTTLE TO PLASTIC BRICK"** submitted by Asha Akter, ID NO:193-47-1101, session: Fall 2019,has been accepted as satisfactory. This work fulfills in part, the requirement for the degree of Bachelor of science on Civil Engineering. Date of Acceptance: 12th February 2024

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Dedicated to

My Parents

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CHAPTER:01
INTRODUCTION

1.1 General

These days, plastic is ubiquitous. People have been using it nonstop for their comfortable lifestyle. Compared to other materials like paper and fabric, its cost was lower. It molds readily and is quite simple to use. It is evident that plastic is not a biodegradable substance. Plastic bottles are typically used to store liquids, such as milk, water, oil, medicine, and shampoo. Every year, almost 500 billion plastic bottles are used. An individual uses 156 plastic bottles annually on average. In America, 60 million plastic bottles are discarded every day. In the United States, 35 billion empty water bottles are discarded every day. Plastic is not biodegradable and will always be present in the land and ocean.

1.2 Background

Bricks are one of the oldest and most widely used building materials in the world. They have a rich history and have been an essential part of construction for thousands of years. Here is some background information on bricks.

1. **Ancient Origins:** The use of bricks in construction dates back to ancient civilizations, with the earliest known examples dating to around 7000 BC in what is now modern-day Turkey. These early bricks were made from sun-dried mud or clay and were called adobe bricks.

2. **Fired Bricks:** The transition from sun-dried bricks to fired bricks, which are more durable and weather-resistant, occurred around 3500 BC in Mesopotamia (modern-day Iraq). These bricks were made by molding clay into shape and then firing them in kilns. The firing process made the bricks harder and less susceptible to moisture.

3. **Roman Influence:** The ancient Romans significantly advanced brick-making technology. They developed a standardized brick size, known as the Roman brick, and constructed vast structures, including aqueducts, bridges, and buildings, using bricks. The use of bricks in Roman architecture spread throughout the Roman Empire.

4. **Middle Ages:** During the Middle Ages in Europe, the use of bricks declined, and stone became the dominant building material. However, bricks remained in use for smaller structures, such as homes and fortifications.

5. **Renaissance and Beyond**: Bricks experienced a revival during the Renaissance in Europe. In the 16th and 17th centuries, brick construction became popular for various architectural styles, including the Dutch Renaissance and English Tudor architecture. Red bricks were commonly used during this period.

6. **Industrial Revolution:** The Industrial Revolution in the 18th and 19th centuries led to significant advances in brick production. Machines were developed to automate the brick-making process, making it more efficient and cost-effective. This industrialization led to the widespread availability of bricks for construction.

1.3 Rational

The consequences of indiscriminate disposal of the thin plastic bottles are quite serious. Plastic pollution is affecting the whole earth, including mankind, wildlife, and aquatic life. It is spreading like a disease which has no cure. We constantly throw out different types of plastic bottles without throwing them out it can be use them various purpose earn lot of money and can have some economical value. There are some available technologies working to produce similar products commercially but, those technologies recycles different kind of plastic products. Therefore, the use of plastic bottles to produce similar products will open a new avenue in recycling and solid waste management.

1.4 Objective

This work has the following objectives

- To make use of the large hazardous waste plastic in effective manner.
- To compare available same-size bricks in BD with the plastic brick.
- To find a suitable mixing (plastic: sand) ratio considering define parameters (compressive strength, water absorption, efflorescence.)

1.5 Scope of the Thesis

The concept of using plastic bottles in the construction of plastic bricks is an innovative and sustainable approach to recycling plastic waste while addressing infrastructure needs. The scope of testing for such plastic bricks typically involves various technical and environmental aspects. Here are some aspects to consider when testing plastic bricks made with plastic bottles:

1.5.1 Material Composition and Properties

- Determine the ideal three ratio of plastic bottles with sand.
- Assess the strength, density, and durability of the bricks.
- Analyze the thermal and acoustic properties of the bricks.

1.5.2 Structural Integrity

- Conduct compression tests to assess the load-bearing capacity of the bricks.
- Evaluate their resistance to cracking, weathering, and deformation under different conditions.

1.5.3 Environmental Impact

- Measure the environmental benefits of using plastic waste in construction.
- Analyze the carbon footprint compared to traditional bricks.
- Assess the leaching of harmful chemicals from the bricks into the soil or water.

1.5.4 Cost Analysis

- Calculate the cost of production and compare it to conventional brick manufacturing.
- Consider the long-term cost savings due to reduced waste management.

1.5.5 Construction & Installation

- Evaluate the ease of handling, transporting.

1.6 Summary

This first chapter described the background and objectives of this experimental works. The next chapter explains all the necessary literature required to explain the works or designs.

CHAPTER:02
LITERATURE REVIEW

2.1 General

plastic bottles are widely used containers made from various types of plastic materials. They serve as a common and convenient way to store and transport liquids and other substances. Plastic bottles can be made from different types of plastic, each with its own characteristics. Common plastics used for bottle manufacturing include PET (Polyethylene Terephthalate), HDPE (High-Density Polyethylene), LDPE (Low-Density Polyethylene), PP (Polypropylene), and PVC (Polyvinyl Chloride). Many plastic bottles are recyclable, and recycling programs have been established in many places to reduce environmental impact. The recyclability of a plastic bottle depends on the type of plastic used. PET bottles, which are commonly used for water and soda, are highly recyclable. Plastic bottles can have a significant environmental impact due to the production of plastic, the energy required for manufacturing, and the potential for litter and pollution if not properly disposed of or recycled. Efforts to reduce plastic waste and promote recycling are ongoing.

2.2 Background

Brick has a long history that spans thousands of years, and it has been crucial to the advancement of human civilizations. Bricks have been used since the Middle East and what is now Turkey circa 7000 BC. Mud bricks were first used by ancient societies like the Mesopotamians and the inhabitants of the Indus Valley. The mud bricks were sun-dried. In order to produce a more durable material, the ancient Egyptians invented methods for baking mud bricks in kilns, which they also used in construction. Brickmaking techniques were greatly advanced by the Romans. They were able to construct more stable structures by mixing lime and volcanic ash to make a kind of mortar. Compared to their forebears, Roman bricks were frequently thinner and larger. Many varieties of bricks, such as hollow and concrete bricks, were created in the 20th century. Because of their strength and longevity, concrete bricks—which are composed of cement and aggregate—have grown in popularity. Bricks can be produced in a range of colors, sizes, and textures thanks to automated machinery used in modern brick manufacturing.

