NATURAL VENTILATION IN ACADEMIC BUILDING DESIGN: A UNIVERSITY SENATE BUILDING

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SUPERVISOR: PROF C. B. CHUKWUALI

AUGUST, 2025

APPROVAL

This research project, "NATURAL VENTILATION IN ACADEMIC BUILDINGS" by OKOYE RAPHAEL CHIDIEBUBE, Reg. No GOU/U21/ARC/153 is hereby approved as a satisfactory project report for the award of the degree of Bachelor of Architecture [B. Arc] in Architecture.

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EXTERNAL EXAMINER — DATE

CERTIFICATION

This is to certify that this report titled "NATURAL VENTILATION IN ACADEMIC BUILDINGS" was done by me, OKOYE RAPHAEL CHIDIEBUBE with registration number GOU/U21/ARC/153 in my partial fulfillment of Bachelor of Science (B.Sc) in the Department of Architecture, 400 Level, under the Faculty of Natural Applied Sciences and Environmental Studies, God frey Okoye University, Thinkers Corner, Enugu East, Enugu State, under supervision

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OKOYE RAPHAEL CHIDIEBUBE
(Researcher)

Date

DEDICATION

I dedicate this project to God the Almighty, the noble institution of Godfrey Okoye University, the Head of Department Dr. Arc Chukwucheta, my supervisor Prof C. B. Chukwuali and my family who have all in one way or the other have continuously tutored, inspired and supported me from the beginning of my academic journey so far.

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I wish to express my sincere gratitude to God almighty for his grace, intelligence and strength to complete this study. The Godfrey Okoye University community as a whole and my family for their constant support.

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ABSTRACT

This exploration examines the integration of natural ventilation strategies in the architectural design of educational buildings, with a specific focus on a college senate building at Godfrey Okoye University in Enugu, Nigeria. Recognizing the critical role that airflow plays in ensuring indoor air quality, thermal comfort, and occupant well-being, the study evaluates existing structures, identifies challenges, and proposes a hybrid ventilation framework that combines passive design principles with demand-controlled mechanical solutions. A mixed-methods approach was employed, combining sensor-based monitoring of indoor environmental quality (IEQ)—including CO_2 concentration, temperature, humidity, and airflow—with interviews and field observations. These methods revealed that many educational buildings suffer from inadequate ventilation, leading to discomfort, reduced cognitive performance, and increased health risks. In response, a contextual design concept was developed, incorporating cross-ventilation, stack ventilation, solar shading, and energy recovery ventilation (ERV). The project demonstrates that a hybrid system, thoughtfully integrated into the existing architectural fabric, can achieve 8 to 12 air changes per hour (ACH), maintain CO_2 levels below 900 ppm, and reduce HVAC energy consumption by 24%. This study contributes a replicable framework for integrating sustainable ventilation practices into institutional architecture, providing actionable recommendations for architects, engineers, and policymakers in tropical climates. It emphasizes the importance of early design-level ventilation planning, user education, and long-term monitoring to ensure the resilienc

e, health, and performance of educational buildings.

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Public buildings are the buildings that are built and sustained by public establishments as well as being used by the government to fulfill the requirements of the community at l arge. Thus, academic buildings are buildings which include faculties, hospitals, libraries, courthouses, in addition to authorities' offices which might be supported financially via p ublic authorities' agencies.

The main reason they are constructed is to supply services which are crucial for the ne twork whether or not it is training, healthcare, authorities, business, or public protectio n. Since they're open for public use these buildings are used by different people each an d every day for various reasons.

These systems typically face high occupancy stages, that could result in low indoor air qu ality if air flow isn't always ensured. Public buildings generally incorporate a variety of people simultaneously and public buildings like hospitals or faculties maintain a lot of pe ople in them for several hours at a time. When a lot of people are crammed right into a c losed environment with terrible air flow, the quality of the surroundings can become com promised very soon. The environment can end up stale, moist, or laden with carbon dioxid e and other pollution. Indoor air deteriorates without desirable ventilation structures to introduce clean air and exhaust stale air.

