Improvement of the Mechanical and Thermal Properties of Clay Bricks by Using Local Materials in Iraq

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ABSTRACT

This research studies the effect of adding industrial wastes materials with different percentages on the thermal and mechanical properties of clay bricks . Different types of admixtures were used in this work, including rubber cuttings, wood saw dust and barley reeds ash with (5%,10% 15% ,20%) by weight of each one respectively. Thermal conductivity, specific heat capacity, compressive strength, flexural tensile strength, porosity and variation of density have been examined for each samples at all percent of addition and comparing with the reference clay bricks samples . Test results show that the admixtures effect on the properties of clay bricks, when used barley reeds ash which the best additives because take good properties, the density of clay bricks is reduced 33%,thermal conductivity reduced 46% and the compressive strength increased 20% comparing with the standard bricks. The experimental work carried in the industrial factory of clay bricks in the Nahrawon city in Baghdad.

Keywords :Porous Brick , Inorganic Wastes , Organic Wastes ,Thermal Conductivity , Compressive Strength ,Density.

تحسين المواصفات الميكانيكية والحرارية للطابوق الطيني باستعمال مواد محلية في العراق

الخلاصة

يهدف البحث الى دراسة نوع جديد من الطابوق الطيني المتسامي, تناول البحث دراسة تاثير اضافة المخلفات الصناعية بنسب مختلفة على الخواص الحرارية والميكانيكية للطابوق الطيني, تم اختيار مفروم الاطارات ونشارة الخشب و مطحون قصب الشعير واضافتها وزنيا كل على حده بنسب (5% ,10% , 15% , 20%) لكل منها على التوالي, تم تقيم مقدار (التوصيل الحرارى, السعة الحرارية النوعية , مقاومة الانضغاط, الكثافة والمسامية) ولكل نسبة من النسب اعلاه ومقارنتها مع الطابوق القياسي (بدون اضافة). تم استنتاج ان استخدام هذه المضافات يوثر على خواص الطابوق الطيني وا ن ا ستعمال مطحون قصب الشعير هو افضل المضا فات وذلك لمواصفا ته الجيدة حيث قلت الكثا فة بنسبة 33% والتو صيل الحراري بنسبة 46% وزادت مقا ومة الا نضغا ط بنسبة 20% مقا رنة مع الطابوق القياسي. تم اجراء النماذج عمليا في معمل تصنيع الطابوق في مدينة النهروان في بغداد.

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Nomenclature

V_f --- volume of water absorbed---(m^3)
V--- volume of material sample---(m^3)
Q--- heat transfer rate---(kj)
K---thermal conductivity ---(w/ m.℃)
A---area (m^2)
T--- temperature (℃)
M---mass of sample (kg)
C---specific heat capacity (j/ g.k)

Greek:

ϑ --- porosity
θ ---change in temperature (℃)
ρ ---density (kg / m^3)

INTRODUCTION

Brick is one of the most common masonry units as a building material due to its properties . Attempts have been made to incorporate waste materials in the production of bricks , for example ,rubber cuttings[1] ,limestone dust and wood saw dust [2] , processed waste tea [3] ,fly ash [4,5] , polystyrene [6] and sludge [7] .

In summer the ambient temperature in Iraq is usually higher than (45℃) ,so preserving an inside condition of (26℃) in an air- conditioning space is a hard task . This task can be achieved easily by proper selection of building material . Thermal and mechanical properties of materials for civil engineering applications are of great importance for the houses performance . The thermal conductivity of materials has a direct effect on both the construction project and the comfort of the house environment . Thermal and mechanical bricks properties play an important role in designing modern building especially when considering wall properties such as insulation rigidity, weight and cost . Heat losses to or from buildings occupy an important factor in air-conditioning science .One of the main factors that affect cooling load in air-conditioning space in the thermal properties of building material such as thermal conductivity and density .

Decreasing thermal conductivity is the dominate factor in reducing heat that could be transfer to the building [1,8] .To enhance brick thermal conductivity properties several methods had been suggested to create voids within the brick [9] . The most common used method is to create uniform cylindrical holes inside brick . This type of brick has disadvantage of that the mortar can enter in to the holes of the brick during wall building which is undesirable since an increase in wall density and thermal conductivity is observed , all these changes in the wall properties are undesirable since increasing thermal conductivity will increase the transfer of heat which result in increase in cooling load while increasing density may increase weight and cost [10] . The enhancement of thermal insulation of brick permits

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significant reduction in building cooling load , rely it is an energy saving matter if once can reduce cooling load sufficient lomaintain constant temperature of (26℃) in a building , so many researches focus their attention in this field. One of the main advantages of reducing thermal conductivity is that a thin wall of low thermal conductivity can replace thick wall where both may reduce heat that could be transmitted through them . The existing of voids inside the bricks have an advantage strength ,weight ratio ,better tensile strain capacity and lower thermal expansion ,as well as superior heat and sound insulation characteristics . New technology involves using light weight construction materials , which comparing to common used brick , have lower thermal conductivity and lower bulk density with higher compressive stress values .Anew proposed method is used where clay is mixed initially to rubber cuttings , wood saw dust ,barley reeds ash, limestone dust , waste tea, polystyrene with different mass fraction , then the mixture (clay plus additives waste) is shaped in a mold as a brick ,the new row brick is fired in brick oven where finally a good performance brick is obtained.

The proposed method is aimed to maintain high compressive strength which result in high load bearing wall, enhance thermal insulation which means a decrease in effective wall thermal conductivity which will result in decreasing in heat that could be flow to or from the wall and decease in density which will lower structural dead load , easier handling ,lower transport costs and higher number of brick produced per tones of clay [11]. It is useful to show some previous studies related to the present research .

