Role of agricultural engineering in environmental and sustainable development for the valley and delta areas: 1465 - 1484

EFFECT OF USING PRESSING ON THERMAL CONDUCTIVITY OF RICE STRAW BRICKS

KHAIRY[1], M.F.A; EL-SSOALY[2], I.S. and EL-BESSOUMY[3], R.R

ABSTRACT

For studying the effect of using pressing on thermal conductivity for rice straw two particle sizes of rice straw were used, large rice straw chops "LRSC" and Small rice straw chops "SRSC". Three moisture contents percentages were used (10, 20 and 30%), three ratios of additives materials (5,10 and 15%) and three formation pressures were used (5.86, 12.37 and 18.51MPa). The thermal conductivity test was carried out on compressed rice straw samples. The results indicated that increasing of deformation pressure lead to decrease the thermal conductivity values for both large and small rice straw chops. The maximum value of thermal conductivity was 0.0362 w/m.°c for large rice straw chops at deformation pressure of 12.37MPa. The minimum value of thermal conductivity was 0.0091 w/m.°c for small rice straw chops at deformation pressure of 18.51MPa.

INTRODUCTION

In the last few years, the production of wastes was increased but the disposal systems didn't meet the requirements, so the wastes are now the cause of serious problems in air, ground and water pollution. One of the most abandoned materials in Egypt is cellulous non-wood fibrous materials, such as rice straw. The total annual Egyptian crop residues are about 30 Tg, about 3 Tg of which is rice straw **(FAO,2005)**. In fact, rice straw is so abandoned that the Egyptian government allowed straw burning at agricultural fields. In the fall of 1999, an autumnal black cloud appeared above several Egyptian cities, with a thick bitter-smelling fog, due to the straw burning. Consequently, instead of burning the straw,

(1) Prof. Of Ag. Eng. Dept. of Ag. Eng., Fac. of Ag. (Cairo), Al–Azhar U.
(2) Ass. Prof. Of Ag. Eng. Dept. of Ag. Eng., Fac. of Ag. (Cairo), Al–Azhar U.
(3) Ass. Lecturer Of Ag. Eng. Dept. of Ag. Eng., Fac. of Ag. (Cairo), Al–Azhar U.

recycling it with a mixture of cement forms a sustainable low-cost building material, which also reduces atmospheric pollution (**Kazragis, 2005).** In addition to these benefits, the straw could act as a thermal insulation material for the unpleasant Egyptian weather. The use of thermal insulation helps reduce energy costs, while creating pleasant indoor temperatures.