Poor ventilation in public homes can cause the building up of pollutants, discomfort, and the transmission of airborne illnesses. Depending on how regularly the inside air is renew ed, quite a few harmful materials can gather. These can be dust, mildew spores, micro or

ganism, viruses, and chemical substances from assets along with cleansing products or materials utilized in production. This can result in discomfort, along with headaches, leth argy, or stinging of eyes, nostril, and throat. Even worse, illnesses which can be transmitt ed by the air consisting of colds, flu, or even COVID-19 can unfold very easily in poorly ve ntilated environments, putting every person in that space or building in harms way and in crease the amount of infected people.

Thus, by expertise and assessing ventilation effectiveness in public homes is important f or public safety and well-being. In mind of a lot of these risks, it's far very imperative th at we observe how proper air flow systems in public buildings function. If these are failin g, they have to be made to function higher to guard the well-being of the daily users of t he buildings. By assessing modern ventilation exercise, constructing managers and policy makers who can educate people about their policies and sell more healthy, safer spaces for the general public.

Ventilation is a key detail in constructing layout and providing proper function to a build ing particularly in public homes in which a variety of people congregate. Ventilation is th e act of bringing clean outdoor air right into a constructing interior in addition to evacu ating stale indoors air. Indoor air first-rate is predicated in this exchange. In the case o f public homes such as colleges, hospitals, government workplaces, libraries, and auditor iums in which a number of people are coming together and continue to be for a long time, proper ventilation turns into an urgent need that must be met. These homes evidently ten d to own minimal natural ventilation due to architectural purposes, so the incorporation of natural air flow measures becomes inevitable.

Effective air flow makes sure that the air in the building is fresh, enough, and breathabl

e, reducing the threat to human health, improving cognitive functions, and ensuring secur e temperatures and humidity ranges. The dilution of airborne pollution like volatile natur al compounds (VOCs), dirt, pathogens which include micro organism, and viruses by way o f fresh air is made possible by powerful air flow. If a building is not provided with enough ventilation, these pollution can reach risky ranges, leading to breathing challenges, head aches, lethargy, or the unfolding of ailment. In addition, studies verify that human beings are capable of clear and proper thinking as well as carry out diverse functions better in side properly-ventilated spaces, revealing a conclusive connection between cognitive ch aracteristic as well as the quality of the air. Indoor temperature in addition to humidity r egulation by way of air flow additionally averts moisture build up, and to the increase of mildew in addition to structural compromise.

1.2 Statement of Problem

Even with the essential feature of air flow, most academic buildings are faced with issue s of negative air flow as well as failure to satisfy air flow requirements. These problems can result in complications within the place of fitness, low productivity, as well as users' dissatisfaction with the homes.

This paper aims at exploring the state of ventilation in academic buildings as well as fig uring out important areas that need improvement.

1.3 Aim and Objective of the Study

The purpose of this paper is to study air flow structures in academic buildings and suppl y tips for development.

Specific goals are:

1. To enhance proper ventilation in academic buildings.

2. To evaluate the challenges associated with ventilation in academic buildings.

3. To assess the effectiveness of modern-day ventilation strategies.

4. To provide pointers for promoting natural ventilation in academic building health stan

dards.

1.4 Research Questions

1. Which air flow systems are commonly applied in academic buildings?

2. List the primary problems that impact ventilation effectiveness in academic buildings.

3. How effective are contemporary air flow systems in maintaining indoor air first-rat

e?

4. How can air flow in academic buildings be optimized?

1.5 Significance of the Study

This is a valuable study as it tackles the very vital subject matter of indoor air quality i

n academic buildings. This leads us to examine the crucial nature of natural ventilation due to the fact it is focused on a key challenge indoor air quality, mainly in buildings in w hich many people congregate, like schools, student hostels, class rooms, faculty buildings and any other academic buildings. Proper indoor air quality is as crucial as clean water or safe electricity. Indoor air quality influences how people experience certain feelings, how well they're able to carry out their work, in addition to if they'll grow to be sick. By t argeting air flow, the study is addressing a totally essential issue in an effort to encoper ate proper indoor air quality exceptionally.

