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Effect of Firing Temperatures on Physico-Mechanical Properties of Clay Bricks Containing Reeds

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***Abstract*—This research studies the effect of changing burning temperature on some properties of clay bricks containing reed crumbs. The experimental program includes production of clay bricks by adding (5-25) % by weight of reed crumbs to the clay before burning. The effect of addition of reed crumbs on properties of the produced brick such as dry density, Water absorption, and compressive strength were studied. Results of this research showed that it is possible to produced lightweight clay brick by adding (5-25) % of reed crumbs. Result also showed that a relatively good dry density and compressive strength could be obtained from the produce clay bricks made from addition of 5% reed crumbs. This type of brick led to save environment from huge amounts of agricultural wastes which its burning led to huge environmental pollution. It is discovered that, rising burning temperature from 800°C to 900°C and then to 1000°C causes a slight decrease in compressive strength and bulk densities values of the produced lightweight fired clay bricks containing reed. On the other hand rising burning temperature to the same degree as above causes a slight increase in the values of water absorption of the manufacture lightweight fired clay bricks containing reed.The laboratory experiments showed that lightweight fired clay bricks containing reed crumbs could be manufacture in the same factories of production of ordinary bricks without need to new machines. The steps of manufacturing this kind of bricks were found in this research the same for the ordinary one. The process of manufacture of lightweight clay bricks containing reed showed economical method of producing this kind of bricks.**

***Keywords*: lightweight clay bricks; agricultural wastes; reed crumbs; dry density; water absorption; compressive strength.**

I. INTRODUCTION

The growth of reeds in channels and rivers causes a decrease in velocity and quantities of water in these channels and rivers (Figure 1). So these plants will be removed In order to purify water of rivers and channels, and then they will be burned in air to get rid of them. This process causes great pollution in the environment as a result of the production of carbon gas (CO, CO_2), and the disperse of agricultural wastes in the air causes air temperature to get raised. Recycling reeds (agricultural wastes) is the process of introducing them into a brick industry. This can help decrease the consumption of raw materials, energy usage, and environmental pollution.

The clay brick is one of the oldest building materials used by humans in Mesopotamia by Sumerians Since more than (5000) years ago B.C and it continued to be used in later ages with both burned and unburned types. It was used by the Babylonians Before about (7000) years ago, and it was also used in the construction of the ziggurat in Ur, 70 km south of Baghdad, as well as in Akrokov 5 km north of Baghdad about 5000 years ago. Many factors affect the quality of the bricks, including the raw materials, the method used in the manufacture and the temperature of burning. The main objectives of this research are Study the effects of changing burning temperature clay soil mixed with reed crumbs wastes in the process of lightweight clay brick on some properties of the produced bricks. Several local and international types of research were done to study the properties of the lightweight clay bricks made by adding different waste.

Bamhidi [1] discovered that, burning of additives agricultural wastes (sawdust, rice-peel, and seed-shell) increases the porosity of the final product resulting in enhanced thermal insulation properties while only a minor reduction in the mechanical strength was observed in addition the ignite of agricultural wastes during the firing process, providing extra thermal energy inside the product and decreasing the required external energy.

Okunade [2] found that , addition of sawdust (for burning out) and wood ash admixtures to a 70:30 parts by weight lacerate-clay mix causes a reduction in the dry density of the finished burnt brick product (from 1755 kg/m^3 for the control mix without admixtures to 1512 $kg/m^3$for mix with 10% sawdust content) and the wood ash admixture. In line with its pozzolanic reaction, it enables to participate in achieving denser products with higher compressive strengths, higher softening coefficients, lower water absorption rates, Increasing contents of sawdust in the mixes produced the opposite results in the finished products.

Fig. 1 The growth of Iraq reeds in channels and rivers

Ismail [3] studied the possibility of using organic residues in clay bricks as sawdust, tobacco residues and grass which were mixed with clay at (0, 2.5, 5, and 10) present by weight. Effects on shaping, plasticity, density, and mechanical properties were investigated. He discovered that the fibrous nature of the additives did not make extrusion problem and higher residue addition required a higher water content to ensure the right plasticity.

