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Post Occupancy Evaluation of Daylight Performance of Libraries Constructed Through TETFund Intervention: A Case Study of Ramat Polytechnic Maiduguri New Library

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Abstract: *The creation and design of Libraries are challenging especially the harvesting and use of natural light for reading and book storage. There is little feedback, using post-occupancy evaluation (POE), investigating Daylight Performance of Libraries Constructed through TETFund Interventions. The objective of this research focuses on the Post-Occupancy Evaluation of Architectural design elements and their possible effects on the Daylight performance of TETFund Built Library for Ramat Polytechnic Maiduguri. The brightness intensity was measured using a light meter in the absence of any artificial light at various points across the Reading rooms on June 7th,8th, and 9th 2022 from 11 a.m. to 2 pm. The Building was modeled as it is with accurate dimensions in Revit. The Model was then imported to Ecotect Software for Lighting Analysis. Calculations were done using Days A java-based add-in software for Ecotect which generates monthly and yearly average data. The data recorded indicates that the daylight received in the various lighting Zones investigated was not uniformly distributed and insufficient to provide a good illuminance level.*

Key words: *Post Occupancy Evaluation, Daylight Performance, Libraries.*

1.0 Introduction:

Post Occupancy Evaluation (POE) is known as a method of seeking feedback on the performance of an occupied building, which is ideally the most systematic evaluation process to observe the overall quality of the building (Norazman, Nashruddin, & Ani 2020). Their application has demonstrated an enormous potential not only to reduce financial and environmental costs but also to improve the quality of life, comfort, and productivity of buildings Occupants (Gary et al., 2018). POE also helps in preparing guidelines on the building's maintenance and future actions in the related building. Besides that, POE is to compare the actual building performance systematically with the current practice. (Norazman, Nashruddin, & Ani 2020).

The Federal Government of Nigeria in a bid to improve the standard of education in tertiary institutions spent large funds to erect new Libraries through TETFund Intervention. The success of library management and efficiency depends on a pleasant and beautiful environment that meets the needs and requirements of users. The creation and design of such an environment are one important objective of libraries (Hashempour, 2018). A good daylighting design will provide large amounts of glare-free light; a poor daylighting design, on the other hand, will provide either inadequate amounts of light - so that electric lighting has to be used frequently - or large amounts of light, together with glare (Boyce et al., 2003). However, there is little feedback, using post-occupancy evaluation (POE), to investigate the Daylight Performance of these Structures (Stephen, et al. 2016).

In order to understand the inherent characteristics of daylight and to use its potential benefits and attributes effectively within the design practice, a set of daylight performance metrics has been proposed (Mardaljevic et al., 2009; Reinhart, 2014; Keskin, 2019). Quantitative evaluations by means of metrics enable relative comparisons between design alternatives as well as absolute comparisons against a benchmark value (Reinhart, 2014; Keskin, 2019). Therefore this research involves the conduct of POE on the daylight performance of the Ramat Polytechnic Maiduguri New library constructed through TETFund so as to serve as a feedback mechanism.

1.2 Problem Statement/Justifications:

Library spaces for centuries have been characterized by volumes and surfaces illuminated with natural light, providing glare-free light in reading spaces (Dean, 2005). The alternative to daylighting, the use of electric power for library lighting, contributes to the strain on electric generation capacity as well as the inefficient use of nonrenewable energy resources. Daylight, which is free, provides the opportunity to greatly reduce these negative impacts created by the overdependence on electric lighting sources (Dean, 2005).

Few POEs have focused specifically on the lighting conditions of a building (Othman, 2017). Buildings are rarely studied in use to determine if the daylight design strategies implemented to achieve the intent of creating a sufficiently day-lit and visually comfortable work environment from the perspective of building occupants, or how occupant behavior affects the level of daylight availability and electrical lighting energy reduction anticipated during design (Konis, 2013)

The satisfaction of daylight for visual performance will depend on how it is delivered. Either good task performance or poor task performance can be expected depending on the amount of daylight delivered and whether glare, shadows, or reflections are produced. Poorly designed daylighting will deliv]er either inadequate amounts of light, so electric lighting has to be used (Boyce et al., 2003).