The problem of increasing field residues and how to dispose are the biggest problems of agricultural biomass wastes in Egypt. The traditional way for disposing is by burning which not only caused pollution to environment, but also loosing an economic value of these residues, if it were used to produce useful products. This problem became greater nowadays which introduce black clouds covered Cairo's Sky and surrounding region during rice harvesting time. The straw burning process may be considered as the main reason for this black clouds appearance especially after developing a rural kitchen in villages. This work aims to study the effect of pressing pressure on thermal conductivity of rice straw with binding materials for the use as isolative material or in building materials manufacture and to specify characteristics of these materials which could be useful to improve the building materials specifications, and that may be useful from the economic side. Instead of considering agricultural residue as drawback, it should become a source of income with real utilization, instead of its harmful effects on our environment. The world health organization (WHO) defined the waste, as some things that its owner doesn't want it somewhere and sometime and this waste became invaluable. They also mentioned that, the English Law for protecting environment defined that waste as any materials are containing materials remains or any materials aren't needed; besides any materials are produced from production processes **(Abdel-Gawad, 1997)**. **Abd El-Ghaffar (1987)** said that, the agricultural wastes are the secondary materials which were produced from agricultural processes whether these processes were biological or during improvement shape of product, and these wastes may be useful or harmful for human. **Alaa El-Din *et al.* (1983)** and **Suliman and El-Zahaby (1998)** mentioned that the crops residues are materials that remain after the edible grain, seed, fruit, or primary fibers has been removed from plant. It includes straw, stalks, stems, hulls, stovers cabs, bagasse and fruit piles, etc. **Abd El-Ghaffar (1987)** mentioned that the farm residues, which are being in accumulated shapes of stalks and straw, these make a large hazard and biggest direct impair on both of life and possession. These heaps are considered the suitable environment for a dwelling or being mice, rates and rodents which may be risk on the plants. Besides, these heaps are considering too a suitable environment to increasing insects and these insects can transfer the diseases from field to another field. These residues are giving a chance (when it storages beside houses or on the houses roofs) to cause a fire hazardous. **Macdonald and Franklin (1969)** reported that wood is exceedingly difficult to define chemically because it is a complex heterogeneous product of nature made up of interpenetrating components generally are classified as : cellulose, lignin, hemicelluloses and solvent-soluble substances (extractives). The percentage of these components are in the range of 40-50%, 15-35%, 20-35% and 3-10% respectively, these components are impossible to separate in quantitative yield without alteration and degradation of their structures. **Saleh and El-Meadawy (1972)** studied the cotton stalks as a fibrous raw material, anatomical structure and chemical composition. The stalks had 80 % wood tissue consisting of libriform fiber with average of 11 mm length and vessel elements. **GDC (2000)** showed in its site that the straw consists of stem and leaves, these are attached to the stem at points called 'nodes', the internodes section is called 'stalk', from the perspective of board making, the stalks are desirable components, besides, any (woody) cell wall consists of three molecule type, all classified as carbohydrates cellulose, hemicelluloses and lignin, by understanding the molecular cell wall structure one can explain and predict the mechanical performance of straw fibers while straw is of course not wood. From a botanical perspective straw has the same fundamental molecular composition as wood and is therefore botanically classified as a 'woody' cell in the other side, 'hemi-cellulose' mechanically, these hemi-celluloses contribute little to stiffness and strength. Lignin gives plant tissue and individual fibers compressive strength without it, fibers would buckle like wet noodles. The most significant differences between straw and wood are straw's higher portion of hemi-celluloses and lower portion of celluloses and lignin. **Kumar and Lottman (1972)** used wheat straw and rye grass tillers to reinforce the foam. They mentioned that the straw and grass stems can be used as reinforcing fibers. They used expendable cardboard rectangular and molds lined with a luminous foil and arranged the wheat straw and rye grass tillers in bundles (about 3 to 5 tillers per bundle and placed vertically in the mold). Urethane foam was produced between and around the tillers by placing about a 50-50 blend of prepolymer and activator in the bottom of the mold immediately after about 30 min. the reinforced foam was removed from the mold and cut into (2 x 2 x 2 in) for testing. **USDE (1995)** said that the straw has been used for centuries by builders who recognized its structural integrity. Beside that, a piece of straw is simply a tube made of cellulose. Tubes are recognized as one of the strangest structural shapes. Straw was first used to reinforce mud against cracking. A lattice of straw criss-crossing a layer of mud produced a surface that remained crack free for decades, or in many cases centuries. **Jones (2001)** indicated that, the strawbale building can actually cause a net decrease in greenhouse gas emissions and straw provides super-insulation at an affordable cost. Strawbale walls are also super-insulative acoustically; there are two recording studios in the USA built of strawbales for their sound proofing quality and insulation. Plastered strawbale walls are less of fire risk than traditional timber-framed walls. American Society of Testing and Materials (ASTM) tests for fire resistance have been completed; the results of these tests have proven that a strawbale infill wall assembly is a far greater fire resistive assembly than a wood frame wall assembly using the same finishes. Straw, particularly organic straw, is a healthy alternative to modern materials. It is natural, and harmless, living within straw wall can enhance the quality of air we breathe. **Kennedy and Wanek (2002)** reported that the straw is commonly underutilized, as it's composted or burned as an agricultural waste product. Straw is available at a cheep price wherever grain is grown and stacked like giant bricks to form a thick wall, bales offer super insulation from the heat or cold or noise outside. It provides a quiet, comfortable living space with modest life-time energy requirements. They also added that unlike manufactured insulation materials, straw is natural and non-toxic and very low in embodied energy. Should a fire get started, lab tests and experience have shown that foam insulations ignite at low temperatures and release poisonous fumes and wood studs and trim will burn readily, but bales, compressed and sealed with plaster, are starved of oxygen and resist combustion. They also added that the building with bales also has the potential to impact global worming by significantly reducing fossil fuel consumption. Also, the earthen plasters have an added advantage of being hydrophilic which mean that they will always wick moisture from straw, acting to protect it from rot. **O'Dogherty and Wheeler (1984)** found that the chopped material, however formed wafers which were considerably less durable than these formed of unchopped material. In the durability test, weight losses of wafers ranged up to 50% for 25 mm chopped material the unchopped straw formed wafers with weight losses ranging up to approximately 1%.

O'Dogherty (1989) mentioned that the effect of chopping straw has shown that briquettes are much less durable as the chap length is reduced to between 25 and 50 mm. **Abd El-Mageed and Mousa (1994)** illustrated the effect of flake sizes on bale volume, there were three groups of chips according to the three screen meshes used, the flakes produced from the first, second and third screen meshes (1.6, 2.2 and 2-8 cm openings) gave the three mean weight lengths of 1.14, 2.03 and 2.4 cm, respectively. They also, added that increasing the screen mesh diameter of the flakes machine resulted in a decreasing in the volume of produced bales. In other words, the bales produced from large flakes had more ability to keep their compressed volume than smaller flakes. This was happening because with increasing the ratio of long particles, the short ones take place between long chips giving a high internal cohesive force, but with small screen meshes a large amount of small chips were produced giving less firm structure and finally large size bales. **Mohsenin and Zaske (1976)** found, when testing sawmill waste in the compaction machine, that by adding 6% waxed shavings with sawmill waste, the wax content decreased residual stress and subsequent expansion and acted as an adhesive resulting in more durability. The stability of wafer can be improved by binding material which either might be added intentionally or are liberated from the material by compression process. **Chancellor (1962)** studied the influence of impact load ranging from 20.7 to 89.65 MPa and lasting of 0.5 to 18.0 milliseconds, and was reported that, the wafer formation was not stable by impact loading as by static loading. **Chancellor (1962)** studied the influence of impact load ranging from 20.7 to 89.65 MPa and lasting of 0.5 to 18.0 milliseconds, and was reported that, the wafer formation was not stable by impact loading as by static loading. **Khairy (1997)** reported that there is a resultant heat when the chopped forage compresses at high pressure and it takes a form of receptacle which was compressed inside it. The forage compresses by applied pressure, heat and organic matters (which are one of forage compounds) effecting. The organic matters effecting are increased by adding water to the forage material through compressor process. **Noakes *et al.* (1953)** illustrated that the method used to measure the heat conductivity is called Lee's method or Lee's disc method for measuring the thermal conductivity of a bad conductors. The sample was put between the two disks of brass and measure T_1 and T_2 by thermometers. They also reported that the following equation was used:

$$m.s[\,(T_3 - T_4) / t] = k\,\pi\, r^2\, [(T_1 - T_2) / x]$$

and

$$k = m.s\,(T_3 - T_4)\, X / \pi\, r^2\, t\,(T_1 - T_2)$$

where :

m : Mass of brass disk (kg).