Halima and Bachir [4] discovered the effect of the addition of a variety of sawdust materials in the production of lightweight insulating bricks. The chemical and mineralogical composition of clays were determined and the clay bricks were fabricated with different quantities of materials (3 to 6 and 9 wt. % for sawdust, 65 wt. % for grey clay, 24 to 27 and 30 wt. % for yellow clay and 2 wt. % of tuff) and firing at 800 and 900°C . They find that up to 9% Eucalyptus sawdust can be incorporated into the material mixture (clays and tuff) and bulk density varies between 1.48 and 1.65 g/cm^3 when sawdust is incorporated. Therefore they can be used in lightweight building material, and the Water absorption and bending strength decreased with the shaping moisture increase.

Jassim [5] improved the local clay brick properties by addition rice husks ash and sawdust at different ratios (2, 3.5, 5 and 6%) from soil weight. He found that best rice husks ash addition ratio was (3.5)% of bricks soil weight and compressive Strength, Flexural Strength, Water absorption and the efflorescence was increased while the density was decreased compared with the reference values.

In this research, Agricultural (reeds) wastes are used to mix with clay to manufacture lightweight clay bricks. This is the most favorable method to fix the problem of getting rid of these waste materials. This research aims to produce this kind of bricks in the same factories of production of ordinary bricks without a need to new machines, since the steps of manufacturing this kind of bricks are the same for the ordinary one, so there are no needs to add any chemical materials.

II. Materials and Method

A. Clay

Adequate quantity of clay was brought from the AL-Nahrawan quarry in Baghdad region to be used in this research. The clay was cleaned and cleared of foreign and organic materials, and then it was dried in an oven to a temperature of 110°c for 24 hours and ground with an iron ball mill to be passed from sieve No. 22 (710) micron. Many tests were done on the clay to study its properties. The physical and chemical properties of the clay used are shown in Table (1).

TABLE I
CHEMICAL PROPERTIES OF THE CLAY USED.

Chemical symbol	**Content in soil (%) Standard**	**Standard requirement[6][7]**
SiO_2	40.80	50-60%
CaO	16.04	5-10%
Al_2O_3	10.49	20-30%
Fe_2O_3	4.90	5-7%
MgO	2.42	1%
K_2O	1.3	2-2.76%
Na_2O	1.08	0.1%
SO_3	2.0	……
T.S.S	2.28	……
L.O.I	18.6	3-4%

TABLE II
PHYSICAL PROPERTIES OF THE CLAY USED.

Type of Test	**Result**	**Test Specification**	**Specification Limit**
Moisture Content %		ASTM D4318 [7]	
Liquid Limit	32		Not more than
Plastic Limit	21.3		Not more than
Plastic Index	11.3		Not more than

TABLE III
THE GRAIN SIZE DISTRIBUTION OF THE USED CLAY.

Type of Test	**Results**	**Limits[8][9]**
The grain size of		
sand	21	20-45%
silt	45	25-45%
Clay	34	20-35%

B. Reeds

Local reeds were used in this study.it was brought from banks of the river in Baghdad region. The shape of reeds was a shredded and 4 cm length. The main characteristics of the used reeds are shown in Table (3). A special manual procedure was used to product reeds crumbs using a small hammer and electrical saw (Figure 2). The reeds were cut off by using an electrical law, and then it was dried in an oven to a temperature of 110°c for 48 hours. The dried reeds were ground by small hammer and converted to crumbs passed from sieve (52) size (300) to be ready for use as an additive for the production of lightweight bricks as shown in Fig (1).

TABLE IV
CHARACTERISTICS OF THE USED REEDS (%) [10]

Description	Abbreviation	Value (Index)
Specific gravity	G.S	2.44
Silica (%)	SiO2	65.2
Sulfur trioxide (%)	SO3***	1.52
Calcium (%)	CaO	6.4
Alumina (%)	Al2O3	12.3
Iron (%)	Fe2O3	2.6
Potassium (%)	K2O**	2.5
Chloride (%)	CI	N.R
Sodium (%)	Na2O	N.R
Phosphorus (%)	P2O5	0.03
Magnesium (%)	MgO	N.R
Titanium (%)	TiO2	0.19
Manganese (%)	MnO	0.08
Moisture Content (%)	w	0
Loss on Ignition (%)	L.O.I	1.47

