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PRODUCTION OF BUILDING BRICKS WITHOUT BURNING OF SUSTAINABLE MATERIALS

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Abstract

The production of high-performance sustainable construction bricks without burning. The process of reusing materials is considered one of the great and influential concerns in the world where the field of sustainable engineering has become the subject of interest of researchers around the world. This paper included the production of building bricks according to the Iraqi description and with high resistance without burning compared to the solid clay bricks. The results of resistance to compression, absorption ratio and inequality were compared to the production structural unit. With high efficiency for all tests and for various reusable materials. Currently there is increasing pressure on energy efficiency for new buildings around the world. This has been partly caused by increased public awareness of the construction of sustainable buildings. In addition, there is pressure on building materials and manufacturers because of new government legislation in the world aimed at reducing energy use and carbon dioxide emissions in new buildings. Research reports on non-flaming building materials called "sustainable technology" in building construction aimed at reducing high-energy inputs, particularly those resulting from the release of clay bricks into furnaces .Cement was used to formulate non-flaming clay brick test samples mostly as a control. The work of the researcher in the development of non-flaming bricks in this field is a great scientific achievement Scientific results such as pressure strength and absorption ratio and other characteristics were among the accepted engineering standards for mud construction units. The non-burning materials showed efficiency in the use of energy and suggested a tremendous economical alternative. This study is one of the attempts to compare burned and unburned bricks as well as the combination of energy use and carbon dioxide emissions for unburned bricks for those used in mainstream construction.

Introduction

For almost 5000 years, fired clay bricks have been used as a construction material in the world. Because baked clay brick is more resistant to cold and damp weather, it can be used to build permanent structures in temperate climates. Fired bricks were used by the Romans, and the Roman troops, which

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had movable kilns, spread bricks throughout the empire. Brick was relegated to low or medium-rise constructions in the late twentieth century, or as a thin decorative veneer over concrete and steel buildings, or for internal non-load bearing walls. The manufacturing process was straightforward: the clay was pulverized and combined with water to the proper consistency before being poured into a mold. A hydraulic press is used to press the clay into steel molds. The formed clay is then burnt (or "burned") at a temperature of about 900 degrees Fahrenheit. To achieve strength, heat to roughly 1000-1300°C. This is commonly done in a continuously fired tunnel kiln in modern brickworks, The kilns used to fire bricks consume a lot of fuel, resulting in a lot of energy consumption and emissions into the atmosphere. Several gases (including carbon gases, hydrogen, and fluorine) and particles are routinely released from brick kilns throughout the manufacturing process. For many countries, these emissions are becoming a major environmental concern.

Some secondary materials and waste kinds are also utilized in the construction of unfired clay bricks as partial substitutes for main clay and as stabilizing agents.

This was developed to address the significant energy input required to create fired clay bricks while also correcting the flaws inherent with sun-baked bricks. Economic growth, more effective resource use, enhanced energy-efficient construction methods, and a reduction in the use of fossil fuels for firing traditional clay bricks are all potential benefits mentioned in this study. The idea of replacing burnt clay bricks with unfired clay bricks in the construction sector has recently sparked renewed interest in research around the world. A detailed grasp of soil stabilisation and the applicability of various wastes, recycled materials as target stabilisation materials or as stabilisers themselves is also required to realize the predicted benefits of our current work (1). Sustainability is defined as preserving natural resources and improving the quality of life for people who use natural resources and energy in a way that allows future generations to live in peace [2].Construction projects use a lot of resources, generate a lot of heat, generate a lot of power, and generate a lot of waste. All of this contributes to pollution. Reducing the negative impact on the environment necessitates the deployment of effective approaches based on a sustainable member philosophy for construction projects [3]. There are three components of sustainability: the environment, society, and economy, which make the life-cycle performance as shown in Figure (1). If the three above components are considered with circle equal in the size the intersection of these circles represents comfort human [4].

