

**Proposed Faculty of Architecture**

**(Maximizing Visual Comfort and Natural Lighting in Lecture Rooms)**

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Architecture**

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## Certification

This is to certify that Azeez Adedamola OLAOYE with matriculation number LCU/PG/002834 carried out this research work titled “Maximizing Visual Comfort and Natural Lighting in Lecture Rooms” in the Department of Architecture, Faculty of Environmental Design and Management, Lead City University, Ibadan, Oyo state, for the award of Master Degree (MSc) in Architecture and that this has not been previously submitted.

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## **Dedication**

This thesis is dedicated to the Almighty ALLAH and the entire OLAOYE family for your constant love and support.

*Do Not Copy, Lead City University, Nigeria*

## Acknowledgement

I am grateful to the management of Lead City University for giving me the massive opportunity to carry out this research and providing an atmosphere conducive for learning. I am overwhelmed in all humbleness and gratefulness to acknowledge my depth to all those who have helped put these ideas together, well above the level of simplicity and into something concrete. I would like to express my gratitude to my esteemed supervisor, Arc. Adenike Olugbesan for all the guidance, support and instructions she provided me throughout this program and to Dr. Adedire, the completion of my MSc would not have been possible without his guidance. To Arc. A. Adeola, Arc. K. Ajijola, Arc. N. Olugbesan, Arc. J. Fasheun-Motesho, Dr. Arc. A. Adegoke, Arc. B. Aseyan, Arc. M. Olaniyan, Arc. D. Oguntunde, lecturers that taught me during the course of this programme, I'm also very grateful, I cannot forget to acknowledge the entire postgraduate members of staff (both academic and non-academic) for making this programme hitch free. I would also like to specially thank Abdul-Lateef OLAOYE, who helped in gathering information and collecting data despite his busy schedules. In spite of the fact that the above-mentioned institutions and persons have aided in the process of this research work, I alone will be answerable and liable for the errors, if existing, in the work.

## **Abstract**

This research will review existing research on lighting design and its effects on human behavior and performance. It also will conduct a case study of a lecture room in a university, where it will analyze the lighting conditions and propose solutions for improving them. The ultimate aim of this research is to provide practical recommendations for architects, engineers, and educators to create more comfortable and sustainable learning environments. It also focuses on maximizing visual comfort and natural lighting in lecture rooms. It will explore different strategies and technologies that can be used to improve the quality of lighting in these spaces, with the goal of enhancing the learning experience for students and reducing energy consumption.

**Keywords:**

**Word count:** 115

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## **Chapter One**

### **Introduction**

#### **1.1 Background of the Study**

Day lighting plays a crucial role in assessing the indoor environmental quality of buildings. Utilizing natural light not only reduces electrical energy consumption but also contributes to creating a space that positively influences the health and well-being of building occupants. Numerous studies have demonstrated that daylight has a significant impact on students' educational experience, leading to increased productivity, improved human performance, and even affecting the production of cortisol, a hormone that regulates the day-night cycles and concentration levels in students (Mangkuto et al., 2019; Moreno and Labarca, 2015). The importance of daylight has long been recognized in school buildings due to its close association with enhancing student performance and overall health.

In addition to its benefits for educational outcomes, day lighting significantly contributes to the aesthetics and physical character of learning spaces while also mitigating potential harmful effects from prolonged exposure to artificial light. Research has shown that the absence of regular natural light exposure can result in symptoms such as fatigue, stress, circadian dysfunction, phase shifting, and Seasonal Affective Disorder (SAD) among building occupants. Recognizing the detrimental consequences of insufficient daylight, it becomes evident that integrating natural light into building design is crucial for ensuring occupant comfort and well-being.

Moreover, harnessing natural light is also an essential strategy for reducing energy consumption. The International Energy Agency (IEA) reports that artificial lighting accounts for approximately 14% of electricity consumption in the European Union. By leveraging day lighting techniques, such as optimizing window placement and incorporating shading devices, buildings can significantly reduce their dependence on artificial lighting, leading to substantial energy savings. Not only does

this contribute to energy efficiency and cost savings, but it also promotes energy and environmental awareness among the general public.

In conclusion, day lighting is a fundamental aspect of indoor environmental quality in buildings. Its utilization not only leads to reduced energy consumption but also has a positive impact on the health, well-being, and educational experience of building occupants, particularly students. Day lighting contributes to the aesthetics and physical character of learning spaces while minimizing the potential negative effects of excessive artificial light exposure. Furthermore, integrating natural light into building design promotes energy efficiency and environmental consciousness. Recognizing the significance of day lighting, it is crucial for educators, designers, and policymakers to prioritize its implementation in building projects to create healthier, more sustain Ensuring good lighting quality in educational environments is a complex task, as various visual activities are performed in classrooms that require specific visual conditions. This challenge becomes even more pronounced in historic buildings that are repurposed or no longer adhere to their original design (Nocera et al., 2018). While day lighting offers numerous benefits, it can also introduce visual discomforts such as glare and unwanted reflections, and may disrupt the thermal balance of rooms by causing overheating. Thus, finding a balance between maximizing daylight harvesting and managing potential discomforts is a crucial challenge for designers (Tabadkani et al., 2018).

Daylight design strategies have been actively employed to address the impact of light on health and enhance visual comfort for building occupants. The trend of incorporating oversized windows in school buildings to maximize natural light and views has highlighted the potential issues associated with excessive sun penetration. Day et al. (2019) emphasize that a well-designed space should consider at least eight factors: ensuring sufficient daylight for tasks, distributing daylight evenly to avoid under lit areas, minimizing glare, regulating electric light levels to conserve energy, providing appropriate circadian stimulation, offering outdoor views, limiting glazing area, and minimizing solar heat gain (Futrell et al., 2019).

Achieving these objectives requires a thoughtful approach to day lighting design. Strategies such as optimizing window placement, utilizing shading devices, and integrating daylight controls can help manage the balance between maximizing natural light and mitigating potential issues. For example, day lighting systems can include sensors and automated shading solutions to adjust light levels and control glare. Additionally, the use of light shelves or louvers can help redirect and diffuse sunlight, minimizing discomfort while still allowing for ample daylight penetration.

Furthermore, the integration of advanced technologies, such as electro chromic or photochromic glazing, can provide dynamic control over light transmission and solar heat gain, contributing to enhanced visual comfort and energy efficiency. These technologies allow for the adaptation of window properties based on changing daylight and climate conditions.

It is crucial for designers, architects, and facility managers to consider these design principles and strategies when planning and renovating educational spaces. Collaboration between experts in lighting design, architecture, and building systems is essential to ensure that visual comfort and energy efficiency are optimized in a balanced manner. Additionally, post-occupancy evaluations and feedback from building users can provide valuable insights for fine-tuning day lighting strategies and addressing any issues that may arise.

In conclusion, achieving good lighting quality in educational environments requires careful consideration of various factors and challenges. While day lighting offers numerous benefits, it must be implemented thoughtfully to manage potential visual discomforts and thermal imbalances. By adopting comprehensive daylight design strategies, incorporating advanced technologies, and fostering interdisciplinary collaboration, it is possible to create educational spaces that maximize natural light while ensuring occupant comfort and energy efficiency and a comfortable learning environment. (F. Nocera et al 2018).

## **1.2 Statement of the Problem**

Many lecture rooms lack proper lighting design and rely heavily on artificial lighting, which can lead to visual discomfort, reduced student engagement, and suboptimal learning outcomes. The absence of natural lighting in lecture rooms may contribute to fatigue, stress, and other negative effects on students' well-being. Additionally, the energy consumption associated with artificial lighting in lecture rooms poses a significant environmental challenge. Therefore, there is a need to address these issues by maximizing visual comfort and incorporating natural lighting effectively in lecture room environments.

The height of openings in lecture rooms is greatly determined by the height of windows and doors an architect wants to use or feels are required to enable proper and efficient natural lighting performance. It is like this because till now there are no proper existing theories carried out through modern innovations, which state a cordial relationship between the height of openings to the quantity and quality of natural lighting in Nigeria, (Adeanjo 2021). Planning and designing of lecture room openings from inception have been underlined to proportioned openings, and usage of specific window typologies to lower cost and improve security wise of long-lasting usage (Faith, 2020). This leads to situations like inefficient lighting circulation, over lighting, poor performance, the effect of glare, discomfort to students, under lighting, need for artificial lighting, which is costly to the educational facility and serves as a form of disadvantage. This alone brings about and gives rise to the need for proper, improved, functional lecture room design. Researchers that previously worked on natural lighting in Nigeria and beyond used methodologies such as daylight factor to properly analyze the effect of natural lighting, which has not put into consideration direct sunlight into spaces together with the dynamic nature of tropic climate, (Salihu, 2022). This gives rise to the need to determine a methodology that put into consideration the factors of natural lighting, quantity and quality of light, window sizes and types. For this reason, climate-based natural lighting performance indicators are checkmated, and assessed to give models using ways to maximize natural lighting and ensure comfort in lecture rooms located in the tropical climate of Nigeria.

### **1.3 Aims and Objectives**

The aim is to maximize visual comfort in lecture rooms by implementing effective lighting design strategies in university lecture rooms design.

The objectives of the study are;

1. To identify the factors that contribute to visual comfort in lecture rooms, including lighting levels, glare, and contrast.
2. To evaluate natural lighting design practices in university lecture rooms in Nigeria.
3. To explore lighting design principles and techniques for maximizing visual comfort in lecture rooms.
4. To assess the design considerations and strategies for incorporating natural lighting into lecture room spaces.
5. To examine the challenges and limitations associated with maximizing visual comfort and natural lighting in lecture rooms, such as cost constraints and building limitations.

### **1.4 Research Questions**

1. What are the current natural lighting design practices in university lecture rooms?
2. What is the impact of the height of openings on the provision of natural lighting in lecture rooms?
3. What is the maximum height of openings for sufficient lighting of lecture rooms in Nigeria

### **1.5 Significance of the Study**

Education center suffers serious illumination problems and visual comfort due to poor access to daylight. Therefore, there is a need to provide better knowledge in developing natural lighting design guides for, architects, school administrators, government, and private organizations to have

full ideas and basic knowledge for the development of lecture rooms in Nigeria. And this comprises the following.

1. Identification and documentation on the existing situation
2. Provision of models to optimize the existing situation
3. Provision of models for new class designs. The incorporation of optimized fenestration decisions concerning day lighting early in the design stage based on specific site and climatic conditions brings about more efficient lecture room design with reduced demands for energy.

### **1.6 Scope of the Study**

The scope of this research involves the study of basic requirements for the design of functioning faculty of Architecture. This study involves the use of energy-efficient natural lighting methods in multi-story lecture rooms. The use of natural lighting involves the application of design methods, spatial organization, and use of materials, with the sole purpose of applying them to get a suitable design, which gives a better solution to lighting problems in lecture rooms.

### **1.7. Definition of Terms**

Natural lighting: refers to the strategic placement of windows, skylights, or other openings in the faculty building or educational building to allow ample natural light to penetrate the interior spaces. The goal is to optimize the use of daylight for illumination, energy efficiency, and

1. Creating visually comfortable environments conducive to architectural education and design activities.
2. Visual comfort: refers to the quality of lighting conditions within the educational spaces. It involves factors such as appropriate lighting levels, absence of glare, suitable colour rendering, and effective use of artificial and natural lighting to create visually pleasing and

conducive environments for architectural activities, including drafting, designing, and evaluating architectural projects.

3. Lecture hall: defined as a specialized space within the faculty building or an educational building specifically designed to accommodate large groups of students for architectural lectures, presentations, and discussions. It is equipped with suitable seating arrangements, audiovisual equipment, and other resources necessary for delivering architectural lectures and facilitating interactive learning experiences.
4. Faculty: refers to the subdivision within the university or college comprising one or more related departments
5. Faculty building: is a dedicated physical structure or facility that houses the offices, studios and other spaces used by the faculty members in the department. It serves as a centralized location for faculty members to conduct research, prepare lectures, hold meetings, and engage in collaborative work related to architecture education and practice.
6. Educational building: refers to a physical structure or facility specifically designed to house the various spaces required for architectural education. It includes classrooms, studios, computer labs, workshops, fabrication facilities, and other specialized areas necessary to support architectural learning, experimentation, and practice. The educational building provides an environment that fosters creativity, collaboration, and hands-on experiences for faculty members and students within the Architecture Departments

## **Chapter Two**

### **Literature Review**

#### **2.1. Conceptual Review**

Background information on the importance of visual comfort and natural lighting in lecture rooms. Visual comfort refers to the visual conditions that promote ease of vision, reduce eye strain, and enhance visual clarity. In lecture rooms, where students spend a significant amount of time engaged in reading, note-taking, and other visual tasks, providing optimal visual comfort is essential for their overall well-being and academic performance. Proper lighting levels, appropriate color temperature, reduced glare, and adequate contrast are key factors that contribute to visual comfort.

Natural lighting, on the other hand, refers to the use of daylight as a primary light source in indoor spaces. It offers several advantages over artificial lighting. Natural light is full-spectrum light, which closely resembles natural daylight and provides better color rendering, enhancing the visibility of materials and reducing eye fatigue. Additionally, exposure to natural light has been linked to various benefits, including improved mood, increased productivity, better concentration, and enhanced cognitive function.

In lecture rooms, where students engage in intensive cognitive tasks, the presence of natural light can positively impact their learning experience. It has been found that access to natural light can improve student performance, increase information retention, and promote a more engaging and stimulating learning environment.

Furthermore, natural lighting contributes to the aesthetics and physical character of lecture rooms, creating a visually pleasing atmosphere. It has the potential to enhance the overall ambiance, making the space more inviting and conducive to learning.

Additionally, incorporating natural lighting in lecture rooms aligns with sustainable design principles and energy conservation efforts. By utilizing daylight as a primary light source, there is a reduced reliance on artificial lighting, resulting in energy savings and decreased environmental impact.

Considering the importance of visual comfort and natural lighting, it is essential for educational institutions and designers to prioritize these factors in lecture room design and renovation projects. By optimizing visual comfort and incorporating natural lighting effectively, lecture rooms can provide an environment that fosters student well-being, engagement, and academic success.

## 2.2 What Is Daylighting

Although light can be described as invisible, its effects are tangible and an inseparable component of architecture. As Meier (1987) clearly acknowledged in an interview, ‘\_For me light is the best and most versatile building material ‘. How light is reflected and what we read into the qualities of that reflected light affects our perception of the solids, of the black lines we draw; immaterial light changes the materials of building (Brawne, 2003). For many years the study of the illumination of a building was limited to solving functional and safety problems. The main aim was to guarantee sufficient levels of light to carry out any given activity without really taking other factors such as psychological comfort and visual fatigue into account (Verges, 2008).

Daylight is the total illumination provided by the direct sunlight, skylight and the diffusely reflected sunlight, which is absorbed and reflected over surfaces, both externally and internally. The technical term of delivering this natural light into an enclosed space is what is generally referred to as day lighting (Salisu, 2015). Day lighting is the use of natural light to

provide illumination in buildings during the day, daylight is an essential resource that is readily available and unlikely to run out for the near future, it has the very special characteristic of having the ability to transform an internal space from uninspiring uniformity into a psychologically uplifting experience.

This ability to both illuminate an area and to make it more interesting, is one of the main reasons that architects try to make provision for daylight to come into a building wherever practical (Kjeld & Richard, 2010). Roaf, Horsley, & Gupta, (2004) stated that lighting cannot just be measured in the amount should include:

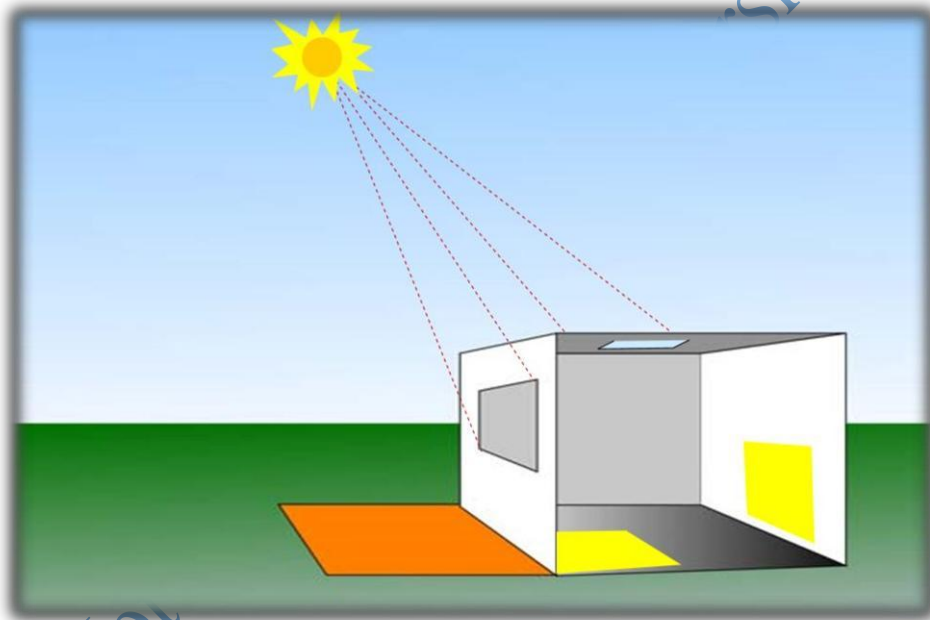
- i. Average illuminance in the working plane.
- ii. Uniformity of illuminance in the working plane.
- iii. Luminance ratios within the space.
- iv. Glare levels in the space.
- v. Direction of light and the effect of shadows.
- vi. Color temperature of light.
- vii. Color rendering of light.

### **2.2.1 Difference between Daylight and Sunlight**

The sun releases a power flux of 63 MW, equivalent to six thousand million lumens, for every square meter of its surface area. Of this around 134 kilolux reaches the earth's outer atmosphere (Thermie Programme Action). People often assume that -sunlight| and -daylight| can be used synonymously. In reality, they have very different physical properties and different effects on sky lighting design. The most important differences are their intensity, their color, and the extent to which their light is scattered, or diffused (Energydesignresource, 2014).

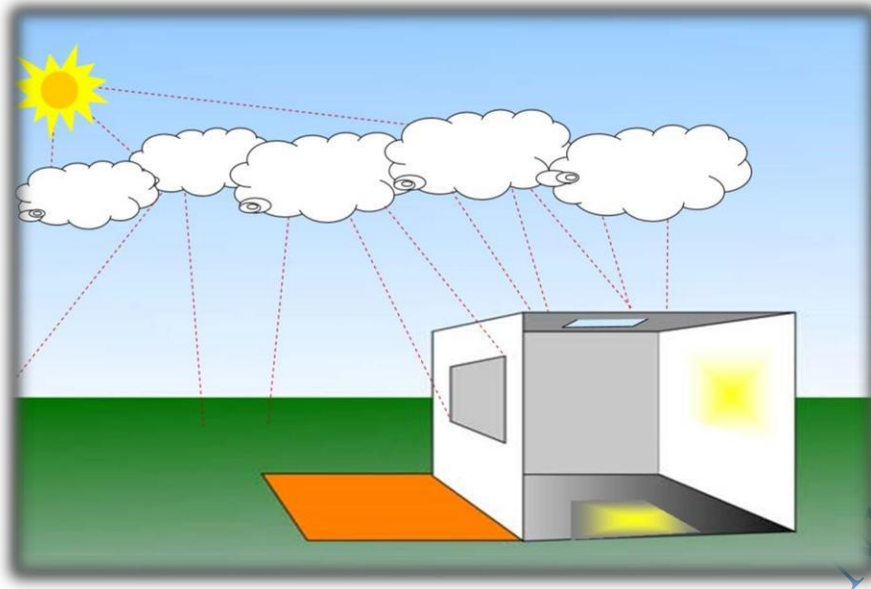
Sunlight on the other hand refers to direct sunshine and is very much brighter than ambient daylight (East Renfrewshire Council Planning Service, 2012). Direct sunlight as seen in fig 2.1 requires control and shading devices to be useful.

Ambient daylight is the volume of natural light that enters a building to provide satisfactory illumination of internal accommodation between dawn and dusk, Daylight from an overcast sky as seen in fig 2.2 is generally the same no matter how the building is orientated.



**Figure 2.1 Sunlight: an illustration of the directional beam emitted by the sun.**

(Source: Lighting Research Center, 2006.)



**Figure 2.2 Daylight: an illustration showing diffused beams of light emitted by the sun.**

(Source: Lighting Research Center, 2006.)

### 2.3 Daylighting and Human Comfort

According to Magnus & Magnus (2012) daily performance of tasks is also very dependent on the lighting conditions, and the visual performance. The visual performance is measured by the accuracy and speed at which a visual task is done. According to thermie programme action, optimal illuminances for different activities has been defined by various researches and study. These are generally based on uniform and constant levels of artificial light falling on the work plane.as seen in table 2.1:

Table 2.1 Some typical recommended illuminances

	ACTIVITY	ILLUMINANCE	RANGE

		(LUX)
1	Corridors/Toilets	100-150
2	Restaurant/Canteen	200
3	Library/Classroom	500
4	General office	500
5	Workbench	500
6	Drawing office	500-750
7	High-precision tasks	1500

(Source: Thermie Programme Action, 2016)

### 2.3.1 Glare

Glare is reflected or uncontrolled light that shines directly into your eyes. Although it is very bright, the light produced by glare does not usually help you see more clearly; instead, it can interfere with your visual comfort, physical safety, and independent performance of everyday activities (Gerritsen, 2016). Glare produced by lighting has been classified into two types— as -discomfort glare and as (more severe) -disability glare. Both of these have consequences in terms of task performance, Both types of glare are caused by source being much brighter than the background against which it is viewed, and are affected by the size, shape and position of the source, as well as by its brightness (Advanced Lighting Guidelines, 2016).

## **2.4 Daylighting in Lecture Rooms**

Over the last decade, many of the world's biggest businesses have made day lighting in the workplace a priority. From improved productivity to better sales, turning off artificial lights and opening the curtains has been a huge help for businesses, Now, a growing number of schools and colleges are taking the initiative and making natural light a key architectural focus. Natural light offers a wide variety of benefits in an educational environment, from improved focus to better student health (Bristolite Team, 2014).

A school with insufficient light can reduce a student's ability to learn due to the effect lighting has on physiology. Poor spectral light can create eyestrain, leading to decreased information processing and learning ability and causing higher stress levels (Samani & Sanaz, 2012). The aim of lighting design is to supply appropriate illuminance, color temperature, and lighting to meet the requirement of the users' vision from physical to psychological (Samani & Sanaz, 2012).

### **2.4.1 Benefits of Adequate Daylighting on Students Performance**

Using natural light or daylight for illumination is one of the hallmarks of a high- performance building. In addition to the benefits of supplying substantial light for free, natural light provides

great physical and psychological benefits to the building's occupants (Dahlan & Mahmoud, 2015). (Bristolite Team, 2014) Stated that the benefits of adequate lighting on students include:

- i. Natural light improves standardized test scores.

Studies indicate that well-designed daylighting is associated with enhanced student performance, evidenced by 13% to 26% higher scores on standardized tests, while poor daylighting design has been shown to correlate with reduced student performance. It makes sense that students and teachers perform better in stimulating, well-lit environments. Daylighting can provide high quality light, stimulating views, and an important communication link between the classroom and adjacent spaces (Heschong Mahone Group, 1999).

- ii. Natural light eliminates common distractions.

During the 1970s, windows were scaled down in school in an effort to remove any visual distractions. The idea was simple, albeit completely wrong – big windows can cause students to look out into the environment instead of focusing on their work. Decades later, many of the same architects are taking the opposite approach, with a far better result. Far from making students more distracted, natural lighting actually makes students significantly more focused and less distracted from their work (Bristolite Team, 2014).