Fig 2 Electrical Saw

C. Mix Proportions and Mixing Process

In order to create the four added reed mixtures for the formation of lightweight clay bricks, the reed was added to the soil with addition rates ranging from (5, 15, and 25) % of the soil weight. The plasticity coefficient was measured according to the Pfefferkorn method [11] in a way to determine the amount of water needed for each addition of the reed crumbs. The plasticity coefficients for soil without and with different percentages of the added reeds are shown in Table (4). The mixing process was carried out in a pivotal pan, and the dough basin was carefully cleaned before each mixing process. To prepare the reference mixture, the soil was moistened with the necessary water (according to the plasticity coefficient), and the mixing process was done in the pivot pan for 15 minutes in order to obtain a homogeneous mixture. As for mixtures containing reed crumbs, the specified amounts of soil and reed crumbs were mixed into the pan for 10 minutes without adding any water to obtain a homogeneous mixture, After that, the water was added to the dry mixture and mixed for 15 minutes again. After the mixing process is completed, the mixture is placed in a closed-loop container for 24 hours to ensure the homogeneous of water with the mixture and disintegration of clay blocks.

TABLE V
THE PLASTICITY COEFFICIENTS FOR SOIL WITHOUT AND WITH DIFFERENT PERCENTAGES OF THE ADDED REEDS.

Mix symbol	Raw materials	Plasticity coefficient (%)
S	Clay (reference)	31
S1	Clay + 5% reed	34
S3	Clay +15% reed	44
S4	Clay + 25% reed	52

D. Samples Formation, Drying, and Firing

The clay bricks samples are formed in the laboratory by Extruded extrusion of air method, using vacuum extruder (Figure 2) a sample of 38 mm width, the thickness of 25 mm and 75mm length dimensions was made. The samples were left in the laboratory to be dried in air for seven days ,and then they were transferred to the drying oven to be dried to a temperature (110±5)°C. After that bricks samples were removed from the oven and left to cool at laboratory temperature (23±2)°C for 48 hours according to requirements of ASTM Standard C67 [12]. The burning process begins by transferring dried samples to an electric furnace where the heating rate and the soaking time are fixed. The dried bricks samples were arranged inside the furnace (Figure 3) in a way to ensure that the heat reaches all facets of the samples equally and to ensure a regular burned process. To determine the optimum temperature that gives the best properties of the product, The dried clay bricks samples were burnt at three degrees of burning (800,900,1000)°C by using electrical furnace (Figure 4). The dried bricks samples of each mixture were burned separately using the same burning program and at the time of soaking for two hours until reaching the intended burning temperature (800, 900, 1000)°C. The burning rate becomes 2°C per minute, to ensure sufficient time for burning of all organic materials with the release of carbon dioxide completely. After the burning process was completed, the furnace was switched off and the bricks samples were left inside until the temperature gradually decreased to the temperature of the laboratory. For testing, the burned bricks samples were removed from the furnace.

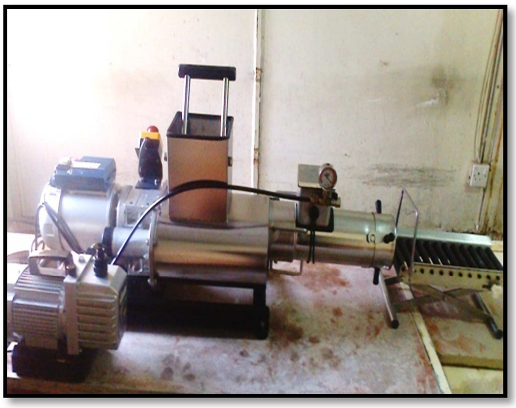

Fig. 3 Laboratory clay extrusion device

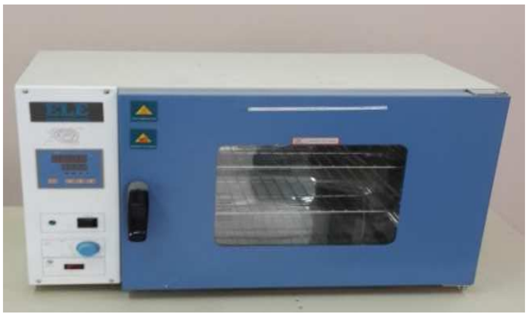

Fig. 4 Curing and drying furnace.

Fig. 5 Burning Furnace.

E. Physical Testing of Bricks Samples

1) Bulk Density Test: After burning process, the bulk density of the burned bricks samples was calculated according to ASTM C373 (ASTM C373) [13], the test includes two steps:

- The brick samples dried into a fixed mass (D)by warming the samples in an oven at 150°C (302°F). After that, we calculate the dry mass, *D*, to the nearest 0.01 g
- After impregnation, the mass (S) of each sample was in. It was suspended in water, and its saturated mass (M) was determined. The dimensions of samples were measured by venire caliper and the weight by a balance with an accuracy of (0.1g). Bulk density value was considered as the rate of examination of six specimens of each mixture.

$$B = D.Vf \quad (1)$$

Where:
Bulk Density (g /cm^3)
D: brick Sample weight after drying(g).
V f: brick sample Volume after burning (cm$_3$).