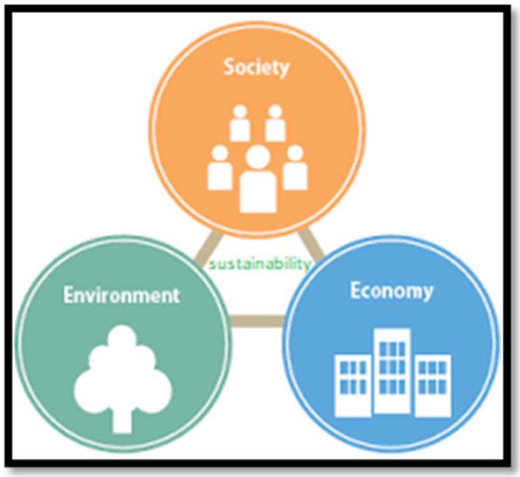

Figure (1) Life-Cycle Performance [4]

Burnt clay brick production and consumption are still widespread worldwide. Brick manufacture is thought to be dominated by China [5]. India is the second-largest producer of bricks, generating 180 billion tons of them annually [6].An worrisome scenario has resulted from the extensive usage of natural resources like clay [7-9].Moreover, the environmental issues are being exacerbated by the day-to-day rise in trash output.As a result, researchers are working to create new building materials that use waste resources. Consuming waste materials will not only lessen the environmental load but also lead to an affordable and long-lasting solution. Moreover, the environmental issues are being exacerbated by the day-to-day rise in trash output.
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Bricks with increased performance have been produced from a variety of waste sources. Burnt clay bricks were successfully made using waste glass, fly ash, and industrial and agricultural wastes [10]. Clay bricks can be made stronger and more porous by using leftover glass[11-12]. . The use of fly ash in the construction of bricks was also quite successful. For fly ash bricks, improved strength and water absorption were seen. Additionally, using fly ash contributes to green building and is environmentally friendly [13-14]. In order to reduce airborne infections and environmental pollution, marble powder can be used in burnt clay bricks. It has been discovered that using marble powder in place of 15-20% of the clay by weight is efficient when making bricks [15].

1.2. Objective

Use of recycled materials to produce bricks without burning process and thus reduce the percentage of clay used in the manufacture of bricks and preserve the environment from toxic gases resulting from ignition .

2. Materials

Mixing ratios.

The main features of the design of the construction brick mix indicate the stability of portland cement content and the change in both the proportion of sand and reusable material with a variation in the percentage of water by each mixture. The mixing ratios used in this study are weight ratios and through the experimental mixture adopted in this study were as follows:

Cement weight 1500g
Sand weight 3000 g
Water weight 750 g

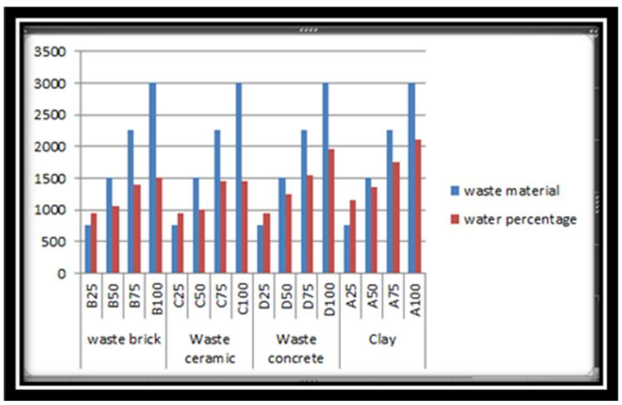
Through the experimental mixture, mixing ratios were adopted for the rest of the material and as in table 1.

Table (1) experimental mixture

Waste material percentage	Cement (C) (gm)	Sand (S) (gm)	Waste material(gm)	Water(gm)
1-ceramic 25%	1500	2250	750	950
50%	1500	1500	1500	1050
75%	1500	750	2250	1400
100%	1500	0	3000	1500
2-brick 25%	1500	2250	750	950
50%	1500	1500	1500	1000
75%	1500	750	2250	1450
100%	1500	0	3000	1450
3-waste concret 25%	1500	2250	750	950
50%	-1500	1500	1500	1250
75%	1500	750	2250	1550
100%	1500	0	3000	1950
4-clay	1500	2250	750	1150

