

# Evaluation of Natural Airflow and Ventilations in High-Rise Residential Structures in Nigeria

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## Abstract

## Original Research Article

The design of residential structures that relies solely on natural ventilation methods has become prevalent in various regions across the globe, and the expansion of this approach has been proven feasible in urban centers as well as in undeveloped areas. Nevertheless, the implementation of natural ventilation in high-rise residential buildings is less frequent, resulting in environmental challenges and financial implications associated with buildings that utilize mechanical ventilation. This study aims to evaluate natural ventilation techniques and the means by which they can be incorporated into multi-story residential edifices. This will be accomplished through specific objectives: to gauge the knowledge of respondents regarding natural ventilation, to comprehend how building operations influence effective ventilation in multi-storey structures, and to identify and analyze additional factors that may impact the operation of natural ventilation and the comfort of its occupants. The research will adopt a quantitative approach, utilizing surveys in the form of questionnaires and various fact-finding inquiries, alongside reviews of journals, books, and articles. In this discussion, the concepts of natural ventilation and associated strategies will be examined to highlight their importance in fostering a naturally ventilated building to decrease energy use and lower dependence on mechanical ventilation for a more sustainable environment. These strategies should be taken into account prior to and during the design phase to enhance their effectiveness. This paper intends to effectively inform the general public and raise awareness about the numerous benefits of having a well-ventilated building.

**Keywords:** Natural Airflow and ventilation, high rise buildings, energy, thermal comfort, natural cooling.

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## Introduction:

The worldwide increase in urbanization, especially in Nigeria, has greatly heightened energy usage in buildings. According to the (IPCC 2014), buildings globally accounted for 32% of total energy consumption in 2010, with residential buildings in Africa consuming more than 79% of that energy. Research conducted in Nigeria by (Ezema et al., 2016), (Adebisi et al., 2008), and (Akinbami and Lawal 2010)

indicated that residential buildings were responsible for an estimated 78-50.4% of overall energy use and electricity consumption. This highlights the necessity of tackling energy consumption in residential buildings to lessen environmental impact. The elevated energy consumption in Nigerian residential buildings is linked to rapid urbanization, climatic factors, and the failure of architects to consider climate-sensitive design (Adebisi et al., 2008). The tropical climate of Nigeria, marked by elevated

temperatures, results in heat accumulation within spaces, contributing to considerable thermal discomfort for residents (Gut and Ackerknecht, 1993). Architects encounter a persistent challenge in defending against and effectively dissipating heat build-up in residential areas (Ogunsote et al., 2011). (Nwofe, 2014) points out that a significant portion of energy consumption in Nigerian buildings is due to active energy use.

appliances are considered uneconomical and contribute to energy shortages, heightened greenhouse gas emissions, and global warming (Ogunsote et al., 2011). In light of global initiatives aimed at reducing energy usage, there is increasing interest in studying natural ventilation due to its efficiency, effectiveness, zero energy demand, and economic benefits in comparison to mechanical systems (Adegbe, 2013). Given the issues associated with high energy prices, limited generation, Devices such as fans and air conditioners are utilized for indoor comfort. Nevertheless, these and erratic supply in Nigeria, investigating natural ventilation for indoor comfort in multi-story buildings in urban areas is crucial (Nwofe, 2014). Natural ventilation plays a vital role in improving thermal comfort in warm climates, with Ayinla (2011) noting its potential effectiveness. Richard (2011) underscores its efficiency in enhancing indoor air quality and its economically viable nature for achieving thermal comfort. The Energy Commission of Nigeria (2003) reported that the final energy expenses for buildings utilizing natural ventilation are 40% lower than those of air-conditioned buildings. Enhanced indoor conditions through natural ventilation can boost occupant productivity and lower healthcare expenditures (Fisk and Rosenfeld, 1997).

In 2009, it was noted that factoring in natural ventilation early during the design phase involves minimal expenses, making it an essential aspect to consider right from the beginning. This research conducted in Abuja aims to evaluate natural ventilation in multi-storey structures, with goals that include assessing the awareness of respondents regarding natural ventilation, understanding operational aspects of buildings that impact ventilation, and investigating the factors that affect its efficiency. The study highlights the

significance of natural ventilation for lowering energy use in residential buildings in Nigeria and improving indoor air quality. It stresses the need to consider natural ventilation throughout the entire building lifecycle, spanning from pre-design through construction to the post-construction stages.

## Literature Review:

### Ventilations

Ventilation, as noted by Awbi (1991), comprises the introduction of fresh outdoor air into a building or space, along with its internal distribution, and plays a vital role in enhancing indoor air quality by diluting and eliminating pollutants to ensure a healthier environment. Natural elements like wind and thermal buoyancy facilitate the movement of outdoor air through specially designed openings such as windows, doors, solar chimneys, wind towers, and trickling ventilators. Natural ventilation is influenced by various factors, including climate, architectural design, and human behavior. Efficiently designed and well-maintained natural ventilation systems provide benefits compared to mechanical alternatives, making them an attractive option for minimizing energy consumption and costs while maintaining a healthy indoor atmosphere. Given the growing recognition of energy's environmental effects, architects should emphasize effective natural ventilation in their design processes.