2.3 Usages in Different Countries

The usage of plastic bottles varies from country to country, influenced by cultural, economic, and environmental factors. Plastic bottles are used for a wide range of purposes worldwide, including storing beverages, personal care products, cleaning supplies, and more. Here are some common usages of plastic bottles in different countries:

2.3.1 Beverage Containers

Plastic bottles are widely used to package beverages such as water, soda, juice, tea, and sports drinks. These bottles are prevalent in most countries and are often associated with convenience and portability

2.3.2 Milk Containers

In many countries, plastic bottles are used to package milk, whether fresh or long-life. This is common in countries like the United States, Canada, the United Kingdom, and Australia.

2.3.3 Personal Care Products

Plastic bottles are commonly used to package personal care products such as shampoo, conditioner, body wash, lotion, and cosmetics. This is a global trend in the beauty and personal care industry.

2.3.4 Cleaning Products

Plastic bottles are used to package various household cleaning products like dishwashing detergent, laundry detergent, and all-purpose cleaners. These are found in most countries.

2.3.5 Edible Oil Containers

In some countries, plastic bottles are used for packaging edible oils like cooking oil. The choice of packaging may depend on local preferences and economic factors.

2.3.6 Condiment Bottles

Plastic bottles are often used for condiments like ketchup, mustard, and mayonnaise in fast-food restaurants and households in various countries.

2.3.7 Pharmaceutical

Plastic bottles are used to package prescription medications, over-the-counter drugs, and dietary supplements in the pharmaceutical industry globally.

2.3.8 Alcohol

In some countries, plastic bottles are used for packaging alcoholic beverages, such as spirits or wines. These bottles are typically made to be lightweight and unbreakable.

2.3.9 Traditional Beverage

In countries with traditional or local beverages, plastic bottles are used to package these drinks. For example, in some Asian countries, herbal teas and traditional health drinks are sold in plastic bottles.

2.3.10 Water Storage

In some regions with limited access to clean water, plastic bottles are repurposed for water storage and transportation. These bottles are filled with potable water and distributed to communities.

2.4 Effect of Plastic Bottle in the Environment

Plastic bottles can have significant environmental impacts when not managed properly. Improper disposal of plastic bottles can lead to litter in the environment. This not only degrades the aesthetic quality of an area but can also harm wildlife that may ingest or become entangled in the plastic. Plastic bottles contribute to the overall volume of plastic waste. They do not biodegrade, so they persist in the environment for a long time, leading to increased landfill usage. The production of plastic bottles consumes valuable resources, including fossil fuels and water. This contributes to the depletion of non-renewable resources and can exacerbate water scarcity issues. The production of plastic bottles generates greenhouse gas emissions, which contribute to climate change. (Qumar A, 2014)This includes emissions from the extraction of raw materials, manufacturing, and transportation. Plastic bottles can find their way into rivers and oceans, where they break down into smaller micro-plastics. These micro-plastics can be ingested by marine life, potentially entering the food chain and harming ecosystems. Some plastic bottles may contain harmful chemicals, such as phthalates and bis-phenol A (BPA). Over time, these chemicals can leach into the environment, posing potential health risks to both wildlife and humans. The production of plastic bottles often involves habitat destruction and disruption, such as the drilling for oil or the creation of plastic production facilities. This can harm natural ecosystems and the species that inhabit them. (Tawhid, 2004)

When plastic bottles are not properly recycled, they can end up in landfills or incinerated, rather than being reused to produce new plastic products. This reduces the overall effectiveness of recycling efforts. To mitigate these environmental effects, it's essential to reduce plastic bottle use, promote recycling and responsible disposal, and invest in alternatives such as reusable containers and sustainable packaging materials. Governments, industries, and individuals all play a role in addressing the environmental impact of plastic bottles.

2.5 Plastic Bottle

A plastic bottle is a container made of plastic that is commonly used for packaging and storing liquid or solid products. Plastic bottles are widely used because they are lightweight, durable, and cost effective. They come in various shapes, size, and types of plastic, with the most common types being PET (polyethylene Terephthalate) and HDPE (High-Density Polyethylene).

2.5.1 Properties of plastic

Table 2.1 Properties of plastic

Resins	**Polyethylene Terephthalate (PET)**	**High Density Polyethylene (HDPE)**
Rigidity (Stiffness)	Moderate to High	Moderate
Resistance to Impact	Good to Excellent	Good to Excellent
Resistance to Heat	Poor to Fair	Good
Resistance to Cold	Good	Excellent

2.6 Types of Plastic (Bottle)

I Polyester, is known as polyethylene terephthalate (PET), is a material commonly found in synthetic fabrics and bottles. Its meeting temperature is 2600 C. It is approved by the Organization of the Plastics Industry with resin ID code 1. ID Resin

II High-Density Polyethylene (HDPE): This material has a melting point of 130.80 C and is used to make pipes. Its ID code for resin is 2.

III Polyvinyl Chloride (PVC): This material is used to make wire insulators and pipes. The melting point of it is 2400 C. Three is its resin ID code.

IV Low-Density Polyethylene (LDPE): This material is used to make packing foams and polythene carry bags. It melts at 900 degrees C.

V Polypropylene (PP):- It is used in the field of medical or laboratory equipment. It has a melting point of 1600 C. Its resin ID code is 5.

VI Polystyrene (PS):- It is a thermocouple, which is using in packing industries. It has a melting temperature of 2400 C. Its resin ID code is 6.

VII Polycaprolactone (PLC):- It has used in 3D printed elements and has a melting temperature of 60 C. Its resin ID code is 7

Figure 2-1 Different types of plastics & identification code

2.7 Concern in Using Plastic Bottle in Bangladesh

Like in many other parts of the world, using plastic bottles raises various health and environmental concerns in Bangladesh. Littering is a major issue in Bangladesh and can be caused by improper disposal of plastic bottles. These bottles may leak into lakes, rivers, and the ocean, polluting the surrounding waterways. Plastic bottles add to the growing landfill problem when improperly managed. They are difficult to biodegrade, and their buildup endangers the quality of the soil and groundwater. Certain plastic bottles have the potential to leak dangerous substances, like bis phenol A (BPA), into the liquids they hold. Long-term exposure to these substances may be harmful to one's health, particularly if the bottles are heated. Plastic bottles have the potential to degrade into smaller particles known as micro plastics over time. Human health is at risk because these micro plastics have the ability to contaminate water sources and possibly make their way into the food chain.

