ATBU, Bauchi Proceedings

The Academic Conference of Harvard Research and Publications International on 21st Century challenges and opportunities: Multidisciplinary Approach Vol. 21, No. 1 on 31st October, 2022– Abubakar Tafawa Balewa University, ATBU, Bauchi, Bauchi State, Nigeria, West-Africa

EVALUATION OF DAY LIGHTING LEVEL IN THE DESIGN OF LIBRARY AT IBRAHIM BADAMASI BABANGIDA UNIVERSITY LAPIA, NIGER STATE, NIGERIA

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Abstract

The various effects of daylighting in coordination with the visual comfort of users and their general health in building environments generally cannot be overemphasized, In recent times there are growing concerns about building academic libraries with sustainability in view to enable and help aid visual comfort and the overall health of its occupants in the various academic libraries in higher tertiary institutions. Thus academic libraries serves as an important part in the overall essence of higher institution learning because its connects students and researchers to higher knowledge and information, which made libraries one of the most used buildings in the covid and post covid -19 era. The post covid-19 era led men to in-depth research which may help in reducing the risk of transmission or even help prevent the spread of the virus, but also improve air quality and lower energy requirements through the use of sustainable building materials. The various use of daylighting as a controlled architectural tool on users preference, perceptions, satisfaction and behavior in university libraries was examined in this study, Passive strategies were employed through consideration of the sun orientation, Climate citing, window placement and also focusing on healthy building environment with sustainable design in terms of indoor and daylighting strategies The methodology employed in this paper includes both qualitative and

descriptive research methods. Then, the various outcomes were obtained based on these standards and methods used. This research filled the gap in the literature on healthy built environments with sustainable design strategy regarding building performance. This paper intends to combine sustainable strategies especially daylighting based on thermal quality and indoor environment quality to achieve a healthy built environment for its users.

Keywords: Sustainability, Built environment, Day lighting, indoor quality.

INTRODUCTION

The UNESCO (2015), defines library as "any structured assembly of printed books and periodical or graphic or audio- visual materials with a workers to provide and handle the use of such materials as are required to meet the informational research, educational, recreational needs of its users". Libraries offer services and products that level the intellectual playing field. That means that they allow people to access high-quality information, to use computers, or to borrow what they want. Daylighting is used by occupants and building users to enhance comfort and general living condition in the building, Achieving optimum daylighting in institutional library is very important aspect of design not only for economy but for sustainability as well as improved thermal and visual comfort of the library users for maximum efficiency and productivity. The main aim in lighting design in buildings such as libraries is to allow the users of the space to carry out their work quickly and accurately, without discomfort. When designing such scenario it is necessary to identify all of the functions that lighting is expected to fulfil. Improved lighting quality. According to the study carried out by Public Works And Government Services Canada (PWGSC) reveals that Lighting quality refers to visual performance, visual comfort and ease of seeing. Daylight is a full spectrum source of visible light. That is, it imparts the same spectral distribution as sunlight (i.e. the same mix of colours and types of light). Unlike electric Lights, which sometimes provide a limited spectral range that is concentrated in the blue/green or yellow/green range, daylight is best suited to human vision. Daylight can also provide any illumination level through proper design. These inherent characteristics of daylight contribute to improved lighting quality by enhancing colour discrimination and rendering, Better occupant comfort and health. Another aspect of daylight is its variability throughout the day, leading to peaked visual interest. The eyes adapt easily to gradual illumination changes, changes not easily attainable with artificial light.

Research has suggested a positive biological response to daylight variability. A properly designed office incorporating daylighting measures can provide a bright or soft mood created by the intrinsic colour and intensity of the light. Reduced light levels over the winter are the cause of major mood swings. This lack of Light can lead to Seasonal Affective Disorder (SAD) in which people experience depression, fatigue, hypersomnia and over eating. These problems can sometimes be resolved by exposure to longer periods of bright light. Lack of light also affects the secretion of the hormone melatonin by the pineal gland. Upsetting the rate of melatonin secretion can affect sleep, body temperature and promote tumour development [Rusak et al, 1995].

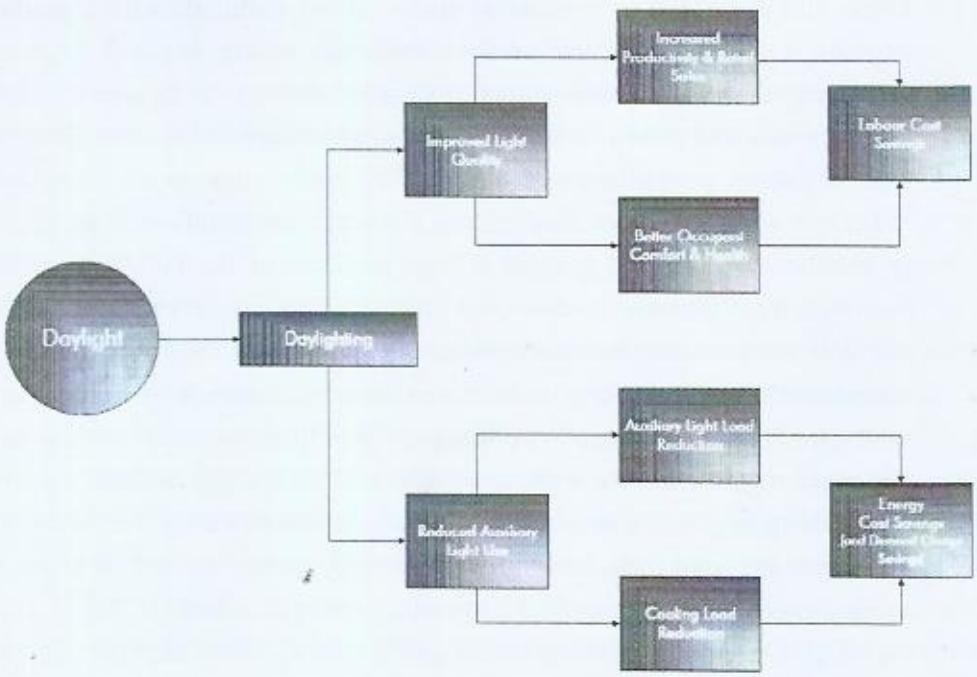

Fig 1. Image showing the benefits of Daylighting in building
Source: Daylighting Guides for Canadian Commercial Buildings, 2002