2) Water Absorption Test: The water absorption test is an indicator of the proportion and type of pores in the burned body. The water absorption of burned bricks samples was calculated according to ASTM C373 (ASTM C373-88, 2006) [13]. The test procedure includes three steps :

- The same procedure in step one in bulk density test was followed here.
- The models of the brick were placed after being cooled and stabilized in a water basin in a manner that ensures water circulation around the samples. Provide the bottom of the basin with a metal mesh to prevent direct contact between the examined models and the bottom of the basin and some of them and some ensure the free circulation of water between the bricks and the bottom. The brick dried models samples will be boiling in Distilled water for 5 hours. Then the models were left to cool in water to room temperature for an additional 24 hours.
- The models were removed from the basin and wiped the water with a cloth and then weigh it (determine the saturated mass, M,)

$$\%W = \{(M - D)/D\}X100 \quad (2)$$

Where:

W: Water Absorption

M: weight of brick after 24 hours in water (g)

D: brick Sample weight after drying(g).

In this test, the rate of examination of six samples of each mixture was considered as water absorption value.

3) Compressive Strength Test: One of the most important tests of bricks and considered as an indicator of the resistance of the product to the external forces placed on it. This test was explained in ASTM standard ASTM C373-88, 2006[13]. According to these specifications, The full height, width and one half of full length of the brick samples dried into a fixed mass (D) by warming the samples in an oven at 150°C (302°F), After that, we calculate the dry mass, D, to the nearest 0.01 g. The brick placed between two plywood sheets and carefully centered between the plates of the compression testing machine as shown in (Figure 3). The load applied at a uniform rate until failure occurs. The compressive strength was calculated by dividing the external load at failure with the applied load area of the brick samples. The rate of examination of six specimens of each mixture was considered as compressive strength value, as follows:

Compressive strength = Load at failure/area subjected to load

Fig. 6 Compressive strength test machine.

F. *The result of Physical Properties Test*

The effects of changing firing temperature on the properties of fired clay bricks are shown in Tables (5). It was observed that most of the reference models and the models containing reeds showed a yellow color when they burned at a temperature up to (1000) °C with varying degrees of yellowing. The models containing reeds showed a light yellow color. Most of the samples showed an external appearance free of defects and cracks, while part of the rest of the cases recorded the appearance of a slight curve in the edges probably because of the extrusion process during the production of the bricks sample. Few percentages of samples showed external cracks probably due to high firing temperature (1000) °C and high addition percentage of sand (21%).

TABLE VI
EFFECTS OF CHANGING FIRING TEMPERATURE ON PHYSICAL AND MECHANICAL PROPERTIES OF FIRED CLAY BRICKS

Mix	Firing temperature	Bulk density(Kg/ m^3)	Water absorption (%)	compressive strength(N/ mm^2)
S (Soil only)	800	1590	19.06	12.64
	900	1579	19.64	12.47
	1000	1610	18.46	13.04
S1 (S + 5% Reed crumbs)	800	1464	25.02	10.55
	900	1440	25.44	10.46
	1000	1405	25.81	10.37
S2 (S + 15% Reed crumbs)	800	1270	36.56	7.55
	900	1221	37.15	7.1
	1000	1193	37.85	6.65
S3 (S + 25% Reed crumbs)	800	1099	47.21	4.36
	900	1035	48.53	3.75
	1000	935	49.02	3.23