Professional organizations have set recommended standards for illumination levels in libraries these include, for example, horizontal Illuminance at tabletop height or vertical Illuminance on the spine of a book in the stacks (Dean, 2005). Visual functions parameters are used to determine whether a given lighting condition permits sight or visibility and are directly related to the physiology of the eye (IES). Good visibility is defined by an adequate quantity of light for the expected visual task and the absence of glare (SHCP, 1999). If this light energy is supplied by electric light fixtures, then there is a consumption of electric energy at a certain rate to supply a given level of light (Dean, 2005). According to Anugrah & Munawaroh, (2017), there are daylight values that have not met the standards at the point of measurement caused by several factors such as floor layout, unit configuration, materials Selection of the inner surfaces, Glazing systems, and window sizing, location, and orientation. This study seeks to investigate the Architectural design effects of these parameters on the overall daylighting performance in the newly constructed Ramat Polytechnic Library with a view to preparing guidelines to inform future design decisions.

1.3 Objectives of the Study:

The aim of this research was to assess the daylight performance of library buildings Constructed through TETFund intervention and compare it with established Standards and benchmarks so as to determine whether daylight conditions gave better visibility. The following were the objectives:

(i) To Study the Architectural Design of The New Ramat Polytechnic Maiduguri Library as it relates to orientation, building form, furnishings, and finishes;
(ii) To determine Daylight availability, variability, and distributions in the library by the use of appropriate instruments;
(iii) To Validate data obtained in (ii) above through computer simulations;
(iv) To recommend better ways of designing libraries that enhance Daylight performance.

2.0 Literature Review:

2.1 Tertiary Education Trust Fund (TETFund)

The Tertiary Education Trust Fund (TETFUND) was established by an Act of the National Assembly in June 2011 which replaced the Education Tax Fund Act Cap. E4 laws of the Federation of Nigeria 2004 and Education Tax Fund (Amendment) Act No 17, 2003. The Fund was set up to administer and disburse education tax collections to the Federal and State tertiary educational institutions in Nigeria (TETFUND, 2014).The Fund’s intervention includes the provision of essential physical infrastructure for teaching and learning, provision of Instructional materials and equipment, research, book development and publication, academic staff training and development, and any other need, which in the opinion of the Board of Trustees is critical and essential for the improvement of quality and maintenance of standards in the educational institutions (TETFund, 2014).

2.2 Post Occupancy Evaluation (POE)

Norazman, Nashruddin, & Ani (2020) Defined Post Occupancy Evaluation (POE) of a building as a process of systematic assessment of the extent to which the occupied buildings meet the needs of the users. It measures the effectiveness of the design, construction, communication, and design occupancy (Norazman, Nashruddin, & Ani 2020). Cranz, et al (2021) also defined Post Occupancy Evaluation (POE) as a research method that examines how buildings function and contributes both to improvements in the building being studied and to general knowledge about how to improve buildings. Post-occupancy evaluations (POE's) of completed buildings provides feedback on the end-quality of a design to the building industry which can assess if the project brief was met and allow researchers to generate knowledge of occupant well-being based on actual user experiences. This can well lead to new recommendations to inform future designs of buildings (Oseland, 2007). Feedback from users of newly constructed buildings provides indications of success and failures in the buildings (Othman, 2017). The evaluation could address any single facet of a built environment such as acoustics, thermal comfort, or lighting, or it could address all of them at the same time (Othman, 2017).