Experts are not sure why daylight reduces time spent on distractions, although one theory claims that since students are free to look around, they're less likely to find distractions within the classroom (Bristolite Team, 2014).

- iii. Natural light is completely free of charge.

Depending on artificial light has more costs associated with it than poor academic performance and a higher number of student sick days. In addition to its negative effects on school performance, artificial light costs a huge amount every month.

With the price of energy on the rise, being able to inexpensively light your school or college is a massive financial advantage. By reducing your utility bills using natural light, you will have a larger budget to spend on important educational activities (Bristolite Team2014). Schools and colleges, particularly those in sunny states like California, can enjoy an extensive range of benefits from natural lighting. Consider day lighting today for a more productive, healthy, cost effective and motivated learning environment (Bristolite Team2014).

## **2.5 Harnessing Day lighting**

Daylight is superior to electric light sources in the measure of light source efficiency. Beyond the simple conclusion that well-designed day lighting can reduce electric energy use in buildings, there are two additional traits of day lighting that make its use compelling (Dean, 2004). In any day lighting system, the light source (directly or indirectly), and the fenestration systems in addition to the building surfaces, determine the quantity and quality of daylight present in the building. The influence on visual comfort can be in terms of the adequacy or inadequacy of lighting, possibility of glare and thermal loads, together with good or poor uniformity within the space (Salisu, 2015).

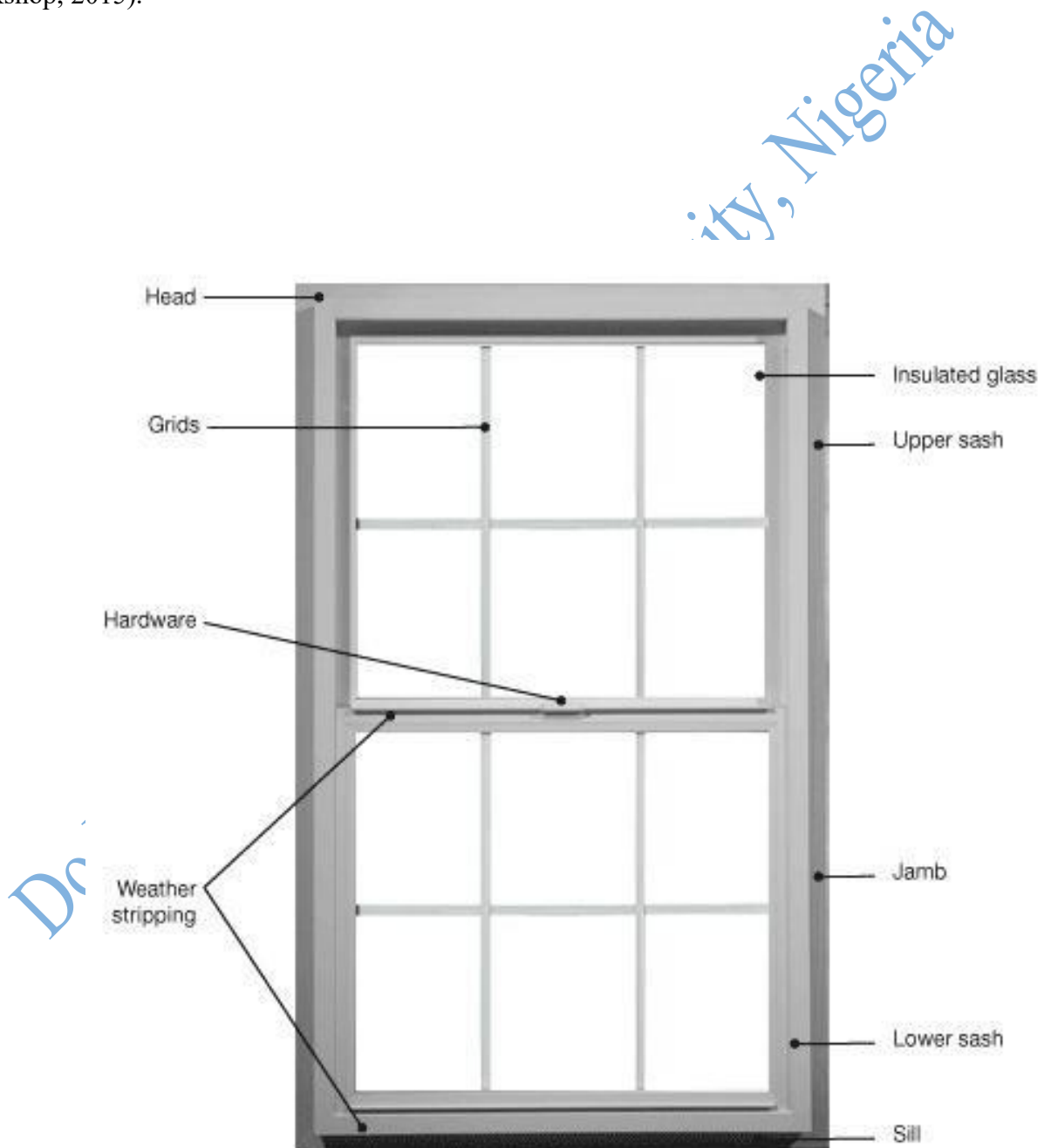
### **2.5.1 Day lighting strategies**

Evenly distributed light is critical to good day lighting, so apertures that are evenly distributed are useful. Continuous-strip apertures are even better, and apertures on multiple sides are often best otherwise rooms can have "hotspots", both in terms of temperature and brightness, Often this is accomplished with horizontal bands of windows that are placed high in a space (to avoid glare and reflect light off the ceiling), or with evenly spaced vertically oriented windows that reach the full height of the room (Autodesk Sustainability Workshop, 2015).

### **2.5.2 Types of Day lighting Aperture**

### 2.5.2.1 Side light

Light coming from side apertures like windows seen in fig 2.3 can only penetrate so far into a building, this is the reason why shallow floor plans are recommended for day lighting multi-story buildings. A simple rule of thumb for most latitudes is that daylight penetrates into a room roughly 2.5 times the height of the top of the window seen in fig 2.4 (Autodesk Sustainability Workshop, 2015).



### Figure 2.3 main components of a window.

(Source:Mandinfinity, 2017)

Clear glass is preferred for day lighting, but this in turn requires carefully designed exterior sun control devices to provide adequate shading. Although internally mounted shades and blinds reduce the high intensity and heat content of direct sunlight, the most effective sun control device is the exterior sunshade. An internal shade, even a light-colored fabric

blind, reduces solar heat gain by about one-third to one-half of the incident solar energy. An exterior shade will create a reduction of 80% of the incident solar energy (Dean, 2004). According to Skylight Council (2011), Side-lighting from windows and doors provides daylight and solar energy along the perimeter of a building. Good day lighting design should consider this side - lighting characteristics:

1. Most daylight is provided through ambient lighting from the sky. The amount of daylight available will vary throughout the day depending on the direction the fenestration is facing. External obstructions are likely to reduce the available daylight.
2. Orientation (north, east, south, west) with respect to the sun's path is a critical factor
3. The need for shading to avoid glare is essential when the sun is low in the sky.

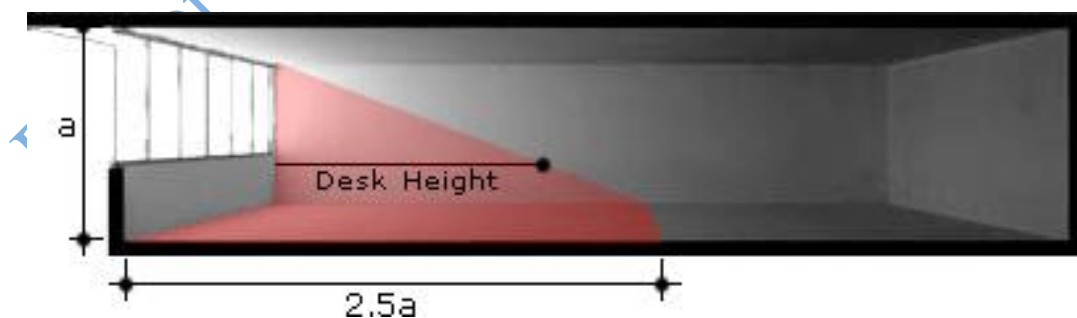


Figure 2.4 Side lighting only reaching into room.

Source: Autodesk sustainability workshop, 2015

Side lighting also have the ability of providing a view of the outside. Notwithstanding these advantages, this fenestration system has some disadvantages. They may cause glare due to high contrast between the aperture and surrounding wall surfaces (Ander, 1995).

Many modern commercial windows employ low-e glazing. Low-e glazing employs two or more panes of glass, one of which is coated with a relatively clear material that reflects infrared energy while passing visible portions of the sun energy. In any building with a cooling season, low-e glass is essential in minimizing solar heat gain. Reflective coatings can also be used; these make the building look mirrored while further decreasing solar penetration. Tinted glass can also reduce solar penetration and glare. Glazing selection is always a compromise between clarity and energy efficiency (Oluwatosin, 2014).

1. Glazing

<b>GLAZING TYPE</b>	<b>SOLAR TRANSMISSION</b>	<b>EQUIVALENT U-VALUE</b>
<b>CLEAR ,SINGLE</b>	75% -89%	1.11

<b>CLEAR DOUBLE</b>	68% - 75%	0.49
<b>LOW-E CLEAR DOUBLE</b>	45% - 55%	0.38
<b>LOW-E TINTED, GREY</b>	30% - 45%	0.38
<b>LOW-E, ARGON</b>	45% - 55%	0.30

Glazing is derived from the Middle English

for 'glass', is a part of a wall or window seen in fig 2.3, made of glass (Dahlin, 2016). Several types of glazing used architecturally includes Translucent Glazing, Tinted Glazing, Metallic Coatings, Multi-Paned Glazing, tempered glass, laminated glass and insulated glazing. The choice of glazing is critical in ensuring good day lighting. A wide range of glazing is available offering both good admission of daylight and low heat gain (Cole, Connery, Rousseau, & Threcker, 1999). A conventional window, single-glazed with clear float glass will transmit approximately 85% of the light that falls upon it. Double or triple glazing will reduce light transmission to 70% and 60% respectively as shown in table 2.2.

Table 2.2 glazing types showing corresponding solar transmission levels and u-value..

Source: innovative design, 2021

Where lighting requirements demand larger areas of glass than would be thermally satisfactory, specially treated glass can be used to control heat losses or gains (Thermie Programme Action). In all cases where windows are used specifically for day lighting, clear glass has an advantage over glazing with Low-E coating because the 10% - 30% reduction in visible light transmission of most Low-E coatings would be required to produce the same daylight benefits (innovative design, 2004). To increase the amount of day lighting window area and glazing visible transmissivity on north- and northeast-facing walls should be increased and the amount of glazing

on west and southwest orientations where sun is difficult to shade effectively with fixed fins or overhangs should be reduced (Cole, Connery, Rousseau, & Threcker, 1999). Studies on window to wall ratio (WWR) by Bokel , (2007)and Mahdavi, Rao, & Inangda, (2013) for Suitable Area Zone with appropriate daylight have stated that 30% - 35% is the appropriate range for adequate day lighting.

## 2. Laser Cut Panels (LCP)

This is an innovative day lighting system used to redirect high angle light upwards towards ceilings by total interior reflections and redirecting low angle light or diffusing light downwards by internal refractions, thus it is used to reflect light into deep rooms. (Tukur 2013). These laser cuts seen in fig 2.5, work by deflecting a fraction of the incoming light through total internal reflection at the surface of the cuts, whilst the remaining light passes through the panel un-deflected. LCP's perform better in climates with clear sky conditions, deflecting direct sunlight into the ceiling avoiding direct sunlight on the work plane (Hirning, 2010



**Figure 2.5 Typical Laser Cut Panel System**

(Source: Urban design system, 2016)

## 3. Transparent Concrete

Translucent concrete is a concrete based material with light-transmissive properties, obtained due to embedded light optical elements like Optical fibers in it as seen in fig 2.6. Light is conducted through the stone from one end to the other. This results into a certain light pattern on the other surface, depending on the fiber structure. (Padma, Johnson, Afzal, & Prasanthi, 2013). Its transmits light without the accompanying effects of heat, It is more durable than other precast panels and is resistant to aging caused by UV radiation. (Italcementi, 2015)

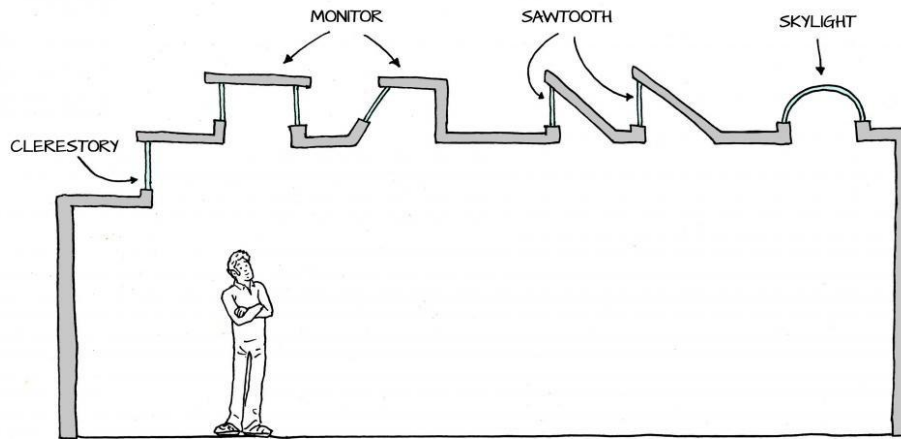


**Figure 2.6 illustration of a typical transparent concrete panel.**

(Source: Italcementi, 2015)

### 2.5.2.2 Top Light

This is the name given to a fenestration system situated in the ceiling/roof plane seen in fig2.7. It has the attributes of providing uniform and high illumination over the horizontal work plane since it receives light from the brightest regions of the sky (IEA TASK 21,2000) Higher apertures are more effective at bringing light deep into the building. This often means glazing in roofs. Skylights are not the only kind of aperture to bring light in through roofs. Other "top lighting" strategies include clerestories, monitors, and saw-tooth or other scoop-shapes. Each has their own advantages and disadvantages in construction cost and how they bring the sun into the space at different times of day and year. (Autodesk Sustainability Workshop, 2015).



**Figure 2.7 Different types of top lighting devices.**

(Source: Autodesk sustainability workshop, 2015)

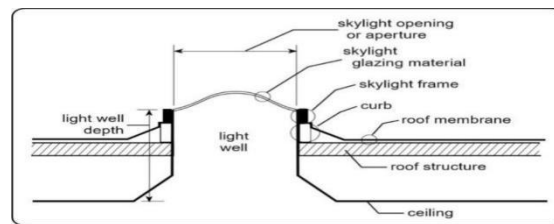
There are basically three different types of top lights - skylights (horizontal or near horizontal aperture to the sky), monitor roof lights and clerestories (which are vertical or nearly vertical projecting glazed apertures) (Salisu, 2015).

Top lighting can provide greater freedom of source placement to achieve more uniform illumination, takes advantage of high wall surfaces and other architectural elements to distribute light where needed, and increases security and privacy. (Kroelinger, 2005)

#### 1) Skylights:

A skylight on a sloped roof cannot see the full sky hemisphere, but only a partial view determined by the slope of the roof. Furthermore, depending upon the angle and orientation of the sloped roof, the sun may not reach the skylight during certain times of the day or year. For example, a skylight on an east-facing roof with a  $45^\circ$  slope will only receive direct sun during the morning and midday hours. In the afternoon it will receive skylight, but only from three-fourths of the sky. As a result, in the afternoon it will deliver substantially less light to the space below than an identical skylight located on a flat roof (Energydesignresource, 2014). Skylights can be successful day lighting roof apertures provided the direct sun is prevented from coming within

view by washing down walls or striking floor or table surfaces. In addition, because of the heat content of direct sunlight, the skylights should be relatively small in area and should be accompanied by large adjacent diffusing surfaces as seen in fig2.8 (Dean, 2004).

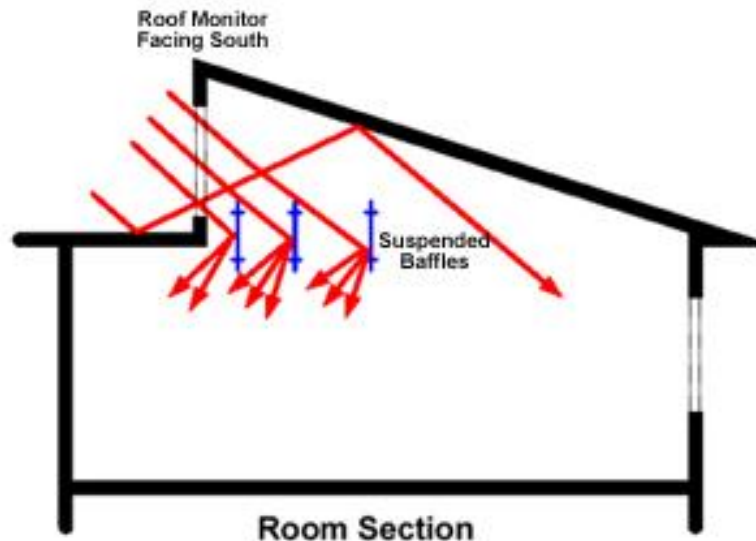


**Figure 2.8 Components of a Typical Skylight**

(Source: Dean, 2004)

## 2) Monitor roof lights

The monitor roof light has vertical glazing in two opposite directions. In this study, north and south orientation is preferred because the south-facing glazing can easily be shaded and the north-facing glazing only admits diffuse daylight to the space. (Ladan, Wayne, & Soolyeon, 2012) Monitor roof permits abundant daylight, especially in buildings where solar orientation or weather does not permit the saw tooth or other more unusual designs. With proper choice of glazing and overhang, a monitor can produce exceptionally balanced and comfortable daylight. (Mark, James, & Christina, 2012) Roof monitors are popped-up extensions of the roof, with vertical glass areas. Large roof monitors often appear to be forms of vertical extensions of the ceiling, and can provide dramatic high internal spaces in special areas seen in fig 2.9 (Dean, 2004)

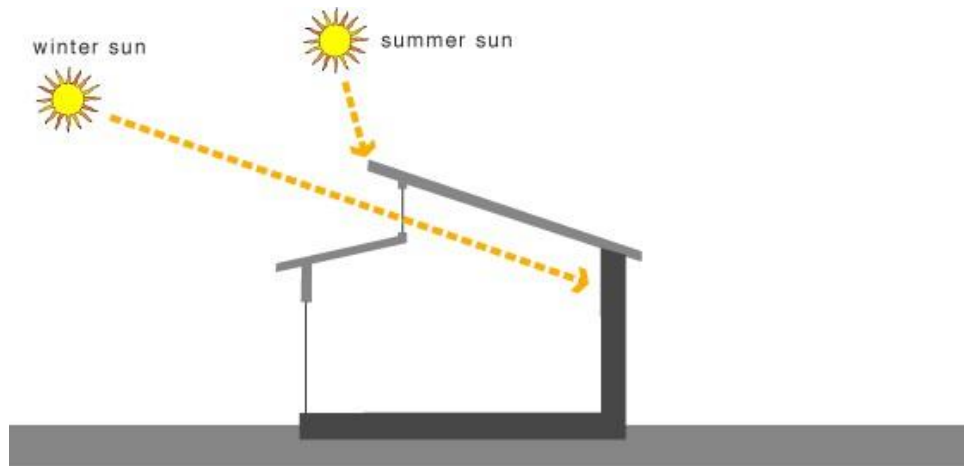


**Figure 2.9 monitor roof.**

(Source: Tao, 2010)

### 3) Clerestories

A clerestory is a series of windows high up in a space. These can be a formal row, like in a cathedral, or a single, simple opening in the wall. Clerestories are often confused with transoms. Transoms are smaller windows stacked on top of other windows or doors. In traditional buildings, transoms were operable allowing air to move around a building while still keeping the safety and privacy of closed lower doors and windows. (Architects, 2015) The single clerestory produces both direct and indirect lighting by introducing light through a vertical clerestory window. Depending on the adjacent roof, some of the light may be reflected downward by the ceiling into the space seen in fig 2.10. However, depending on site orientation, the relatively high percentage of direct light can be glaring. (Oluwatosin, 2014)

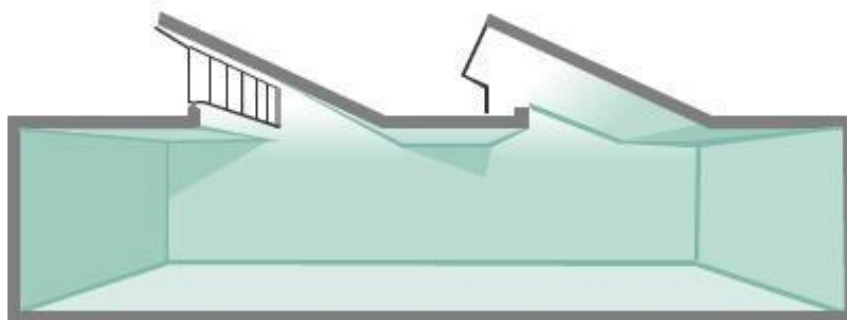


**Figure 2.10** illustrations of clerestories taking in light

(Source: m. gerwing architects, 2015).

#### 4) Saw tooth roof

A saw-tooth roof is a roof comprising a series of ridges with dual pitches either side. The steeper surfaces are glazed and face away from the equator to shield workers and machinery from direct sunlight. This sort of roof admits natural light into a deep plan building or factory. (Babylon, 2015) Saw tooth are apertures with vertical or angled glazing installed in a slopped roof plane seen in fig 2.11. Saw tooth are most effective when used in series of three and were historically used in industrial and manufacturing buildings as the primary light source. Saw tooth slope is generally at a 45-degree angle. (Kroelinger, 2005).



### **Figure 2.11 illustration of a saw tooth roof.**

(Source: build 2022).

Saw-tooth roof produces both direct and indirect lighting but, by bouncing a high percentage off the adjacent slanted ceiling, increases the amount of downward light and can minimize the amount of direct light. If the saw tooth glazing faces north, it can be an excellent source of natural light for a large interior area. (Oluwatosin, 2014).

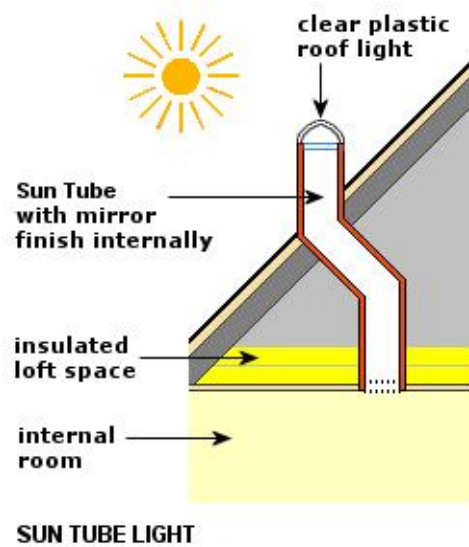
#### **2.5.3 Light pipes**

Light tubes or light pipes are physical structures used for transporting or distributing natural or artificial light for the purpose of illumination, and are examples of optical

Waveguides. In their application to day lighting, they are also often called tubular day lighting devices, sun pipes, sun scopes, or daylight pipes. Light pipes may be divided into two broad categories: hollow structures that contain the light with a reflective lining, and transparent solids that contain the light by total internal reflection. The principles governing the flow of light through these devices are those of non-imaging optics (Bernfart, 2014).