Ventilation performs a totally essential role in academic buildings to make sure the well -being of the dwellers are met and also helps to keep hygiene.

There are exclusive ventilation necessities for every type of academic building. For exa

mple:

1. Fresh air in academic institutions enhances the concentration of both staff and stude nts, decreases infection-related absenteeism, and affords a more fit environment for b oth the students, academic and non-academic staff.

2. Government offices need easy air for employees' productiveness in addition to visitor s comfort.

This findings are beneficial to architects, engineers, facility managers, and policymaker s by way of supporting them in their pursuit to apprehend poor air flow conditions as well as providing practical solutions for enhancement. The conclusions of this observations w ill no longer stay on paper they will be treasured by a number of experts and officials:

1. The architects and engineers can apply the findings to academic buildings with advanc ed airflow from the beginning.

2. Facility managers, who oversee the operations of buildings, may be aware of where th eir air flow structures are failing and the way to repair them.

3. Policymakers, those answerable for growing requirements and guidelines can practice the study to establish or replace building codes and public health requirements. By seeing how proper indoor air quality in buildings are functioning, such experts can act to improv e academic buildings to be healthier and more effective.

Ultimately, improving indoor air quality in public buildings will ensure a healthier, more se cure, and excellent environments for all the people in the building. The last purpose of t his study is to enhance the every day lives of people in academic buildings through indoor air quality. Improved ventilation benefits include:

1. Lessen the threat of spreading illnesses (specifically respiratory diseases).

2. Enhance comfort via temperature and humidity management.

3. Better productiveness and concentration in workplaces, colleges, and different public spaces. Enhancing air flow isn't solely a technical answer but also a practical solution f or all users of academic buildings.

1.6 Scope and Limitations

The sub ject matter of the study is academic buildings. Focusing mainly on a university se nate building. It aims at encooperating natural ventilation systems, their overall perform ance, alongside challenges being faced in a senate building in regards to natural ventila tion. The study targets academic buildings in the academic sector

1.7 Organization of the Report

This report is prepared as follows:

1. **Chapter One:** Introduces the study, presenting the background of the study, statement of the research problems, the aim and objectives, the research questions, the significanc e of the research, the scope of the research, and the definition of terms.

2. **Chapter Two:** Introduces a literary review of ventilation concepts, standards, and best practice.

3. **Chapter Three:** This includes geographical location or area of study with short history, physiography, climate, vegetation, population, culture, and economic development.

4. **Chapter Four:** Outlines methodology, methods of data collection, analysis methods, as w ell as research design.

5. **Chapter Five:** It discusses the findings of the study and ventilation assessment of a uni versity senate building.

6. **Chapter Six:** Offers conclusions and recommendations regarding enhancing ventilation

1.8 Definition of Special Terms

i. Ventilation: The act, process or system involved bringing in and extracting air in a spa ce or area with a view to maintain indoor air quality.

ii. Indoor Air Quality (IAQ): The quality of the air in the building, decided with the aid of po llutants, moisture, and air flow.

CHAPTER TWO

LITERATURE REVIEW AND CASE STUDIES

2.1 Conceptual Framework

2.1.1 Concept of Natural Ventilation in Academic Buildings

Natural air flow is the method of supplying and putting off air from an indoor space with out using mechanical systems. Instead, it is based on natural forces consisting of wind st ress and temperature differences (also called the stack effect) to move clean air into a

cademic buildings and out of doors in a building and exhaust stail air out side. In the con text of public buildings—like university senate buildings, colleges, and government offic es natural air flow or ventilation is a conventional but distinctly effective method for pr eserving indoor air quality, particularly in regions with warm to hot climates.

Natural ventilation or air flow can be achieved through:

1. Cross-ventilation: Air enters via openings (like windows) on one side of the building an d exits through openings on the other side, either opposite or adjacent to one another.

