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Ministry of Higher Education and Scientific Research
University of Babylon
College of Materials Engineering
Department of Ceramic and Building Materials Engineering

Re--use of brick waste in the manufacturer ceramic products

A Graduation Project
Submitted to the Department of Ceramic and Building Materials Engineering at College of Materials Engineering -University of Babylon in Partial Fulfillment of the Requirements for Bachelor Degree of science Materials Engineering - Ceramic

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ABSTRACT

Bricks are considered one of the most common construction units as building materials due to its characteristics. Many attempts have been made to combine waste with clay production bricks and recycling this waste by merging it with building materials is the ideal practical solution to reduce pollution. This research includes recycling brick waste production clay bricks by adding different proportions with clay to make clay bricks, in two ways. The first is a pressing process in addition to adding three different proportions with clay. The second method is the extrusion process, which is by adding a higher percentage and a lower ratio to the brick powder with clay. It also includes a study of the effect of brick powder on physical, chemical and mechanical properties on the brick, so the results showed that some properties decrease with the increase of brick powder, such as decrease in porosity and decrease in compaction. The positive result is a decrease in flowering during the extrusion process, which was not observed in the pressing process.

DEDICATION

First, I thank **Allah** who gave me the ability and desire to complete this work. I would like to express my deep appreciation and sincere thanks to my supervisor **Dr. Shaima'a J. Kareem** for her endless supported, guidance and advice. Her encouragement helped me to go on and complete this research. I was lucky to have such a supportive supervisor.

I would like to thank the Materials Collage in the Babylon University for giving me the opportunity to get the B.Sc.-degree in materials science.

Sincere thanks are also expressed to the staff of the Material Engineering College especially in ceramic and building materials.

Finally, I would like to thanks my family; my friends and everyone helped me to accomplish the present work.

CONTENT

CHAPTER FOUR

CHAPTER ONE

INTRODUCTION

1-1 INTRODUCTION

One of the most serious of these problems is the increase waste in building materials. Waste is largely in the world from factory waste to get rid of these problems by recycling waste to make other materials that benefit in another field, such as using construction waste, which is damaged or unused bricks and recycled use in the field of the ceramics industry. This contributes to reducing the disposal problems associated with this waste, and provides economics, i.e. mixing brick powder with clay to make ceramic materials. The management of the aforementioned waste is one of the main environmental concerns in the world, with the peak of spaces designated for landfilling due to its constantly increasing cost.

Presently large amounts of Ceramic waste are generated in ceramic industries with an important impact on environment and humans The use of the replacement materials offer cost reduction energy savings, arguably superior products, and fewer hazards in the environment Indian ceramic production is 100 Million ton per year. In ceramic industry, about 15%-30% waste material generated from the total production. This waste is not recycled in any form at present. However, the ceramic waste is durable, hard and highly resistant to biological, chemical, and physical degradation forces. The Ceramic industries are dumping the powder in any nearby pit or vacant produced spaces, new their unit although notified areas have beets marked for dumping. This leads to serious environmental, dust pollution and occupation of largest areas of land, especially after the powder dies up so it is necessary to dispose the ceramic waste quickly and use in the construction industry. As the ceramic waste in piling up every day, there is pressure on ceramic industries to find solution for its disposal

2-2 PREVIOUS STUDIES

Brick is one of the most demanding masonry units. It has the widest range of products, with its unlimited assortment of patterns, textures and colors. Several researches have been carried out in the last few decades on creating new types of bricks using additives, often consisting of residual urban and industrial materials

2003, Ismail Demir, and Mehmet Orhan, have be investigated the addition of waste-brick material in brick production. Find waste bricks cane considerable harm to the environment. During production, especially in the firing, transportation and construction procedures, large amounts of bricks broken and have to be dumped in landfills or used as a filling material. For this purpose, the chemical and mineralogical structures of waste brick in WestAnauha, Turkay, were investigated. After pulverizing, the samples were divided into two categories: (A) passing through a 4.75 mms sieve (coarse) and (B) passing a 600 μm sieve (fine). In order to obtain comparable test results, ratios of the waste (0, 10, 20 and 30% by mass) were added to the rawbrick clay. Standard test methods were used to determine the mechanical properties of the bricks at different firing temperatures. The results show that at a mass of 30% fine-waste material additive fired at 900°C, the test sample has an adequate strength. The reuse of this material in the industry would contribute to the protection of farmland and the environment.

2010, Carlos Maurício Fontes Vieira and Sergio Monteiro, have be investigated a possible solution to this environmental problem through the mixture of fired brick wastes (north of the State of Rio de Janeiro, Brazil), up to 20 wt.%, with clay bodies to produce red ceramics. Cylindrical pressed bodies were fired at temperatures varying from 500 to 1100°C. After firing, samples were then tested for linear shrinkage, water absorption and mechanical strength. The results showed that brick waste addition did not changed the workability of the clay and that up to 5 wt.% of waste no detrimental effect occurred on the fired properties at all temperatures.

2012, Aeslina Abdul Kadir, and Noor Amira Sarani, have be studied many attempts have been made to incorporate wastes into the production of bricks. For examples, there are rubber, limestone dust, wood sawdust, processed waste tea, fly ash, polystyrene and sludge recycling such wastes by incorporating them into building materials is a practical solution for pollution problem. A wide range of successfully recycled materials and their effects on the physical and mechanical properties of bricks have been discussed. Most manufactured bricks with different types of waste have shown positive effects by producing lightweight brick, increased porosity and improved the thermal conductivities of fired clay bricks. Nevertheless, reduced performances in number of cases in terms of mechanical properties were also demonstrated.

2016, Chiara Coletti, eta al, have be focused on the recycling of waste brick in order to be able to market new types of bricks. In this work, we explored the possibility of using ceramic sludge in brick production, aiming to find an alternative eco-friendly additive to produce ‘‘eco-bricks’’ characterized by suitable mechanical and aesthetic properties and durability. For this purpose, two types of bricks produced by an Italian factory (SanMarco-Terreal) were compared with a newly designed brick obtained from the same starting clay, with the addition of ceramic sludge in place of the traditionally used siliceous sand. Bricks and raw materials were investigated with a multivariate approach, consisting in the mineralogical and chemical analysis, and the final products microstructural investigated and their physical-mechanical properties determined. Results show that bricks produced with added ceramic sludge can substitute traditional bricks well, fulfilling aesthetic requirements and maintaining sufficient mechanical properties. However, one drawback was that these new materials did not respond to freeze-thaw cycles, high lighting their potential vulnerability in cold climates.

1-3 RESEARCH OBJECTIVES:

1- Recycling factory waste, reusing bricks in industry, and how can benefit from them.

2- How to reduce factory waste

3 - Determine the suitable method of recycling brick waste

4- Knowing the physical and mechanical properties of bricks.

1-4 AIM OF THE STUDY:

The aim of this study is to reuse the brick residues from the Al-Hawra brick factory in Al-Mahaweel district. In this research, production of bricks by adding these wastes in different proportions and to determine the physical and mechanical specifications of the new bricks in order to get rid of these wastes and contribute to the protection of farmland and the environment.

