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Development of thermal Insulating Material from Agricultural Waste

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Abstract—*One of the major problems of today's buildings is to maintain the internal environment to comfort zone without mechanical air conditioners. Maintaining comfort zone by using air conditioners requires lots of energy. However, the use of air conditioning can be reduced by using some thermal insulation in the building construction. Common thermal insulators that can be used for the same are mineral wool, lightweight cellular concretes, foam glass, fiberglass, phase change materials, agricultural waste etc. The agricultural waste includes saw dust, rice husks, coconut husk etc. This work is exploring the potential of agricultural wastes that can be developed for thermal insulation. This is a solution which can reduce the energy consumption in making the comfort zone. In this research work, saw dust has been taken as thermal insulating material. A brick of saw dust coated with cement has been prepared as an alternative to existing brick for the construction of buildings. From experiments it has been seen that the brick made of saw dust have lower thermal conductivity than that of existing bricks. Therefore, it can be proposed that it can be used for making the bricks for walls and roofs of the buildings.*

Keywords*: agricultural waste, saw dust, thermal insulation, thermal conductivity.*

1. INTRODUCTION

In a country like India, it requires a rapid growth in infrastructure and the basic requirement of the present buildings is to maintain the inner atmosphere or temperature up to the comfort zone .i.e. 20 to 25^0C. Various electrical equipments such as air conditioners, room blowers etc are being used in different seasons for obtaining the temperature up to the comfort zone. In most of the countries worldwide, this trend is leading to increased environmental pollution and global warming due to the use of fossil fuels on daily basis to maintain comfort inside buildings [1].

The houses in old days were made of agricultural waste materials such as wheat stick and other agricultural waste which provides us a perfect environment for living. India is having a large area for agriculture; the wastes produced out of these are used either for animal feeding or for burning purpose. Energy demand in buildings can significantly be reduced with the use of thermal insulating materials. One of the techniques for reducing the demand of air conditioning is to apply thermal insulation in walls and roofs [2]. The inorganic building insulating materials such as mineral wool, lightweight and cellular concretes, foam glass, fiberglass, plastic foams, Styrofoam and expanded perlite can be used in the construction of buildings as a thermal insulating material [3]. Besides their long-term financial benefit, the use of some of the inorganic insulating materials may be harmful to human health [4].

In the present investigation, agricultural waste has been used as insulating material for building construction. A structure which is composite of cement and agricultural waste can be used for the construction purposes after proper design and consideration.

2. AGRICULTURAL WASTE

Waste generated by harvest and post harvest operations from agricultural industries are usually burned or dumped into the landfills. The major problem associated with these waste is inadequate storage and improper handling in rural areas. The problem of waste management / utilization in rural areas can be resolved by using it these as building materials. Some of the agricultural wastes, such as rice hulls, bagasse, coconut husk, corn cobs and saw dusts, have high fibrous content (ligno-cellulosic compounds), are being used as the main ingredient for composite materials for manufacturing the boards or panels [5].

All these natural fibers have excellent physical and mechanical properties and can be utilized effectively in the development of composite materials for various building applications.

3. PROBLEM FORMULATION

Maintaining the temperature of room at ambient temperature in summer as well as in winter season is very costly due to high cost of air conditioning systems and huge amount of energy is consumed in maintaining the room temperature to the comfort zone. The requirement of air conditioning system can be minimised if walls are made of insulating or low thermal conductivity material.

In the present investigation a composite brick of saw dust and cement is prepared and its thermal conductivity were analysed with the help of thermal conductivity testing rig. The thermal conductivity testing rig has been fabricated according to *Ogedengde,* et al [6].

4. EXPERIMENTAL PROCEDURE

4.1 Preparation of working sample

The biomass material used in this project was saw dust. The sample was prepared into the following steps. First the saw dust was collected from carpentry shop, dried and sieved into a particle size of 0.4 to 2 mm. The sieved saw dusts were mixed with epoxy solution (Polyvinyl Acetate) so as to create bond between the particles. This mixture was then filled in the mould and compressed by a mechanical press to obtain the block of saw dust as shown in the Fig.1. The force applied was 15 kN. The block prepared by compression was taken out of the mould and placed in oven to remove the moisture present in it. The dry blocks were coated with cement to get the brick as shown in Fig. 2.

Fig. 1: Block of saw dust

3.2 Schematic of Apparatus

The testing rig (Fig. 3) for determining the thermal conductivity is as per standard followed by Ogedengbe et al [6].