2.8 Rules & Regulation

A 2002 amendment to Section (6A) of the Bangladesh Environment Protection Act, 1995 established fines for the production, importation, marketing, sale, transportation, and distribution of plastic bottles. Bangladesh is likewise having difficulty discouraging the use of Environment Conservation Act of 1995 makes specific provisions against it. According to a study conducted by the Eco-Social Development Organization (ESDO), Bangladesh produces about 250 tons of waste made of single-use plastic each month.

CHAPTER:03
METHODOLOGY

3.1 General

This chapter outlines the precise procedures used to make plastic brick out of a mixture of sand and plastic bottles. The following is a general overview of the methodology:

1. Examine the current technological landscape.
2. Research the market and current products so that the design can be modified.
3. Material estimation.
4. Create a mold.
5. Make a prototype.
6. Evaluate the strength of the model.

The preceding chapter covered the history and analysis of the current market and technology. The steps that follow are outlined here

3.2 Study the existing technology

A thorough analysis of the material and current recycling technologies was conducted using online resources, such as published videos and articles. The preceding chapter contains a list of the precise findings**.**

3.3 Study and selection of design components

In Bangladesh, used plastic bottles are widely available. However, they might need to be cleaned before being used as a raw material for bricks. The other ingredient is sand, another widely used building material. An appropriate stance and method were chosen for this section to guarantee the highest quality of work output.

3.4 Collection of materials

3.4.1 Plastic Bottle

Since this analysis was experimental in nature, used plastic bottles were gathered from various sources. For instance, directly from various residences, from the landfill, and from spots that are chosen at random where plastic bottles are occasionally thrown. After collected them, and then used for this analysis.

3.4.2 Sand

A bag of sand was collected from the construction site for this experiment.

3.5 Source of Data

Experiments were conducted to gather all of the data. In order to conduct the experiments, different proportions of plastic bottles and sand were heated to various temperatures.

3.6 Instruments list to create a model pavement bricks

Various types of instruments and properties were used in this job because it was experimental in nature. The list appears below.

- A Pan (medium size)
- A weight scale
- A Flat spoon (To shake the hot mixture)
- A Thermometer
- A mold

3.7 Procedure

a. In this experiment, the weight of the Mixture where the plastic bottle and sand proportion was 1:2, 1:3,1:4.

b. A pan was used to heat the Mixture properly through a burner.

c. The temperature was between 220 °C to 310 °C. The temperature was measured through a thermometer.

d. Heat the plastic bottle after making the liquid, then we will mix the sand.

e. After mixing the sand and the plastic together and two are well mixed then we will put in a mold .

Figure 3-1 : producing bricks out of plastic bottle

3.8 Brick Laboratory tests:

3.8.1 Compressive strength test:

3.8.1.1 Introduction

A Universal Testing Machine (UTM) is used to test the compressive strength of bricks in order to determine their load-bearing capacity under compression. Typically, structures that support weight are constructed with bricks. Brick-based load-bearing masonry structures bear the brunt of compression. Therefore, the most crucial factor in determining a brick's critical suitability for construction is its compressive strength.

3.8.1.2 Sampling of Bricks for compression test

Using nine randomly selected brick samples, smooth the surface by grinding the bricks' bed faces. When the specimen is at room temperature, remove it and remove any extra moisture. The bricks should be submerged in room-temperature water for 24 hours before being removed and their wet weight measured and dry with 100°C using oven then measure dry weight.

Figure 3-2 Temperature measure& dry process

3.8.1.3 Testing of samples

1. Position the samples so that their flat faces are horizontally oriented toward the testing machine's plates. As a result, the face filled with mortar is facing the plate upward.

2. Until a crack appears or a failure occurs, progressively apply a uniform load of 14 KN/mm2 (143 kg/cm2) per minute, and note the highest and final load at failure. The governing value of the compression for that specific sample is the highest load. Table the results of various bricks' compressive strength tests. (Vairagade, 2014)

Figure 3-3 Compressive strength test

3.8.2 Water Absorption Test

3.8.2.1 Introduction

Bricks are porous and dry, moisture from the weather, mortar, and concrete mix can naturally be released and absorbed by them. If the bricks are sufficiently dry and absorb moisture from the mortar or concrete mix when they are laid, the mortar becomes weak and inadequate. Because there isn't enough water in the mortar for the hydraulic reaction between the cement and water, the bricks and mortar don't bond. Consequently, it is weakening the masonry's overall strength and, ultimately, the structure.

Brick durability, including quality, weathering behavior, and degree of burning, is measured through water absorption tests. A brick is more resilient to damage if its water absorption rate is less than 7%. Bricks' degree of compactness can be ascertained through water absorption tests. Bricks absorb moisture from the surrounding air through pores on their surface. As bricks' surface becomes more porous, so does their ability to absorb water. Bricks that have a water absorption rate of less than 3% are therefore considered oxidized.

3.8.2.2 Prepare sampling and testing methods

1. As a specimen, select nine randomly selected bricks from three distinct brick ratios. The specimen should be dried in a ventilated oven at an average temperature of 100°C until it reaches a noticeably constant mass. Once the specimen has reached room temperature, measure its dry weight (W1).

2. Let the completely dry sample dissolve in clean water for a full day at room temperature (27°C).

3. After removing the specimen from the water, then wipe away any remaining water using a moist cloth and weigh the specimen (W2)

4. The method used to calculate the water absorption (%), (W2-W1)/W1*100

The maximum permissible value of water absorption (%) of the different types of bricks is shown below in table-3.5.

Table 3-1 The permissible value of water absorption

Types of Bricks	Maximum Permissible value
First-class bricks	15%
Second class bricks	20%
Third-class bricks	25%

3.9 Efflorescence test for bricks

3.9.1 Introduction

A white, crystalline layer called efflorescence forms on the bricks' surface. When the alkaline salt in the brick dries, it leaves behind a whitish powder due to the salt absorbing moisture from the air. In the event that pyrite was found in the brick-making clay and the water utilized contained Gypsum, this could also occur. The development of white powder particles on the brick surface is known as efflorescence. The most frequent cause of efflorescence is the movement of groundwater via capillary action into building foundations and into brickwork.

3.9.2 Remedies and testing methods

Before beginning construction, sand testing should be performed and should use well-fired bricks. The building should have proper DPC. Dry brushing and washing should be used to eradicate efflorescence. During the dry season, this efflorescence may reduce intensity.

