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Thermal Comfort Analysis of Different Roofing Materials

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ABSTRACT— ***This paper discusses on reducing indoor temperature vis-à-vis making indoor temperature comfortable for occupant by application of suitable cheap building materials such as the wall and the roof. The discussion is prompted by the daily rise in the cost of building materials at the expense of dwindling economic indices especially in developing nations. The survey was done in a typical rural environment in Abakaliki, Nigeria. Two types of prototype buildings were used for the study: mud block with thatched roof and mud block with corrugated roof. The outside and inner temperature of the two buildings were taken at interval of 30 min for a period of 6 months. The average temperature in each case was evaluated. Our results indicates that the inner room temperature for the thatched roof was significantly lower than that of the corrugated roofs throughout the day. The difference between the maximum inner temperature for the thatched roof and the corrugated roof is 4 ^{o}C, while the difference between the minimum is 6.0 ^{o}C.***

Keywords— Indoor, thatched, temperature, corrugated, mud block.

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1. INTRODUCTION

Energy is paramount in sustainable technological development of any nation. Nigeria is blessed with reasonably high quantity and quality of various energy resources. These energy resources ranges from the renewable (biomass, solar, wind and hydro energy) sources) and the non-renewable (oil, gas, coal etc) sources. Presently, the dominant energy source in this part of the world is oil and its derivatives. These accounts for more than 70% of the total energy consumption except in rural areas where biomass in the form of wood dominates [1- 2]. The dwindling oil price has greatly affected the situation in the world today especially in Nigeria. This problem calls for an urgent and proactive measures in dealing with energy challenges. It is believed that the best alternative is in finding means of harassing solar energy [2-4]. Generally, a passive solar building is designed to maximize utilization of environmental resources while minimizing consumption of the conventional fuels used for heating, cooling and energy distribution/man agement. In passive systems, thermal energy flow is by natural means involving conduction, convection radiation and evaporation [4-7]. Conventional energy supplies are very expensive in Nigeria, equally, the cost of building materials are also very expensive in Nigeria. It is therefore pertinent to develop a solar powered cooling/heating systems which will eliminate/reduce the existing conventional energy supply crisis. This work is therefore geared towards analysis of the effect of walls and rooftops on indoor temperature using two buildings: one with mud block and thatched roof and one with mud block and corrugated roof.

2. EXPERIMENTAL

The study area is in Abakaliki at longitude 8.1000°E and latitude 6.3333° N, Abakaliki is located in South Eastern Nigeria [8]. The mud house with thatched roof was erected in Nkaliki Unuhu in Abakaliki using mud block, wood, raffia (grass) and rope. The thickness of the mud block is 0.15m. The internal and external dimension of the buildings are 3.1m x 2.0m x 1.7m. The thickness of the block is 0.15m while the internal and external dimension of the building are 1.58m x1.35m x 1.3m . The materials for the thatch roof were sourced locally in the bush, while the corrugated sheet were procured from Abakaliki building material market. The inner and outer temperatures of the buildings were measured using mercury in glass thermometers. The readings were taken six (6) months between March to September. Reading were taken from 8:00am to 12:00 midnight at interval of thirty minutes for the specified period in 2014.

3. RESULTS AND DISCUSSION

Fig.1 shows the plot of temperature (inner and outer) against time for the mud block thatched roof . The plot shows that the inner temperature increased gradually with time and suddenly dropped around 11.00hrs. This may the point of temperature inversion. The inner temperature then gradually decreased with time. This could be attributed to the fact that the thatch has air spaces which helps in the reduction of heat flux by evaporation from the roof [9] and also to the fact that the thatch are normally laid layer by layer which is similar to a parallel plate configuration [5, 9]. Thus each layer will absorb its own heat leading to a progressive heat loss along the layers. This reduction of heat flux causes reduction in the temperature of the inner room. The plots shows also that the outside temperature increased with time up to 16 hours before it began to decrease with time, As would be expected, as the sun moves over the equator the solar flux radiated decreases leading to lower outside temperature [3,4]. The maximum inner temperature recorded is 34.2 ^{o}C as against outside temperature of 38.2 ^{o}C. This implies that room is comfortable almost throughout the day.