s : Specific heat for brass material (J/kg.°C).

t : Loosing heat time from T_3 to T_4 (Sec.).

x : Thickness of sample (m).

T_1, T_2 : Surface temperatures for sides of brass disks (°C).

Everett (1978) defined that the thermal conductivity (k) is a measure of the rate of heat transfer through a material from face to face (not from air to air) it is expressed as:

- Heat units transmitted in unit time — watts (J/s)
- Through unit thickness — m

- Of unit area m^2
- Of unit temperature difference between the faces k
- i.e.

w/m.°k

The k values of materials vary with density, in the examples quoted from 0.029 to 3725 w/m.°k with corresponding variations in density from 64 to 9000 Kg/m^3, conductivity values also vary with temperature, porosity and moisture content. With a moisture content of 20 percent, volume by volume, most building materials transmit between two and three times as much heat as they do when they are dry, the "k" value of compressed straw slabs was about 0.101 w/m.°k for bulk density about 865 kg/m^3. **McCabe (1993)** determined the insulating value for wheat bales and rice straw bales. He found that, the moisture content and bale density effecting insulating values and bales used for construction should have the driest possible conditions for greatest insulating value. Dry bales have higher insulating values than bales with moisture contents because the moisture migration transfers heat, strawbale construction has high insulating value, Rice straw is similar to wheat straw in its insulating value, the positioning of straw bale does have an effect on the insulating value of the bale and home energy usage can be reduced by 12.4% by using this building material. **Jones (2001)** reported that the straw provides super-insulation at an affordable cost, the "K" value of straw in a straw bale was 0.09 w/m.°k.

MATERIALS AND METHODS

The rice straw variety used was Sakha 101 from season 2000/2001. The average length of this variety was about 900 mm **(Kamel, 1999)**. Tow particles size of rice straw were used in this study, large and small chops. These chops were obtained by using a grinding forage machine. A lot of rice straw was put in the grinding machine in the Farm of Animal Production Department, Faculty of Agriculture, Al-Azhar University. The rice straw output from the machine was separated into tow forms, due to nature of straw as a soft material, one over the concave (large chops) and the other under it (small chops). The lengths of small shredding straw were 7 mm ≤ L≤ 20 mm, while the lengths of large grinding straw were 25 mm $\leq$ L$\leq$ 210 mm. Alluvium materials was added as a building material to rice straw to increasing its stability as a building material, due to the lack of organic matter as mentioned before. These materials were dredged from canals and rivers which were considered as a waste material, its cheap price and availability in huge amounts all over the year. These materials were not used with cotton stalks because they have higher values of organic matters than rice straw. The pressure was used in this study as an important variable to perform a building material from rice straw. The pressure is compacted the chops; the heat generated from the pressure increased the effect of organic matter with moisture content to stick the chops together as a binding material. The press is formed by one of two speed hand pump with automatic exchange and simple acting cylinder with automatic return Made by SICMI sa.s., Trecasali (Parma), Italy (1996). The samples were compressed in a cylindrical shape to satisfy the requirements of the other measurements. A cylinder was used to compress samples inside it which is manufactured from mild steel in the workshop of Agricultural Engineering Department, Faculty of Agriculture, Al-Azhar University. Its inner diameter is 105.4 mm; outer diameter is 110 mm, and length of 210 mm. The cylinder was divided in longitudinal direction into two equal parts to ease release the specimen without any deformation. The two equal parts of the cylinder were connected by two steel rings. In order to compress the sample inside the compression cylinder, two disks of steel were used. The diameters of disks were 104.5 mm (0.9 mm less than compression cylinder diameter) to decrease the friction between disks and the cylinder inner surface. A hollow circle was done in one side of the upper disk with diameter equal the diameter of the pressing apparatus cross-head. This hollow circle has a depth of 2 mm and in the center of disk surface to insure that the pressure always directed to the cylinder axis. The upper and lower disks thicknesses were done to be 32.5 mm and 30.5 mm, respectively. The specimens obtained from the cylinder after compression was formed to a disk shape with diameter of 104.5 mm and the thickness differs according to the treatments. In order to study the thermal conductivity of the samples of building material, an apparatus was developed according to Lee's method **(Noakes *et al.*, 1953)**. The apparatus was constructed at the workshop of Agricultural Engineering Department, Faculty of Agriculture Al-Azhar University. The apparatus is shown in figs. (1 and 2) consists of, as shown in Figs: (1) an electrical heater of 1 kw. (2) Steam unit made from stainless-steel. (3) A hose to transport the steam to the steam chamber. (4) Steam chamber, its height of 100 mm and diameter is 105 mm (5) Brass disk attached with a steam chamber, its diameter is 105 mm and thickness is 10 mm. (6) Lower brass disk its mass is 740 g. (7) Thermometer. (8) Supported chains.