For testing the samples, fill a small flat dish with distilled water and place one end of the brick in the dish. Water should fill the dish to a depth of 25 mm. Cover the flat dish with a suitable glass cylinder to prevent excessive evaporation. Place a similar amount of water in the dish and let it evaporate as previously after the entire water has been absorbed and the brick looks to be dry. After that, the bricks are ready to be examined for efflorescence and the results are reported.

3.9.3 Unit weight of bricks

The particular weight of a material, also known as the unit weight, is its weight per unit volume. The material's unit weight is simply defined as Mass per Volume (M/V) (kg/cum). The unit weight of a brick is (M/V) if it weighs 3.25 kg (M) and has a total volume (V). Unit weight can also express as its density. A brick's unit weight is its weight per unit volume. Which implies how much weight of a brick can be placed on a unit volume. The weight of a brick is stated in kilograms or KN, and its volume is measured in cubic meters. Here is shown the below table-3.4

3.10 Evaluating Brick Quality

3.10.1 The steps for evaluating brick quality were as follows

1. Using a scale of 1 to 3, rank the features and attributes of bricks. where a number between 1 and 3 denotes poor, moderate, and excellent quality, respectively.

2. A general category is used to assign the rating. Thinking about the importance of compressive leverage (kg/cm^2) as an illustration. Bricks are categorized as poor if their compressive strength is less than 88 kg/cm^2, as moderate if it is between 88 and 155 kg/cm^2, and as excellent if it is greater than 176 kg/cm^2.

Similarly, Table 3.1 was used to classify the Standard compressive strength test (per ASTM C62-13a), water absorption (%), efflorescence, and unit weight (kg/m3).

Table 3-2 Brick classification based on different Characteristics

Compressive strength (PSI)	**Water absorption (%)**	**Efflorescence**	**Unit weight (kg/m^3)**
0-1250 Grade NW-poor	>25 poor	Large: poor	<670 poor
	22-25 slightly poor	Little: slightly poor	671-1340slightly poor
1250-2205 Grade MW-good	20-22 moderate	Slight: moderate	1341-1680 moderate
	16-19 good	Slight-Nil: good	1681-2000 good
>2500 Grade SW-excellent	0-15 excellent	Nil: excellent	>2000 excellent

3.11 Test available bricks in Bangladesh

3.11.1 Solid (Auto) brick

Solid 1st class brick used in various construction works because its strength quality was good. It is hard and heavy.it is safe and strong for office, residence and other works and use it without doubt.

Figure 3-4 solid brick

3.11.2 Normal Brick

Burnt clay bricks have been used in construction for ages .Burnt clay bricks are made by mixing wet clay into a mold and drying it in the sun. After drying it in the sun it is fired in a kilns.

Figure 3-5 Normal clay brick

3.11.3Concrete Brick

Concrete bricks are made in factories by combining aggregates and cement. Sometimes stones are used to increase its strength. Concrete bricks are commonly created in molds victimization hydraulic pressure, whereas clay bricks are typically extruded by employing a die .

Figure 3-6 concrete brick

3.11.4Engineering Brick (3 holes)

Engineering bricks designed to make the wall of house. It is used the enhance the beauty of wall and it is applied in some samples of manhole, sewers and basic foundations .

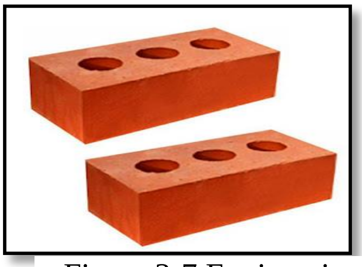

Figure 3-7 Engineering (3holes) brick

3.11.5Engineering Brick (10 holes)

Bricks with ten holes are a novel kind of building material. Hollow bricks are lightweight, strong, readily available, and from a technical standpoint, they give the structure adequate strength.

position. It makes the building colder by reducing induced heat because of the hollow area inside. While clay hollow bricks are more durable but more expensive and harder to find, cement hollow bricks are less expensive. By using bricks with 10 holes, the structure's overall weight is decreased and its wall thickness is also decreased, increasing the structure's lifespan and internal space.

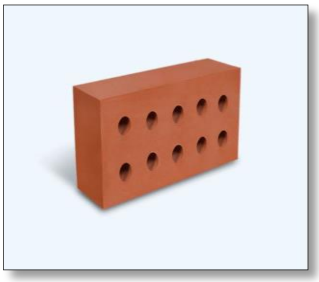

Figure 3-8Engineering (10holes) brick

3.11.6 Paver Block

Paver blocks are heavier than other blocks and in a variety of size. A paver blocks does not have mix around .Generally formed concrete paving blocks are used for heavy duty projects such as roads and walkways to withstand heavy loads. Paver blocks has the ability to support heavy loads, to withstand breakage, which makes it good for use in concrete blocks. There are several colors of metal oxides used extensively in the coloring process, although these colors may eventually discolor the concrete. It is suitable for road ,pavements and other surfaces if installed properly. paver bricks are very durable and can easily last for 15 to 20 years.

Figure 3-9 Paver block

3.12 Summary

This chapter describes the process following for materials and scope of making bricks from collected plastic bottle and sand. The following chapter describes the result, comparison between normal brick to plastic bricks, and Discussion.

CHAPTER:04
RESULT & DISCUSSION

4.1 General

This chapter includes an analysis of the various findings as well as the outcomes of the experiment and other tests carried out in the study. The general characteristics of different kinds of bricks. Bricks' appearance, length, width, and height, as well as their percentage water absorption rate and Table 4.1 lists the average unit weight (kg/m3) and compressive strength (kg/cm2) along with the results of the efflorescence test. To determine the average result of the samples, the average value of three samples must be computed after obtaining individual test results of various 18 and a total of 54 samples of various 6 types of bricks with the same dimension and size.

As a result, the tests can be compared to our exciting data. In the following chapter, we will compare the samples and determine their quality based on the data, having computed their average value.

