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IMPROVEMENT THE MECHANICAL AND THERMAL PROPERTIES OF CONCRETE HOLLOW BLOCKS BY USING LOCAL MATERIALS IN IRAQ

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ABSTRACT
This research studies the effects of adding industrial wastes admixtures with different percentages on the thermal and mechanical properties of concrete hollow blocks (CHB).Different types of admixtures were used in this work ,including ,rubber cuttings ,wood saw dust and barley reeds ash with(5% ,10% ,15% ,20%) percent of each one . Thermal conductivity ,specific heat capacity, compressive strength ,flexural tensile strength and variation of density have been examined for each specimen at all percents of admixtures , and comparing with the reference concrete specimens.. From the obtained test result ,the study concluded that the use of these admixtures in (CHB) significantly effects of thermal conductivity , specific heat capacity ,compressive strength ,flexural tensile strength ,especially at (5%) of adding materials ,as well as utilization of additives in (CHB) to produce low density mixtures with barley reeds or as high density concrete using when rubber cuttings in the (CHB) mixture.

تحسين المواصفا ت الميكانيكة و الحرارية للبلوك المثقب الكونكريتى باستعمال مواد محلية فى العراق

الخلاصة

تناول البحث دراسة تاثير اضافة المخلفات الصنا عية بنسب مختلفة على خواص الحرارية و الميكانيكة للبلوك الكونكريتي المثقب ، تم اختيار مفروم الاطارات و نشارة الخشب ومطحون قصب الشعير واضا فتها بنسب (5%، 10% ،15% ،20%) لكل منها ،تم تقيم مقدار التوصيل الحرارى ، مقا ومة الانضغاط ، و الكثافة للبلوك الكونكريتى المثقب ولكل نسبة من النسب اعلاه ومقارنتها مع الخرسانة المرجعية (بدون اضافة). تم استنتاج ان استخدام هذه المضا فا ت يوثر عاى خواص البلوك (العزل الحرارى ، المقا ومة ، الكثافة) وان نسبة 5% من كل مضاف اعطت زيادة في المقا ومة بنسبة 8.4% لمفروم الاطارات و 13% لنشارة الخشب وكذلك زيادة في العزل الحراري بنسبة 12% بينما قلت الكثافة با ستعمال مطحون قصب الشعير وزادت عند استعمال مفروم الاطارات مقا رنة بالخرسانة المرجعية .

Key word; Urban wastes – Agro wastes – thermal conductivity -density – compressive strength.

INTRODUCTION

Thermal and mechanical properties play an important role in designing modern building especially when considering such as insulation , rigidity , weight and cost .Heat losses to or from building occupy an important factor in air – conditioning space is 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[Turgut2008,Solemez1991] .

Concrete is one of the most widely used construction materials ,due to its good durability comparing the cost .However , when the concrete member is subjected to severe environments ,its durability can significantly decline due to corrosion of concrete and embedded steel reinforcement nowadays ,the use of admixtures are placement of cement or aggregate is on the rise .Neville and broks refer to additives as substance which is added at the cement manufacturing stage , while admixtures imply addition at the mixing stage . Scientists are continuously on the lookout for materials which can be used as substitutes for conventional materials or which possess such properties as would enable their use for new designs and innovations .

Concrete using admixtures and alternative materials fall under this subject . The successful utilization of waste materials depends on its use being economically competitive with the alternative natural ,these costs are primarily made up of handling proceeding and transportations .For these mentioned reasons many research works were endeavored to make use of the enormous quantity of wastes like , rubber tires (chopped worn – out tires) ,iron splinters (scrape),wood saw dust , ash rice husk and silica gel ,to investigate the basic properties of concrete mixes with different admixtures , produce light weight concrete , improve strength of concrete , and reduce costs of construction ,as well as ,reduce environmental pollution and preventing the accumulation of the raw materials .Industrial wastes admixtures of concrete , generally have two main categories , organic wastes (agro – wastes), like wood saw dust , cork granular ,concrete pith ,and rice husks , and inorganic wastes (urban wastes)like broken brick aggregate ,silica gel , flexi crete ,iron splinters ,silica fume ,and chopped worn -out tires [ACI.1999,Ganesan .K 2008] .