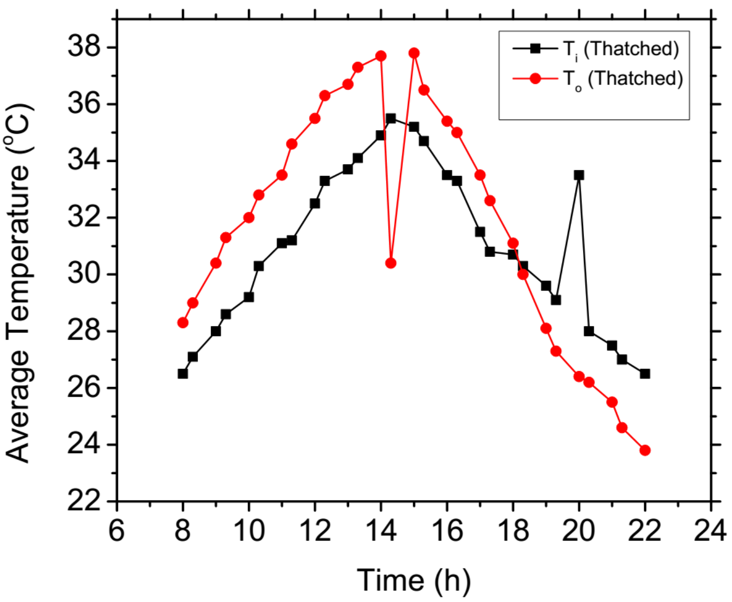

Figure 1: Plots of average temperature against time (thatched roof)

Fig. 2 is the plot of temperature against time for mud block house with corrugated sheets roof. The graph illustrates that the inner temperature started to rise up from the morning to reach the peak 14.00 hours which may be probably when the sun is perpendicular to the roof before it started falling. Similar behaviour has been reported by other authors in the literature [3,5]. A sudden rise and fall in temperature was noticed between 19.00hrs and 21.00 hours followed by gradual fall of temperature with time. The plot reveals that the average maximum inner temperature is 32 ^{o}C while the maximum outside temperature is 37.2 ^{o}C. The plot shows a reduction of inner temperature where all reading where recorded lower than the outdoor temperature. However the reduction in the inner temperature where less significant when compared to the trend in Fig. 1.

The plot of the inner temperatures for the mud block with thatched roof and the mud block house with corrugated sheets is as displayed in Fig. 3. The plot reveals that with a thatched roof, temperature as low as 20 ^{o}C was recorded in the morning hours as compared to 26 ^{o}C recorded in the morning hours for corrugated roof. The plot also show that temperature distribution in the corrugated roof was high almost throughout the day and was relatively moderate for the thatched roof. This could be attributed to the combined effect of radiation both from the roof and from the walls [7, 9]. This because as the corrugated sheets absorbs solar radiation, they become heated and the heat is radiated into the interior thereby raising the temperature of the interior. At night however, the walls radiates the heat it absorbed in the day thereby making the inner room temperature to go high as well [10-11]. With roof thatched the radiated heat from the walls is nullified by the effect of evaporation from pockets of air trapped in the thatch making the inner room temperature at a comfort level [11-13]. It has been established that solar passive buildings usually incorporate materials with high thermal mass that will retain heat effectively and good insulation to prevent heat loss [14]. Moreso, a low surface area to volume ratio is ensured to minimise heat loss in such buildings and that the indoor thermal comfort can also be improved through "passive cooling" [15]. Research done by Nwofe [7], indicate that energy efficient buildings are designed in a way that ensures that energy is used at a reduced cost, and in a sustainable and conserved manner.