4.2 Testing result of samples: (plastic Bricks)

4.2.1 The compressive strength test results

Table 4-1 The test result for compressive strength

Ratio	Bricks Types	Appearance test (visual)	Sample type	Dimension (mm) (L*W*H)	Weight(dry) (Kg)	Compressive Strength (PSI)
1:2	Plastic bricks	Sound, firm, well-burned, consistent size, shape, and color, texture homogeneous.	S-1	241x114x70	3.29	1405
			S-2	241x114x71	2.94	1203
			S-3	241x114x70	3.00	1169
1:3	Plastic brick	Sound, firm, well-burned, consistent size, shape, and color, texture homogeneous	S-1	241x114x66	2.9	970
			S-2	241x114x70	3.27	1104
			S-3	241x114x69	3.27	903
1:4		Sound, firm, well-burned, consistent size, shape, and	S-1	241x114x66	3.25	836
			S-2	241x114x70	3.00	1004

		color, texture homogeneous	S-3	241x114x69	2.81	803

4.2.2 The test results for water absorption of bricks

Table 4-2 The test result for water absorption

Ratio	Bricks Type	Appearance test (visual)	Sample type	Weight(dry) (kg)	Weight (wet) (kg)	water Absorption (%)
1:2	Plastic bricks	Attractive Flat, Smooth, sharp	S-1 S-2 S-3	3.29 2.94 3.00	3.35 3.05 3.06	1.8% 2.74% 2.00%
1:3	Plastic bricks	Attractive Flat, Smooth, sharp	S-1 S-2 S-3	2.90 3.27 3.07	3.07 3.31 3.15	5.86% 1.22% 2.61%
1:4	Plastic brick	Attractive Flat, Smooth, sharp	S-1 S-2 S-3	3.25 3.00 2.81	3.35 3.15 3.03	3.08% 5.00% 7.8%

4.2.3 The efflorescence test result of different bricks

Table 4-3: The efflorescence test result

Ratio	Bricks Type	Sample types	Weight (dry) kg	Tendency to Efflorescence
1:2	Plastic bricks	S-1 S-2 S-3	3.29 2.94 3.00	Nil Nil Nil
		S-1	2.90	Nil

1:3	Plastic bricks	S-2 S-3	3.27 3.07	Nil Nil
1:4	Plastic bricks	S-1 S-2 S-3	3.25 3.00 2.81	Nil NIL NIL

4.2.4 Unit weight of different bricks

Table 4-4 The unit weight result test

Ratio	**Bricks Type**	**Sample types**	**Weight (dry) kg**	**Dimension (mm) (L*W*H)**	**Unit weight (kg/m3**
1:2	Plastic bricks	S-1 S-2 S-3	3.29 2.94 3.00	241x114x70 241x114x71 241x114x70	1710 1507 1560
1:3	Plastic bricks	S-1 S-2 S-3	2.90 3.27 3.07	241x114x66 241x114x70 241x114x69	1599 1701 1620
1:4	Plastic bricks	S-1 S-2 S-3	3.25 3.00 2.81	241x114x69 241x114x64 241x114x65	1714 1707 1574

4.3 Average plastic brick property test results

Table 4-5 Brick property test summery

Ratio	Bricks Type	Ave. Dimension (mm) (L*W*H)	Ave. Weight (dry) kg	Ave. Weight (wet) kg	Ave. Compressive Strength (PSI)	Ave. water Absorption (%)	Efflorescence	Ave. Unit weight (kg/m^3
1:2	Plastic bricks	241x114x70	3.08	3.16	1258	2.18%	Nil	1593
1:3	Plastic bricks	241x114x68	3.08	3.17	992	3.23%	Nil	1640
1:4	Plastic bricks	241x114x66	3.02	3.17	982	5.3%	Nil	1665

4.4 Comparison of different Ratio of bricks

4.4.1 Average compressive strength of bricks type

Figure 4.1 displays the average compressive strength and average unit weight of several bricks. The results indicate that the ratio of 0f 1:2 plastic bricks has a higher compressive strength than other ratios. Furthermore stronger is the 1:3 brick's compressive strength. The 1:4 ratio is smaller than other ratios. The crushing strength and, consequently, the pressure required to break the bricks decrease with decreasing value. On the other hand, it seems that this graph also imports unit weight values.

The measurement of unit weight for materials is very important because the unit weight helps determine the weight of the structure, the load that the materials can carry, the quantity of materials needed for a given space, and whether the materials will either float or sink. Therefore, the material unit weight is more important for any building goal. Figure 4.1 shows the unit weight of various brick ratios. The result of calculating

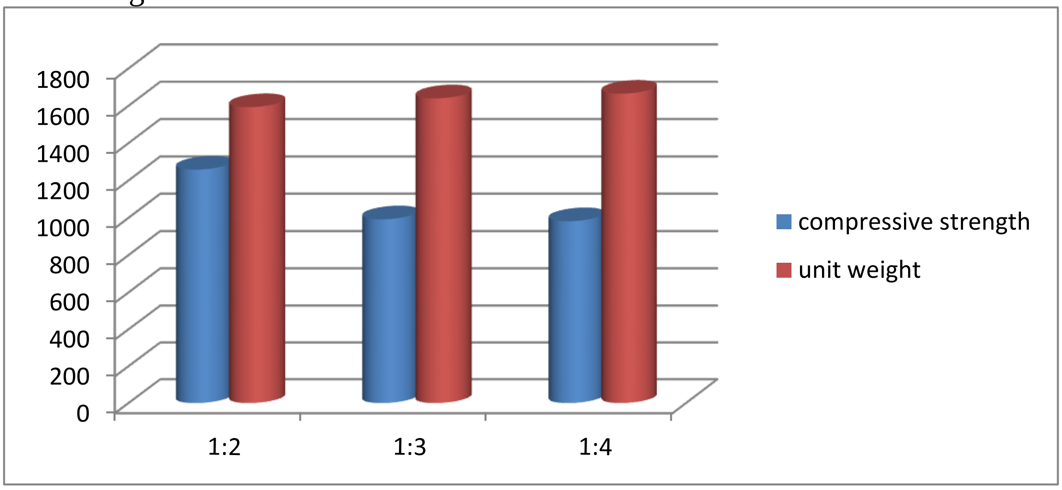

Figure 4-1 Ave. compressive strength &unit weight of bricks

the unit weight shows that all ratios are moderate and that the unit weight value is based on interesting data.

4.4.2 Average water absorption rate of different brick types

The bricks were weighed both before and after they were submerged in fresh water for a full day in order to measure the water absorption. The quality improves with a lower water absorption value. Conversely, a higher water absorption rating denotes poor quality**.** It's possible that the ratio of 1:2 to 1:3 is less than 10%, indicating that the bricks are first class, and the ratio of 1:4 indicates second class bricks. There aren't many manufactured bricks, which suggests that these are premium bricks.