25%				
50%	**1500**	**1500**	**1500**	**1350**
75%	**1500**	**750**	**2250**	**1750**
100%	**1500**	**0**	**3000**	**2100**

*Through table (1) it is found that the ratio of cement is stable and the percentage of sand changes depending on the proportion of reused materials. In the proportion of 25% of the reused material, the sand has been replaced by 25%, meaning the ratio of sand will be 2250 grams and the reusable material 750 grams (2250+750 =3000)



Relationship between percentage of material and water

2.1. Cement

Ordinary Portland cement (type 1) is used in this work. They are stored in an appropriate condition to avoid any external exposure.

Tables 2 and (4) respectively show the chemical composition and physical properties of cement used in the experimental study to produce construction bricks. The cement used complies with Iraqi specifications No. 5/1984 (19) and table (3) shows the main components of the cement calculation using the Bojo equation.

2.2. waste material

Reused materials were used in the manufacture of construction bricks where ceramic break, brick break, concrete and clay were used collected as materials in excess of the need from nearby construction areas and were then cleaned from suspended impurities and then milled and sifted to make their softness mimic the softness of cement to integrate mixing materials when mixed and integrated.

2.3. Fine aggregate

Natural sand has been selected and used in traditional mixtures, while soft sand (glass) is selected and used for special mixtures for the production of building bricks in our research. Table 5 shows the classification of the natural sand used. The results indicate that the exact aggregate classification is within the requirements of the Iraqi standard specification No. 45/1984 (20).

2.4. Water

Potable, acid-free water and impurities in aggregate should be used. Water quality and quantity must be checked obligatorily.

Table (2) Chemical Compounds* for Cement

Oxide Composition	Abbreviation	Content by weight (%)	Limit of Iraqi Specification No.5/1984[19]
Lime	CaO	63.11	-
Silica	SiO_2	20.66	-
Alumina	Al_2O_3	5.13	-
Iron oxide	Fe_2O_3	3.36	-
Magnesia	MgO	2.32	5.0 (max)
Sulfate	SO_3	2.05	2.8 (max)
Loss on ignition	L.O.I.	2.39	4.0 (max)
Insoluble	I.R.	0.68	1.5 (max)
Lime saturation factor	L.S.F.	0.93	(0.66-1.02)%

Table (3) Main Cement Compounds (BoJo Equation)

Tricalcium Silicate	C_3S	54.72
Dicalcium Silicate	C_2S	18.04
Tricalcium Aluminate	C_3A	7.92
Tetracalcium aluminoferrite	C_4AF	10.21

Table (4) Physical properties of the cement used*

Physical Properties	Test Results	Limits of Iraqi Specification No.5/ 1984 [19]
Specific surface area(Blaine method),(m^2 /kg)	330	230 (min)

Setting time (vicat's apparatus) Initial setting time, (hrs: min.) Final setting time, (hrs : min.)	1 : 50 3: 40	0:45 (min) 10:00 (max)
Compressive strength, (MPa) 3 days 7 days	27.2 37.4	15 (min) 23 (min)
Soundness (Autoclave method), (%)	0.22	0.8 (max)

Table (5) Fine debris gradient

Sieve size (mm)	Natural sand (for NSC) *		Fine sand (for HFRPC)**	
	Cumulative passing %	Limits of Iraqi Specification No.45/1984 [20] for Zone 2	Cumulative passing %	Limits of Iraqi Specification No.45/1984 [20] for Zone 4
10	100	100	100	100
4.75	100	90-100	100	95-100
2.36	98	75-100	100	95-100
1.18	88	55-90	100	90-100
0.600	52	35-59	95	80-100
0.300	26	8-30	53	15-50
0.150	9	0-10	10	0-15

*All tests were made in the National Center for Construction Laboratories and Research (NCCLR), Baghdad, Iraq.

** The test is performed in the constructural Materials Laboratory of faculty of Engineering Al-Mustansiriayah University Iraq.