LITERATURE REVIEW

Phillips (2013) opined that the use of natural daylight began when natural light (solar radiation) entered the early man's cave through various openings. He explains further that the cause of latest trend and the interest in optimum daylight design was due to the high cost of fossil fuels as well as the realization that sources of electricity had a finite life and that daylight related more too human spirit and

an enhanced quality of life. According to the US Department of Energy (DOE 2006), lighting is a substantial energy consumer and a major component of the services cost in many buildings. Increasing energy efficiency can bring opportunities to limit the rate of increase electricity consumption, to reduce the need for capital intensive supply systems and to mitigate climate change.

Dickson (2014), also opined that up to the middle twentieth (20th) century almost all schools and workplaces used daylight as the main source of lighting, the advent of cheaper energy and the introduction of fluorescent lights in the 1950's and 1960's made daylight as an illumination source almost irrelevant. Daylighting design is therefore an energy efficiency measure in building design that offers best quality performance of the occupant or users of a space as well as reduction in energy consumption coupled with the cost of running the building. Stern (2006), highlighted that the energy efficiency measures for buildings are approaches through which the energy consumption of a building can be reduced while maintaining or improving the level of comfort in the building. Thus, day lighting design aimed at, reducing energy consumption for lighting in building, reducing electricity consumption of office equipment and appliances and also improved efficiency and quality of works environments

PRINCIPLE OF OPTIMUM DAYLIGHTING

Ander (2012) defined daylighting as the controlled admission of natural light, direct sunlight and diffused skylight into a built structure for the purpose of reducing the electricity consumption and saving energy. Daylight is a full spectrum source of light to which human vision is naturally adapted and studies have shown that proper harnessing of daylighting in building can increase productivity, decrease sick time and increase sales (Adaji 2015). According to (Sandanasamy *et al.*, 2013), design of daylighting in buildings (libraries) will be influenced by the climate, geographic location characteristics, building type and client requirements. Sandanasamy *et al.*, (2013), also suggested the following guidelines in designing a building with optimum daylight penetration, Avoiding direct penetration sunlight and skylight unless needed for thermal comfort, Bouncing of daylight to create indirect daylight, filtering of daylight into buildings using of sustainable design principles such as the use of renewable energy source (sun, wind or water) minimization of the use of artificial light (electric lighting) consideration of appropriate land use of locally available and

renewable building materials, Maximizing ceiling height to gain better light distribution determining whether daylight is primary or supplementary in lighting design proper planning of building geometry and interior spaces. Bennett (2008), opined that the principles behind daylighting make use of the luminance (amount of light intensity) distribution from the sun, surrounding sky, buildings and clouds. The principles of optimum daylighting design are therefore dependent on the availability of natural daylight which is a factor of building site/ location and the immediate site condition in the building surroundings. for instance availability of obstructions. Principles of daylighting also depends or are influenced by climatic condition which involves the identification and assessment of seasonal and prevailing climatic conditions, most importantly ambient temperature and sunshine intensity. Summarily, according to Lechner (2001), daylighting principles depend on the availability of natural light (based on the latitude of the building site and surrounding condition of the building),Climate, Orientation of buildings The availability of natural light is determined by luminance levels and patterns of the sky condition or overcast. Peter (2010), explained that the overcast skies produce evenly diffuse light over the sky dome. Light coming from overhead is three times brighter in overcast skies than light coming from the horizon. This is because the cloud density is thinnest directly above in zenith and gets denser as the cloud compacts towards the horizon. When ignoring the direct sun rays, the overcast sky is actually brighter than a clear sky because of the amount of reflected light off the cloud. According to brown (2001), the illumination from an overcast sky is therefore fairly constant throughout the day and is strongest in its zenith. Although, Lechner (2001) noted that due to the sun's strong rays, the amount of illumination varies depending on the position of the sun in the sky and for better daylighting design the use of side lighting techniques that emphasizes the vertical light for clear sky conditions and top lighting techniques which take advantages of the horizontal lighting for the overcast is most preferred.