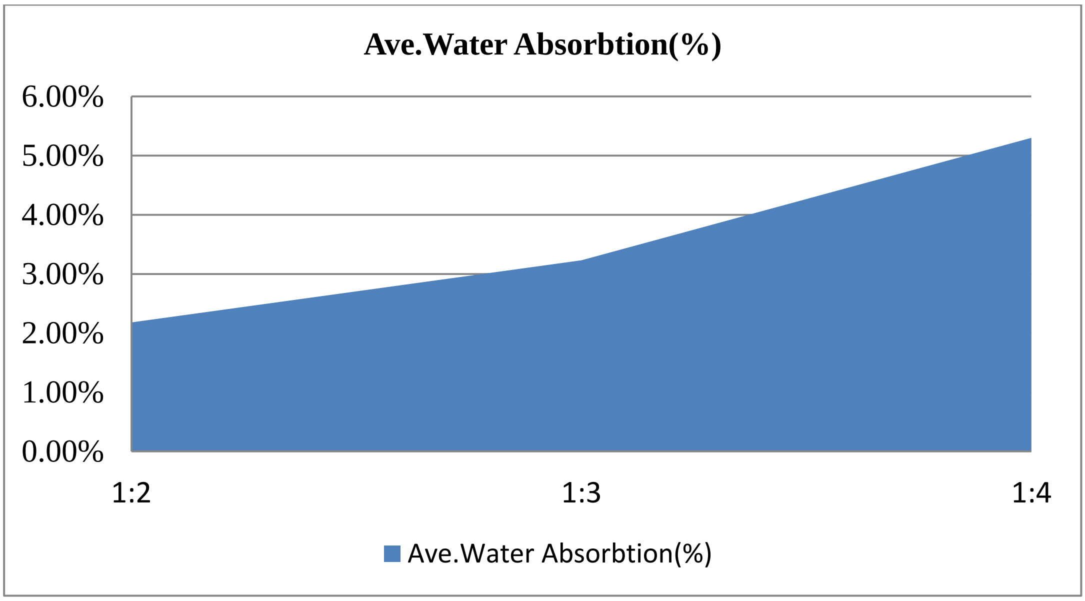

Figure 4-2Ave. water absorption rate of different ratio

4.5 Comments

After doing the Comparison of different Ratio of bricks it is seen that 1:2 ratio is much better than others ratio like its compression strength is very high and water absorption is very low. Among all of the comparison 1:2 ratio provided more acceptable value.

4.6 Testing result of samples: (Normal Bricks)
4.6.1 The compressive strength test results

Table 4-6 The compressive strength & unit weight of brick

Numbers	Types of bricks	Types of sample	Dimension (mm) (L*W*H	Weight(dry) (Kg)	compressive strength psi	Unit Weight
01	Normal Brick	S-1 S-2 S-3	236x114x68 231x110x67 235x108x67	2.67 2.77 2.84	995 1017 984	1459 1627 1670
02	Auto Brick	S-1 S-2 S-3	233x115x67 236x114x68 235x113x65	3.43 3.45 3.46	1144 1195 1229	1910 1885 2004
03	Engineering (10 holes) Bricks	S-1 S-2 S-3	240x115x70 240x115x69 241x114x70	3.33 3.36 3.33	1165 1124 1084	1723 1764 1731

4.7 The efflorescence and water absorption

Table 4-7 The Efflorescence & water absorption of brick

Numbers	Types of bricks	Types of sample	Dimension (mm) (L*W*H	Weight(dry) (Kg)	water Absorption (%	Tendency to Efflorescence
01	Normal Brick	S-1 S-2	236x114x68 231x110x67	2.67 - 3.20 2.77 - 3.20	19.85 15.52	Nil Nil

		S-3	235x108x67	2.84 – 3.36	18.30	Nil
02	Auto Brick	S-1 S-2 S-3	233x115x67 236x114x68 235x113x65	3.43 – 3.78 3.45 – 3.77 3.46 – 3.98	10.20 9.27 15.02	Slight Slight Slight
03	Engineering (10 holes) Bricks	S-1 S-2 S-3	240x115x70 240x115x69 241x114x70	3.33-3.50 3.36-3.52 3.33- 3.48	5.10 4.76 4.50	Nil Nil Nil

4.8 Average brick property test results

Table 4-8 Summery of brick property test

No	Types of bricks	Ave. Dimension (mm) (L*W*H	Ave. Weight (dry) kg	Ave. Weight (wet) kg	Ave. Compressive Strength (PSI	Ave. water Absorption (%)	Efflorescence	Ave. Unit weight (kg/m3
01	Normal Brick	234x110x67	2.76	3.25	998	17.89%	Nil	1585
02	Auto Brick	234x114x66	3.45	3.84	1189	11.50%	Slight	1933
03	Engineering (10 holes) Bricks	240x114x69	3.34	3.50	1124	4.79%	Nil	1739

4.9 Comparison of different types of brick with plastic brick

4.9.1 Average compressive strength of bricks type

The graph shows that there are four types brick those are normal brick, Auto brick, Engineering (10holes) brick and plastic brick. It can be observed that in this graph the value of normal bricks is lowest similarly the highest value of compressive strength is plastic bricks .Engineering (10holes) brick.

4.9.2 Average compressive strength of bricks type

The graph shows that there are four types brick those are normal brick, Auto brick, Engineering (10holes) brick and plastic brick. It can be observed that in this graph the value of normal bricks is lowest similarly the highest value of compressive strength is plastic bricks .Engineering (10holes) brick