CHAPTER TWO
THEORITCAL PART

2-1 BRICKS

Brick is one of the most common masonry units as a building material due to its properties. Many attempts have been made to incorporate wastes into the production of bricks. For examples these are rubber, limestone dust, wood sawdust, processed waste tea, fly ash, polystyrene and sludge. The main raw material for bricks is clay besides clayey soils, soft slate and shale, which are usually obtained from open pits with the attendance of disruption of drainage, vegetation and wildlife habitat. Clays used for brick making vary broadly in their composition and are dependent on the locality from which the soil originates. Different proportions of clays are composed mainly of silica, alumina, lime, iron, manganese, salphur and phosphates. The principal properties of bricks that make them superior building units are their strength, fire resistance, durability, beauty and satisfactory bond and performance with mortar. Additionally, bricks do not cause indoor air quality problems. The thermal mass effect of brick masonry can be a useful component for fuel-saving natural heating and cooling strategies such as solar heating and nighttime cooling. They have moderate insulating properties, which make brick houses cooler in summer and warmer in winter, compared to houses built with other construction materials. Clay bricks are also non- combustible and poor conductors.

Material for clay bricks are most valued due to their ceramic characteristics. Clays are derived from the decomposition of rocks such as granite and pegmatite, and those used in the manufacture of brick are usually from alluvial or waterborne deposits. The presence of rock particles causes the clays in burn in its bricks of varying colors and appearance. The important properties of clays that make them highly desirable as brick materials are the development of plasticity when mixed with water, and the hardening under the influence of fire, which drives off the water content. Normally, the physical nature of the raw materials controls.

Figure (2-1)

2-1-1 Raw Materials Used in the Brick Industry

Clay is the primary raw material used in the manufacture of bricks because it is the most abundant natural material on earth and has certain properties such as plasticity that allow it to be formed or molded when mix it with water. Where the clay blocks are made of agricultural soil or sandy clay deposits spread in most parts of Iraq. The composition of these sediments varies in different regions, and varies according to the depth from which the soil is taken.

It was found that the proportions of soil components involved in the manufacture of bricks are 15 clay, 40-55 silt, 20 fine sand, and 8% coarse sand. Some modifications have been made to the soil, such as adding sand if its percentage is too small or removing salts from the soil.

The secondary clay materials are compounds of alumina and silica, and small amounts of lime and magnesia Sodium or potassium are compounds of iron, usually oxides or hydroxides or Carbonates are always impurities in clay bricks, affecting the color of the bricks. The soluble salt content according to BS 3921 is {Maximum (by mass) Mg + Potassium + Na = 0.25% and Sulphate = 1.6%}. Clays containing up to 3% iron oxide give a white to Creamy or orange, changing to a pink-red color and with the iron oxide content rising to between 8 and 10%. By adding manganese dioxide at a ratio of 1 to 4, a range of gray and brown colors can be produced Due to the versatility of raw materials, it can easily be formed into a large batch In terms of shapes and sizes, and the flexibility that this gives to design and construction, brickwork has remained Clay is cost effective.

2-1-2 Mineral with Bricks

Clay is a material found in most types of soil used in the manufacture of ceramics and bricks. Geologists describe clay as very small particles (i.e., particles) of soil less than four micrometers in diameter. The word clay also means a substance from the earth composed of certain types of eroded silicate minerals that are less than 1/1 in size, 256 mm.

Clays consist primarily of very small, lamellar particles of alumina and silica bound together by water. There are different substances in clay that can give it different colors. For example, iron oxide can make clay red. As for carbon compounds, they give shades of gray different from.

2-2 USING LEFTOVER BRICKS WITH BRICKS

How can you recycle the world's stock of treated sewage and boost the construction industry at the same time?

Turn that solid waste into building bricks. Biological solid waste is a byproduct of the wastewater treatment process and can be used as fertilizer on reclaimed land or as building material. About 30% of the world's solid waste is stored or sent to landfills, consuming valuable land and potentially emitting greenhouse gases, causing environmental challenges.

Now, a team from RMIT University in Melbourne, Australia, has demonstrated that combining bio-solid waste with clay bricks could be a potential solution for both brine (wastewater) treatment and the building brick industry. Many research showed how making bricks containing solid waste requires only about half the energy of traditional bricks. In addition to being more economical than traditional bricks in terms of production, solid waste bricks also have a smaller thermal conductivity, so they transfer less heat, which gives buildings a higher environmental performance.

The European Union produces more than 9 million tons of bio-solid waste per year, while the United States produces about 7.1 million tons, and Australia produces 327,000 tons of bio-solid waste annually.

The use of bio-solid waste in bricks could be a solution to these major environmental challenges. It is a practical and sustainable proposal to recycle the bio-solid waste currently stored around the world. The research tested the physical, chemical and mechanical properties of clay bricks that contain different proportions of biological waste. The bricks contain 15% solid biological waste, as a minimum; can consume these five million tons.

2-4 MANUFACTURING OF BRICKS

2-4.1 Stages of Making Clay Bricks

In general, the brick making process consists of several stages:

Stage 1: Preparation of raw materials

Stage 2: molding

Third stage: drying

The fourth stage: burning and cooling

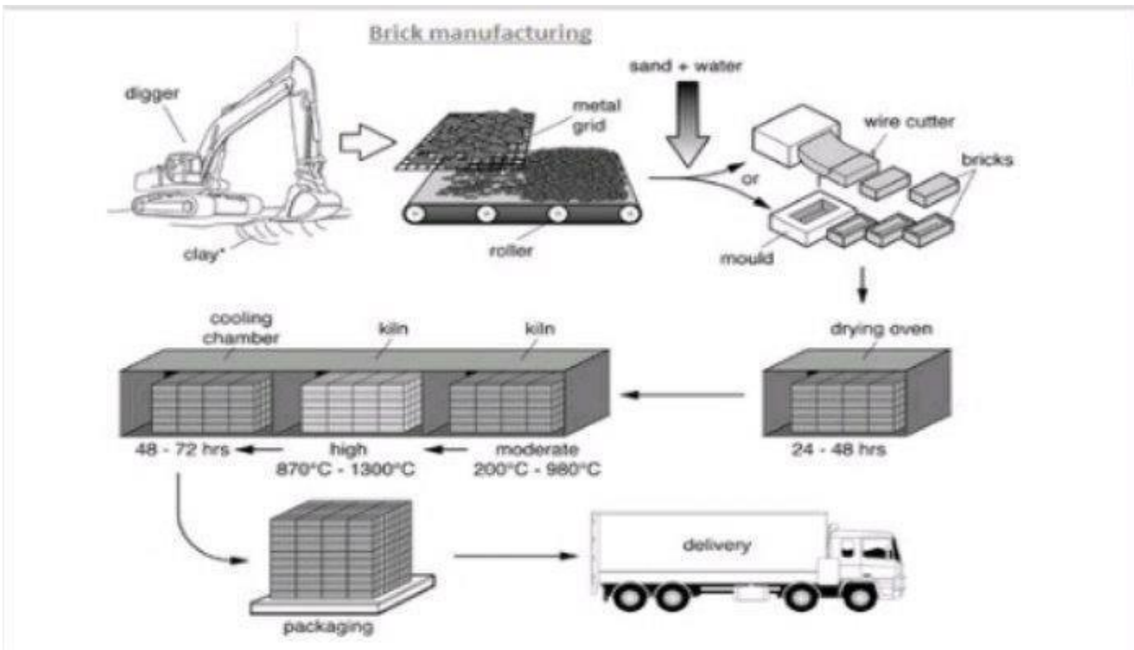


Figure 2: Clay brick manufacturing process.

1- *First Stage: The Preparation of Raw Materials*

Heavy earth-moving equipment such as bulldozers, skimmers, and mechanical shovels are used. For the extraction of clay and oil shale crushing and mixing After raw materials are transported from the quarries by truck, the materials are stored to enable the mixing of different types of slurry. Belt conveyor feeds the materials separately to the primary crushers. These reduce the particle size to 3-mm or less. Followed by mixing the slurry to obtain the desired properties, color and strength.