III. RESULTS AND DISCUSSION

A. *Bulk Density Result*

The results of the bulk density tests are presented in Table (6) and plotted in Figs (1) and (2) for all mixtures. Test result found that, the bulk density value of reference mix (S) made from soil burned at (800) °C was equal to (1590) Kg/m^3which is higher than the same mix but burned at (900)°C and equal to (1579) Kg/m^3 and lesser than the bulk density of the same reference mix but burned at (1000)°C and equal to (1610) Kg/m^3. These behaviors were due to two factors affecting bulk densities values. The first one is the breakdown of calcium carbonate and organic materials which release of carbon dioxide. The disappears of calcite mineral due to the breakdown of $CaCO_3$ carbonate at a temperature of (800 - 950)°C, which continues until the maximum burning temperature, leaving a low-density porous particle. This is confirmed by the chemical analysis of the soil as the value of (L.O.I) about (18.6 %) causing a decrease in the value of the density of the product. This process increases porosity and reduces density. The second factors affecting bulk densities values is the increase of the amount of bonding material and mineral phases when the mixes burned at a temperature of (1000)°C obtained from the process of sintering, which reduces the porosity and increases the bulk density and the factor that overcomes the other shows its effect on bulk density of the body. This causes the effect of the increase of an amount of the bonding material and mineral phases when the soil burned at (1000) °C are more affected than the release of carbon dioxide. It was noted from the results of Table (6) and shown in Figs (1) that dry densities values of reference mix (S) burned at (800, 900,1000)°C are higher than the dry densities values of the mixes soil with 5% reed crumbs (S1) , mixes soil with 15% reed crumbs (S2) and dry densities values of the mixes soil with 25% reed crumbs (S3) burned at the same degree respectively. The percentage of decrease for the dry densities values of the mixes (S1), mixes (S2) and mixes (S3) burned at (800,900,1000)°C was (7.9,20.1,30,9), (8.8,22.67,34.45) and (12.74,25.90,41.9) compared to dry densities values of reference mix(S) burned at the same degree of firing respectively.

These results indicate a marked decrease in dry density with an increase in the percentage of the addition of the reeds crumbs. These attitudes were due to the reduce of the proportion of clay in the mixture and replace it with low-density reeds crumbs which led to decrease the number of mineral phases which are responsible for the density of the product after cooling. It was obvious from the result in Table (6) and plotted in Fig.2 that increasing burning temperature causes a slight decrease in dry densities. The percentage of decrease in bulk densities for clay bricks samples (S), (S1), (S2) and (S3) burned at (900)°C were (0.69,1.64,3.86,5.82) % compared to the same clay bricks samples but burned in (800)°C. More decreases in bulk densities were observed when the burning temperature raise over (900)°C and become (1000)°C. The percentage of decrease in bulk densities for clay bricks samples (S1), (S2) and (S3) burned in (900)°C were (2.4,2.2,9.6) % compared to the same clay bricks samples but burned in (1000)° C. These decreases in bulk densities are due to the increase in the percentage of loss of reeds weight when burning temperature rise from (800)°C to (900)°C and to (1000)°C which leaving a porous object and low density.

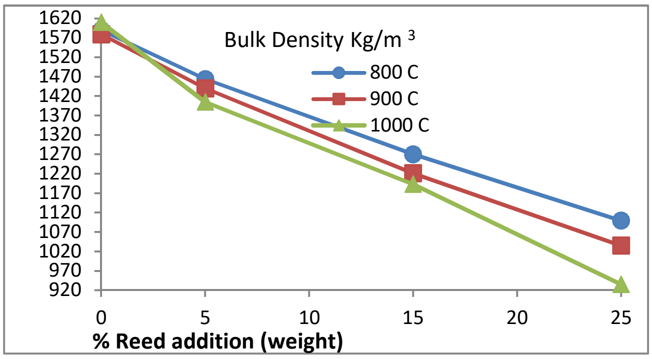

Fig. 7 Effects of % Reed addition on bulk dry density of fired clay bricks exposed to different burning temperature

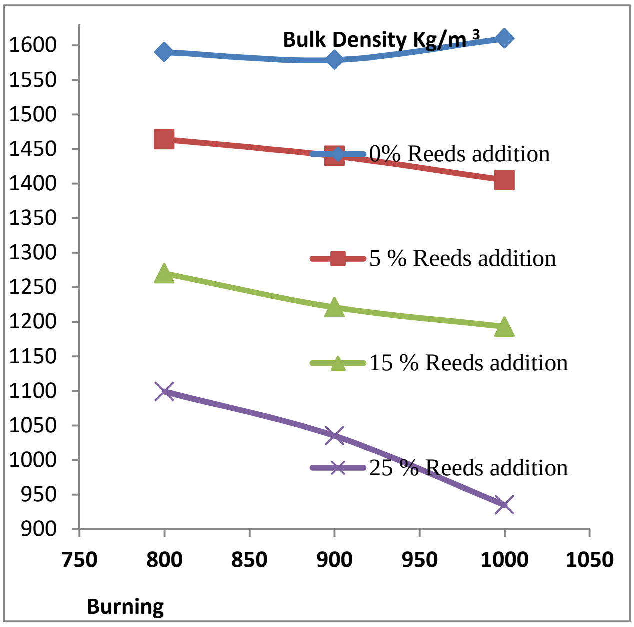

Fig. 8 Effects of burning temperature on bulk dry density of fired clay bricks containing different % Reed addition