It is useful to show some previous studies related to the present .The stress - strain behavior of light weight concrete in compression is , compared to normal density concrete of the same compressive strength ,generally characterized by linear ascending branch, lower E- modulus and less ductility in the post failure region . The characteristics are usually more pronounced with increasing compressive strength and decreasing dry density . The very name high performance concrete smacks of advertising an allegedly distinct . Former name is (high strength concrete) but in many cases , it is a high durability that is the required property , although , in order ,it has high strength ,either very early or at 28 days or even later , in some application ,a high modulus of elasticity is the property sought .

Al-Dahkeel ,studied the corrosion of steel reinforcement in high performance light weight aggregate concrete containing rice husk ash and corrosion inhibitor . She concludes that the use of the combination of high range water reducing admixture ,rice husk ash and migrating corrosion inhibitors enhances the durability ,and corrosion resisting characteristics of the predicted high performance light weight aggregate concrete Al-Dahkeel2002] . The heat - insulation capacity is favorable characteristics of light weight concrete . the case of fire . Moreover , the aggregate is stable at high temperature ,having itself been process at temperature in excess of (1100 °C)[Hplm.T.A1999] .

Al- Ani[2002] . Investigated the corrosion process of steel reinforcement in high performance structural light weight aggregate concrete (HP-SLWC) . He used porcelinite to produce the light weight concrete .

Al-Wahab[2003] .Studied the fire resistance properties of porcelinite light weight concrete .In this investigation acement of (430 kg / m^3) was used giving concrete with density range between (1850-1920 kg / m^3) and 28 days compressive strength between (22.27-29.6 Mpa) .

Al-Timimy[2001] . Investigated the properties of glass fiber reinforced concrete using metakaolin material with (10% ,30% , 50%) as a partial replacement by weight of cement . The microstructure characteristics obtained using the scanning electron microscopy are in agreement with the X-ray diffraction examination . These tests clearly indicated that the metakaolin concrete specimens have higher proportion of (C-S-H) and less amounts of calcium hydroxide compared to concrete mixes without metakaoline . The aim of this work is to investigate some properties of concrete mixes with different additives , e.g, thermal conductivity , compression strength , flexural tensile strength, density and their influences on concrete behavior .

INORGANIC WASTES

Rubber cuttings

Chopped worn-out tires (ch.w. T) concrete consist of , aggregate chopped worn –out tiers , and water 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) particilies varies ,and almost pass through the No.4 (5mm) sieves .Furthermore , (ch.w.T) have favorable characteristics such as high resistance to weather changing conditions , very low water absorption , light weight with absolute density around (0.92-0.95 gr /cm^3) and density (045 gr/cm^3) as well as thermal insulation[Al.Sakinij 1998] .

Organic wastes

Saw dust

Natural organic materials such as wood saw dust have been used for making light weight concrete . Saw dust is abundantly available in most places but it often contains substance which retards the hydration and hardening of cement . The extent of deleterious effect varies with the type of wood , and hard wood like mango and sal are known to seriously inhibit hydration .High drying shrinkage of saw dust -cement limits its use to design where freedom of movement is possible .The introduction of sand in to cement -saw dust mix has been found to reduce the drying shrinkage ,while reducing thermal insulation and increasing density . A common characteristic of light weight concrete is their comparatively high moisture movement with the consequent changes in dimensions accompanying changes in moisture content .Saw dust cement products show relatively higher percentage of volume change as reflected in the moisture movement.

Barley reeds ash

Lightweight concrete using barley reeds as aggregate has been used for making precast blocks and slabs 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 .

MATERIALS

Cement

The cement used throughout this work was ordinary Portland cement produced by Tasloga factory in Sulymania .It is stored in air light plastic containers to avoid exposures to different atmospheric condition .The chemical analysis and physical tests results of the used cement are given in (1) and (2) respectively . They conform to the Iraqi specification No (5/1984) .