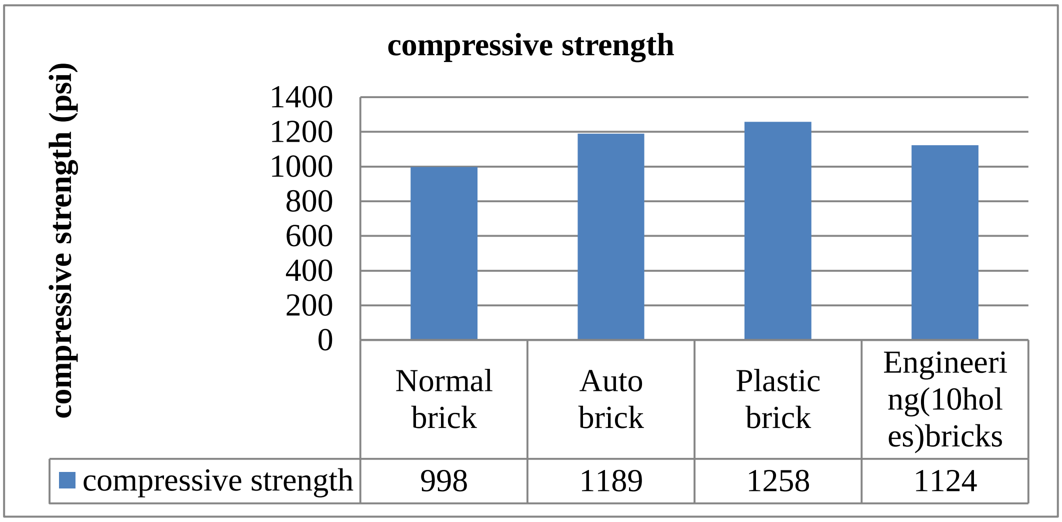

Figure 4-3 Ave. compressive strength of brick

is significant and similar to the plastic brick. The crushing strength and, consequently, the pressure required to break the bricks decrease with decreasing value. It also demonstrates how less stable bricks are.

4.9.3 Average unit weight of different bricks

This is very important because the unit weight helps determine the weight of the structure, the load that the materials can carry, the quantity of materials needed for a given space, and whether the

In water, materials will either float or sink. Therefore, the material unit weight is more important for any building goal. The unit weights of the various types of bricks are shown in Figure

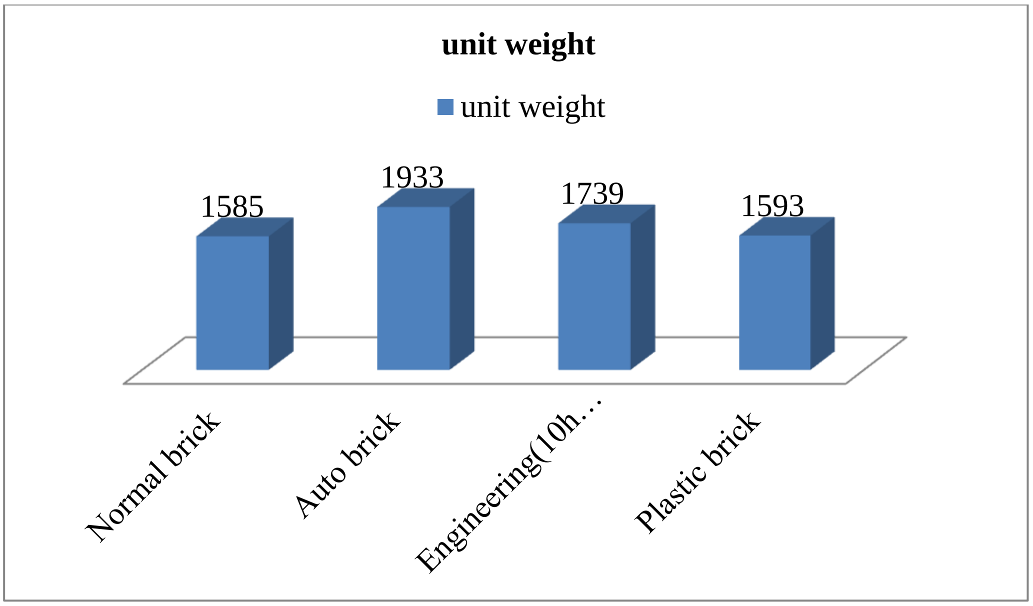

Figure 4-4 Ave. unit weight of different bricks

4.9.4 Average water absorption rate of different brick types

The lower the water absorption value, the better the quality. In the other case, a greater water absorption rating indicates low quality. It can be the water absorption rate for Auto Brick, and Normal indicating high which is denote low quality. On the other hand the water absorption rate of plastic brick is rather low, indicating that they are high quality. The findings were shown in Figure-4.5

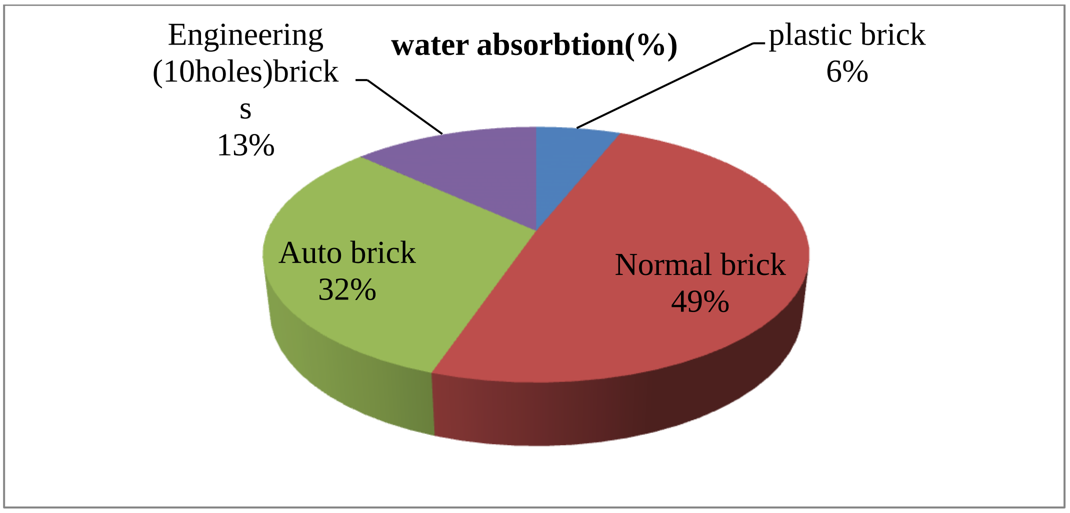

Figure 4-5 Ave. water absorption of different bricks

4.10 Quality of Brick index (QIB)

Table 4.12 presents the test data-derived quality of various brick types in accordance with Table 3.10.1

Table 4-10 Quality of brick Index

Types of Bricks	Ave. compressive strength	Ave. Unit weight	Ave. water absorption (%)	Efflorescence	Quality of Brick Index (QIB)	Bricks Quality
Normal brick	1	3	4	5	3.25	Moderate
Auto brick	1	4	5	5	3.75	Moderate
Engineering(10 holes)brick	1	4	5	4	3.5	Moderate
Plastic brick	2	5	4	5	4	Good

4.11 Comments

I had categorized the data (1–5) in accordance with table 3.10.1's requirements. To determine the brick quality index (QIB), we then had to average all rating values. Bricks were categorized according to their quality index (QIB), which ranged from poor to excellent.