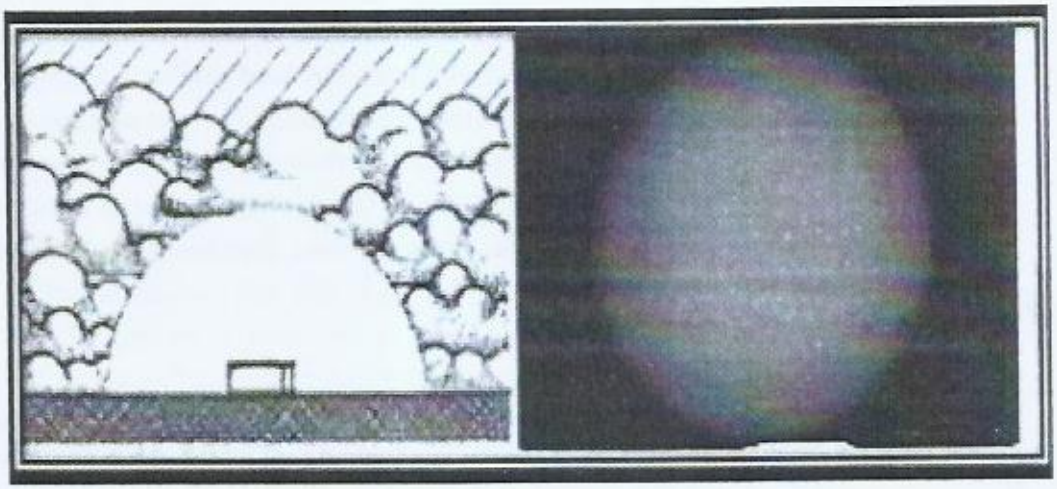

Fig 3. Showing Overcast Sky Conditions
Source: Brown (2001)

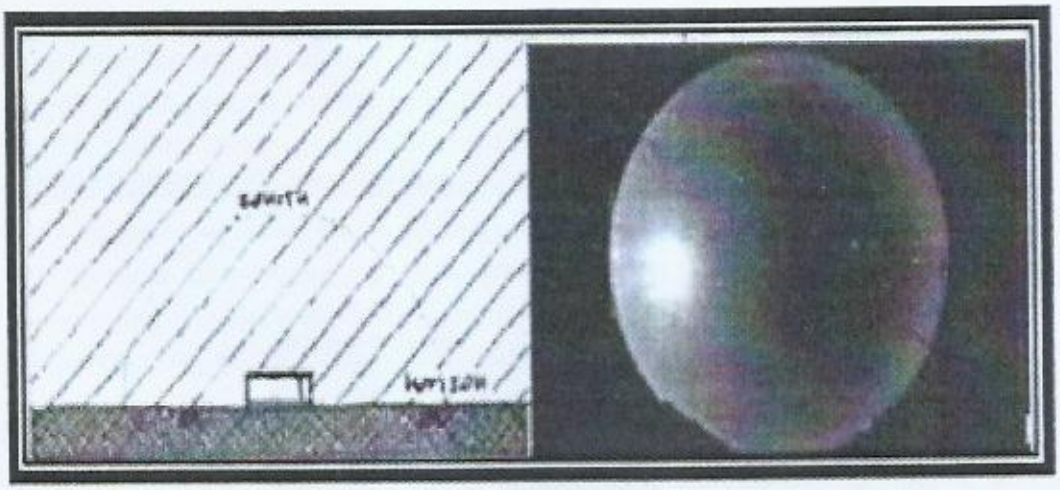

Fig 3. Showing Clear Sky Conditions
Source: Brown (2001)

DAYLIGHT FACTOR

The daylight factor is a measure of natural daylight efficiency in a space. It quantifies the amount of light in a given point in a space relative to the simultaneous amount of daylight available outside the space. A daylight factor of 2 percent means that the indoor light is 2 percent of the available outside daylight. That is, if the outside daylight is 9000 lx, the indoor daylight would be 180 lx. Therefore, a daylight factor of 1 percent will provide a low level of light while a daylight factor of 2 percent will be an average daylight space. A daylight factor of

5 percent will be perceived as a bright daylit space. This is a simple method use in daylighting calculation. Studies have shown that daylight illumination can vary from 5000 lx in a heavily overcast sky to over 40,000 lx in direct sunlight. But this is much greater than what is required for indoor daylighting. Typical indoor illumination requirements are less than 500 lx for workplaces and other areas such as mosques and churches require more lighting depending on the size and function. (Edward M. Dean, AIA. 2004.)

BUILDING ORIENTATION

In order to maximize and optimally make use of daylighting benefits, buildings can be positioned and located to take the best possible advantages of sun's path throughout the day, as well as seasonal variations. Generically speaking, buildings that have their long axes running east and west have better daylighting potential. This creates the issue of having half of the building units facing north and the other half facing south. However, the diffuse light of northern exposure still provides more than enough luminance to serve the interior lighting needs. A good design strategy to tackle the building orientation is to design the windows and other aperture to admit or excludes solar energy based on their orientation. It has been established that south-facing windows should admit winter solar and the east and westfacing windows should exclude low angle daylight. Overhangs and fins may be used to prevent glare and overheating. Another important strategy that complements orientation is to provide shallower spaces on the north side and deeper spaces on the south side to accommodate the varying depths of daylight penetration.

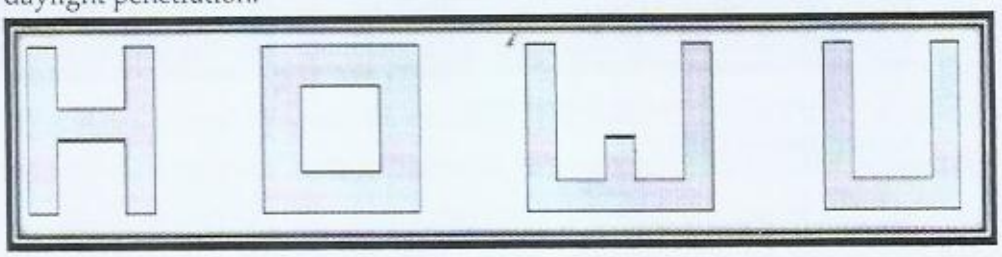

Figure 4: Examples of Building Footprints with High Daylight Access.
Source: Day lighting design guide for Canadian commercial buildings, 2002.