Fine aggregate

Ai-Ukhaider natural sand of (4.75mm) maximum size was used for concrete mixes of this work .Test indicate it is conform to the limits of Iraqi specification No(45/1984).

Course aggregate

The washed natural gravel of irregular shaped and size analysis indicates the conformance of the aggregate to the limils of Iraqi specification No(45/1984) .

Water

Potable water was used for both mixing curing .

Admixtures

Industrial wastes admixtures (rubber cuttings , saw dust , barley reeds ash) were use in this work .The chemical composition of these admixtures as shown in table (3,4,5,) .

EXPERIMENTAL TEST

Experimental work have been carried out according to Iraqi specification code 1989 (CBRI-1989) and B.S (1881-1983) for compressive strength test and density , and according to ASTM (C192-07) for flexural tensile strength tests .The admixtures were used with different weight percentages of (5% ,10% ,15% and 20%) for rubber cuttings ,wood saw dust and barley reeds ash , from cement content the mixing ratio of reference concrete are 1:2:4 ,with water cement ratio (w/c) of (0.5).Average of three specimens of each ratio was casted cured for 28 days [1989,1983,2007] .

Thermal conductivity

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 hollow block concrete .Fig (1) represents the test apparatus (Less disc apparatus) type (Griffin and George) with tested the sample of hollow block concrete 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 amp) 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 of all disks . The sample used to measure the thermal conductivity using the (Lee,S Disk) method is in the form of adisk whose thickness (d_s=0.0035 m) is small relative to its diameter (D= 0.04) . Using athin sample means that the system will reach thermal equilibrium more quickly . The heat transfer across the thickness of the sample is given by [Murthy2004] .

$Q = K \ .A \ . T_2 - T_1 \ / \ d_s$ (1)

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

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

And the value of (e) can be calculated from the following equation[Roneaux2001] .

$I.V= \pi .r^2 .e.(T_1+T_3)+ 2.\pi.r.e [d_1 .T_1+0.5d_s(T_1+T_2) +d_2.T_2+d_3.T_3]$ (3)

Specific heat capacity

It is a measure of the thermal storage capacity of the material .The specific heat capacity of a concrete hollow blocks indicates the relative amount of heat energy the wall built with it is capable of storing per unit mass .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 concrete hollow blocks is determined from the classical heat capacity equation .

$C= \ Q \ / \ m \ \theta$ (4)

DISCUSSION OF THE RESULTS

Effect of admixtures on compressive strength

The tests results that there are different behaviors for concrete with each type of admixtures .This research revealed that the compressive strength increase by (5%) for all admixtures except for barley reeds where it decreases with the increasing addition percentage as shown in table (6).

Rubber cuttings have notice able increase of compression strength at 5% of admixtures (fig-2). This increase is about 8.4% ,from reference concrete (with no admixtures concrete) and decrease for other percentages (in both ratios 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 concrete .This can be attributed to the high content of SiO_2 in saw dust ,and the fibers texture of this material which reflect in concrete mixture. However ,barley reeds descending behavior in all admixtures percentages in both mixing ratios ,which could be a result of elongated shapes of reeds and the high content of the loss of ignitions.

Effect of admixtures on density

The results of light weight concrete hollow blocks density with admixtures show significant density decreasing (from normal concrete) for barley reeds than wood saw dust ,rubber cuttings as shown in (fig 3) and table (7). Barley reeds have low density and elongated shapes which allow more of voids and pores in the CHB mixture to provide light weight concrete.

Effect of admixtures on the flexural tensile strength

Figure -4, shows the behavior of flexural tensile strength of concrete hollow blocks due to the admixtures of different percentage of rubber cuttings , wood saw dust and barley reeds .From this figure , the development of flexural tensile strength of concrete hollow blocks with rubber cuttings is decreased applicably with the increase in rubber cuttings contents . Wood saw dust play good role in CHB behavior to increase strength , but the maximum strength was with 10% of saw dust . Moreover, barley reeds ash in CHB mixture with adding percentage 5% gives higher flexural strength than reference concrete , while decreased the flexural strength when percentage of barley reeds was increased as shown in table (8).