- **Grinding**

Grinding conveyor belts carry the mixed slurry away for secondary crushing, which is usually done by means of a pan mill. The mill has two heavy steel wheels, to crush the slurry.

- **Examination**

Before the molding process, the slurry is screened and large pieces are returned to the mill for further grinding other.

2- The Second Stage: Molding

The first step in the molding process is to produce a homogeneous plastic mass slurry. Typically, this is accomplished by adding water to the slurry in the mixing chamber. After that, the plastic clay block is ready for molding. There are three main processes: Bricks hard clay, soft clay and dry pressing.

- **Extrusion Process**

In the solid clay method, water is mixed in a ratio of 10 to 15% with clay to produce plasticity. After mixing clay with water, the clay passes through a degassing chamber to remove air bubbles in the clay. This It increases the workability of clay and increases its plasticity and resistance. Next, the clay is extruded through a mold to produce a column of clay. Then an automatic cutter cuts the clay column to create the individual bricks. The high-pressure conditions of the extrusion process make the clay body very dense and hard, resulting in strength and higher intensity automatically.

Dry Press Process

This process is particularly suitable for low plasticity slurry. The slurry is mixed with a small amount of water (up to 10 percent), and then pressed into steel molds under pressure (3.4 to 10.3 MPa) by hydraulic presses.

3-Third Stage: Drying

Before the bricks are fired, they must be properly dried. The moisture content must be reduced to 8 by volume. In hot countries, there is sufficient sun for the drying process; most brick makers take full advantage of this free source of energy by placing the bricks in an open area under the sun. The most prominent disadvantage of this process is that it long time (14 to 21 days), especially in the rainy season. To reduce the drying cycle, the brick makers introduced some mechanical means of drying. The two most common methods are tunnel or chamber dryers. These methods work as follows:

- **Tunnel dryers:**

Bricks are produced and then placed on flat rail cars or peer carts. The carts are pushed through the tunnel. This process can take anywhere from 40 to 50 hours.

- **Chamber Dryers**

Chamber dryers are large chambers where bricks are packed into trolleys stretcher. The capacity of the rooms may be from 50,000 to 60,000 bricks. Hot air is introduced into the room. Drying time is between 30 and 45 hours. Most of the water evaporates in the drying phase at temperatures ranging from 38°C to 204°C). In all cases, temperature and humidity must be strictly regulated to avoid cracking bricks.

4- Fourth Stage: Burning and Drying

The bricks are fired between 10 and 40 hours, depending on the type of kiln and other variables. There are several types of ovens used by manufacturers. The most common type is tunnel ovens, followed by rotary ovens. The fuel may be natural gas, coal, sawdust, methane from landfills, or a combination of these fuels.

Dry clay is placed in special compounds to be burned inside the kiln. Many chemical and physical changes occur when the bricks are burned, and they can be summarized as follows:

1- At (150-400) degrees Celsius: the loss of some of the chemically combined water with the clay occurs.
2- At (573) degrees Celsius: Alpha quartz turns into B quartz, and an expansion of up to 3 occurs.
3- At (600) degrees Celsius: clay minerals decompose, the sintering stage begins, and the bricks begin to harden. 18% and recovers during cooling after this process.
4- 4- At (650-850) degrees Celsius, where carbonate decomposes, which is the most common and important calcium carbonate, and it is undesirable in bricks because it causes porous brick formation due to its decomposition into Cao, which causes the phenomenon of lime explosion and CO2 gas release $CaO + CO_2$ $CaCO_3$. Carbon dioxide causes an outward pressure, trying to get out of the mass limits, which results in. It causes an expansion in the volume of the mass, and the exit of carbon dioxide leaves air gaps and a highly porous brick, thus increasing the absorption of the mass, which is an undesirable characteristic.
5- At (950-900) degrees Celsius: final hardening occurs and the color of the bricks remains constant (brown).
6- At 1400 degrees Celsius: the raw materials begin to melt and turn into glass, as the brick loses its shape and dimensions and becomes brittle. Cooling: After the burning process is over, the cooling process begins. The cooling time rarely exceeds 10 hours in tunnel kilns and from 5 to 24 hours in rotary kilns.

CHAPTER THREE
EXPERMENTAL PART

3.1 GENERAL VIEW:

This chapter focuses on the preparation methods, materials, and equipment that are used and the measurements, which characterize the fabricated product in this study. Figure (3-1) show the step of forming samples and tests.