Buildings are rarely studied in use to determine if the daylight design strategies implemented to achieve the intent of creating a sufficiently daylit and visually comfortable work environment from the perspective of building occupants, or how occupant behaviour affects the level of daylight availability and electrical lighting energy reduction anticipated during design (Konis 2013). Othman, (2017) Conducted POE at The School of Environmental Studies Modibbo Adama University of Technology. It was geared towards understanding the needs and preferences of occupants regarding window size, shape and position, view angle, daylight, and lighting conditions. Konis (2013) comprehensively assessed the outcomes of the retrofitted elevation of an open-plan office building in terms of daylighting quality (Konis, 2013). Hiring et al. carried out a series of studies that correlated the results of POE studies with luminance maps in open-plan offices to generate a new glare index, Unified Glare Probability (UPG) (Hirning et al. 2014, Hirning *et al.* 2017). There however seems to be a gap or lacking literature as it concerns POE studies of TETFund built Libraries in Nigerian tertiary institutions.

2.3 Illuminance and Illuminance level (lux)

Illuminance is the measure of the amount of light received on a surface. It is typically expressed in lux (lm/m^2). Illuminance levels can be measured with a lux meter or predicted through the use of computer simulations with recognised and validated software Velux (2014). The illuminance and its distribution on the task area and its surrounding area have a great impact on how quickly, safely, and comfortably a person perceives and carries out a visual task (CIBSE, 1994).

Several different illuminance recommendations for tasks are available, depending on the types of buildings and rooms. The Cost-Effective Open-Plan Environment field study, conducted by the Institute for Research Construction (National Research Council, Canada) recorded that illuminance larger than or equal to150lx are classified as appreciable daylight (Reinhart, 2010). Furthermore, the IESNA recommends 50–100lx, provided directly onto the individual task area, as the general range of illuminance required for working with CRT screens in laboratory areas (IESNA 2000). In addition, the Canadian Labour Code states that for task positions in offices where ‘‘continuous reading or writing is performed,’’ the minimum illuminance shall not be less than 500lx (approximately 50 footcandles). Moreover, people have been observed to tolerate much lower illuminance levels of daylight than artificial light, particularly in diminishing daylight conditions at the end of the day. It is not unusual for people to continue reading a newspaper at levels as low as 50lx, which is at least five times lower than the recommended artificial lighting levels for reading (Baker, 2000).

2.4 Daylight performance metrics

In order to predict or understand the daylight performance of room space and set a scale for building designers to use when comparing aspects of various daylighting schemes, a set of daylight performance metrics have been proposed (Mardaljevic et al., 2009; Reinhart, 2014, Keskin, 2019) such as Daylight Autonomy (DA), Useful Daylight Illuminance (UDI) and daylight factor (DF). Quantitative evaluations by means of metrics enable relative comparisons between design alternatives as well as absolute comparisons against a benchmark value (Reinhart, 2014).

Daylight performance metrics are typically assessed for either a single sky condition (static) or a series of consecutive sky conditions (dynamic) (Keskin, 2019). Daylight factor and illuminance distributions are static daylighting metrics, i.e. they are based on a single sky condition. Dynamic or climate-based metrics are based on all sky conditions that occur in a year at a given building site (Petinelli & Reinhart 2006). Another important point is that the dynamic daylight performance metrics are generally supposed to be measures for buildings with respect to their energy efficiency (Reinhart & Walkenhorst 2006) The average daylight factor, on the other hand, can be considered as a good indicator of the appearance of a room (Tregenza & Wilson 2011). The metrics are critical for designers to be able to balance these criteria, and make informed trade-offs among them (Reinhart & Walkenhorst 2006).

2.5 Daylight Autonomy

It was proposed as the occupied time of a space during which the minimum illuminance prescribed by regulation is achieved (Reinhart & Walkenhorst, 2001). The new European standard, EN-17037 Daylight in Buildings, brings a requirement of 50% of daylight hours during the year, with daylight provision of a minimum of 300 lx for 50% of the area and 100 lx for 95%

of the area (Mardaljevic et al., 2013). Daylight provision refers to the level of illuminance achieved across a fraction of a reference plane for a fraction of daylight hours. Daylight hours in this standard refers to the time from sunrise to sunset. This means at least six hours of 300 lx of daylight on average throughout the year, which occurs between 7 AM and 5 PM (the occupancy period of a typical office space) (Obradovic & Matusiak 2020). Considering the dynamic variations of sky brightness distribution throughout the year, DA can more accurately evaluate the natural lighting quality of office space during the year (Li, Li & Chen 2020). Based on these legal requirements, the daylight autonomy distribution at a workplace is defined as the percentage the occupied times per year when the average desktop illuminance is above 500lx (CLC 1991).