Fig. 2: Finished brick block

In this arrangement three thermometers were placed at different positions to measure the temperature. Test sample was placed in between two thermometers (T_A and T_B) and heating coil is placed between thermometers T_B and T_C. Now the arrangement is placed in between a holding device to prevent the air entering between the sample and other parts. An electronic multi-meter is connected in heating coil so as to measure the current (I) and voltage (V) across it.

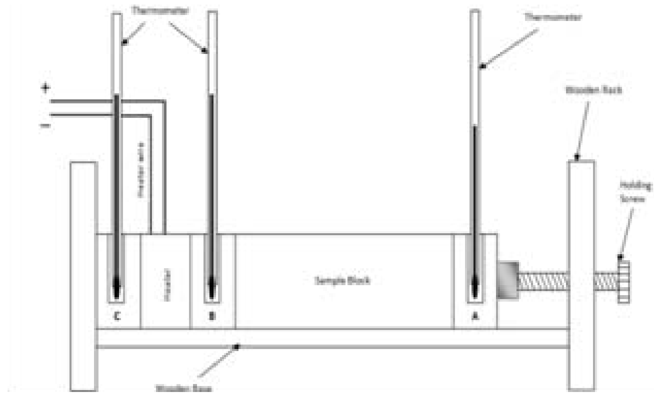

Fig. 3: Test apparatus arrangement [6]

5. RESULTS AND DISCUSSION

The test for determination of thermal conductivity (k) has been performed on three samples of same specification with varying voltage. In this experiment the thermal conductivity is calculated by using equation $\boldsymbol{K = \frac{el}{2A(T_B - T_A)}\left(a_S \frac{T_A+T_B}{2} + 2\, a_A T_A\right)}$ which was proposed by *ogedengde,* et al [6].

Where, a_A, a_B, a_C and a_S are the exposed surface areas (in m^2) of block A, B, C and the working sample respectively. T_A, T_B and T_C are the temperatures of block A, B and C above ambient (i.e. the true temperature of the discs minus the ambient temperature).

Length of sample block, l = 0.2286 m

Length of temperature block, l_o = 0.0128 m

Width of sample/ temperature block, b = 0.1016 m

Height of sample / temperature block, h = 0.0762 m

a_A=a_C = Side area + Flat surface area =$2l_o\ (b + h) + b\square h$ = 0.0122936 m^2

a_B= exposed surface area of block B = $2l_o\ (b + h)$ = 0.00455168 m^2

a_S= exposed surface area of sample = $2l\ (b + h)$ = 0.08219016 m^2

The current (I), voltage (V) and temperature (T) of samples S1, S2 and S3 are shown in table 2, 3 and 4

Table 1: Test sample S1

S. no	Current (I) in ampere	Voltage (V) in volt	Temperature reading in 0C			Thermal conductivity(K) in W/mK
			TA	TB	TC	
1	4.7	0.026984	25	28	28	0.589438
2	4.7	0.036125	26	30	31	0.589434
3	4.7	0.045287	28	33	33	0.589435
4	4.7	0.054521	29	35	35	0.589436
5	4.7	0.063646	33	40	40	0.589438
6	4.7	0.072772	37	45	46	0.589441
7	4.7	0.091307	40	50	50	0.589439

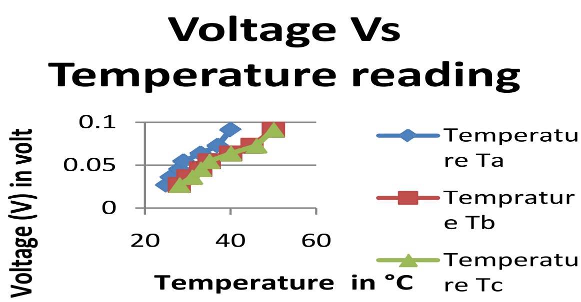

Fig. 4: Voltage Vs Temperature curve for sample S1

Table 2: Test sample S2

	Current (I) in ampere	Voltage (V) in volt	Temperature reading in 0C			Thermal conductivity(K) in W/mK
			TA	TB	TC	
1	4.7	0.026984	24	27	27	0.589443
2	4.7	0.036124	26	29	30	0.589433
3	4.7	0.045287	28	32	32	0.589436
4	4.7	0.054521	29	35	35	0.589436
5	4.7	0.063646	32	40	40	0.589439
6	4.7	0.072772	37	45	45	0.589441
7	4.7	0.091306	40	49	50	0.589437

