Evaluation Of The Thermal Difference Between Mud Brick House And Cement Block House In Girei, Adamawa State, Nigeria.

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Abstract :The adverse effects of extreme climatic conditions, which cause discomfort to man and also hamper various human activities in their various residences is quite alarming. To man, buildings should serve as protectors from adverse environmental occurrences. This research analyzed the thermal characteristics of brick material among other building material as a means of recommending the fitting brick material in Girei, Adamawa State, Nigeria. This study evaluated the significant difference between mud brick house and cement block house. Mud brick house performed a little better than cement block house when it comes to heat regulation. Cement block house has a mean value of 35.44^{0}C while mud brick house has 34.88^{0}C in the dry season, while in the rainy season, cement block has 30.1600 and mud brick has 26.7600 as their mean values. Using SPSS Package at 0.05 level of significance, there was a significant thermal difference between the two buildings at both seasons considered. Values were lesser than 0.05 in both seasons as the rainy season was 0.001 and dry season was 0.000 respectively.

[Adediran. S. Adekunle, Adebayo. A. Abel, Zemba A. Ambrose. **Evaluation Of The Thermal Difference Between Mud Brick House And Cement Block House In Girei, Adamawa State, Nigeria.** *Academ Arena* 2015;7(11):94-97]. (ISSN 1553-992X). http://www.sciencepub.net/academia. 11. doi:10.7537/marsaaj071115.11.

Key words: Mud Brick House; Cement Block House; Temperature

1. Introduction

There is always a continual need for man to protect himself. Man needs to be secluded from various environmental occurrences. Effects of extreme climatic conditions, which cause discomfort to man and also hamper various human activities, could be reduced by the provision of environmental services. Buildings are essentially modifiers of micro climate; a space isolated from environmental temperature and humidity fluctuations, sheltered from prevailing winds and precipitation, and with enhancement of natural lights (Olanipekun, 2002).

Various climatic factors should be put into consideration when planning for and building residential buildings. These factors go a long way to determine how comfortable the occupants will be after the completion of the project. The choice of proper site of the building, and the selection of adequate building fabric should be considered when planning for residential building projects According to Ajibola (2001), the attainment of high level of comfort in building (residential and public) depends on the amount of the solar radiation excluded from the interior space. The aim should therefore be to avoid solar radiation as much as possible and to allow for illumination, without this, much money will be invested on the use of active energy for air-conditioning, ventilation and illumination in order to attain high level of thermal and visual comfort in buildings. The use of active energy should be minimized by the designer. The thermal performance of buildings is considered one of the most criteria of successful building design. It aims to provide the most comfortable environment for occupants and thus minimizing the energy demand for cooling and heating requirements.

The thermal performance of a residential building refers to the process of modeling the energy transfer between a building and its surroundings. Various heat exchange processes are possible between a building and the external environment. Heat flows by conduction through various building elements such as walls, roof, ceiling, floor, etc. Heat transfer also takes place from different surfaces by convection and radiation. Besides, solar radiation is transmitted through transparent windows and is absorbed by the internal surfaces of the building. Parameters like temperature, relative humidity and solar radiation should be considered in building design. Buildings should respond to passive energy and have minimum use of active energy for comfort. Building design in tropical areas should aim at minimizing evaporative cooling of the occupants of the spaces so as to achieve thermal comfort.

2. Study Area

Girei is located between latitude 9^0 11 and 9^0 39 North and Longitude 12^{0}21 and 12^0 49 east. Girei is situated within Girei local government. The local government is boarded by Song Local government area in the North, Furore Local Government area in the east, while River Benue acts as a physical boundary between the local government area, and Yola North and Demsa local government areas (Adebayo, 1999).

Girei LGA experiences dry an wet seasons with temperature and humidity varying with seasons. Girei local government area falls under the Sudan Savannah type of vegetation and it experiences distinct dry and wet seasons with temperature and humidity varying with seasons. (Saka *et.al*, 2013).

The wet or rainy season fall between April and November, which is characterized by single maxima in August. Seventy percent of the total rainfall in the area happens to fall within four months of May – August. The area has an average of 62 rainy days while average amount of rainfall recorded in the area is 972mm. The dry season which is the harmattan period is between Decembers to March.

Temperature in Girei is relatively high all year round. The temperature of Girei ranges from 27-40° C. The coldest months which are December and January are of the average temperature 15°C, while the hottest period within the area being April and May with an average temperature of 34°C. It has an average minimum temperature of 20.5^0C and maximum temperature of up to 40^0C (Adebayo, 1999).

The monthly global solar radiation are not uniform throughout. The peak of radiation being the month of March, April, May and June. The least value of global solar radiation is in January, this could be explained in terms of peak of cold harmattan season. The wet season is basically during the months of August and September (Medugu and Yakubu, 2011)

3. Methods

3.1 method of data collection

Field investigation was carried out on two buildings; one with cement block and the other with mud brick. The measurement of indoor air temperature was recorded hourly simultaneously for 25 hours (12am to 12am). The 25-hour measurements were taken at two different seasons (Dry hot and Rainy Seasons). The Rainy Season temperature data was taken on the 17 -18, September 2014 for both buildings while the Dry Hot Season temperature data was taken on the 27-28, March 2014. A field assistant took the hourly reading of one of the samples while the researcher took the hourly indoor readings for the other sample together with the ambient temperature data. The measurements were taken to compare the thermal performances between the buildings at a given ambient temperature. A thermometer dimple (-10 to 360^0C) was obtained from the Department of Chemistry, Modibbo Adama University of Technology, Yola and was used to take the measurements.

