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Value Jet Office Complex, Alausa, Ikeja, Lagos: Analysis of Daylighting Performance in Administrative Buildings in Nigeria

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Abstract **- Globally, energy conservation to reduce the running cost of buildings especially institutional buildings have been a priority. Efforts have been geared towards achieving this through design process. The importance of daylighting in administrative buildings has long been acknowledged as a valuable source of energy savings and visual comfort. In Nigeria, administrative buildings are the top energy consumers. The performance of daylighting in administrative buildings was studied in this research work. In carrying out the study, a major administrative building has been selected for this analysis. Various parameters were generated from existing research work on the indicators and determinants of daylighting performance of an administrative building and a simulation program of the building was carried out to determine the result. With the purpose of analysing the information gathered, a descriptive analysis was used to analyse the performance of daylighting in the building, which was explained further in the methodology. There search offered simulation findings using the software Insight360®to determine the performance of daylighting in percentage at different areas in the building that is expose to direct sun light with the result stating that daylighting decreases slightly towards the middle of the space at an average of 31.7 %. This is due to the extent at which light travels as well as other surfaces that reflect and absorb light, resulting in a reduction in the intensity of the light. Towards the extreme of the space, daylighting diminished to a minimum level of 2.9% due to the light exposure rate and total material absorption. In general, the design of administrative buildings should be such that daylighting performance is optimized from the design stage with the aid of Building Information Model (BIM) software to ensure proper lighting-based illumination.**

Keywords: Building Daylighting, Daylighting Performance, Daylighting Analysis, Energy Efficient and Administrative Buildings.

I. INTRODUCTION

Efforts have been made globally in reducing the running cost of buildings. Vitruvius, many years ago, defined a good building design as one that satisfies three key components namely; durability, convenience, and beauty (Wong, 2017). Daylighting falls under the boosting of the convenience and beauty of a building (Musa, 2019). In recent times, according to Edward (2021), daylighting is a critical component in lowering a building's energy demand in order to achieve Net Zero Energy Building (NZEB) status. The daylighting performance of a structure is always measured in terms of the daylight factor (DF), which is defined as the ratio of internal illumination to the total illumination available on a horizontal plane from an unobstructed overcast sky(Razon, 2017).

In a study carried out by Afolami (2018), the measures to save energy and reduce artificial lighting in administrative buildings leading to the profound definition of daylighting as the controlled emission of daylight, direct sun-ray, and diffused skylight into a building was highlighted. The study further stated various issues behind optimal daylighting in administrative buildings and how it could be resolved using architectural design measures. That study has been expounded in this research paper by going further to explain how computer simulations in modern-days apart from architectural design measures can also be used to boost the optimization of daylighting in administrative buildings. According to Atolagbe (2020), daylighting has been recognized as a cost-effective means of reducing energy use and improving visual comfort in buildings.

In a study carried out by Al-Khatatbeh and Ma'bdeh (2019), majority of the administrative buildings observed, ignore the crucial resource that nature freely provides which is daylighting to the use of artificial lighting. The study revealed that the performance of workers in such buildings was negatively impacted because artificial illumination has psychological and physiological impact on human life(Al-Khatatbeh & Ma'bdeh, 2019). Daylight emanates from the sun, and the light entering buildings is either direct sunlight or

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reflected sunlight (Larysa & Martseniuk, 2021). A bright sunny sky can produce up to 100,000 lux of illumination, yet this level of brightness can induce glare and overheating, Le-Corbusier emphasized on the value of light in architecture to be very key in building design. Building Daylighting analysis is important for the study of daylight efficiency in a building, as well as daylighting research and architectural design evaluation, which can be done with the help of computer simulation systems(Fonseca & Kruger, 2021).Babarinde and Alibaba(2018)did not only have an architectural view of daylighting, but also saw the necessity to define the role of day lighting in various aspects of structures such as visual stimuli, lighting energy savings, reduction in building energy savings, increase of operating costs and the increase in productivity among others.