SKYLIGHTS AND SOLAR TUBES

Skylights and solar tubes can provide daylight through the roof into the interior spaces below. Skylights often allow heat in during the sunny day and can cause glare in the interior. The use of diffusing glazing can be used to minimize or

eliminate the problem associated with skylight. It is an established fact that daylight from above can have sculptural effects but adequate steps / control must be put to optimize visual effect as well as glare control in the interior. A typical example of sculptural effect of daylight strategy was observed in Le Corbusier's chapel Notre Dame Du Haut in Ron Champ, France.

Solar tubes daylighting systems bring natural light indoors by capturing light from the roof top and efficiently transferring it down a reflective tube into the interior spaces. A dome on the roof channels the light to interior spaces by refracting, reflecting and concentrating solar light into small tube using mirrors and lenses. The tubing perfectly fits between the roof members and it is installed without any structural deficiencies in the roof design. At the ceiling level, a diffuser that resembles a recessed light fixture spreads the light evenly in the interior space. The solar tubes are capable of bringing daylight into interior spaces without the associated heat gain and glare problems of skylights. Solar tubes can save energy by replacing electric lights for daytime light in rooms that do not have windows. Energy savings can be lost however if the tube is not air sealed and insulated (Dickson, 2014).

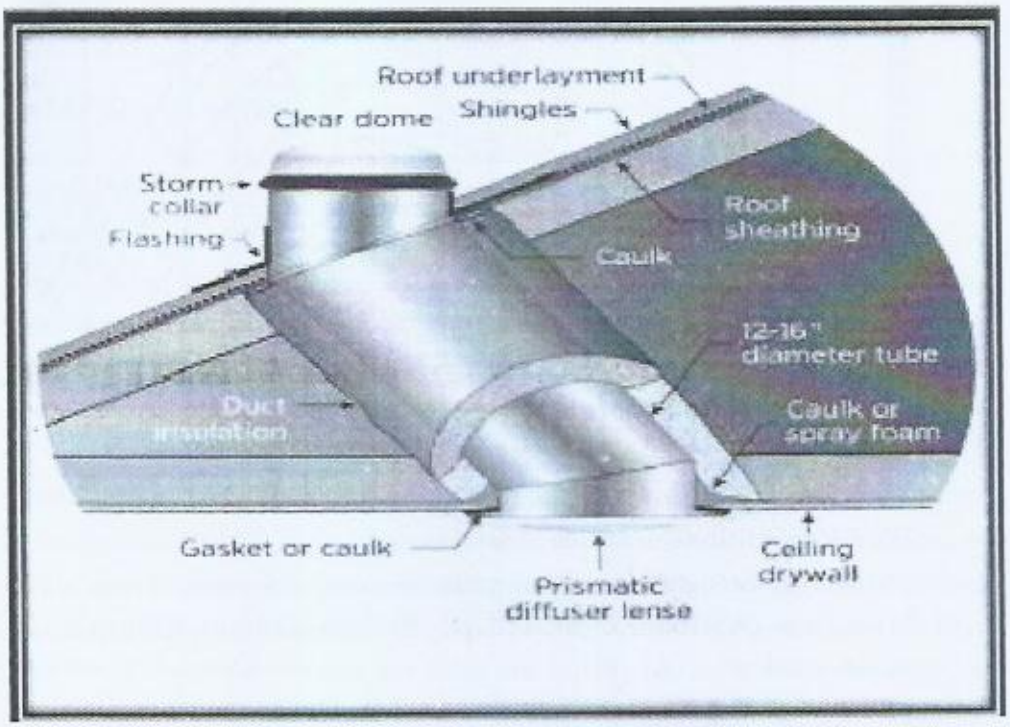

Figure 5: Cross-section of light tubes Source: Dulley (2006)

WINDOW

WINDOW ORIENTATION

Greatest amount of energy is realized from the sun at noon on a bright sunny day except on a cool weather day. The greatest amount of energy received through a window is when the sun is perpendicular to the window, and 30 to 35 degrees above the horizon. A south, east or west-facing window will receive about the same annual maximum of solar radiation. The time and date that the maximum energy is received depends on the building's latitude and the wall orientation. The Earth rotates 15 degrees every hour; therefore, when a window is oriented 30 degrees east of south, the maximum heat gain will be about two hours before solar noon. East and west facades experience their maximum solar gain during the summer, whereas a south-facing surface receives its annual maximum in the late fall or winter.