B. Water Absorption Result

The water absorption test results are listed in Table (6) and showed in Figs (3) and (4). The water absorption of reference mix (S) made from soil only burned at (800)°C was (19.06) % which was lesser than water absorption of (19.64) % of same mix but burned at (900)°C and higher than water absorption of the same mix but burned at (1000)°C of (18.46) %. This is due to the disappears of calcite mineral due to the breakdown of $CaCO_3$ carbonate at a temperature of (800 - 950)°C causing a low density porous particle which increase the water absorption value of mix burned at (800)°C compared to the same mix burned at (900)°C, The increase the amount of bonding material and mineral phases when the mixes burned at a temperature (1000)°C led to reducing the water absorption value of the mix compared to mix burned at (900)°C.

The test results of the mix samples contain reed crumbs shows an increase in water absorption values with the increase in the addition of the reed crumbs compared to values of water absorption of the reference mix models made without reed crumbs. The percentage of increase in water absorption values of mixes samples (S1),(S2)and(S3) burned at (800,900,1000)°C were (23.82,47.86,59.62) % ,(22.8,47.13,59.53) % and (29.02,51.22,62.3) % compared to (S) burned at the same temperature respectively . This behavior which shown in Figs (3) are due to the release of gases caused by the burning of reed crumbs and resulting gaps and hair channels which increases the proportion of pores in the body of clay bricks in addition to the release of carbon dioxide caused by the breakdown of calcium carbonate in the soil. The replacement of a part of the soil with the addition of reed crumbs reduces the output of the metal phases that fill the pores. In addition to that, it is generally found from the results of the tests plotted in Figs (4) that rising the burning temperature from 800 to 900°C causes a slight increase in a water absorption values. For example, the percentage of increase in water absorption for clay bricks samples burned in (900)°C (S, S1, S2, S3) were (2.95, 1.65, 1.61, 2.71) % compared to the same clay bricks samples but burned in (800)0C. More increases in water absorption were observed when the burning temperature raise over (900)°C and become (1000)°C. The percentage of increase in water absorption for clay bricks samples burned in (1000)°C (S1, S2, S3) were (1.84,2.19,1.01) % compared to the same clay bricks samples burned in (900)°C. The increment in water absorption values with rising burning temperature from 800 to 900°C and then to 1000°C may be attributed to an increase in the number of free gases resulting from burning of reed crumbs and an increase in the amount of carbon dioxide released from the breakdown of calcium carbonate and burning of organic materials and these gases during their outflow causing an increase in the proportion of pores and their interconnections.

Results from Table (6) indicate that, the fired clay bricks with the percentages of incorporated reeds addition (5%) satisfied the water absorption requirements of ASTM Standard C 62 [14]of no limit (for max limit 5-hour boiling), for clay bricks grade NW, used for not exposed to severe abrasion by weathering action like partitions.

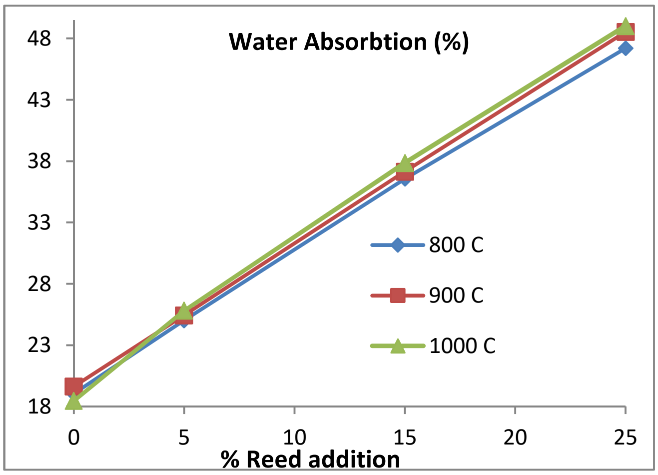

Fig. 9 Effects of % Reed addition on water absorption of fired clay bricks exposed to different burning temperature

