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Thermal Conductivity of Reinforced Cement Stabilized Lateritic Brick

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Abstract: This study presents an experimental study carried out to determine the thermal conductivity of reinforced cement used as construction materials. The thermal conductivity was determined using the Resistance to Thermal Shock method. It was shown that the effect of incorporation of periwinkle shell (sea shells) results to the decreasing of the thermal conductivity and density. It was also obtained that the thermal conductivity as a function of time increases slightly between 11.00-12.00 pm in a sunny day for the lateritic brick.

Key words: Thermal conductivity, cement, brick, periwinkle, density, lateritic, reinforced

INTRODUCTION

The cost of building material is often exorbitant, particularly when most of the materials have to be imported. It is preferable to build with locally available materials that have durability and the cost is within the reach of the common people. Opara (1999) studied the need for the use of local building materials and construction technology. In tropical climate, heat poses an important consideration that must be considered in the design of suitable and affordable housing that is environmental friendly. The process of evolving standards for building design in respect of thermal comfort can be carried out in two stages; the climate analysis and element specifications (Williams, 1952). Earth blocks have been used in home construction in many countries for a long time. Research has shown that it is possible to provide construction materials and methods that are appropriate for such environment and are affordable.

Efforts have shown that bricks made from lateritic soil can be improved upon by the addition of periwinkle shells as reinforcement to produce strength high enough to meet building standards. Akinmusuru (1994) has shown that inclusion of grid of wood or bamboo cores significantly improves the bending strength of laterite walls brick for appropriate use by rural dwellers.

The compressive strength of the bricks can be further increased by the addition of ordinary Portland cement to the lateritic soil mix (Adesanya, 1996). Dirisu showed that between 8 and 12% cement content by weight has been used in producing cement stabilized lateritic brick of adequate strength and durability. They also achieved optimum compressive strength of 4% cement content with a compact effort of 3N m^{-2}. This research is to determine the effect of addition of periwinkle shell (sea shell) to the mixture of eagle cement and lateritic soil brick on the thermal conductivity.

All materials expand and contract to some extent as their temperatures rise or fall. The coefficient of thermal expansion is the measure of a material expansion or contraction with temperature.

Several researches have been carried out in measuring the thermal conductivity of materials and variety of methods have been used, namely; 3Ω method, steady state techniques, transient and thermal resistance techniques, etc.

MATERIALS AND METHODS

The materials used in this study were lateritic soil, Eagle cement, periwinkle shells (sea shells) and water. Lateritic soil is commonly found in the Niger Delta and is usually traditional building materials, mainly from Ahoada town and Port Harcourt city. The cement used is Eagle cement. The percentage of cement used is 10%. The physical and chemical analysis of lateritic soil from the two dumps is shown in Table 1 and 2 while Table 3 shows the physical analysis of some materials.

Periwinkle is found in vast quantities in the Niger Delta region of Nigeria. It is used in cooking food, while the bye product used for this study which is the shell, referred to as periwinkle shell. The lateritic dump near Ahoada is slightly dark-red earth evacuated by bulldozers of the Ahoada-East Local Government. The laterite is characterized by the

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Table 1: Chemical analysis of lateritic soil from the two dumps

Composition	Ahoada (%)	Port Harcourt (%)
SiO_2	68.32	68.35
Fe_2O_3	18.34	18.40
Al_2O_3	6.00	6.30
TiO_2	0.10	0.15
CaO	0.20	0.15
MgO	0.20	0.25
Na_2O	0.80	0.85
K_2O	0.50	0.60
Ion on ignition	5.54	4.95

Table 2: Physical properties of lateritic soil at the two dumps

Physical properties	Ahoada	Port Harcourt
Bulk density	1.80	1.86
Comprehensive strength (N mm^{-2})	1.60	1.50
Specific gravity	2.60	2.62
P.H.	9.10	9.20
Soluble salt	1%	0.50% (trace)
Mechanical composition clay	30%	28.5%
Silt	26%	26%
Sand	44%	46%

phenomenon of light swelling on absorption of water and coagulates in blocks when dry. While the laterite from Port Harcourt is dark dry in colour and expansive in character by the phenomena of swelling on absorption of water and shrinkage on drying. Clean water was used in the production of bricks as impure water containing salt causes corrosion on bricks (Opara, 1999). The studied sample were:

- Lateritic soil 80%
- Eagle cement 10%
- Periwinkle shell 6%
- Water 4%

Thermal conductivity measurement: The thermal conductivity measurements were based on thermal resistance method. The reinforced cement stabilized lateritic brick is suddenly heated from outside, the non uniform distribution of temperature causes temperature stresses to arise in the external layer of the material, liable to crack the brick. It can be seen that upon rapid heating of the brick, the outer layer tends to expand while the inner layer are not yet heated through which results in compression stresses in the session.

If a thermal pulse takes the nature of a sudden cooling of the brick surface, the thermal contraction of the surface layer tend to break the neighbouring section of the surface layer away from each other since the tensile strength is less than the compressive strength. The value of Temperature Coefficient (TC) of material expansion is extremely important for the thermal resistance. Using the Schott-Winkelmann parameter, the coefficient K which determines the relative resistance of a material to thermal shock is given by:

Table 3: Thickness, density and thermal conductivity of some materials

Materials	Thickness (m)	Density (kg m^{-3})	Thermal conductivity (Wm K^{-1})
Fibreglass	2.80	0.077	0.032
Polystyrene	1.90	0.033	0.029
Rigid polyurethane foam	4.70	0.039	0.036
Flexible polyurethane foam	2.60	0.019	0.044
Nigerite tile (Asbestos cement)	1.32	1.500	0.240
Concrete (21:2:4)	3.48	2.300	1.061
Motar (1:2)	3.86	2.200	0.484
Terrazzo tile	2.83	2.000	0.800
Marble (carvara marble)	1.97	2.100	1.718
Clay brick (oregun Ikeja)	1.80	1.600	0.246
Wood	3.09	0.500	0.132
Ferro cement (1:2)	3.94	2.000	0.803
RCSLB	18.00	1.600	0.200
Ordinary brick	1.90	1.600	0.800
Light brick	1.90	1.600	0.600

$$K = \frac{\partial t}{\alpha E}\sqrt{\frac{\lambda}{Dc}} = \frac{\alpha t}{\alpha E}\sqrt{y} \qquad (1)$$

Where:

∂t	=	Tensile strength
α	=	TC of the linear expansion
E	=	Modulus of elasticity
λ	=	Coefficient of thermal conductivity
D	=	Density
c	=	Specific heat capacity
$y = \lambda/Dc$	=	Temperature conductivity

The Eq. 1 shows that the resistance of a material to thermal shocks increases with growth in temperature conductivity and decreases in Temperature Coefficient (TC) of expansion. It implies that 1/a inverse to TC of expansion to estimate approximately the resistance of the materials of a definite type to thermal shock, since the other values except for α vary for different kind of brick within more restricted limits.

A reinforced cement stabilized lateritic brick is destroyed in the case of sharp changes in the temperature by the amount:

$$\Delta T = AK \qquad (2)$$

The parameter A depends on the sign of ΔT and the shape and dimension of the reinforced cement stabilized lateritic brick but does not depend on the composition of reinforced cement stabilized lateritic brick. It is inversely proportional to the square root of the thickness of the product. The resistance of reinforced cement stabilized lateritic brick to thermal shock is drastically reduced by impurities and defects on the surface which can easily be explained by the theory of strength of a brittle body. The K-value is determined by the physical and mechanical properties of the reinforced cement stabilized lateritic brick that is its composition and method of production.

RESULTS AND DISCUSSION

The experimental results for the two reinforced lateritic bricks studied at the two locations; Ahoada and Port Harcourt are shown in Table 4.

Results obtained from the experimented solution of the reinforced cement stabilized lateritic bricks were computed. It is shown that the performance of the bricks is dependent upon the amount of firing, laterite type and method of reinforcement. Table 4 and Fig. 1 shows that the thermal conductivity of reinforced cement stabilized lateritic brick of Ahoada laterite has less conductivity to that produced with laterite of Port Harcourt dump. As the temperature increases, the thermal conductivity also increases. The effect of incorporating periwinkle shells to the cement stabilized lateritic brick is to reduce the thermal conductivity of the brick. Figure 2 shows that as time increases in a sunny day, the temperature tends to increase due to the amount of radiant intensity falling to the earth thereby resulting to fractional change in thermal conductivity of the reinforced cement stabilized lateritic brick.

The thermal evaluation of some building and insulating material at mean temperature of 40°C shows that reinforced cement stabilized lateritic brick have a less thermal conductivity than other known bricks and that lower density leads to lower conductivity.

Table 4: Temperature and time variation with thermal conductivity of reinforced cement Stabilized lateritic from two dump site

		Thermal conductivity (W m K^{-1})	
Time (h)	Temperature (°C)	Ahoada brick	Port Harcourt brick
8	30	0.195	0.200
9	40	0.195	0.200
10	50	0.196	0.201
11	60	0.198	0.210
12	70	0.210	0.220
13	80	0.221	0.230
14	90	0.238	0.240

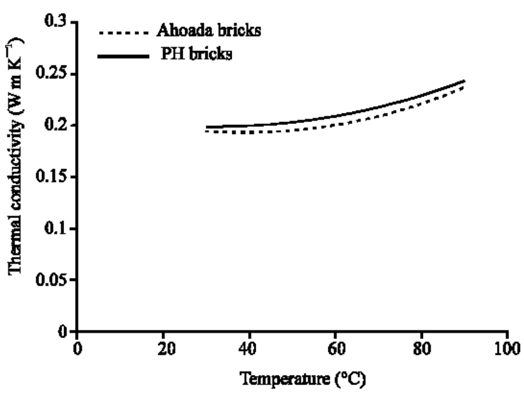

Fig. 1: Thermal conductivity and temperature

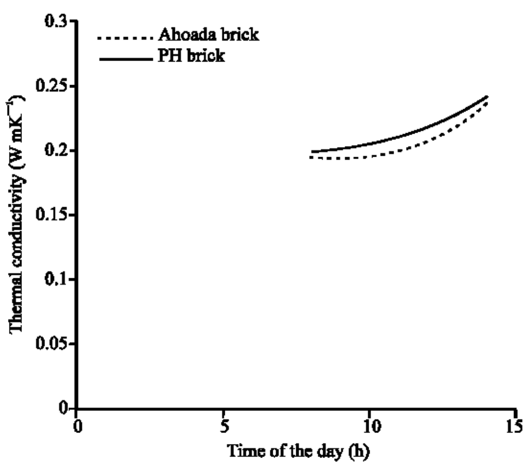

Fig. 2: Thermal conductivity and time of the day

CONCLUSION

An experimental study was carried out on the thermal conductivity of reinforced lateritic bricks made from lateritic soil of dumps from two locations. In order to increase the durability and reduce water absorption, cement and well grounded periwinkle has been added to the brick. Results obtained show that cement content of about 10% and well grounded periwinkle shells is enough to give adequate strength and durability to the brick. The effect of adding periwinkle and other sea shells leads to decrease in thermal conductivity. Thus the thermal conductivity of bricks is a function of the material that gives a non-linear relation. Generally, the results obtained in this study agree with those of Opara (1999) and Meukam *et al.* (2002).

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