OPTIMIZING DAYLIGHTING IN THE DESIGN OF PROPOSED EXPOSITION CENTER, ABUJA

By

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DECLARATION

I hereby declare that the work in this dissertation titled 'OPTIMIZING DAYLIGHTING IN THE DESIGN OF PROPOSED EXPOSITION CENTER ABUJA' was performed by me in the Department of Architecture under the supervision of Dr. A.J. Ango and Dr. H.T. kimeng. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this work has been presented for another degree or diploma at any institution.

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CERTIFICATION

This dissertation entitled 'OPTIMIZING DAYLIGHTING IN THE DESIGN OF PROPOSED EXPOSITION CENTER ABUJA' by Abdullahi YUSUF meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

TO MY LATE FATHER MR. WILSON WAKAWA.

ABSTRACT

Getting light into the building entity in a clever way is an important stride to designing energy efficient buildings. Learning how to use daylighting, in an efficient way while having control will reduce energy demands in buildings and also facilitate a good visual comfort for users especially in a developing country like Nigeria where most trade fare take place using artificial lighting which increases operational cost. Most Exposition tend to use artificial lighting because proper daylighting design has not been integrated into the building. This study identifies different daylighting techniques that will reduce operational cost and at the same time, create a good visual experience. Literature on daylighting were studied, in which the advantages of daylighting in buildings were identified, different daylighting techniques and system were examined and various ways daylighting can reduce operational cost. The research methods adopted where exploratory case study, experimentation, visual survey of the various features inclined to the research work. Quantitative data collection method where adopted through personal observation /field survey, sketches, photographs and case study check list as data collection instrument. Case studies of relevant exhibition Centre buildings were analysed using variables such as the building envelope shape, geometry and location of aperture, surface characteristics, special distribution of light, illuminance ratio, colour rendition and visual noise, model of three case study buildings were carried out and run through simulation soft wares such as Ecotect, Radiance and daysim using data from metrological department. The various material properties used in the modelled building under observation where altered in terms of their "u-factor" "R-value" and Solar Heat Gain Coefficient (SHGC) and it was observed that energy consumption in terms of lighting was reduced by 35%. An important finding of the research was that a conscious proposition that will fuse daylighting as a major design consideration in term of materials and design considerations is essential for a successful daylighting design for buildings. This finding affects the design process from optimizing building orientation, the perfect size, form and

glazing treatment for windows, working with bright interior surface and shading for visual comfort. For the research design, atrium, laminated glass, and light shelves was appropriate for use. The implication of this finding opens a new dimension to the design of Exposition centres.

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List of abbreviations, definitions, glossary and symbols

A	Area
aSE	Annual Sun Exposure
CBDM	Climate-Based Daylight Modelling
DA	Daylight Autonomy index
DAcon	Continuous Daylight Autonomy
DAmax	Maximum Daylight Autonomy
DF	Daylight Factor
DSP	Daylight simulation percentage
EERE	Energy Efficiency and Renewable Energy
EPW	Energy Plus Weather file
IGU	Insulated Glass Unit
LEED	leadership in energy & environmental design
NREL	National Renewable Energy Laboratory
RVP	Relative Visual Performance model
SAD	Seasonal Affective Disorder
SHGC	Solar Heat Gain Coefficient
TMY	Typical Meteorological Year
UDI	Useful Daylight index

UDI<100	Useful Daylight index less than 100 lux
UDI100-2000	Useful Daylight index of 100 to 2000 lux, representing useful daylight
UDI>2000	Useful Daylight index greater than 2000 lux, representing excess daylight
UGR	Unified Glare Ration
VDT	Visual Display Terminals
VCP	Visual comfort probability
VT	Visible Transmittance

Glossary

Candela (cd)	is the intensity of the light source. A light source may emit one candela in a narrow beam, or in all directions. The intensity of the light would remain the same, but the amount of light would be different.
Daylight Factor (DF)	is a measure of natural daylight in an interior space, representing the amount of light at a given point in a space relative to the simultaneous amount of daylight available outside. The daylight factor is defined as DF= (Ei/Eo) x 100% Where, Ei = IL luminance due to daylight at a point on the in door's working plane. Eo = simultaneous outdoor IL luminance on a horizontal plane from an unobstructed hemisphere of overcast sky.
Daylight Level	To test and maintain required lighting levels it is standard practice to use a light meter. These instruments will provide a luminance reading based on either Lux or Foot-Candles. Lux (Lux) is a unit of illumination of one square meter, which is one meter away from a uniform light source. It is a European standard of measurement. Foot-Candles (FC) is also a unit of illumination. It measures one square foot that is one foot away from a uniform light source. It is a U.S measurement standard.

