Oct 2013. Vol. 4, No. 4 ISSN2305-8269
International Journal of Engineering and Applied Sciences

www.eaas-journal.org

THERMAL CHARACTERISTICS OF LATERITE-MUD AND CONCRETE-BLOCK FOR WALLS IN BUILDING CONSTRUCTION IN NIGERIA

Alausa S.K.[1*], Adekoya B.J.[1], Aderibigbe J.O.[2] ,Nwaokocha, C. F.[1]
[1]*Department of Physics, Olabisi Onabanjo University, Ago-Iwoye Ogun State, Nigeria*
[2] *Department of Physical Science, Ondo State University of Science and Technology, Okitipupa, Nigeria*
alausakunle@yahoo.com OR alausajunior@gmail.com

ABSTRACT

The thermal characteristics of laterite-mud samples and concrete-block samples were investigated using a Lees' apparatus with a view to find which of the two samples would be a better heat insulator for the purpose of constructing self-cooling houses. The study showed that concrete-block sample has a thermal conductivity of 0.435 $Wm^{-1}K^{-1}$, thermal resistance of 2.299 $mKW^{-1}$and thermal diffusivity of $1.215x10^{-4}$ m^2s^{-1} while the thermal conductivity, resistivity and diffusivity for laterite-mud sample were 0.523 $Wm^{-1}K^{-1}$, 1.912mKW^{-1} and $1.126x10^{-1}m^2s^{-1}$ respectively. The results indicated that concrete-block has a higher potential for heat resistivity and therefore has better heat insulating capability than laterite-mud.

Keywords: *laterite-mud, Lees' apparatus, building design, thermal characteristics*

1.0 INTRODUCTION

Shelter is one of the three basic needs of humanity. Housing as an essential need of man is as old as humanity, evolved through centuries of activities; from dwelling in caves to skyscrapers and attractive structures that respond to stimuli in the environment recently (Mbamali and Okotie, 2012). The building construction culture of pre-independence in Nigeria was absolutely dependent on the use of earth (laterite-soil) for house constructions, and then the use of concrete-blocks were insignificant (Alagbe, 2011). The huge influx of various brands of cement into the country after independence in 1960 encouraged the importation of Western building techniques (Alagbe, 2011). The use of cement for building is high in recent time and the erstwhile laterite-soil building culture is gradually diminishing. The post-independence in Nigeria witnessed many rural centers acquiring new status and the discovery of petroleum in 1970s brought unprecedented prosperity and development including the upsurge of infrastructures particularly in the state capitals, urban centers and towns (Mbamali and Okotie, 2012).
Heat flow through a material medium is strongly dependent on the thermal properties and the nature of the material. The heat transmission by conduction through a medium depends on the bonding between molecules and radiation transfer is a function of temperature. The heat convection through solids is negligible for small pore sizes and the degree of heat conduction through a solid determines if the material is suitable for heat insulation or conduction (Akpabio et al., 2001).

The heat experienced in the interior spaces of buildings in tropical regions is through various surfaces including the walls (Akpabio, 1999, Alausa et, al., 2011). The walls release the absorbed heat from the environment into the interiors of buildings by the process of conduction and radiation which causes discomfort to the inhabitants (Etuk et. al., 2003). It is therefore essential to consider how to reduce or eliminate if possible the heat in the interior spaces when constructing the walls of living houses

International Journal of Engineering and Applied Sciences

www.eaas-journal.org

such regions. The interior spaces must be made conducive and comfortable for the general well-being of the occupants. The present study was aimed at determining the thermal properties of laterite-mud and concrete-blocks and find which would be more suitable as a heat insulator for the purpose of constructing walls of houses in tropical region including Nigeria.

Laterite-soil particles are greasy, sticky when wet and hard when dry. These characteristics and attributes make laterite-soil good material for constructing the walls of houses. Concrete-blocks made from cement, aggregate (sharp sand) and water mixed in simple ratio (Plumb, 1991) form the major component of the walls of modern buildings.

2.0 MATERIALS AND METHODS

Laterite-soil and sandy-soil samples were collected from the same location on the main campus of Olabisi Onabanjo University, Ago-Iwoye (Lat 6^o 55' 55" N, Long 3^o 52' 58" E) at an elevation of 30m. Water was added to the laterite, mixed and matched to form mud. The mud was molded into circular disc, dried to constant mass and carefully shaped to a required diameter, d (110.0mm) and thickness x (6.0mm).