3. Creating mixing materials

The materials represented by cement, sand and clay were prepared, but for reusable materials, these excess materials were collected from nearby construction areas such as broken ceramics, broken bricks and concrete. The materials were assembled, prepared and cleaned from impurities and then milled in

the laboratory and then sifted with a sieve size 200 with a soft approach to the softness of the cement until it merged into the total mixture of bricks.
The images below are shown by the materials used and the tools of grinding, sifting, mixing and vibration.

Figure(2) materials before grinding process

Figure (3) materials after grinding and sifting

Figure (4) wooden molds used in casting

4- Casting procedure

The molds are filled with the prepared mixture in two equal layers. Each layer is compressed using the same vibrator. After the top layer has been pressed, it is settled using a steel shovel. After this stage, all samples are covered with nylon sheets to prevent moisture loss. After 24 hours, samples are extracted from the molds and then treated in the water.

The samples were prepared for the mechanical properties of the construction brick. The control models include 16 brick models according to the Iraqi standard specification No. 25 of 1988 dimensions (240*115*75) mm

Figure (5) Casting models and Open molds and take out samples after 24 hours

Figure (6) models of product bricks

Models produced where the symbols are as follows:

C :ceramics

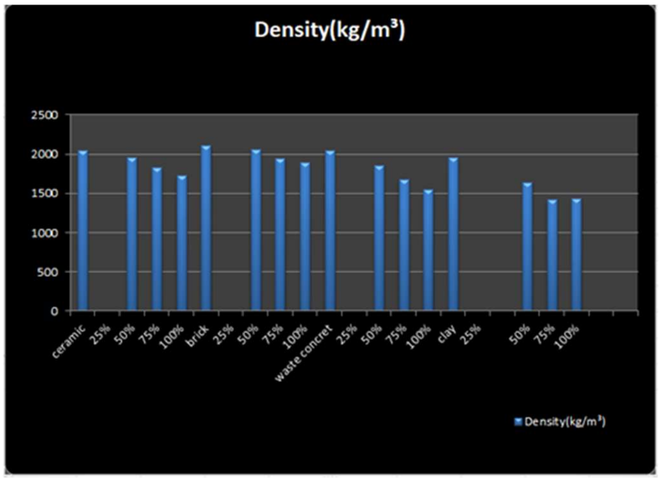
B :breaking the bricks
D : concrete
A: clay
Tests on the bricks

5.a- Density
The density of the brick produced was measured using the dimensions of the bricks (24*11.5*7.5 mm)

Table (6) Density of brick produce

Waste material percentage	Dry weight(kg)	Density(km/m³)
1-ceramic 25%	4.2218	2039
50%	4.0373	1950
75%	3.7973	1830
100%	3.5847	1730
2-brick 25%	4.3834	2110
50%	4.2666	2060
75%	4.0325	1940
100%	3.9293	1890
3-waste concret 25%	4.2537	2050
50%	3.8444	1850
75%	3.4780	1680
100%	3.2150	1550
4-clay 25%	4.0426	1950
50%	3.3986	1640

75%	**2.9463**	**1420**
100%	**2.9795**	**1430**



Relationship between density and percentage of material

2- Dimensions test

‣ Purpose

Know that the dimensions of the tabwah conform to the specifications for the purpose of using them in construction. Bricks usually work in technical standard dimensions on the basis of the ease of making, transporting and using it in construction to obtain as much binding as possible, so the width-to-length ratio is approximately equal to 2:1, while the fish varies between (5-10) cm and most likely 7 cm.

‣ Specification:-

The Iraqi standard 25 for 1988

Table (7) showing the results of the dimensions test

Symbol	**length**	**Width**	**thickness**
1	**190.5**	**91.9**	**61.5**
2	**192.1**	**92.3**	**61.9**
3	**192.2**	**92.5**	**60.56**

Average	**23.95**	**11.53**	**7.665**
Inequality	**0.21%**	**0.26%**	**2.2%**
level limits	**3±**	**3±**	**4±**

C- Absorption test

The absorption rate is to know the percentage of water absorption and the amount of tolerance of bricks to external pressures, i.e. the amount of water absorbed has to do with the porosity of the bricks where the higher the porous ratio, the greater the absorption of water. Porosity is defined as the amount and size of gaps in the material.