Energy rating (ER)	is a rating system that compares window products for their heating season efficiency under average winter conditions.
Fenestration	A window system with or without glazing (opaque), but with frames or obstructions like burglar proofing, which allow the admission of daylight or air.
IL luminance	the combined visible light striking a surface with the SI units of lumens/m2 or lux.
Lumen (lm)	describes the amount of light produced by a light source. A 60-watt incandescent bulb produces 900 lumens; a 36-watt T8 fluorescent tube produces around 3,000 lumens. The amount of energy that strikes a surface is usually measured in *lux*.
Luminance	is the measured brightness of a surface and is expressed in candelas per square metre (cd/m2). Humans perceive light in logarithmic fashion along a vertical Scale (a doubling of brightness is perceived as an increase of about 50 per cent).
Lux (lx)	describes the amount of light that strikes a surface. A lighting designer may try to achieve alight level of 500 lux at desk height in an office. Lux is a unit of illumination equal to one lumen per square meter. The imperial measure is *foot-candle*, which is one lumen per square foot. 1 Lux = 0.0929 FC, 1 FC – 10.76 Lux
Low-emissivity (low-e)	are coatings applied to window glass to reduce heat loss from inside without reducing solar gain from outside.

Reflectance	The ratio of light reflected by a body to the incident light.
Sealed insulated glass	they are glass of two or more layers used to lower the heat gain in a building.
U value	measure how effective a material is an insulator. The lower the U-value is, the better the material is as a heat insulator.
Visual Display Terminals	they are glare filters that attach directly to surface that can help reduce glare.

1.0 INTRODUCTION

1.1 Background of Study

The history of daylighting in architecture is punctuated by major developments, such as the discovery of new structural systems which allowed larger openings, and hence better natural lighting. Arguably, however, the one single event which could be considered pivotal, but also detrimental to the role of daylighting in architecture, was the invention of fluorescent lighting in the mid-1930s (Oksanen, 2017). This gave the architect virtual carte blanche (complete freedom) to design deep, windowless spaces, in which lighting levels were consistent no matter where an occupant was located. No longer was the building necessarily designed to take advantage of natural light, and architects were thus deprived of an important design element, one which their predecessors had considered so vital to the crafting of their architecture (Barret, 2014). Learning how to use daylighting, efficient lights, and good controls to both reduce energy demands and make people happier and more productive. The sun is predictable and daylight can be a very reliable source of light. Sunlight, views, and daylight are different though, and need to be carefully managed. Daylighting, or using sunlight to illuminate your building, is an effective way to both decrease your building's energy use and make the interior environment more comfortable for people. In commercial buildings, electric lighting accounts for 35 - 50% of total electrical energy consumption (Autodesk, 2015). Strategic use of daylight can reduce this energy demand. Daylight also improves people's comfort and productivity. Even when you cannot use daylighting, good lighting design can reduce energy use significantly. Both are important in Net Zero Energy Buildings (Autodesk, 2015). However, Daylighting is not just adding windows, if uncontrolled direct beam radiation is screaming through exhibition windows can negate daylighting strategies

altogether. The most important aspect of daylighting design is to understand how it affect human nature in addition to energy and maintenance benefits (Russell, 2014).

Furthermore, various studies agree that lighting is a major factor in determining the way in which people experience the internal environment, how they experience buildings, as well as how they are able to respond to certain tasks (Widich, 2013). Daylight studies show that daylighting has an important role in health and mental development (Tukur, 2013).However, 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 (Vegas, 2008).Le Corbusier one of the most well-known architect of the modern movement once said that in addition to the three dimension of any building which are; grid reinforced concrete columns, absence of supporting walls, free design. There is a fourth dimension called nature, which brings sunlight and fresh air to building occupants (Labib, 2013). In the late nineteenth century, many architects excluded daylight from their designs and replaced it with fluorescent lights Building professionals even argued that daylight was a luxury that could be disregarded. In 1936, one author for the Architectural Record noted "science has advanced to the point where artificial lighting can be a competitor to daylighting (Barret, 2014). Moreover the importance of day light as an integral part of human life cannot be over emphasized, it very essential in shopping mall, exhibitions and market places, of which architects have negated the responsibility of providing good day light to the hands of other professionals who must a times provide artificial lighting of various types that most at times do not provide the needed visual comfort (Vegas, 2008). Therefore, it is difficult to overestimate the significance of daylight, and of sunlight, in the character of a building and in the lives of the people who use it. There are, of course, some building types, such as cinemas,

theatres or nightclubs, where being cut off from the world outside is an essential part of the experience. In others, department stores or museums for example, daylight may be excluded from large areas of the building so as to give full play to carefully designed display lighting. But most interiors which are to be occupied by people, as opposed to goods or machinery, need plenty of light, and until the middle years of this century the limits of natural lighting were critical determinants in the plan of a building and in the design of its external envelope (Group, 2010).

1.2 Problem Statement

There is need to design sustainable Exposition centres in order to minimise the extensive energy consumption in lighting, with the epileptic power shortage in the country and the need to improve sales through proper use of daylighting as studies have shown that daylighting in expositions halls help in improving sales (Eduardo, 2012). Shortage of electricity in Nigeria have been a major problem which increase the cost of running exposition in terms of lighting up spaces especially in developing countries like Nigeria (Sadik, 2015) . Large fractions of today's exposition' electricity consumptions are due to electric lighting which account for 20-30% of a typical non-domestic building's electricity consumption in the United States, "roughly 40% of electricity consumption in exposition buildings is attributable to lighting" (Hinnels, 2008). Electricity consumption reduction in terms of using passive daylighting and energy-efficiency are two major determinant that can help in reducing carbon emission and help in achieving a greener environment (Christoph, 2011).