Costanzo, Evola and Marletta (2017) opined that Architecture is the masterly, correct and magnificent play of volumes brought together in light. However, it is believed that the history of architecture is the history of the fight for light. All these are various differing viewpoints by researchers over the years that pointed out the importance of daylighting in modern-day building development, which necessitated this study. The aim of this study is to analyse the daylighting performance in administrative buildings in Nigeria. In achieving the aim, the objectives that guided the study are to; examine daylighting principles in selected administrative building; and analysing building daylighting exposure in key spaces of a selected administrative building.

II. METHODOLOGY

The whole study framework is depicted with the use of both qualitative and quantitative data collection methods (Iorakaa, 2018). In other words, various principles were taken into consideration from existing research studies on the parameters of how to ascertain the indicators and determinants of daylighting performance in administrative building to a simulation program was carried out to determine the result. In analysing the information gathered, descriptive analysis was used to analyse the performance of daylighting in the building. Insight360® as a data-generating tool for architects and integrated teams was used, which has centralized access to performance of data and advanced analytical engines.

Architects may approach the design process with a better grasp of the aspects that lead to better building performance outcomes throughout the building lifespan with tight integration with Revit and Insight360® immediate access to guidance and suggestions on how daylighting analysis simulations can be generated.

2.1 Study Area

Interdisciplinary research (as in the social sciences) on a specific geographic, sociocultural, or political area aiming at gaining a scientific understanding of the area as a whole and comparing it to other areas is referred to as a study area. This research was carried out at Co-Creation Hub which is located at; 294B Herbert Macaulay Way, Yaba, Lagos State, Nigeria. Latitude: 6.490. Longitude: 3.384, which is in the sub-urban setting of the large town with (population range273, 079 inhabitants) 101212 Yaba, with a land mass of about (7.5miles).

Figure 1: Shows the precise location of Co-Creation Hub
Source: (Google Map-2022)

Figure 2: Illustration of Co-Creation Hub building
Source: (Field Study, 2022)

2.2 Daylighting Simulation Analysis

The brightness (Flux) of the building per unit area calculated in REVIT, this sort of computation permits a great number of parameters to be changed to customize the study, including the sky model, illumination calculation times (day and hour), illuminance upper and lower limits, and height above the illuminance floor in the calculation plane.

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III. RESULTS

The research objective is to analyse Building daylighting exposure in key spaces of a selected administrative building. In order to archive this objective, descriptive method of analysis was used.

Figure 3: The Location of Co-Creation Hub Building
Source: (GoogleMap, 2022)

Figure 4a: Perspective View of the Modelled Co-Creation Hub Building Using Revit
Source: (Researcher's Field Work, 2022)

Figure 4b: Perspective of the Modelled Co-Creation Hub Building Using Revit
Source: (Researcher's Field Work, 2022)

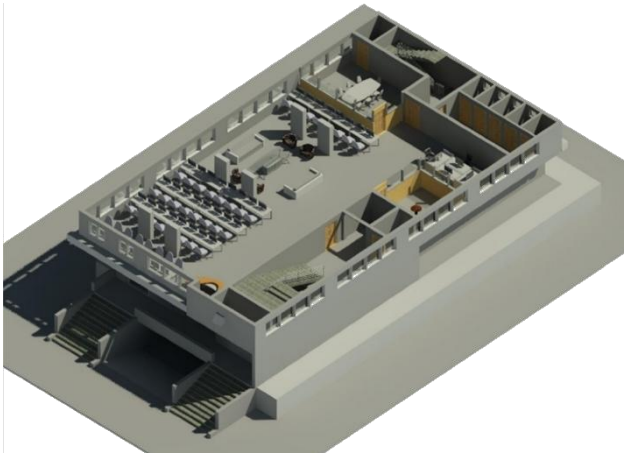

Figure 5: Sectional Perspective of Co-Creation Hub Building showing the Interior Space
Source: (Researcher's Field Work, 2022)

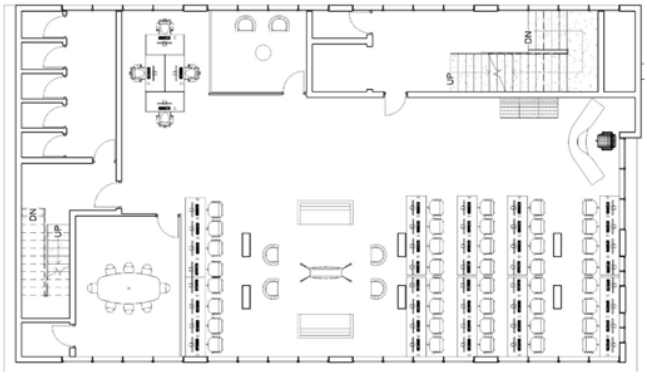

Figure 6: Floor Plan of the Co-Creation Hub Building
Source: (Researcher's Field Work- 2022)

