VENTILATION REQUIREMENTS IN STANDARD UNIVERSITY LECTURE THEATRES:

A CASE STUDY OF FRANCIS IDIBIYE AUDITORIUM, FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE

BY

OGINNI OLALEKAN EBENEZAR

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LECTURER: PROF. OLU. OGUNSHOTE

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In human, metabolic process involves complex organic molecules being broken down to simpler molecules, such as carbon dioxide and water vapor; these wastes are removed from the body through respiration. Concentration of these wastes is an indication of the indoor air quality of a particular enclosed space in time.

Studies show that increase in level of these wastes within an enclosure may cause occupants of the space to grow drowsy, get headaches, or function at lower activity levels, especially when filled to maximum capacity.

It is therefore imperative that a university lecture theater in which large numbers of students may be organized for different academic activities must be provided with means through which oxygen will be replenished, the concentration of carbon dioxide and water vapor will be diluted, and airborne pollutants such as dust, smoke and volatile organic compounds will be removed, unpleasant odors will be eradicated and ultimately increase thermal comfort of the users.

Having considered different factors on which air flow through buildings is predicated, such as the sizes of the openings, numbers and position of openings, opening components and some other external factors, also carefully assessing them on how they have affected the ventilation in a given existing University lecture theater, it became obvious the level of ventilation that is desirous in a standard university Lecture Theater.

Key Words: Ventilation, Cross Ventilation, Lecture Theater, Air flow, Air Movement
INTRODUCTION

Ventilation includes both the exchange of used inside air by the outside as well as circulation of air within the building. It is an important factor for maintaining acceptable indoor air quality in buildings; it is majorly for supply of fresh air, body cooling and structural cooling or heating. Methods for ventilating a building may be divided into natural or Mechanical ventilation. The amount of ventilation will depend critically on the size and placement of openings in the building. It is useful to think of a natural ventilation system as a circuit, with equal consideration given to air inlet and outlet. Openings between rooms such as transom windows, louvers, grills, or open plans are techniques to complete the airflow circuit through a building. A certain amount of air movement ordinarily is provided by air leakage through small gaps in the building's walls, especially around windows and doors. Such unplanned ventilation may be enough for homes, but not for public buildings such as offices and university lecture theaters. Air flow around building is determined by the shape, height, and orientation and planning of buildings.
BASIC CONCEPTS IN VENTILATION

Ventilation is the replacement of used air in any space by outside air to provide high indoor air quality. Ventilation is used to remove unpleasant smells and excessive moisture, introduce outside air, to keep interior building air circulating, and to prevent stagnation of the interior air.

Ventilation includes both the exchange of air to the outside as well as circulation of air within the building. Cross ventilation is ventilation achieved when opposite walls of an enclosure are being placed with openings. Ventilation is measure in volume of air change per hour.

Natural ventilation is the ventilation of a building with outside air without the use of a fan or other mechanical system, by stack effect and wind pressure. It can be achieved with openable windows when the spaces to ventilate are small. In more complex systems it can be achieved through temperature and pressure differences between spaces, warm air in the building can be allowed to rise and flow out of the upper openings to the outside thus forcing cool outside air to be drawn into the building naturally through openings in the lower areas. In warm or humid months, in many climates, maintaining thermal comfort solely via natural ventilation may not be possible so conventional air conditioning systems are used as backups.

Mechanical or forced ventilation is achieved through an air handling unit or direct injection of air to a space by a fan. A local exhaust fan can enhance infiltration or natural ventilation, thus increasing the ventilation air flow rate.
Mixed Mode Ventilation or Hybrid ventilation: utilizes both mechanical and natural ventilation processes. The mechanical and natural components may be used in conjunction with each other or separately at different times of day. The natural component, sometimes subject to unpredictable external weather conditions may not always be adequate to ventilate the desired space. The mechanical component is then used to increase the overall ventilation rate so that the desired internal conditions are met. Alternatively the mechanical component may be used as a control measure to regulate the natural ventilation process, for example, to restrict the air change rate during periods of high wind speeds.

Infiltration is uncontrolled air flow into or through a building especially through gaps in doors and windows. Infiltration is separate from ventilation, but is often used to provide ventilation air.
DISCRIBTION OF THE AUDITORIUM

Francis Idiye Auditorium, designed to sit about 500 people for multipurpose use is located within the serene administrative core of the Federal University of Technology Akure.