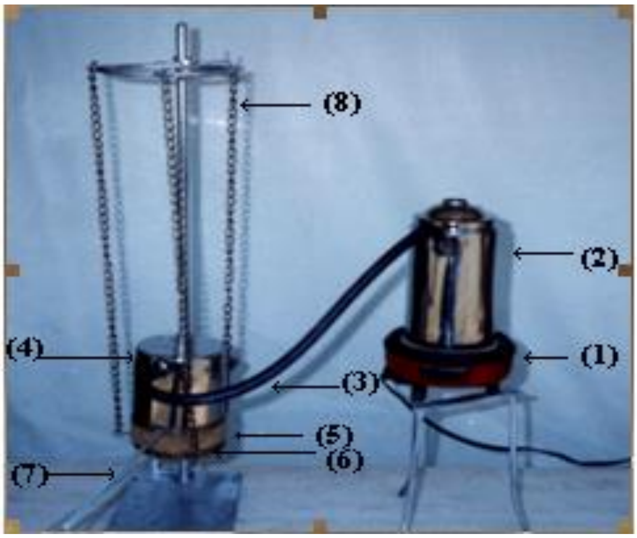

Fig. (1) : Thermal conductivity apparatus.

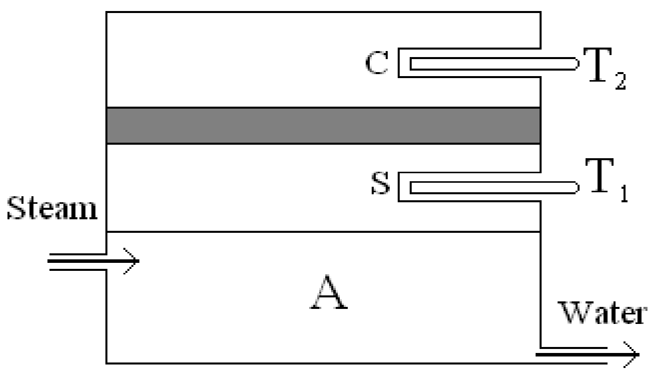

Fig. (2) :A schematic diagram for steam unit and sample of thermal conductivity Apparatus (C, S) Brass disks, (B) Sample, (T_1, T_2) thermometers.

The Lee's method **(Noakes *et al.*, 1953)** for the thermal conductivity determination of a bad conductor was used on all samples. A sample (B) of thickness (x) and radius (r) was placed between the two brass disks (S, C). The steam generated from water and transport through a hose to the steam chamber (A). There is a period of waiting until the readings (T_1) and (T_2) of thermometers (1) and (2) are steady. As brass is an extremely good conductor the thermometers can be taken as an indicator to the temperatures of sample faces. Thus the temperature gradient in the steady state is (T_1 - T_2) / x. The rate of heat flow through the sample is found by the following way. The temperature of (B) is steady it is therefore the sample receiving heat by conduction from (A) with the same rate which the sample loosing heat to surroundings from (C). For calculating the rate of heat loss from (C), the mass (m) of the disk (C) is found and the specific heat (S) of brass obtained from a set of tables. The disk (C) is then only heated gently and raised to few degrees of temperature (T_3) a above (T_2). The specimen alone is placed on a top of (C) and the time (t) sec. is taken for the temperature to fall to (T_4) which is far below (T_2) as (T_3) was above it. The thermal conductivity for sample was calculated from the following equation:

$$k= \frac{m.s\,(T_3-T_4)\,x}{t\,(T_1-T_2)\pi\,r^2} \quad .... \quad (1)$$

$$\frac{32229.2\,(T_3-T_4)x}{t\,(T_1-T_2)} \quad =$$

where :

k : Thermal conductivity for sample (w/m.°C).

m : Mass of brass disk (C) 0.74 (kg).

r : The radius of sample (m).

t : Time (sec.).

S : Specific heat for brass, (380 J/kg.°C).

x : Thickness of sample (m).

The previous equation resulted from the following theoretical approach: The rate of heat flow through disk, its radius (r) and surface temperatures was T_1 and T_2.

$$\frac{dQ}{dt} = k\,\pi\,r^2\,[(T_1 - T_2)\,/\,x] \;....... \qquad (2)$$

where :

x : The thickness of disk.

k : The thermal conductivity for disk material.

and (k) is defined as the quantity of heat which flow in one second in disk direction through a cross area 1 cm^2 and 1 cm thickness when the temperature difference between its two surfaces is 1°C. In a constant case T_1 and T_2 , the quantity of heat which pass through the disk dQ/dt in one second equal to the rate of loss of heat from disk (C) and equal :

$$\frac{dQ}{dt} = \frac{m.s\,(T_3 - T_4)}{t} \qquad .... \quad (3)$$

where :

t : The cooling time from T_3 to T_4.

s : The specific heat for disk material.

m : Mass of brass disk (C).

From equation (2) , (3) resulted the thermal conductivity of sample.

$$m.s[\,(T_3 - T_4)\,/\,t] = k\,\pi\,r^2\,[(T_1 - T_2)\,/\,x] \qquad .... \quad (4)$$

The mass was measured by a digital electronic balance with accuracy of 0.1 g for a mass of 5 kg, the time was measured using a digital stop watch with accuracy of 0.01 sec., the lengths were measured by a steel tape and the moisture content "MC" was measured using an electric oven with temperature ranged from 35°C to 210°C.