3.2 Result and Discussion

Table 1 shows the mean temperature values of the buildings at the two seasons and it is clearly seen that the cement block house has the higher mean values than the mud brick house in both seasons. In the rainy season, cement block has mean value of 30.1600 while mud brick has 26.7600 in the same season. At dry hot season, cement block house had 35.4400 mean value while mud brick has 34.8800 mean value at the same season. The table further shows that mud brick has the lower minimum values (31 and 25^0C) in both dry hot and rainy seasons. Mud brick also has a lower maximum values in both dry hot and rainy seasons (37 and 30^0C) while cement block house has 37 and 33 ^{0}C as maximum temperature in both dry and rainy seasons.

By observing the collected data, the temperature within the cement block house rises faster than the mud brick house. This is due to the fact that a mud brick construction is built with great attention to the thickness and mass of the wall thus giving a higher thermal qualities. These types of walls slow the penetration of heat during the day and retrocede it usefully during the night. Mud brick has lower minimum thermal values, but has the same maximum value with cement block house at the dry hot season, which later dropped a little faster than the cement block house at around 6pm. The thermal mass of mud brick walls provide a more constant temperature throughout the year than the usual industry alternatives (Nillumbik Mud brick Association Inc, 2011). The thermal performance of a wall made from high grade mud bricks is 53% greater than 300mm of granite, 35% greater than 200mm of concrete, 14% greater than 230mm of solid brick (Nillumbik Mud brick Association Inc, 2011). An analysis of the simulation studies revealed that indigenous materials such as mud bricks have significantly better thermal properties as compared to contemporary building material (Soofia *et.al*, 2006).

Table 1: Mean, Minimum and Maximum Temperature Values of the Sampled Buildings (^{0}C)

Statistical Measures	**Cement block (dry season)**	**Mud brick (dry season)**	**Cement block (rainy season)**	**Mud brick (rainy season)**
Minimum	33.00	31.00	28.00	25.00
Maximum	37.00	37.00	33.00	30.00
Mean	35.4400	34.8800	30.1600	26.7600

Table 2: The Mean Differences and the Significance of the Difference between the Buildings (^{0}C)

Pairs of the houses in both seasons	**Mean Difference / T-Value**	**Significance (2 tailed)**
cement block (rainy season) - mud brick (rainy season)	3.40000 / 11.549	0.000
cement block (dry season) - mud brick (dry season)	0.56000 / 3.934	0.001

3.3 The Influence of Ambient Temperature on Indoor Temperatures of the Sampled Buildings

The ambient temperature has a direct influence on the indoor temperature. The extent of the influence depends on the characteristics of the material used for the buildings.

Regression analysis was applied to assess the relationship between the buildings' temperature and the ambient temperature individually, that is, each building temperature to the ambient temperature in the two seasons.

Table 3 provides the R and R^2 values. As shown in tables the R value represents the simple correlation which is 0.825 (cement block house in the dry hot season), 0.804 (mud brick house in the dry hot season), 0.796 (cement block house in the rainy season), and 0.485 (mud brick house in the rainy season) respectively, which indicates a high degree of correlation between the buildings' temperatures and the ambient temperature. The lower R value (0.485) of the mud brick during the rainy season can be explained by the high solubility feature of the brick giving a greater difference between the indoor and the ambient temperature.

The R^2 value (the "**R Square**" column) indicates how much of the total variation in the dependent variable (indoor temperature) can be explained by the independent variable (ambient temperature). In this case, 68.1% can be explained in cement block house in the dry hot season, 64.7% in mud brick house in the dry season, 63.3 % in the cement block house in the rainy season and 23.6% in the mud brick house in the rainy season. The 23.6% falls in the rainy season which still explains the solubility feature of the mud brick building material. With these stated results (R^2 values), it shows some other factors (majorly the properties of the building material) are responsible for the indoor temperature of the cement block and mud brick houses other than the ambient temperature. With the value of R^2 obtained for the cement block house in both seasons, larger amount of the indoor temperature of cement block is explained by the ambient temperature, which indicates that there is greater influence of ambient temperature in the case of cement block house than mud brick houses. Conversely, there is as low as 23.6% of R^2 value at the rainy season because mud is highly soluble as stated earlier. This is why many times; the encountered pathology of mud walls is directly linked to high solubility of the walls. At the rainy season, a lot of water sinks into the mud walls, giving a greater difference between the ambient temperature and the indoor temperature than would have been if there was no rain. The F-Values show that all the equations are significant at 0.05 level of significance. Table 4 provides us with the necessary information to predict indoor temperature of the cement block house and the mud brick house (dry season and rainy season) from the ambient temperature. The regression equations relating the constant and the coefficient of the ambient temperature are shown in table 4 below.

Table 3: Results of Regression Analysis

Buildings and Ambient Temperature	Season	R	R^2	F	Sig.
Ambient and Cement block House	Dry	0.825	0.681	49.197	0.000
Ambient and Cement Block House	Rainy	0.796	0.633	39.693	0.000
Ambient and Mud Brick House	Dry	0.804	0.647	42.101	0.000
Ambient and Mud Brick House	Rainy	0.485	0.236	7.092	0.014

Table 4: Seasonal Regression Equations of the Indoor Temperature of the Sampled Buildings

Building Types Indoor Temperature (^{0}C)	Season	Regression Equation with T-values
Cement Block House	Dry	25.603 +0.279(Ambient Temperature) $(18.142)^{**}$ $(7.014)^{**}$
Cement Block House	Rainy	17.765 + 0.449(Ambient Temperature) $(8.977)^{**}(6.300)^{**}$
Mud Brick House	Dry	22.589 + 0.348 (Ambient Temperature) $(11.851)^{**}(6.489)^{**}$
Mud Brick House	Rainy	19.909 + 0.248(Ambient temperature) $(7.694)^{**}$ $(2.663)^{*}$

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11/10/2015