In applications for day lighting, they are also often called sun pipes, solar pipes, solar light pipes, daylight pipes, tubular skylight, sun scoop or simply tubular day lighting device seen in fig 2.12. In comparison to conventional skylights and windows, a light pipe offers better heat insulation properties and more flexibility for use within buildings, however with little visual contact with external environment (Jeong & Gon, 2010). Sun tube lights are highly effective at transferring daylight into parts of buildings that have little or no natural lighting. They can be used to replace artificial lighting and will therefore substantially reduce the annual energy consumption of a home. In many cases, sun tube lights will be used to provide all the light for an internal space but they can also be used to compliment an artificial lighting scheme. (Low Energy House, 2016). Light

pipes perform the same function as other skylight strategies, the only different is the way daylight is transported into internal spaces by using highly reflective tube. This system is also known as solar pipe, tubular daylight guidance system or mirror pipe. Compared to conventional skylights and windows, a light pipe offers better heat insulation properties and are more flexible (Jeong & Gon, 2010). The challenges of light pipe system utilization includes high initial cost, maintenance and user awareness (Aslila, Lokman, & Narimah, 2015)



**Figure 2.12 illustration of a typical light pipe**

(Source: Low Energy House, 2016)

#### **2.5.4 Fenestration materials**

The fenestration consists of frame components and a daylight aperture. The frames are made from either timber, steel, aluminum, alloys or some form of plastics. To complement them, daylight apertures may have a void, a transparent or a translucent glazing layer between the source of natural illumination and the interior space (Salisu, 2015).

### **2.6 Conceptual Framework for Day Lighting Calculation**

According to Abubakar, (2015) Research into day lighting has undergone various concepts since 1895 and these concepts are

1. The Daylight Factor Concept
2. The \_Design Sky 'Concept
3. The \_Total Flux 'or Lumen Concept of Day lighting
4. The \_Split Flux' Concept of Day lighting
5. The PSALI (Permanent Supplementary Artificial Lighting of the Interior)
6. The Static Point illuminance and Luminance Measurement Concept
7. Climate-Based-Daylight-Modelling (CBDM).

### **2.6.1 The daylight factor concept**

The daylight factor (DF) is a very common and easy to use measure for the subjective daylight quality in a room. It describes the ratio of outside illuminance over inside illuminance, expressed in percent. The higher the DF, the more natural light is available in the room (Clear Comfortable Low Energy Architecture, 2016). It is expressed as such:

$$DF = SC + ERC + IRC$$

SC is the sky component

ERC is the externally reflected component

IRC is the internally reflected component

It is usually expressed as a percentage of internal illuminance to unobstructed outdoor horizontal illuminance under a standard CIE overcast sky condition and is assumed to be a worst case

scenario which does not consider any form of direct sunlight. This concept, irrespective of climate and location, has been elevated to a 'performance metric' whereby design guidelines worldwide currently recommend provisions in terms of daylight factors (DF) (Mardaljevic, Heschong, & Lee, Daylight metrics and energy savings, 2009).

According to Grant, (2015) The Daylight Factor and the light inside a room are made up of three separate components:

1. The sky component – light arriving at a point in a room coming directly from the sky
2. The externally reflected component – light arriving at a point in a room reflecting into it from an external obstruction
3. The internally reflected component – light arriving at a point in a room having been reflected from an internal surface.

These three components can be recorded and added to give the overall daylight factor. Modification of the daylight factor method has been proposed by some researchers to allow for the effect of a clear sky and direct sunlight (Khalid, 1996).

### **2.6.2 'Design sky' concept**

This concept is applied together with an established daylight factor for a given space. This method ensures that the required illumination will be reached or exceeded 85 per cent of the time, but it does not show the distribution pattern or quality. The major shortcoming of this concept is that it is based on the 'daylight factor' concept with all its shortcomings (Salisu, 2015).

### **2.6.3 'Total Flux' Concept or Lumen Concept**

The lumen method is recommended by the Illuminating Engineering Society of North America. In this method, natural light received inside a room is a function of light incidence on the window

plane (Khalid, 1996). This method allows for the estimation of absolute illuminance values at three stations inside a room. The first point is located at 5 feet from the window wall, the second is in the center of the room and the third is 5 feet from the back wall of the room. All these points are on a center line perpendicular to the window wall and at 0.75 meters above the floor level.

According to Khalid, (1996) the illuminance at any of the three station points can be found as follows

$$E = E_s A_g T_g C_s K_s + E_g A_g T_g C_g K_g$$

Where:

$E_p$  = absolute illuminance value at the station point

$E_s$  = exterior illuminance from the sun and the sky incident on the window

$A_g$  = area of glazing

$T_g$  = transmission of glazing

$E_g$  = exterior illuminance reflected from the ground to the window

$C_s, C_g$  = coefficients representing the relationship between the light reaching the window and the room length, room width and the reflectance of the interior walls of the room

$K_s, K_g$  = coefficients representing the relationship between the light reaching the window and the ceiling height, room width and the reflectance of the interior walls of the room

#### 2.6.4 'Split-flux' concept

Split-flux method, which is an empirical formula for calculating the IRC, based on the formula proposed by Arndt. The split-flux method proposes that one treat the flux entering the room in

two parts. In this method, the window is divided into two parts by a horizontal imaginary plane passing through the center of the room. The first part is the flux coming from the sky and any external obstruction above the imaginary plane. The second part is the flux coming from the ground and any external obstruction falling below the imaginary plane. The first flux summations are then multiplied times the average reflectance of the lower surfaces of the room; the second with the reflectance of the upper surfaces of the room. Then the unit sphere method is applied for the inter-reflection of light. In this way the split-flux formula treats external obstructions in the form of horizontal band of infinite length (Kota,2007).

#### **2.6.5 PSALI (Permanent Supplementary Artificial Lighting of the Interior Concept)**

PSALI is a system of combined artificial lighting and day lighting, where the two are blended together to provide an even illumination. Parts of the room are permanently lit by artificial light (Grant, 2015). PSALI retains most of the psychological advantages of artificial lighting, but can illuminate deeper plan rooms than could be lit with daylight alone. The principle of PSALI is to provide illumination that appears to be of good daylight character even though most of the working illumination may be from artificial light (Grant, 2015)

1. Large variation of light during workday does not adversely affect visual performance.
  - I. Lightness Constance
  - II. Variations in daylight occur slowly over a period of time
  - III. Contrast ratios remain constant
2. Daylight and artificial light are easily combined
3. Supplemental systems must be coordinated so lighting levels do not change abruptly.

PSALI is also used to control the switching of lights on and off as daylight levels go up and down. In bright light, all illumination may be provided by daylight. At night, all lighting is artificial. Light-level switching of luminaires is known as photoelectric switching (Grant, 2015). This concept involved the use of artificial illumination to aid the provision of lighting within deep lecture rooms. With this concept came smaller windows and the insufficient daylight became permanently supplemented by artificial means. This may not be an appropriate solution for the tropics, which has abundant daylight and certainly not for Nigeria where epileptic power supply is common (Salisu, 2015).

#### **2.6.6 Static Point Illuminance and Luminance Measurement Concept**

This concept is based on simulations or measurements under either real or artificial skies, or using computer tools (digital models and lighting software). This concept considers not only the diffused daylight entering a room, but also direct sunlight and its internal lighting effects (Salisu, 2015).

### **2.7 Climate-Based-Daylight-Modelling (CBDM)**

Climate-based daylight modelling is the prediction of various radiant or luminous quantities (e.g. irradiance, illuminance, radiance and luminance) using sun and sky conditions that are derived from standard meteorological datasets. Whilst it hardly needs remarking that daylight is inherently climate-dependent and time varying, the accepted evaluation method, called the daylight factor, makes no account of this everyday reality. The principles of climate-based daylight modelling have been described in various publications since the first reports around the turn of the millennium (Mardaljevic, 2000). However, it is fair to say that acceptance has been slow amongst significant sections of the daylighting community, both practitioners and researchers (Mardaljevic, 2006). The ability to undertake a year round assessment of day lighting using site-specific climatic datasets and orientation of the building into consideration makes this the

methodology of choice for this research. It takes into consideration direct sunlight, diffused daylight and the inter-reflected daylight within a space into consideration when simulating. With access to computer hardware and software at affordable costs, this methodology will counter the limitations of the daylight factor and the single point in time methods (Salisu2015). Using CBDM in place of daylight factors provides far greater detail about light distribution and intensity which allows the building design to be adjusted to maximize the use of sunlight and daylight. Annual weather data are used to calculate lux levels and targets can be set which are relative to user needs (Cundall Johnston and partners, 2015).

With CBDM the direct sun and diffuse components will be dynamic in their intensity and altitude for each façade: north, south, east and west. Therefore while orientation has allows been understood, the analysis and result will now detail the impact of the sunlight and daylight and inform the designer on the quantity and quality of the light within the space (Antonutto, 2013). The EFA Output Specification has a very different approach to daylight design compared with previous building programs and school design guides. In the past, design for daylight within the learning environment has been a numerical process based on a static overcast sky. The ambition was to deliver a certain percentage of diffuse light into the space (daylight factors) and achieve a degree of uniformity (Cundall Johnston and partners, 2015).

Derived from CBDM concept, a set of daylight specific performance indicators have been put forward by the proponents of this concept. These indicators have the ability to quantify and qualify day lighting in climate region, taking into consideration the location of the building and orientation inclusive of most climate peculiarities (Salisu, 2015).

They include:

1. Performance Indicators for Quantity

- a) Daylight Autonomy (DA) at a specified work plane location is defined as the percentage of the year when a minimum target illuminance for the day lit space is met by daylight alone. In

mathematical terms, daylight autonomy is the percentage of annual work hours during which all or part of a building's lighting needs can be met through day lighting alone (lutron, 2013). In general, a Daylight Autonomy threshold of 60% of the work plane illuminance (500 lux) that meets the recommended illuminance requirement is considered good day lighting, especially for lecture rooms(Architectural Energy Corporation, 2006). For values below the prescribed minimum illuminance, a modified version of the above metric known as continuous Daylight Autonomy (DAcon) allocates credit for partial daylight that does not meet the target illuminance (Reinhart et al.,2006, Architectural Energy Corporation, 2006). DA is based on extensive research on lecture rooms and shows how well daylight penetrates into a space with appropriate display of the distribution pattern. In the absence of an upper limit on the allowed illuminance levels (until it meets the DAMax, which is ten times the benchmarked space illuminance level), poorly performing spaces with direct sunlight which is below the DAMax could do quite well with this metric. The DAMax of a factor of ten times the recommended illuminance is not backed by actual research, but is intuitive (Architectural Energy Corporation, 2006 and Reinhart et al., 2006).

b) Useful Daylight Illuminance (UDI)

UDI is defined as the annual occurrence of illuminance across the work-plane that is within a range considered -usefull by occupants – 100 to 2000 lux (Cundall Johnston and partners, 2015). A. They decided to base the criteria on the useful daylight illuminance (UDI) metric. The useful daylight illuminance approach is founded on occupant responses to daylight levels, as reported in several studies (Mardeljevic, Brembilla, & Drosou, 2016).It calculates the percentage of total number of occupied hours that 'useful' daylight enters a space at a selected point on the work plane (Salisu, 2015). It is the provision of ambient light at the work plane at illuminance levels is subdivided into:

UDI<100 represents illumination less than 100 lux.

UDI 100-2000 represents useful daylight

UDI>2000 represents an excess supply of daylight

Thus, only three metrics are used to characterize the hourly-varying daylight illuminances for an entire year at each of the calculation points.

c) Simplified daylight glare probability (DGPs)

A major departure of DGP relative to other metrics summarized in this paper is that glare sources are determined by comparing areas of bright luminance against the total vertical eye illuminance for a viewing hemisphere of  $2\pi$  sr. Therefore, DGP can evaluate direct sunlight falling on a work plane as a glare source while at the same time a dim visible sky might not be perceived as such. Specular reflections can also be seen as glare sources. A glare probability  $>.45$  corresponds to intolerable glare – an estimated 45 percent of people would feel discomfort in such a lighting situation, while a value  $<.3$  is considered imperceptible (Jakubiec & Reinhart, 2012).

d) Spatial Daylight Autonomy (sDA)

It is a single quantitative value for a space unlike the multiple values obtained in the Daylight Autonomy (DA) scheme. It has been put forward quite recently in the IESNA publication IES LM-83 (IES Daylight Metrics Committee, 2012).. It identified two levels for acceptability of performance: ‘Preferred’ and ‘Nominally Accepted’. The ‘Preferred’ level is defined as a space with sufficiency of ambient daylight to meet or exceed 75% of sDA300, 50%, being the analysis points on the horizontal surface that meet or exceed 300 lux for 50% of the analysis period from 8am to 6pm. The ‘Nominally Accepted’ is defined as a space with sufficiency of ambient daylight for at least 55% of sDA300, 50%, being the analysis points on the horizontal surface that meets or exceed 300 lux for 50% of the analysis period from 8am to 6pm. This concept provides a single number for a space, more like the daylight factor (DF). It has already been experimentally

verified to predict occupant satisfaction using a study of 61 different spaces by the authors (IES Daylight Metrics Committee, 2012). On the other hand, the performance metric for all types of spaces are the same- be it a classroom or an office, which may highly be unlikely due to peculiarities of the different working environments. Being a relatively new concept, preconfigured tools for calculations are not available at present. Simplified daylight glare probability DGPs.

## 2. Performance Indicators for Quality

a. Proposed Daylight Autonomy Uniformity Index (DAui). Uniformity has often been expressed in terms of a ratio of two quantities - maximum to minimum, maximum to average and average to minimum illuminance over a work plane (IESNA, 2000). Uniformity in day lighting could also be taken to be the distribution of daylight across the work plane at an assumed height. Salisu, (2015) to assess uniformity in the spaces that have fenestrations on opposite facades, proposed a daylight autonomy uniformity index (DAui). This will be calculated as a ratio of maximum measured daylight autonomy to the average daylight autonomy of the assessed space and the closer this value is to  $\_1$ ; the more the daylight is uniformly distributed in the space.

b. Useful Daylight Illuminance greater than 2000 lux (UDI>2000). Using this indicator, which is one of the three bins of the Useful Daylight Illuminance concept of CBDM, an assessment of the probability of solar gains and glare can be undertaken. Using a threshold of 2000 lux, these two qualities of daylighting in a space can be assessed using simpler and less complicated methods of flagging of potential areas of thermal and visual discomfort. This threshold was arrived at after extensive survey on occupants in day lit office environments under a wide range of illumination conditions (Nabil & Mardaljevic, 2005). Though it will be ideal to achieve a 5% value or less for this performance indicator, the SLL (Society of Light and Lighting, SLL, 2011) has come up with the following criteria:

- i. For new buildings, the combined value of the UDI<100 and UDI>2000 on a horizontal work plane should not exceed 20% of the assessed time of the activity period.

- ii. For refurbished buildings, the UDI>2000 should not exceed 20% of the assessed time.
- c. The Annual Sunlight Exposure (ASE) is a relatively new performance indicator put forward recently by the IESNA. This is a metric that describes the potential for visual discomfort by calculating the number of hours in a year that direct sun is incident on a surface. A threshold of 1000 lux for 250 hours in a year was selected based on user surveys as an indicator for tolerance level that can be used to compare spaces (IES Daylight Metrics Committee, 2012). This metric can flag potential issues of thermal discomfort and glare caused by direct sunlight from the sky, but does not provide for glare from specular reflections or veiling glare. Being a relatively new metric, preconfigured tools for calculations are not available at present (Salisu, 2015).

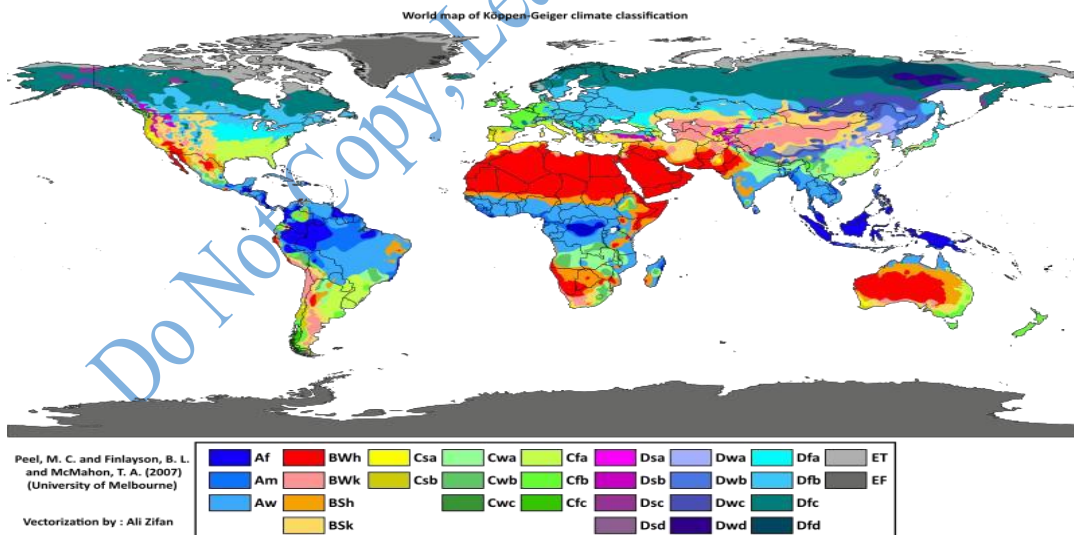
## **2.8 Climate and Day lighting**

Climate is the long-term expression of weather; in the modern world, climate is most noticeably expressed in vegetation and soil types and characteristics of the land surface (Egeh & Okoloye, 2010). The climate of a region is characterized by its fundamental properties of air temperature, the rate and form of precipitation, the rate of evaporation, humidity, cloudiness (including the amount and type of clouds), solar and long wave radiation rates, wind speed and direction, and air pressure (Salisu, 2015) The climatic characteristics of a site can dictate the significance of the use of overcast illumination as a design influence and the use of the mirror box artificial sky as a prediction tool. Projects with sites that experience predominantly overcast conditions can be well served by mirror box artificial sky testing. Primarily sunny climates require different day lighting strategies and might only use the mirror box to check performance for the occasional overcast day. Knowing a project's regional climate and lighting characteristics and understanding the percent of daylight hours each month that the sky is clear versus overcast gives important weight to the hierarchy of decisions about the kinds of day lighting techniques to be used in a design for a given locale (Ball State University,2016).

The quality of day lighting design depends heavily on solar altitude, weather, and other time-dependent environmental factors. Yet very few existing tools provide the user with some understanding of the annual performance of a day lighting design, and similarly few lighting metrics focus on this temporal aspect of light measurement (Siân, Magali, & Marilyne, 2007).

### 2.8.1 Climatic zones

The Köppen climate classification is one of the most widely used climate classification systems. Russian German climatologist Wladimir Köppen first published it in 1884, with several later modifications by Köppen himself, notably in 1918 and 1936. Later, German climatologist Rudolf Geiger collaborated with Köppen on changes to the classification system, which is sometimes referred to as the Köppen–Geiger climate classification system. The system is based on the concept that native vegetation is the best expression of climate. Thus, climate zone boundaries have been selected with vegetation distribution in mind. It combines average annual and monthly temperatures and precipitation, and the seasonality of precipitation (Liquidsearch, 2016).



**Plate 1 The Köppen climate classification.**

Source: Peel, Finlayson, & McMahon 2002

The Köppen climate classification scheme divides climates into five main groups (A, B, C, D, and E), each having several types and subtypes. Each particular climate type is represented by a two- to four-letter symbol.

Group A: Tropical/mega thermal climates:

Tropical rainforest climate (*Af*)

Tropical monsoon climate (*Am*)

Tropical wet and dry or savanna climate (*Aw*)

Group B: Dry (arid and semiarid) climates:

Desert climate BW: Hot desert (*BWh*), Cold desert (*BWk*)

Steppe climate (Semi-arid) BS: Hot steppe (*BSh*), Cold steppe (*BSk*)

Group C: Temperate/mesothermal climates:

Dry-summer or Mediterranean climates (*Csa*, *Csb*, *Csc*)

Temperate or subtropical hot-summer climates (*Cwa*, *Cfa*)

Maritime temperate climates or Oceanic climates (*Cwb*, *Cwc*, *Cfb*, *Cfc*)

Maritime subarctic climates or subpolar oceanic climate (*Cfc*)

Temperate highland climates with dry winters (*Cwb*, *Cwc*)

Group D: Continental/microthermal climates

Hot summer continental climates (*Dsa*, *Dwa*, *Dfa*)

Warm summer continental or hemiboreal climates (*Dsb*, *Dwb*, *Dfb*)

Continental subarctic or boreal (taiga) climates (*Dsc, Dwc, Dfc*)

Continental subarctic climates with extremely severe winters (*Dsd, Dwd, Dfd*)

Group E: Polar and alpine climates:

Tundra climate (*ET*)

Ice cap climate (*EF*)

### **2.8.2 Climatic Zones in Nigeria**

Nigeria is located along the West African coast in between latitudes 3°-15°E and longitudes 4°-14°N with a distinctly tropical climate that varies from the damp and very humid in the south to the hot and semi-arid climate in the north. Divisions of the country into southern and northern regions are obviously simplistic and lacking in scientific conviction. The country has three distinct climate types according to the Köppen system as modified by Trewartha and Horn, 1980. This is noticeable as one moves from the southern region through the middle belt and up to the northern states (Salisu, 2015).

In line with its close proximity to the equatorial belt and the Atlantic Ocean, Temperatures are generally high and consistent, and seasons are more aptly characterized by the difference in rainfall than a change in the mercury. For example, in Lagos, the average high in January is 31°C and 23°C, and in June it's 28°C and 23°C; though June is the season with peak rains and in January one would be lucky to see the smallest drop of water squeezed from the sky. In the south of the country, a coastal region that includes Lagos and the oil-rich area of Port Harcourt, it's incredibly humid, but it rarely gets hotter than 32°C. This area is defined by two rainy periods, one short period and one long period (Expatarrivals, 2016).

#### **a. The Tropical Wet Climate**

The Tropical Wet Climate is found in the southern part of the Nigeria and extends to the confluence of the two main rivers in the middle belt region of the country. The weather is constantly warm and humid with a lot of rainfall as the major characteristic of this climate, averaging over 2000mm which goes up to 4000mm in the coastal regions. The cloud cover can be quite substantial with the position of the sun remaining high throughout much of the day resulting in cloudy days. The prevalent ecology is the rainforest which is characterized by a huge variety of plants which grow all year round, insects and animals (Salisu, 2015).

b. Tropical Wet and Dry Climate or Tropical Savanna Climate

The tropical wet-and-dry climate regions are located adjacent or around tropical wet climates, but in more elevated regions, occurring in uplands at altitudes of 500m or higher. The first major characteristic of this climate is that it has a distinct dry season during when hardly any rainfall occurs. This season occurs for periods of between three to six months. Annual total rainfall for this climatic type usually range from 1000mm to 1500mm. Cloud cover patterns follow the rainfall during the wet season and clear skies during the dry. The dry season is distinguished by high monthly mean temperatures of up to 40°C with a correspondingly monthly mean minimum temperatures as low as 13°C. After the wet season, a dry, harsh, cold and dusty period of two to three months known as the harmattan precedes the dry season. During this period the skies are mostly overcast. The major ecology of this climate is the savannah, which consists of flat grassland with occasional groups of trees or individual trees (Salisu, 2015).

c. The Hot-Semiarid Climate or Steppe Climate

Semi-arid climates have little rainfall and are usually located in-between the tropical wet- and – dry climates and the desert climates. The predominant feature of this climate is that it is dry with hot weather for significant periods of the year. It has the characteristics of dryness (both in rainfall and relative humidity). The hot dry season comes with clear skies and hot winds, while at the end

of the year, a cold and dusty harmattan for about three months becomes the dominant feature. The amount of rainfall in this region varies between 250 to 750mm per year and occurs for a period of three or four months starting from May or June and is normally brief and intense. However, despite when the rainfall occurs, the sky is generally clear and the annual precipitation rate is less than the sum of the potential rate of evaporation of groundwater and the water lost by transpiration of plants (Heerwagen, 2004). The major ecology of this climate type is the Sahel savannah made up of shrubs and grassland with occasional trees. (Salisu, 2015)

Similar to most of West Africa, Nigeria's climate is characterized by strong latitudinal zones, which become progressively drier moving from the north from the coast. Rainfall is the key climatic variable, there are timed alternation between the wet and dry seasons in most areas. Two air masses control rainfall--moist northward-moving maritime air coming from the Atlantic Ocean and dry continental air coming south from the African landmass (U.S. Library of Congress, 2015).