Lacrrier et ,al [12] . " Analyzed numerically the vertically perforated bricks .They reported that walls can be constructed without any other materials than clay and mortar . They reported that heat transfer in these assemblies is not totally understood. For perforated brick construction ,it is indicated that convection heat transfer is negligible in the perforations. Therefore , the thermal resistance of the brick increases .In a particular study of the ruptures it is concluded that the convection present in these regions is a local phenomenon since it breaks the thermal bridges created by the mortar fill .

Recently , del Coz Diaz j. j[13] " carried out an experimental and numerical study to investigate the thermal transmittance ,U,of a wall made of Arliblock bricks . They observed that wall insulation decreases with the increase in the mortar and material conductivities .They also noticed that changing the profiles of the holes alters the rate of the heat transfer through the hollow blocks . Then , they studied major variables influencing the thermal conductivity of masonry materials and carried out an optimization study for different brick geometries based on both thermal resistance and weight .

AL-Hazmy [14] . "Investigated the heat transfer through a common hollow building brick. Insulation assessment of the building blocks was examined based upon the heat transfer rate. Three different configurations for building bricks were studied including a gas –filled and insulation –filled cavity . Results show that the cellular air motion inside blocks cavities contributes

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significantly to the heat loads .The insertion of polystyrene bars reduced the heat rate by a maximum of 36 % .Lee and pessiki carried out a study to investigate the performance characteristics of precast concrete sandwich wall panels with two or three withes separated by air layers . It was found that , in general , the thermal performance of three-Wythe panels is better than that of two –Wythe panels due to the increased thermal path length. EZBAKHE . H [15] ," studied the properties of building materials are an important axis of research in economy of energy in building there are many methods of measurement of thermal conductivity , especially the method of guarded hot plate and the method of radial heat flax , these methods give thermal conductivity with agood accuracy but they are slow and different in the experimental .

J.J.GOZ.DIAZ [16] . " Studied the major variables in fencing the thermal conductivity of masonry material are illustrated in this work by taking blocks made from no-fine light weight concrete and different motor properties .

J.M.Sala [17] ." Explained adjustment procedure of a calibrated hot -box unit and execution of the corresponding tests to measure the dynamic thermal properties of wall needed to calculate the thermal load of building.

M.ZUKOWSKI [18] ."Study was focused on the vertically perforated masonry unit filled with prelate insulation .Based on measurement and numerical calculations the thermal performance of the new hollow brick was determined .

INORGANIC WASTES

Rubber cuttings

Chopped worn-out tires (Ch.w.t) brick consists of, aggregate chopped worn-out tiers at various proportions .Since the chopped worn-out have low density ,the product has the property of light weight ,the size of (Ch.w.t) particles varies ,and almost pass through sieves. Furthermore , (Ch.w.t) have favorable characteristics such as high resistance to weather changing conditions , very low water absorption .The chemical composition of these admixtures as shown in Table (1) .

PHYSICAL PROPERTIES

Grading

The grading of rubber cuttings, wood sawdust and barley reeds ash is the same of grading of sand according to the Limit of Iraqi specification No.45 /1984 (% by weight) and second grading zone ,the physical properties of rubber cuttings as shown in Table (2).

ORGANIC WASTES

Wood saw dust

Natural organic materials such as wood saw dust have been used for making light weight bricks .Saw dust is abundantly available in most places but it often contains substance which retards the hydration and hardening of

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bricks. The extent of deleterious effect varies with the type of wood . High drying shrinkage of wod saw dust -bricks limits its use to design where freedom of movement is possible. The chemical composition of wood saw dust as shown in Table (3) and physical properties in Table (4).

Barley reeds ash

Light weight brick using barley reeds as aggregate has been used for making precast bricks for walls and slabs for wall partitions . The waste products of barley reeds generated from the accumulation of the outer covering of barley grains during the milling process .This additive is used as apozzolana by special process to confirm the engineering requirements .The chemical composition of barley reeds are as shown in Table (5)and physical properties of barley reeds in Table (6).

MATERIALS

Clay

Table (7) Chemical composition of Clay (analysis was made at X-Ray diffract-Meter type XRD -6000) ,the clay pass from Sieve 0.075 mm size.

EXPERIMENTAL TEST

The main idea in creating porosity in brick is that the admixtures were used with different weight percentages of (5% ,10% ,15% ,20%) for rubber cuttings ,wood saw dust and barley reeds ash will be mixed with wet clay and the created wet brick enter the oven , the admixtures will be burn inside the bricks after it occupies an original volume inside the clay and after firing process the volume of the admixtures will be filled by the product of burning (ash and gases). The voids volume will be filled by gases since the resulting ash will occupy about (6%) of the original volume also the mass reduction is calculated and it is found to be about (90%). The additives (rubber cuttings, wood sawdust and barley reeds ash) will be burnt which result in gases and ash that have negligible weight and density , the porosity of the brick can be controlled by the initial mass fraction of additives that mixed with wet clay.

BRICK MANUFACTURING

The raw material (clay) is crushed and grinded ,then the blend of ingredients desired for each particular batch is selected and filtered then the wet clay is mixed with a proper mass of additives before being sent to brick shaping processes (pressing) , then the samples are dried to remove excess moisture that might cause cracking during the firing process. Next , they are fired in big ovens (900°C) for ten hours and then naturally cooled within two days.

DENSITY

A simple procedure has been used to measure the density of the brick where dimensional and mass measurements are used to obtain density also

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apparent porosity can be obtained as conforms to ASTM standard C373-88 [21]. The uncertainties are found to be around ± 0.2% .

COMPRESSIVE STRENGTH TEST PROCEDURE.