Effect of admixtures on thermal conductivity

Table -9, show the thermal conductivity of CHB with different percentages of admixtures .The thermal properties of CHB are of interest for variety reasons , thermal conductivity and diffusivity are relevant to the development of temperature gradient , thermal strainers ,warping and cracking in the very early life of CHB in service , fig 5- show 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 .It is clear that the increase in water cementations ratio leads to a decrease in thermal conductivity value of CHB ,this is due to presence of voids with in the CHB matrix which affects thermal conductivity of the produced material .

Effect of admixtures on specific heat capacity

The plot of the specific heat capacity against percentage admixtures in fig -6 , indicates that all the blocks with the admixtures have slightly lower values (except the 5% block) than that of the control block , hence , lower heat energy storing capacity and lower thermal mass . In tropical environment ,these blocks will lose heat gained during the day faster ,table -10 .

CONCLUSIONS

This study has been carried out to investigate the behavior of CHB due to adding organic and inorganic wastes mixtures .The study concludes the following aspects .

1- This research revealed that the compressive strength by 5% of all admixtures percentages except for barley reeds which caused a decrease with all admixtures percentage.

2- Rubber cuttings have noticeable increase of compression strength at 5% admixtures . This increase is about 8.4%.
3- Wood saw dust increased compressive strength about 13% at 5% of additive materials.
4- Barley reeds showed decrease in all admixtures percentages in both mixing ratios of CHB .
5- Light weight CHB density showed less density decreasing for rubber cuttings , wood saw dust ,than barley reeds .
6- Flexural tensile strength of mixed CHB with rubber cuttings decreases considerably by increasing admixtures , however wood saw dust increased flexural strength but the preferable percentage is 10% and 5% of barley reeds in CHB mixture.
7- Thermal conductivity reduces with increasing add percentages about 12% at 5% of additive materials.

Table 1. chemical composition of the cement*

Compounds composition	Abbreviation	%By weight	Iraqi specification No5/1984
Lime	Cao	61.7	---
Silica	Sio_2	22.1	---
Alumina	Al_2o_3	4.4	---
Iron oxide	Fe_2o_3	2.74	---
Sulphate	So_3	2.65	< 2.8%
Magnesia	Mgo	2.5	<5%
Loss ignition	l.o.i	1.9	<4%

*The test was ran in NCCRL

Table 2. physical properties of cement

Physical properties	Test results	Iraqi specif No5/1984
Specific surface Area blain method	375	>230
Initial setting Final setting	196 283	>60 <600
Soundness	0.2%	<0.8%
Compressive streng Of mortar(Mpa) 3day 7day	 15.3 27.5	 >15 >23

Table 3. 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 4. 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 5. chemical composition of Barley reeds ash (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. The compressive strength of CHB samples with different admixtures type.

Add percentage of Admixtures	C.S of CHB contain Rubber cuttings,N/mm^2	C.S of CHB contain Wood saw dust N/mm^2	C.S of CHB contain Barley reeds ash N/ mm^2
0%	23.6	24.61	22.8
5%	25.5	27.5	20.6
10%	21.4	20.6	19.2
15%	17.3	18.2	18.6
20%	14.8	23.02	17.1

Table 7. The density of CHB samples with different admixtures type .

Add percentages of Admixtures	Rubber cuttings g/cm^3	Wood saw dust g/ cm^3	Barley reeds ash g/ cm^3
0%	2.61	2.55	2.1
5%	2.58	2.59	1.9
10%	2.43	2.44	1.7
15%	2.37	2.38	1.5
20%	2.14	2.29	1.2

Table 8. The flexural tensile strength of CHB sample with different admixtures type

Add percentages of admixtures	Rubber cuttings Mpa	Wood saw dust Mpa	Barley reeds ash Mpa
0%	6.42	5.6	5.62
5%	6.11	5.9	6.65
10%	4.66	6.22	5.59
15%	3.55	6.1	5.24
20%	2.74	6.02	4.54