The results of daylighting simulation of the Co-Creation Hub Building using BIM software are shown below, the spaces evaluated for this simulation were the **Workstation** and **Meeting Room**, which yielded a variety of findings;

A) Workstation

i. Maximum Daylighting: 2,248.0 lux.
ii. Average Daylighting: 952.3 lux.
iii. Minimum Daylighting: 88.4 lux.

For this case, the data were:

a) Sky model: Perez All-Weather Sky;
b) Date/Time: 6/14/2022, 1:00pm (Solar Data: GHI: 242 W/m2; DNI: 462 W/m2; DHI 71W/m2).
c) Threshold: Lower and upper: 500 and 3000 lux.
d) Analysis plane Height: 1200mm above the floor.
e) Clear sky.
f) 36% above threshold w/o shades is the recommended percentage for illuminance for this analysis.

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The results of the simulation were:

Total for **Workstation** (high, average, low).

High-2248lux multiplied by 100% divided by 3000lux = 74.9% Passing above threshold.

Average- 952.3lux multiplied by 100% divided by 3000lux = 31.7% Passing either below threshold.

Low- 88.4lux multiplied by 100% divided by 3000lux = 2.9% Passing below threshold.

Figure 5 below, depicts the area of space with maximum daylighting luminance of 74.9 % at the window area, which is most exposed to direct sun light, and decreases slightly towards the middle of the space at an average of 31.7 % due to the extent to which light reaches an interior space as well as other surfaces that bounce back and absorb light, resulting in a reduction in the high level of light, while towards the end of the space, daylighting is totally diminished to a minimum level of 2.9% due to light exposure rate and material absorption.

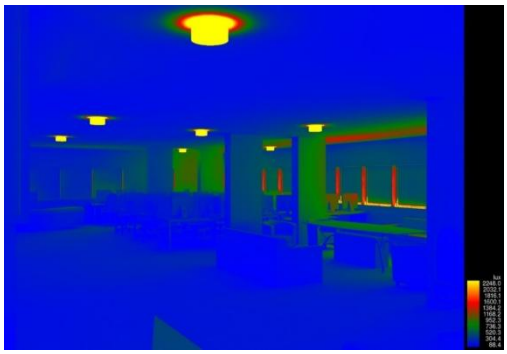

Figure 7: Illustration of Daylighting in the Workstation with Furniture
Source: (Researcher's Field Work, 2022)

Figure 6 below depicts the high degree of exposure that daylighting receives in an empty room without furniture versus a space with furniture, as well as how this affects the quality of daylighting in that space (Hirs & Mohelnikova, 2018).

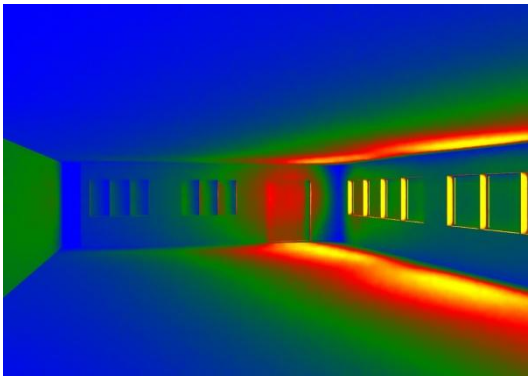

Figure 8: Illustration of Daylighting in the Workstation without Furniture
Source: (Researcher's Field Work- 2022)

B) Meeting Room

i. Maximum Daylighting: 2190.7 lux
ii. Average Daylighting: 944.0 lux
iii. Minimum Daylighting: 112.8 lux

For this case, the data were:

a) Sky model: Perez All-Weather Sky;
b) Date/Time: 6/14/2022, 1:00pm (Solar Data: GHI: 242 W/m2; DNI: 462 W/m2; DHI 71W/m2).
c) Threshold: Lower and upper: 500 and 3000 lux
d) Analysis plane Height: 1200mm above the floor
e) Clear sky.
f) 36% above threshold w/o shades is the recommended percentage for illuminance in an office building for this analysis.