Test procedures

Two types of residues were used in this study rice straw and cotton stalks. In order to study some building characteristics as affected by the following variables:

1. Residues types.
2. Residues shape.

3. Moisture content "MC" (%) wb.
4. Binding materials percentages (%).
5. Applied pressure "MPa".

The experiments were carried out at the Researches Center of Agricultural Engineering Department, Faculty of Agriculture, Al-Azhar University. Three levels of moisture content (low, medium and high) were used. The low moisture content was measured and recorded directly according to the standard number ASAES358.2DEC93 (ASAE standard year book, 1993). In order to achieve medium and high moisture content this must be 20% and 30%. The water was sprayed to the residues. The mass of spraying water was calculated as follows:

$$W = m\,[(Mc_2 - Mc_1)/(100 - Mc_2)] \qquad \ldots\ldots\ldots\ldots \qquad (5)$$

where :

W : Spraying water mass.

m : Sample mass at low MC 10% (wb)

Mc_1 : Moisture content at low MC 10% (wb)

Mc_2 : Moisture content at medium low MC 20% (wb) or high moisture MC 30 % (wb)

For medium moisture content "MC" 20%

$$W = 0.125\ m$$

For high moisture content "MC" 30%

$$W = 0.286\ m$$

To make homogenous mixture the residues were stirring manually during spraying water. Five samples were taken from each moisture content level and the moisture content was measured. The moisture content adjustment was executed day by day. Four percentages of alluvium, as binding material, were add to rice straw residue, due to the lake of organic matter as mentioned before. The ratios were 0, 10, 15 and 20%

by weight. Three formation pressures of 5.68, 12.37 and 18.51 "MPa" Each sample had a constant weight of 100 g. The sample was put inside the compression cylinder and compressed between tow disks by hydraulic pressing at a selected loading level for a constant hold time of 30 min. The thickness of sample was recorded several times when the sample was under pressing. The sample was released from the cylinder at the end of pressing and thickness of sample was recorded too. Finally, each sample was put into a plastic page to conserve the moisture content and stored inside a wooden container for a period of 12 months.

RESULTS AND DISCUSSION

Effect of pressing pressure on thermal conductivity for free samples:

Table (1) and Fig. (3) illustrated the relationship between thermal conductivity "k" and formation pressures "FP" of free compressed samples at different moisture content for large and small rice straw chops.

The obtained data indicated that the thermal conductivity decreases with the increase of formation pressure at different moisture content for both large and small rice straw chops. The values of thermal conductivity were lower (high insulation) at small chops than large chops for rice straw chops. This is may be due to that the large chops have wide porous than small chops. The samples of large and small cotton stalks chops were not enough to carry out this test because of the effect of microorganisms and moisture content increasing. The minimum value of thermal conductivity was 0.0091 w/m.°c at 18.51 MPa and 7 % moisture content; the maximum value was 0.0362 w/m.°c at 12.37 MPa and 9 % moisture content for large and small rice straw chops. The values of thermal conductivity at 7 % moisture content were lower than values at moisture content 8 and 9 % respectively, this means that the moisture content increases the thermal conductivity (low insulation), this because that the

Table (1) : Thermal conductivity "k" (w/m.°c) for large & small rice straw chops "LRS and SRS".

Residues size	Moisture content after 12 months "MC" (%)(wb)	Formation pressure "FP" "MPa"	Thermal conductivity "k" (w/m.°c).	
			MC (%)	Rice straw "RS"
Large chops "L"	8	5.68	7	0.0218
		12.37		0.0180
		18.51		0.0155
	9	5.68	8	0.0219
		12.37		0.0187
		18.51		0.0172
	10	5.68	9	*
		12.37		0.0362
		18.51		0.0308
Small chops "S"	8	5.68	7	0.0150
		12.37		0.0104
		18.51		0.0091
	9	5.68	8	0.0153
		12.37		0.0114
		18.51		0.0100
	10	5.68	9	0.0306
		12.37		0.0259
		18.51		0.0199

*: Missing specimens (unstable specimens).moisture migration heat transfers these results were agreed with **McCabe (1993)**.