1.3 Justification for the Study

Current movement tend towards sustainable architectural design with more emphasis to natural and passive design element. With the increase damage of the ecosystem through global warming, as architects. Therefore there is need to carry out a study on how to

improve lighting of the interior space without depending much on electricity supply, thereby conserving and making Exposition centre cost effective while reducing energy consumption, in a country with poor electricity supply which gives an added advantage to running process buildings. The projects deals with reducing energy consumption in Exposition centres through the use daylighting as a substitute for electricity.

1.4 Aim and Objectives

The aim of this research is to study energy conservation by the use of daylighting.

The objectives include;

1. To explore the concept of daylighting from literature.
2. To establish how daylighting features have been incorporated in the design of exposition centres from case studies.
3. To empirically determine user requirement, response and attitude to daylighting visibility in exposition centres.
4. To demonstrate findings from the research in the design of exposition centre Abuja.

1.5 Research Questions

The questions to be addressed by this dissertation are as follows:

1. What daylighting concepts exist in literature?
2. How can daylighting be harnessed in the design of Exposition centres?
3. What are the basic principles of daylighting design?
4. To what extend has daylighting being used in Exposition centres in Nigeria?
5. How can daylighting be optimised in the design of an exposition centre for Abuja?

1.6 Scope of the Study

This research will involve the study of exposition in Nigeria as part of a facility. Exposition centre in the country are either provided in a facility or are an extension of the facility. There is no single exposition in the country. The proposed Exposition centre to be sited along airport road of the Federal Capital Territory Abuja essentially have a scope centred on daylighting aimed at improving lighting conditions, improved sales, energy efficiency and a greener environment. The Exposition centre contains all essential facilities that a present day trade fair should have. Such components shall include; Exhibition halls with sound proof partitions, Exposition, Indoor space, Registration halls, Café and restaurants, Service centres, among others. The centres to be studied are centres that contain state of the art facilities when it comes to exposition. Foreign case studies will also be included since we do not have a single expo exhibition in the country. This research tend to study related issues/ literature concerning existing Exposition in Nigeria. This has become imperative in order to have a standard and possible addition to existing exhibition centres. Information will also be gathered from field work carried out on buildings with emphasis on daylighting.

1.7 Research Significance

Adopting environmentally sustainable design principles in the design and construction of exposition centres through the use of daylight improves the living comfort, brings high investment return to its owners and as well meets best practise standard all over the world. This research information will help in identifying and addressing the key areas of optimizing daylighting in energy efficient building design. More also this research shall be a solution to government and exposition owners on the ways to optimize daylighting for a greener environment.

1.8 Summary

In this chapter the research topic was clearly stated i.e. optimizing daylighting in exposition centres through the various strategies and principles of optimizing daylighting. The research work has comprehensively gave a background of the study, identified the stated the problem that called for the research ,justified the topic of the research, outlined the aim and objectives ,identified what the research questions are, state out the scope and significance of the study. All this where discussed in chapter one.

2.0 LITERATURE REVIEW

2.1 Daylighting

Daylight consists of two words “day” and “light”. The word “day” according to Microsoft Encarta dictionary (2011), Daylighting can be defined as that visible light which is emitted via the electromagnetic radiation from the sun (Yohannes, 2011), is a part of a twenty four hour period when it is light, between sunrise and sunset, and, the word ‘light’ is defined as the energy which produces a sense of brightness that makes seeing possible i.e. fig 2.1 Combine the two words, “day light” is the condition of brightness created by the rays of the sun during the day. Therefore, “daylighting” according to (Ander, 2010) is the controlled Admission of natural light into a space through openings to reduce or eliminate artificial lighting.



Fig 2.1: Daylighting
Source: A2ua.com.

daylighting create a visually stimulated and productive environment for building occupants in terms of health and well-being, while reducing as much as one-third of total building energy costs (Ander, 2010)Energy savings can be achieved either from the reduced use of artificial (electric) lighting or from passive solar heating or cooling. Artificial lighting energy use can be reduced by simply installing fewer electric lights

because daylight is present, or by dimming/switching electric lights automatically in response to the presence of daylight, a process known as daylight harvesting.

2.1.1 Sources of light

Some material bodies emit light and others do not. Light comes from sources such as the sun in the sky and from other sources close at hand on the earth such as fire or lamps (Nick, 2013).They "give" light as we say where as ordinary object do not. Non-luminous objects only reflect some part of the light that falls on them from a source, and yet we can see the non-luminous bodies along with the luminous ones , in fact most of the things that need to be seen are non-luminous, they are seen by reflected light. Light sources can be grouped into:

2.1.1.1 Direct sources: this include:

1. Daylighting
2. Artificial lighting

2.1.1.2 Indirect sources: this include

1. All surfaces that reflect light.

2.1.2 Advantage of Daylighting.

The major advantage of daylighting are the following

1. Practical nature
2. Energy conservation
3. Cost factor
4. Health and well-being
5. Aesthetic nature

2.1.2.1 Practical nature

By providing a direct link to the dynamic and perpetually evolving patterns of outdoor illumination, daylighting helps create a visually stimulating and productive environment

for building occupants, while reducing as much as one-third of total building energy costs (D.Ander, 2014).