Table 9. thermal conductivity of CHB sample with different admixtures type

Add percentage of admixtures	Rubber cuttings w/ m.k	Wood saw dust w/ m.k	Barley reeds ash W /m.k
0%	0.7	0.62	0.61
5%	0.66	0.53	0.50
10%	0.57	0.44	0.41
15%	0.48	0.41	0.32
20%	0.44	0.39	0.21

Table 10. Specific heat capacity of CHB sample with different admixtures type

Add percentage of admixtures	Rubber cuttings Kj /g.k	Wood saw dust Kj/ g.k	Barley reeds ash 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

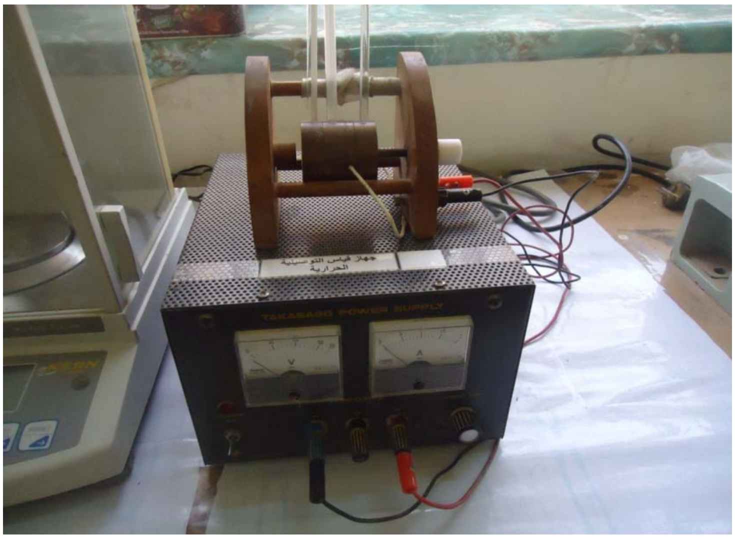
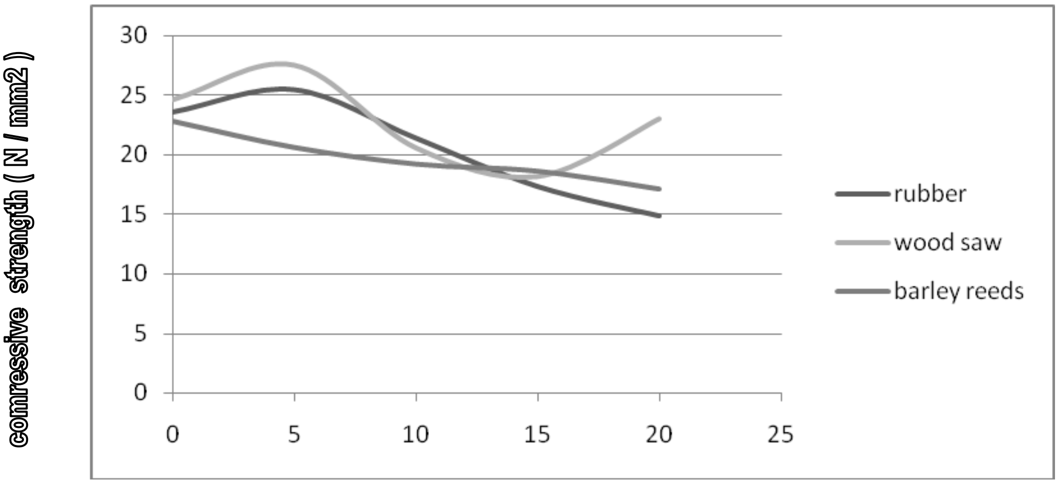
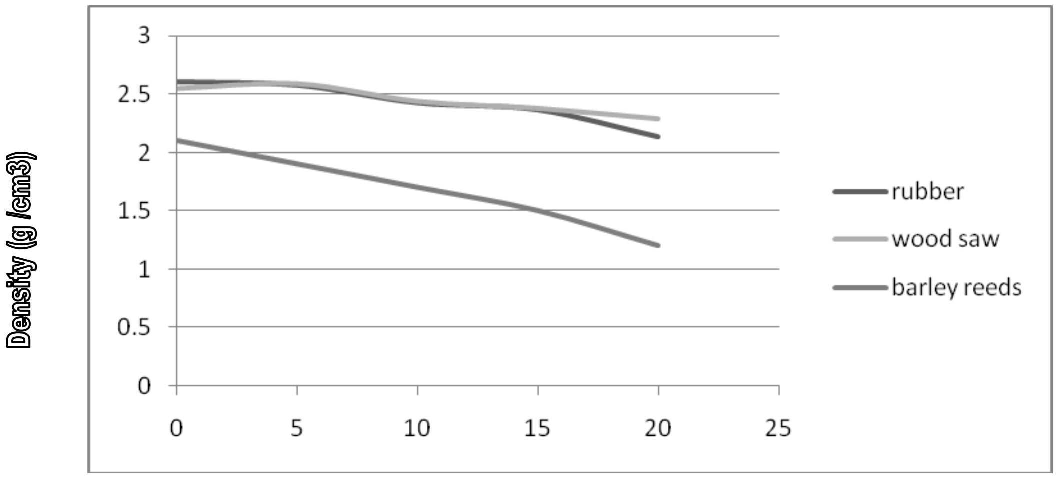