The compressive strength of bricks produced in the United States ranges from about (7 to 105 MPa) , varying according to the use to which the brick are to be put. In England clay bricks can have stress of up to (100MPa) although a common house brick is likely to show a range of (20-40 MPa).High compressive stress indicates good quality bricks and reduces crack formation .The typical range of compressive stress is (10-140MPa). ASTM C -62 specifies minimum compressive strength requirements which are for severe weather (21MPa) ,for moderate weather (17MPa) and for normal weather (Interior) 10MPa.

The compressive strength test procedure is as follow:

1- Test brick flat wise under compressive load.
2- The brick must be dried and its surfaced coated with shellac to prevent moisture absorption ,which can reduce the measured strength.
3- The bearing surface must be capped with capping material to provide smooth surface.

Compressive strength can be affected by many parameters such as porosity ,firing procedure, type of clay.The dry compressive strength of brick samples as shown in Fig.(1) is determined by using the compression test machine as shown in Fig.(2).The compression load is applied on to the face of the sample having a dimension of ($23 \times 11 \times 7$ cm^3). The compressive strength is determined by dividing the maximum load by the applied load area of the brick samples ($23 \times 11 cm^2$).The uncertainties in the compressive strength measurement device are found to be around ± 3.5%.

POROSITY

Presence of admixtures may increase , decrease or maintain the porosity of the main material depending on the aggregate sizes . The volume of liquid absorbed by a porous medium is an indication of its pore volume and it is a good a proximate measure of its porosity .Hence , porosity (ϑ) is obtained with the relation .The values of porosity are as shown in Table (9).The created voids brick reduce the effective thermal conductivity of brick, the created voids shown in Fig. (3-4-5-6).

$$\vartheta = V_f / V \times 100\% \qquad (1)$$

V_f = volume of water absorbed (m^3)

V = volume of material sample (m^3)

THERMAL CONDUCTIVITY TEST PROCEDURE

The experimental part was carried out in the Laboratory of department of material engineering in university of technology to determine experimentally the thermal conductivity of clay bricks samples of admixtures with rubber cuttings ,wood saw dust and barley reeds ash, the size of sample ($0.02*0.02*0.012m^3$) . The test apparatus (Less disc apparatus) type

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(Griffin and George) with tested the sample of clay bricks and some accessories to measure the temperature of both sides of the sample in order to calculate the thermal conductivity as shown in (Fig -7) .The values of thermal conductivity are as shown in Table(10).

The heater is switch on from the power supply with (V=6 vol and I =0.2 amp) to heat the brass disks 2 and 3 and the temperature of the all disks increase in nonlinear relationship and at different rates with the heat source .And the temperature were recorded every 5-minutes until reach to the equilibrium of all disks . The sample used to measure the thermal conductivity using the (Lee,s Disk) method is in the form of a disk whose thickness (d_s= 0.0035m) is small relative to its diameter (D=0.04) .Using a thin sample means that the system will reach thermal equilibrium more quickly . The heat transfer across the thickness of the sample is given by :

$$Q = K . A [T_2 - T_1 / d_s] \quad \dots \quad (2)$$

d_s = Thickness of sample =0.012 m

And the thermal conductivity can be calculated by using the following equation [19].

$$K = e [T_1 +2 / r(d_1 + 0.5 d_s) .T_1 + d_s. T_s /] / (T_2 - T_1 /d_s) \quad \dots \quad (3)$$

r = radius of Lees Disk =0.02 m

And the value of (e) can be calculated from the following equation [20].

$$I .V = \pi .r^2 .e .(T_1+T_3) + 2.\pi.r.e [d_1.T_1+ 0.5d_s(T_1+ T_2) +d_2.T_2+ d_3.T_3] \quad ..(4)$$

d_1 , d_2 ,d_3 = Thickness of Lees Disks = 0.012 m

The thermal conductivity measurement presented in this paper was measured using a guarded hot plate that conforms to ASTM Standard C177-85 [22].The accuracy of this procedure in the thermal conductivity measurement device is tested to be about ±4% of the true value of the thermal conductivity .

SPECIFIC HEAT CAPACITY

It is a measure of the thermal storage capacity of the material. The specific heat capacity of a clay brick indicates the relative amount of heat energy the wall built with it is capable of storing per unit mass, the values of specific heat capacity are as shown in (Table -11) . Walls with high specific heat capacity can store more energy , have a larger thermal lag ,and thus , generally be more effective for thermal storage and peak load shifting . This time lag effect contributes to shifting demand to off-peak periods and improves overall thermal efficiency .specific heat capacity of the clay brick

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is determined from the classical heat capacity equation .The specific heat capacity device which is used in this work is as shown in Fig.(8) .

$$C = Q / M .\theta \qquad (5)$$

DISCUSSION OF THE RESULTS

Effect of admixtures on compressive strength

The test results that there are different behaviors for clay bricks with each type of admixtures. This research revealed that the compressive strength increase by (5%) for all admixtures. Rubber cuttings have notice able increase of compression strength at 5% of admixtures (Fig-9). This increase is about 8.4% from reference brick (with no admixtures bricks) and decrease for other percentages (in both ratio of mixing).This could be attributed to the inclusions of cuttings inside existing voids and pores through mixture ,which behaves as bond material while ,when increasing the addition ratio (more than 5%), the rubber will act as weakness regions . Wood saw dust increase the compressive strength about 13% at when using 5% admixtures percentage compared to reference brick.

Effect of admixtures on density

A simple procedure has been used to measure the density of the brick where dimensional and mass measurement are used to obtain density also apparent porosity can be obtained as conforms to ASTM standard C373-88 [21]. Table (12) shows the values density of admixtures ,knowing the density of porous brick and measuring weight and volume of the porous brick . An enhancement in thermal insulation is observed as porosity increases where the thermal conductivity is decreased. The reduction in thermal conductivity is even better than the common used hollow brick of the same porosity, Fig (10) shows the density with different admixtures .Concerning density a reduction in density is observed as mass fraction of admixtures in original wet clay brick increased ,this is clear since more volume will be occupied by dust before it burns leaving voids inside firing brick ,this reduction in density will decrease cost necessary to achieve the task of insulation as thermal conductivity reduced.