3.2 RAW MATERIALS

1-mud

2- Distilled water

3- Bricks waste powder

3.3 EQUIPMENT AND TOOLS

1-Baker capacity 250

2-Nano mill

3- A device for granular examination of brick powder

4- Mixing device

5-sensitive scale

6- Pressing devic

7- Extruder

8-oven

9-Sifters

10-Cylindrical steel mold

11-Hydraulic piston 12- Drying oven

13-Steel spoon

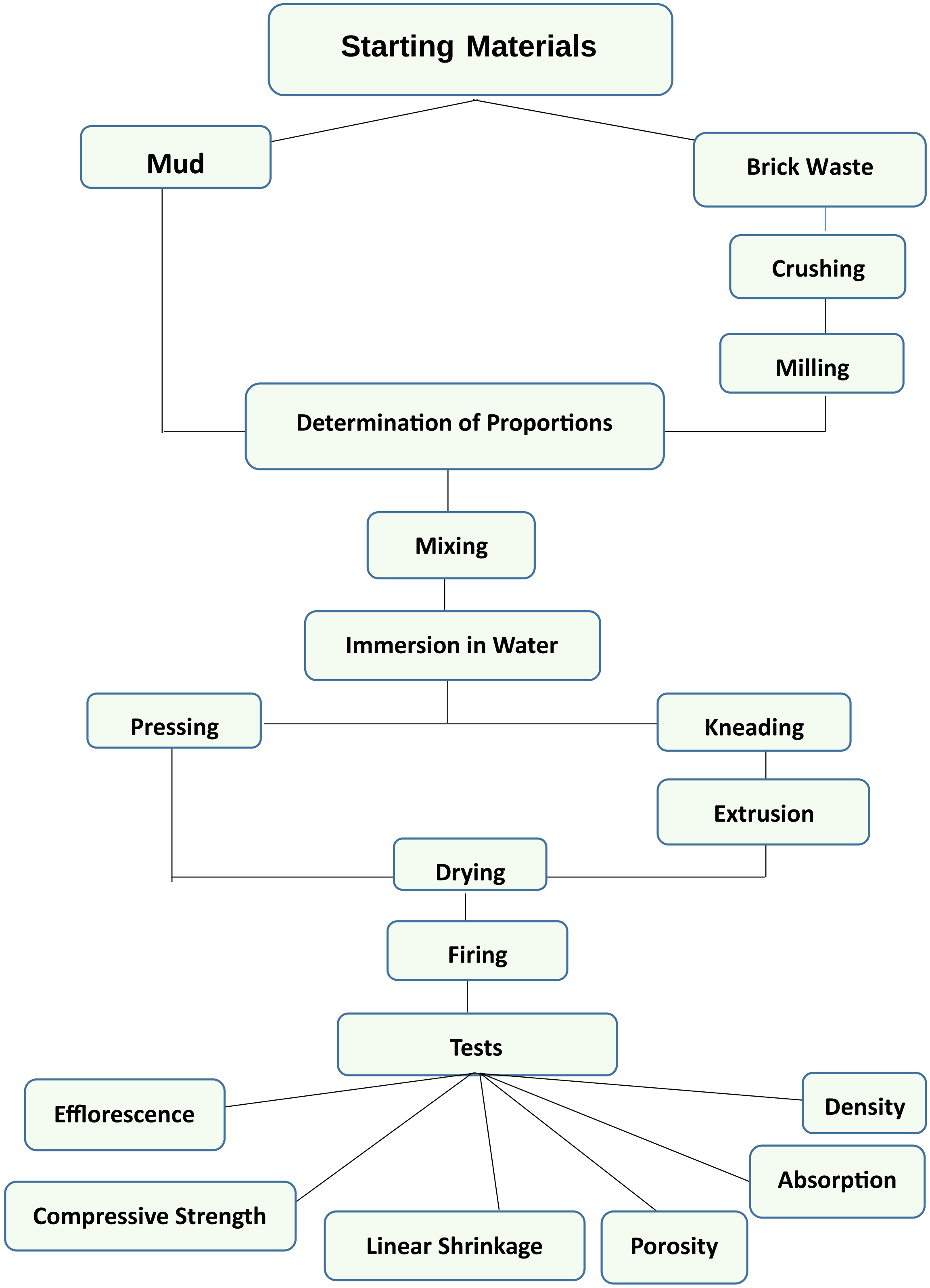


Figure (3-1) Flow Chart for Steps of Forming Samples

3.4 PREPARATION POWDERS:

3.4.1 Milling Process

The most important raw materials for making bricks are clay and brick powder. We take brick waste from Al-Hawraa factory is located in Iraq, specifically in the Al-Mahaweel area. It is broken and then ground with precision in an iron hammer, after which it is sifted with a household sieve, then placed in a blender for a whole day, and then placed in a nano mill for a whole day until it becomes nano-sized, and after that It is used in the pressing and extrusion process.

Figure (3-2) Powder of waste brick

3.4.2 Sample Mixing

Samples of brick powder and its mixture with clay are for bidden. The batches were prepared to represent the mixtures, which consist of finely mud and waste brick each batches mixing to get a homogeneous mixture as shown in table (3.1).

Table (3.1) Type and proportion of starting materials, which represented the constituents of each, batch mixture.

Mix no.	Mud wt.%	Waste Brick %
Batch 1	**90**	**10**
Batch 2	**80**	**20**
Batch 3	**70**	**30**

3.5 FORMING

The forming stage was applied to prepare the specimens by Semi-dry pressing method:

1. Semi-dry Pressing Method

Sample were prepared mud powder and waste brick as a wt.%. At first, mud powder was weighed and dry mixed thoroughly in an mortar pestle with the required amount waste brick (to form 3 batch). This was followed by addition of desired volume of PVA solution so that final PVA content of the batch was 2%. A high carbon, high steel die (20 mm inside diameter and a height of 40 mm) was utilized, and the sample thickness was 25 mm as shown in fig (3-3). Acetone was utilized for cleaning the die to prevent pollution and oil was used for lubrication. Samples were produced by semi-dry pressing in a hydraulic press (Carver Press USA as shown in fig (3-4)) at a various load 15 kg / cm^2, with soaking time of 90 seconds. The formed cylindrical shape are then taken out of the press.

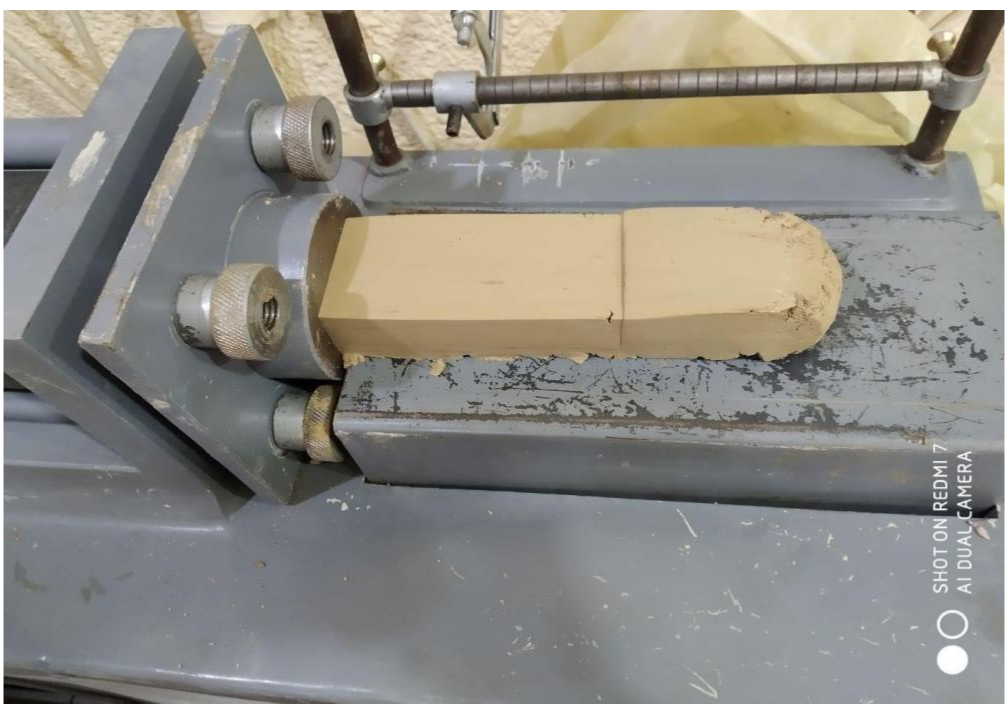
Figure (3-3:) Pressed sample

Figure (3-4) Pressing Machine

2- Extrusion Process

It is the process of forming bricks used where the material is compressed clay through the extrusion mouth. It has the same cross-sectional shape required. One of the most important advantages of the extrusion process over other processes is its ability to produce very complex cross-sectional shapes. It also produces final products with a high presence and surface. The extrusion process may be continuous to produce large lengths or non-continuous production, relatively short lengths. Also old, cold or hot forming.

In the laboratory, the first step is to prepare clay that is physically examined, and we take an amount of about 81g of it in a dish and leave it for two weeks. The proportion of water that we immerse is about 60 mm. We will notice the absorption of water. After that, we prepare about 0.7585kg of clay, then put it in a rectangular dish and immerse it in water by 240 mm, then leave it for a whole week. The paste of mud and waste brick is knead it to make a plastic dough in the form of a ball and then to enter it into the mold is then extracted from the extrusion side and completed the final form as shown in fig (3-5).