2.5.1 Continuous Daylight autonomy (DAcon)

In 2006, Rogers extended the DA and introduced the DAcon (Rogers, 2006). DAcon represents the percentage of the floor area that exceeds 300 lux for at least 50% of the time giving partial credit below 300 lux. For example, if an interior grid point has 150 lux in a given time due to daylight, DA300 would give it 0 point whereas DAcon300 would give it 150/300=0.5 point. This daylight metric would be useful for estimating the energy savings for dimming or multi-level switching controls (Burmaka, et al. 2020).

2.5.2 Maximum Daylight autonomy (DAmax)

The DAmax was introduced by Rogers in 2006, to consider discomfort risks depending on excessive light levels (Rogers, 2006). The DAmax can be defined as the annual percentage of time during which a maximum illuminance level is trespassed, which may lead to visual discomfort. Percentage of floor space where the light level exceeds 10 times the required light level (5000 lux) for 5% of work hours (Li, Li & Chen 2020). This metric is an indicator of quality related to all types of glare – such as direct sun, reflected sun, high ambient brightness, and overly bright sky. DAmax indicates that the benefits of daylight autonomy are not overshadowed by glare conditions that decrease comfort and performance. (Li, Li & Chen 2020).

2.6 Useful daylight illuminance

Nabil and Mardaljevic (2005 and 2006) proposed the UDI, which is defined as the illuminances at the workplane within the range of 100lux - 2000lux. For each point in the room, there is a set of three metrics: the percentage of time that a point was less than the minimum threshold (<100 lux), which may not be any useful assistance in the perception of the visual environment or performance of visual tasks; more than the maximum threshold (>2000 lux), which may produce visual or thermal discomfort; between the bounds of minimum and maximum (100-2000 lux), which is called useful daylight illuminance (UDI) (Nabil and Mardaljevic, 2006). UDI can reflect the natural lighting distribution in different illuminance intervals, because it can independently evaluate the natural lighting conditions above 2000lx, and can be used to predict the glare conditions in office space (Li, Li & Chen 2020). The EN17037 (2018) standard states that at least 50% of an area should be illuminated for at least 50% of the time, and therefore the aim was to simultaneously maximize the time and the area.

IEA SHC Task 50 (2016) categorized illuminance less than 100 lx, as UDI fell-short (UDI-s); illuminance greater than 100 lx and less than 300/500 lx as UDI supplementary (UDI-s); illuminance greater than 300/500 lx and less than 2000/2500 lx as UDI autonomous (UDI-a); illuminance greater than 2000/2500 lx, as UDI exceeded (UDI-e).

2.8 Daylight factor

Daylight Factor Approach (DFA) is the most commonly accepted daylight performance metric, though it provides the worst daylighting condition (Hopkinson et al., 1966) under the traditional overcast sky. Such DFA is not flexible enough to predict the dynamic variations in daylight illuminance when the sun's location varies and the sky condition becomes non-overcast (Littlefair, 1989).

Lately, DF calculations have been extended under all sky conditions ared is no longer static and it can take into account the building directions, solar positions and the effects of direct and reflected sunlight (Li, Li & Chen 2020). In Comparison with DA and UDI, the main advantage of DFA is that DFs are strongly correlated with the room parameters, particularly the window area, the visual transmittance and building orientation. It could be easily to change the room parameters (i.e. t and W) to meet the DF criteria. In addition, DFs can be obtained based on simple design tools such as chart, diagrams and simple formula. (Li, Li & Chen 2020).