Fig . 1 Lees disc apparatus



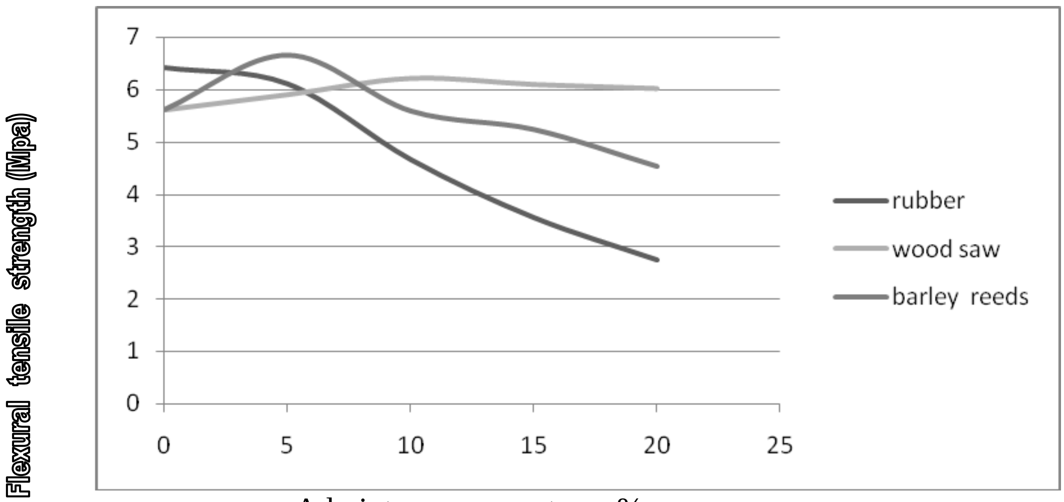
Admixtures percentage%

Fig- 2 compressive strength of CHB with different admixtures



Admixtures percentage %

Fig- 3 Density of CHB with different admixtures



Admixtures percentage %

Fig -4 Flexural tensile strength of CHB with different admixtures

