EVALUATION OF THERMAL AND MECHANICAL PROPERTIES OF THE BRICKS

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ABSTRACT

A new type of porous brick is proposed .Feathers Livestock is well mixed initially with wet clay so that when the clay and feathers livestock mixture put in a mold of brick and entered the oven in firing process , voids are created inside it .The created voids will enhance the total performance of the brick since its reduced density32% ,thermal conductivity41% ,and increased compressive stress 18% , all these properties are measured experimentally and good performance has been obtained .From this work , it has been obtained that ,as porosity increased ,the thermal conductivity and density are reduced and a margin reduction in compressive stress is observed but the compressive stress is still larger than that of the common used hollow brick . These measured data lead to obtain new type of effective brick having good performance with no possibility of mortar to enter inside the holes of the common used hollow brick .The mortar has a determent effect on thermal properties of the wall .

Keywords: porous brick , Feathers Livestock ,compressive stress , thermal conductivity , Density .

تقييم المواصفات الميكانيكية و الحرارية للطابوق

الخلاصة :-

يهدف البحث الى دراسة نوع جديد من الطابوق المتسامي ، حيث تم مزج ريش الدواجن مع الطين الرطب ووضع المزيج فى موديل خاص بالطابوقة وبعدها وضعت فى الفرن الحرارى ،تم اخذ اوزان مختلفة من ريش الدواجن لانتاج اربعة نماذج ،احدثت هذه العملية فجوات داخل الطابوقة ، هذه الفجوات عززت من مواصفات الطابوقة حيث قللت من الكثافة بنسبة 32% والمحتوى الحرارى 41% وزادت من صلادة الطابوقة بنسبة18% جميع هذه المواصفات تم اجراوها عمليا فى معمل تصنيع الطابوق فى منطقة النهروان فى بغداد وتم الحصول عاى افضل مواصفات للطابوقة وكذلك فى هذا العمل نلاحظ زيادة فى مسامية الطا بوقة والمحتوى الحرارى والكثافة اقل. تم مقارنة صلادة النوع الجديد مع الموديل العادى المستخدم فى البناء فكانت الصلادة مقاربة وجيدة . هذا الموديل سوف يقلل من كمية المو نة التى تدخل فى ثقوب الطابوقة العادية وتقليل المونة سوف يوثر على تحسين مواصفات الحائط .

INTRODUCTION

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 .

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 [Turgut,2008] .

To enhance brick thermal conductivity properties several methods had been suggested to create voids within the brick [Aeslina,2010] ,the most common used method is to create uniform cylindrical holes inside brick .This type of brick has a 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 [Asokan,2007] .

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 of a higher strength , weight ratio , better tensile strain capacity and lower thermal expansion , as well as superior heat and sound insulation characteristics[Topcu,1997] . 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 decrease in density which will lower structural dead load , easier handling ,lower transport costs and a higher number of bricks produced per tones of clay[Kihc,2003].It is useful to show some previous studies related to the present research.

EZBAKHE . H[2000] ,studied the properties of building materials is 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 a good accuracy by 40% but they are slow and different in the experimental .

.GOZ.DIAZ.J.J[2007] ,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 .

.Sala.J.M[2008] ,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 .

.ZUKOWSKI . M[2010] .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 .

The aim of this work is:

1- To enhancement the mechanical and thermal properties of clay bricks by using local materials in Iraq.
2- To compared between hollow clay bricks and samples which is used.

METHODOLOGY

The main idea in creating porosity in brick is that the feathers livestock will be mixed with wet clay and when the created wet brick enter the oven , the feathers will be burn inside the brick after it occupies an original volume inside the clay and after firing process the volume of the feathers will be filled by the product of burning (ash and gases) .

The main volume will be filled by gases since the resulting ash will occupy about 5% of the original volume also the mass reduction is calculated and it is found to be about 90% .The feathers will burn 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 feathers that mixed with wet clay .
A test has been made for solid ,hollow and proposed bricks to measure their density and thermal conductivity also the compressive stress is measured (see table 1) .

Table.1: Some thermal and mechanical brick properties.

sample	mass	ρ	φ	σ	K (th)	K(ex)
	kg	kg/m3	%	Maps	w/m.k	w/m.k
Solid brick	_	1780	_	40.8	0.9	0.9
Hollow brick	_	1300	0.18	30.7	0.64	0.63
Sample-1	0.06	1455	0.17	36.6	0.67	0.68
Sample-2	0.11	1380	0.23	35.1	0.64	0.62
Sample-3	0.14	1270	0.29	34.2	0.54	0.53
Sample-4	0.2	1200	0.31	33.3	0.53	0.51

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 . The compressive stresses of brick produced in the united states ranges from about (7 to 105) Maps ,varying according to the use to which the brick are to be put . In England clay bricks can have stress of up to (100) Maps although a common house brick is likely to show arrange of (20 -40)[Shibib,2010] .

Compressive Stress Test Procedure.