Temperatures throughout Nigeria are generally high; temperature variations during the day are more pronounced than seasonal one's with highest temperatures occur during the dry season; rains moderate afternoon highs during the wet season. Average highs and lows for Lagos are 31° C and 23° C in January and 28° C and 23° C in June. Although average temperatures vary little from coastal to inland areas, inland areas, especially in the northeast, have greater extremes. There, temperatures reach as high as 44° C before the onset of the rains or drop as low as 6° C during an intrusion of cool air from the north from December to February. Topographic relief plays a significant role in local climate only around the Jos Plateau and along the eastern border highlands (U.S. Library of Congress, 2015).

### **2.8.3 Technology for Climate-Based-Daylight-Modelling**

Several software can be used in implementing a Climate-Based-Daylight-Modelling study. These tools include Radiance, a lighting software (a UNIX based software), Ecotect Analysis (a

Windows based building simulation software) and Daysim (a Windows - based annual daylight analysis tool).

#### 1) Autodesk Ecotect Analysis

Autodesk Ecotect Analysis is a stand-alone tool for climate-responsive, pre-design analysis of weather and solar site data, Ecotect is a standalone program that can read model files from other programs such as AutoCAD, Max, Maya Sketchup, etc. for analysis (Marchese, 2006). It was developed as a Windows-based environmental analysis and building simulation software by Dr. Andrew Marsh, The software has the ability to export models/drawings with all the embedded building data and import results of analysis and visualizations in various formats. It provides a logical 3-D interface for parametric modelling with plug-ins to more specialized software like Radiance, EnergyPlus and Daysim for analysis (Salisu, 2015).

One of the functions of the software is that it can analyze simple natural lighting performances of buildings with illuminance at points based on the daylight factor concept It executes this using the British Research Establishment (BRE) split-flux method for determining the natural light levels at points within a model. For more accurate and comprehensive lighting analysis, it can output Radiance scene files for direct input into Radiance Lighting Simulation System (Salisu, 2015).

#### 2) Radiance Lighting Simulation and Rendering System

Radiance lighting simulation and rendering system is a physically-based rendering system tailored to the demands of lighting design and architecture developed by author at Lawrence Berkeley Laboratory (LBL) and Ecole Polytechnique Federale de Lausanne (EPFL) in Switzerland.

The simulation uses a light-backwards ray-tracing method with extensions to efficiently solve the rendering equation under most conditions (Ward, 1994). According to Ward, (1994) the principal design goals of Radiance were to:

- i. Ensure accurate calculation of luminance.

- ii. Model both electric light and daylight.
- iii. Support a variety of reflectance models.
- iv. Support complicated geometry.
- v. Take unmodified input from CAD systems.

These goals reflect many years of experience in architectural lighting simulation; some of them are physically-motivated, others are user-motivated. All of them must be met before a lighting simulation tool can be of significant value to a designer (Ward, 1994). It has been found to be more accurate in predicting illumination levels than most of the lighting software used in determining illumination in a space, though with the disadvantage of being slow and non-user friendly (Ubbelohde & Humann, 1998)

## **2.9 Findings from Literature Review**

This chapter was devoted to reviewing relevant literature that pertains to this study with the aim of identifying gaps, which exists in the study of day lighting. The review identified different strategies of harnessing day lighting and identified side windows as the easiest and most commonly used for multi-story buildings. The review revealed a systematic development of daylight assessment methods and concepts, of day lighting developed through the years. A new concept known as CBDM came into being to assess the dynamic quantities and qualities of day lighting. A new quality assessment index, known as Daylight Autonomy Index (DAui), was put forward along with the useful daylight index (UDI)

## **Chapter 3**

### **Methodology**

#### **3.1 Introduction**

The Faculty of Architecture is committed to the study of the natural and artificial systems primarily comprising cities, buildings and industrial products. The Faculty and its curricula are organized around two basic disciplines of design and planning. Problems ranging from the creation of industrial products and architecture to landscapes and settlement systems are covered in lectures, field work and studios, where the aim is to bring together knowledge, methodology, theory and high levels of professional skills within the framework of projects.

The curricula have a further aim of advancing a professional capacity in students to:

- interrelate the local and the universal within the processes of design and planning of space, built form and industrial products,
- identify and formulate problems, along with the generation and interpretation of knowledge relevant to the discipline, social and cultural contexts under study,
- increase technical know-how, aesthetic sensibilities and moral concerns,
- ensure specialization in key areas of interdisciplinary nature,
- Improve quality of research and design at every scale of person-environment interaction, with special emphases on energy, housing and settlement forms -both those that refer to our cultural heritage and those of a universal kind.

Within the scope of its commitments, the Faculty aims to promote its relation with the other national and international universities and undertakes pure and applied research, consultancy to public and

private sectors and associative functions in the professional milieu both at national and international levels.

The Faculty of Architecture has opportunities for scholarly and applied research as well as design work which the staff and students engage in at different levels. The aim of the research programs is to contribute to knowledge, to promote good design and integrated planning as well as to provide pertinent material for more comprehensive teaching. Students are encouraged to participate in research at undergraduate, Master's and Doctoral levels, and through it are brought into direct contact with the actual conditions and practical problems in Turkey and the world. The staff are all highly qualified and well-versed in their subjects. The students who choose to come to Faculty of Architecture have consistently been the best prepared and most motivated ones.

### **3.1.1 List of Selected Case Studies**

The case studies were aimed out on 3 existing faculty buildings in Nigeria and 3 international faculty buildings which are:

- I. Daniels faculty of architecture, university of Toronto, Canada.
- II. Faculty of architecture, university of Porto, Portugal. (faup)
- III. School of architecture, university of Miami,
- IV. Faculty of environmental design and management, university of Ife, Osun state
- V. Faculty of environmental science, university of Lagos, Lagos state
- VI. Faculty of environmental studies, the polytechnic Ibadan.

### **3.1.2. Factors to Consider in Case Studies for Maximizing Visual Comfort and Natural Lighting**

When evaluating a design for day lighting, a number of architectural factors can be taken into consideration to ascertain the effectiveness of their approach. Day lighting is the

intentional use of natural light to illuminate a building's interior spaces. The following are possible objections to an architectural firm's usage of day lighting:

Several elements should be taken into account while conducting case studies for enhancing visual comfort and natural lighting in a university building in order to comprehend and assess the design solutions used. Here are some important details to remember:

1. Orientation and Site Analysis: Analyze the faculty building's orientation in relation to the site and how that orientation influences how natural light is distributed throughout the day. While buildings with bad orientation may find it difficult to maximize natural light, those with the best solar orientation might benefit from day lighting options.
2. Day lighting Strategies and Techniques: Examine the building's design's use of day lighting techniques. This includes how windows are positioned and how big they are, whether skylights or light wells are used, and whether reflective surfaces are used to improve day lighting in deeper parts of the building.
3. Interior Layout and Space Functionality: Look at the interior design to see how nicely the rooms are arranged in respect to the light. Offices, study areas, and other locations that require a lot of natural light should be placed in a way that allows for optimal natural lighting.
4. Glazing and Shading Systems: Assess the efficacy of the shading systems and the type of glazing used in windows. Natural light can be maximized while glare and solar heat gain are controlled through high-performance windows. Additionally, shading elements like shades, overhangs, or louvers should be created to control light levels as necessary.

5. Interior Design and Light Colors: Keep the color scheme and interior design in mind. Light-colored materials and surfaces can assist direct natural light farther into rooms, minimizing the need for artificial lighting.
6. Integration of Artificial Lighting: Analyze the relationship between natural and artificial illumination. The structure should include responsive lighting controls that change the intensity of artificial lighting in response to the presence of natural light, maintaining proper brightness levels and consuming the least amount of energy possible.
7. Day lighting Simulation and Analysis: Review the outcomes of day lighting simulations or analyses performed throughout the design process, if they are available. This information can be quite helpful in predicting how well the building's day lighting measures will work.
8. User Comfort and Well-being: Take into account comments made by users or residents of the faculty building regarding their experience with visual comfort. Surveys or post-occupancy evaluations can offer insightful input on how well the design creates an environment that is aesthetically comfortable.
9. Sustainability and Energy Efficiency: Examine the structure's energy usage and contrast it with those of similar buildings. Reduced reliance on artificial lighting and, thus, lower energy usage for lighting should be evident in a well-designed college building with optimal day lighting.
10. Adaptability and Flexibility: Analyze the building's ability to adjust to shifting daylight circumstances over the course of the year. A more adaptable and comfortable environment is offered by structures that can handle different light levels and human preferences.

11. Natural Ventilation: In some circumstances, enhancing natural light may also involve natural ventilation techniques. Examine how the design keeps visual comfort and day lighting objectives while including natural ventilation solutions.

12. Impact on Productivity and Learning: Take into account studies on how natural light, eye comfort, and productivity interact in learning environments. Buildings that effectively utilize natural light may have a positive effect on how well students learn and how productive staff members are. The success and efficacy of the design solutions for improving visual comfort and natural lighting in faculty buildings can be better understood by taking these elements into account during case studies.

By considering these factors during case studies, one can gain valuable insights into the success and effectiveness of the design strategies for maximizing visual comfort and natural lighting in faculty buildings.

S/N	FACTORS	GOOD	FAIR	POOR
I.	<b>Orientation and Site Analysis:</b>	✓		
II.	<b>Day lighting Strategies and Techniques</b>		✓	
III.	<b>Interior Design and Light Colors</b>	✓		
IV.	<b>Interior Layout and Space Functionality:</b>	✓		
V.	<b>Glazing and Shading Systems:</b>	✓		
VI.	<b>Interior Design and Light Colors:</b>		✓	

VII.	<b>Integration of Artificial</b>		✓	
VIII.	<b>Day lighting Simulation and Analysis:</b>	✓		
IX.	<b>User Comfort and Well-being:</b>	✓		
X.	<b>Sustainability and Energy Efficiency</b>		✓	
XI.	<b>Adaptability and Flexibility:</b>	✓		
XII.	<b>Natural Ventilation</b>	✓		
XIII.	<b>Impact on Productivity and Learning</b>	✓		

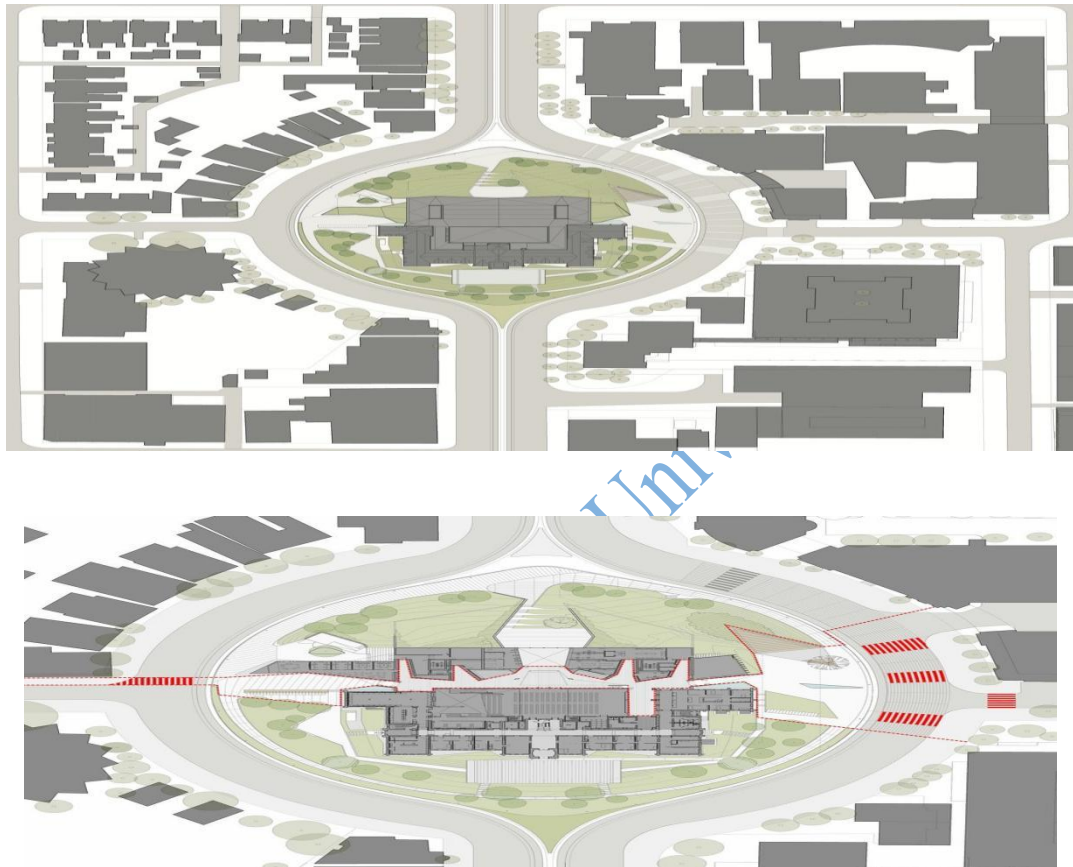
### 3.2 Case study analysis

#### 3.2.1 Description of the building (Case study 1)

**Daniels faculty of architecture, university of Toronto, Canada.**

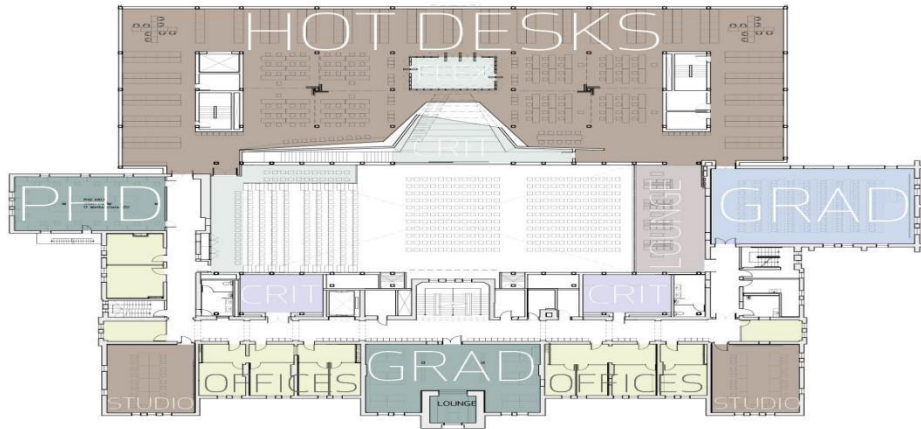
The building is named John H. Daniels Faculty of architecture, university of Toronto, Canada. The faculty embodies a holistic approach to urban design and sustainability. As the new home for the John H. Daniels Faculty of architecture, landscape, and design, its purpose is to engage students and the broader community in dialogue about the built environment. At the center of one of Toronto's few circular parcels, the project anchors the southwest corner of the University and opens the circle to the public after years of inaccessibility. It restores the historic and forgotten building to its original grandeur while also integrating a new addition. The north-south axis characterizes symbolic

relationships to the City, while the east-west axis is activated by pedestrian traffic. On the western edge, a discreet arcade addresses the residential scale of the adjacent neighborhood.



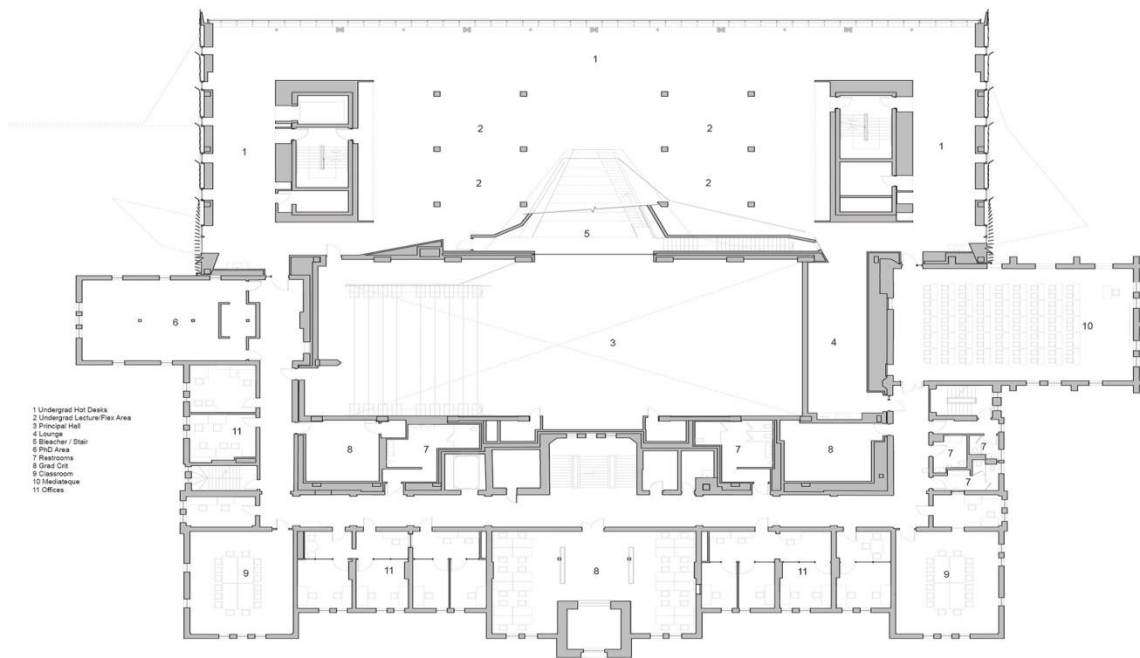
**Figure 1; Site plan faculty of architecture u.o.t. Canada**

(Source; Google search)



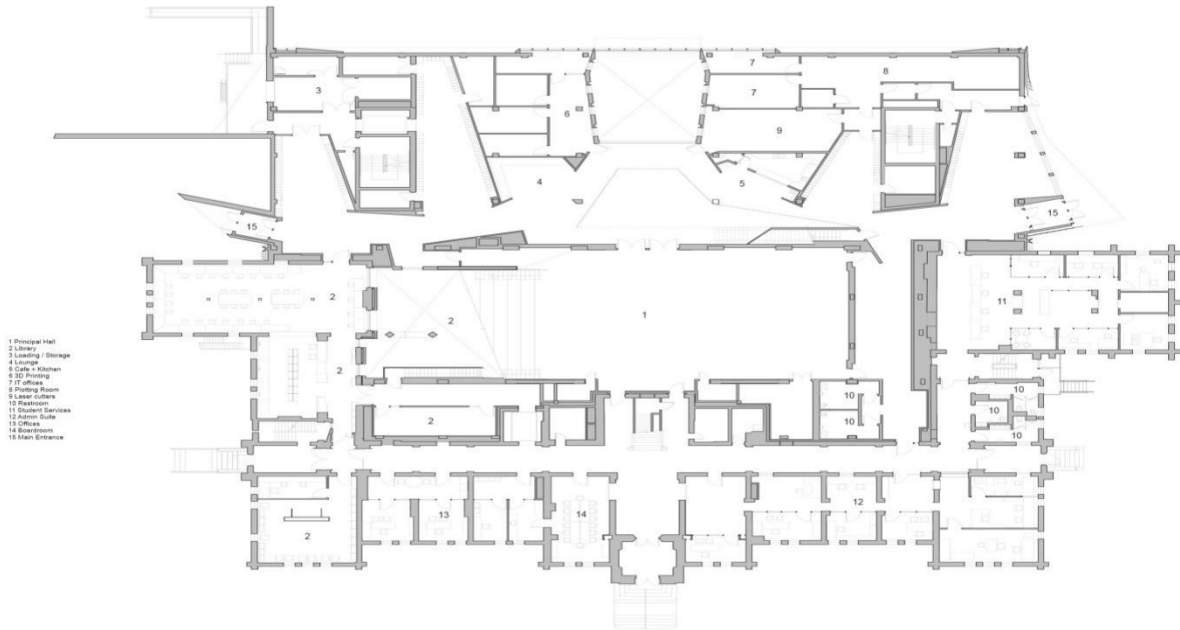
**Figure 2; Floor plan faculty of architecture u.o.t. Canada**

(Source; Google search)



**Figure 3; Floor plan faculty of architecture u.o.t Canada**

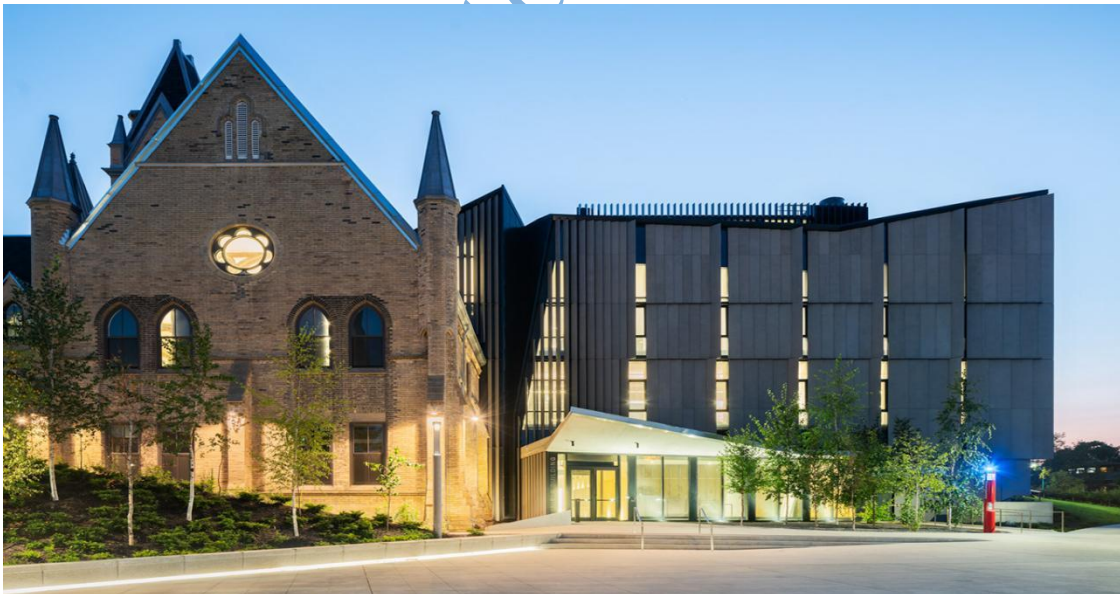
(Source; Google search)



**4; Floor plan faculty of architecture u.o.t. Canada**

(Source; Google search)

Figure



**Figure 5; 3 Dimensional view**

(Source; Google search)



**Figure 6; right/east view**

(Source; Google search)



**Figure 7; 3d view with good landscape**

(Source; Google search)



**Figure 8; Well organized presentation**



**Well circulated stair hall**

(Source; Google search) Figure 9;



**Figure 10; Lecture theatre**



**Figure 11; well stocked library**

(Source; Google search)

### **3.2.2. Appraisal of the Building**

## Merits

- . Good ventilation through good plan widths
- . Good lighting through the orientation of the building
- The combination of soft and hard landscape for efficient courtyard
- Efficient access and exit to the faculty
- . High quality finishes on walls and floors
- East-west orientation which reduces exposure to solar radiation
- Good considerable access for disable with ramps at lecture entrances
- Large courtyard space for reading, group discussion and circulation

## Demerits

- . Uncovered terrace at the second floor that give way for architectural defect.
- . Limited access for parking.
- . Layout of the building lacks an intuitive and cohesive flow.
- Poor zoning of administrative section in the faculty.
- Parking lot not defined.

