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# A REVIEW ON PASSIVE DESIGN STRATEGIES: ASSESSING THERMAL COMFORT IN ARCHITECTURAL DESIGN STUDIOS AT THE RIVERS STATE UNIVERSITY, NIGERIA

**by**

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## ABSTRACT

*Passive design takes advantage of natural energy flow for achieving and maintaining thermal comfort. It involves the application of suitable building orientation, materials and landscaping. This paper reviewed the strategies adopted to achieve adequate ventilation and thermal comfort in architectural design studios using the Faculty of environmental sciences building in Rivers state university as a study. It was highlighted that through a building's envelope, the structure and the surrounding exchange some energy fluxes in both senses, depending on the energy quantity required, produced and consumed inside the same building and the one coming from the external environment. The research was accomplished by gathering primary and secondary data that were available for review. Some strategies that were considered important in achieving thermal comfort and adequate ventilation in the studios such as the building's orientation check, adherence to narrow plan design and site planning, window size and positioning, the use of ceiling fans and vegetation were highlighted. The study identified that the studios in the architecture department are thermally comfortable with the courtyard system serving as a medium for bringing in fresh air to the studios and dismissing the warm air in the spaces to the atmosphere. There is a generous adherence to cross ventilation which makes the spaces well aired and comfortable. In this work, it was established that the spaces were constructed with materials that had high insulation properties which has the capacity to avert the negative effects of the weather in the area, improving cooling inside the building and the spaces, which increases comfort and reduces the cost of energy because with the parameters for achieving thermal comfort and ventilation adhered to, the need for alternative energy supply is reduced saving costs for its users, reducing the effects of noise pollution and contributing to reduced carbon emissions in the atmosphere which can be harmful to health of the users.*

**Keywords:** Building orientation. Thermal comfort, Natural ventilation, Passive design

## INTRODUCTION

Consolidation of solar powered latent procedures in buildings assists with limiting burden on conventional systems like warming, cooling, ventilation and light. Passive design gives warm and visual comfort by utilizing normal fuel sources and sinks.

When the solar passive architectural ideas are applied to plan, the stack on traditional frameworks (HVAC and lighting) is decreased. Designers, however, can accomplish a solar-based passive design by considering the large scale and miniature environment of the site, applying bioclimatic engineering configuration highlights and exploiting the normal assets on the site. Passive design techniques can be used to reduce and, in some cases, eliminate mechanical air conditioning requirements in areas where cooling is a dominant problem. The cost and energy effectiveness of these options are both worth considering by client and designer. Contained within this section are rules of thumb and an explanation or the essentials of passive cooling systems. Natural ventilation is clearly a valuable tool for sustainable development as it relies only on natural air movement and can save significant amounts of fossil fuel-based energy by reducing the need for mechanical ventilation and air conditioning. Reducing electrical energy used for cooling contributes to the reduction of greenhouse gas emission form the electrical generating plant providing the energy (Richard, 2007). Currently, energy constraint and global warming are the biggest challenges confronting the planet (Nilcon, 2008).

The need to lessen our utilization of energy and to give clients more authority over their nearby surroundings are valid justifications for creators to reexamine the part of characteristic ventilation in structures and to get comfortable with the essential standards included (Richard 2007).

## 2.0. LITERATURE REVIEW

Passive Design is a term that explains the maintenance of comfortable temperature in buildings by exploiting the climatic and innate components of an area to induce optimum benefit for users of the buildings while cutting back on the dependence on mechanical systems for heating, cooling, and lighting. In the thought process of Passive Design, two crucial considerations are climate and comfort. The crucial measures for the consideration of passive design and its techniques to be beneficial and effective are climatic consideration and comfort. Passive Design regards a particular way of constructing buildings using the natural movement of heat and air, passive solar gain and cooling in order to maintain good internal comfort. Through the use of passive solutions it is possible to eliminate or reduce the use of mechanical systems and the energy demand by 80% as well as the CO2 emissions.

This paper reviews the strategies adopted to achieve adequate ventilation and thermal comfort in buildings using the department of environmental sciences building in Rivers state university as a study.

**Natural Ventilation and Passive Design**

Natural ventilation is a profitable apparatus for sustainable development because of its reliance on natural air movement and can spare noteworthy sums of fossil fuel by decreasing the dependence on mechanical ventilation and air conditioning. The reduction of electrical energy utilized for cooling has a great contribution towards reducing green house gases from electrical producing plants that supply energy.

In early times, designers utilized natural air movement as an apparatus for addressing foul air removal and thermal comfort in buildings. Since the 20$^{th}$ century, mechanical ventilation methods and air conditioning systems have been adopted to compensate the significant increase in heat gain experienced in most lightweight and exceedingly glazed buildings. This expanded utilization of mechanical services has provided designers and users of buildings with an extraordinary bargain of flexibility in terms of building envelopes and internal flexibility.

