INVESTIGATING WINDOW CHARACTERISTICS FOR THERMAL COMFORT IN RESIDENTIAL BUILDINGS: A CASE OF GOVERNMENT HOUSING ESTATES IN NIGERIA

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Abstract: The purpose of ventilation is to provide fresh air for comfort and to ensure healthy indoor air quality by diluting contaminants. The study aimed at investigating window characteristics in selected residential buildings of government housing estate in south-west Nigeria. The study identifies the characteristics of existing housing types with the use of systematic random sampling. Based on the survey result, 31% of windows used were louver type, 10.5% were sliding window, while 36.5% were casement type. The investigation further demonstrated that 35.0 % of the inhabitants preferred casement window type because it gives the most astounding characteristic ventilation. The study also resulted that 47.2 of the windows in the living room were 1.2x1.4m, while 38.7% windows in the living room were 1.2x1.5m and just 14.1% of windows in the living room having 1.2x1.8m. In case of bedroom, it was also revealed that 66.9% of bedroom's windows were 1.2x1.4m, while 20.2% windows in the bedroom were 1.2x1.5m, 12.9% of bedroom's windows having 1.2x1.8m as their sizes. The implication is that, both living rooms and bedrooms of houses in the estate were not properly ventilated. The investigation concluded that with sufficient and satisfactory utilization of louver or casement window types with adequate sizes and numbers, ventilation can be enhanced in residential buildings.

Keywords: Casement, Louvre, Window Sizes, Residential Buildings, Thermal Comfort, South-West Nigeria.

Introduction: Housing is one of the basic needs of man in addition to food and clothing. It embraces all social services and utilities such as good road networks, electricity and potable water supply among others that make an environment conducive for living. Housing has a profound influence on the welfare of mankind and it is used to measure the physical, economic and historic evidence of civilization all over the world (Abumere, 1989). The United Nation (2000) described housing as a physical environment in which the family as the society's basic unit develops. This definition of housing is in agreement with that developed by the World Health Organization cited by Omole (2010) which considered residential environment to be one that includes the physical structure used for shelter as well as all necessary social wellbeing facilities for the family and individual. However, as important as housing is, the incidence of urban population increase has created severe housing problems, resulting in overcrowding and inadequate dwellings, and in a situation in which 60% of Nigerians can be said to be homeless (Olotuah and Ajenifujah, 2009). Rapid population growth creates problems toward adequate and efficient supply and distribution of basic utilities and services for the city inhabitants. The situation has become so pathetic such that, overcrowding, slum and substandard housing as well as unhealthy and poor environmental conditions are expressions of this problem. Thus, access to decent housing has become a challenge worldwide, especially in developing countries (Abotutu, 2006). Housing provision in most nations of the world is made through a blend of public and private sector initiatives; Nigeria is not an exemption to this development. For instance, it has been observed that about 80% of the available housing stocks in Nigeria are provided by private sector initiatives, while only 20% of them are public sector housing (Ademuliyi, 2010). As a package of shelter and services, housing is a veritable tool for macro-economic development. The purpose of ventilation is to provide fresh (or at least outdoor) air for comfort and to ensure healthy indoor air quality by diluting contaminants. Historically, people have ventilated buildings to provide source control for both combustion products and objectionable odours (Sherman, 2004). While the majority of naturally ventilated residential buildings are in Europe, few have recently been constructed in the U.S. This may be because, methods for integrating natural ventilation in residential buildings are not well known. Unfortunately in Nigeria, though we are blessed with good climatic condition yet, natural ventilation system is currently underutilized in some residential buildings. As a result, there is an urgent need for sustainable housing development towards naturally ventilated residential buildings which are environmental friendly in order to give good and positive impact to its inhabitants against prevailing problems of mechanical ventilation system, such as: need for space, increase rate of energy consumption, noise generation within and outside of buildings and difficulties in cleaning and maintaining. These among others are the focus of this study, to investigate natural ventilation in residential buildings in Owode Estate, Apata, Ibadan with a view to specifying widow characteristics for use in subsequent residential building designs. However, there has not been much research work on windows characteristics for thermal comfort in this warm humid climatic region like Nigeria. With this view, the study aims at investigating window characteristics for thermal comfort in residential buildings in Government Housing Estate, Apata, Ibadan. Therefore in addressing the thermal comfort sin the offices of the study area to support the research the following research questions addresses the window conditions:

1. What are the types of windows in use in Government housing estate in the study area?
2. What are the sizes of windows in use in the residential building in the study Area?
3. How many windows are situated in spaces in residential buildings in the Study Area?