### 3.2.3. Visual Comfort and Natural Lighting Consideration Factors

- **Accessibility and circulation**

Entrance into the building is seeing from the approach which is attached to the reception hall. Vertical circulation is used which moves from the stair to lobbies, connected to every offices and other facilities and back to the stair hall.

- **Daylight strategies**

The faculty building draws day lighting from both sidelight and skylight concept of daylight strategies. Illumination enters the building through south and north orientation with wide and high windows which is seeing around the building including lecture rooms and studio. Day lighting is also been tapped from the sky through the sky light with transparent roofing sheet been used. This two strategies gives the faculty excellent introduction of daylight, with every part of the building enjoys natural light without issues of dark area. Courtyard is introduced in the faculty to further throw natural lighting into the lobbies and offices.

- **Shading device**

There is presence of shading device around some part of the building. This shading device came inform of projected walls, fin walls and overhangs which helps to reduce driving rain and curb the effect of glare that might cause discomfort to the students and staffs.

- **Ventilation**

The faculty building is conducive for learning due to the free airflow that enters the building through openings such as doors and windows. Also there is use of artificial source of ventilation through air conditioners in many parts of the building. Both means of ventilation is achieved which makes the building comfortable for its users.

- **Fire safety measures**

Fire escape route is taken into consideration in this building. Lobbies are linked directly to the stair hall for evacuation of students and staffs in case of emergency. Fire extinguishers, fire space routes and sand pots are positioned at required points to curb effect of any fire outbreak. Emergency exit is created with spacious stair hall to allow easy passage of students and staff in case of fire outbreak.

S/N	FACTORS	GOOD	FAIR	POOR
I.	Orientation and Site Analysis:	✓		
II.	Daylighting Strategies and Techniques		✓	
III.	Interior Design and Light Colors		✓	
IV.	Interior Layout and Space Functionality:	✓		
V.	Glazing and Shading Systems:	✓		
VI.	Interior Design and Light Colors:		✓	
VII.	Integration of Artificial		✓	
VIII.	Daylighting Simulation and Analysis:		✓	
IX.	User Comfort and Well-being:	✓		
X.	Sustainability and Energy Efficiency		✓	

<b>XI.</b>	<b>Adaptability and Flexibility:</b>	✓		
<b>XII.</b>	<b>Natural Ventilation</b>		✓	
<b>XIII.</b>	<b>Impact on Productivity and Learning</b>	✓		

### 3.3 Description of the Building (Case Study 2)

#### **Faculty of Architecture of the University of Porto (FAUP)**

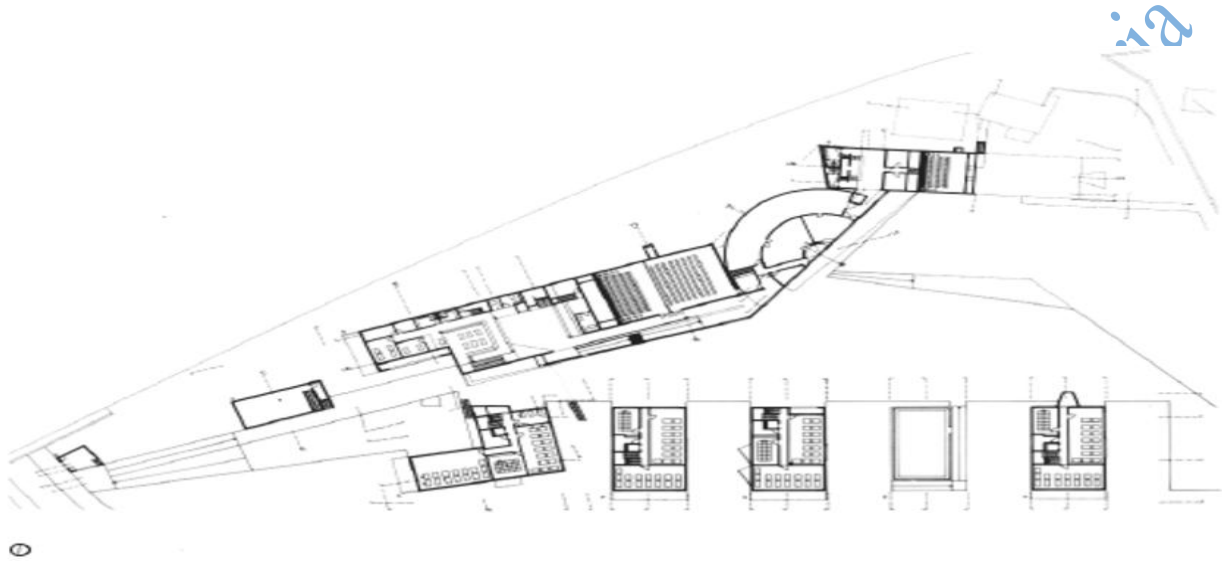
The Faculty of Architecture of the University of Porto (FAUP), is located west of the center of the city of Porto, Panorâmica Via Edgar Cardoso, 4150-755, Portugal, in the Campo Alegre, where even many nineteenth-century villas are preserved and enjoys abundant vegetation. It is a floor terraces above the river mouth.

The location of the School whose first site was allocated for the project in 1984, has two major territorial characteristics:

1. It is a space being on the banks of the Duero River presents a landscape and a remarkable vegetation.
2. Being located in the middle of the access to the Porto-Lisbon motorway is given an intermediate and peripheral character.

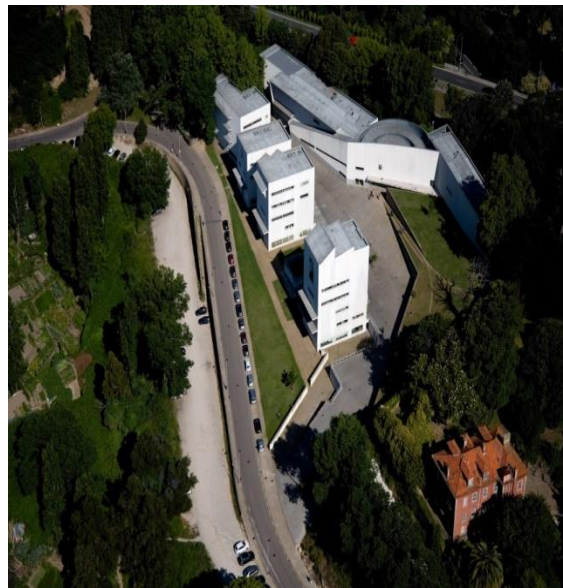
Adjacent to the old stone wall of the estate, the new faculty buildings stretch out along two vertices of the triangular site, enclosing between them a courtyard and meeting place. Between 1985 and 1996, the architect, Alvaro Siza Vieira carries out the design and construction of the Faculty of Architecture of

the city of Porto until then was integrated into the Faculty of Fine Arts. Functionalist architect trend is resolved in your project all future problems that a building of this magnitude can reach present without neglecting other important issues such as shape, space. The first building was built between 1984 and 1986 year in which the adjoining plot that allowed the construction was obtained grow, stretching its construction until 1996



**Figure 12; Site Plan of Faculty of Architecture, University of Porto, Portugal. (Faup)**

(Source; Google search)



**Figure 13; Area View**

**Figure 14; Area View with Adjoining Road**

(Source; Google search)



**Figure 15; Well Defined Approach**

**Figure 16; 3 Dimension View**

(Source; Google search)

Do Not Copy, Lead C...



**Figure 17; Linear parking lot of the faculty**

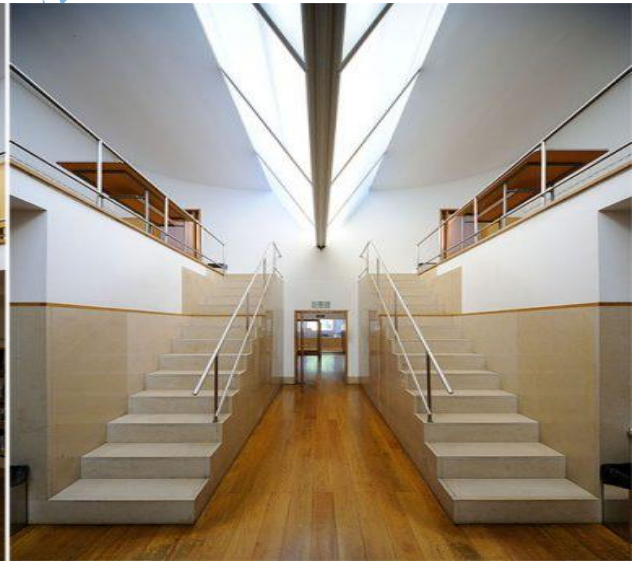


**Figure 18; Perspective view of the faculty**

(Source; Google search)



**Figure 19; Well Stocked Library**



**Figure 20; Dual Stair Case access to other space**

(Source; Google search)



**Figure 21; Good / Gentle Ramp**



**Figure 22; Well Lighted Reading Area**

(Source; Google search)

### **3.3.1 Appraisal of the Building**

#### **Merits**

- Good ventilation through good plan widths
- Good lighting through the orientation of the building
- The combination of soft and hard landscape for efficient courtyard
- Efficient access and exit to the faculty
- High quality finishes on walls and floors
- East-west orientation which reduces exposure to solar radiation
- Good considerable access for disabled with ramps at lecture entrances

- Large courtyard space for reading, group discussion and circulation

#### **Demerits**

- Uncovered terrace at the second floor that give way for architectural defect.
- Limited access for parking.
- Layout of the building lacks an intuitive and cohesive flow.
- Poor zoning of administrative section in the faculty.
- Parking lot not defined.

### **3.3.2. Visual Comfort and Natural Lighting Consideration Factors**

- **Accessibility and circulation**

Entrance into the building is seeing from the approach which is attached to the reception hall. Vertical circulation is used which moves from the stair to lobbies, connected to every offices and other facilities and back to the stair hall.

- **Daylight strategies**

The faculty building draws day lighting from both sidelight and skylight concept of daylight strategies. Illumination enters the building through south and north orientation with wide and high windows which is seeing around the building including lecture rooms and studios. Day lighting is also been tapped from the sky through the sky light with transparent roofing sheet been used. This two strategies

gives the faculty excellent introduction of daylight, with every part of the building enjoys natural light without issues of dark area. Courtyard is introduced in the faculty to further throw natural lighting into the lobbies and offices.

- **Shading device**

There is presence of shading device around some part of the building. This shading device came inform of projected walls, fin walls and overhangs which helps to reduce driving rain and curb the effect of glare that might cause discomfort to the students and staffs.

- **Ventilation**

The faculty building is conducive for learning due to the free airflow that enters the building through openings such as doors and windows. There's presence of openings on all sides of the building. The opening gives easy passage of air in and out of the spaces which makes the building comfortable for its users.

- **Fire safety measures**

Fire escape route is taken into consideration in this building. Lobbies are linked directly to the stair hall for evacuation of students and staffs in case of emergency. Fire extinguishers, fire space routes and sand pots are positioned at required points to curb effect of any fire outbreak. Emergency exit is created with spacious stair hall to allow easy passage of students and staff incase of fire outbreak.

S/N	FACTORS	GOOD	FAIR	POOR
I.	<b>Orientation and Site Analysis:</b>	✓		

II.	Daylighting Strategies and Techniques		✓	
III.	Interior Design and Light Colors	✓		
IV.	Interior Layout and Space Functionality:	✓		
V.	Glazing and Shading Systems:			✓
VI.	Interior Design and Light Colors:	✓		
VII.	Integration of Artificial		✓	
VIII.	Daylighting Simulation and Analysis:		✓	
IX.	User Comfort and Well-being:	✓		
X.	Sustainability and Energy Efficiency	✓		
XI.	Adaptability and Flexibility:		✓	
XII.	Natural Ventilation	✓		
XIII.	Impact on Productivity and Learning	✓		

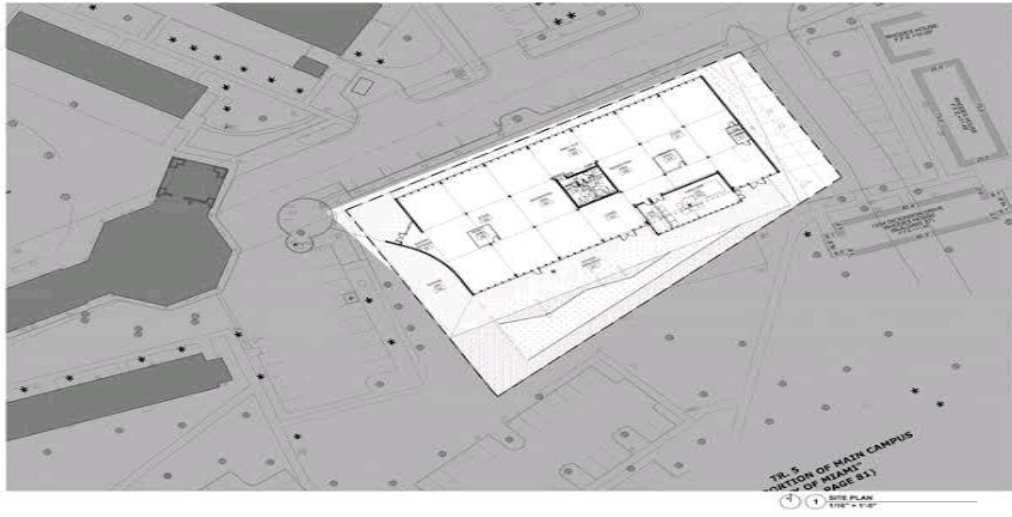
### 3.4 Building Description (Case Study 3)

**School of architecture, university of Miami, Coral Gables, FL, United States.**

The faculty is named school of architecture, university of Miami. Located at Coral Gables, FL, United States. Designed and build by Arquitectonica in 2018 with size 10,000 sqft - 25,000 sqft at the center of an intersection, creating a plaza and adjoining pathway that act as a link from the campus to the

Miami Metrorail. The southern wall peels away to address the portico of the existing auditorium and gallery. The warping corner of the roof folds over the southernmost tip of the building, shading the interior space from the strongest sunlight. The building has tall and flexible spaces, both indoors and outdoors. Narrow steel pipe columns support the 18-foot high ceilings to create a sense of openness and allow natural light to permeate the building. Operable windows encourage fresh air and reduced use of air conditioning.

The studio space is based on a twenty-five-foot square module of four student desks repeated to total 13,000 square feet. The main entrance spills into an informal lobby and continues as a corridor that runs through the studios and out a garage door into the rear access road. The corridor has movable boards and model podiums for informal critiques or exhibitions. The studios on the south side of the circulation passage are intended for the design-build studio courses and have direct access to the outdoor work area. Within the space, there are smaller volumes including the fabrication lab, which punctures the façade. The open plan accommodates seventy-six desks and is adaptable to future work/study styles. The faculty offices are movable and could be redesigned and rebuilt by students each year, making a setting for creativity and collaboration. The new studio building for the University of Miami provides a space conducive to learning and studying, but also serves as a teaching tool by illustrating some of the basic tenets of modern architecture. The new studio building can operate throughout the daytime hours without the need for artificial lighting.



**Figure 23; Layout of the school of architecture Miami University**

(Source; Google Imagery)



**Figure 24; Approach view of the school of architecture with adjoining road**

(Source; Google Imagery)



**Figure 25; Picture showing wide expanse of fixed glass which gives enough illumination into the building layout of the school of architecture Miami University.**

(Source; Google Imagery)



**Figure 26; Picture showing wide studio space which is well lit through the side light of lighting strategy.**

(Source; Google Imagery)



Figure 27; Picture showing spacious lecture room



Figure 28; Picture showing well

defined staff lounge studio.

(Source; Google Imagery)



**Figure 29; Picture showing spacious general staff office      Figure 30; Picture showing cad room  
for training of software**

(Source; Google Imagery)



**Figure 31; Picture showing adequate wood and metal workshop with external premises for  
continuous workshop practice**

(Source; Google Imagery)



**Figure 32; Picture showing efficient roofing style which shades the building from driving rain and glare which might cause discomfort to students.**

(Source; Google Imagery)

### **3.4.1. Appraisal of the Building**

#### **Merits**

- Good ventilation through good plan widths
- Good lighting through the orientation of the building
- The combination of soft and hard landscape for efficient courtyard
- Efficient access and exit to the faculty
- High quality finishes on walls and floors
- East-west orientation which reduces exposure to solar radiation
- Good considerable access for disable with ramps at lecture entrances

#### **Demerits**

- Limited access for parking.
- Layout of the building lacks an intuitive and cohesive flow.
- Parking lot not defined.
- extinguishers, fire space routes and sand pots

### **3.4.2. Visual Comfort and Natural**

- **Accessibility and circulation**

Entrance into the building is seeing from the approach which is attached to the reception hall. Vertical circulation is used which moves freely from one space to another and to lobbies, connected to every offices and other facilities.

- **Daylight strategies**

The faculty building draws day lighting from the sidelight concept of daylight strategies. Illumination enters the building through south and north orientation with wide and high windows which is seeing around the building including lecture rooms and studios.

- **Shading device**

There is presence of shading device on the building. This shading device came in form of projected roofing style which shades the interior spaces automatically. It helps to reduce driving rain and curb the effect of glare that might cause discomfort to the students and staffs.

- **Ventilation**

The faculty building uses artificial source of ventilation as the openings in the building are fixed. No natural ventilation can penetrate into the building. This source also gives easy passage of air in and out of the spaces which makes the building comfortable for its users.

- **Fire safety measures**

Emergency exit is created with spacious door way to allow easy passage of students and staffs in case of fire outbreak. But no fire equipment seen.

S/N	FACTORS	GOOD	FAIR	POOR

XIV.	<b>Orientation and Site Analysis:</b>	✓		
XV.	<b>Daylighting Strategies and Techniques</b>	✓		
XVI.	<b>Interior Design and Light Colors</b>		✓	
XVII.	<b>Interior Layout and Space Functionality:</b>	✓		
XVIII.	<b>Glazing and Shading Systems:</b>	✓		
XIX.	<b>Interior Design and Light Colors:</b>		✓	
XX.	<b>Integration of Artificial</b>		✓	
XXI.	<b>Daylighting Simulation and Analysis:</b>	✓		
XXII.	<b>User Comfort and Well-being:</b>		✓	
XXIII.	<b>Sustainability and Energy Efficiency</b>		✓	
XXIV.	<b>Adaptability and Flexibility:</b>	✓		
XXV.	<b>Natural Ventilation</b>			✓
XXVI.	<b>Impact on Productivity and Learning</b>	✓		
XXVII.				

### 3.5 Building Description (Case Study 4)

## **Faculty of environmental design and management, university of Ife**

The building is named faculty of environmental design and management, university of Ife, Ile- Ife, Osun state. The faculty is a 2 floors building which has so many spaces in it like the offices, studios, laboratories, conveniences, meeting room, H.o.ds offices etc. This spaces are regularly used and has proper illumination and ventilation. The faculty is sub divided into different sections like, the technical, academics, utility, non-academic and the administrative block. Faculty of environmental science has a wide vertical window, a simple and clear form and a free façade, the building has 5 different department with the sixth in view from the oral interview conducted. The department are as follows

- Architecture
- Urban and regional planning
- Estate management
- Quantity survey
- building Technology

### **Sections in the faculty**

The above mentioned spaces are jointly grouped sections by sections according to their functions and usefulness, these sections systematically listed as below;

- The technical section
- The academics
- The utility

- The non-academics
- The administrative section



**Figure 33; Aerial View of Faculty of Environmental Design and Management**

(Source: Author's field work)



**Figure 34; Well Illuminated, spacious lobby, of the faculty**

(Source; Author's field work)



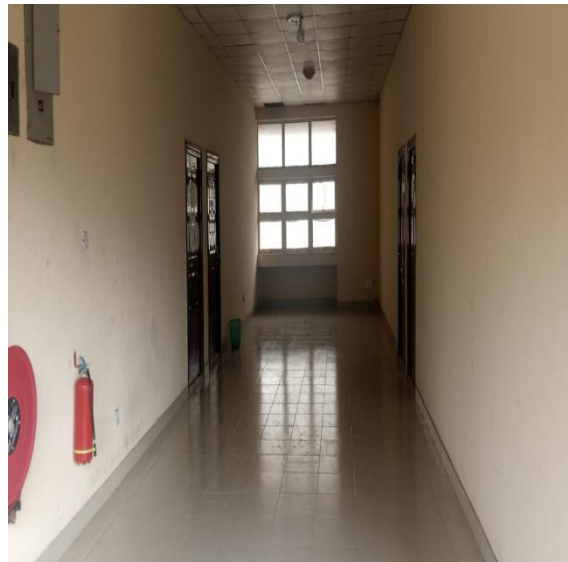
**Figure 35; Spacious Parking Lot**

**Figure 36; Well Illuminated and Ventilate Studio**

(Source; Author's field work)



**Figure 37; Spacious Lecture Room**



**Figure 38; Wide Lobby connecting offices**

(Source; Author's field work)

### 3.5.1 Appraisal of the Building

#### Merits

- Well celebrated and well defined entrance.
- Good circulatory lobby.
- Provision of exit doors for escape.
- Well defined parking lots.
- Well ventilated and well lighted usable space.

### 3.5.2. Visual Comfort and Natural Lighting Consideration Factors

- **Accessibility and circulation**

Entrance into the building is seeing from the approach which is attached to the reception hall. Vertical circulation is used which moves from the stair to lobbies, connected to every offices and other facilities and back to the stair hall.

- **Daylight strategies**

The faculty building draws day lighting from the sidelight concept of daylight strategies. Illumination enters the building through south and north orientation with wide and high windows which is seeing around the building including lecture rooms and studios.

- **Shading device**

There is presence of shading device around some part of the building. This shading device came inform of lobby at both sides of the building which automatically shades the interior spaces from driving rain and this curb the effect of glare that might cause discomfort to the students and staffs.

- **Ventilation**

The faculty building is conducive for learning due to the free airflow that enters the building through openings such as doors, windows. The opening gives easy passage of air in and out of the spaces which makes the building comfortable for its users.

- **Fire safety measures**

Fire escape route is taken into consideration in this building. Lobbies are linked directly to the stair hall for evacuation of students and staffs in case of emergency. Fire extinguishers, fire space routes and sand pots are positioned at required points to curb effect of any fire outbreak. Emergency exit is created with spacious stair hall to allow easy passage of students and staff incase of fire outbreak

S/N	FACTORS	GOOD	FAIR	POOR
VIII.	Orientation and Site Analysis:	✓		

XIX.	Daylighting Strategies and Techniques		✓	
XX.	Interior Design and Light Colors		✓	
XXI.	Interior Layout and Space Functionality: ✓		✓	
XXII.	Glazing and Shading Systems:	✓		
XXIII.	Interior Design and Light Colors:	✓		
XXIV.	Integration of Artificial		✓	
XXV.	Daylighting Simulation and Analysis:		✓	
XXVI.	User Comfort and Well-being:	✓		
XXVII.	Sustainability and Energy Efficiency			✓
XXVIII.	Adaptability and Flexibility:		✓	
XXIX.	Natural Ventilation	✓		
XXX.	Impact on Productivity and Learning		✓	

### 3.6 Description of the Building (Case Study 5)

The faculty of environmental science, university of Lagos is a 2 floors building which has so many spaces in it like the offices, studios, laboratories, conveniences, meeting room, head of departments offices etc. This spaces are regularly used and has proper illumination and ventilation. The faculty is

sub divided into different sections like, the technical, academics, utility, non-academic and the administrative block.