**Utilization of Natural Ventilation**

The genuine test for normally ventilated structures is the arrangement of satisfactory cooling in the warm season. Under this condition, it is important to have adequate external wind pressure to make air development inside the structure and, especially, through the involved zones.

Under sweltering, dry summer conditions, when the external air temperature is well over the decent interior level, it could be important to close off the outer air until the temperature drops to more adequate levels.

In pre-second world war structures like schools and clinics, this was accounted for by having high roofs to store huge volumes of air, and by utilizing roof fans to give individual cooling.

In warm, damp environments, normal ventilation is utilized to upgrade indoor warm solace by decreasing the impacts of relative mugginess above average.

The other testing time for normally ventilated structures is in the cool season. The test at that point is to confine approaching air to accomplish the base vital natural air without causing cold drafts or over-the-top warmth misfortune.

Considerably under quiet cooler conditions, the distinction in temperature between the structure inside and outside air will typically make adequate stack impact to attract natural air.

The stack impact is achieved by warm air ascending to be depleted through undeniable level outlets thus attracting colder, heavier air from outside. Open flames are an extraordinary type of this with air being depleted up the vent. Practically, the utilization of characteristic ventilation in current structures is generally regular in moderately low ascent, shallow arrangement structures like lodging, schools, wellbeing focus, and little office units. An air development of 1.0 m/s is the breaking point before papers on a work area will begin to blow around.

## 3.0. METHODOLOGY

The case study examined were the Design Studios at the Department of Architecture, Faculty of Environmental Sciences in Rivers State University, Port Harcourt.

In accomplishing this research, primary and secondary data were acquired. Meanwhile, secondary data were based on chosen accessible articles, article journals and books for further reviews and examination.

The following issues have been investigated:

i. Energy use practices of users (appliances used, energy used by those appliances)
ii. Energy use for cooling and ventilation in typical design studios at the Department of Architecture, Faculty of Environmental Sciences in Rivers State University, Port Harcourt.
iii. Cooling load analysis of the users.



Data gathering strategies were divided into a mixture of qualitative and quantitative approaches. The following different combinations of data gathering strategies were adopted;

i. Physical survey of the case study building.
ii. Quantitative calculation of energy use and Architectural drawings of the case

## 4.0. FINDINGS AND DISCUSSION

Passive design takes advantage of natural energy flow in maintaining the thermal comfort of a building. It involves the application of appropriate building orientation, building materials and landscaping. Passive design is achieved through set strategies that have stood the test of time in areas where design process are being planned and executed with time.

Passive design strategies use ambient energy sources instead of purchased energy like electricity or natural gas. These strategies include day lighting, natural ventilation, and solar energy.

### *Building's Orientation*

Orient buildings to maximize their exposure to the prevailing warm wind direction. The orientation of a building governs the implementation of passive technologies implementation within the design. Well-designed buildings should have most of the rooms oriented, towards the equator. The studios in Department of Architecture, Faculty of Environmental Sciences building at the Rivers State University, Port Harcourt satisfy this strategy causing a maximal exposure to the prevailing warm wind direction and a satisfactory implementation of passive design techniques in the building's design. This is because the majority of windows are designed into the equator-facing wall, where the sun penetration into the building is maximized and the design studios are sited to gain maximum benefit from cooling breezes in hot weather and shelter from undesirable winds in cooler seasons. This does not mean that the orientation of the building should be varied from north towards prevailing breezes, as it does not have to face directly into the breeze to achieve good cross-ventilation (Ming fang 2002).

### *Adherence to narrow plan design and site planning*

Site and building planning is a vital part of passive designing, where every components position result in a major aspect of the microclimate generated around the site. Zoning and massing aid to achieve desired microclimate in different climates. The massing of the Faculty of environmental science building of the Rivers state university, Port Harcourt helps to achieve thermal and visual comfort levels because it has been designed to suit the climatic requirements of the area. This massing of the faculty blocks help regulate the wind during the hot season and achieve ventilation wind flow in cooler season. Designing spaces with a comparatively slim plan forms across the air direction as shown in the figure one below help to facilitate the passage of air through the space and encourages thermal comfort.