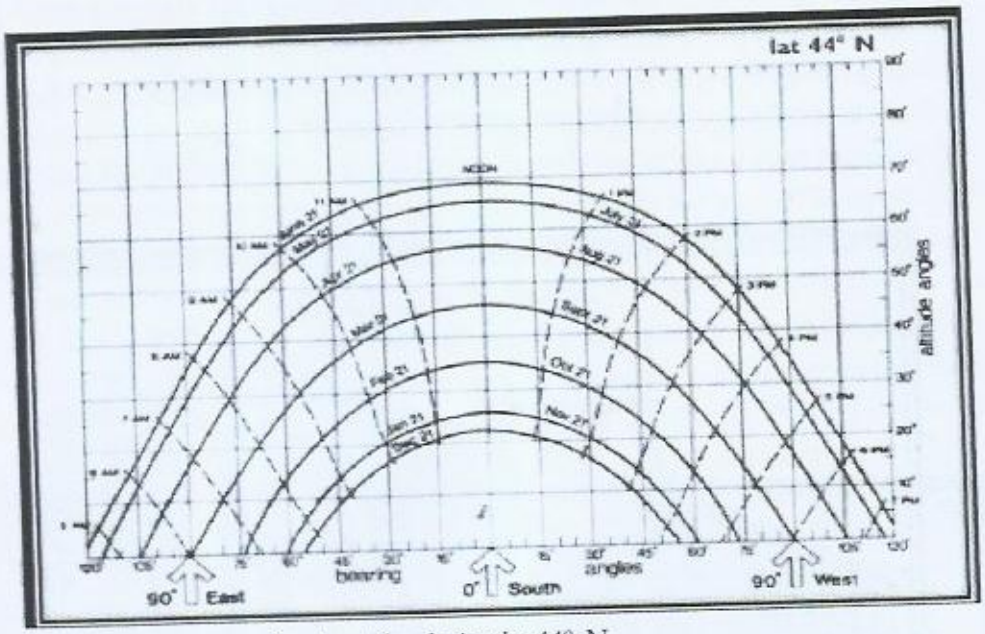

Figure 6: A sun path chart for latitude 44° N.
Source: Edward M. Dean, AIA. 2004

WINDOW SIZING

The average daylight factor equation can be used to estimate the required window to wall ratio (WWR) for adequate daylight. Mathematically, it is expressed by the equation below:

WWR= A glazing / A gross wall

Where,

A glazing is the net glazing area (window area minus mullions and framing, approximately 80% of the opening). A gross wall is the gross exterior wall area (width of the bay by floor to floor height). The daylighting analogy shown in the figure below provides a simple formula for calculating window size based on the desired level of natural lighting.

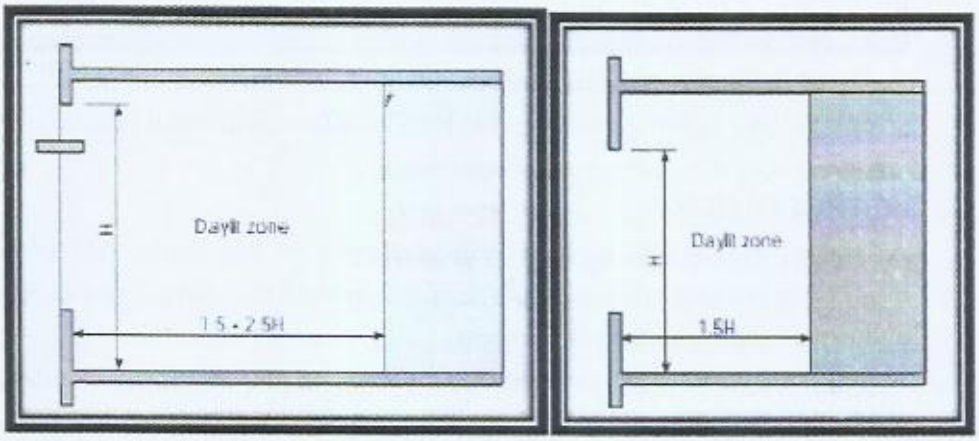

Figure 7: Daylight Depth as a Function of Window Height.
Source: Day lighting design guide for Canadian commercial buildings, (2002).

EXTERIOR SHADING

According to day lighting guide for Canadian buildings a good shading system will permit lower levels of artificial illumination to be specified, because the eye can accommodate itself without strain to function within a wide illumination range. Exterior shading devices are effective at controlling solar heat gain. Interior window shading will allow much of the solar energy into the building and will allow more heat sometimes an unwanted partner of daylight, to enter the building. Light-colored interior shading will reflect some of this energy back through the window. Interior shading is most effective at controlling glare and offers the ability to be controlled to suit the tolerances of the occupants, especially if using shades which draw upward instead of down. South-facing windows are the easiest to shade. Horizontal shading devices, which block summer sun and admit winter sun, are the most effective. East- and west-facing windows are best shaded with vertical devices, but these are usually harder to incorporate into a building, and limit views from the window. On lower buildings, well-placed deciduous trees on the east and west will reduce summer overheating while permitting desirable winter solar gains.

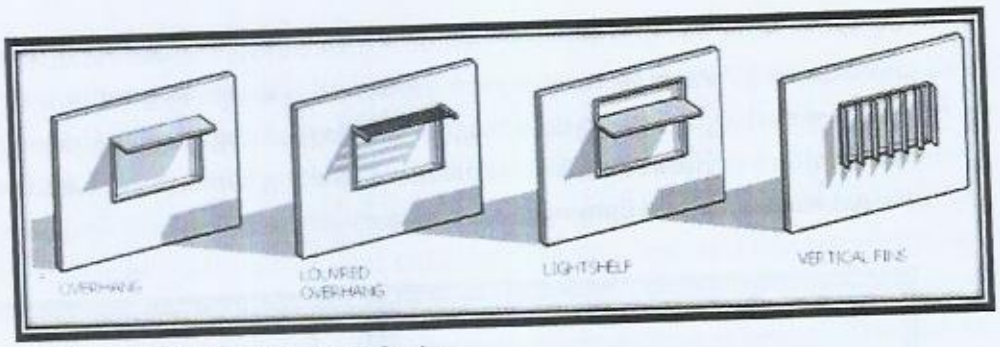

Figure 8: Exterior shading devices.
Source: Day lighting design guide for Canadian commercial buildings, (2002);

METHODOLOGY

A qualitative research method was employed in this study; this involves a descriptive research employed as a scientific method that can be used in observing and describing the nature of a subject.

A desk study was done on relevant material related to proper circulation in public buildings especially markets. After that, case studies were carried out as a primary source of data collection method adopted in this study, were relevant information was obtained through physical observation. An observation guide was drafted by the researcher. This gave the researcher more focus on needed parameters to observe and information to extract. Some of the students (thirty students) of the institution were approached to give their opinions of the lighting in a survey. Questions on the survey concerned impressions of brightness and darkness, visual comfort of the windows, and comparison to other libraries.