2.1.2.2 Energy conservation

Daylighting has the potential to provide significant cost savings. For example, using an estimated incremental first cost increase of $0.50 to $0.75 per square foot of occupied space for dimmable ballasts, fixtures, and controls, daylighting has been shown to save from $0.05 to $0.20 per square foot annually (Shaw, 2010)

2.1.2.3 Cost factor

The energy savings from reduced electric lighting through the use of daylighting strategies can directly reduce building cooling energy usage by an additional 10% to 20%. Consequently, for many institutional and commercial buildings, total energy costs can be reduced by as much as one-third through the optimal integration of daylighting strategies.

2.1.2.4 Health and well-being

It have being reported that daylight environments increase occupant productivity and comfort, and provide the mental and visual stimulation necessary to regulate human circadian rhythms (Wymelenberg, 2014).

2.1.2.5 Aesthetic nature

Aesthetics is a study of the interaction of our senses with our emotions, in short, our taste. A study of our most important sense, the vision, and the influence of the interaction between daylight and artificial light on our vision is of great importance to a deeper understanding of aesthetics (Volt, 2011). Furthermore the science of daylighting design is not just how to provide enough daylight to an occupied space, but how to do so without any undesirable side effects. Beyond adding windows or skylights to a space, it involves carefully balancing heat gain and loss, glare control, and variations in daylight availability. For example, successful daylighting designs will carefully consider the use

of shading devices to reduce glare and excess contrast in the workspace. Additionally, window size and spacing, glass selection, the reflectance of interior finishes, and the location of any interior partitions must all be evaluated. (Roaf, 2004) Opine that lighting cannot just be measured in "amount" alone, and that indicators of good lighting should include:

2.1.3 Indicators of good lighting

1. Visual comfort
2. Visual delight
3. Average IL luminance in the working plane
4. Uniformity of IL luminance in the working plane
5. Luminance ratios within the space
6. Glare levels in the space
7. Direction of light and the effect of shadows
8. Colour temperature of light
9. Colour rendering of light

2.2 Daylighting Strategies in Building Design

"Architecture is the masterly, correct and magnificent play of masses brought together in light" Le Corbusier, versune architecture (Towards a new Architecture) Paris 1922 (Adolf, 2008).from the fig1.1 below the main part of the famous structure by le Corbusier when it comes to daylighting consist of two concrete membrane separated by 2.26 meters forming a shell which constitute the roof of the building. A space of several centimetres between the shell of the roof and the vertical envelop of the wall furnishes a significant entry of daylight. The floor of the chapel follows the natural slope of the hill and clown towards the chapel alter.

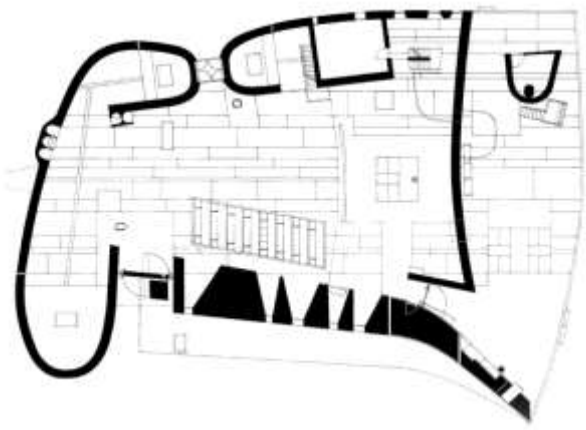


Fig 2. 2: The floor plan of Le Corbusier's chapel at Ron champ
Source: Architectural moleskine.blogspeed.

Daylighting is formed from the interior as seen in Fig 2.2 by a system of opening covered with clear glass, and, in place, with coloured glass through which one can see the cloud or the movement of foliage and even passers-by. The interior of one of the wall of the chapel is painted in intense red while a little further on the wall leading to the sacristy is painted in violet this are made in other to have adequate daylight for worshipers in the chapel. This is one of the greatest achievement in terms of daylighting design, which allows for proper utilization of the passive lighting source as seen in Fig 2.3.



Fig 2. 3: The interior of Le Corbusier's chapel at Ron champ
Source: www.galinsky.com/buildings/ronchamp/.

Furthermore from the exterior it can be noted that the openings are positioned and constructed in a way that will allow for easy passage of light into the interior space in terms of size and shape i.e. in fig 2.4



Fig 2. 4: The exterior of Le Corbusier's chapel at Ron champ
Source: www.galinsky.com/buildings/ronchamp/.