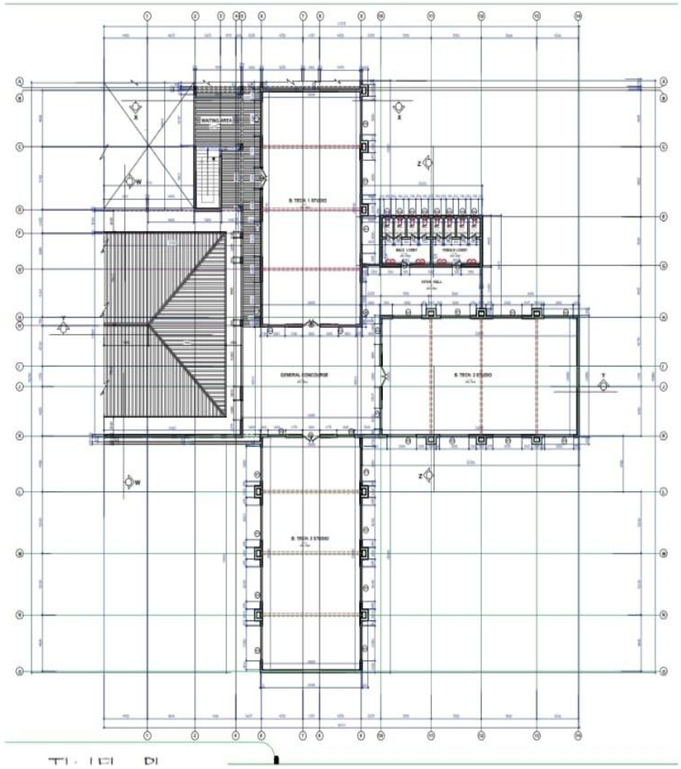

*Figure 1: Floor plan showing the studio spaces of the building.*

**Source:** (Department of architecture, Rivers state university 2021)



***Window size and positioning***

The window sizes and positioning influences the conditioning of the studio spaces within the Faculty of environmental science building of the Rivers state university, Port Harcourt. There are wall openings positioned to facilitate the passage of air through the building. To achieve thermal comfort and adequate air flow, the window to floor area ratio (WFR) of the spaces in the study building was calculated by dividing the area of the window by the area of the floors. Correspondingly, the window to wall area ratio (WWR) in the different units was calculated by dividing the window area by wall area.

| | Spaces | Window orientation | Floor area(m2) | Window area(m2) | Wall area(m2) | WFR | WWR |
|---|---|---|---|---|---|---|---|
| 1 | Studio 1 | North East-North West | 200 | 21.6 | 252 | 0.108 | 0.08 |
| 2 | Studio 2 | East North- East South | 200 | 21.6 | 252 | 0.108 | 0.08 |
| 3 | Studio 3 | South East- South West | 200 | 21.6 | 252 | 0.108 | 0.08 |

The table above shows the Window to floor area ratio (WFR) and window to wall area ratio (WWR) of the architecture studios in the rivers state university. All the windows are effective in allowing day light and airflow because of their orientation. As a result, the lights in these units need not to be kept on throughout the day and adequate airflow is achieved.

***Use of vegetation***

Landscaping and vegetation play an important role in defining the microclimate of a site. Components just like the water bodies, shading trees, orientation and placement of building blocks. The number of arduous paving will affect the warmth trapped round the building leading to the heat island effect. Additionally, it will increase the run from the site therefore reducing the moistness around the site because of lack of percolation. Water bodies act as natural coolers for hot and dry climates. Vegetation is a component that can be adopted to change the external wind direction, enhance ventilation, and incoming air. They provide shading on building and hard paving, act as sound barrier to obstruct the noise entering in the site when placed around the site boundary and provide shading when placed near the building envelop. The study building has sparse vegetation spread around it which can be a disadvantage because the studios are exposed to both harsh and mild conditions of the weather.

### *Use of ceiling fans*

Employ ceiling fans wherever applicable to attenuate the necessity for cold air conditioner. The use of fans was employed in the study building which is a cost effective and sustainable practice in achieving thermal comfort.

*Figure 2: Interior of the design studio showing the use of fans for cooling.*

**Source**: (Researcher, 2021)

## 5.0. CONCLUSION AND RECOMMENDATION

This study has identified that the studios in the architecture building are relatively thermally comfortable considering the criteria that determine how it can be achieved in buildings and spaces. Although the building satisfies the aspect of adequate vegetation and shading for preventing the spaces from adverse weather effects, the courtyard system serves as a medium for bringing in fresh air to the studios and dismissing the warm air in the spaces to the atmosphere.

There is a generous adherence to cross ventilation which makes the spaces well aired and comfortable.

In this work, it was established that the spaces were constructed with materials that had high insulation properties which has the capacity to avert the negative effects of the weather in the area, improving cooling inside the building and the spaces, which increases comfort and reduces the cost of energy because with the parameters for achieving thermal comfort and ventilation adhered to, the need for alternative energy supply is reduced saving costs for its users, reducing the effects of noise pollution and contributing to reduced carbon emissions in the atmosphere which can be harmful to health of the users.

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