Effect of admixtures on thermal conductivity

Fig(11) shows the relationship between thermal conductivity and admixtures percentages in this work . It is clear that the increase of admixtures leads to decrease in thermal conductivity value .

Effect of admixtures on specific heat capacity

The plot of the specific heat capacity against percentage admixtures in Fig(12) , indicates that all the bricks with the admixtures have slightly lower values except the 10% brick .Lower heat energy storing capacity and lower thermal mass .In tropical environment, these bricks will lose heat gained the day faster.

Effect of admixtures on porosity

The variation of porosity with percentage admixtures is presented in (Fig)13, the results show that all the bricks with the admixture are more porous than that of the control .This increase in porosity may be as a result

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of trapped air bubbles that are interconnected .The product of burning inside voids will decrease the thermal conductivity since the void has negligible effect on effective thermal conductivity of which is observed experimentally in Fig (14,15,16) . It is found experimentally that the escape of burning product from the porous brick due to high pressure which generates inside voids will leave having negligible mass of ash and gases with a pressure near atmospheric pressure. It can be seen that as the percentage of admixtures increases, the dry density and therefore thermal conductivity of bricks decreases as shown in fig 17 ,18 ,19 . In the new proposed type of brick, a reduction in compressive stress is observed as porosity increased as shown in Fig (20 ,21,22) , this is explainable since the bearing material in the brick will be reduced but the compressive stress is still higher than that of hollow brick .

The experimental data for different type of brick are measured experimentally .Anew proposed type has been found which have low density, low thermal conductivity and high compressive stress which may be the best choice for a brick and no holes , the holes allows some mortar to enter through them which will increase effective thermal conductivity of the wall and its cost . This determinate effect will not be existed in our new proposed type of brick since it has no holes where in our model the effective thermal conductivity of the brick will be almost that of the wall .

CONCLUSIONS

Anew type of porous brick is proposed .Industrial wastes is well mixed initially with wet clay so that when the clay and wastes mixture molded as brick and entered the oven in firing process ,voids will be created inside it. The wastes would burn leaving ash and gases of negligible weight and density leaving void inside the brick .

1- The created voids will enhance the total performance of the brick.
2- The density of clay brick sample contain of rubber cuttings is reduced 27%, wood sawdust 32% and the barley reeds ash 33%.
3- The thermal conductivity of clay brick sample contain of rubber cuttings is reduced 34%, wood sawdust 43% and barley reeds ash 46%.
4- The compressive strength of clay brick sample contain of rubber cuttings is increased 25%, wood sawdust 22% and barley reeds ash 20%.
5- Barley reeds ash considered the best additives because take good properties.

REFERENCES

[1].Turgut ,.P. and Yesilata, .b. “Physics-mechanical and thermal performance of newly developed rubber-added bricks” Energy and Buildings, vole 40 , pp 679-488 (2008).

[2].Turgut ,. P. and Algin, H .M .”Limestone dust and wood saw dust as brick material “Buildings and Environment ,vole 42 , pp 3399-3403 (2006) .

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[3].Demir, I . “An investigation on the production of construction brick with processed waste tea “ Buildings and Environment , vole 41 ,pp 1274-1278 (2005).

[4].Kayali, O .”High performance bricks from fly ash “proceeding of the world of coal Ash conference Le.xinton . Kentucky (2005).

[5].Lin. K . L .” Feasibility study of using brick made from municipal solid waste incinerator fly ash slag “ Journal of hazardous material ,vole .137 ,pp 1810-1816 (2006).

[6].Veiseh ,s . “ The use of polystyrene in light weight brick production “ Iranian polymer journal , vole 12 , No -4 pp324-329 (2003).

[7].Basegio,” Environmental and technical aspects of the utilization of tannery sludge as a raw material for clay products “Journal of the European Ceramic Society , vole 22 ,pp 2251-2259 (2002).

[8].Solemez. M .S .” On the effective thermal conductivity“ Buildings and Environment , vole 34, pp1-5 (1991).

[9].Aeslina . “ Density, strength ,thermal conductivity and Ieachate characteristics of light weight fired” International journal of civil and Environmental Engineering , vole 24 ,pp 179-184 (2010).

[10].Asokan pappu , “ solid wastes generation in india and their recycling potential in building materials “ Building and Environment , 42 ,pp 2311-2320 (2007).

[11].Zcanf .’Strength lightweight concrete made with scoria aggregate mineral admixtures .Cem Concrete Res 33 ,pp1595-1599 (2003).

[12].Lacarrie , re ,B “ Numerical study of heat transfer in awall of vertically perforated brick; influence of method “ Energy and Buildings ,35 ,pp 229-237 ,(2003).

[13].Del Coz Diaz ,j j. “Non-linear analysis of light concrete hollow brick walls by the finite element method and experimental validation , Applied Thermal Engineering ,26 ,pp 777-786 (2006).

[14].Ai- Hazmy , M. M .” Analysis of coupled natural convection conduction effects on the heat transport through hollow building blocks , energy and Buildings,38,pp515-521(2006).

[15].Ezbakhe .H .” Method of testing thermal conductivity at steady state for insulating material “world rune warble energy congress, No6 ,Brighton (2000).

[16].j.j . GOZ. DIAZ .” Analysis and optimization of the heat insulating light concrete hollow brick walls design by the finite element method “Applied thermal engineering ,27,pp1445-1456 ,June (2007).

[17].J.M.Sala.”Static and dynamic thermal characterization of a hollow brick wall “Energy and Building, 24,pp 1513-1520 (2008).

[18].M.Zukowsk “ Experimental and numerical investigation of a hollow brick filled “Energy and Buildings , 42 ,pp1402-1408 (2010).