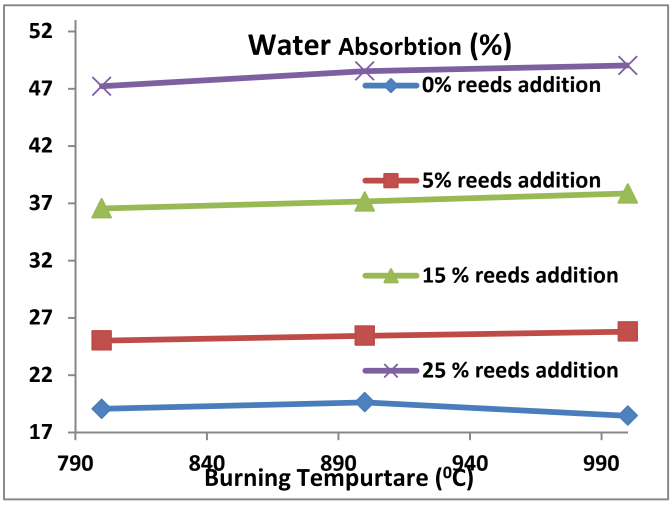

Fig. 10 Effects of burning temperature on water absorption of fired clay bricks containing different % Reed addition

C. *Compressive Strength Result*

The compressive strength affected by many interrelated factors such as metal components, burning temperature, chemical reactions between components and resulting in different phases. The results of the compressive strength test were included in a Table (6) and showed in Figs (5) and Figs (6). The compressive strength for clay bricks samples (S) decreases from 12.64 to 12.47 (N/mm^2) when the burning temperature rises from 800°C to 900° C.This behavior is due to the breakdown of calcium carbonate and organic materials which release of carbon dioxide. This process increases porosity and absorption, reduces density and compressive strength. In addition, the compressive strength of clay bricks samples (S) rises from 12.47 to 13.04 (N/mm^2) when the burning temperature rises from 900°C to 1000° C.This increases in compressive strength are due to the increase of the amount of bonding material and mineral phases obtained from the process of sintering, which reduces the porosity and increases density and compressive strength of the body. The results in a Table (6) also showed a significant decreasing in compressive strength with adding (5%, 15% 25%) reed crumbs to the soil used for the manufacture of clay bricks samples. The percentage of decreasing in compressive strength values of clay bricks samples (S1) , (S2) and (S3) burned at (800,900,1000)°C were (16.53,16.11,20.48) %, (40.26,43.06, ,49.03) % and (65.50,49,75.23) % compared to (S) burned at the same temperature respectively.

The decrease in compressive strength values may be due to the decrease of amount of mineral phases and bonding materials in clay bricks samples caused by the decreasing in proportion of clays within the content of raw materials increase in the amount of free gases resulting from burning of reed crumbs and the reduce of the amount of mineral phases which increase porosity and decrease compressive strength. Fig. (6) Represents the relationship between the compressive strength and burning temperature ranging from (800 to 1000)°C with different percentages of reed crumbs. It is noted that a slight decrease in compressive strength with rising the burning temperature from (800 to 1000)°C. The percentages of decrease in compressive strength for clay bricks samples burned in (900)°C (S, S1, S2, S3) were (1.35, 0.85, 5.96, 13.99) % compared to the same clay bricks samples but burned in (800)°C. While the percentages of decrease in compressive strength for clay bricks samples burned in $(1000)^0$C (S1, S2, S3) were (0.86, 6.34, 13.87) % compared to the same clay bricks samples but burned in $(900)^0$C. This decrease in compressive strength for clay bricks samples with rising the burning temperature from (800 to 1000)°C was caused by the increase in the number of free gases resulting from burning of reed crumbs when rising degree of burning from (800 to 1000)°C which led to increase porosity and decrease density and compressive strength . According to ASTM Standard C 62 [14], the minimum compressive strength (average for five bricks) for grade NW equal to (10.3) Mpa, this grade intended for use in building construction not subjected to loading such as interior masonry walls and partitions, not exposed to severe abrasion by weathering action. It is noted from the results of Table (6) that, the compressive strength of only mix (S1) which have values equal to (10.55, 10.46, 10.37) satisfies the compressive strength requirements for Grade NW of ASTM Standard C 62[14].