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

Compressive stresses can be affected by many parameters such as porosity firing procedure ,type of clay .The dry compressive strength of brick samples is determined by using the compression test machine . The compression load is applied on to the face of the sample having a dimension of (230 * 110* 70) mm .The compressive strength is determined by dividing the maximum load with the applied load area of the brick samples . The equation used by for composite material having voids can be used for predicting theoretical thermal conductivity which can be written as[Shibib,2010] .Test indicate it is conform to the limits of Iraqi specification No. 45 / 1984.

$$K_{th} = K_{sb} * 1- \varphi + (1 - \varphi)^2 / 2 \quad (1)$$

The compressive strength device which is used in the work as shown in fig (1).

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 many sample of brick incorporating feathers livestock . Fig (2) represents the test apparatus (Lees disc apparatus) type (Griffin and George) with tested the sample of brick and some accessories to measure the temperature of both sides of the sample in order to calculate the thermal conductivity .

The heater is switch on from the power supply with (V =6 vol and I =0.2 A) to heat the brass disks (2 , 3) and the temperature of the all disks increases in nonlinear relationships and at different rates with the heat source . And the temperature were recorded every (5 minutes) until reach to the equilibrium temperature 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 =0.0035 m) is small relative to its diameter (D =0.04m) . Using a thin sample means that the system will reach thermal equilibrium more quickly .

The heat transfer (Q) across the thickness of the sample is given by [Murthy.2004] :

$$Q = K A * T_2 - T_1 / d_s \quad (2)$$

And the thermal conductivity can be calculated by using the following equation [12] .

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

And the value of (e) can be calculated from the following equation[Rondeaux,2001].

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

RESULT AND DISCUSSION

Fig (3) show images of the sample . The created voids inside brick reduce the effective thermal conductivity of brick see table (1) . The created voids shown in fig (4) are filled by product of burning . The product of burning inside voids (which has a negligible weight and density) will decrease the thermal conductivity since the void has negligible effect on effective thermal conductivity of the brick , so a reduction in thermal conductivity is expected as porosity increase which is observed experimentally in fig (5) and table (1) .

Knowing the density of porous brick and measuring weight and volume of the porous brick , one can calculate porosity of the 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. Concerning density reduction in density is observed as mass fraction of feathers livestock 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 and size necessary to achieve the task of insulation as thermal conductivity reduced .

It is found experimentally that the escape of burning product from the porous brick due to high pressure which generates inside voids will leave voids having negligible mass of ash and gases with a pressure near atmospheric pressure . It can be seen that as the percentage of feathers livestock increases ,the dry density and therefore thermal conductivity of brick decreases as shown in fig (6) .In the new proposed type of brick , a reduction in compressive stress is observed as porosity increased as shown in fig (7) ,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. A new 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

1- The density of clay brick is reduced 32% from the standard clay brick.
2- The thermal conductivity reduced 41% .
3- The compressive strength increased 18% from the standard clay brick.

NOMENCLATURE

K- thermal conductivity [$w.m^{-1}.k^{-1}$]

Greek

--density [$kg.m^{-3}$]

σ-- compressive stress [Mpa]