Table 1. Checklist for observation and assessing sampled Libraries.
Source: Author's field work

S/No	Variables
1	Building Position / Orientation.
2	Window Orientation.
3	Window sizes / Location of Windows.
4	Presence of Shading Devices For Proper Lighting.
5	Visual Comfort Assessment for users
6	Level of light Penetrations at different levels of the day

A non-random sampling techniques was adopted in this study, which involves intentional selection of specific samples relevant to the subject of judgment. These samples were selected to be subjected under observation by the researcher in line with the drafted observation schedule, in order to extract information relevant to the study. The following are listed samples (Libraries) selected to be observed as shown in table 2.

Table 2: List of Sample Libraries.

Source: Author's field work

S/No	Sample / Location
1	Summit University Library, Offa Kwara State.
2	Ibrahim Badamasi Babangida Library, Federal University Of Technology, Minna, Niger State.
3	Isa kaita Library, Kaduna Polytechnic, Main Campus, Kaduna State.
4	University of Illorin Main Library, Illorin, Kwara State.
5	National Library Of Singapore, Singapore.
6	Harmony Library Fort Collins, Colorado, USA.

DATA ANALYSIS

In this research, data gotten have been examined using qualitative data evaluation principles. The data acquired by the researcher using the observation guide was examined using the Microsoft office excel software, and the outcomes were presented using plates and figures.

BUILDING ORIENTATION

Building Orientation into the site is an important factor to consider, because it defines how the building is been designed to accommodate proper daylighting. The university libraries observed shows that 60% of the whole Libraries observed has good building orientation points, while 20% has excellent which is a foreign Libraries and the remaining 20% don't have.

Table 3: Building Orientation / Position

Source: Author's field work

SCHOOL LIBRARIES	Poor	Good	Excellent
Summit University Library, Offa Kwara State.	●		

Ibrahim Badamasi Babangida Library, Federal University Of Technology, Minna, Niger State.		●	
Isa kaita Library, Kaduna Polytechnic, Main Campus, Kaduna State.		●	
University of Illorin Main Library, Illorin, Kwara State.		●	
Harmony Library Fort Collins, Colorado, USA.			●

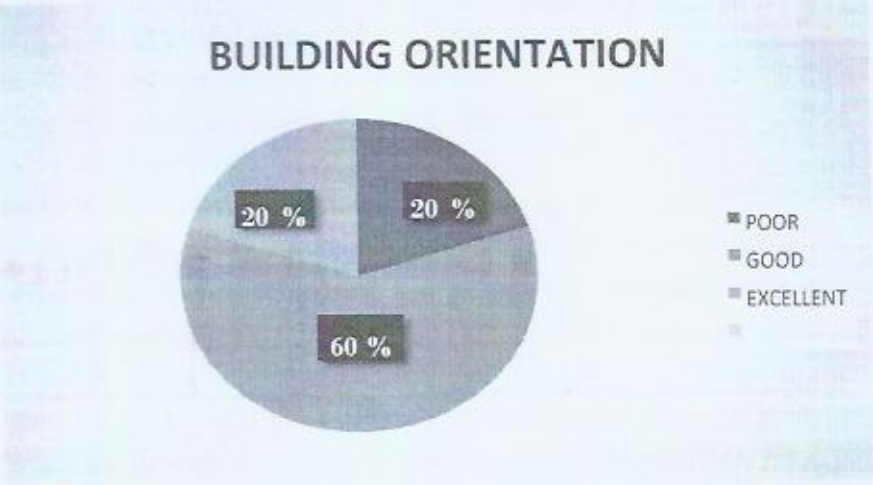

Fig 9 : Percentage distribution Building Orientation

Source: Author's field work.

WINDOW ORIENTATION

Considering window orientation for each sample, results and the data collected shows that most libraries have poor window orientation to enable maximum daylighting , the chart shows 60% having poor window orientation while 40% having proper window daylighting because it defines how the building is been designed to accommodate proper daylighting.

Table 4: Window Orientation

Source: Author's field work

SCHOOL LIBRARIES	Poor	Good	Excellent
Summit University Library, Offa Kwara State.	●		

Ibrahim Badamasi Babangida Library, Federal University Of Technology, Minna, Niger State.		●	
Isa kaita Library, Kaduna Polytechnic, Main Campus, Kaduna State.	●		
University of Illorin Main Library, Illorin, Kwara State.		●	
Harmony Library Fort Collins, Colorado, USA.	●		

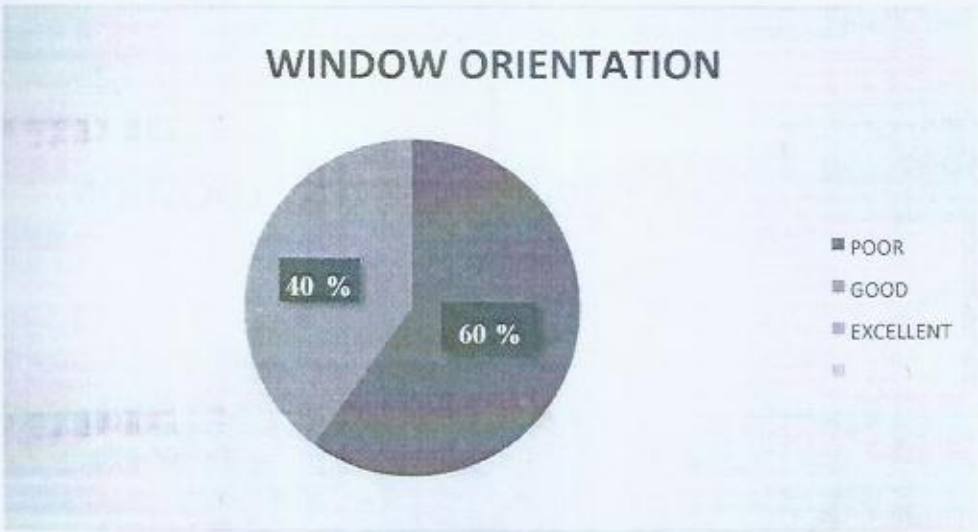

Fig 10: Percentage distribution Building Orientation

Source: Author's field work.