2.9 Illumination Levels in Libraries

It is concerned with the distribution of the brightness of surfaces, not just the task or object of interest, but also the surrounding surfaces, the views of which contribute to a person's overall perception of the space and satisfaction with it (Baker & Steemers, 2002). For daylighting design, it is necessary to provide the required quantity of light to perform different visual tasks recommended by standards. According to British Standard Light and Lighting (2011), minimum illuminance of 300 lux should be available in general spaces in libraries. For more intensive visual tasks like reading and writing, 500 lux should be provided. Moreover, 200 lux should be maintained vertically on the bookcases in the library.

3.0 Research Methodology:

3.1 Study Area

The Study Area is Ramat Polytechnic, Maiduguri Borno State Nigeria. It lies along Maiduguri-Jos Road, Opposite the Government Women Secondary school, Board of Internal Revenue and

Police College Maiduguri. It is located between Metro Police Barrack and Government College Maiduguri. The Case Study Building is the Ramat Polytechnic Maiduguri New Library which was constructed in 2015 through TETFund Interventions and Put to use in 2019. The Building is located between Latitude 11 50’ 18.20”N and Longitude 13 7’ 55.20” E.

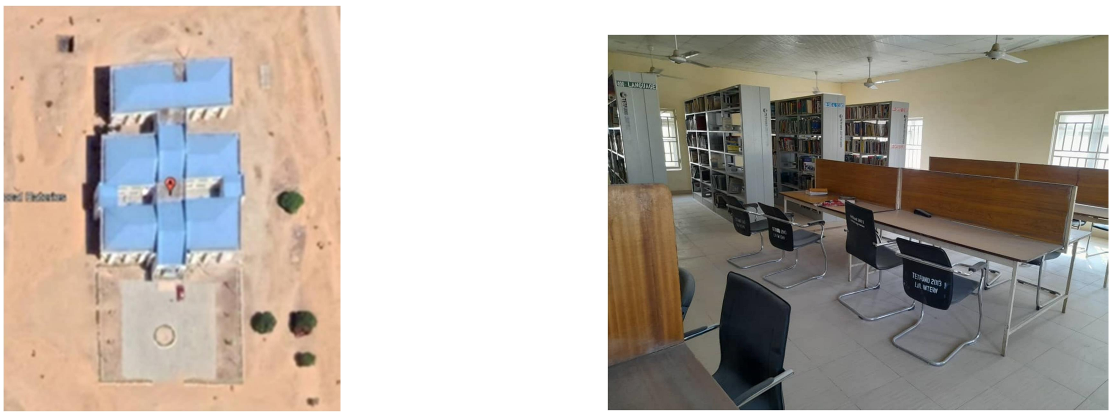


Figure 1: (a) Goggle Map showing the New Library; (b). One of the Reading Room Source: Authors’ Field survey

Figure 2: Front View of the New Library. Source: Authors’ Field survey

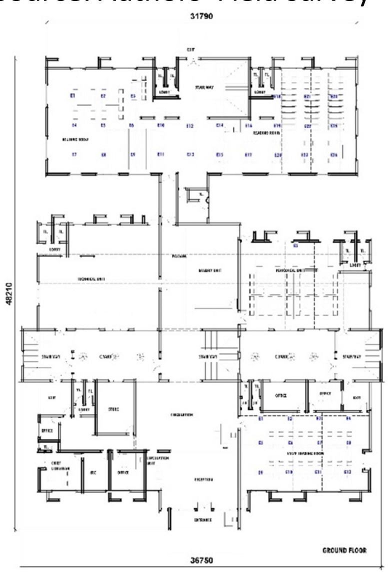
3.2 Physical Measurements of the New Library

The interiors and exteriors of the library spaces were measured in line with Quek & Jakubiec (2019). This acts as a geometric reference for the precise construction of a 3D surface model so as to approximate the interior layout including dimensions and positions of furniture. A Laser distance meter was used for measuring distances while a Sunche HS1010A light meter was used for taking illuminance levels of the various lighting zones as shown in Figure 3. Figure 4 and Table 1 shows the Layout and Descriptions of the various Lighting Zones.