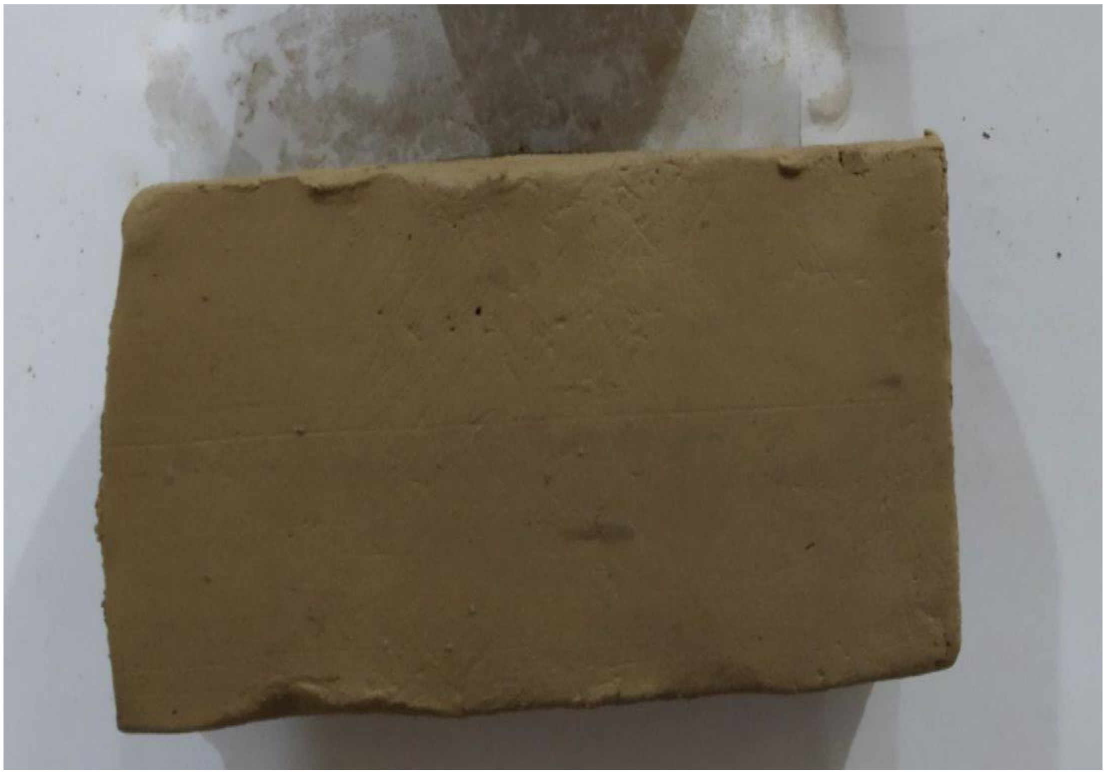


Figure (3-5) Extrusion Process

3- Drying:

One of the most important stages in the clay-brick production process is the drying process. The product must be dry enough to get enough ‘green’ strength for handling. The pressed and extruded samples were dried 24 hours in the laboratory, on 105°C

4- Firing

The firing process is the last stage for manufacturing bricks and for obtaining the final product. The pressed and extruded samples was burned at a temperature of 1000 degrees Celsius. A program for burning samples is every minute 10 degrees, the residence time is two hours.

Figure (3-6:) The pressed and extruded samples after firing

3.6- PHYSICAL TEST MEASUREMENT

3.6-1 Particles Size Measurement:

Leaser particle size analyzes (Better size 2000. At the Department of Ceramic Engineering and building materials/ College of Engineering Materials/ Babylon University) was used to measure particle size and particl size distribution of the produced powder.

3.6-2 Apparent Density of Powder:

The apparent density is calculated by pouring the powders in a vessel of weight while is empty then it is poured the powder in the vessel of weight with powders. The apparent density was calculated by the following formula:

$\rho = (W_2-W_1) / V_P$……………………………………(3-1)

W1: Weight vessel empty (g), W_2: Weight vessel with powder (g),

V_P: Powder Volume (cm^3), ρ: apparent density (g/cm^3)

3.6.3 Apparent porosity, Water Absorption and bulk density:

The density, apparent porosity and absorption were measured according to Archimedes method according to (ASTM C373-88) as follow:

1- The test specimen was dried in an drying oven at (110) for (24) hours and allow to cooled to room temperature and their dry mass (D) were record.
2- All the specimen was immersed in a beaker of distilled water and boil for (5) hour, and then allow to soak for an additional 24 h, to record the suspended weight (S).
3- Every specimen was blotted lightly with a moistened cotton cloth to remove the excess water from the surface, and the saturated mass was determined (M).
4- The apparent porosity, bulk density, can be measured using following equation:

Apparent porosity =[(M-D)/(M-S)]*100% ………………….(3-2)

Water Absorption =[(S-D)/D]*100% ……….…………….(3-3)

Bulk density =[D/(M-S)] ………………………………...(3.4)

3.6.4 Linear Shrinkage:

The Linear Shrinkage will be measured according to ((ASTM - C1407) as follow:

L.S % =$L_o - L/L_o \times$ % ………………………………… (3.5)

$L_{o:}$ Sample length before firing

L: Sample length after firing

3.6.5 Efflorescence Test

The purpose of the experiment: Determine the percentage of soluble salts present in the bricks that appear on the surface of the bricks by using apparatus and device:

1. Flat metal utensils with a depth of not less than 5 cm and containing distilled water with a height of not less than 2.5 cm.
2. Drying room temperature (~24) °C, well ventilated.

Test Method: The method of work

1- Each brick is placed on its smaller end in a flat container containing distilled water at a depth of 2.5 cm. It is left in the drying room for seven days, with distilled water added whenever the container dries.

2- The bricks shall be dried in the same room for a period of not less than three more days in the same pots, but free of distilled water.

3.7 MECHANICAL TEST (COMPRESSIVE TEST)

The strength of a material is its capacity to withstand destruction under the action of external loads. The compressive test was used for determining the strength and deformation properties of the specimen under uniaxial load.

It is commonly known that most ceramic materials have high compressive strength. The compressive of sample was determined by using universal testing machine in the polymer laboratories / College of Material Engineering/ University of Babylon.

Cylindrical samples of the length is twice. This test is done according to the ASTM (C-733-88) standard. Compressive strength of each sample is then calculated using the formula:

$$\sigma_C = \frac{F}{A} \quad \text{(3-6)}$$

where: σ_C : compressive strength in (MPa), F : Applied load until fracture(N), A: Cross sectional area (mm^2).

CHAPTER FOUR
RESULS & DISCUSSION

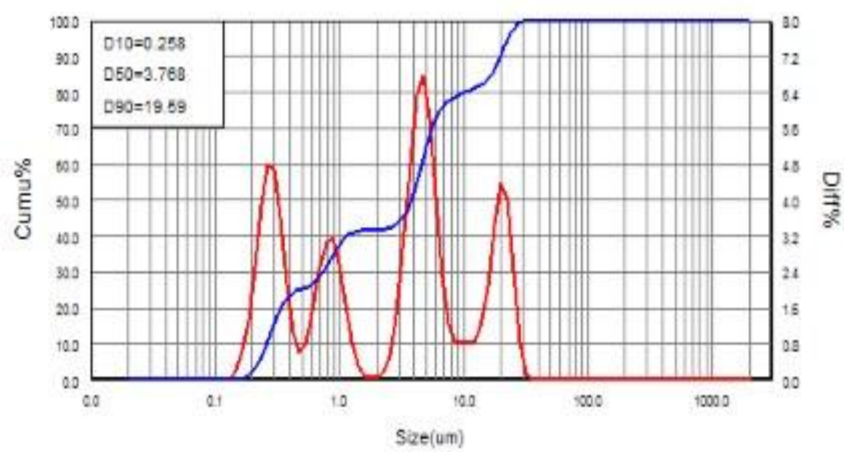
4.1 INTRODUCTION

This chapter includes the main results obtained from the experimental work. Farther more illustrated in results and discussion of brick samples for two methods.

4.2. PHYSICAL RESULTS

4.2.1 Powder characteristic

Particle size analysis is necessary to identify the particle size of the brick waste. Figure (4-1) shows the particle size analysis of brick waste. It may be noted from this figure, there are three populations of particles size distribution, so particle size of brick waste is about ~ 0.3768 μm. The result of apparent density for brick waste is about ~ 1.0189 g/cm^3 that mean the powder heavy.