WINDOW SIZES / LOCATION

Considering window sizes and location for each sample, results and the data collected shows that most percentage of windows have proper sizes and location, the chart shows 60% having window sizes, while 40% having poor window daylighting because it defines how the building is been designed to accommodate proper daylighting.

Table 5: Window Sizes / location

SCHOOL LIBRARIES	Poor	Good	Excellent
Summit University Library, Offa Kwara State.	●		

Ibrahim Badamasi Babangida Library, Federal University Of Technology, Minna, Niger State.		◎	

Source: Author's field work

Isa kaita Library, Kaduna Polytechnic, Main Campus, Kaduna State.	◎		
University of Illorin Main Library, Illorin, Kwara State.		◎	
Harmony Library Fort Collins, Colorado, USA.		◎	

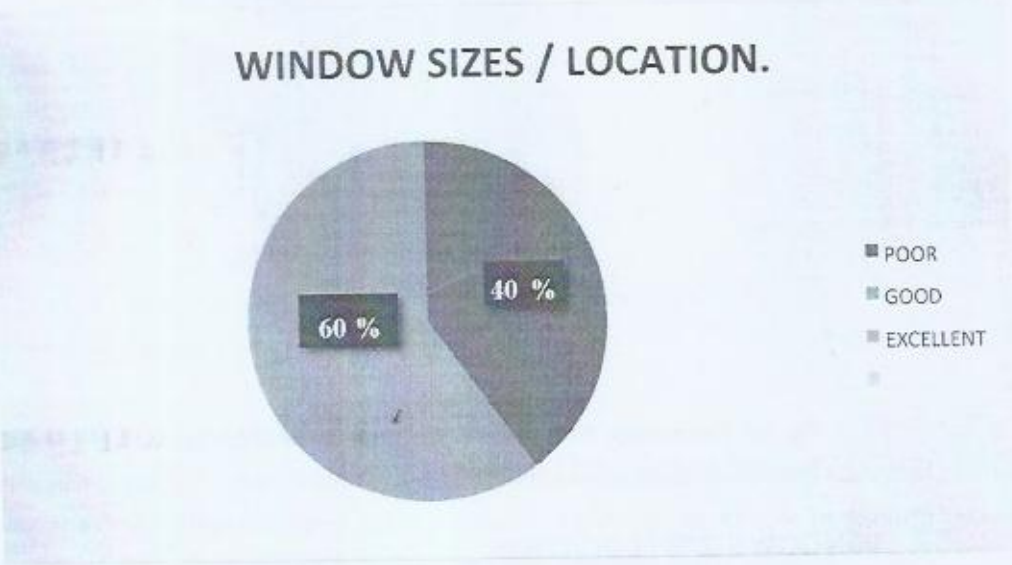

Fig 11: Percentage distribution Building Orientation
Source: Author's field work.

SHADING DEVICES

Considering shading devices sample, results and the data collected shows that percentage of shading devices used on the buildings are evenly distributed between good and bad and a lower portion have excellent shading devices.

Table 6: Shading Devices

Source: Author's field work

SCHOOL LIBRARIES	Poor	Good	Excellent
Summit University Library, Offa Kwara State.	◎		
Ibrahim Badamasi Babangida Library, Federal University Of Technology, Minna, Niger State.		◎	
Isa kaita Library, Kaduna Polytechnic, Main Campus, Kaduna State.	◎		
University of Illorin Main Library, Illorin, Kwara State.		◎	
Harmony Library Fort Collins, Colorado, USA.			◎

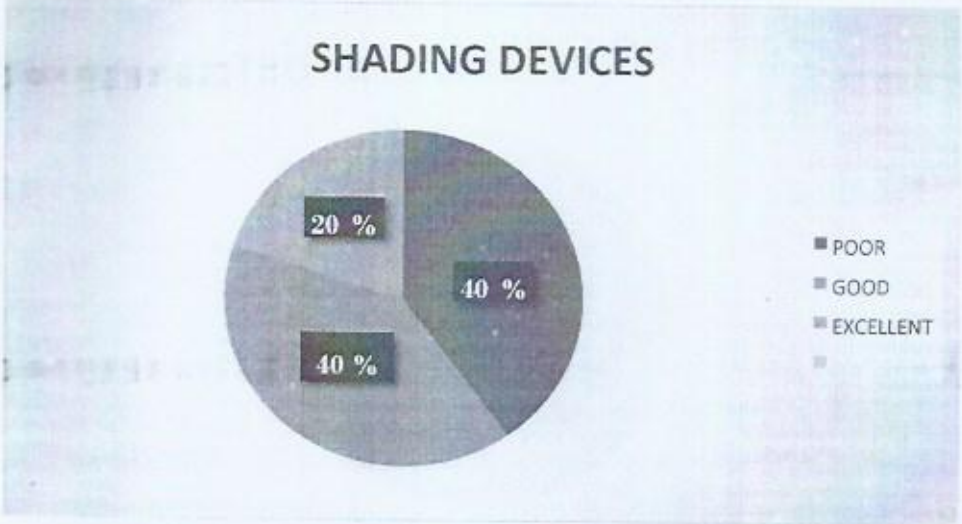

Fig 12: Percentage distribution Building Orientation

Source: Author's field work.