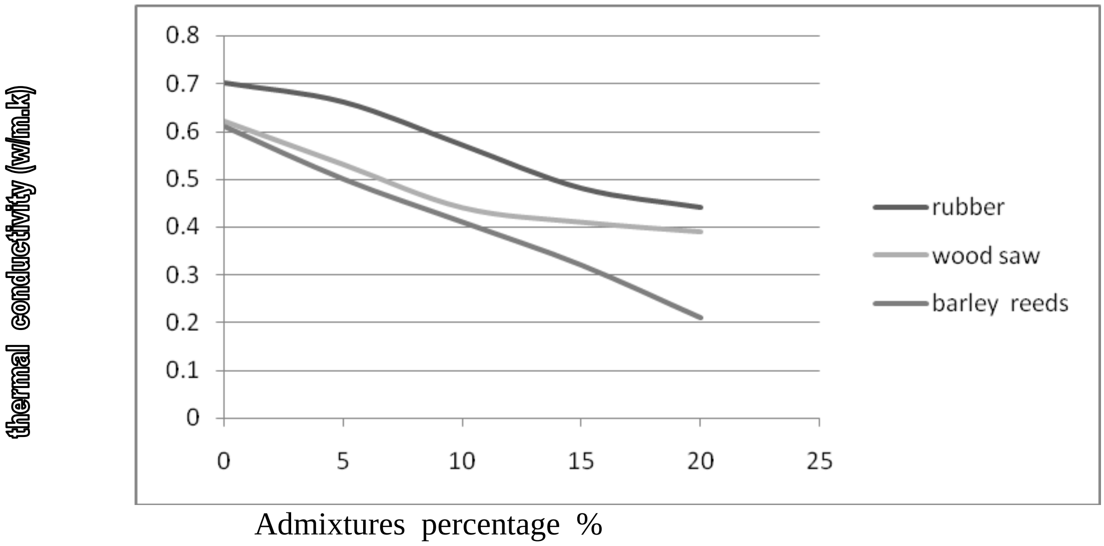


Fig- 5 thermal conductivity of CHB with different admixtures

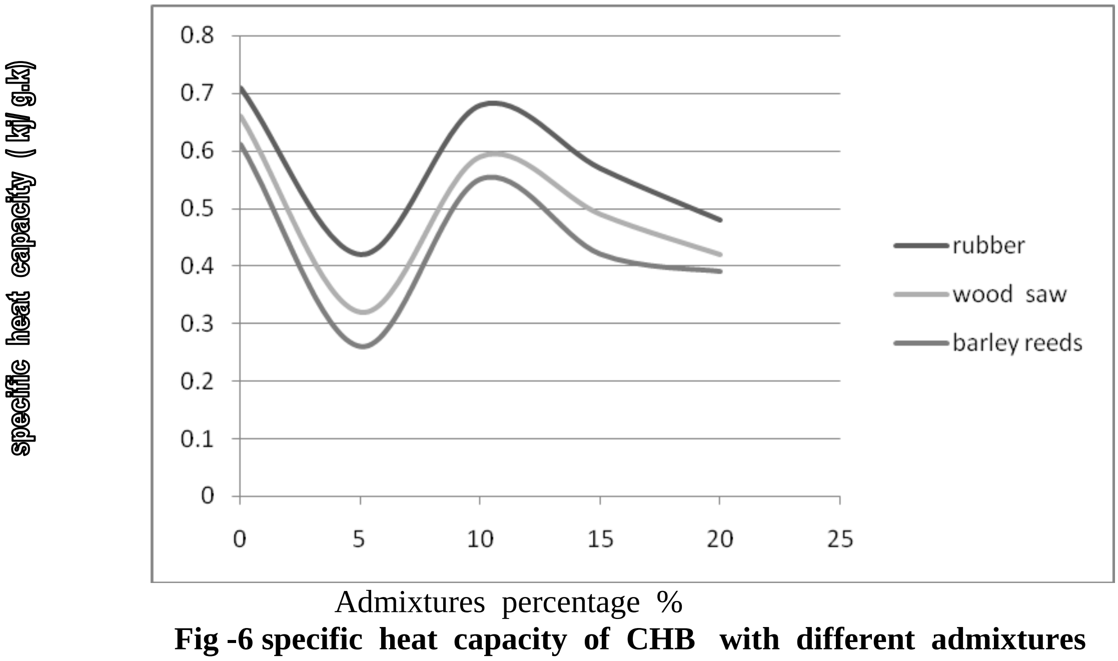


Fig -6 specific heat capacity of CHB with different admixtures

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