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Investigating the Thermal Properties of Hybrid Composite (Rice Husk, Saw Dust and Bagasse) for Building Thermal Insulation

Mbimda Ali Mbishida
(Nigerian Building and Road Research Institute, North-Central Zonal Office Jos, Plateau State, Nigeria)

Abstract

The thermal properties of Rice Husk, Bagasse and Saw Dust which are regarded as an Agricultural/environmental waste were investigated to determine their use as thermal insulators. The composite percentages in each sample wastes were varied at increasing and decreasing quantities to determine the best mixtures. The criteria for evaluation include the experimental determination of Thermal Conductivities and Specific Heat Capacities for composites samples and other dependable properties. The results from evaluations have identified that sample VII with 0.231Wm^{-1}k^{-1}and 22.114m^{-1} is the best mixed with more rice husk and a considerable percentage of bagasse to less percentage of sawdust. This work has explored the potentials for using composite samples of Rice Husk, Bagasse and Saw Dust as materials for thermal insulation, a solution which offers a reduction in resource use, promotes recycling of the wastes, less dependent on toxic chemical types in wood/cellulose based insulators, in addition to reducing energy consumed by altering internal air conditions.

Keywords - *Thermal Properties, Composites, Insulation, Agricultural Waste.*

I. INTRODUCTION

Thermal insulation is an important technology to reduce energy consumption in buildings by preventing heat gain/loss through the building envelope. Thermal insulation is a construction material with low thermal conductivity, often less than 0.1W/mK. These materials have no other purpose than to save energy and protect and provide comfort to occupants [1].

Commonly used inorganic building insulating materials include mineral wool, lightweight and cellular concretes, foam glass, fibreglass, plastic foams, Styrofoam and expanded perlite [2]. However, besides their long-term financial benefit the use of inorganic insulating materials may be harmful to human health and body and also cause environmental pollution, such as emissions of toxic gas and particle, and stick to the skin [3]. Also, the production of these materials is highly energy-intensive, and the eventual disposal is an environmental hazard [4]. Therefore, alternative materials having the same or better properties as the conventional material need to be explored as it can offer lower-cost [5]. One of the alternative materials that have been widely investigated is a natural fibre. This material is elementary to get, and it is cheap [6]. This need has prompted research in the direction of renewable fibrous thermal insulation made from trees, plants or animals. These naturally occurring materials can regenerate itself, requires less energy for production and biodegrade easily when disposed of as waste which will significantly reduce the negative environmental impact [7]. In many countries, increased interest in the use of agro-fibres as building thermal insulation is being researched. Published work from many different regions of the world indicates the use of agricultural materials, such as coffee husk and hulls, wood, waste tea leaves, coconut husk, bagasse, cotton and oil palm for particleboard production [8], [9] and [4]. Using agricultural by-products as thermal insulation also generates economic development for farming and rural areas [4].

In this research, agricultural/industrial waste materials (rice husk, sawdust and bagasse) were investigated for thermal insulation application in building. This research aims to develop renewable and environmentally friendly thermal insulation composite products with the view of reducing waste in the environment.

II. MATERIAL AND METHOD

A. Preparation of composites and test specimen

The materials used for test specimen were all collected at the Yelwa market, Bauchi, Nigeria. They were first of all screened for dirt before cleaned and ground to smaller particle sizes of 0.075mm. A sample mixed in various percentages were also combined with 5% binder (starch/water) to ensure proper compaction. The total mixtures were filled into the mould and compacted. Then allowed to dry for some hours under the sun for three days. A total of nine samples were produced in different percentage composition.

Table 1: Composition of Samples Mixture in Percentage

SAMPLES	RICE HUSK (%)	SAW DUST (%)	BAGASSE (%)
I	40	30	30
II	30	30	40
III	30	40	30
IV	50	25	25
V	25	25	50
VI	25	50	25
VII	60	20	20
VIII	20	20	60
IX	20	60	20

B. Determination of Thermal Conductivity

The HILTON Thermal Conductivity Apparatus at Thermodynamics Laboratory of Abubakar Tafawa Balewa University, Bauchi was used for the determination of the thermal conductivity. The linear section was used to determine the thermal conductivity of the samples under investigation. Cooling water was feed into one side of the apparatus to maintain a steady gradient. The instrumentation provided permits accurate measurement of temperature and power supply. Quick response temperature probes, with a resolution of 0.1ºC, gives an accurate digital readout in degrees centigrade. On the apparatus, power control to provide a continuous variable electrical output of 0-100 watts with direct readout was made available [10].