Literature Review: Increased focus on sustainability and the environmental impact of energy used has resulted in natural ventilation becoming an attractive option for many buildings. (Awbi, 2003). Historically, natural ventilation in buildings relies on wind and thermal buoyancy as driving forces. Mankind has used these driving forces throughout history to create the desired thermal environment and to transport away undesired contaminants. From the first primitive living quarters with the fireplace in the centre of a tent or a cabin, the technique we take advantage of to control and adjust indoor climate has grown ever more sophisticated. This technique has in the 20th century, been dominated by mechanical ventilation and air conditioning. These technologies have developed into systems of great complexity with an increasing number of components, need for space, and use of energy. Despite this, many of the mechanical systems do not manage to deliver the desired indoor climate. Because of this contradiction, the focus has again been put on simpler, more robust and less energy consuming solutions. Thus, the building itself, with its envelope, rooms, corridors and stairways, rather than the ducts familiar from mechanical ventilation systems, is used as air path. A natural ventilation concept is therefore, highly integrated in the building body and will consequently have influence on building design and architecture.

Thermal Comfort: According to Olufowobi & Adenuga, (2006), a building is required to perform many functions and provision of thermal comfort is one of them. Energy consumed in buildings to provide thermal comfort is related to the climate in which the buildings are located as well as the thermal properties of the fabrics. In the course of providing thermal comfort for building occupants, it is essential to consider the influence of prevailing climatic conditions on the thermal performance of such buildings. Particularly for residential buildings, thermal comfort and mental ability are important and are related to each other. It is known that ventilation has the following three major functions:

(i.) Replacement of stale air with fresh air from outside to promote good health
(ii.) Cooling of indoor air and cooling of building structures
(iii.) Body cooling for comfort.

Thus (ii) and (iii) above are related to the use of natural ventilation to provide relief from thermal discomfort. The supply of fresh air for good health is required in all buildings throughout the world. Whereas, health ventilation is all that may be required in buildings located in temperate and cold climates, this is not so in low-energy buildings in warm climates, where the need goes beyond fresh air supply; there is additional requirement for natural ventilation to offer relief from warm discomfort by way of physiological cooling. Natural ventilation is created by pressure differences between the outside and the inside of the building; this pressure difference may be wind-driven, or due to air temperature differences (buoyancy effect). In general, wind-driven natural ventilation is easier to achieve in a warm-humid climate as that of Nigeria; it merely requires a low outdoor wind speed to create

adequate indoor air speeds. The air temperature differences are usually not high enough to generate any effective air movement.

Classification of Natural Ventilation: Natural ventilation may be classified into two; these are wind driven ventilation and stack ventilation.

1. **Wind Driven Ventilation:** Wind driven ventilation or roof mounted ventilation design in buildings provides ventilation to occupants using the least amount of resources. Drawbacks include the use of equipment that is high in embodied energy and the consumption of energy during operation. By utilizing the design of the building, Wind driven ventilation takes advantage of the natural passage of air without the need for high energy consuming equipment. Wind catchers are able to aid Wind driven ventilation by directing air in and out of buildings.

2. **Stack Driven Ventilation:** Buoyancy ventilation can be induced by temperature (known as Stack ventilation) or by humidity (known as cool tower). Most commonly used is the stack driven ventilation. For stack ventilation to work properly, there must be a temperature difference. However, stack driven ventilation is limited to a lower magnitude than wind driven ventilation. It is also very dependent on the inside and outside temperature differences.