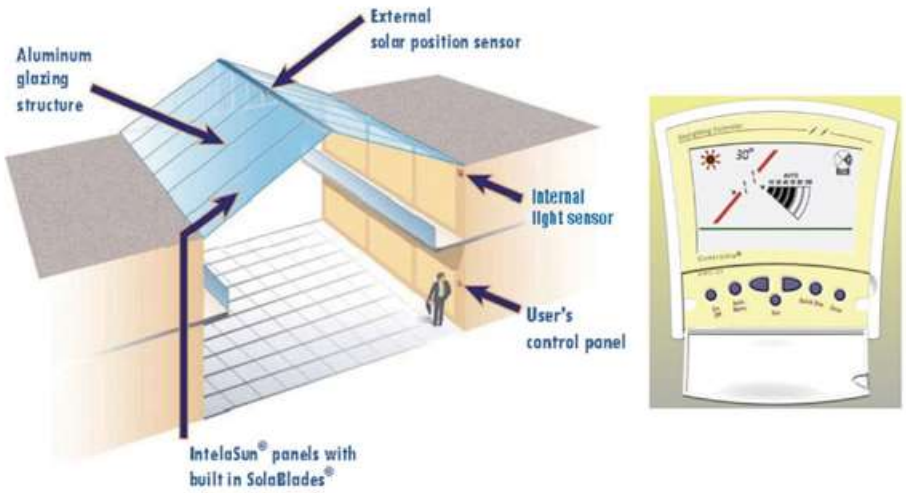


Fig 2. 5: Intelligent controlled daylighting system
Source: Copyright © Intela sun 2014.All Right Reserved.

Throughout history, daylight has been a primary source of lighting in buildings, Supplemented originally with burned fuels and more recently with electrical energy.

Before daylight was supplemented or replaced with electric light in the late 19th-century, consideration of good daylight strategies was essential. As we entered the mid-20th-century, electric light supplanted daylight in buildings in many cases. Fortunately, during the last quarter of the 20th-century and early years of this century, architects and designers have recognized the importance and value of introducing natural light into buildings. (Kroelinger, 2005). Over the year's daylighting from the sun have been the primary source of lamination in most commercial and public space which need a wide opening to allow for easy transmission of light to the interior space. But the sun is not always static therefore there is a need to controlled its movement using sensors. Efficient lighting using intelligent controlled daylighting (such as the intelligent control system, Fig 2.5 shows how light from the sun can be controlled at various time of the day efficiently to acquire maximum satisfaction), this system has to be user friendly while conserving energy (lewis, 2010). Daylight is an essential resource that is readily available and unlikely to run out for the foreseeable future. It also 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 (Agency, 2010).Daylighting reduces the need for electric light by introducing natural light into a building. Daylight programs are established to build market demand for daylighting as a means of improving indoor environmental quality; to overcome technological barriers to effectively reap the energy savings of daylight; and to inform and assist state and regional market transformation and resource acquisition program implementation efforts (Center, 2004). Coated low-emissivity glazing have achieved widespread market penetration and user acceptance as a means of optimizing daylighting while obtaining net energy savings. Several less

conventional technologies, including light pipes, prismatic panels, and electro chromic glazing are still undergoing development in order to overcome barriers of architectural integration, cost, and user acceptance (Sweitzier, 1993).

2.2.1 Potential Draw Backs to Daylighting

There are some disadvantages that daylight have even though it is highly recommended especially in residential and public building .daylighting have the following disadvantages as follows:

1. Increased heat gains
2. Increased cooling load
3. Glare
4. Increased electric lighting load.
5. Functional interference (example projectors).

2.2.2 Potential Benefits of Daylighting

Even though there are some drawbacks to daylighting in some cases, there have being records of some of the usefulness accrued to daylighting in buildings which are enormous, as daylighting is recommended in most buildings

1. Reduced electric lighting load
2. Reduced internal gains
3. Reduced cooling loads
4. Improves lighting conditions
5. Occupant satisfaction
6. Occupants comfort
7. Connection to nature
8. Time orientation

9. Health: circadian rhythms. etc.

2.2.3 Factors affecting the use of daylighting.

Daylighting in most buildings have some challenges when it comes to the use of the light in question. The following are the basic factors that affect the use of day light within a building.

1. Characteristics of the lighting
2. The task.
3. The visual system of the observer.

2.3 Basic principles of daylighting

Daylight needs to be considered at the outset of designing a building as daylighting strategies and architectural design strategies are inseparable. Daylight can not only replace artificial lighting, reducing lighting energy use, but also influence both heating and cooling loads. (agency & johnsen, 2010). Begin by planning the building so that every occupied space has access to a source of natural light, such as a windows or skylights - giving special attention to windows that provide a view. The following principle are to be followed when designing for daylighting:

1. Reduce the size of the east and west sides of the building.
2. Maximize south and north sides of the building.

The sun rises from the eastern part of any site as that is where the sun is located therefore there is a tendency that a lot of the direct ray from the sun may affect the building structure only if shading device are going to be provided. North-facing windows present no solar heating problems, South-facing windows are the easiest to protect with overhangs, awnings, and light shelves (Vosko, 2014).

2.3.1 Control of daylighting through design approach

When designing for daylighting which should be fused to the building at an early stage of the design there are some criteria that should be followed to derive maximum benefits of daylight.

2.3.1.1 Daylighting Design Criteria.

The architect or designer of the building envelop is expected to give adherence to the following design requirements.