The entire experimental procedure was done per the experimental procedure for the determination of thermal conductivity using HILTON Thermal Conductivity Apparatus as reported by Kyauta *et al.* (2014). The HILTON Heat Conduction apparatus was used to measure Heat across a circular sample linearly under various temperatures; it was also used to carry out the Thermal Conductivity measurement across the composite samples. The temperature displayed on the apparatus in conduction experiments were read from six sensor point as named T_1, T_2, T_3, T_7, T_8 and T_9. These describe temperature profile across heater, sample and cold section. The Power from the heater was kept at 15W. Thermal conductivity was computed by running a script on MATLAB using the six sensor readings tabulated in Table 2. Extrapolation between T_4 and T_6 was done to obtain accurate results. Using MATLAB (scripted code), it generated corresponding polynomials to match T_1, T_2 and T_3 for a hot section to the right above and T_7, T_8 and T_9 cool section below the graph to the left.

III. RESULTS AND DISCUSSION

A. Results

Table 2: Thermal Properties of Composite Sample of Rice Husk, Bagasse and Saw Dust

	Thermal conductivity (k) $Wm^{-1}K^{-1}$	Specific Heat Capacity (c) $Kg^{-1}K^{-1} \times 10^3$	Thermal Resistivity (r) $W^{-1}mk$
Standard Error	±0.002	±0.006	±0.1367
Sample I	0.319	1.861	3.1368
Sample II	0.314	1.285	3.2264
Sample III	0.375	1.951	2.5535
Sample IV	0.321	1.179	3.1213
Sample V	0.251	0.677	9.9893
Sample VI	0.494	0.911	2.0440
Sample VII	0.231	1.235	4.4294
Sample VIII	0.289	0.752	3.4743
Sample IX	0.325	0.568	3.0849