Faculty of environmental science has a wide vertical window, a simple and clear form and a free façade, the building has 5 different department with the sixth in view from the oral interview conducted. The department are as follows

- Architecture
- Urban and regional planning
- Estate management
- Quantity survey
- Building technology

### **Sections in the faculty**

The above mentioned spaces are jointly grouped sections by sections according to their functions and usefulness, these sections systematically listed as below;

- The technical section
- The academics
- The utility
- The non-academics
- The administrative section



**Figure 39; Well celebrated approach view of the faculty with disabled access and adjoining packing lots.**

(Source; Author's field work)



**Figure 40; Longitudinal view of the faculty with adjoining road**

**Figure 41; Well defined parking lots.**

(Source; Author's field work)



Figure 42;

**Picture showing Lecture Theater of faculty with good landscape design and green area**

(Source; Author's field work)



**Figure 43; Well lighted and spaced architecture studio    Figure 44; Well lighted lobby to the department of building technology.**

(Source; Author's field work)

### 3.6.1 Appraisal of the Building

#### Merits

- Well celebrated and well define entrance.
- Good circulatory lobby.
- Provision of exit doors for escape
- Well defined parking lots
- Well ventilated and well lighted usable space.

#### Demerits

- The parking space is not well defined
- Lobby is not spacious enough
- No emergency fire equipment found
- Lack of faculty library/ cafeteria

### 3.6.2. Visual Comfort and Natural Lighting Consideration Factors

- **Accessibility and circulation**

Entrance into the building is seeing from the approach which is attached to the reception hall. Vertical circulation is used which moves from the stair to lobbies, connected to every offices and other facilities and back to the stair hall.

- **Daylight strategies**

The faculty building draws day lighting from the sidelight concept of daylight strategies. Illumination enters the building through south and north orientation with wide and high windows which is seeing around the building including lecture rooms and studios.

- **Shading device**

There is presence of shading device on the building. This shading device came in form of projected walls, fin walls and which helps to reduce driving rain and curb the effect of glare that might cause discomfort to the students and staffs.

- **Ventilation**

The faculty building is conducive for learning due to the free airflow that enters the building through openings such as doors, windows. The opening gives easy passage of air in and out of the spaces which makes the building comfortable for its users.

- **Fire safety measures**

Fire escape route is taken into consideration in this building. Lobbies are linked directly to the stair hall for evacuation of students and staffs in case of emergency. Fire extinguishers, fire space routes and sand pots are positioned at required points to curb effect of any fire outbreak. Emergency exit is created with spacious stair hall to allow easy passage of students and staff incase of fire outbreak.

S/N	FACTORS	GOOD	FAIR	POOR

<b>I.</b>	<b>Orientation and Site Analysis:</b>	✓		
<b>II.</b>	<b>Daylighting Strategies and Techniques</b>	✓		
<b>III.</b>	<b>Interior Design and Light Colors</b>		✓	
<b>IV.</b>	<b>Interior Layout and Space Functionality:</b>		✓	
<b>V.</b>	<b>Glazing and Shading Systems:</b>	✓		
<b>VI.</b>	<b>Interior Design and Light Colors:</b>		✓	
<b>VII.</b>	<b>Integration of Artificial</b>		✓	
<b>VIII.</b>	<b>Daylighting Simulation and Analysis:</b>	✓		
<b>IX.</b>	<b>User Comfort and Well-being:</b>		✓	
<b>X.</b>	<b>Sustainability and Energy Efficiency</b>		✓	
<b>XI.</b>	<b>Adaptability and Flexibility:</b>		✓	
<b>XII.</b>	<b>Natural Ventilation</b>	✓		
<b>XIII.</b>	<b>Impact on Productivity and Learning</b>	✓		

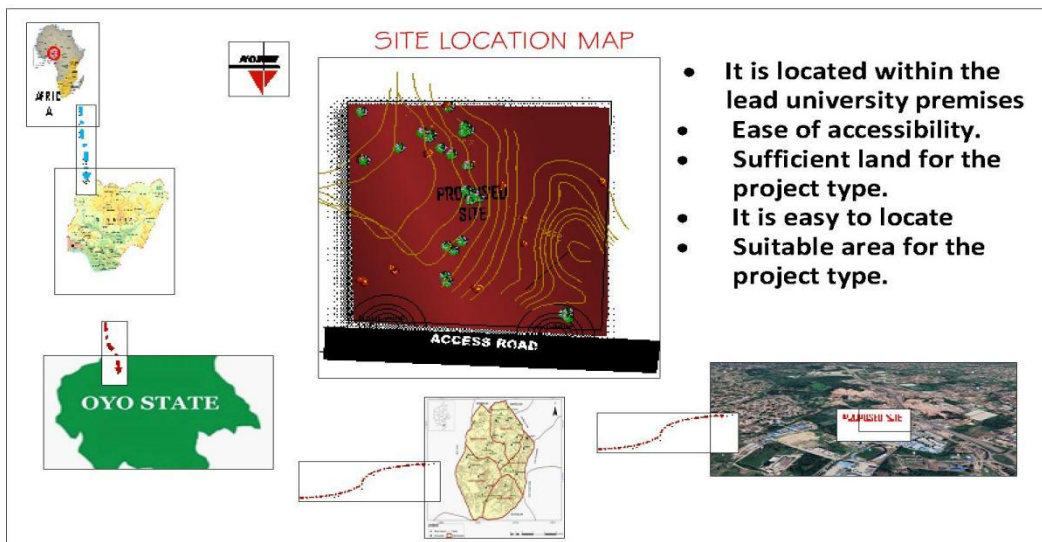
## Chapter Four

### Site Analysis and Design Synthesis

#### 4.1 Study Area

##### 4.1.1 Site Location

The site of the proposed faculty of architecture is located within the Lead City university premises, Lagos/Ibadan express road, Oyo state, Nigeria. The city of Ibadan is the administrative headquarter of the old western region of Nigeria and now Oyo state's capital. It is the third largest metropolitan area, by population, in Nigeria.



**Figure: 4.1 Location Map**

(Source: Google Imagery)



**Figure:4.2 Location Map**

(Source: Google Imagery)



**Figure 4.3 Source; Researcher`s field work**

The facility's functional use is strongly impacted by the site development for this project; hence it was vital to take certain factors into account when choosing the location;

- Land use
- Accessibility
- Proximity to another educational spaces
- Topography
- Expansion possibilities

#### **4.1.2 Site Location Criteria**

Site analysis is strictly done at the beginning of every project to analyse the proposed site critically so as to have deep knowledge of the site area, neighbourhood, drainage pattern, existing buildings on the site, topography, details and other key features of the site which can affect proposed project. These are considered and analysed properly before any serious work can be done on the site. A number of characteristics peculiar to the proposed site influenced its selection. They include;

1. Location of every site is important and it is a big criteria to consider before choosing a particular design or project. a big contributing factor to this design. It is easily accessible and has a relatively flat topography which makes construction easy.
2. The access roads is also a criteria which is considered while choosing this design. There is access roads that leads to the site from the main university road. These road links other places like faculties, hostels, church e.t.c and are well defined with walkways and drainage patterns.. After construction, the faculty building will be easily seen by passers-by.
3. Another contributing factor is that Lead City university is increasing in size and students. The population of students at Lead City university as at 2015 till 2023 has increased drastically to a

higher percentage. This gives room for more accommodating faculties to cater for the students of more lecture rooms and educational facilities.

4. The site is also zoned for faculty building.

#### **4.2.3 Site Analysis**

The site is a necessary aspect of a design proposal where the larger percentage of project development starts making impact from. The chosen site of every project determines the final result of the development stage been the entity where start and finish of project takes place in all aspects. The main aspect of the site, its climatic condition are complex interaction of any factor, topography, scope, patterns, neighborhood, humidity, orientation, vegetation, water availability, direction of sunlight, etc. The success of every project or design to a maximum extent lies on the site analysis and informed site selection process. The layout of this faculty on site will be determined by the information gotten from the site analysis such as physical features, topography, accessibility, sun direction e.t.c. The existing features in close proximity to the site will directly influence the form and economy wise with which the design and building will eventually comes out. Thorough analysis of the site is conducted so as to enhance better understanding of the site and to come up with suitable, well planned design that will work perfectly on the site which is greatly necessary for this study so as to achieve the aim of this design. Proper analysis determines and helps the functional development of the design and enhance proper relationship that exist between site and building. Every design solution must be aimed to be a direct reflection of the site, a function of the site and natural adaptation of its environment.

#### **Site Accessibility**

There is easy accessibility of both pedestrian and vehicular movement in and out of the site. It is accessible from the university major road which runs through and connect with other faculties and important educational facilities like library, school clinic etc.

### **Nearness to Public Utilities**

The site has good link access to amenities like road, library, electricity, school clinic, security, sport pavilion, water etc.

### **Drainage and Topography**

The site is blessed with steep gentle slope which is spread evenly throughout the site area. It is however of great necessity to cater for a required slope by standard which will work with drainage to move rain and other used water away from the site.

### **Vegetation**

Ibadan is located within the tropics of Nigeria which has two specific seasons' namely dry and cold seasons. Lead City University is located in Ibadan and enjoys this two great seasons as well with the other educational and public places in the city. This two seasons brings a variety of vegetation ranging from short grasses, evergreen trees, thick undergrowth on the site and its immediate environment. Soil in this part of tropics region is always loamy which has relatively good bearing capacity. The Site for this design has good load bearing capacity and solid ground, has no presence landforms which is suitable for the construction of the proposed faculty. The site is covered with trees, shrubs, vegetable leaves and thick tall grasses. All unwanted trees, and shrubs are to be removed.

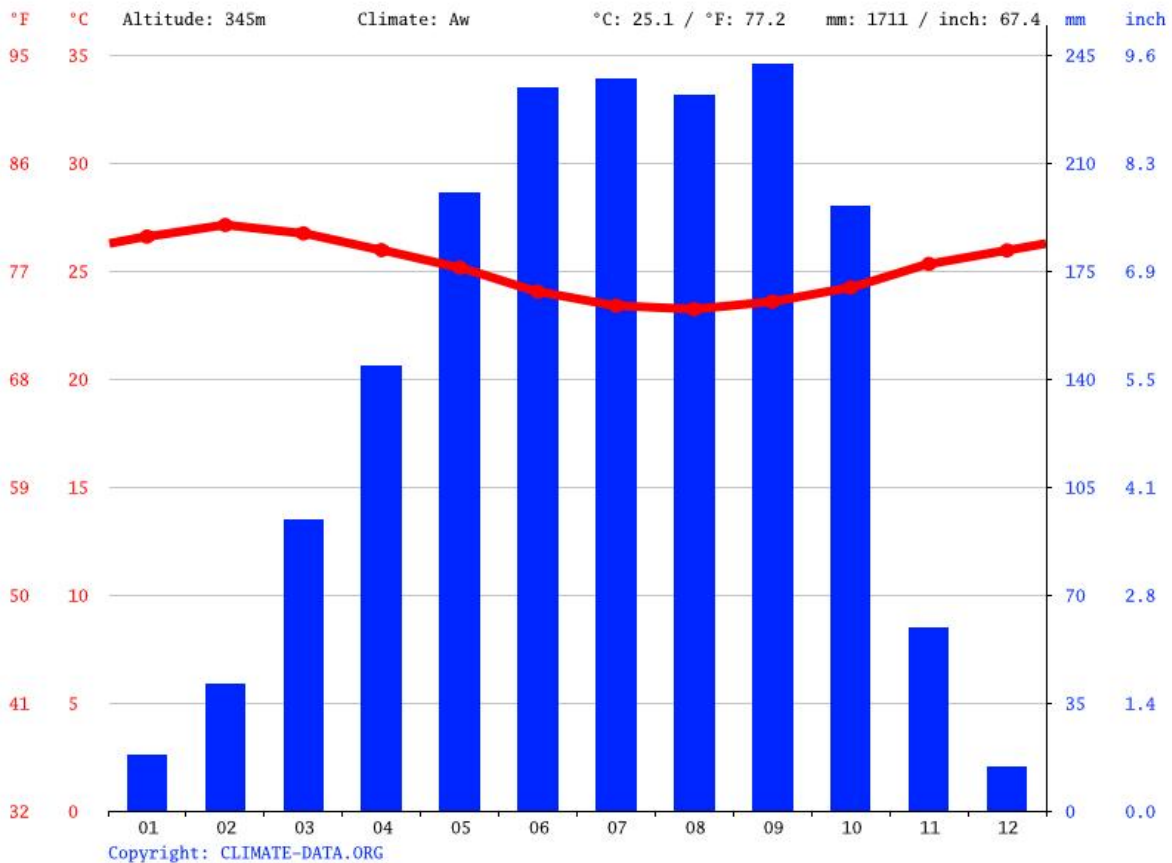
### **Soil Condition**

The site displays a relatively good surface, and sub-surface soil condition, solid laterite soil which is suitable for construction stage. It is free from all geographical conditions and it is certified for construction processes with no rock crops. , Presence of clay soil is found on the site and it will be packed together to make Hydra form, the hydraulic compressed brick used on site.

### **Wind Direction**

The wind direction is another important factor in site analysis because of its impact on site and building at large. It brings about comfort and discomfort depending on how it is handled. The south-

west trade wind brings about cold humidity which gives comfort ability to the end user whereas, the north-east trade wind brings about dry dust and harmattan which gives discomfort to the end user. Adequate ventilation is taking as an integral part of every design solution in other to maximize effective use of the interior space.. Natural ventilation inflow is one of the bedrock of this project design, thereby considering the orientation of the building to enjoy and achieve the best of the wind direction inform of ventilation into the spaces., The longest sides of the proposed building are positioned in a way to absorb maximum amount of air flow while the shorter sides are positioned towards the direction of the north-east trade wind

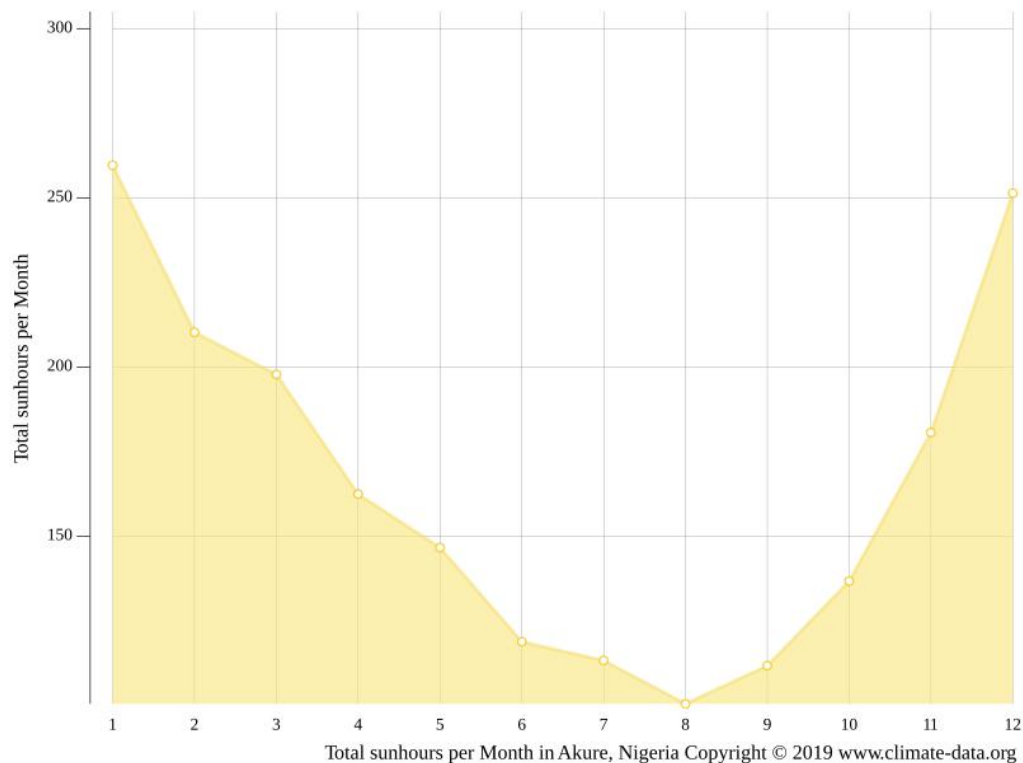


**Figure 2; Climate graph/weather by month**

Source; Climate-data.org

## Sunlight and Temperature

Ibadan is one of the states that enjoys 50-60 percentage of sunshine throughout which gives the faculty of architecture opportunity to solar gain which is converted in to electricity for it use.. The orientated of the faculty building is done in such a way that it minimize the quantity of heat gain into the spaces, therefore the shorter sides helps to access little heat energy is gained into the interior spaces.. Introduction of solar panels are established and used on the roof to further reduce the effect of heat gain and solar radiation into the interior spaces with the aim of giving total comfort to the students and increase their willingness to attend classes without heat complain.



**Figure 3; Sunshine hours per month**

Source; Climate-data.org

#### **4.2.1 Project analysis and design synthesis**

#### **4.2.2 Brief Analysis**

In the last few decade, the world has begun making a shift to sustainable and environmentally friendly alternatives of power one of which is day lighting. Daylight is the total illumination provided by the direct sunlight, skylight and the diffusely reflected sunlight, which is absorbed and reflected over surfaces, both externally and internally. The technical term of delivering this natural light into an enclosed space is what is generally referred to as day lighting. Lighting quality has direct influence on students learning performance shows that day lighting in schools significantly increase students test scores, promote better health, physical development, reduces operating cost, improves student vision and perception. The careful introduction of this lighting and its importance in lecture rooms is a good and more reasons to maximize visual comfort and natural lighting in lecture rooms. This also provides sufficient illuminance on a work surface for various task and maximize visual comfort through glare.

#### **4.2.2 Brief Development**

After thorough analysis of the six case studies in this study, some important spaces were seen to be necessary for a faculty of architecture to perform efficiently. These spaces were critically studied to deduct the required standard spaces needed in the design, their function, number of unit per students, amount needed for adequate use and performance. These spaces are;

- Outdoor parking
- Entrance foyer
- Lecture rooms
- Lecture theater
- Architecture studios
- Lecturers offices

- Workshops
- Faculty library
- Presentation/ Seminar rooms
- Conveniences
- Cafeteria
- Exhibition room
- Meeting room
- Business area
- Cad room
- Emergency exit

#### 4.2.3 Design Criteria

**Lightening;** Adequate and proper lightening must be provided throughout the spaces in the building to give efficient visual comfort. Lecture rooms and studios needs a high level of lightening to enable students perform their daily task efficiently. Natural lightening must be greatly considered before artificial source.

**Ventilation;** Faculty buildings requires good ventilation systems to replenish oxygen, minimize unpleasant odour and dust generated in the building. A good ventilation system can be achieved within the building by either passive (natural) or active (artificial) means.

**Circulation;** Easy circulation flow must be greatly considered because of the volume of the users such as lobbies, stair halls etc. Entrance and verandas must be spacious enough to aid easy movement of students and staffs.

**Flexibility;** Maximum flexibility is a great criteria in faculty design and which must be taken serious in any educational facility. It gives ability to access spaces easily, move about easily, expand, give room to changes and renovations whenever duty call for it. This flexibility in design should affect the departments by having a simple design with distinctive approach which bond them together and leave no room for confusion in department's identification.

**Comfort;** Comfort simply refers to maintaining required temperatures and air flow in and around the building. Layout of the faculty building must give room to easy use of spaces without stress and all spaces must be well illuminated and ventilated for better use. This gives better comfort ability to the users.

**Sustainability;** Sustainable architecture is a key criteria when planning and designing of buildings of high profile and every other building type. The use and reuse of this spaces must be greatly considered. Sustainable architecture looks more into reducing negative environmental impact through the use of energy efficient techniques.

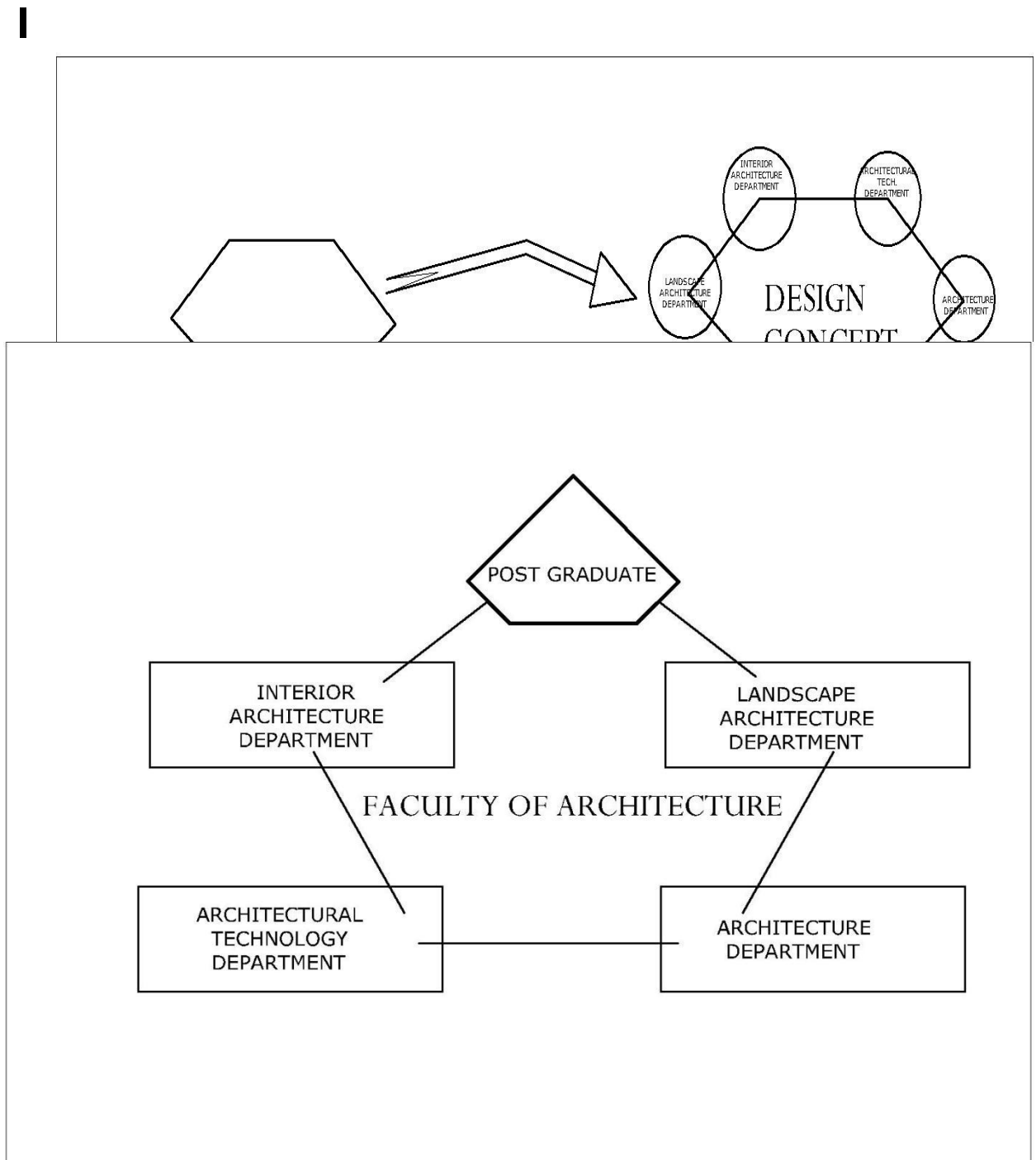
**Safety;** Safety of lives and properties is very important and it must be considered as a criteria for designing a faculty building because of the multitude of end users it has. Active and passive measures are taken to protect lives and properties in the faculty building. Fire extinguishers, fire space routes and sand pots will be positioned at required points to curb effect of any fire outbreak. Emergency exit must be created with spacious stair hall to allow easy passage of students and staff in case of fire outbreak.