Research Methodology: This research is descriptive and analytical in nature and therefore relies on field survey. Reconnaissance survey was carried out in order to get acquainted with the existing situation in the study area. It also examined physical attributes and characteristics of building such as window openings. Questionnaire were used to obtain information on house types, peoples' perception on the mechanisms provided as well as efficiency of natural ventilation within the living room and bedroom of the houses. Also the field survey approach was used to obtain information on the physical characteristics of the building, such as number, sizes, types and percentage area of openings (windows) and orientation of building and sizes of rooms or spaces to be investigated. Relevant information from published and unpublished literatures such as textbooks, journals, seminar paper, past project and internet materials among others were sourced. These provided the background information on conceptual and theoretical frame work of the study. The sample frame is Owode Estate Apata, Ibadan and using the road network of the estate, the choice of zones was based on the sizes of the estate: since the estate was basically characterized by less dense development, in order to achieve a good and reliable sample frame , notable area in which their boundaries were obvious was used as a criterion for the selection. A total of six (6) estate zones were sampled altogether and they include: first gate, second gate, northern side, southern side, central and Anglican church side of the estate. Systematic random sampling was used for the study. The first building was chosen at random, while others were chosen at interval of five (5) buildings along each street. In all, a total of one hundred and sixty-three (163) residents of the area were chosen for questionnaire administration thereby, representing 5% of the population. This is shown in Table 1

Table 1: Sample Size

Zone	No. of Buildings	No. of Questionnaires Administered
First gate	357	18
Second gate	752	38
Northern side	430	22
Southern side	400	20
Central	632	32
Anglican church side	689	34
Total	**3260**	**163**

Source: Author's Fieldwork (2018).

Case Study Figure 1: 2 bedroom bungalow

PARROT as 2 bedroom bungalow with the followings:
Lounge -19sqm
Dinning -9sqm
kitchen -7sqm
bedroom(ensuite) -12sqm
toilet -2.7sqm.

Source: Author's Fieldwork, (2018).

Figure 2: 3 Bedroom Floor Plan

DUCK as 3 bedroom bungalow with the followings:
Lounge / Dinning -22sqm,
kitchen/Store-10sqm,
Master's bedroom & Toilet-16sqm, bedroom & toilet-14sqm.

Source: Author's Fieldwork, (2018).

Figure 2: 4 Bedroom Floor Plan

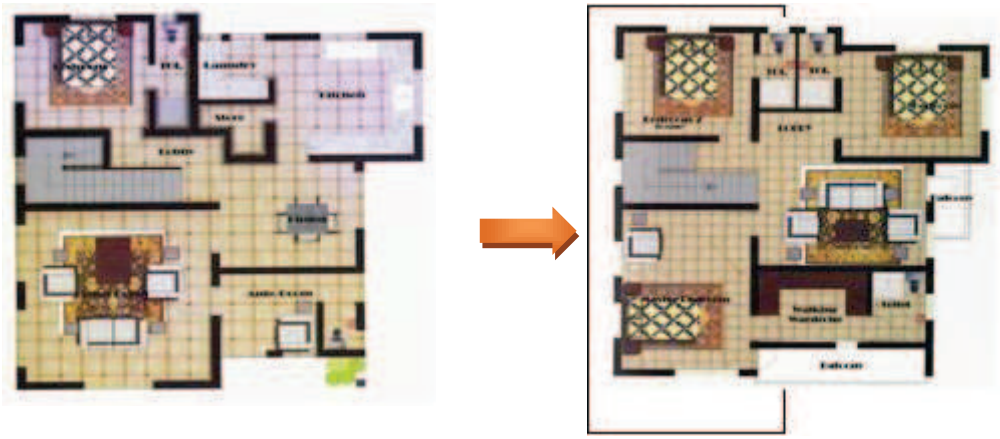
HAWK as 4 bedroom bungalow with the followings:
Ante Room -6.5sqm
Lounge & Dinning-34sqm
kitchen & Store-11sqm
Master's bedroom & Toilet -24sqm
bedroom & toilet (average) -18sqm
Car port -15sqm

Source: Author's Fieldwork, (2018).