2. Stack ventilation: Warm air rises evidently and exits through excessive-degree openin gs, drawing cooler air in via low-level openings.

3. Single-sided air flow: Air movement into and outside of a room occurs through opening s on the identical side, usually useful in slim rooms or spaces that cannot have an openin g either adjacent or opposite to one another due o several reasons.

4.Natural air flow strategies are normally incorporated into the early stages of building design to maximize their effectiveness.

2.1.2 Importance of Natural Ventilation in University Senate Buildings

In university senate buildings, where meetings, reliable functions, and administrative wor k are achieved daily, appropriate indoor air flow satisfaction and thermal comfort are v ital. Natural air flow gives a couple of benefits:

1. Energy efficiency: Reduces reliance on mechanical ventilation and air conditioning sys tems, leading to lower electricity intake and expenses.

2. Health improvement: Provides a steady supply of fresh clean air, reducing the build-up of carbon di oxide (CO_2) and indoor pollution, and assisting in the reduction of airborne disease transmission.

3. Thermal comfort: Maintains suitable temperature and humidity levels, especially when designed with nearby climate in mind (local climate).

4. Environmental sustainability: Supports green building certifications like LEED and BRE EAM with the aid of decreasing the building's carbon footprint.

2.1.3 Methods for Achieving Natural Ventilation

To reap powerful natural air flow, the layout below needs to considerd:

1. Building orientation: Positioning the building to make proper use of prevailing wind dire ctions to the benefit of the occuants.

2. Window design: Use of operable windows, louvres, or vents strategically positioned to facilitate air movement.

3. Atriums and courtyards: Internal spaces that act as lungs for the building, promoting good ventilation to provide both vertical and horizontal air flow.

4. Shading devices: Elements like overhangs, fins, and pergolas that allow air glide freely as well as minimizing direct solar heat gain (sunlight).

5. Material selection: Use of breathable and thermally responsive substances that help r egulate indoor climate.

In the layout of a university senate building, wherein distinct spaces like places of work, meeting rooms, and occasion halls are present, a hybrid method is frequently preferred combining natural air flow for everyday operations and mechanical assist for the durati on of peak occupancy or adverse climatic situations.

2.1.4 Challenges of Natural Ventilation in Public Buildings

Like everything in life, natural ventilation has both advantages and disadvantages. Thes e disadvantages are expressed as challenges:

1. Climate barriers: In regions with excessive humidity, severe heat, or pollution, relying c ompletely on natural air flow may not be sufficient.

2. Control difficulties: Unlike mechanical systems, natural air flow can be difficult to reg ulate exactly, resulting in occasional challenges or troubles.

3. Security concerns: Open building windows or vents may additionally compromise buildin g security or protection.

4. Noise intrusion: Buildings in noisy environments may face problems while using operabl e windows for natural air flow.

5. Building layout barriers: Existing buildings, like older structures might not have been o riginally designed for optimized airflow, making retrofitting complex and pricey.

2.1.5 Integration of Natural Ventilation with Modern Building Systems

Modern exercise frequently combines natural ventilation with mechanical systems to cre ate a "blended-mode" ventilation strategy.

1. Mechanical systems (like fans or air conditioners) are activated usually when natural techniques are inadequate.

2. Smart sensors display indoor air quality parameters (CO_2 levels, temperature, humidit y) and modify air flow routes more adequately.

3. Architects and engineers design buildings to prioritize natural airflow first in the cons truction of the building than resorting to mechanical solutions.

Such strategies allow university senate buildings to store energy at the same time as ma king sure that indoor air quality stays consistently good.

2.1.6 Concept of Ventilation in Public Buildings

Ventilation refers to the deliberate delivery of good and clean air and the removal of st ale air from a building to keep desirable indoor air quality (IAQ). Particularly in public b uildings which includes university senate buildings, in which administrative and education al activities take place, ventilation is essential for preserving healyh, thermal comfort, a nd productivity. According to **ASHRAE Standard 62.1** (on Ventilation for Acceptable Indoo r Air Quality, proper ventilation not only controls odours and pollutants but also plays a r ole in energy efficiency and sustainable building design).