1. Avoid Direct Sunlight and Sunlight on critical tasks.
2. Bounce Daylight off surrounding surfaces to diffuse light in more even brightness.
3. Bring Daylight in from above to obtain deeper penetration.
4. Filter daylight to avoid harshness of direct sunlight and skylight.
5. Maximize ceiling heights to gain better light distribution.
6. Use design strategies that separate View glass from Daylight glass.
7. Develop appropriate control strategies i.e. dimmers.
8. Building geometry and spatial arrangements should promote rather than preclude distribution of daylight.
9. Buildings should be massed and configured so maximum number of spaces are near daylight.

2.3.2 Approaches to improving visual comfort

In order to ensure visual comfort it is necessary to ensure that the lighting allows a good level of visual performance and does not cause distraction. This can be done by the following:

1. Identify the visual task to be performed and then determine the characteristics of the lighting needed to allow a high level of visual performance of the task, for example, by using the RVP model (Relative Visual Performance model).

2. Reduce disability glare by selection, placement, and aiming of luminaries to reduce the luminance of the luminaries close to the common lines of sight.

3. Reduce discomfort glare by selection and layout of luminaries. Use VCP (visual comfort probability) or UGR (Unified Glare Ration) to estimate the magnitude of discomfort glare.

4. Using high-reflectance surfaces in the space will help reduce discomfort glare by increasing the background luminance against which the luminaries are seen.

5. Consider the density and extent of any shadows that are likely to occur. If shadows are undesirable and large-area shadows are likely to occur, use high-reflectance surfaces in the space to increase the amount of inter-reflected light.

6. Shadows cannot be avoided because of the extent of obstruction in the space, provide supplementary task lighting in the shadowed areas. If dense, small-area shadows occur in the immediate work area, use adjustable task lighting to moderate their impact.

7. Reduce veiling reflections by reducing the specular reflectance of the surface being viewed, or by changing the geometry between the viewer, the surface being viewed, and the observer, or by increasing the amount of inter-reflected light in the space. If the reflections are occurring on a self-luminous surface, such as a VDT screen, use dark letters on a bright background. This will reduce the impact of any veiling reflections seen on the screen (Peter R. B., 2003)

2.3.3 Importance of daylighting in exposition centres

According to (Ruck N. , 2000) Daylight provides high illuminance and permits excellent colour discrimination and colour rendering. These two properties mean that daylight

provides the condition for good vision. However, daylight can also produce uncomfortable solar glare and very high luminance reflections on display screens, both of which interfere with good vision. Thus, the effect of daylight on the performance of tasks depends on how the daylight is delivered. All of these factors need to be considered in daylighting design for Expo/ Exhibition centres. Daylight strategies and systems have not always lived up to their promise as energy efficiency strategies that enhance occupant comfort and performance. These strategies include the following.

2.3.3.1 Side lighting

For centuries side lighting has been a primary way of introducing light into a building. Besides supplying light side lighting can provide views, create orientation, allow connectivity to out-of doors and allow ventilation during less harsh times of the year. Side lighting aims to distribute daylight into the depth of a space to provide enough light for performing a task in the room while avoiding glare and allowing a view to the outside i.e. Fig 2.6.



Fig 2. 6: Clerestory side lighting
Source: lighteditor.org

Whereas in side lighting for the tropics, the use of direct sunlight should be discouraged from view directions and visual task lighting due to the high probability of glare and thermal discomfort along the perimeter walls (Salisu, 2015). Daylight openings and

external controls should vary by compass direction since each façade of a building, based on orientation, receives differing amounts of daylight throughout the day and across seasons. Location of openings in walls can be low, middle, or high depending on desired distribution and structural and wall system restrictions.

2.3.3.2 Single Side Lighting

These method of fenestration, introduces light on one side. Light is brighter on the side with fenestrations. Other end of the room will appear darker. It is Use to achieve useful work surface illumination throughout the space, the ratio between the depth of the room and the height from the floor to the top of a full-room width window in single side lit spaces should be limited to 1:2 or 2:5 as seen below in Fig 2.7 if interior surface reflectance are high.



Fig 2. 7: Plan of single side lighting
Source: viewers.org.

2.3.3.3 Bilateral Lighting

Here, the Windows are placed on opposite sides as seen in Fig 2.8 to introduce light from opposite ends. Also achieved by placing a clerestory at the opposite end.it Provides

relatively even illumination. To achieve adequate lighting quantity in a space on opposite ends.



Fig 2. 8: Bilateral lighting.
Source: viewers.org.

2.3.3.4 Top lighting

Top lighting penetrates a building from above the ceiling plane or is concentrated and referred to the interior as to lighting top lighting can provide greater freedom of source plan and more illumination, takes advantage of high wall surfaces and proves from better lighting There are several ways of letting daylight in through the roof. A classic concept is the saw tooth clerestories of old factories. This and a few other examples are reviewed below. They present ways of achieving high and uniform levels of illumination. But there are also drawbacks, most methods are only possible to use on the top floor and as overhead light sources they can give glare problems through veiling reflections. The latter issue can be dealt with by placing the top lighting sources correctly or by diffusion through reflection or the use of baffles i.e. Fig 2.9 (Erik, 2002).