φ—porosity

Subscript

th—theoretical
ex – experimental
sb – solid brick

Fig.1. The compressive strength device

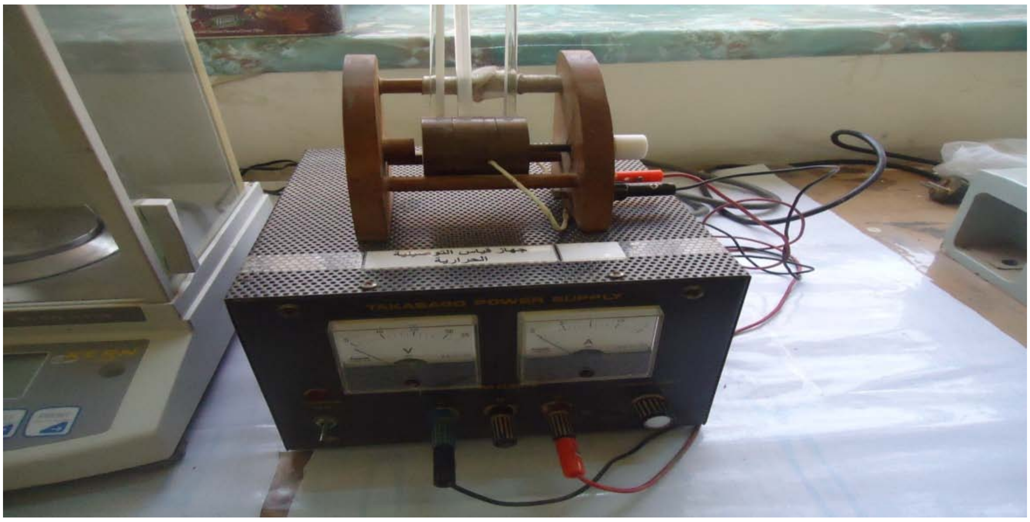

Fig.2. Lees apparatus

Fig.3.Samples 1,2,3,4

Sample.1

Sample.2

Sample.3

Sample.4

Fig.4. The created voids

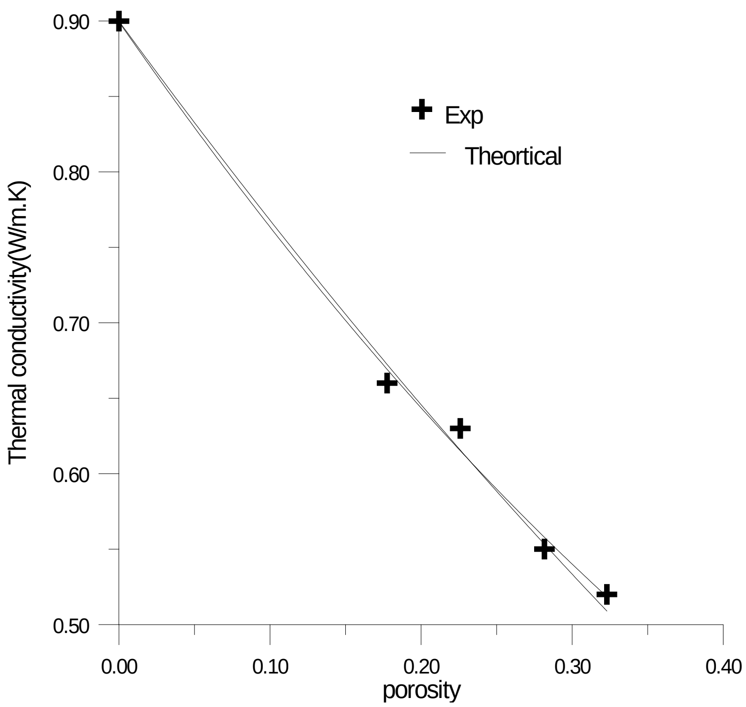

Fig.5. Variation of thermal conductivity with porosity, the experimental variation of thermal conductivity with porosity can be expressed as $k_{ex} = 0.899884 - 1.36893\varphi + 0.49143\varphi^2$

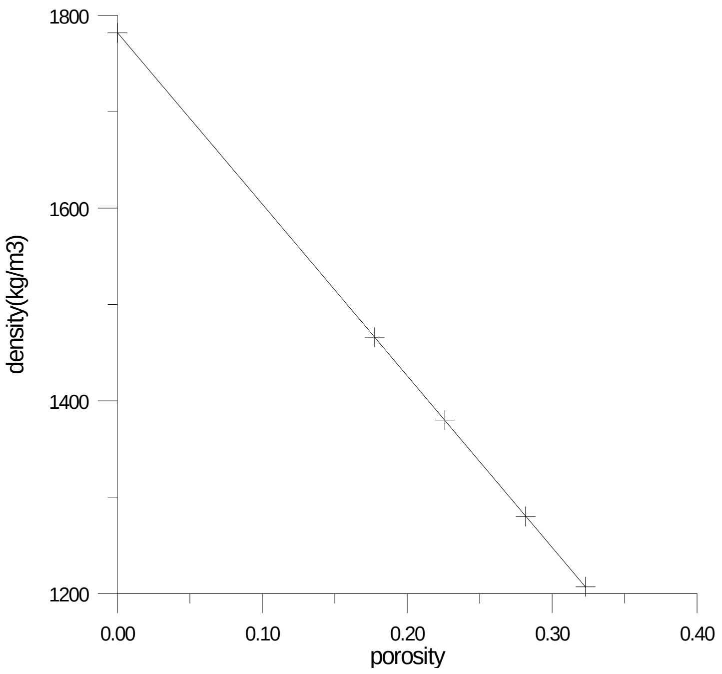

Fig.6.The variation of density with porosity

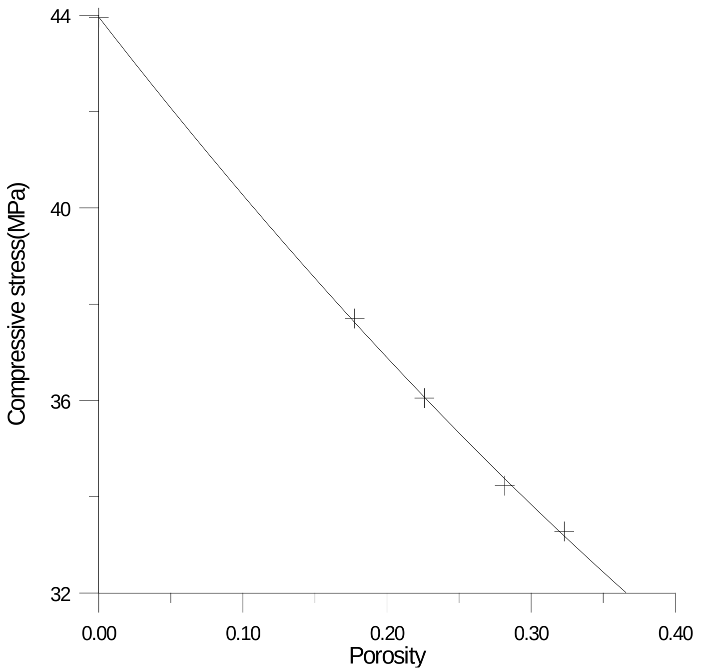

Fig.7.. The variation of compressive stress with porosity

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