[19].Murthy.”Thermal analysis of epoxy based fiber rein forced “IE journal -84 ,April (2004).

[20].Rondeaux. F.” Thermal conductivity measurement of epoxy system at low temperature “ Cryogenic Engineering Conference (CEC) ,USA (2001) .

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[21].ASTM standard C373-88, standard test method for water absorption , bulk density , apparent, porosity and apparent specific gravity of white ware products, 1999.

[22].ASTM standard C-177-85 ,Standard test method for steady -state heat flux measurement and thermal transmission properties by means of the guarded hot plate apparatus ,Annual Book of ASTM Standards ,4.06,1985.

Table (1) Chemical composition of tires rubber cuttings*.

Composition	Content %
Rubber hydrocarbon	48
Carbon black	31
Acetone extract	15
Ash	2
Residue chemical balance	4

*analysis was made at Babylon tires factory .

Table(2). Physical properties of rubber cuttings.

property	Specification	Result	Limit of I.O.S. No.45/1984
Bulk specific gravity	ASTM C128-01	1.2	-
Absorption %	ASTM C128-01	0	-

Table (3) Chemical composition of wood saw dust (analysis was made at X-Ray diffract- Meter type XRD- 6000).

Oxide composition	Content %
Sio_2	86.2
$Casio_3$	2.8
Mgo	2.5
Al_2o_3	4.5
So_3	2.2
Loss of ignition	1.8

Table (4). Physical properties of wood sawdust.

Property	Specification	Result	Limit of I.O.S. No.45/1984
Bulk specific gravity	ASTM C128-01	0.8	-
Absorption %	ASTM C128-01	Saturated surface dry	-

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Table(5) Chemical composition of barley reeds (analysis was made at X-Ray diffract –Meter type XRD-6000).

Oxide composition	Content%
Sio_2	87.5
Cao	1.5
Mgo	1.7
R_2o_3	3.6
So_3	0.4
Loss on ignition	5.3

Table(6).physical properties of barley reeds.

Property	Specification	Result	Limit of I.O.S. No.45/1984
Bulk specific gravity	ASTM C128-01	0.5	-
Absorption%	ASTM C128-01	Saturated surface dry	-

Table (7) Chemical composition of Clay (analysis was made at X-Ray diffract-Meter type XRD -6000) ,the clay pass from Sieve 0.075 mm size.

composition	Content %
Al_2o_3	20
Sio_2	60
Iron oxide	5
Lime	5
magnesia	10

Table (8).The compressive strength of clay bricks samples with different admixtures type.

Sample	Add percentage Of admixtures	.rubber cuttings	Wood sawdust	Barley reeds ash
		MPa	MPa	MPa
Solid brick		40	40	40
Hollow brick	0%	30	30	30
Sample-1	5%	32	36	38
Sample-2	10%	31	35	35
sample-3	15%	30	32	34
Sample-4	20%	30	31	32

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Table (9) .The porosity of clay brick samples with different admixtures type .

Samples	Add percentage	Rubber cuttings	Wood sawdust	Barley reeds ash
	%	%	%	%
Solid brick		0.12	0.12	0.12
Hollow brick*		0.12	0.12	0.12
Sample-1	5	0.14	0.18	0.19
Sample-2	10	0.17	0.23	0.24
Sample-3	15	0.21	0.29	0.33
Sample-4	20	0.24	0.31	0.35

*Hollow bricks is commonly used type in middle east having 10 holes of diameter 2.5 cm through the depth of the brick distributed equally through the brick its dimension is $23\times11\times7$ cm^3.

Table (10) The thermal conductivity of clay bricks samples with different admixtures type.

Sample	Add percentage	K of rubber Cuttings	K of wood Saw dust	K of barley Reeds ash
		w/m.k	w/m.k	w/m.k
Solid brick		0.9	0.9	0.9
Hollow brick	0%	0.63	0.63	0.63
Sample-1	5%	0.72	0.68	0.62
Sample-2	10%	0.69	0.62	0.58
Sample-3	15%	0.64	0.53	0.52
Sample-4	20%	0.59	0.51	0.48

Table (11) .The specific heat capacity of caly bricks samples with different admixtures type.

Add percentage of Admixtures	C of samples contain Rubber cuttings	C of samples contain Wood saw dust	C of samples contain Barley reeds ash
	Kj / g.k	Kj / g.k	Kj / g.k
0%	0.71	0.66	0.61
5%	0.42	0.32	0.26
10%	0.68	0.59	0.55
15%	0.57	0.49	0.42
20%	0.48	0.42	0.39

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Table(12) The density of clay bricks samples with different admixtures type .

Sample	ρ (rubber cuttings)	ρ (wood saw dust)	ρ (barley reeds ash)
	kg /m^3	kg /m^3	kg/ m^3
Solid brick	1780	1780	1780
Hollow brick	1300	1300	1300
Sample-1	1512	1455	1419
Sample-2	1467	1380	1347
Sample-3	1391	1270	1228
Sample-4	1295	1200	1198

Figure(1) .samples of clay brick.


Figure(2).The compressive strength device


Figure(3).The created voids of sample-1


Figure(4)The created voids of sample-2

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Figure(5)The created voids of sample-3

Figure(6)The created voids of sample-4

Figure(7)The specific heat capacity device.