2.3.3.5 Skylights

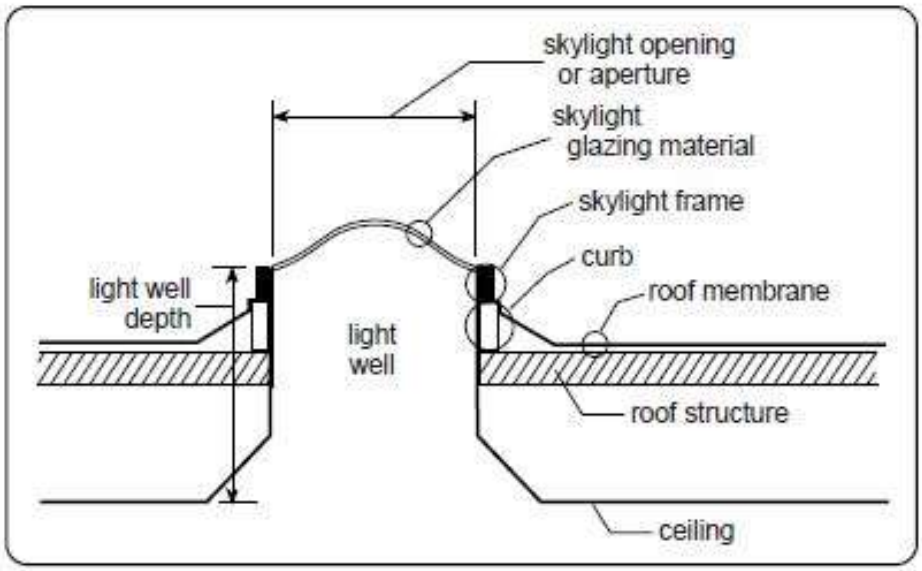


Fig 2. 9: Typical sky light
Source: artisticskylight.com © all rights reserved.

These are openings in the roof that let daylight in. They are horizontal or just slightly sloped and because of this they view a large part of the sky dome. This allows them to transmit a high level of illumination. Direct sunbeams are undesirable and this calls for some kind of diffuser. For skylights diffusion can be achieved by for example translucent glazing, baffles or by placing the skylight next to a back wall that acts as reflector. Also other kind of reflectors can be used to bounce the incoming light in the e.g. ceiling. Horizontal skylights collect more light and heat in the summer than in winter. If they are sloped towards the south (for the northern hemisphere), they will provide light more uniformly throughout the year. As the slope increases, the skylights eventually become clerestories or monitors as in Fig 2.10. Skylights can also be combined with heliostats to make them an active system. The heliostats than track the sun to always provide the skylight opening with high levels of illumination.

2.3.3.6 Clerestories



Fig 2. 10: Clerestories
Source: Ferromobius.wordpress.com

Monitors, clerestories and saw tooth clerestories all use vertical or steeply sloped glazed openings on the roof. They can be either north or south facing. On the northern hemisphere south facing openings will provide a high, but varying, level of illumination i.e. Fig 2.10. Except for a very northern latitudes direct sunbeams are easy to shade. North facing openings will provide a low, but near to constant, level of illumination. East- or west facing openings are avoided because it is difficult to shade the low sun. South facing clerestories are often a good solution that will provide good lighting all year and also sun heating in the winter.

2.3.3.7 Types of clerestories

There are various types of roof clerestories which include:

2.3.3.7.1 Roof Monitor or Double Clerestory

The use of high windows on two opposite sides above the ceiling line. Usually oriented along the east and west axis relatively even and balanced quality of light achieved

compared to a single clerestory. To deliver daylight deep into interior areas of buildings i.e. Fig 2.11. Used especially in churches.

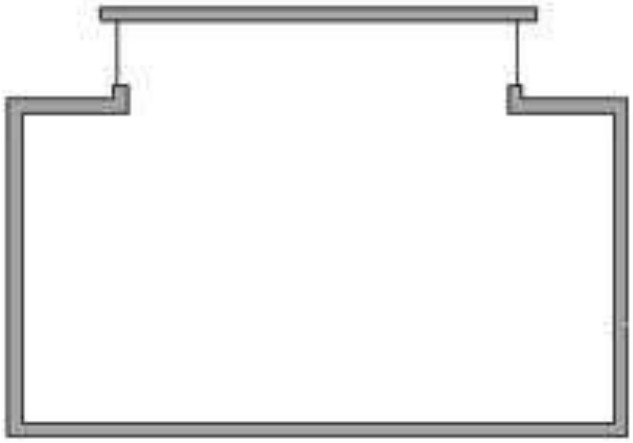


Fig 2. 11: Roof monitor double clerestory
Source: viewers.org.

2.3.3.7.2 Saw tooth Clerestory

Use for high windows and angled ceiling to produce more indirect reflected light. Usually oriented to the north it has even lighting quality and deep penetration achieved when oriented to the north due to indirect reflection of light in the interiors. Use To deliver daylight deep into interior areas of buildings i.e. Fig 2.12. Used especially in factories and warehouses.