The results of the simulation were:

Total for **Meeting Room** (high, average, low).

High-2190.7lux multiplied by 100% divided by 3000lux = 73.0% Passing above threshold.

Average- 944.0lux multiplied by 100% divided by 3000lux = 31.4% Passing either below threshold.

Low- 112.8lux multiplied by 100% divided by 3000lux = 3.7% Passing below threshold.

Figure 7 below shows that the area of space with maximum daylighting luminance of 73% is at the window area of the meeting room, which is most exposed to direct sun light. It decreases slightly towards the middle of the space at an average of 31.4 % due to the extent at which light reaches interior spaces as well as other surfaces that bounce back and absorb light, causing a reduction in the high level of light, while towards the far end of the space, it is at an average of 3.7%. This is due to the extent at which light travels.

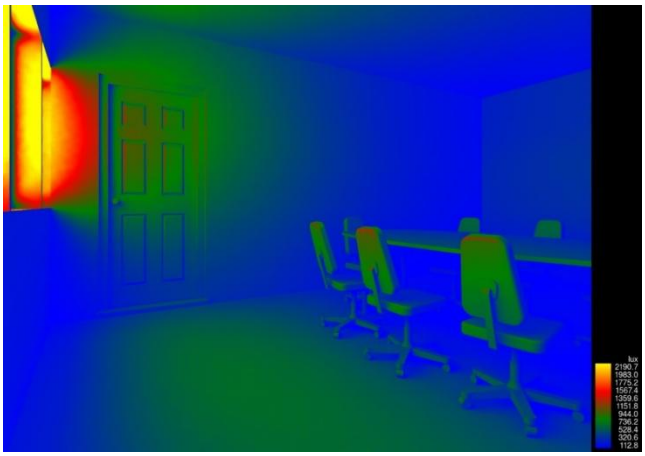

Figure 9: Illustration of Daylighting in the Meeting room with Furniture
Source: (Researcher's Field Work, 2022)

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IV. DISCUSSION

In order to achieve the required objectives as stated earlier on, the case study research design was adopted. The research instruments adopted in the study were literature review and data simulation. Descriptive analysis was used as the data analysis techniques in the study.

Firstly, the study revealed the daylighting principles in selected administrative buildings as shown in the literature review. Secondly, the study revealed that analysing building daylighting exposure in key spaces such as the work station, the maximum daylighting luminance of 74.9% is at the window area, which is most exposed to direct sun light. This decreases slightly towards the centre of the space at an average of 31.7 % due to the extent at which light penetrates a space as well as other surfaces that bounce back and absorb light. This resulted in a reduction in the high level of light, while towards the extreme of the space; daylighting is totally diminish to a minimum level of 2.9% due to the light exposure rate and material absorption.

Thirdly, the study revealed that analysing building daylighting exposure in key spaces such as the meeting room, the maximum daylighting luminance of 73% is at the window area of the meeting room, which is most exposed to direct sun light. This decreases slightly towards the centre of the space at an average of 31.4%. This is due to the extent at which light penetrates a space as well as other surfaces that bounce back and absorb light, causing a reduction in the high level of light, while towards the end of the space, it is at an average of 3.7% due to the extent at which light travels.

In general, the design of administrative buildings should be such that daylighting performance is optimized from the design stage with the aid of BIM software to ensure proper lighting-based illumination.

V. CONCLUSION

To make the best use of available daylighting, all options for enhancing daylighting system utilization must be used in conjunction with artificial lighting management systems (Costanzo, Evola, & Marletta, 2017). When daylighting levels are insufficient for the work being performed, the artificial lighting system will compensate. Finally, it could be suggested that adapting or reorganizing the Co-Creation Hub buildings in order to implement some of the given ideas could be a good way to improve environmental quality. In the case of the spaces, it will also help to give the building a regional identity and minimize the architectural "uniformity" of this typology, which is incompatible with the unique climatic circumstances as well as both visual comfort and energy efficiency goals.

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