The sandy soil and cement were measured in simple ratio of 3 to 1 and thoroughly mixed before the water was added to form concrete. The cement-concrete was molded into a circular disc, dried to constant mass and carefully shaped with a diameter, d (110.0mm) and thickness x (6.0mm). The thermal conductivity of each sample was determined using Lee's apparatus (Nelkon and Ogborn, 1985; Ekpe and Akpabio, 1994; Alausa et. al., 2011). Each sample in turn was sandwiched between the cylindrical hollow brass base and brass slab; and the arrangement was fitted to the steam chest of Lee's apparatus. Steam was passed into the apparatus and temperatures T_1 (^{o}C) of the brass slab and T_2 (^{o}C) of the brass base were recorded at steady state. The experiment was repeated three times and the mean temperatures T_1 and T_2 determined. By Fourier law, the conductive heat transfer in a given material as expressed by Nelkon and Ogborn, 1985 is

$$H = \frac{KA(T_2 - T_1)}{x} \quad (1)$$

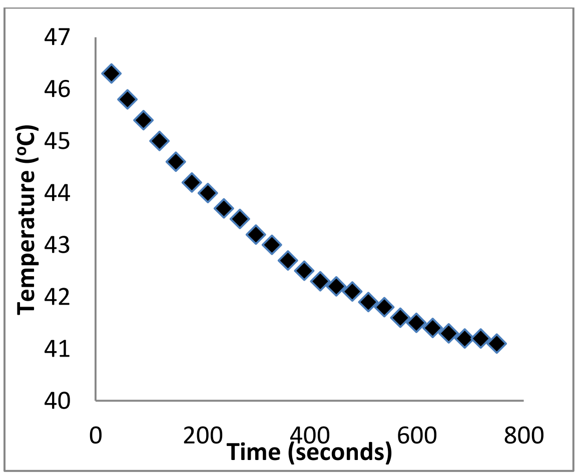
where H is the rate of heat transfer at steady state, K is the thermal conductivity
A is the cross-sectional area of the sample, T_2-T_1 is the temperature difference in the steady state, x is the thickness of each sample

The experimental setup was disconnected and the brass slab was heated directly on the heating chamber until its temperature was about 5^{o}C higher than the value recorded in the steady state. The heating chamber was removed and the brass slab was allowed to cool down while the sample was placed on it and the temperature readings were recorded at intervals 30 seconds until the temperature was about 5^{o}C below the steady state. The procedure was repeated three times and the average temperature readings were determined.

Theoretically, the rate of heat loss by the brass slab together with the sample at steady state is determined by measuring the rate at which the brass slab cools. This rate of heat loss is given by

$$H = mc\frac{d\theta}{dt} \quad (2)$$

where H is the rate of heat loss, m is the mass of the brass slab, c is the specific heat capacity of the brass, $\frac{d\theta}{dt}$ is the temperature gradient from each cooling curve (Figure1 and Figure 2)



International Journal of Engineering and Applied Sciences

www.eaas-journal.org

Figure 1: Cooling curve for laterite-mud sample

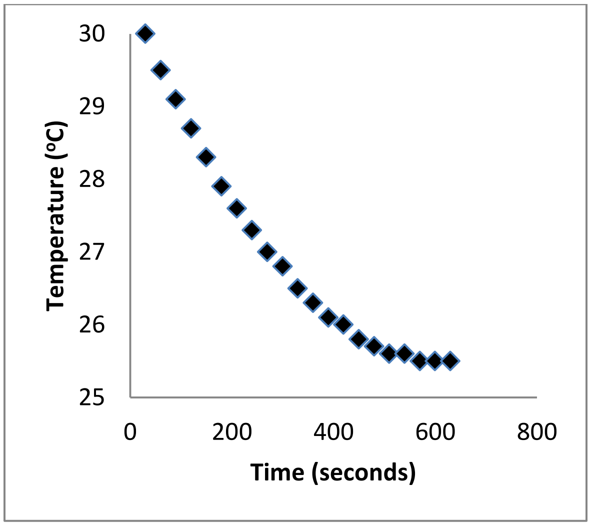


Figure 2: Cooling curve for concrete-block sample

Using equations (2) and (3), the thermal conductivity K was determined using Alausa et al (2011)

$$K = \frac{mcx}{A(T_1 - T_2)} \frac{d\theta}{dt} \qquad (3)$$

The thermal resistivity, r, is defined as the reciprocal of thermal conductivity, K therefore r was determined using

$$r = \frac{1}{k} \qquad (4)$$

where k is the thermal conductivity.

The thermal diffusivity was determined using the relationship given by Silva et al (1998)

$$\lambda = \frac{k}{c\rho} \qquad (5)$$

where k is the thermal conductivity, c is the specific heat capacity of the samples, determined by method of cooling correction and ρ is the bulk density, determined by weighing and displacement method (Nelkon and Parker, 1982).