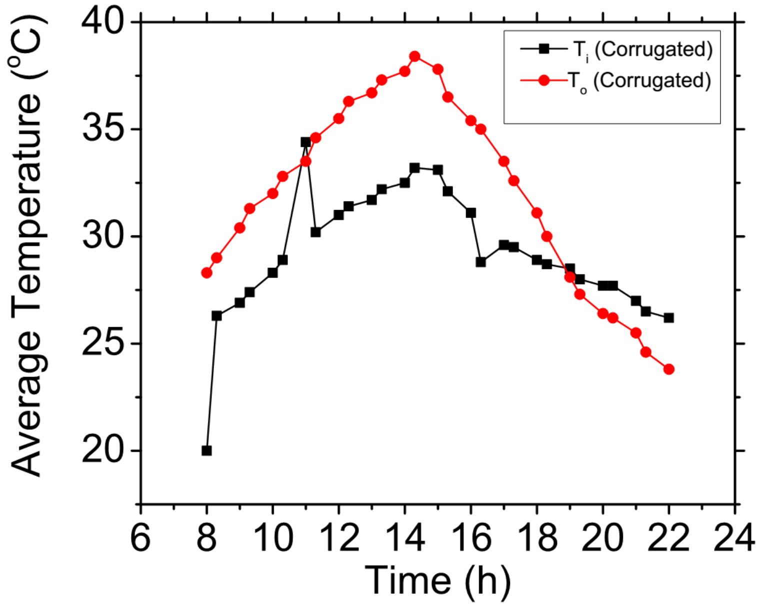

Figure 2: Plots of average temperature against time (corrugated roof)

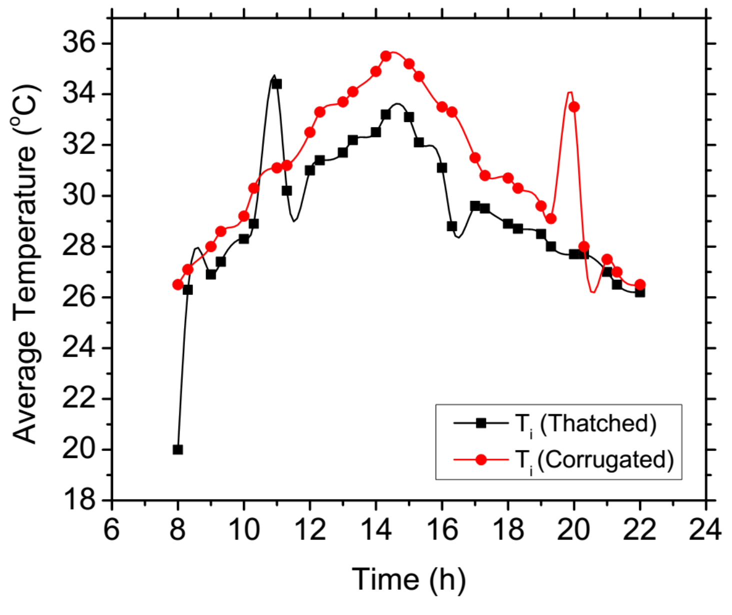

Figure 3: Plots of average temperature against time (Thatched and corrugated roof)

The present investigation points to the fact energy efficient building can be achieved by using locally available and cheap building materials such as mud and thatched roofs. It is generally understood that buildings that are not energy efficient require more mechanical/electrical devices to achieve thermal cooling in tropical areas and thermal heating for cold regions. These devices are very expensive and also contribute green house gases to the atmosphere, thereby making the environment more unfit for human survival.

4. CONCLUSION

Based on the results so far, it can be inferred that heat radiates into a room through its surrounding walls as well as the roofing. It is therefore capable of providing a comfortable thermal environment depending on the materials used. It can be deduced that temperature is always cooler in the house built with mud block on thatch roof than mud block on corrugated roof because of difference in thermal properties of the two materials.

5. ACKNOWLEDGEMENTS

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