(a)


(b)

Figure 3: (a) Laser distance meter; (b) Sunche HS1010A light meter
Source: Authors' Field survey

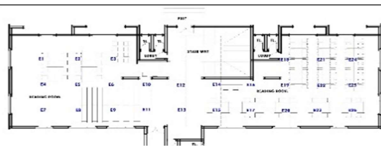
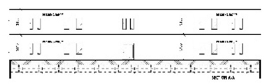
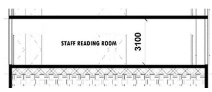
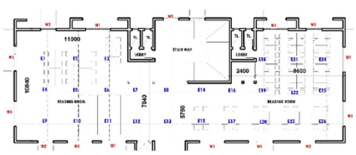
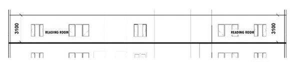
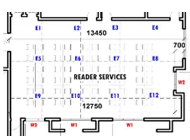
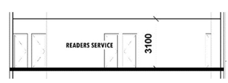


(a)

(b)

Figure. 4: (a) Ground Floor Plan of the library; (b) Upper Floor Plan of the library Source: Authors' Field survey

Table 1: *Layout and Descriptions of the Lighting Zones.*

Name of Lighting Zone	Layout	Section	Remark
Ground Floor Reading Room			The East and West walls each has two windows while the North and South Walls each has six windows. The North Wall also has a Glass Door on Aluminum Frame. The total area of the windows is 47.4 m². Sizes of windows are 1.5 x 2.4m for W1 and 1.5x 1.5 for W2
Staff Reading Room			East walls has one window while the South Wall has three windows. The West and North walls are shared with other covered Spaces. The total area of the windows is 11.7 m². The West wall is a covered passage. Sizes of windows are 1.5 x 2.4m for W1 and 1.5x 1.5 for W2
First Floor Reading Room			The East and West walls each has two windows while the North and South Walls each has six windows. The North Wall also has a Glass Door on Aluminum Frame. The total area of the windows is 47.4 m². Sizes of windows are 1.5 x 2.4m for W1 and 1.5x 1.5 for W2
Readers Service			The East wall has one window while the South Wall has three windows. The West and North walls are shared with other covered Spaces. The total area of the windows is 22.5 m². The sizes of windows are 1.5 x 2.4m for W1 and 1.5x 1.5 for W2.

3.3 Validation study

The brightness intensity was measured using a Sunche HS1010A light meter in absence of any artificial light at 29 points and 12 points across the Ground Floor Reading room and Staff Reading Room respectively, on June 7^{th},8^{th} and 9^{th} 2022 at 11 a.m. to 2 pm. The same Measurements were done across the First floor reading room and reader service at 29 points and 12 points respectively. After that, the real model was simulated in Ecotext software. In the measurement and modeling stages, efforts were made to keep the model free of any factor that might introduce error into the final results. The measured data were compared to the simulation results, as shown in Table 2. The results indicated similar trends of behaviours in both the measured data and the simulation results with only minor differences between the corresponding values. This validates the simulation results in this paper.

Table 2: *Comparison of the measured data with the simulation results*

Space	Measured Values	Simulation Values
Ground Floor Reading Room	327	600.24
Staff Reading Room	93.78	381.76
First Floor Reading Room	125.51	781.12
Reader Service	97.47	643.07