VISUAL COMFORT

Considering visual comfort sample, results and the data collected shows that percentages observed in term of visual comfort for users in the buildings are evenly distributed between good and bad and a lower portion have excellent visual comforts

Table 7: Visual Comfort Assessment

Source: Author's field work

SCHOOL LIBRARIES	Poor	Good	Excellent
Summit University Library, Offa Kwara State.	●		
Ibrahim Badamasi Babangida Library, Federal University Of Technology, Minna, Niger State.		●	
Isa kaita Library, Kaduna Polytechnic, Main Campus, Kaduna State.	●		
University of Illorin Main Library, Illorin, Kwara State.		●	
Harmony Library Fort Collins, Colorado, USA.			●

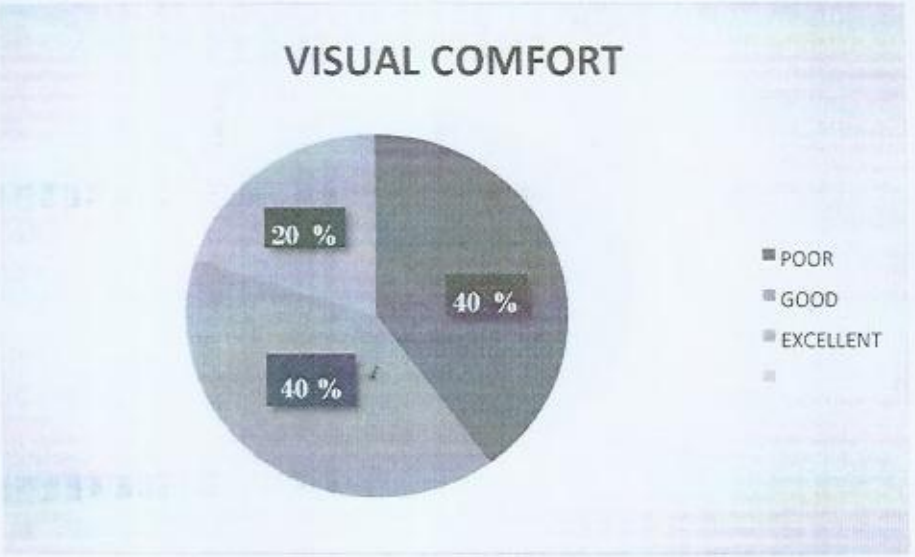

Fig 13 : Percentage distribution Building Orientation

Source: Author's field work.

LIGHT PENETRATION LEVELS

Considering light penetration levels sample, results and the data collected shows that percentages observed in terms of light levels for users in the buildings are evenly distributed between excellent and poor and a lower portion have good light penetration levels.

Table 8: Light Penetration Levels

Source: Author's field work

SCHOOL LIBRARIES	Poor	Good	Excellent
Summit University Library, Offa Kwara State.	●		
Ibrahim Badamasi Babangida Library, Federal University Of Technology, Minna, Niger State.			●
Isa kaita Library, Kaduna Polytechnic, Main Campus, Kaduna State.	●		
University of Illorin Main Library, Illorin, Kwara State.		●	
Harmony Library Fort Collins, Colorado, USA.			●

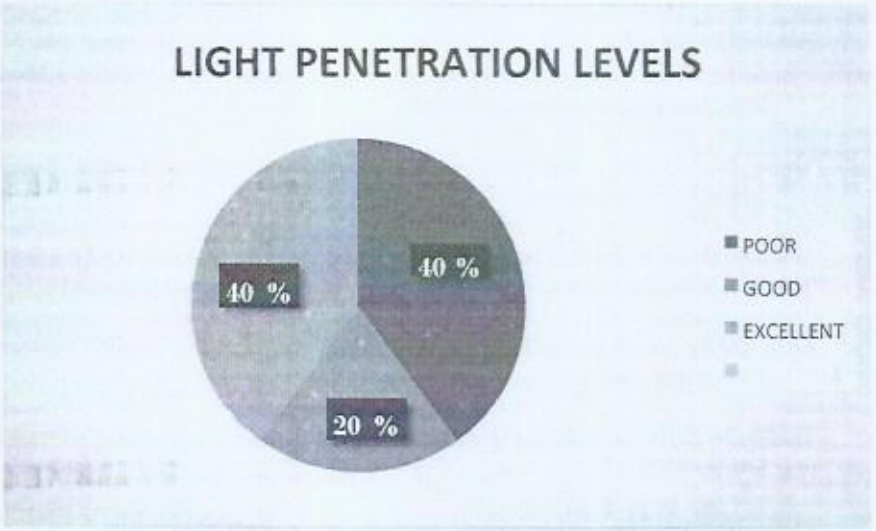

Fig 14: Percentage distribution Building Orientation

Source: Author's field work.

CONCLUSION AND RECOMMENDATION

The study result revealed that most majority of university libraries in Nigeria mostly in the northern part of the country are averagely designed putting into consideration optimum daylighting principles as a vital emphasis for user comforts in the building. Therefore most of them are not designed properly as regards daylighting and visual evaluations

Therefore this research recommends that the implementation of optimum daylighting principle for most libraries most be emphasized especially in the area of building orientation and window orientation and sizes to ensure optimum daylighting comfort, for the users in libraries and also most window sizes most be proportional to the space and size of the various spaces and skylighting can also be employed to correct buildings with poor daylighting supply.

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