University senate buildings, being the most important administrative facility in a universi ty often accommodate massive numbers of team of workers, faculty, and site visitors. A ctivities inside those buildings which may include conferences, administrative work, and c eremonial activities that require effective air flow to avoid carbon di oxide (CO_2) buildin g up, airborne transmission of illnesses, and soreness because of poor air exchange.

2.1.7 Importance of Ventilation in University Senate Buildings

1. Health and Safety: Good air flow reduces the concentration of airborne pollutants like dirt, pathogens, and the risk of volatile organic compounds (VOCs).

2. Productivity and Comfort: Adequate clean air flow improves cognitive capabilities and leads to good decision making among administrative personnel.

3. Energy Efficiency: Ventilation systems may be optimized alongside with HVAC designs t o minimize power use at the same time as making sure comfort is attained.

4. Compliance with Standards: Institutions need to observe air flow codes inclusive of **AS HRAE 62.1**, **WHO** recommendation guidelines, and local building guidelines.

2.1.8 Summary of Findings from Case Studies

From the Nigerian and global examples, several styles emerge:

1. Natural ventilation on its own is increasingly becoming insufficient due to changes in t he weather or climate, higher rate of occupancy, and increase of indoor heat.

2. Hybrid or mixed-mode ventilation systems are more resilient and sustainable for acad emic buildings like senate buildings.

3. Maintenance is a difficult, without it, even well-designed structures underperform.

4. Smart systems that regulate indoor air flow based on occupancy and indoor air qualit y (IAQ) sensors are becoming the new widespread standard abroad, enhancing not only h ealth outcomes but also power savings.

5. Retrofits have to appreciate the building's original layout even as it integrates conte mporary air flow upgrades.

2.2 Theoretical Framework

The theoretical framework for this study is to examine ventilation in public university bui ldings, especially a university senate building, is anchored on two most important environ mental theories: **Indoor Environmental Quality (IEQ) Theory** and **Thermal Comfort Theory.**

2.2.1 Indoor Environmental Quality (IEQ) Theory

Indoor Environmental Quality (IEQ) theory principles emphasizes that the high-quality of t he indoor environment, along with exceptional air quality, lighting, acoustics, and thermal situations, has a direct impact on occupants' health, comfort, and productiveness. Ventil ation holds a crucial position inside of the indoor environmental quality theory (IEQ), as it directly impacts the concentration of indoor pollution, humidity, and the level of tempera ture. According to this theory, effective ventilation has to continuously introduce enough good air and at the same time also expel contaminated or infected air to bring about a h ealthy, comfortable, and a proper and effective work environment. Poor ventilation com

promises indoor environmental quality (IEQ), leading to health problems such as respirato ry sicknesses and illness, allergic reactions, fatigue, and reduced cognitive performanc e.

2.2.2Thermal Comfort Theory

Thermal consolation idea, as introduced to the public by Fanger's **Predicted Mean Vote (PMV)** and **Predicted Percentage Dissatisfied (PPD)** models, underlines the idea that the thermal comfort or satisfaction is prompted by means of environmental variables such a s (air temperature, humidity, air speed and velocity) and personal or private variables li ke (clothing insulation and rate of metabolism). Ventilation is a key environmental varia ble which could alter indoor air temperature and humidity, contributing to or detracting from thermal comfort. In a university senate building, where intellectual performance is critical, accomplishing thermal comfort via right air flow becomes even more vital for re taining cognizance, reducing strain that causes stress, and optimizing decision-making.

2.2.3Relationship Between Theories and Study

Both indoor environment quality (IEQ) and Thermal Comfort theories emphasize that prop er and adequate air flow isn't just a mechanical system process but a human-centered d esign difficulty. This theoretical technique helps one to understand how the study's explor ation into how present day ventilation systems in a university senate building either supp orts or detract from occupant well-being, operational effectiveness, and the overall su stainability of the building.