3.4 Simulation study

Parameters considered for simulating the Lighting Zones is presented in Table 3

Table 3: *Parameters considered for simulating the Lighting Zones*

Spaces	Location	Floor		Window					Material and Surface Reflectance				
		Width	Length	Area	Sill Height	No	Orientation	WWR	Floor	Wall	Ceiling	Window	Furniture
Ground Floor Reading Room	Ground	29.0	10.9	47.2	0.8	15	North /South/East /West	60	Grey	Off- White	White	Tinted Blue Glass White Aluminum Frame	Brown Tables Black Chairs Ash Book stacks
Staff Reading Room	Ground	13.2	7.9	11.7	0.8	4	South /East	34	Grey	Off- White	White	Tinted Blue Glass White Aluminum Frame	Brown Tables Black Chairs Ash Book stacks
First Floor Reading Room	First	29.0	10.9	47.2	0.8	15	North /South/East /West	60	Grey	Off- White	White	Tinted Blue Glass White Aluminum Frame	Brown Tables Black Chairs Ash Book stacks
Readers Service	First	13.2	7.9	15.3	0.8	5	South /East	44	Grey	Off- White	White	Tinted Blue Glass White Aluminum Frame	Brown Tables Black Chairs Ash Book stacks

3.4.1 Simulation Assumptions

ii Site Description: The investigated building is located in Maiduguri Intl (11.90 N/ 13.10 E).
ii User Description: The zone is occupied Monday through Friday from 8:00 to 20:00. The occupant leaves the office three times during the day (30 minutes in the morning, 1 hour at midday, and 30 minutes in the afternoon). The total annual hours of occupancy at the work place are 2625.0.The occupant performs a task that requires a minimum illuminance level of 500 lux.
iii Lighting and Blind Control: The office has no dynamic shading device system installed.
iv Radiance Simulation Parameters
The rendering parameters imported by Radiance in Daysim are listed in Table 4.

Table 4

Radiance Simulation Parameters

Ambient bounces	Ambient divisions	Ambient supersamples	Ambient resolution	Ambient accuracy	Limit reflection	Specular jitter	Direct jitter
5	1000	20	300	0.1	6	1.0000	0.0000

3.4.2 SIMULATION PROCEDURE

1. The Building was modeled as it is with accurate dimensions in Revit. Then analytical model was generated as shown in Figure 5 through the use of room, which include four zones to be simulated, namely:

i. Zone 1 Ground Floor Reading Room
ii. Zone 2 Staff Reading Room
iii. Zone 3 First floor Reading Room
iv. Zone 4 Reader Services

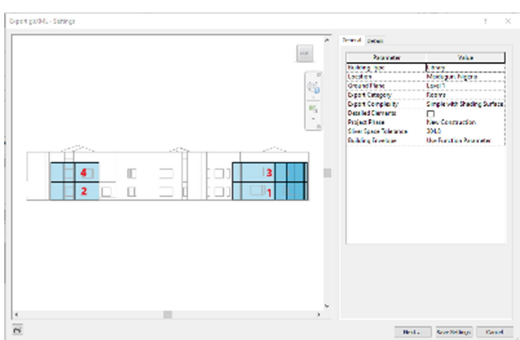


Figure 5:The four zones simulated

2. The Model was exported to green Building Format (GBXML) for further analysis and simulation with suited parameters such as Building Typology, Shading Type. Location etc.

3. The Building was imported Into Ecotect Software for Lighting Analysis and Calculations as shown in figure 6.

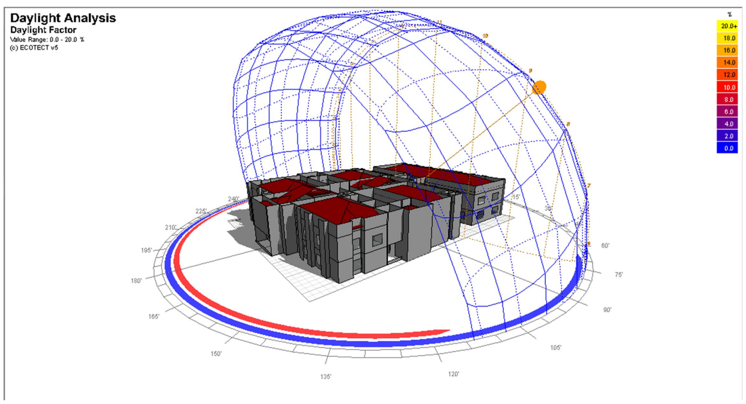


Figure 6: The 3D view of the Building imported into Ecotect Software

4. The location and the weather files were changed to get accurate weather data suiting the project (Maiduguri weather files/Clear Sky was used)

5. Materials for Floor Ceiling walls and windows were adjusted according to the building materials

6. The analysis grid was set up to perform the first round of calculations and adjusted desk height (750mm) to get pa roper reading at that level.