It is about 50m to the Senate building, surrounded by a large span of green area and bounded at its south by the J.T Useni Utility Center and Wema Bank. At the western side flows a natural stream with thick forest cover. It is linked directly with the senate roundabout through Ododuwa Road. The road actually terminates in front of the auditorium.

The building is octagonal in shape, with large openings on six of the eight sides, leaving the North West and South East walls blank for the provision of the conveniences and back stage facilities.
There are two main defined entrances, one on the North East elevation and the other on the South West Elevation. Meanwhile, the other four sides, Northern, Eastern, Southern and Eastern elevations are equally provided with large openings which can double as doorways and fenestrations. These elevations are recessed and provided with verandas to exclude the sun and prevent rain water from entering the building.

The auditorium is in double volume, with the mezzanine floor sitting directly on the verandas at the ground floor, the upper floor is only being projected into the main hall by minimal cantilever. There is an effective air space above the auditorium.

**METHOD OF STUDY**

The work is aimed at carrying out a critical study on an existing facility which is a lecture theater so as to find out how ventilation was catered for within and around the building and to conclude if the building is well ventilated or not. These would form a basis for recommendation of ventilation requirements in standard university lecture theaters.

**MODE OF STUDY**

- Direct case study was carried out on the facility.
- Some students and members of staff who had used the facility at one point or the other were interviewed about the level of comfort that was experienced as a result of exchange and movement of air when the Auditorium was at its full capacity.
CLIMATE OF AKURE

Even though the study took place in the month of August when the temperature of Akure is never at the maximum and when the rainfall and humidity are at the highest points. From the available data and the understanding of climatic zoning in Nigeria, it could be established that Akure enjoys a moderate tropic climate with maximum temperatures rarely rising above $33^0$ C and minimum temperatures rarely falling below $20^0$ C. Relative humidity also ranges between 86% and 40%. There is some form of precipitation throughout the year, even though there are distinct wet and dry seasons. There is usually more than six hours of sunshine, even during the rainy season. Therefore the result of the finding can be generalized for the rest of the months

Average Climatic Condition in Akure

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<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
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<tbody>
<tr>
<td><strong>Mean Monthly Maximum Temperature ($^0$C)</strong></td>
<td>32.1</td>
<td>33.5</td>
<td>33.4</td>
<td>32.3</td>
<td>31.6</td>
<td>29.0</td>
<td>29.0</td>
<td>28.2</td>
<td>29.1</td>
<td>30.4</td>
<td>32.2</td>
<td>31.4</td>
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<tr>
<td><strong>Mean Monthly Minimum Temperature ($^0$C)</strong></td>
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<td>20.0</td>
<td>21.7</td>
<td>22.0</td>
<td>21.1</td>
<td>20.8</td>
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<td>20.1</td>
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<td>19.8</td>
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<td></td>
<td>Mean Daily Maximum Relative Humidity (%)</td>
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<td>65.1</td>
<td>75.9</td>
<td>78.4</td>
<td>79.6</td>
<td>83.2</td>
<td>86.6</td>
<td>85.8</td>
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<td></td>
<td>Mean Daily Minimum Relative Humidity (%)</td>
<td>43.6</td>
<td>40.0</td>
<td>48.2</td>
<td>54.0</td>
<td>56.5</td>
<td>59.1</td>
<td>62.8</td>
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<td>61.4</td>
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<td>Precipitation (mm)</td>
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<td>33.5</td>
<td>65.6</td>
<td>79.1</td>
<td>154.4</td>
<td>169.5</td>
<td>209.9</td>
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<td>Hours of Sunshine</td>
<td>7.9</td>
<td>8.1</td>
<td>7.4</td>
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<td>8.1</td>
<td>7.5</td>
<td>6.9</td>
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<td>1.2</td>
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<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.1</td>
<td>1.2</td>
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Source: Analysis of data collected from weather stations in Akure by federal University of Technology, Akure (FUTA) Students
FINDINGDS

BUILDING SHAPE AND ORIENTATION.

The building is octagonal in shape with six of its sides provided with large openings. This allows air flow through the building no matter the direction from which the wind is blowing. Because of this form it could not be established if there was emphasis on the layout of the building, but it was clear that North – South orientation was considered with longer sides facing the North/ west and South / East.

VOLUME OF THE BUILDING

The auditorium is in double volume, there is an upper floor gallery sitting directly on the verandas at the ground floor, the upper floor is only being projected into the main hall by minimal cantilever. There is a clearance of about six meters above the gallery providing an effective air space within the auditorium. Since air flow improves with volume, this has actually helped the ventilation within the facility.