Figure(8)Lees Disc apparatus

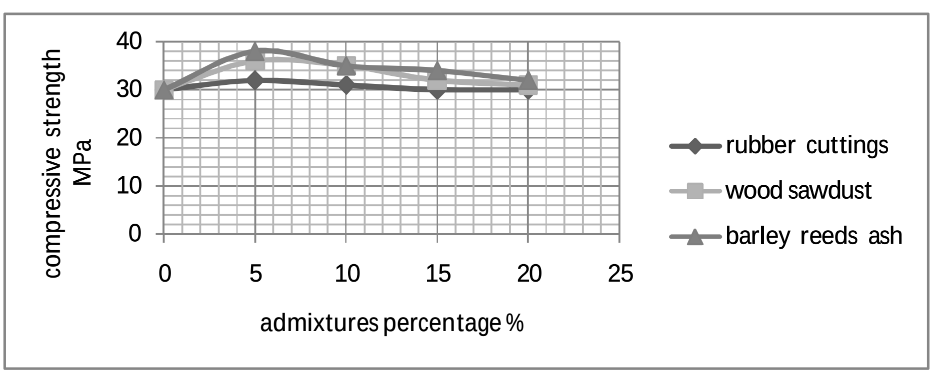

Figure (9) Compressive strength of clay bricks with different admixtures.

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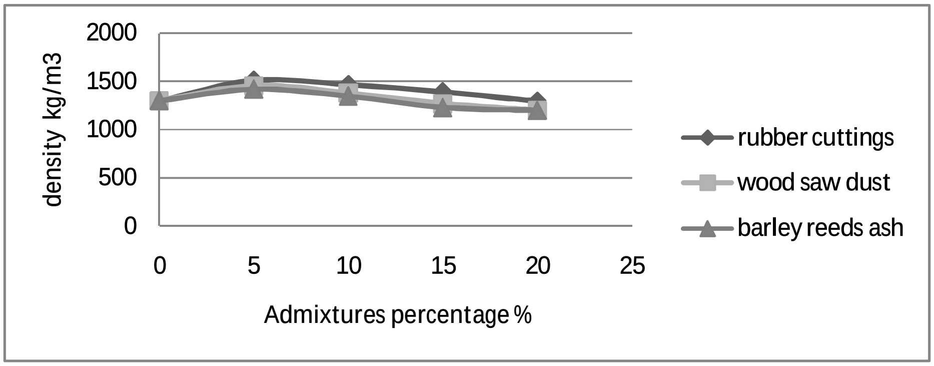

Figure (10) . The density of clay brick with different admixtures.

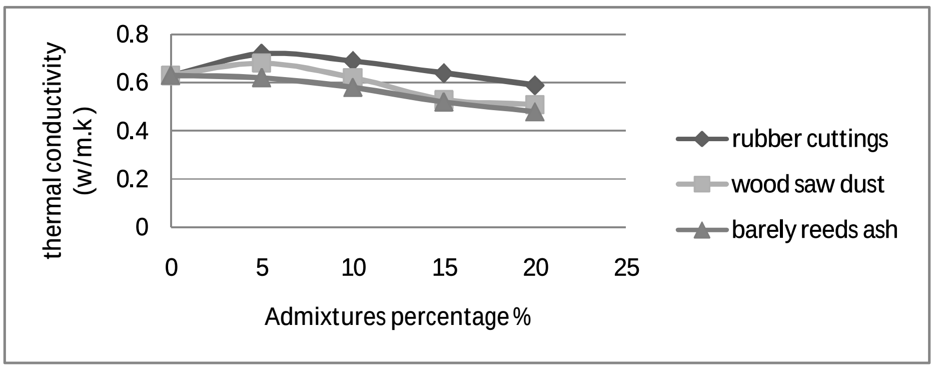

Fig ure(11) .T he thermal conductivity of clay brick with different admixture.

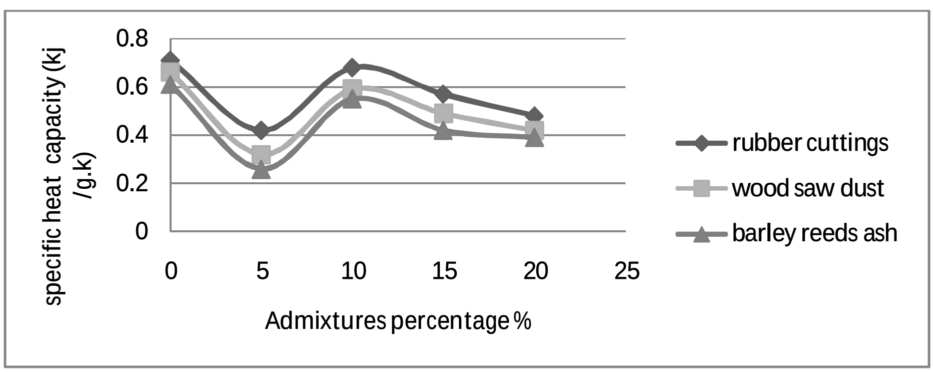

Figure (12) .Specific heat capacity of clay brick with different admixtures.

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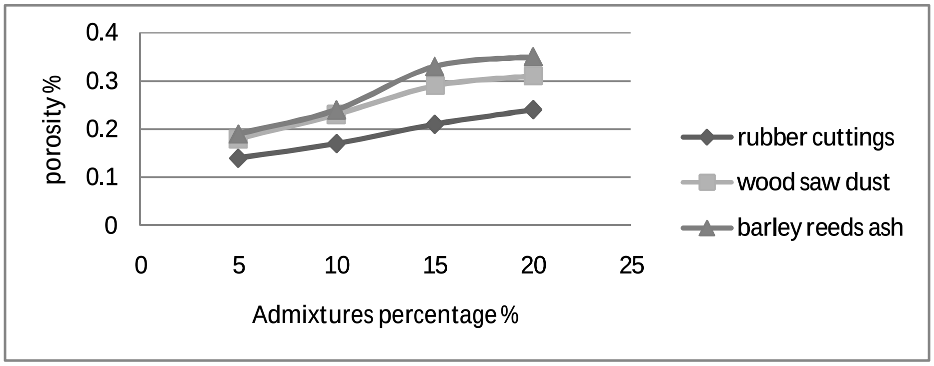

Figure (13) . porosity of clay brick with different admixtures.