7. Artificial light was turned off and the mage output scale and size were adjusted.

8. With this data, illuminance Levels and Daylight factors were calculated in Radiance an add-in app for Ecotect used to get better and more efficient results.

9. 2D Grid point data and Rendered images with lux values and averages are generated as shown in Table 5

10. The process was repeated for the remaining zones 2-4

11. Daylight Autonomy and UDI were calculated using Daysim. A java-based add-in software for Ecotect which generates Monthly and yearly averages for lighting calculations.

Table 5: *Analysis of Simulation Results*

Lighting Zone	Daylight Factor (DF)	Daylight Autonomy (DA) (%)		Useful Daylight Index (UDI) (%)		
	DF 2% or higher	DAcon Above 40%	DAmax Above 5%.	UDI<100	UDI 100-2000	UDI>2000
Ground Floor Reading Room	45%	73%	20%	100%	0%	0%
Staff Reading Room	23%	79%	9%	49%	0%	51%
First Floor Reading Room	66%	93%	60%	28%	0%	72%
Reader Service	47%	90%	0%	100%	0%	0%

4.1 Results from the Physical measurements

The result from the Physical measurements (Table 4) shows Average illuminance values between 93.78 lux and 327 lux. The data recorded indicates that the daylight received in the various lighting Zones investigated was not uniformly distributed and insufficient to provide a good illuminance level.

4.2 Simulation Results for the Lighting Zones

The result from the simulation (Table 8) shows the following:

1. Daylight Factor (DF) Analysis for the Ground Floor Reading Room, Staff Reading Room, First Floor Reading Room and Reader Service indicates 45%, 23%, 66% and 47% respectively of illuminance sensors have a daylight factor of 2% or higher. If the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zones would not qualify for the LEED-NC 2.1 daylighting credit 8.1 as the area ratio of sensors with a daylight factor over 2% would need to be 75% or higher (www.usgbc.org/LEED/).

2. Useful Daylight Index (UDI) Analysis the Ground floor reading room and Reader Service are: UDI<100=100% while for the Staff Reading room and First floor reading room are 49% and 28% respectively. According to Nabil and Mardaljevic, (2006) and EN17037 (2018) the UDI fell-short, that is the percentage of time that a point was less than the minimum threshold (<100 lux), which may not be any useful assistance in the perception of the visual environment or performance of visual tasks. However other Useful Daylight Indices (UDI) for the Staff Reading room and First floor reading room 51% shows and 72% experience UDI>2000 which may result to glare problem assistance in the visual environment or performance of visual tasks therefore UDI is exceeded (IEA SHC Task 50, 2016).

3. All illuminance sensors for the Ground Floor Reading Room, Staff Reading Room, First Floor Reading Room and Reader Service respectively indicates 73%, 79%, 93% and 90% of DAcon above 40%.
4. All illuminance sensors for the Ground Floor Reading Room, Staff Reading Room and First Floor Reading Room respectively indicates 20%, 9% and 60% of DAmax above 5%. DAmax represents Percentage of floor space where the light level exceeds 10 times the required light level (5000 lux) for 5% of work hours.

Conclusion

What is therefore evident from yearly simulations of the existing scenario is that:
1 The availability and Distribution of Daylight, was poor;
2 Glare issues may occur near the windows.
3 Therefore efforts should be geared towards improving the useful indices of the investigated areas by way of retrofitting. This may include placement of additional daylight apertures, use of brighter finishing materials and furniture.

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