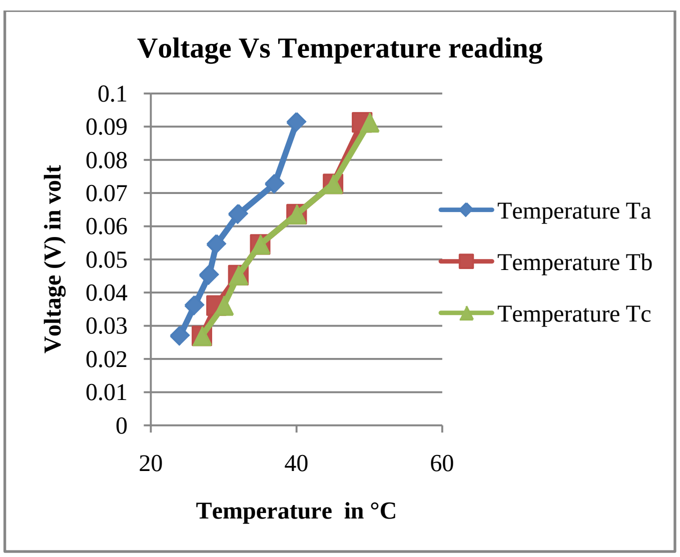

Fig. 5: Voltage Vs Temperature curve for sample S2

Table 3: Test sample S3

S. no	Current (I) in ampere	Voltage (V) in volt	Temperature reading in 0C			Thermal conductivity(K) in W/mK
			TA	TB	TC	
1	4.7	0.026984	24	27	28	0.589443
2	4.7	0.036125	26	30	30	0.589434
3	4.7	0.045287	27	33	33	0.589439
4	4.7	0.054521	29	35	35	0.589436
5	4.7	0.063646	33	39	39	0.589436
6	4.7	0.072772	37	45	44	0.589441
7	4.7	0.091306	40	49	50	0.589437

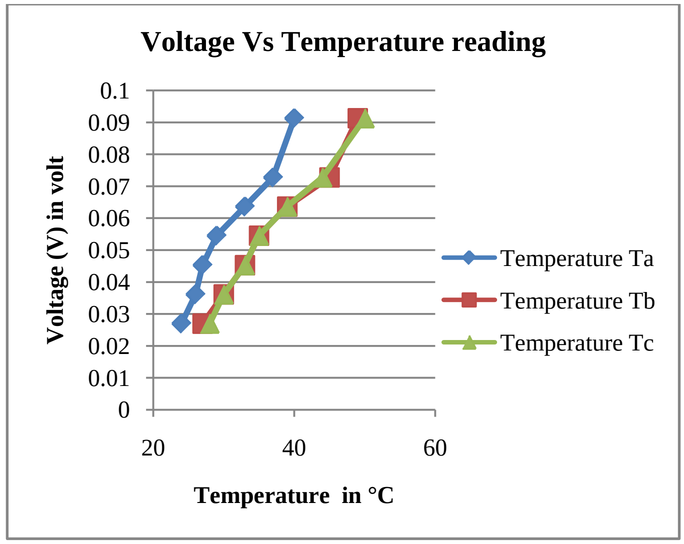

Fig. 6: Voltage Vs Temperature curve for sample S3

Voltage Vs Temperature curve for sample S1, S2 and S3 are shown in Figs. 4, 5 and 6 respectively.
It is observed from Tables 2, 3 and 4 that every value of the thermal conductivity (k) is almost constant for all the values of voltage.

6. DISCUSSION

The thermal conductivity (k) of brick determined from the experiment is observed to be 0.589 W/mK, which is very less than the thermal conductivity of brick used in construction of building i.e. 1.03 W/mK . Therefore, the brick presently used in building construction may be replaced with the brick proposed for heat insulation. However, before replacing the existing brick, the study of strength of proposed brick must be done.

7. CONCLUSIONS AND SCOPE FOR FUTURE WORK

The thermal conductivity (k) of composite block made of saw dust and cement is observed to be 0.589 W/mK. These agricultural wastes which are presently used for burning purpose only can be used for making block and can be used for building construction process. This will also reduced the energy which is utilized in air conditioning process.

There are many more agricultural wastes that can be used for the same purpose after determination of its thermal conductivity. More tests like strength and fire resistant test have to be performed for its better usability.

The next stages of work consider applications as a thermal insulation material using life cycle analysis (LCA) to evaluate environmental and health impacts. The LCA of using waste materials will be a gateto- gate analysis, i.e. commencing with the waste product of food production as it leaves the gate of the food production factory to the exit gate of the insulation manufacturing process. Whilst this assumes the waste material is essentially free, the analysis will consider the harmful effects of residual agricultural chemicals such as insecticides and fertilizers.

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