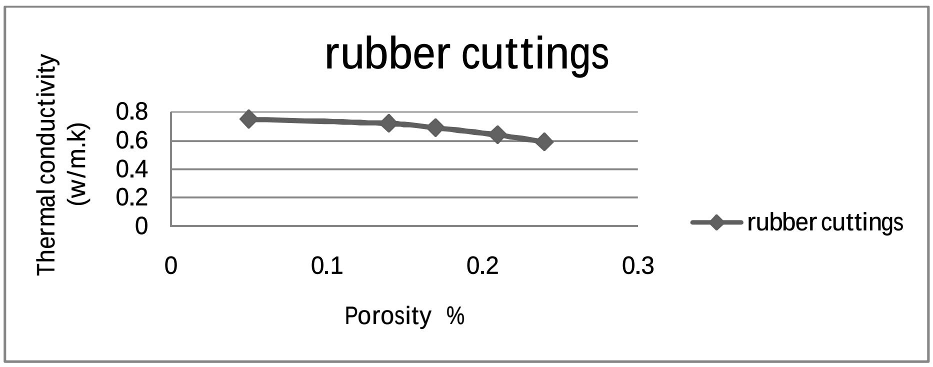

Figure (14) .Variation of thermal conductivity with porosity of rubber. cuttings wastes

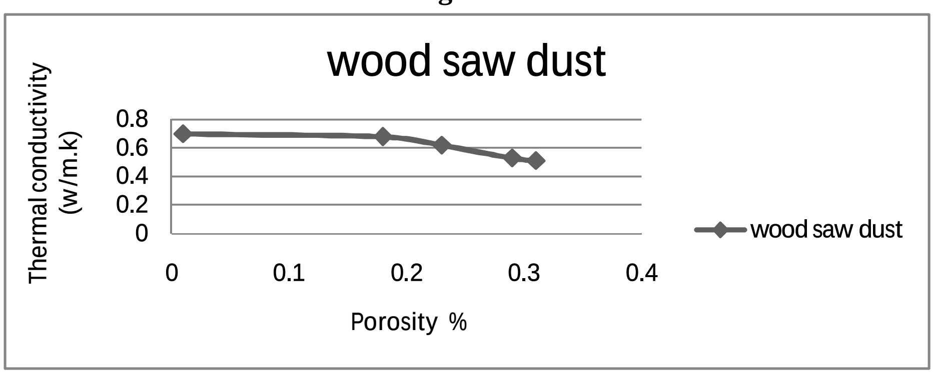

Figure (15) Variation of thermal conductivity with porosity of wood saw dust wastes.

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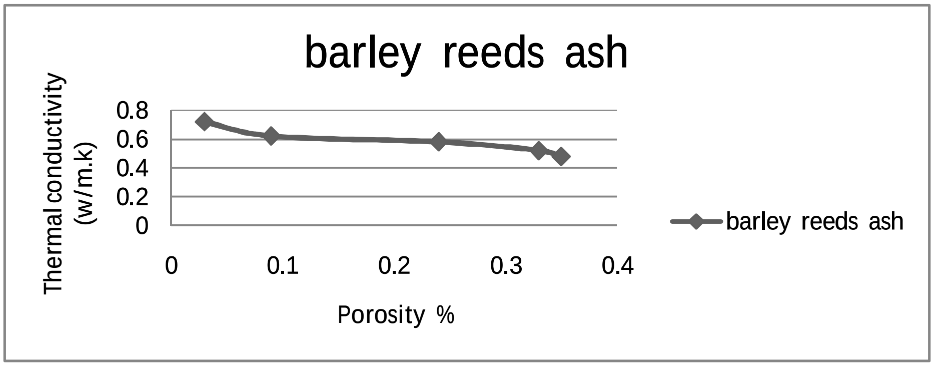

Figure (16) .Variation of thermal conductivity with porosity of barley reeds ash.

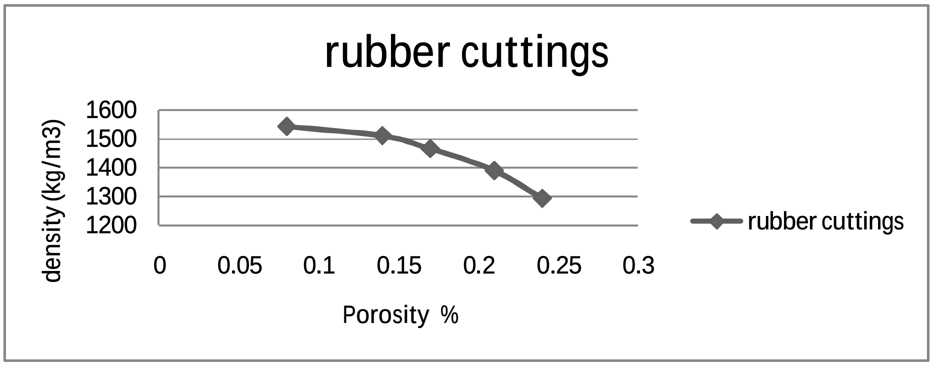

Figure (17) .Variation of density with porosity of rubber cuttings.