### The Three Key Design Components of Natural Ventilation

- (i) Site Design — the placement of buildings, arrangement, orientation, and landscaping;
- (ii) Building Design — the kind of building, its purpose, overall shape, exterior envelope, natural ventilation approach, internal layout of spaces and uses, thermal mass, and any heating, ventilation, and air-conditioning systems that may be present; and
- (iii) Vent Opening Design — the location of openings, the variety

of openings, their sizes, and the control methods used.

### Site Design

Site design entails integrating buildings into the surrounding landscape, allowing for slight alterations that take environmental factors into account. To maximize natural ventilation, one should utilize the site's existing airflow patterns. For multiple structures, it is advisable to ensure exposure to South-West winds while avoiding North-East winds in warmer climates. The shape and orientation of buildings should be designed to create negative pressures in the airflow wakes (Aynsley et al., 1977).

### Building design

In straightforward buildings, elements such as roof configuration, aspect ratios, and the incorporation of overhangs, wind walls, and recessed areas contribute to efficient natural ventilation. For larger and more intricate structures, employing computational fluid dynamics is advisable for optimal design and to avoid cold draughts (Fluent, 2003). Compact designs with careful arrangement of internal spaces and expansive windows on the windward side promote better airflow.

### Windows and Glazing

The building's envelope, especially windows, doors, and skylights, affects heat gain/loss and internal air movement. Windows, which are defined as openings that permit light and air to enter, significantly impact the thermal efficiency of the building

envelope (Carmody et al., 1996). As outlined by (Al-Saadi, 2006) and (Datta, 2001), glazed windows provide natural illumination, decrease structural weight, and improve visual appeal. Properly shaded and strategically positioned windows can substantially lower a building's energy consumption (Szokolay, 2004). The window-to-wall ratio (WWR) is vital for the thermal environment within a building (Carmody et al., 1996). (Bokel, 2007) investigated the influence of window size and placement on energy requirements, proposing an ideal WWR of around 30% in the upper section of the facade. A WWR between 20% and 40% is considered acceptable, as larger ratios have a negligible effect on lighting demands. Additionally, selecting appropriate glazing types, sizes, orientations, and positions to minimize the sun's effects on the interiors of residential buildings are key considerations.

### Methodology

The research methodology functions as a systematic strategy to tackle research issues (Kothari and Gaurav, 2014). In this study, a quantitative research approach was selected due to its organized and statistical characteristics, which facilitate the gathering of numerical data for an objective and definitive measurement of variables. This method enables statistical analysis to confirm hypotheses. Primary data was gathered through direct observations and questionnaires distributed to users of chosen multi-storey residential buildings (a total of 124 questionnaires).

The questionnaires included questions about demographics, socioeconomic status, building operations, and building features. Secondary data was collected from a variety of sources, including conference proceedings, academic journals, books, theses, projects, seminar papers, architectural drawings, and credible online resources.

### Results And Discussions

**Building Envelope Features** A significant majority of respondents, 117 (94.4%), reported using cement blocks for wall finishing, while only a small number, 2 (1.6%), opted for wood and zinc respectively. A substantial portion of the respondents, 105 (84.7%), indicated that they use tile for their floor finishing, followed by cement at 9 (7.3%) and carpet/rug at 8 (6.5%). Most respondents, 65 (52.4%), use ceiling boards for their ceiling finishing, while 57 (46%) reported using asbestos.

**Respondent Opinions on Building Envelope Features**

Variable	Frequency	Percent
Material Used for Wall Finishing		
Earth/Mud	3	2.4
Wood	2	1.6
Cement Block	117	94.4
Zinc	2	1.6
Total	124	100
Material Used for Floor Finishing		
Tile	105	84.7
Wood	2	1.6
Cement	9	7.3
Carpet/Rug	8	6.5
Total	124	100
Material Used for Ceiling Finishing		
Asbestos	57	46
Carton	2	1.6
Ceiling Board	65	52.4
Total	124	100

Source: Survey Data, 2025.

**Demographic data of the respondents** This section outlines the demographic details of the respondents in the study area, including aspects such as gender, age group, and educational

attainment. The distribution of demographics among respondents is illustrated in the survey results. It was observed that a higher percentage of males (65.3%) participated in the survey compared to females (34.7%). A significant majority of the respondents (93.5%) fell within the 18-30 age range, while a smaller segment (6.5%) was aged between 45-60 years. In terms of education levels, 73.4% held a bachelor's degree, and 14.5% possessed a master's degree.