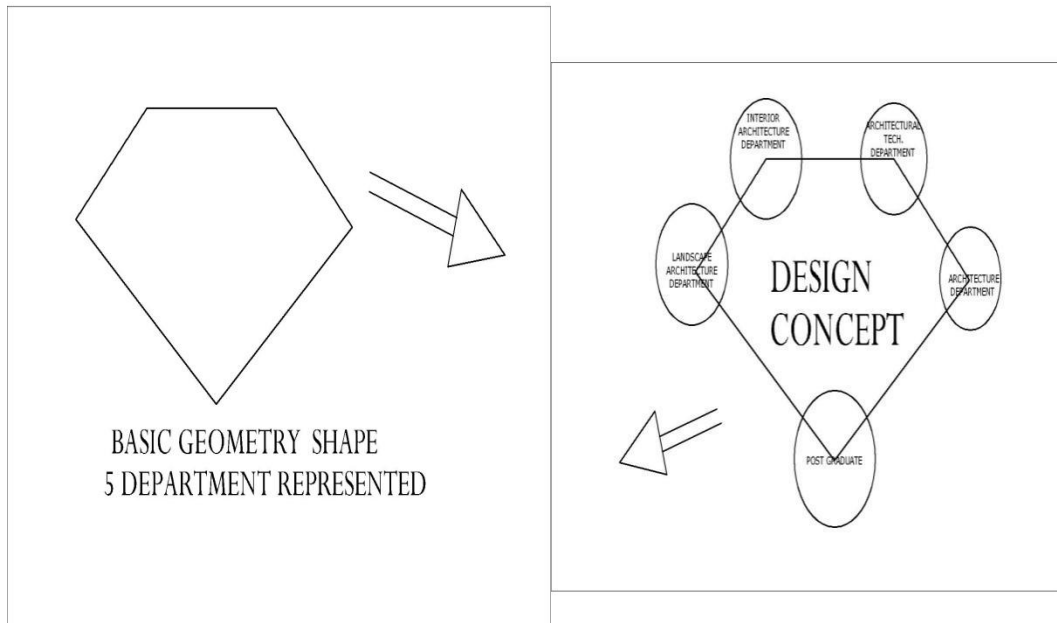
#### **4.2.4 Conceptual Development**

Ideas are gotten from different areas of life depending on the type of design one ventures into. This great ideas when combined together gives great concept which are used in architecture to develop elegant designs. This ideas are sometimes either elements, non-living or living things. There are alot of idea types;

1. Essence; This refers to looking more beyond the function of the proposed design
2. Metaphor: This refers to abstract thinking of great ideas, ways of inventing great designs both in architecture and engineering.
3. Ideal; which simply refers to way of solving architectural problems.
4. Pragmatic; This simply refers to looking critically at the main function of the design development, then shaping the design along the functional part

Nigeria





### Site Concept

Site concept is a design pattern that gives visible way out to whatever concept the designer is about to come out with. It serve as guidelines in planning of the elements on site. Every site concept must be done along with the site analysis information. Hence, it should be design in such a way that carries along all the existing features on the site It should not be done in isolation and must be used to plan the site. The site of this proposed faculty of architecture was designed critically with the information on the site analysis, taken into consideration the existing features and basic amenities and it takes its access from the existing roads. Access exit and entrance are linked to the road towards the north of the site. for easy ingress and egress. Service access for emergency, delivery is linked to the major road of the school leading to the second gate for easy access to the government road the road. General parking area is designed immediately after the outdoor sitting area while staff parking area is positioned close to the faculty for easy access into the office space.

According to the design rules, consideration is given to the special students with sitting area and spacious car park for easy movement in and out of their cars which as positioned not too far from the building. Their car parks are placed very close to the building.

The electrical and mechanical point is positioned at the rear of the site so as to service the building at every needed time. Refuse disposal area is also positioned at the rear of the site for easy collection and movement out of the premises through the road that leads to the second gate.

### **Building Concept**

Basic geometry shape informed the design shape of the faculty with the 5 departments which formed the faculty. Basic shape inform of polygon is applied to give the 5 departments proper design and space circulation as well as to give proper connection in between them as passage ways for circulation and free flow into each other. The design start with the polygon shape and finally into a regular shape which gives room for more interior spaces to evolve instead of been limited to few spaces because of the shape. The coming together of all this inspire the shape/internal arrangement and functionality of this design.

#### **4.2.5 Conceptual Development**

The functional relationship chart showcase the interrelationship between various spaces in the facility. It gives insight of how the spaces interwoven and their relationship. It helps the architect or designer to easily determine spaces that are related or not to another. It gives easy functionality of design and aid zoning of spaces. Principles of functional relationship include;

1. Green areas with hard and soft landscape.
2. Buildings orientation to determine conveniency and maximize thermal comfort.
3. Solution to traffic congestion i.e., pedestrian, vehicular etc.

4. Unity, functionality, aesthetics.

#### **4.2.6 Space Allocation/ Schedule of Accommodation**

Spaces were grouped into three depending on their relationship to one another and the similarities of activities performed in them.

##### **Public**

- Outdoor parking
- Entrance foyer
- Lecture rooms
- Lecture theater
- Workshops
- Faculty library
- Presentation/ Seminar rooms
- Conveniences
- Cafeteria
- Exhibition room
- Business area
- Cad room
- Architecture studios

##### **Semi- public**

- Lecturers offices
- Meeting room
- Courtyard

- Store
- Hod's office
- Dean office

Schedule of Accommodation

S/N	SPACE	NO OF UNIT	UNIT AREA (M)	TOTAL UNIT AREA (sqm)
1.	Entrance	1	4332 x 10782M	46.708 sqm
2.				
3.	Reception	1	8054 x 10969	88.344 sqm
4.	Lecture room	16	9000 x 10002	90 sqm
5.	Lecture theater	2	23408 x 30530	714.646 sqm
6.	Studio	20	9000 x 10002	90 sqm
7.	Workshop	2	9000 x 10600	95.400 sqm
8.	Business area	1	5875 x 7200	42.300 sqm
9.	Cafeteria	1	12825 x 20460	262.271 sqm
10.	Kitchen	1	7000 x 10000	70 sqm
11.	Exhibition hall	1	7142 x 18823	

12.	Machine and Fabric room	1	8743 x 9000	78.687 sqm
13.	General store	2	3259 x 8600	28.001
14.	Faculty Office	1	8813 8892	78.365
15.	Department meeting room	1	14471 x 13050	188.846 sqm
16.	Head of department office	5	4496 x 5860	26.346 sqm
17.	Enquiry office	1	3525 x 3635	12.813 sqm
18.	Conveniency	72	1000 x 1500	1.5 sqm
19.	Stair hall	18	5058 x 7715	12.813 sqm
20.	Seminar room	2	9000 x 10000	90 sqm
21.	Presentation room	2	9000 x 10000	90 sqm
22.	Cad room	2	9000 x 10000	90 sqm
23.	Library	1	10600 x 20450	216.770 sqm

24.	E-library	1	12934 x 16184	209.323 sqm
25.	Senior Lecturers office	48	3833 x 4400	16.865 sqm
26.	Assistance lecture office	10	3560 x 5705	20.309 sqm
27.	Professors office	12	3833 x 4400	16.865 sqm

#### 4.2.7 Construction Methods and Materials

In the last few decade, the world has begun making a shift to sustainable and environmentally friendly materials. This materials are used in the makeup of his project design. Here are the factors that determine the choice of those materials;

- Durability
- Functionality
- Rules and regulations
- Availability in Ibadan
- Aesthetics
- Climatic condition

Substructure; reinforced concrete columns and beams

Walls; Hollow sand Crete block walls, reinforced concrete columns

Hollow sand Crete block walls for internal partition

Interior walls; Airlite paint to give protection against growth of microbes, mold and to eliminates germs

Floor; Suspended floor slab, imported tiles, clay tiles

Door: Glass doors, wooden panel and steel doors.

Roof; Long span aluminium roofing sheet covered with solar panel, roof gutter.

Ceiling; wooden ceiling finished with Airlite paint

. Fire extinguishers, fire space routes and sand pots are positioned at required points to curb effect of any fire outbreak. Emergency exit is created with spacious stair hall to allow easy passage of students and staff in case of fire outbreak.

#### **4.2.8 Building Services**

Duct are spaces generally created to cover the vents of conveniences, service layout of pipes and other mechanical outlets around the building. This service space area serve as open duct for pipes and wiring which is spacious enough for accessibility to fix every issues. Some deep areas like conveniences, store, workshops needs natural lighting as well as artificial lighting to keep the spaces running. The circulation space will be ventilated by through courtyards which gives maximum natural light. Active and passive measures are taken to protect lives and properties in the faculty building. Fire extinguishers, fire space routes and sand pots are positioned at required points to curb effect of any fire outbrea. Emergency exit is created with spacious stair hall to allow easy passage of students and staff incase of fire outbreak.

## **Chapter Five**

### **Conclusion**

#### **5.1.1 Project Appraisal**

The study used sustainable materials and approaches which can be used in designing faculty building in Nigeria to create eco-friendly environment and cost effective buildings. Series of case studies were looked into in the course of this thesis.

The findings in the case studies and theories investigated earlier in the course of this study will be employed in this design. They include; Maximizing natural lighting to tackle every activities, fin walls, overhangs to reduce glare and discomfort while yielding better result by giving good visual comfort to the students, use of colours in the interior to brighten the mood of students and further awaken their moral to study more and spend more time in the lecture room, solar panels on the roof top to reduce the amount of heat gain into the lecture rooms. The use of energy saving light materials to bring about efficient artificial lighting to support the day lighting to spaces that would be used in evening times such as studios and conveniences.

Potted plants and other ornamental plants will be positioned along the circulation area to create we feelings, home away from home scenario and cool connection to nature while at the other end helps to remove toxic air from the building.

Natural lighting through the courtyards and wide windows will be introduced into circulation spaces in the course of the design.

Spacious and defined circulation flow will be employed to connect different departments and facilities within the faculty. Special student will be catered for in terms of accessibility and movement.

Simple and direct site circulation flow will be put into consideration in the course of this design to further ease the movement of pedestrian, motorist in and out of the site. This is vital and will be greatly considered on site. Pedestrian walk ways will be designed in such a way to not cut across the vehicular route to avoid accident.

Materials seen in the case studies that will be used in this design include;

- Wide stair case; This helps movement in and out of the building comfortable
- Curtain walls; Helps to throw enough natural lighting into the space
- Wide circulation; this flow aid easy movement of students in their large numbers from one lecture hall to another especially when there's combined lectures.
- Fins; to reduce glare in the interior spaces and stabilize visual comfort.
- Steel; Steel is one of the most commonly used materials as reinforcement for construction due to its high strength, durability and relatively low cost.
- The paint finish (Airlite paint) material will be used in the interior to neutralize pollutants, disallow the growth of mould and microbes, and ensure the absence of germs.

## **5.2 Conclusion**

This study set out to achieve maximum effect of natural lighting and visual comfort in lecture rooms and other facilities to enable students and staffs get high level of comfort ability while using the faculty building. All theories studied gives model and strategy which is followed to derive best design of this faculty to a larger extent. In terms of visual comfort, shading device, overhangs are introduced to curb the effect of glare which usually causes discomfort to students while learning. More so, large sized openings are used to enhance the level of natural light that comes into the lecture rooms in form of useful day lighting which helps the students in many areas such as the improvement of student performance and health conditions, improved ability, concentration, focus, academic excellence, and so on. All this put together gives better output in terms of functionality of the faculty. Moreover, daylight contributes considerably to the aesthetics and physical character of a learning space, as well as in limiting potential harmful effects from prolonged artificial light exposure. All this is achieved in the designing of the faculty which makes it a topnotch and a body of knowledge to future designers, architects, researchers and students at large.

### **5.3 Recommendation**

Not so enough has been done to proffer sustainability in the design and construction of faculty building in Nigeria. This is greatly caused by the fact that faculty building and the concept of sustainability is novel in this part of the world. This study has provided to a greater extent solutions to most challenges facing faculty building in terms of visual discomfort and natural lighting issues and has added much information to the body of knowledge. A lot of research and progress need to be done for Nigeria to be in a world level in terms of designing of sustainable faculty building design.

1. Shading devices should be introduced to reduce the effect of glare and maximize visual comfort around the lecture rooms.

2. Natural lighting strategies should be adopted to maximize the opportunity of day lighting in the faculty
3. Opening at the northern side of the building should have a minimum height of 2700mm to ensure great impact of day lighting while also minimizing risk of glare.

*Do Not Copy, Lead City University, Nigeria*

## REFERENCES

1. Citation: Amanda de Morais Alves Figueira et al. *Ijsrm.Human*, 2022; Vol. 20 (4): 7-28.
2. Wang, S.; Chen, B.; Suo, J.; Zhao, J.R. Impact of building morphology and outdoor environment on light and thermal environment in campus buildings in cold region during winter. *Build. Environ.* **2021**, *204*, 108074  
[IOP Conference Series: Earth and Environmental Science, Volume 665, International Conference on Energy and Sustainable Environment 23-25 June 2020, Covenant University, Nigeria](#)
3. Citation Anthony Sholanke et al 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **665** 012008
4. The role of artificial lighting in architecture design; A literature review Anthony Sholanke<sup>1</sup>, Oladimeji Fadesere<sup>1</sup> and Daniel Elendu<sup>1</sup>
5. Sholanke\_2021\_IOP\_Conf.\_Ser.\_Earth\_Environ.\_Sci.\_665\_012008
6. Anthony Sholanke et al 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **665** 012008
7. Tekce, I., Artan, D., & Ergen, E. (2021). An empirical study of visual comfort in office buildings. *Smart Innovation, Systems and Technologies*, *200*, 319–331.  
[https://doi.org/10.1007/978-981-15-8131-1\\_29](https://doi.org/10.1007/978-981-15-8131-1_29)
8. Wanas, A., Aly, S. S., Fargal, A. A., & El-Dabaa, R. B. (2015). Use of Kinetic Facades to Enhance Daylight Performance in Office Buildings with Emphasis on Egypt climates. In *JOURNAL OF ENGINEERING AND APPLIED SCIENCE* (Vol. 62, Issue 4).
9. Matusiak, B., Luminous Environment in School Buildings, Barbara Matusiak, PhD, Norwegian University of Science and Technology, Norway, accessed date on 16th October, 2019.
10. Z. Gou, “Human factors in green building: Building types and users’ needs,” *Buildings*, vol. 9, no. 1. Multidisciplinary Digital Publishing Institute, p. 17, 2019

11. (Mangkuto et al 2019, Moreno and Labarca 2015) Optimization of the design of the primary school classrooms in terms of energy and daylight performance considering occupants' thermal and visual comfort. <https://www.sciencedirect.com/science/article/pii/S2352484720300627..>
12. **(F Nocera, A Lo Faro, V Costanzo, C Raciti - Sustainability, 2018)**. Daylight performance of classrooms in a mediterranean school heritage building. Optimization of the design of the primary school classrooms in terms of energy and daylight performance considering occupants' thermal and visual comfort. [https://scholar.google.com/scholar?q=F.+Nocera+et+al+2018&hl=en&as\\_sdt=0&as\\_vis=1&oi=scholar](https://scholar.google.com/scholar?q=F.+Nocera+et+al+2018&hl=en&as_sdt=0&as_vis=1&oi=scholar)
13. Tabadkani, A, Banihashemi S, Hosseini MR et al 2018. Daylighting and visual comfort of oriental sun responsive skins; A parametric analysis. Building Simulation, 2018, 11 (4), pp. 663 - 676
14. (Day et al. 2019) (Futrell et al., 2019) by S Alitema · 2022. A Post Occupancy Evaluation of daylight performance in classrooms at River Road Elementary School for Optimal Visual Comfort in Climate Zone 4C.
15. (Elzeyadi, 2018) by S Alitema · 2022. A Post Occupancy Evaluation of daylight performance in classrooms at River Road Elementary School for Optimal Visual Comfort in Climate Zone 4C.
16. (DiLaura et al. 2011; EN 2019; IES 2013) by S Alitema · 2022 A Post Occupancy Evaluation of daylight performance in classrooms at River Road Elementary School for Optimal Visual Comfort in Climate Zone 4C.
17. Advanced Lighting Guidelines. (2016). Avoid Glare. advanced lighting guidelines.
18. Ander, G. (1995). Daylighting performance and design. New York : Van Nostrand Reinhold. .
19. Ander, G. D. (2014): Whole building design guide: Day lighting. Retrieved October, 14, 2017 at; <http://www.wbdg.org/resources/daylighting.php>

20. Antonutto, G. (2013). new school of thought. Newsletter the society of light and lighting vol 5 issue 6. Nov/Dec.
21. Archdaily. (2015, april 23). melbourne-school-of-design-university-of-melbourne-johnwardle-architects-nadaaa. Retrieved from Archdaily: <https://www.archdaily.com/622708/melbourne-school-of-design-university-ofmelbourne-john-wardle-architects-nadaaa>
22. Architects & Building Branch. (1999). Lighting Designs for Schools. norwich: Her Majesty 's Stationery Office.
23. Architects, M. (2015). clerestory- architects glossary. Retrieved July 1, 2023, from m. gerwing architects: <http://mgerwingarch.com/2010/12/12/clerestory-architectsglossary/>
24. Architectural Energy Corporation. (2006). Daylighting metric development using daylight autonomy calculations in the sensor placement optimization tool. Technical report prepared for CHPS. Retrieved from <http://www.archenergy.com/SPOT>.
25. Aslila, A. K., Lokman, H. I., & Narimah, K. (2015). Optimization of the daylighting system by using a light pipe system in a building. Padang: The 2nd International Conference on Construction and Building Engineering (ICONBUILD 2015),
26. Autodesk Sustainability Workshop. (2015). Apertures for Daylighting. Retrieved 7 7, 2016, from Autodesk: <http://sustainabilityworkshop.autodesk.com/buildings/aperturesdaylighting>
27. Axarli, K. & Tsikaloudaki, K. (2007): Enhancing visual comfort in classrooms through daylight utilization. Proceedings on Clima 2007: Wellbeing Indoors
28. utilization. Proceedings on Clima 2007: Wellbeing Indoors
29. Babylon. (2015). sawtooth roof translation. Retrieved July 8, 2023, from babylon: <http://translation.babylon-software.com/saw+tooth+roof/>

30. Ball State University. (2016). Climate and Daylight. Retrieved July 1, 20223, from Ball State University:
31. <http://cms.bsu.edu/academics/centersandinstitutes/ceres/mirrorbox/backgroundpages/background/climateanddaylight>
32. Bernfart, E. (2014, may). solar tube lighting. Retrieved july 13, 2023, from prezi<https://prezi.com/eji9b9d4fmrq/solar-tube-lighting/>
33. Bokel, R. M. (2007). The Effect Of Window Position And Window Size On The Energy Demand For Heating, Cooling And Electric Lighting. Building Simulation . Delft: Delft Technical University.
34. Brawne. (2003). Architectural thought: the design process and the expectant eye. In Brawne, Architectural thought: the design process and the expectant eye. oxford: architectural press.
35. Bristolite Team. (2014, june 13). Bristolite daylight system. Retrieved may 5, 2023, from Bristolite: <http://www.bristolite.com/blog/natural-light-and-education-the-benefitsof-daylighting-for-schools-and-colleges/>
36. Build. (2016). sawtooth roof. Retrieved July 8, 2023, from <http://www.build.com.au/sawtooth-roof>
37. Catalina Gutierrez. (2016, November 12). faculty-of-architecture-and-urbanism-universityof-sao-paulo-fau-usp-joao-vilanova-artigas-and-Carlos-cascade. Retrieved from arch daily: <https://www.archdaily.com/799088/ad-classics-faculty-of-architectureand-urbanism-university-of-sao-paulo-fau-usp-joao-vilanova-artigas-and-carloscascaldi>
38. Clear Comfortable Low Energy Architecture. (2016). daylight factor. Retrieved july 15, 2016, from [http://www.newlearn.info/packages/clear/visual/daylight/analysis/hand/daylight\\_factor.html](http://www.newlearn.info/packages/clear/visual/daylight/analysis/hand/daylight_factor.html)

39. Cole, R., Connery, K., Rousseau, D., & Threaker, I. (1999). green building design & construction guidelines. santa monica.
40. Cundall Johnston and partners. (2015). Baseline Design – Daylight Strategy. Baseline Design – Daylight Strategy.
41. Dahlan, A. S., & Mahmoud, A. E. (2015). The Impact of Day Lighting in Classrooms on Students' Performance. International Journal of Soft Computing and Engineering,9.
42. Dahlin, E. (2016). The Rebuilding and Restoration of America: Get What You Want Not What You're Given. newyork: Dorrance Publishing.
43. Danny, H. W., Tang, H. L., Eric , W. M., & Tariq, M. (2009). Classification of CIE standard skies using probabilistic neural networks. INTERNATIONAL JOURNAL OF CLIMATOLOGY, 1.
44. Dean, E. (2004). Daylighting Design in Libraries. California: Libris Design Project. Designing buildings wiki. (2017, December 4). window parts. Retrieved from Designing buildings wiki: Designing buildings wiki
45. Dean, E. (2004): Natural light in the library. Architecture Week. Retrieved from
46. [http://www.architectureweek.com/2004/1201/environment\\_1-1.html](http://www.architectureweek.com/2004/1201/environment_1-1.html)
47. Dr David Suzuki Public School. (2016). Light Shelves and Solera. Retrieved July 13, 2023, from Dr. David Suzuki Public School: <http://www.suzukipublicschool.ca/buildingfeatures/light/light-shelves-and-solera.html>
48. Dubois, M.C. (2011): Impact of shading devices on daylight quality in offices: Simulation with Radiance. TABK Rapport. Lund Institute of Technology, Department of Building Science.
49. East Renfrewshire Council Planning Service. (2012, DECEMBER). Supplementary Planning Guidance: Daylight and Sunlight Design Guide. Daylight and Sunlight Design Guide, p. 1.
50. Egan, M. D., & Olgyay, V. (2002). Architectural Lighting. New York: McGraw-Hill.

51. Egeh, E., & Okoloye, C. (2010). Tropical Climatology. LAGOS: NATIONAL OPEN UNIVERSITY OF NIGERIA.
52. Energydesignresource. (2014). skylighting design guideline. california: Heschong Mahone Group, Inc.
53. Erwine, B., & Heschong, L. (2002). Lighting for Learning. Paper presented at the Lightfair International Seminar Preview.
54. European Commission Directorate-General for Energy, ECGGE (1994): Daylight in buildings. A Thermie Programme Action Healthy Schools Network, Inc. (2012): Day lighting. Retrieved August 17, 2017 from: [www.healthyschools.org/downloads/Daylighting.pdf](http://www.healthyschools.org/downloads/Daylighting.pdf)
55. Expatarrivals. (2016). Weather in Nigeria. Retrieved July 14, 2016, from expatarrivals: <http://www.expatarrivals.com/nigeria/weather-in-nigeria>
56. FAU. (2016). A FAUUSAP. Retrieved from FAU: <http://www.fau.usp.br/a-fau/>
57. Femi, A. (2015, November 10). vanguard. Retrieved June 20, 2023, from vanguard: <http://www.vanguardngr.com/2015/11/75-nigerians-lack-access-to-regular-power/>
58. Fisher, A. (1992). Tolerances in lighting design. Proceedings of the CIE seminar on computer programs for light and lighting. Vienna, Austria: CIE.
59. Gabe Cross. (2010, January 24). Daylighting From East and West facing windows. Retrieved from Green Cross: <http://gabegreencross.blogspot.com.ng/2010/01/daylighting-from-east-and-westfacing.html?m=1>
60. Gerritsen, B. (2016, August). VisionAware. Retrieved June 24, 2023, from Lighting and Glare: <http://www.visionaware.org/info/everyday-living/home-modification-/lighting-and-glare/123>
61. Grant, M. (2015). 16 - Natural Lighting. 16293: Environmental Engineering Science 1. Glasgow: University of Strathclyde.