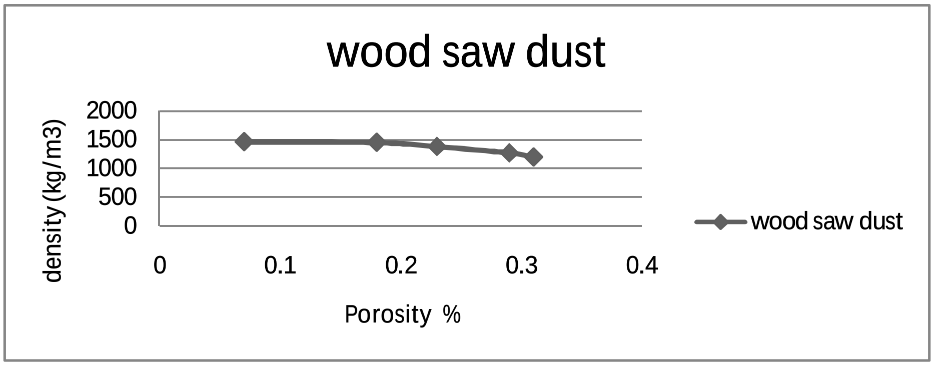

Figure (18). Variation of density with porosity of wood saw dust.

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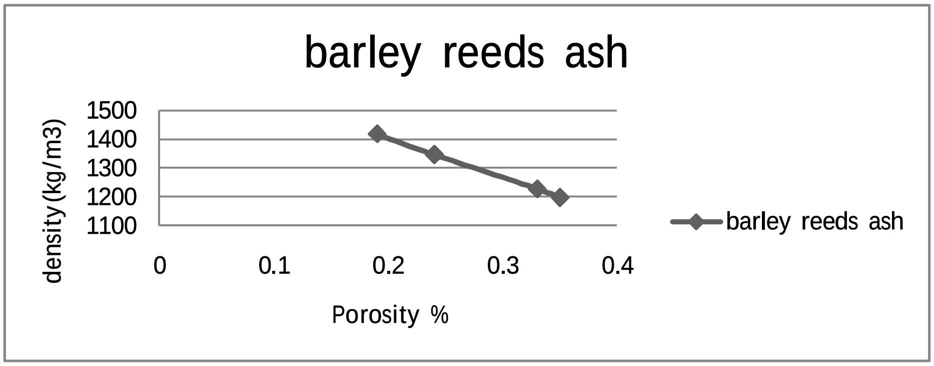
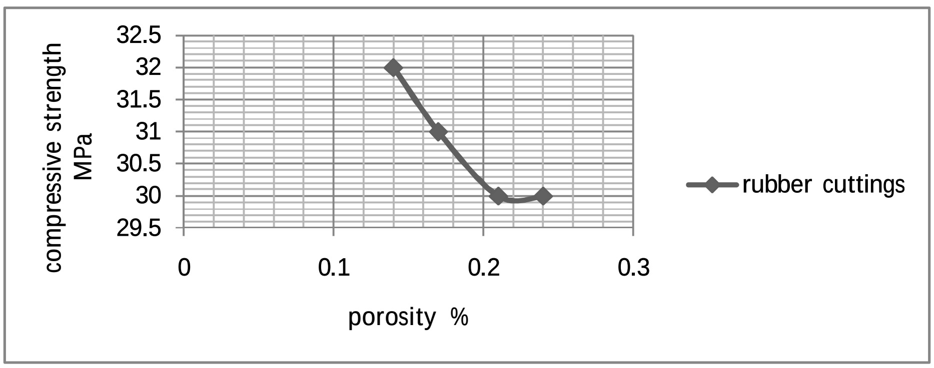
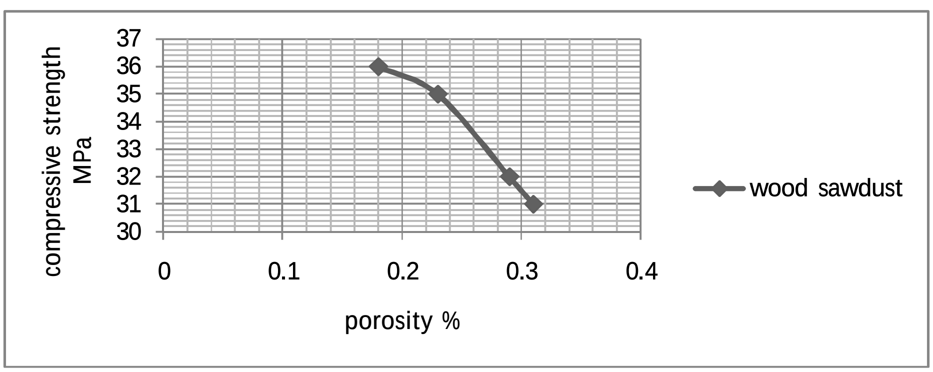


Figure (19) . Variation of density with porosity of barley reeds ash.



Figure(20). Variation of compressive strength with porosity of rubber cuttings.



Figure(21). Variation of compressive strength with porosity of wood sawdust.

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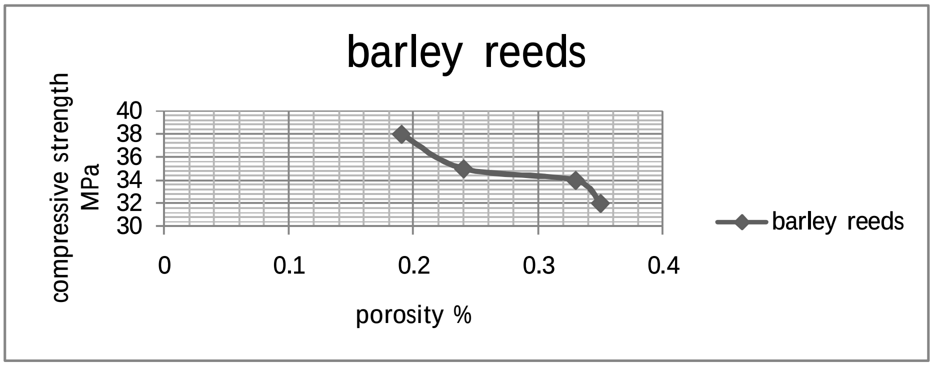

Figure(22). Variation of compressive strength with porosity of barley reeds.

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