Plate 2: picture showing the clearance space above the auditorium.
NUMBER AND SIZE OF OPENINGS.

At the ground level, the North, East, South, and West elevations are provided with 3 numbers openings each, rising from the floor to the door level measuring at 2100mm x 2400 each. These openings are covering more than 70 % of the surface area of each elevation.

The two entrances on the North/East and South/West are equally provided with wide opening spanning across the entire elevation, covering about 80% of the surface area.

On the upper floor, the entire elevations are also provided with wide openings in alignment with the provision on the ground floor except that they were reduced to normal window height. There is no burglary proof or mosquito net which could have reduced the flow of air by some percentage.

Plate 3: Photographs showing the use of Wide opening to allow air flow into the facility
Plate 4: Photographs showing the use of Wide opening to allow air flow into the facility

POSITION OF THE OPENINGS

The shape of the building has actually made it that opposite elevations are identical to one another, this implies that similar openings are all positioned directly opposite each other. Cross ventilation is experienced at every point within the facility.

LOCATION OF THE BUILDING

The building is located close to the natural green belt there is also an existence of a stream flowing through the greenbelt. This water body helps humidification and evaporative cooling; this also improves the quality of air that flows in to the building.
Plate 5: Photograph of the natural vegetation and water body that help to improve the quality of air around the auditorium

**WIDTH OF THE BUILDING**

The wall to wall distance of the building is about 20 meters, considering this to its overall height and the surface area of the openings allowed for air flow, the width is good enough for perfect cross ventilation.

**RELATIONSHIP WITH OTHER BUILDINGS**

The building is almost free standing; the closest tall building around is about 50 meters away. Wema bank and the neighboring Utility facility are bungalow and are widely spaced from the building, therefore the problem of a building obstructing the air flow or building placed in the wind shadow of the other is non existing.
Plate 6: an extract from the map of Federal University of Technology Akure. Showing the location of the Auditorium and its relationship with other existing facilities and nature.

The Francis Idiye Auditorium is seen label 47
THE EFFECT OF TREES, SHRUBS AND LAWNS

Ventilation is affected by plant materials; they provide shade and control relative humidity and air movement. Air crossing hard reflective or absorptive surfaces like parking lots and sidewalks is warmed, but air passing through trees and plants will be cooled and are allowed through the wide openings into the building.

Plate 7: photographs showing the use of soft landscape elements to augment the quality of ventilation air around the facility
AIR FLOW BY MECHANICAL MEANS

Wind pressure being the major force responsible for air flow through buildings. When the natural movement of air by stack effect combined with the wind pressure is insufficient for body cooling, especially during the hot dry season, it is therefore necessary to employ mechanical means to improve ventilation.

15 numbers ceiling fans were hung to the ceiling to maximize wind pressure for air movement. There were wall fans mounted at strategic positions, especially under the projection of the upper floor where air flow could be insufficient.

Plate 8: ceiling and wall fans been installed inside the auditorium to improve air movement when need arises.
CONCLUSION AND RECOMMENDATION

The outcome of the assessment conducted on the Francis Idibiye Auditorium suggests that proper natural ventilation is being achieved in the building. This was due to the reasons stated below:

- The shape of the building allows inflow and outflow of air from any direction
- North – South planning was considered
- Large openings are placed in opposite walls of the buildings
- There was no use of barrier or screen that could reduce air flow through the windows
- The building is not too wide considering the height and amount of opening provided
- Use of verandah on all the sides at the ground level and use roof gutter projection at the upper level to exclude the sun and rain penetration.
- The use of landscape elements to increase the quality of air around the building.
- The building is sited far away from other building that could disrupt air flow through it.
- The building is surrounded by natural green belt; this has also improved the quality of air around the building.
- Ceiling and wall fans have been installed to provide necessary air movement for body cooling when need arises.
- The gallery is not covering any portion of the main auditorium below.
Finally, the level of ventilation required in standard university Lecture Theater should be the type that has the capacity of effectively and totally remove carbon dioxide, water vapor, and air borne pollutants, it must be able to replenish oxygen and facilitate body cooling such that the students will experience thermal comfort and they will be able to operate at their maximum capacity. The ventilation must be as natural as possible so as to save energy consumption which could be deployed into other important use within the University. This could be achieved if some of the factors analyzed above are considered in designing or sitting a student lecture theater.
Refeerences