62. Gut, P., & Dieter, A. (1993). *Climate Responsive Building: Appropriate Building Construction in Tropical and Subtropical Regions*. SKAT.
63. Heerwagen, D. (2004). *Passive and active environmental controls*. New York: McGraw-Hill.
64. Heschong Mahone Group. (1999). —*Daylighting in Schools—An Investigation into the Relationship between Daylighting and Human Performance*. Pacific Gas & Electric Company and funded by California utility customers.
66. Hirning, M. G. (2010). *Theoretical comparison of innovative window daylighting devices for a sub-tropical climate using radiance*. Institute for Energy, Congress Centre Messe Frankfurt.
67. IEA TASK 21. (2000). *Daylight in buildings: A source book on daylighting systems and components*. Berkeley: Lawrence Berkeley National Laboratory.
68. IES Daylight Metrics Committee. (2012). *Approved method: IES spatial daylight autonomy (sDA) and annual sunlight exposure (ASE)*. New York: Illuminating Engineering Society of North America.
69. IESNA. (2000). *The IESNA lighting handbook, reference & application*. New York: IESNA.
- innovative design. (2004). *guide for daylighting schools*. daylight dividends: lighting research center Rensselaer Polytechnic Institute.
70. Italcementi. (2015). *Light-transmitting panels*. Italy: italcementigroup. Retrieved April 13, 2023, from Italcementi.
71. Jakubiec, J. A., & Reinhart, C. F. (2012). The ‘adaptive zone’—A concept for assessing discomfort glare throughout daylighted spaces. *Lighting Research and Technology*, 44(2), 149-170.
72. Jeong, T. K., & Gon, K. (2010). Overview and new developments in optical daylighting systems for building a healthy indoor environment. *Building and Environment*, 256-269 .
73. Kennelly, P. J. (2014). *General Sky Models for Illuminating Terrains*. INTERNATIONAL JOURNAL OF GEOGRAPHICAL INFORMATION SCIENCE.

74. Kensek, K., & Suk, J. Y. (2011). Daylight Factor (overcast sky) versus Daylight Availability (clear sky) in Computer-based Daylighting Simulations. *Journal of Creative Sustainable Architecture & Built Environment*, CSABE Vol. 1, November, 2011.
75. Khalid, A. A. (1996). *Prediction of interior daylight*. Masdar: Masdar Institute of Science and Technology.
76. Kjeld, J., & Richard, W. (2010). *Daylight in Building*. ECBCS Annex 29 / SHC Task 21.
77. Kleindienst, S., Bodart, M., & Andersen, M. (2013). Graphical Representation of ClimateBased Daylight Performance to Support Architectural Design. *LEUKOS, The Journal of the Illuminating Engineering Society of North America*.
78. Kota, S. (2007). *Historical Survey of Daylighting Calculations Methods and Their Use in Energy Performance Simulations*. Texas: Department of Architecture, Texas A&M University College Station, Texas.
79. Kroelinger, M. D. (2005). *Daylight in Buildings . Implications VOL 3 ISSUE 3*.
80. Ladan, G., Wayne, P., & Soolyeon, C. (2012). *Design Optimization of Daylight Roofing Systems: Roof Monitors with Glazing Facing in Two Opposite Directions*. North Carolina: North Carolina State University.
82. Liberman, J. (1991). *Light medicine of the future*. Mexico: Bear & Company Publishing.
83. Lighting Research Center. (2006). *Arch Studio: Daylight Characteristics and Design*. Troy: Rensselaer Polytechnic Institute.
84. Liquidsearch. (2016). Köppen Climate Classification. Retrieved July 14, 2016, from liquidsearch: [http://www.liquisearch.com/köppen\\_climate\\_classification](http://www.liquisearch.com/köppen_climate_classification)
85. Low Energy House. (2016). Sun Tube Lights. Retrieved July 13, 2022, from Low Energy House: <http://www.lowenergyhouse.com/sun-tube-lights.html> Lutron. (2013). *Daylight Autonomy made possible by Lutron*. Coscia Moos Architecture.

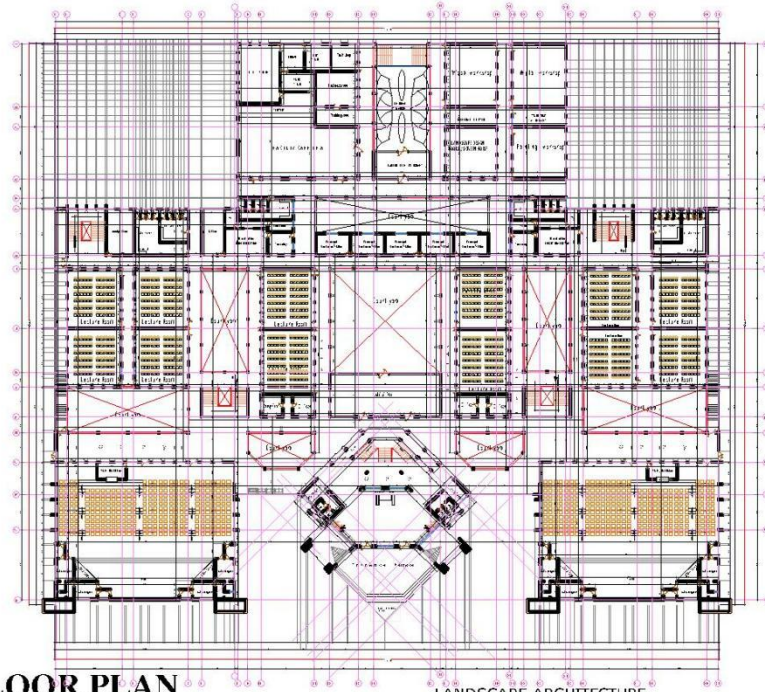
86. Magnus, H., & Magnus, O. (2012). daylight and thermal comfort in a residential passive house. Göteborg: chalmers university of technology.
87. Mahdavi, A., Rao, S. P., & Inangda, N. (2013 ). Parametric Studies on Window-To-Wall Ratio for Day lighting Optimisation in High-Rise Office Buildings in Kuala Lumpur, Malaysia. 5 Journal of Design and Built Environment Vol.12 June.
88. Mandinfinity. (2017). Parts of a window. Retrieved from Mandinfinity.com: <http://mandinfinity.com/parts-of-a-window/>
89. Marchese, P. (2006). S213 - Introduction to Ecotect Energy Design . microdesk.
90. Mardaljevic, J. (2000). The simulation of annual daylighting profiles for internal illuminance. Lighting Research and Technology, 32(3).
91. Mardaljevic, J. (2006). Examples of Climate-Based Daylight Modelling. CIBSE National Conference 2006: Engineering the Future 21-22 March 2006 (p. 2). London: CIBSE National Conference.
92. Mardaljevic, J., Heschong, L., & Lee, E. (2009). Daylight metrics and energy savings. Journal of Lighting Research and Technology 41, 261-283.
93. Mardaljevic, j., Brembilla, E., & Drosou, n. (2016). Real-world validation of climate-based daylight metrics: mission impossible. Presented at: CIBSE Technical Symposium 2016, 14th-15th April 2016, HeriotWatt University, (pp. 1-12). Edinburgh: Chartered Institute of Building Services Engineers (CIBSE).
94. Mark, K., James, R., & Christina, S. (2012). Lighting Design Basics. John Wiley & sons.
95. Mirrahim, S., Nik Ibrahim, N., & Surat , M. (n.d.). Effect of daylighting on student health and performance. Computational Methods in Science and Engineering. Retrieved from <http://www.wseas.us/elibrary/conferences/2013/Malaysia/MACMESE/MACMESE-20.pdf>

96. Nabil, A., & Mardaljevic, J. (2005). Useful daylight illuminance: A new paradigm to access daylight in buildings. *Journal of Lighting Research and Technology*.
97. National Universities Commission. (2017). Benchmark Minimum Academic Standards Nigerian Universities for Environmental Sciences. Abuja: NUC.
98. Nigeria places. (2016). Delta State, Nigeria. Retrieved July 14, 2016, from Nigeria places: <http://nigeriaplaces.com/asaba/delta-state-nigeria/>
99. Nilson, A. M. (2012). Digital systems: Development of techniques for optical characterization and performance evaluation. Retrieved from <http://urn.kb.se/resolve>
100. Ogunsote, O. O., & Ogunsote, P. B. (2002). Defining Climatic Zones for Architectural Design in Nigeria: A Systematic Delineation. *Journal of Environmental Technology* 1(2) 2002 1 - 14.
101. Oluwatosin, A. O. (2014). Beauty and Fashion Centre Abuja: Exploring the Use of Daylight to Enhance Visual Comfort. Zaria: AHMADU BELLO UNIVERSITY, ZARIA.
102. Oyetunmibi, O. (2015). Applied Climatology: Shading Devices. Akure: DEPARTMENT OF ARCHITECTURE,
103. Padma, B., Johnson, D., Afzal, B. P., & Prasanthi, K. (2013). Optical Fibres in the Modeling of Translucent Concrete Blocks. *International Journal of Engineering Research and Applications (IJERA)* Vol. 3, Issue 3, May-Jun 2013, 13.
104. Peel, M. C., Finlayson, B. L., & McMahon, T. A. (2007). updated world map of the Koppen-Geiger climate classification. Victoria: the University of Melbourne, Australia.
105. Philip, D. (2004). Daylighting: Natural Light in Architecture. In D. Philip, Daylighting: Natural Light in Architecture (p. 18). Italy: Architectural Press.

106. Plympton, P., Susan, C., & Kyra, E. (2000). Daylighting in Schools: Improving Student Performance and Health at A Price Schools Can Afford. American Solar Energy Society Conference, (p. 1). Wisconsin.
107. Roaf, S., Horsley, A., & Gupta, R. (2004). Closing the loop: Benchmarks for sustainable buildings. London: RIBA Enterprises Ltd.
108. Researchgate.net/figure/Climatic-zones-in-Nigeria-adapted-from Akinsanola-and-Ogunjobi 2014\_fig1\_3308786292022.
109. Salisu, A. S. (2015). Optimizing Fenestration For Daylight Provision In The Architecture Of Secondary Schools In Nigeria Using Climate-Based Daylight Modelling. zaria: Ahmadu bello university, Zaria.
110. Samani, S. A., & Sanaz, A. S. (2012). The Impact of Indoor Lighting on Students' Learning Performance in Learning Environments: A knowledge internalization perspective. Malaysia: University Technology Malaysia (UTM) Malaysia.
111. Shaily, R., & Vipul, S. (2011). Design Guide: Horizontal Shading Devices and Light Shelves.
112. Shuttleworth, M. (2008, april 1). case study research design. Retrieved from explorable: <http://explorable.com/case-study-research-design>
113. Siân, K., Magali, B., & Marilynne, A. (2007). Graphical Representation of Climate-Based Daylight Performance to Support Architectural Design. Massachusetts: Massachusetts Institute of Technology.
114. Skylight Council. (2011, march). Daylighting Basics. Daylighting and Energy Savings, p.1.
115. Society of Light and Lighting, SLL. (2011). SLL lighting guide 5: Lighting for education. London: CIBSE.

117. Supriya, G., & Kavish, M. (n.d.). daylighting in Schools and related case-studies. arizona: arizona state university.
118. Tao. (2010). daylighting: lighting design. Retrieved July 8, 2016, from tao for energy codes: <http://www.claritylearningsolutions.com/demos/ERS/eed-light-access.html>
119. Thermie Programme Action. (n.d.). Daylighting in Buildings. The European Commission Directorate-General for Energy (DGXVII). Retrieved from [http://erg.ucd.ie/UCDERG/pdfs/mb\\_daylighting\\_in\\_buildings.pdf](http://erg.ucd.ie/UCDERG/pdfs/mb_daylighting_in_buildings.pdf)
120. Tukur, R. B. (2013). Harnessing daylight potentials as a tool for visual and thermal comfort in residential buildings. Nottingham: University of Nottingham. .
121. U.S. Library of Congress. (2015). Climate. Retrieved Dec. 24, 2022, from country studies: <http://countrystudies.us/nigeria/33.htm>
122. Ubbelohde, M. S., & Humann, C. (1998). Comparative evaluation of four daylighting software programs. Proceedings of ACEE Summer Study on Energy Efficiency in Buildings.
123. Urban design system. (2016). Window screening. Retrieved Feb., 13, 2022, from Urban Design Systems: <http://www.urbandesignsystems.com.au/window-screening.html> Verges, M. (2008). Light in architecture. In M. Verges, Light in architecture.
124. Velux. [Learn about daylighting and the controlled use of natural light \(velux.com\)](http://www.velux.com/learn-about-daylighting-and-the-controlled-use-of-natural-light)
125. Ward, G. J. (1994). The RADIANCE Lighting Simulation and Rendering System. Computer Graphics (Proceedings of '94 SIGGRAPH conference).
126. Xtralite. (2012). Design Principles. Xtralite.

## APPENDICES

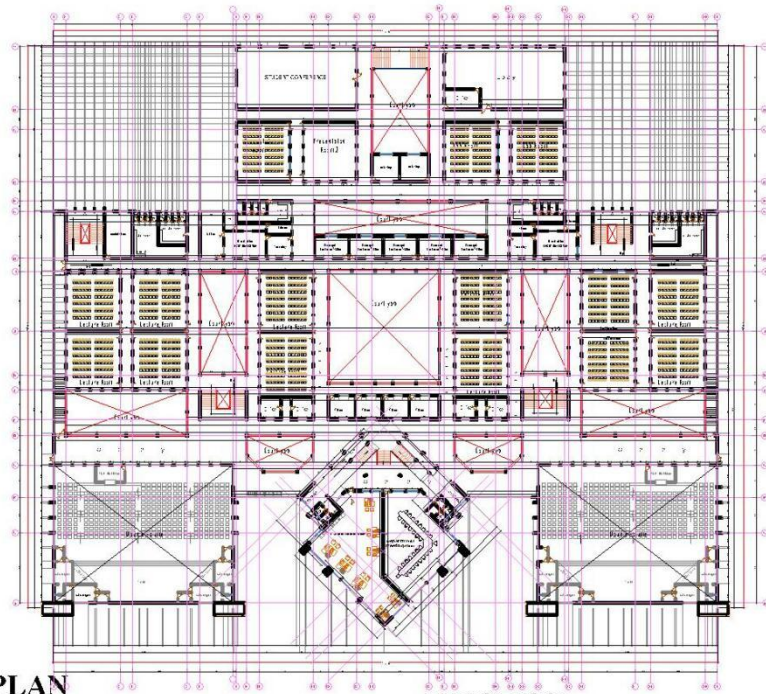


**GROUND FLOOR PLAN**

LANDSCAPE ARCHITECTURE  
ARCHITECTURAL TECHNOLOGY

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TITLE MSC. 2 ARCHITECTURE				
COURSE CODE 251				

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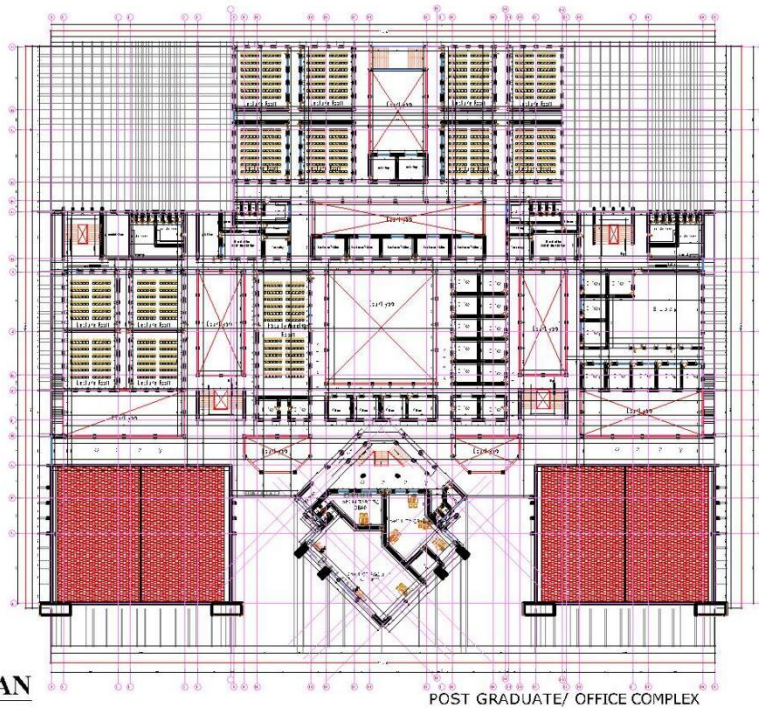


**FIRST FLOOR PLAN**

INTERIOR DESIGN  
ARCHITECTURE DEPARTMENT

NAME OLA OYE AZEEZADE DAMOLA	SUBJECT ADVANCED DESIGN STUDIO IV	PROJECT TITLE proposed: FACULTY OF ARCHITECTURE FOR LEAD CITY UNIVERSITY IBADAN, TOLL GATE LAGOS/IBADAN EXPRESS WAY, IBADAN, OYO STATE	SUBJECT TITLE FIRST FLOOR PLAN	COURSE LEAD CITY UNIVERSITY IBADAN
MAJOR LCU/FG/002834	SCALE 1:500		SHEET NO 1	DATE 2023
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COURSE COPY 751				DESIGNER ARC. DR. ADE DIRE FUNMILAYO DR. OPALEYE, ARC. AJUOLA

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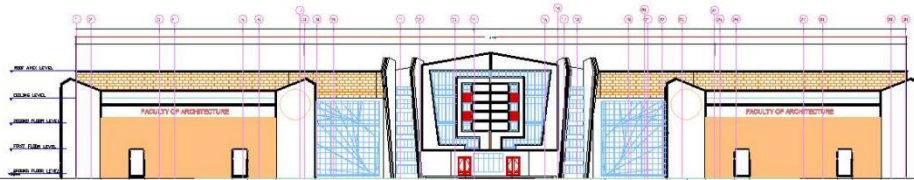


**UPPER FLOOR PLAN**

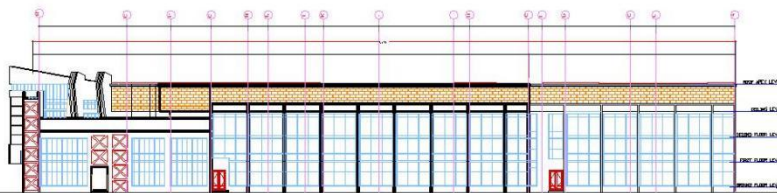
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NAME OLA OYE AZEEZADE DAMOLA	SURVISOR ADVANCED DESIGN STUDIO	PROJECT TITLE proposed: FACULTY OF ARCHITECTURE FOR LEAD CITY UNIVERSITY IBADAN, TOLL GATE LAGOS/ IBADAN EXPRESS WAY, IBADAN, OYO STATE	SHEET TITLE UPPER FLOOR PLAN	CUSTOMER LEAD CITY UNIVERSITY IBADAN.
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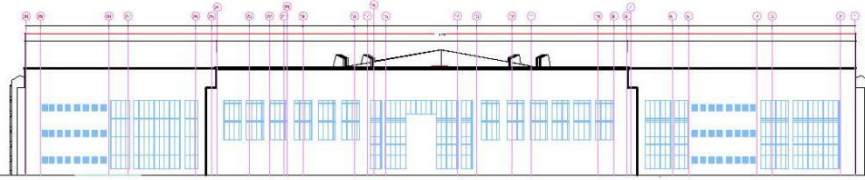
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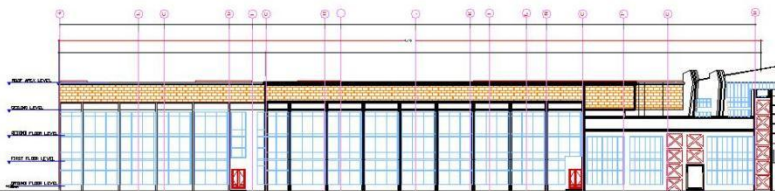
**RIGHT SIDE ELEVATION**

NAME OLAJOYE AZEEZADEMOLA	SUBJECT ADVANCED DESIGN STUDIO IV	PROJECT TITLE proposed: FACULTY OF ARCHITECTURE FOR LEAD CITY UNIVERSITY IBADAN, TOLL GATE LAGOS/ IBADAN EXPRESS WAY, IBADAN, OYO STATE	SUBJECT TITLE ELEVATION	COURSE LEAD CITY UNIVERSITY IBADAN
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TITLE MSC. 2 ARCHITECTURE				
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## BACK ELEVATION



## LEFT SIDE ELEVATION

NAME OLAJOYE AZEEZADE DAMOLA	SURVISOR ADVANCED DESIGN STUDIO IV	PROJECT TITLE proposed: FACULTY OF ARCHITECTURE FOR LEAD CITY UNIVERSITY IBADAN, TOLL GATE LAGOS/ IBADAN EXPRESS WAY, IBADAN, OYO STATE	SHEET TITLE ELEVATION	CUSTOMER LEAD CITY UNIVERSITY IBADAN
SCALE 1:500			SHEET NO. 1	DESIGNER ARC. DR. ADEDIRI F. UNMILAYO DR. O. BALUYE, ARC. A. JUOLA
TITLE MSC. 2 ARCHITECTURE				
COURSE CODE 751				







## **Biodata**

### **A. Personal Data**

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Place of Birth: Ibadan, Osun, State

Nationality: Nigerian

Marital Status: Single

Name and Address of Next of Kin: Olaoye Jeleel

### **B. Educational background**

#### **Educational Institutions Attended with Dates**

##### a. Primary Education

i. Rikky Tommy Nursery and Primary School, Ibadan 1996 - 2002

##### b. Secondary Education

i. Iwo Grammar School, Iwo 2002 - 2008

##### c. Higher Education

i. Federal Polytechnic Ede 2010 – 2012

ii. Federal Polytechnic Ede 2015 – 2017

iii. Lead City University 2019 - 2021

### **C. Academic and Professional Qualifications with Dates**

i. Bachelor of Science (B.Sc) Architecture 2021

ii. Higher National Diploma in Architectural Technology 2017

iii. National Diploma in Architectural Technology 2012

iv. National Examination Council 2008

v. Primary School Leaving Certificate 2010

**D. Work Experience with Dates**

Evergreen Design Associates	Current
National Youth Service Corps	2018-2020
EP-Graph Consult Ashi road, New Bodija, Ibadan	2013 - 2015
Archicrest Consultant Bodija, Ibadan, Oyo State	2012 - 2013

.....  
Date

.....  
Signature

*Do Not Copy, Lead City University, Nigeria*

### The University Compliance Certificate

This is to certify that the Thesis by Azeez Adedamola OLAOYE with matriculation number LCU/PG/002834 in the department of Architecture, Faculty of Environmental Design and Management, Lead City University, Ibadan, is in full compliance with the University format and style of Thesis.

.....

Date

.....

Signature

Do Not Copy, Lead City University, Nigeria