Diam um	Percent
0.100	0.00
0.200	2.43
0.500	25.10
1.000	37.69
2.000	41.76
5.000	64.91
10.000	79.71
20.000	90.74
45.000	100.00
75.000	100.00

Figure (4.1): **Particle size analysis of brick waste**

4.2.2 Apparent porosity, Water Absorption and Bulk Density:

The results of pressed samples at different ratio of brick waste (10, 20, 30%) the apparent porosity and water absorption decreased while the bulk density increased with increased the ratio of waste brick as shown is Figs. (42), (4-3), and (4-4), the reason of that behavior the apparent density of brick waste higher than of mud of brick and distribution of waste brick powder will be closed the pores and cavities so decreasing the porosity and absorption. The results of extruded samples at different ratio of brick waste (10, 30%) are shown in Fig. (4-5), (4-6), and (4-7). The apparent porosity and water absorption decreased while the bulk density increased with increased the ratio of waste brick that behavior similar to pressed samples, but note the value of porosity and water absorption higher while density less than pressed samples. Because of the higher ratio of water in mud, which used in extrude samples and the load in pressing process more than in extrusion process.

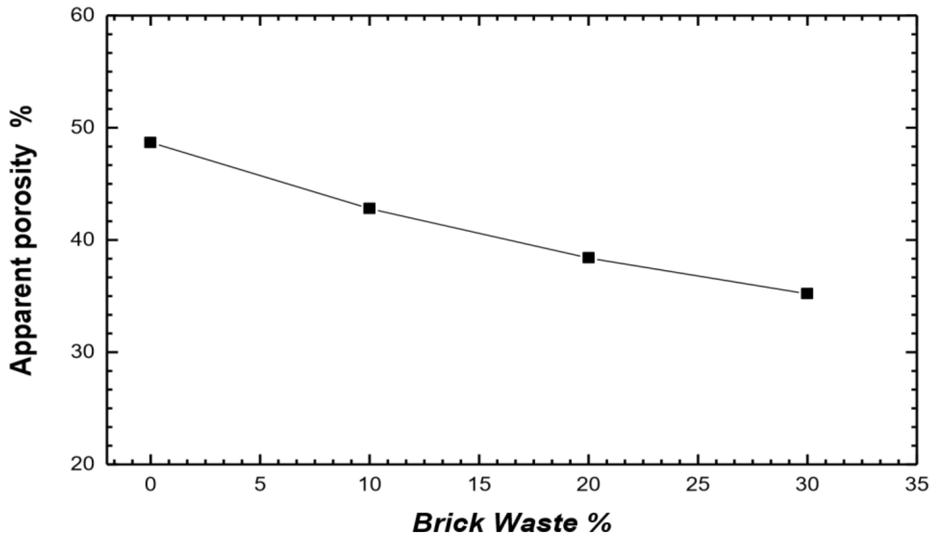


Figure (4.2): Apparent Porosity with different ratio of brick waste for pressed samples

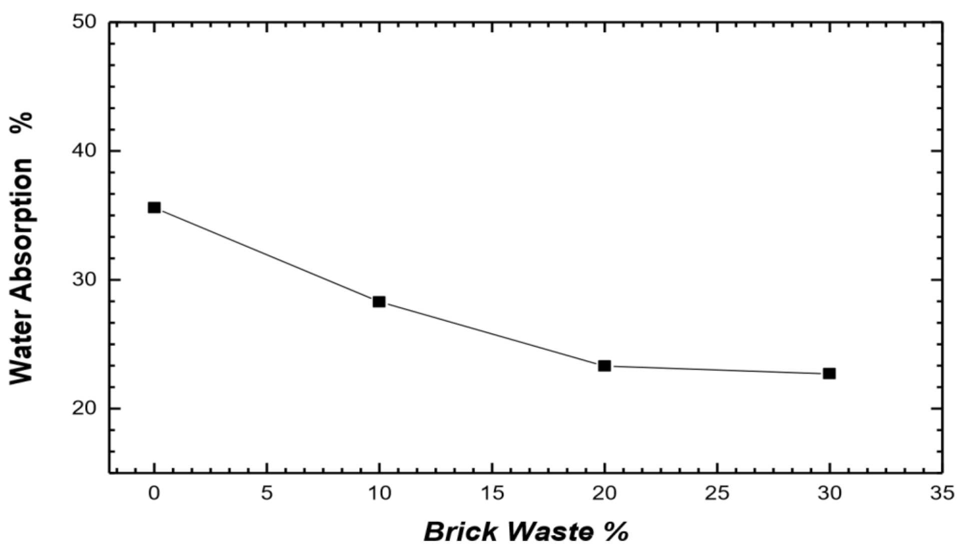


Figure (4.3): Water Absorption with different ratio of brick waste for pressed samples

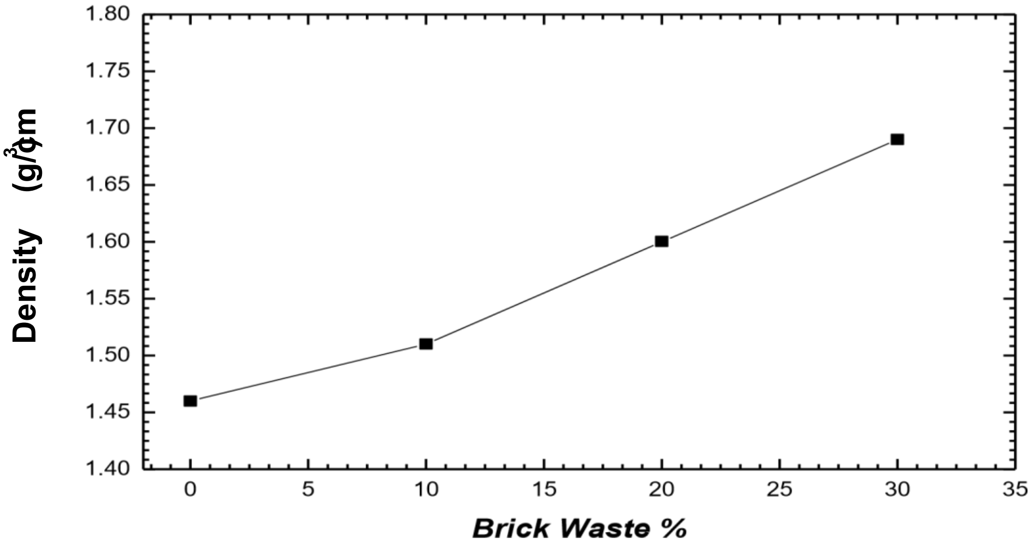


Figure (4.4): Bulk density with different ratio of brick waste for pressed samples

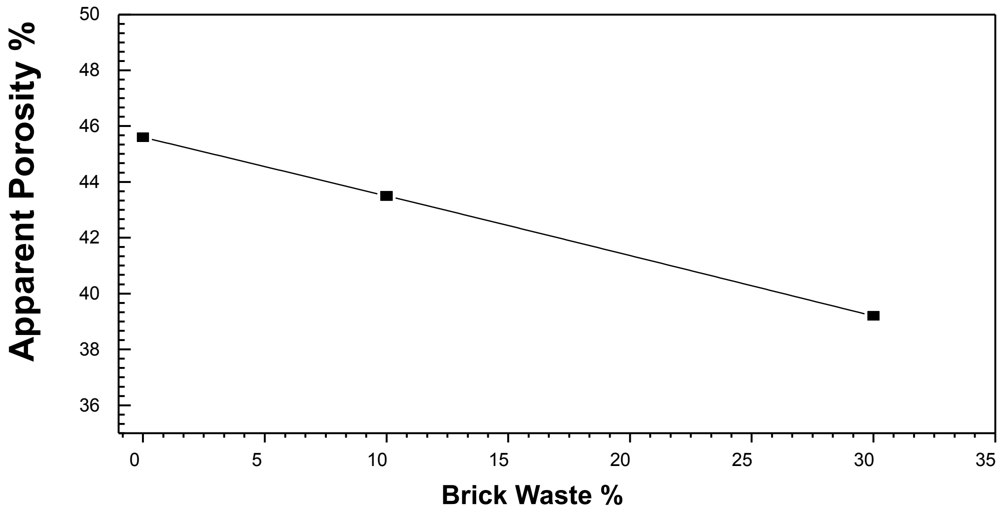


Figure (4.5): Apparent Porosity with different ratio of brick waste for extruded samples