Absorption is defined as the ability of the substance to absorb water by the gaps in it.

Specification:-

*If the brick class (a) should be the upper limit of absorption ratios for the rate of 10 bricks is (20)."

*If the brick class (b) should be the upper limit of absorption ratios for the rate of 10 bricks is (24)."

*If the brick class (c) should be the upper limit of absorption ratios for the rate of 10 bricks is (26)."

Figure (7)Develop and take out models from the water basin

Figure (8)Drying models in the drying oven

Table (8) showing the results of the Absorption test

Waste material percentage	Dry weight	Wet weight	Water absorption(%)
1-ceramic 25%	4.2218	4.370	3.51
50%	4.0373	4.230	4.7
75%	3.7973	4.025	5.9
100%	3.5847	3.875	8.09
2-brick 25%	4.3834	4.520	3.11
50%	4.2666	4.420	3.59
75%	4.0325	4.210	4.4
100%	3.9293	4.195	6.7

3-waste concret 25%	4.2537	4.390	3.2
50%	3.8444	4.035	3.2
75%	3.4780	3.740	7.53
100%	3.2150	3.550	10.4
4-clay 25%	4.0426	4.225	4.51
50%	3.3986	4.025	18.43
75%	2.9463	3.735	26.7
100%	2.9795	3.535	18.64

3- Compressive strength

The purpose of the examination: -

Set compression resistance to bricks

- Iraqi standard 25 in 1988

Class A: Compression is equal to (18 N/mm2) per 10 bricks and (16 N/mm2).

Class B: Compression is equal to (13 N/mm2) per 10 bricks and (11 N/mm2).

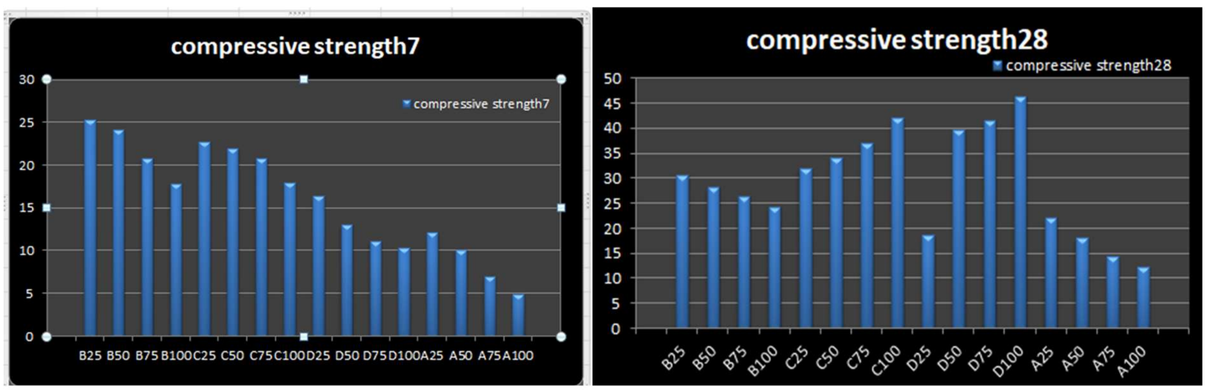
- Class C: Compression is equal to (9N/mm2) per 10 bricks and (7 N/mm2) .

Table (8) showing the results of the compressive strength test

Waste material percentage	Average compressive strength (N/mm^2)7days	Average compressive strength (N/mm^2)28 days
1-ceramic 25%	22.7	32.07
50%	21.9	34.2
75%	20.84	37.13

100%	17.9	42.2
2-waste brick 25%	25.33	30.6
50%	24.14	28.1
75%	20.84	26.26
100%	17.82	24.35
3-waste concret 25%	16.34	18.52
50%	13.001	39.74
75%	11.07	41.5
100%	10.35	46.42
4-clay 25%	12.09	22.02
50%	10.09	18.06
75%	7.01	14.3
100%	4.89	12.32

Figure (9) showing the compressive strength test



Relationship between compressive strength and percentage of material at 7 days And 28 days

Efflorescence test

Purpose:

Determine the percentage of salts in the bricks.