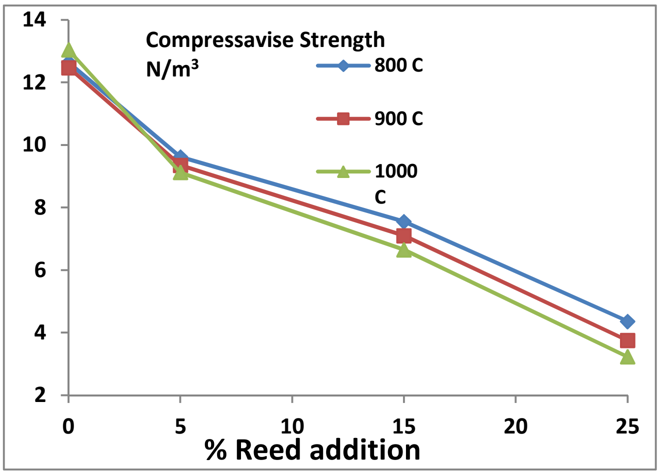

Fig. 11 Effects of % Reed addition on compressive strength of fired clay bricks exposed to different burning temperature

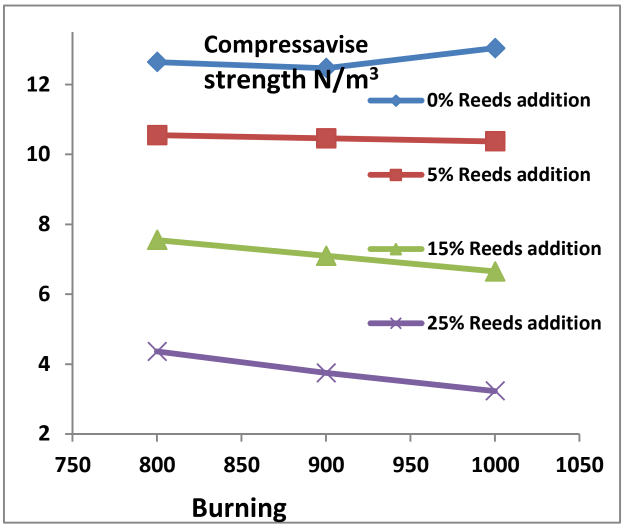

Fig. 12 Effects of burning temperature on compressive strength of fired clay bricks containing different % Reed addition.

IV. Conclusions

It is possible to produce lightweight fired clay bricks by incorporate not more than 5% (by weight) of reed crumbs to the clay soil satisfying the compressive strength and water absorption requirements for grade NW of bricks (used for partitions) according to for ASTM Standard C62 [14]. The incorporation of (5%,15%, and 25%) of reed crumbs cause decrease in the bulk density of the reference samples by (7.9,20.1,30,9) ,(8.8,22.67,34.45) and (12.74,25.90,41.9) when they burned at (800,900,1000)°C respectively. A slight decrease in bulk densities values between (0.69,1.64,3.86,5.82)% occurs when the burning temperature rise from 800^0C to 900°C for clay bricks samples with (0%,5%,15%, and 25%) of reed crumbs and A slight decrease also in bulk densities values (2.4,2.2,9.6) % for samples with (5%,15%, and 25%) of reed crumbs. The addition of (5%, 15%, and 25%) of reed crumbs causes a significant increase in water absorption. The percentage of increase in water absorption values of the mixes contain of (5%,15%, and 25%) reed crumbs samples are (23.82,47.86,59.62) % ,(22.8,47.13,59.53) % and (29.02,51.22,62.3) % compared to reference samples without reed crumbs when the degree of burning temperature (800,900,1000)°C respectively. A slight increase in the values of water absorption is found with the increase in the degree of burning temperature from 800°C to 900°C and then to 1000°C. It is discovered a significant decreasing in compressive strength with adding reed crumbs to the soil used for the manufacture of clay bricks samples. The percentage of decreasing in compressive strength values of clay bricks samples with (5%,15%,25%) reed crumbs when it burned at (800,900,1000)°C were (23.89,40.26,65.50)%, (25.02,43.06,69.93)% and (30.06,49,75.23)% compared to reference samples burned at the same temperature respectively. Rising burning temperature from 800°C to 900°C and then to 1000°C causes a slight decrease in compressive strength. The percentages of decrease in compressive strength for clay bricks samples burned in (800)°C were (1.35, 2.80, 5.96, 13.99) % compared to the same clay bricks samples but burned in (900)°C. While the percentages of decrease in compressive strength for clay bricks samples burned in (900)°, C were (2.46,6.34,13.87)% compared to the same clay bricks samples but burned in (1000)°C. The produce lightweight fired clay bricks could be manufactured in the same factories of production of ordinary bricks without the need to new machines, since the steps of this kind of bricks are the same for the ordinary one, and there are no needs to add any chemical materials.

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