**Demographic distribution of the respondents**

Variable	Frequency	Percent
Gender		
Male	81	65.3
Female	43	34.7
Total	124	100
Age range		
18-30 years old	116	93.5
45-60	8	6.5
Total	124	100
Highest academic qualification		
High School	14	11.3
Bachelor	91	73.4
Master	18	14.5
Doctor	1	0.8
Total	124	100
The floor of your home is?		
First floor	100	80.6
Middle section	11	8.9
Upper section	13	10.5
Total	124	100

Source: Survey Data, 2022

The survey revealed that a substantial proportion of respondents (80.6%) reside in homes that have a first floor, with 10.5% on upper floors and 8.9% on middle floors. In terms of how long they have occupied their current residences, 57.3% stated they have lived there for more than 18 months, 16.9% for 12-18 months, and 11.3% for less than 6 months. Regarding the size of households, 56.5% reported having 0-5 members, while 33.9% mentioned having 5-10 members. A significant majority (63.7%) rated their knowledge of

natural ventilation as very good. Overall, respondents considered the natural ventilation systems in their buildings adequate, with 46% reporting they find them adequate often and 44.4% sometimes. Approximately 58.1% indicated that all rooms receive cross-ventilation, whereas 41.9% did not. Furthermore, 40.3% sometimes utilize mechanical ventilation, and 34.7% do so often. How would you describe your knowledge of natural ventilation?

Variable	Frequency	Percent
No knowledge	1	0.8
Fair knowledge	44	35.5
Very good knowledge	79	63.7
Total	124100	

Adequacy of natural ventilation systems in the building?

Variable	Frequency	Percent
Never	21	16.6
Rarely	10	8.1
Often	57	46.0
Sometimes	55	44.4
Total	124100	

Are all the rooms cross-ventilated?

Variable	Frequency	Percent
Yes	72	58.1
No	52	41.9
Total	124100	

How frequently do you use mechanical ventilation?

Variable	Frequency	Percent
Always	10	8.1
Often	43	34.7
Sometimes	50	40.3
Rarely	21	16.9
Total	124100	

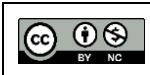
Is the building shaded in any way?

Variable	Frequency	Percent
Yes	55	44.4
No	69	55.6
Total	124100	

Window types in the rooms

Variable	Frequency	Percent
Slide hung window casement type	36	29.0
Top hung window	10	8.1
Sliding window	65	52.4

Louvers window | 13 | 10.5 | | Total | 124100 | Preferred ventilation system | Variable | Frequency | Percent | |-----|-----|-----| | Natural wind | 10282.3 | | Mechanical | 22 | 17.7 | | Total | 124100 | Source: Survey Data, 2022 With respect to shading, 55.6% of respondents (69 individuals) reported that the building was not shaded, while 44.4% (55 individuals) indicated that it was. Concerning window types, 52.4% (65 individuals) utilized sliding windows, 29% (36 individuals) had slide-hung windows, and 8.1% (10 individuals) opted for top-hung windows. A large majority (82.3%) preferred natural wind for ventilation, with a small portion favoring mechanical systems. Building Operations The vast majority of respondents (91.9%) reported cooking in a separate kitchen, while merely 4.8% cooked in their rooms. For cooking, 87.1% utilized gas, whereas 10.5% used electric cookers. Most participants (91.9%) claimed that none of their family members smoked, while 8.1% reported otherwise. Regarding indoor activities, 58.1% stated they do not dry clothes inside, while 41.9% confirmed that they do. For lighting within their homes, 83.9% primarily use electricity, and 9.7% rely on solar energy. Respondents' views on building operation | Variable | Frequency | Percent | |-----|-----|-----| | Where do you carry out your cooking? | | | | Inside the room | 6 | 4.8 | | Separate room in the house (i.e., Kitchen) | 11491.9 | | Separate building outside the house | 4 | 3.2 | | Total | 124100 | | Variable | Frequency | Percent | |-----|-----|-----|



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| Which of the following do you
use in the house for cooking? |||
Electric cooker | 1 | 10.5 | | Gas |
10887.1 | | Charcoal | 1 | 0.8 | |
Kerosene | 2 | 1.6 | | Total |
124100 | | Variable | Frequency |
Percent | |-----|
---|-----|-----| | Do you or
anyone in the family smoke in the
house? ||| Yes | 1 | 8.1 | | No |
11491.9 | | Total | 124100 | |
Variable | Frequency | Percent | |
-----|-----|-----|
--|-----| | Do you or anyone
dry clothes in the house? ||| Yes
| 52 | 41.9 | | No | 72 | 58.1 | | Total
| 124100 | | Variable | Frequency
| Percent | |-----|
---|-----|-----| | Please
indicate your main source of light
in the house at night | | |
Electricity | 10483.9 | | Generator
| 6 | 4.8 | | Solar | 2 | 9.7 | | Lamp |
2 | 1.6 | | Total | 124100 | | Chi-
Square Test on Preferred
Ventilation System and Building
Characteristics | Variable | Value
| df | Asymptotic Significance (2-
sided) | |-----|
-|-----|-----|-----|
-----| | Pearson Chi-
Square | 3.533a | 3 | 0.317 | |
Likelihood Ratio | 3.35930 | |
    
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### Conclusion and Recommendations

The findings of the study indicate that there is a significant lack of awareness regarding natural ventilation techniques and their application within buildings. Thus, it is essential to develop guidelines that integrate these techniques into multi-storey buildings to support architects, builders, and other industry professionals at various stages of design and construction. These strategies should encompass factors such as the placement of

openings, the positioning of those openings, the quantity and dimensions of the openings, the types of openings used, suitable landscaping, architectural design, spacing between buildings, and correct orientation.

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