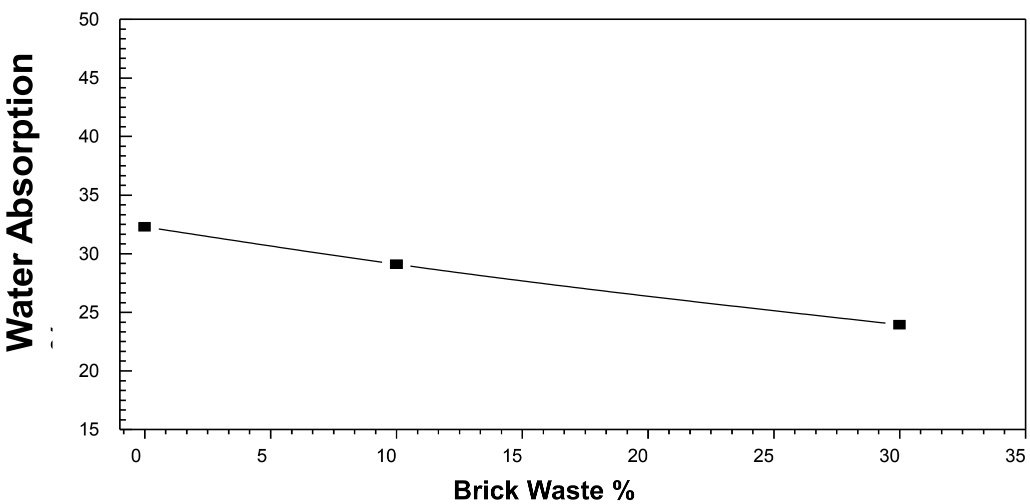


Figure (4.6): Water Absorption with different ratio of brick waste for extruded samples

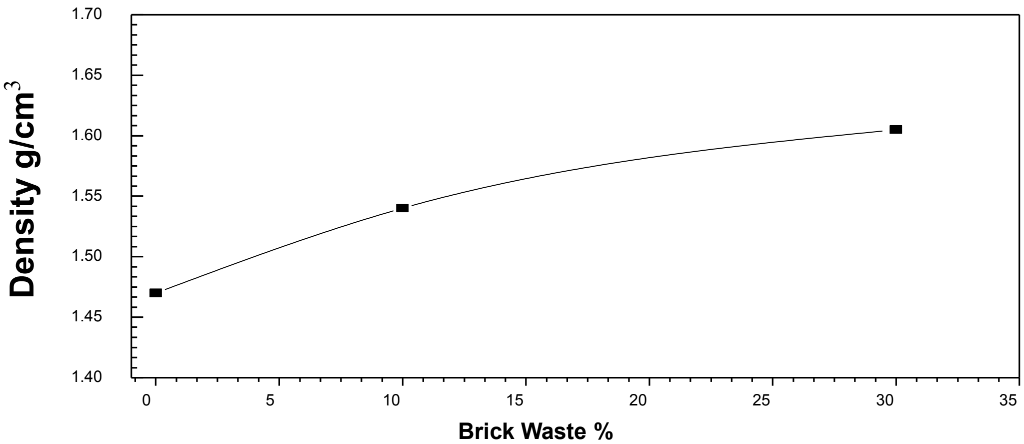


Figure (4.7): Bulk density with different ratio of brick waste for extruded samples

4.2.3 Linear Shrinkage:

The results of pressed samples at different ratio of brick waste (10, 20, 30%) the linear shrinkage percentage decreased with increased the ratio of waste brick as shown is Fig. (4-8). Fig. (4-9) show the results of linear shrinkage for extruded samples, which decreased with increased different ratio of brick waste (10, 30%) that agree with the results of the porosity and density of brick above. More, the value of linear shrinkage percentage for extruded samples higher than the pressed samples because of higher ratio of water in extrusion process.

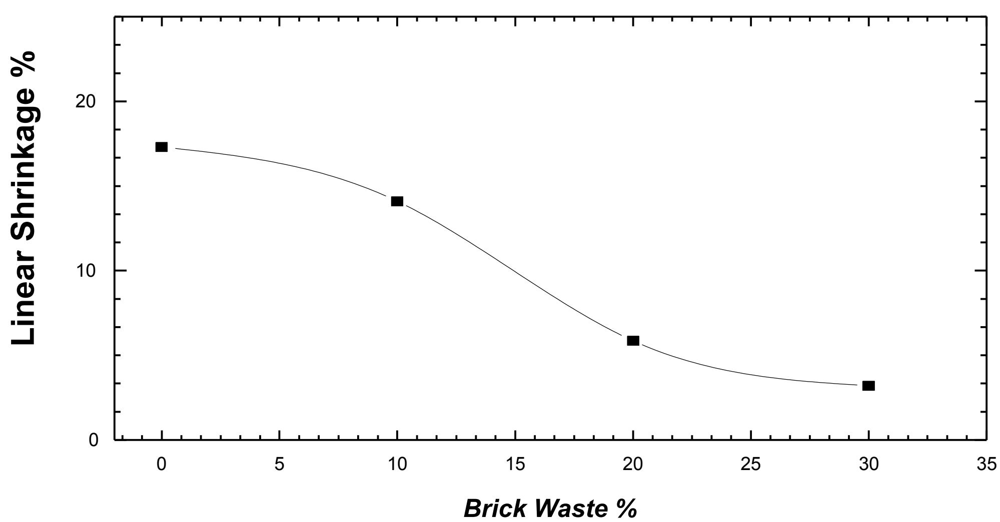


Figure (4.8): Linear Shrinkage with different ratio of brick waste for pressed samples

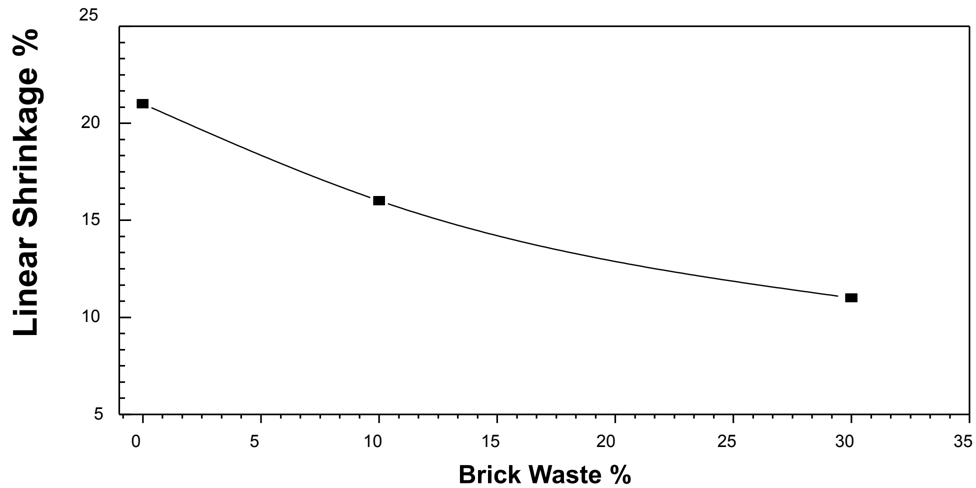


Figure (4.9): Linear Shrinkage with different ratio of brick waste for extruded samples

4.3.4 Efflorescence

The purpose of efflorescence to determine the percentage of soluble salts present in the bricks that appear on the surface of the samples after immersing them in distilled water for seven days. The results of the examination showed that the pressed samples did not show traces of efflorescence, so no values were recorded for them, while the extruded samples showed traces of efflorescence on their surface, and the results are shown in Fig (4-10).