3.0 RESULTS AND DISCUSSION

Table1 showed the results of thermal conductivity (k), thermal resistivity (r), and thermal diffusivity (λ), for laterite-mud sample and concrete-block sample. As presented in Table1, laterite-mud exhibited higher thermal conductivity than the concrete-block. This higher value of thermal conductivity indicated that the rate of heat flow was higher in the laterite-mud sample than the concrete-block sample and as such laterite-mud walls have a tendency of conducting heat more than the concrete-block walls from the atmosphere.

Table1: Thermal properties of laterite-mud and concrete-block

Samples	Thermal conductivity ($Wm^{-1}K^{-1}$)	Themal resistivty (mKW^{-1})	Thermal diffusivity (m^2s^{-1} $x10^{-4}$)
Laterite-mud	0.523	1.912	1.126
Concrete block	0.435	2.299	1.022

The thermal resistivity and diffussivity were higher in concrete-block sample than the values obtained for laterite-mud sample. The higher thermal resistivity and diffusivity showed that concrete-block walls will resist heat from the atmosphere than the laterite-mud walls.

The results in the present study were compared with the values reported in a previous work. The thermal conductivity values of 0.697 $Wm^{-1}k^{-1}$ and 0.620 $Wm^{-1}k^{-1}$ for mud-brick and cement-plaster was respectively reported (Ajibola and Onabanjo, 1995). The results showed that thermal conductivity in mud-brick was higher than cement-plaster and this was in similar trend with the present study. Etuk et. al., 2005 reported the thermal conductivity value of 0.60 $Wm^{-1}k^{-1}$ for mud-brick. This value was about 31% higher than the value obtained for laterite-mud sample.

International Journal of Engineering and Applied Sciences

www.eaas-journal.org

4.0 CONCLUSION

The characteristic of concrete-blocks with low thermal conductivity compared to laterite-mud indicated that concrete blocks are better insulators of heat and would be good materials for the construction of walls for self-cooling building. Although the costs of building houses with concrete-blocks are very expensive in Nigeria but one of the importance to note in building design and construction, particularly in tropical region, is the consideration of the indoor environmental conditions most conducive to comfort, health safety and the general well-being of the occupants (Ajibola and Onabanjo, 1995). The study therefore recommended concrete-blocks for walls to minimize heat conductivity from the environment to the interior and make self-cooling buildings in Nigeria.

REFERENCES

1. Ajibola, K., and Onabanjo, B. O. (1995) Investigation of cocos nucifera as a potential insulator for buildings, Renewable Energy 6 (1), 81-84
2. Akpabio, G. T. (1999) Thermal response of different walling materials for a self cooling building design preliminary investigation, Global Journal of Pure and Applied Sciences 5 (1) 139-141
3. Akpabio, L. E., Ekpe, S. O., Etuk, S. E., Essien, K. E. (2001) Thermal properties of oil and Raffia palm fibers, Global J. Pure and Appl. Sci. 7(3) 575-578
4. Alagbe, O. A. (2011) Enhancing sustainable housing development in Nigeria using compressed stabilized laterite bricks. Journal of Sustainable Development and Environmental Protection 1 (3) 51-59
5. Alausa, S. K., Oyesiku, O. O., Aderibigbe, J. O., and Akinola, O.S., (2011) Thermal properties of Calamus deerratus, Raphia hookeri and synthetic board in building design in Southwestern Nigeria 5 (4) 281-283
6. Ekpe, S. D. and Akpabio, G. T. (1994) Comparison of thermal properties of soil samples for a passively cooled building design. Trad. J. Phys., 18 117-122
7. Etuk, S. E. and Akpabio, I. E. (2003) Investagation of Raphia Hookeri trunk as a potential ceiling material for passively cooled building design. Ghana J. Sci. 43, 3-7
8. Etuk, S. E., Akpabio, L. E., Akpabio, K. E. (2005) Determination of thermal properties of cocos nucifera trunk for predicting temperature variation within its thickness. The Arabian J. Sci Eng. 30 (1A) 121-126
9. Mbamali, I and Okeke, A. J. (2012) An assessment of the threats and opportunities of globalization on building practice in Nigeria. African International Journal of contemporary Research 2 (4) 143-150
10. Nelkon, M and Ogborn, J. M. (1985): Advance Level Practical Physics 4th edition, Heinemann Educational Book Pg 67
11. Nelkon, M., and Parker P (1982) Advance Level Physics 5th Edition , Addison-Wesley pg 24-25
12. Plumb, G. (1991) Factors affecting mortar and concrete characteristics. IAEA Regional Training Course on Management of Spent Sealed Radiation Sources 15-26 April, Nairobi Kenya
13. Silva, T. S., Alves, A. S., Pere U., Tsuzuki, H., Nakamura, O., D. Aguita Neto, M. F., An, S.Y., Fereira Da Silva, A and Vesissid, N. (1998) Thermal diffusivity of lead iodide. J. Appl. Phys 83 (11) 6193-6195