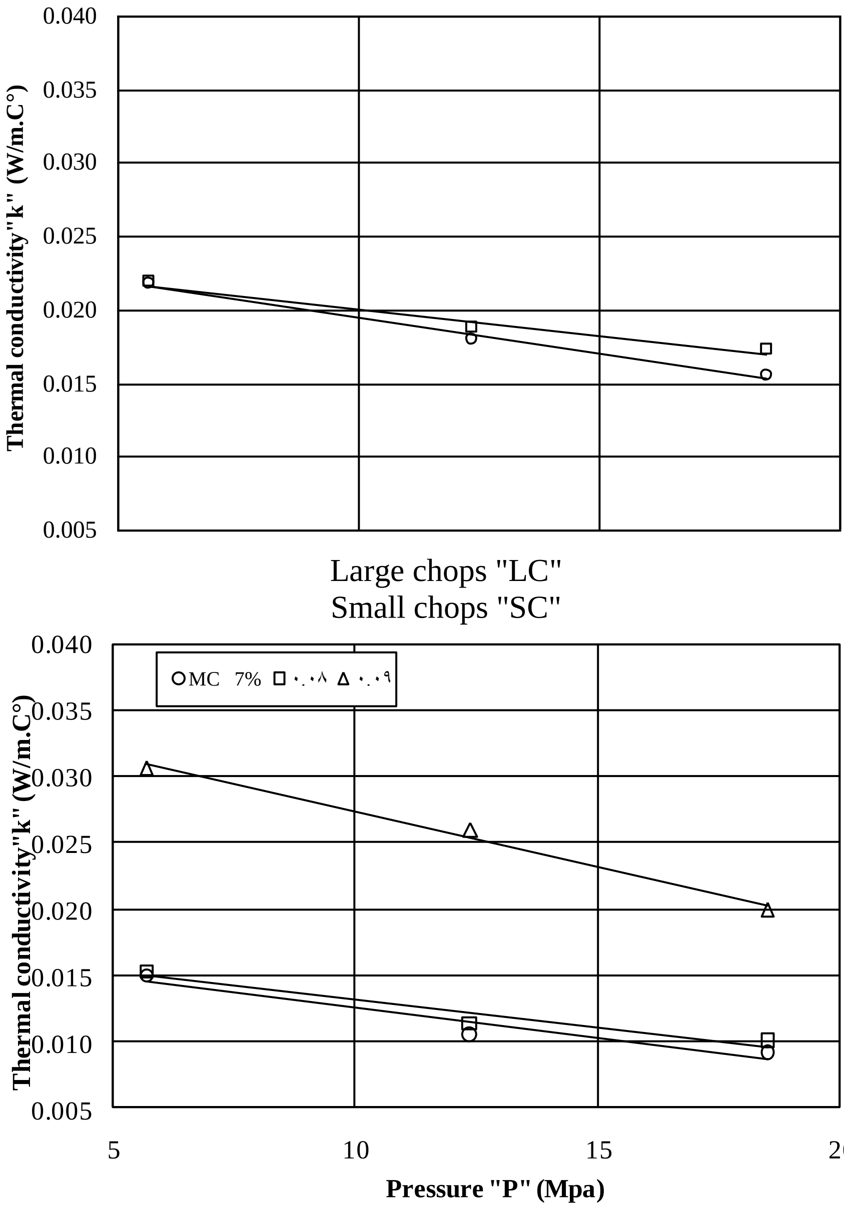

Fig. (3) : Effect of formation pressure "FP" on thermal conductivity "k" at different moisture content for large and small rice straw chops "LRS and SRS".

Effect of binding material percentage on thermal conductivity:

Table (2) and Fig. (4) revealed the relationship between thermal conductivity "k" and binding material percentage "Bm" (%) of free compressed specimens at different moisture contents and formation pressures for large and small rice straw chops. The obtained data indicated that the thermal conductivity decreases with increase of binding material percentage at different moisture content for both large and small rice straw chops. The values of thermal conductivity were lower (high insulation) at small chops than large chops.

Table (2) : Thermal conductivity "k" (w/m.°c) with bonding materials percentage "Bm" (%) for large and small rice straw chops "LRS and SRS".

Residues size	Formation pressure "FP" "MPa"	Binding materials percentage "Bm" (%)	Thermal conductivity "k" (w/m.°c). Moisture content after 12 months "MC" (%) wb		
			7	8	9
Large chops "L"	5.68	0	0.0218	0.0219	*
		5	0.0216	0.0217	*
		10	0.0215	0.0216	0.0417
		15	0.0207	0.0212	0.0372
	12.37	0	0.0180	0.0187	0.0362
		5	0.0173	0.0177	0.0351
		10	0.0171	0.0175	0.0349
		15	0.0162	0.0165	0.0282
	18.51	0	0.0155	0.0172	0.0308
		5	0.0143	0.0147	0.0305
		10	0.0135	0.0147	0.0284
		15	0.0132	0.0145	0.0265
Small chops "S"	5.68	0	0.0150	0.0153	0.0306
		5	0.0140	0.0144	0.0257
		10	0.0129	0.0136	0.0247
		15	0.0126	0.0127	0.0236
	12.37	0	0.0104	0.0114	0.0259
		5	0.0101	0.0113	0.0207
		10	0.0091	0.0110	0.0183
		15	0.0086	0.0097	0.0177
	18.51	0	0.0091	0.0100	0.0199
		5	0.0081	0.0098	0.0157
		10	0.0074	0.0097	0.0156
		15	0.0074	0.0086	0.0141