Bricks were classified as moderate when (3<QIB<4), as well as good when (4<QIB<5) and excellent when (QIB=5). Bricks were also specified as slightly poor when (0<QIB<2), moderate when (2<QIB<3), and poor when (0<QIB<2). Among all types of bricks in table 4-12 it can be proved that plastic is good than other brick.

CHAPTER 05
CONCLUSION &RECOMMENDATION

5.1 Conclusions

This work's primary goal is to figure out how to make plastic Bricks out of recyclable plastic bottle and compare to the available normal bricks. After multiple attempts and an increase in the ratio of plastic bottle to sand, the goal was accomplished and strong bricks. Consequently, it can be concluded that recyclable plastic bottle can be used to make plastic brick. Broadly this study can be concluded flowing decision.

1. Hazardous plastic waste has been used in 1:2, 1:3, 1:4 ratios to produce plastic brick.
2. Same size bricks available in Bangladesh have been compared with plastic brick on the basis of compressive strength, water absorption, Efflorescence where plastic brick shows better result than the others.
3. After comparing different mixing ratios of bricks, it shows that 1:2 ratio is better than the others.

5.2 Recommendation

Since it has been established that plastic bottles can be used to produce brick, this research should go on. The limitation encountered during this experiment should be removed as much as possible by future research. Among the specific suggestions could be:

- To ensure even heating and reduce the chance of a flame occurring, use an improved mixing and heating chamber. When choosing the device, improved temperature control in the mixture should be a key consideration.
- For the hot mixture, use a mechanical mixing technique.
- Create a new machine or improve an existing one that is operational in a commercial setting.

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APPENDIX
Test Result for Compressive Strength Test

Table for Compressive Strength plastic Brick:

Preparing Date: 13-08-2023

Crushing Date: 19-12-2023

Specimen No.	Specimen Name	Compressive strength		Avg. Compressive Strength (Psi)
		KN	Psi	
01	Plastic Bricks (1:2)	210	1405	1258
02		180	1203	
03		175	1169	

Specimen No.	Specimen Name	Compressive strength		Avg. Compressive Strength (Psi)
		KN	Psi	
01	Plastic Bricks (1:3)	145	970	992
02		165	1104	
03		135	903	

Specimen No.	Specimen Name	Compressive strength		Avg. Compressive Strength (Psi)
		KN	Psi	
01	Plastic Brick (1:4)	125	836	982
02		150	1004	
03		120	803	

Table for water Absorption concrete brick

Preparing Date:13 -08-2023

Measuring Date: 18-12-2023

Specimen No.	Curing Duration	water Absorption (%)	Ave. water Absorption (%)
01	24 hr (1:2)	1.8%	2.18%
02		2.74%	
03		2.00%	

Specimen No.	Curing Duration	water Absorption (%)	Ave. water Absorption (%)
01	24 hr (1:3)	5.86%	3.23%
02		1.22%	
03		2.61%	

Specimen No.	Curing Duration	water Absorption (%)	Ave. water Absorption (%)
01	24 hr (1:4)	3.08%	5.33%
02		5.00%	
03		7.8%	

Table for Unit weight plastic brick

Preparing Date:13 -08-2023

Measuring Date:18-12-2023

Specimen No	Ratio	Dimension (m3) (L*W*H)	Weight(dry) kg	Unit weight (kg/m3)	Avg. Unit weight (kg/m3
01	1:2	0.00195	3.29	1710	1585
02		0.0094	2.94	1507	
03		0.00195	3.00	1560	

Specimen No	Ratio	Dimension (m3) (L*W*H)	Weight(dry) kg	Unit weight (kg/m3)	Avg. Unit weight (kg/m3
01	1:3	0.0018	2.90	1599	1933
02		0.00195	3.27	1701	
03		0.0018	3.07	1620	

Specimen No	Ratio	Dimension (m3) (L*W*H)	Weight(dry) kg	Unit weight (kg/m3)	Avg. Unit weight (kg/m3
01	1:4	0.0018	3.25	1714	1739
02		0.0018	3.00	1707	
03		0.0017	2.81	1574	

Calculation:

Sample Calculation

For Ratio (1:2)

Standard brick size = 9.5x4.5x2.75

= 0.242x0.115x0.07 m^3

= 0.0019481 m^3

Volume of plastic = 1/3x 0.0019481

= 0.0006494 m^3

= 0.90267x3 kg

= 2.70801 kg

Volume of river sand = 2/3x 0.0019481

= 0.0012987 m^3

= 2.143x3 kg

= 6.429 kg

For Ratio (1:3)

Volume of plastic = 1/4x 0.0019481

= 0.000487025 m^3

= 0.677x3 kg

= 2.031 kg

Volume of river sand = 3/4x 0.0019481

= 0.001461075m^3

= 2.4107x3 kg

= 7.23234 kg

For Ratio (1:4)

Volume of plastic = 1/5x 0.0019481

= 0.00038962 m^3

= 0.5416x3 kg

= 1.625 kg

Volume of river sand = 4/5x 0.0019481

= 0.0015585m^3

= 2.5715x3 kg

= 7.7145 kg

Total plastics = 6.3637 kg = 7kg

Total sand = 22kg

Calculation of Compressive Strength Test:

We Know,

Compressive Strength of brick = Maximum compressive load / Cross Sectional Area

Such as,

Maximum Compressive load

= 210 KN

= 210 x 224.81

= 47210.1 lb [1KN=224.81lb]

And Cross Sectional Area,= 190/25.4*114/25.4

= 33.6 sq. inch

Here,

Dimension of UTM plate = 190 mm

Width of brick sample = 114 mm

So, Compressive Strength of brick = Maximum compressive load / Cross-Sectional Area

= 47210.1/33.6 = 1405 Psi

Calculation of water absorption:

Here,

W1= 3.29kg (dry weight)

W2 = 3.41 kg (moist weight)

The water absorption (%) = (W2-W1)/W1*100

= (3.41-3.29)/3.29*100

= 3.65 %

Unit weight calculation:

Here,

Area of a brick = 0.24m*0.114m*0.070m

= 0.00192 m3

Unit weight = Dry weight of the brick sample/ total area of brick (cum)

= 3.29/0.00192

= 1713.54 kg/m3 (Ans)