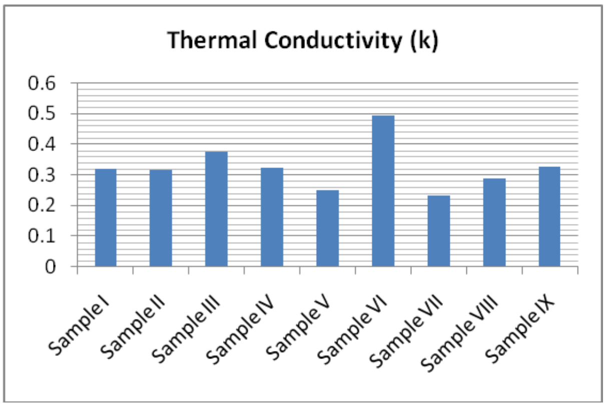

Figure 1: Distribution of Samples' Thermal Conductivity

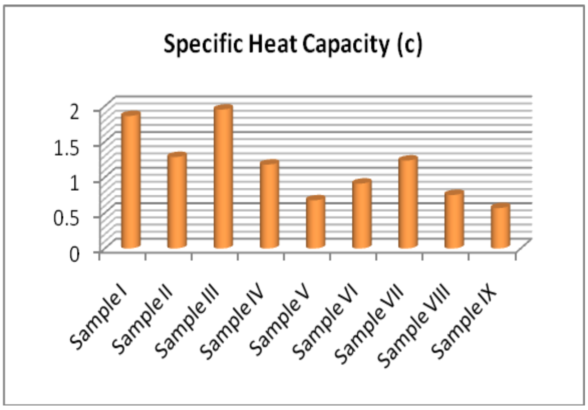

Figure 2: Distribution of Samples' Specific Heat Capacity

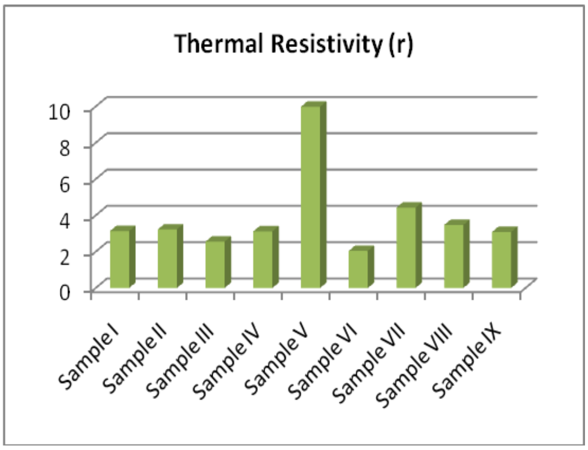

Figure 3: Distribution of Samples' Thermal Resistivity

B. Discussion of Results

The three critical qualities of a thermal insulation material derived from agricultural waste are resource availability, physical properties and environmental impact. Critical physical properties include resistance to fire, mould growth, insect damage and biodegradable. Bagasse has low thermal conductivity, and it is environmentally friendly; it can be made into boards or panels without using any chemical resin. Comparing Table 2 and Fig. 1 results with the documented values for common wood-based/cellulose insulating material as given by [11] which shows the following thermal conductivity, Asbestos cement sheet 0.319 $W^{-1}mK$ brick building 0.600 $W^{-1}mK$ pine wood 0.138 $W^{-1}mK$ and oak wood 0.160 $W^{-1}mK$. It proofs that the prepared samples fall within the same range. Similarly comparing the computed values on Table 2 with those given for wood-based insulating materials, we have the required ranges as 0.735-8.130 $W^{-1}mK$, which is satisfied by all our sample values. Samples II and V show bagasse stops at 50% and shows no improvement at high quantity 60% sample VII while sample III, VI and IX with sawdust increasing is seen dangling up and downwards.

Fig. 1 and Fig. 3 show the results of thermal conductivity and thermal Resistivity, respectively. Careful observation between the two Figures proofs that an increase in thermal Resistivity reduces thermal conductivity. Hence, increasing the thermal Resistivity of material will lower its thermal conductivity, thereby making it a suitable insulation material.

IV. CONCLUSION

The bases for a recommendation as substitute or replacement are considered under these three essential qualities. They are resources availability, physical properties, and environmental impacts when using these waste considered (Rice husk, Bagasse and Sawdust). The used of these materials reduces the risk of environmental pollution. Also, it has been able to show that these wastes can be used for the production of panels or broadsheet of required thickness for used as walling materials or thermal resistant materials. In proving that all samples passed each test and recommended ranges, it shows that it favours insulation materials for naturally cooled design in sub/tropical region.

REFERENCES

[1] F. Al-Neshawy, CIV-E1010 Building Material Technology Lecture notes on Thermal Insulations for Building, Aalto University School of Engineering, Aalto, Finland. (2017) 3-21.

[2] K. Manohar and D. W. Yarbrough, A comparison of Biodegradable Fiber Insulation with Conventional Fibrous Insulation, Proc. of the International Conf. on Thermal Insulation, White Sulphur Springs, West Virginia, (18) (2003) 13– 15.

[3] H. H. Liang and M. C. Ho, Toxicity characteristics of commercially manufactured insulation materials for building applications in Taiwan, Construction Building Materials, (21) (2007) 1254-1261.

[4] S. Panyakaew and S. Fotios, Agricultural waste materials as thermal insulation for dwellings in Thailand. Preliminary Results, PLEA 2008–25th Conference on Passive and Low Energy Architecture, Dublin, (2008).

[5] Y. Y. Mohd Yuhazri, H. Sihombing, A. R. Jeefferie, M. A. Z. Ahmad, A. G. Balamurugan, M. N. Norazman, A. Shohaimi, Optimization of coconut fibres toward heat insulator applications. Global Engineers & Technologist Review, 1(1) (2011) 35-40.

[6] S. Guilbert, C. Guillaume, and N. Gontard, New packaging materials based on renewable resources, properties, applications and prospects. Food Engineering Interfaces, Food Engineering Series, Springer, Part 5, (2011) 619-630.

[7] K. Manohar, Renewable building thermal insulation – oil palm fibre. International Journal of Engineering and Technology, 2(3) (2012) 475-479.

[8] S. Tangjuank, Thermal Insulation and Physical Properties of Particleboards from Pineapple Leaves. International Journal of Physical Sciences, 6 (19) (2011) 4528-4532.

[9] K. Manohar, D. Ramlakhan, G. Kochhar, and S. Haldar, Biodegradable Fibrous Thermal Insulation, Journal of Brazilian Society of Mechanical Science and Engineering (28) (2006) 45-47.

[10] E. E. Kyauta, D. M. Dauda, and E. Justin, Investigation on Thermal Properties of Composite of Rice Husk, Corncob and Baggasse for Building Thermal Insulation, American Journal of Engineering Research (AJER), 03 (12) (2014) 34-40.

[11] J. Twidell and T. Weir, Renewable Energy Resources, London: E. and F. N. Sponse, (1990) 418.

[12] Sarath Menonr, Vishal Narange, Sreedevi.k "Experimental Investigation of Performance of Rockwool Filled Concrete Block", International Journal of Engineering Trends and Technology (IJETT), 7 (2) (2017) 78-82.