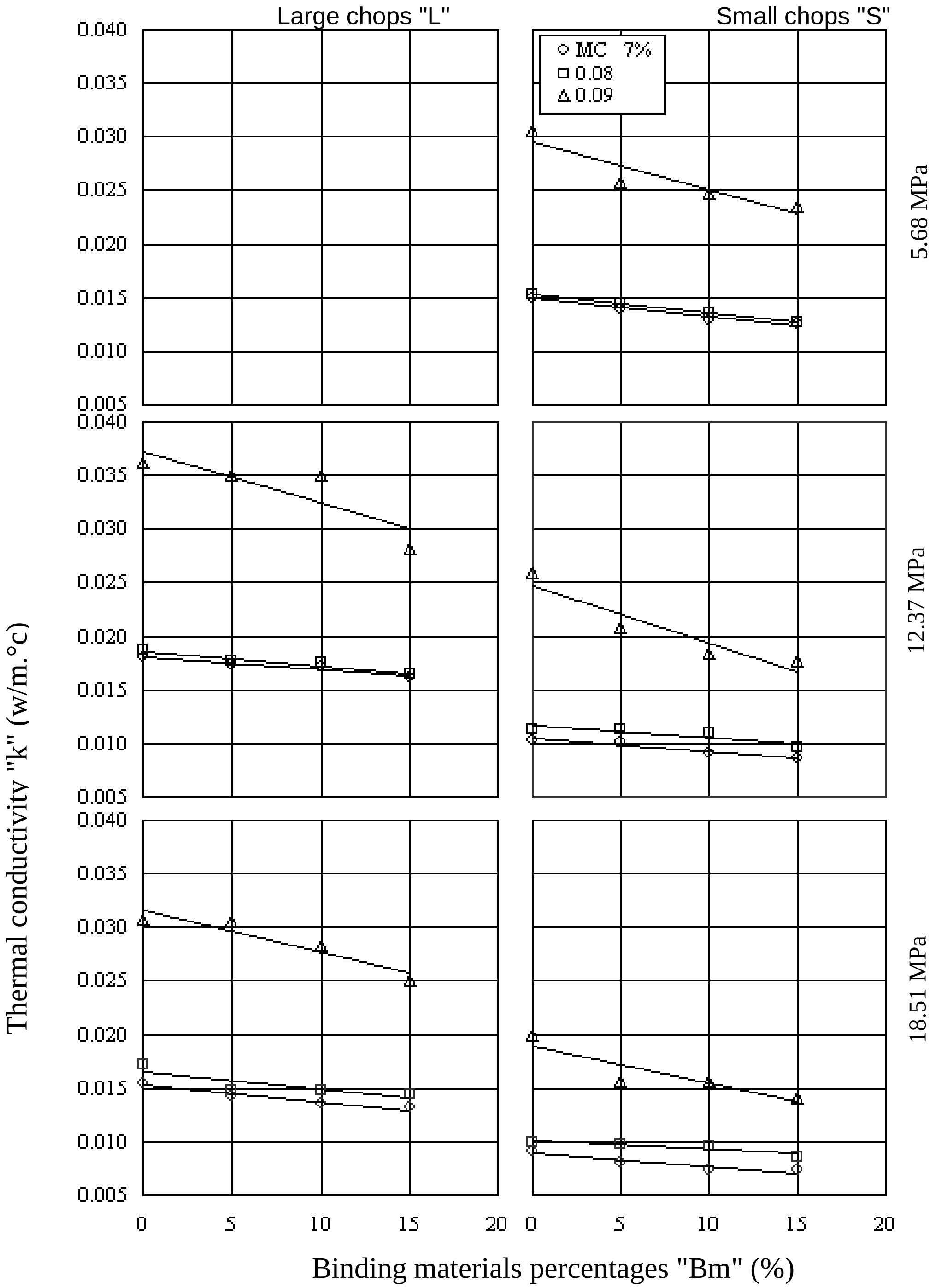

Fig. (4) : Effect of binding materials percentage "Bm" (%) on thermal conductivity "k" (w/m.°c) at different formation pressures and moisture contents "MC" for large and small rice straw chops "LRS and SRS".

This is may be due to binding material percentage and lower porous. The minimum value of thermal conductivity was 0.0074 at 15 % binding material percentage, 18.51 MPa and 7 % moisture content; the maximum value was 0.0417 at 10 % binding material percentage, 5.68 MPa and 9 % moisture content for large and small rice straw chops. The values of thermal conductivity were lower at 7 % moisture than 8 and 9 %, respectively, this occurred because the moisture content migration heat transfers these results were agreed with **McCabe (1993)**.the values of thermal conductivity were lower at 18.51 MPa than 12.37 and 5.68 MPa, respectively.

REFERENCES

Abd El-Gawad, A.A., (1997). Wastes recycling technology 1st. ed., El-Dar El-Arabia for publishing and distribution, Naser City, Cairo, ARE, : 512 (in Arabic).

Abd El-Ghaffar, E.A., (1987). Planning of agricultural structures, 1st. ed., El-Shahby Center for publishing and distribution, Laskareds Street, Ghapreyal-Ramel, Alexandria, ARE : 390 (in Arabic).

Abd El-Mageed, H.N.; and H.N. Mousa, (1994). Factors affecting formation of Bales from cotton stalks flakes, Misr J. Agr. Eng., 11 (4) : 1099-1122.

Alaa El-Dine, M.N.; S.A. El-Shimi; M.H. Mahmoud; and A.M. Abdel Aziz, (1983). Biogas for Egyptian villages (Energy - feltilizer - forage) Soil and water research institute, Agri. Research Center, (257) (in Arabic).

Chancellor, W.J., (1962). Formation of hay wafers with impact loads, Agricultural Engineering, 43 (3) : 136-138 (c.f. Abd El-Mageed and Mousa, 1994).

Everett, A., (1978). Materials, the Anchor press, Ltd., BT Butsford, 4 Fitzharding Street, London, Great Britian, : 23, 309.

FAO (Food and Agriculture Organization of the United Nation) (2005). Quarterly bulletin of statistics, New York**.** (c.f. Moussa,2008).