Figure 4: Ground & First Floor Plan of **3** Bedroom Terrace Apartment.

Source: Author's Fieldwork, (2018).

Figure 5: Ground & First Floor Plan of 4 Bedroom Duplex.



Source: Author's Fieldwork, (2018).

Data Analysis: The data obtained from the study were analysed with frequency counts and percentages.

Objective: To investigate window characteristics on thermal comfort in the study area.

Table 2: Window Type

Type	Frequency (N)	Percentage (%)
Louver	51	31.0
sliding	17	10.5
Casement	59	36.5
Projected	36	22.0
Total	**163**	**100**

Source: Author's Fieldwork, (2018).

Out of the respondents that utilized window, casement window constituted (36.5%) while louver blade was (31.0%). Also, projected window type was (22.0%), with sliding window being (10.5%) as shown in table 2.

Table 3: Number of window(s) in the Living room and Bedroom

Number of Window(s)	Living room		Bedroom	
	F (N)	(%)	F (N)	(%)
1	77	47.2	116	71.2
2	36	22.1	47	28.8
3	23	14.1	-----	-----
4	27	16.6	-----	-----
Total	**163**	**100**	**163**	**100**

Source: Author's Fieldwork, (2018)

Table 4: Window Size in the Living room and Bedroom

Window size	Living room		Bedroom	
	F (N)	(%)	F (N)	(%)
(1.2x1.4)m	77	47.2	109	66.9
(1.2x1.5)m	63	38.7	33	20.2
(1.2x1.8)m	23	14.1	21	12.9
Total	**163**	**100**	**163**	**100**

Source: Author's Fieldwork, (2018).

Number of window in the living room varies from 1-4 windows while in bedroom; it was 1-2 windows. 47.2% of living rooms had 1 window while 22.1% living rooms had 2 windows. Also, 14.1% living rooms had 3 windows, with 16.6% living rooms having 4 windows. Furthermore, 71.2% of bedrooms had 1 window, while 28.8% bedrooms had 2 windows. The implication of this is that, the bulk of the houses in the estate had 1 bedroom which may be due to the sizes of the family living in them (Table 3).In terms of window's sizes it was shown that, 3 different sizes of window were used in both the living room and bedroom. According to table 4. 47.2% of the windows in the living room were 1.2x1.4m, while 38.7% windows in the living room were

1.2x1.5m, with 14.1% of windows in the living room having 1.2x1.8 m. In case of bedroom, it was also revealed that 66.9% of bedroom's windows were 1.2x1.4m, while 20.2% windows in the bedroom were 1.2x1.5m, with 12.9% of bedroom's windows having 1.2x1.8m as their sizes. The implication is that, both living rooms and bedrooms of houses in the estate were not properly ventilated according to Chand (1976) recommendation and also reviewed by Ayinla (2011) that window openings should be between 30-50% of the exposed wall area.

Conclusion: The study found out that the means of achieving natural ventilation were through windows and courtyard in buildings: 41.0% of windows were of louver type, 10.5% were sliding, 47.5% were of casement type. The study further disclosed that, majority of residents preferred louver and casement window types because they both give the highest natural ventilation. The study also resulted that 47.2 of the windows in the living room were 1.2x1.4m, while 38.7% windows in the living room were 1.2x1.5m and just 14.1% of windows in the living room having 1.2x1.8m. In case of bedroom, it was also revealed that 66.9% of bedroom's windows were 1.2x1.4m, while 20.2% windows in the bedroom were 1.2x1.5m, 12.9% of bedroom's windows having 1.2x1.8m as their sizes. The implication is that, both living rooms and bedrooms of houses in the estate were not properly ventilated.

Recommendations: The study hereby recommends that the designers must be aware that the occupant's views must be put into consideration so as to allow for thermal comfort in the residential buildings. The study further recommends that with sufficient and satisfactory utilization of louver or casement window types with adequate sizes and numbers, ventilation can be enhanced in residential buildings.

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