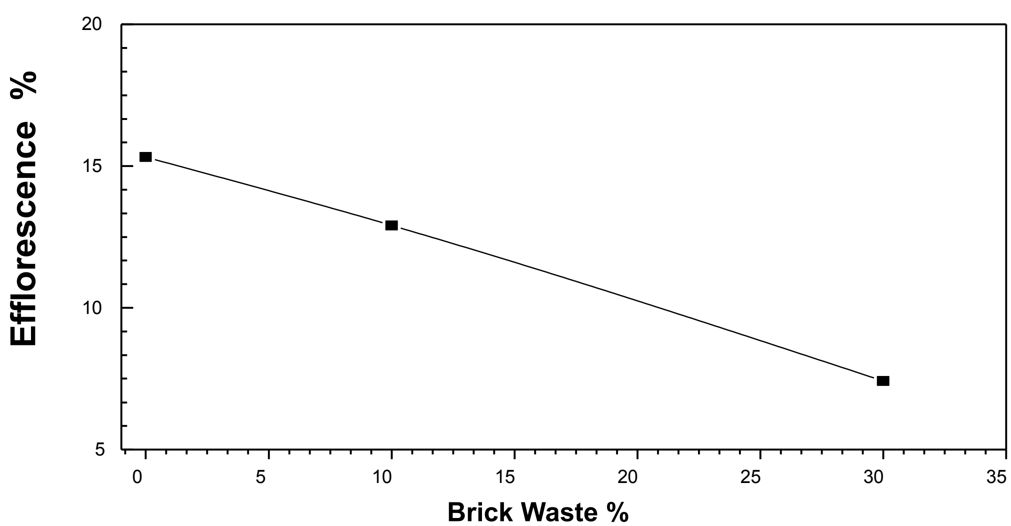


Figure (4.9): Efflorescence ratio with different ratio of brick waste for extruded samples

4.4. Mechanical Result (Compressive strength):

The compressive strength of the bricks in semi dry method higher than extrusion method with different ratio of brick waste as shown in Figs (4-10) and (4-11). It is also noticeable that with the increase in the percentage of powder of brick waste, the resistance increases, due to the increase in the density of the samples, because the apparent density of the powder is higher than the base material. That result agree with the physical properties

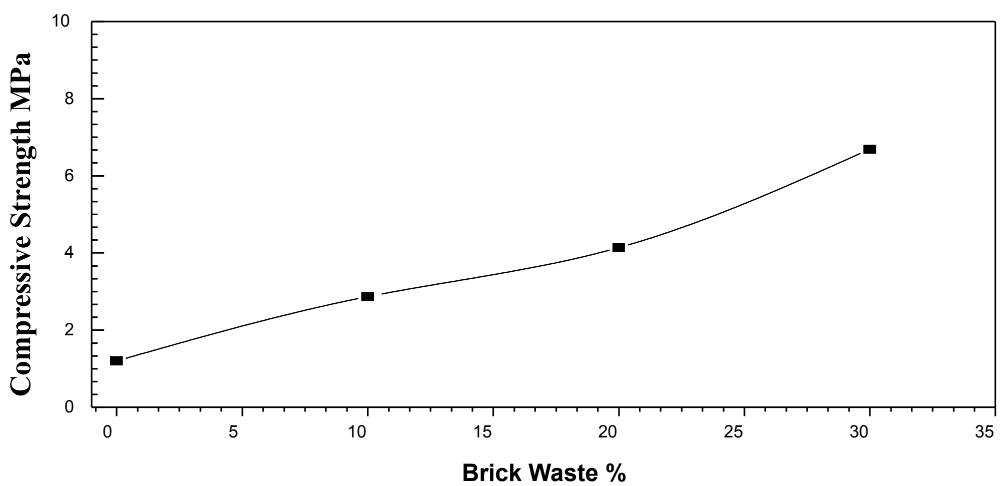


Figure (4.10): compressive strength with different ratio of brick waste for pressed samples

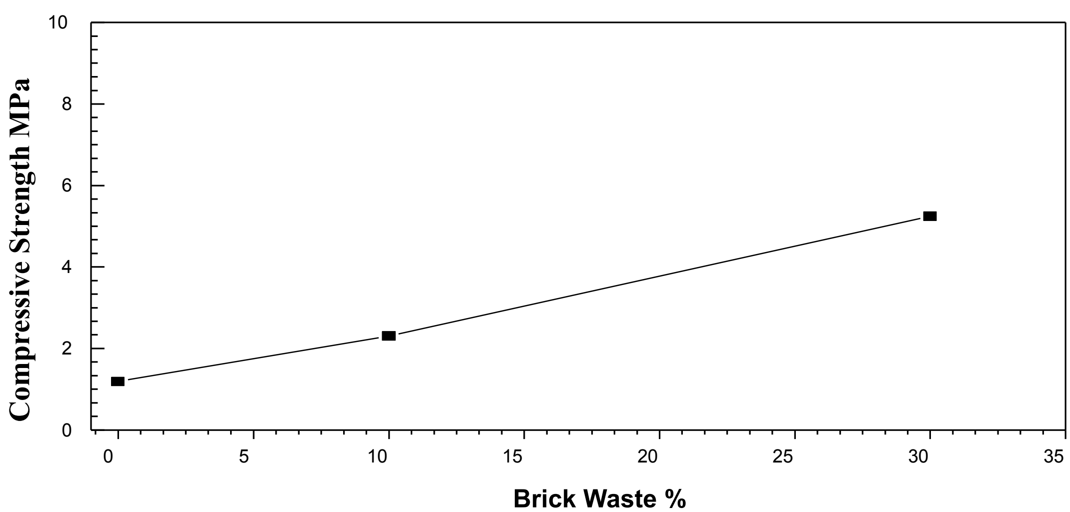


Figure (4.11): compressive strength with different ratio of brick waste for extruded samples

CHAPTER FIVE
CONCLUSIONS
&
RECOMMENDATIONS

5.1 CONCLUSIONS

1- Using two suitable methods to preparation the brick by semi – dry pressing and extrusion process. Extrusion process more suitable method to preparation new bricks (with brick waste) than pressing process.
2- The porosity and water absorption decrease as the ratio of brick waste will increase, and for presses samples better than extruded samples.
3- The density increase as the ratio of brick waste will increase, and for presses samples better than extruded samples.
4- the pressed samples did not show traces of efflorescence, while the extruded samples showed traces of efflorescence on their surface
5- The compressive strength of samples increasing with decreasing the ratio of brick waste will increase. , and for presses samples better than extruded samples.

5.2 RECOMMENDATIONS

1- Studying the effect of nano brick - waste additives on the same raw materials properties.
2- Studying the effect of different calcinations temperature brick properties.
3- Studying the effect of different types of waste additives (glasses waste, building waste... etc.) on the ceramic materials properties.

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