GDC (Gold Board Development Corporation), (2000). The case for straw, http ; //www.goldboard-com/straw/botany. htm.

Jones, B. (2001). Information Guide to strawbale building, Amazon Nails, Hollinroyd farm, Todmordeu, ol148J, www.strawbalefutures. org.UK.

Kamel, O. (1999). Rice harvesting losses utilizing two different harvesting techniques of Japanese combines, 7th conference on the role of agricultural engineering and Mechanization in the large scale, Agricultural Development projects in Egypt, Mech. Dep., Faculty of Agri., Alex., Uni. Egypt 27-28 October, 1999, Misr J. Ag. Eng., 16 (4) : (37-25).

Kennedy, J.F.; and C. Wanek, (2002). The Art of natural building, every body loves straw bale, new society publishers, Canda, 291.

Khairy, M.A. (1997). Harvesting and post harvesting machinery, booklets, Ag. Eng. Dep., Faculty of Agriculture, Al-Azhar University, Nasr City, Cairo, Egypt : 27 (in Arabic).

Kazragis, A.,(2005). Minimization of atmosphere pollution by utilizing cellulose waste, Journal of Environmental Engineering and Landscape Management, 13(2): 81-90.

Kumar, K.S.; and R.P. Lottman, (1972). Using straw to reinforce rigid Urethan foam, J. Ag. Eng., : 45-46.

Macdonald, R.G.; and J.N. Franklin, (1969). Pulp and paper manufacture, McGraw-Hill, USA, 1 : 42-44, 51-56 (c.f. Abd El-Mageed, 1981).

McCabe, J.C. (1993). The thermal resistively of straw bales for construction, M.Sc. Thesis, Gradute College, University of Arizona, USA. http://solstice-crest-rog/efficiency/ straw insulation/straw-insul.htm/:30

Mohsenin, N.; and J. Zaske, (1976). Stress-relaxation and Energy requirements in compaction of unconsolidated materials, J. Agr. Eng. Res. 21 (2) : 193-205.

Moussa, I.A.,(2008). Effect of some adhesive matter on agricultural wastes as building materials, MSc., Thesis, Ag. Eng. Dept., Faculty of Agriculture, Al-Azhar University.:4,20,23.

Noakes, G.R.; A.M. Oxon; and F. Inst, (1953). Text-Book of heat, Macmilan and Co., Liwnrled, London, : 337-338.

O'Dogherty, M.J.; and J.A. Wheeler, (1984). Compression of straw to high densities in closed cylindrical dies, J. Ag. Eng. Res. 29 (1) : 61-72.

O'Dogherty, M.J. (1989). A review of the mechanical behavior of straw when compressed to high densities, J. Ag. Eng. Res. 44 (4) : 241-265.

Saleh, T.M.; and S.A. El-Meadawy, (1972). Egyptian cotton stalks, Egyptian Journal of Chemistry, 15 (4) : 361-367.

Suliman, A.E.; and A.M. El-Zahaby, (1998). Utilization of some field crops residues, 1st international conference on Rationalizate of Energy in Agriculture Ag. Mech. Dep., Faculty of Agriculture, Mansoura Univ. 17-18 March, 1998 : 173-187.

USDE Department of Energy (1995). House of straw, straw bale construction comes of age, office of building technology, State and Community programs, WWW.straw bale control. com or WWW.green builder-com/down.

الملخص العربى

تاثير استخدام الضغط على التوصيل الحرارى لطوب قش الأرز

محمد فايد عبد الفتاح خيرى[١] ابراهيم سيف السؤالى[٢] رزق ربيع كامل البسومى[٣]

لدراسه تاثير استخدام الضغط لتشكيل طوب قش الأرز على التوصيل الحرارى تم تقطيع قش الارز الى مجموعتين مختلفتين في الحجم (قطع كبيره وقطع صغيره) وتم استخدام ثلاث نسب رطوبه على الموجموعتين السابقتين وتلك النسب كانت (١٠و٢٠و٣٠%) حيث تم استخدام ثلاثه مستويات من ضغط التشكيل (٥,٨٦, ١٢,٣٧ و ١٨,٥١ميجا باسكال) وتم قياس التوصيل الحرارى للعينات الناتجه حيث اظهرت النتائج ان: تؤدى زيادة مستوى ضغط التشكيل الى انخفاض قيم التوصيل الحرارى لكلاً من قش الأرز المقطع قطع كبيرة وصغيرة. وكانت اعلى قيمة للتوصيل الحرارى (٠,٠٣٦٢ وات/م.م°) فى حالة قش الأرز المقطع قطع كبيرة عند ضغط تشكيل (١٢,٣٧ميجا باسكال) . وأقل قيمة للتوصيل الحرارى (٠,٠٠٩١ وات/م.م°) فى حالة قش الأرز المقطع قطع صغيرة عند ضغط تشكيل ١٨,٥١ميجا باسكال .

(١) أستاذ الهندسة الزراعية – كلية الزراعة بالقاهره - جامعة الازهر.
(٢) أستاذ الهندسه الزراعيه المساعد- قسم الهندسة الزراعية – كلية الزراعة بالقاهره - جامعة الازهر.
(٣) مدرس مساعد الهندسة الزراعية – كلية الزراعة بالقاهره - جامعة الازهر.