Standard screening specifications

Specification Standard Iraqi Iraqi standard specifications adopted in this standard Iraqi specification no. 24 for 1988)

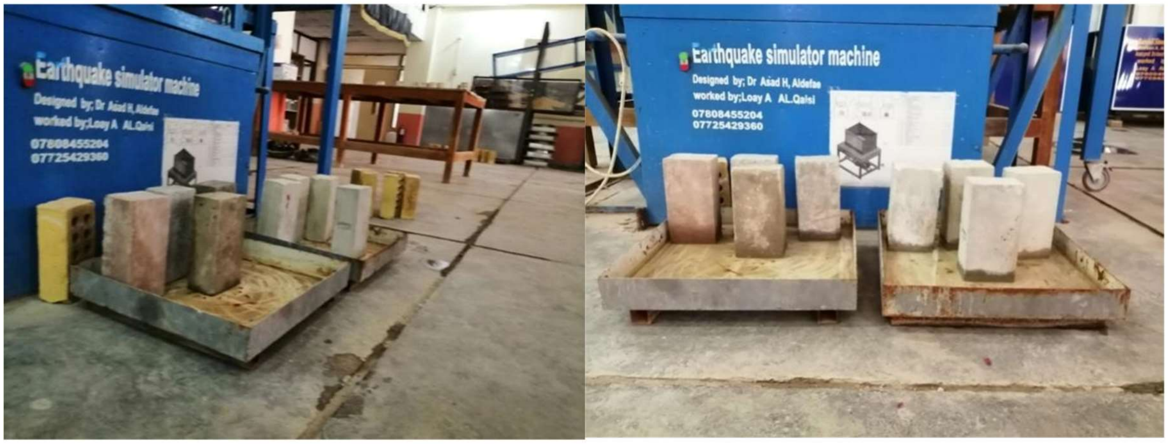


Figure (10)showed the Efflorescence test

5. Results and Discussion In this work

- Discussion of the results of mechanical properties of concrete tests6Through table 6 for dimensions of reusable materials, the ratio of variation in length and width as well as fish is identical to Iraqi specifications. Through table 7, the absorption rate of the produced bricks was very good. Through table 8, it was noted that the mechanical properties (compression resistance) of the building unit produced by bricks according to the Iraqi specifications by the dimensions of the standard Iraqi bricks (24, 11.5 and 7.5) were shown through During the pressure resistance test for the production bricks, the resistance to compression is very high compared to the iraqi solid brick, where the highest resistance to compression was recorded for the manufactured bricks of reusable materials. 25.33(Mika Pascal is seven days old and this value is very high compared to the resistance of compression to the silent Iraqi bricks). Where the compression resistance test was carried out for a group of clay bricks manufactured in Iraqi factories, the pressure resistance rate was recorded(6.197) Mpa Therefore, the brick produced is higher than the first class, which was the ratio in the refinery (18) Mpa The highest compression resistance value was 25.33 Mpa, while the smallest was 4.89 mpa Pascal at the age of seven days. While the highest compressive strength value was recorded at 28 days for the recycled concrete brick, it was 46.42 Mpa , and efflorence was light.

The results of the examination of the bricks produced without burning when compared with the iraqi solid bricks show that the resistance of the cooker produced is much higher than the standard, as well as the ratio of absorption with the conformity of dimensions to the Iraqi describers and is considered a tremendous economic alternative, while preserving the environment of toxic gases.

6. Conclusion

- A wide variety of waste materials have been studied for the production of bricks.
- Although much research has been conducted, the commercial production of bricks from waste materials is still very limited. The possible reasons are related to the methods for producing

bricks from waste materials, the potential contamination from the waste materials used, the absence of relevant standards, and the slow acceptance of waste materials-based bricks by industry and public.

- For wide production and utilization of bricks from waste materials, further research and development is needed, not only on the technical, economic and environmental aspects but also on standardization, government policy and public education

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