Thus, this study makes use of those theoretical lenses to:

1. Assess the role of good air flow in enhancing indoor air quality (IEQ framework).

2. Evaluate the capacity of ventilation systems to keep comfortable thermal situations

(Thermal Comfort framework).

3. Identify gaps wherein present practices fall don't meet up to standard and recommen d improvements primarily based on recognized human-centric environmental theories.

These frameworks offer a solid academic foundation for investigating the complicated i nteraction between good and proper design of ventilation systems, experience of the oc cupants, and the functionality of the buildings capability inside the context of public uni versity buildings.

2.3 Review of Ventilation Standards and Guidelines for Public Buildings

2.3.1 Introduction

Ventilation requirements, guidelines and standards set up the minimal necessities for ma king sure of a comfortable, wholesome and safe indoor environment. In public buildings which include university senate buildings, where a great number of people congregate fo r prolonged intervals, adherence to set up air flow standards is essential for good healt h, productiveness, and basic occupant well-being.

Different national and worldwide bodies have formulated ventilation requirements. Thes e standards include elements like rate of air change, indoor pollutant control, mechanic al and natural ventilation requirements, and energy conserving performance concerns.

2.3.2 Major International Standards and Guidelines

A. ASHRAE Standard 62.1 (American Society of Heating, Refrigerating, and Air-Condition ing Engineers)

1. Title: Ventilation for Acceptable Indoor Air Quality

2. Key Requirements:

    a. Specifies minimal air flow charges based on occupancy and ground location.

b. Emphasizes the use of outdoor air for dilution of indoor contaminants.

c. Encourages the use of Demand-Controlled Ventilation (DCV) for big variable-occupancy areas.

d. Requires normal maintenance and commissioning of ventilation systems to make sure of effectiveness.

3. Application to Senate Buildings: Meeting rooms, workplaces, and lobbies require particular outdoor airflow charges to preserve air freshness and save the occupants from CO_2 buildup.

B. WHO Guidelines on Indoor Air Quality

1. Focus Areas: Biological contaminants, chemical pollutants, moisture, and mildew.

2. Relevance: WHO highlights the function of ventilation in reducing airborne sickness transmission, which have become especially distinguished throughout the COVID-19 pandemic.

3. Application to Senate Buildings: Highlights the need for mechanical or natural air flow structures which could acquire at the least 6 air exchanges per hour (ACH) in highly populated or enclosed areas.

C. CIBSE Guide A (Chartered Institution of Building Services Engineers, UK)

1. Scope: Environmental design for healthful, comfortable homes.

2. Key Points:

a. Recommends minimal outside air delivery of 10 liters per second in regards to office spaces.

b. Promotes natural ventilation in which viable, supported with the aid of mechanical systems whilst important.

3. Application to Senate Buildings: Focuses on balancing thermal comfort and IAQ, specifi cally in older university buildings tailored to fashionable desires.

2.3.3 Nigerian Ventilation Standards and Guidelines

A. Nigerian Building Code (NBC, 2006 Edition)

1.Ventilation Provisions:

a. Requires homes to have either good enough natural air flow through home windo ws and different openings or mechanical ventilation when natural means are inadequate.

b. Mandates a minimal openable window area with a minimum of 10% of the groun d area for naturally ventilated rooms.

2. Application to Senate Buildings: Highlights the necessity for operable windows in workp lace spaces, lobbies, and conference rooms in university buildings.

B. Federal Ministry of Environment Guidelines

1. Emphasis: Encourages sustainable and environmentally pleasant building practices, to gether with using natural air flow to limit energy intake.

2. Application: University senate buildings are encouraged to combine passive design tec hniques for air flow along power-saving technology.

C. National Environmental (Air Quality Control) Regulations, 2014

1. Although not a building-particular code, it sets broader goals for keeping wholesome i ndoor air quality, not directly influencing air flow requirements in public institutions.

2.3.4 Key Parameters in Ventilation Standards

1. Air Change Rate: Number of times the air within an area is changed with air from outsi de per hour (ACH). Recommended minimums vary depending on occupancy and room funct ion.