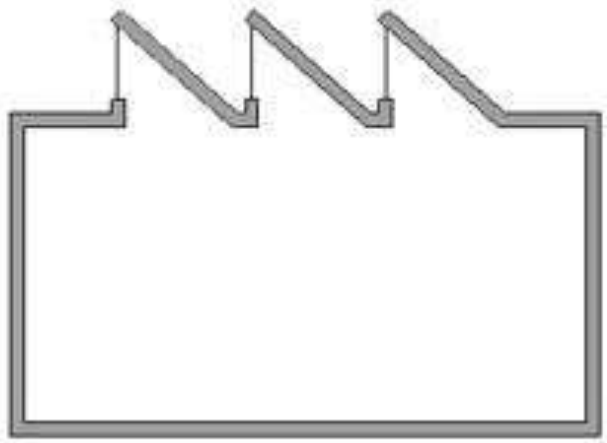


Fig 2. 12: Saw tooth clerestory
Source: viewers.org.

2.3.3.7.3 Light Shelf

Provides both indirect light and shading, increasing the amount of daylight penetration. Reduced brightness contrast between the interiors and the exteriors, and prevents the direct view of sun or sky i.e. Fig 2.13. Use to Increase daylight penetration.



Fig 2. 13: Light shelf
Source: viewers.org.

2.3.3.7.4 Awning

Extended shades used on the east and west facades of the building. Reduced brightness contrast between the interiors and the exteriors i.e. 2.14. Used to provide shade to the building apertures.



Fig 2. 14: Awning
Source: viewers.org.

2.3.3.7.5 Sun pipes

This is a less architectural system, it is more technical and on the limit of being an active system. Actually some of these systems are active and have heliostats included, an example of such a system is the Heliobus active systems. The Solar tube system is an example of a passive sun pipe see Fig 2.15.

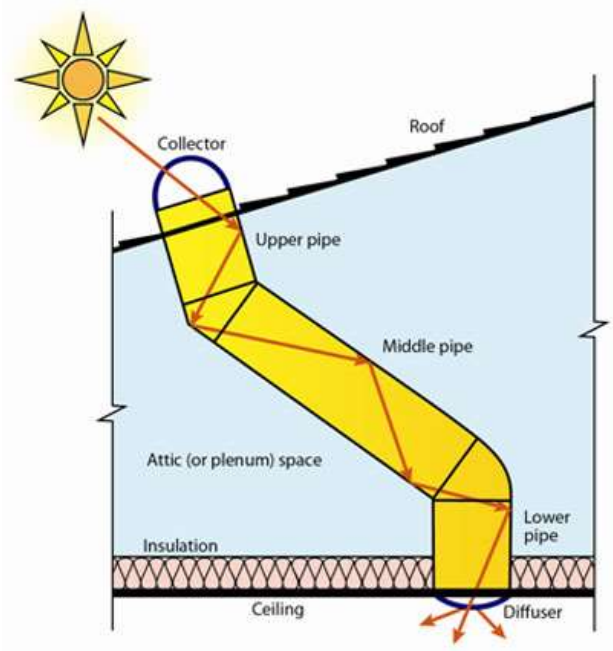


Fig 2. 15: Sun pipes
Source: lowerenergyhouse.com.

The light collector for this system is simply a transparent dome with a reflector inside, which is placed on the roof. The collected light is transmitted through the roof by a tube with a highly reflective inside. Where the tube cuts through the ceiling the light is released into the room in question through an acrylic diffuser. Light can be reflected both on a high-reflective roof and on a bright interior wall or ceiling to increase both the amount of light entering the building and the utilisation of it. Also other kinds of inner reflectors, or daylight fixtures, can be used to improve the function of this top lighting system.

2.3.4 Health and well being

The availability of daylight and its impact on the health and wellbeing of building users is generally nowadays acknowledged as fact and writing some five years later it will still be relevant (Gallagher, 1999).cites winter statistics for the north of the United States, pointing out the serious nature of an illness known as seasonal affective disorder (SAD). Six percent of New York residents suffer severe depression during winter, but as many as 50% of the residents suffer mild symptoms, including low energy, and disturbed eating and sleeping patterns. Gallagher believes that this behavioural problem has a specifically environmental cause. (Ashehoug, 2008) Is also very specific on the issue of health. and wellbeing of the occupants of buildings, and suggests that " light can also be considered on physiological and biological grounds as being essential for the wellbeing of a building's occupants owing to its non-visual effects such as brain stimulation and body orientation and balance. A good luminous environment therefore depends not only on environmental and task lighting design, but also on the spectral composition effects of the light on individuals. Great architects, including the designers of the Parthenon, the craftsmen of the Gothic cathedrals, and indeed certain twentieth-century architects, have understood the impact of natural light and its importance for putting human beings in touch with their environment" (Ashehoug,

2008).It is no coincidence, therefore, that natural light has always played a key role in the design of certain building types, in particular where human emotional wellbeing could be an issue, including sacred and religious architecture. (Steger, 2010) Considers that "natural light… [Has] a fundamental effect on the atmosphere of sacred spaces. Light and shadow determine the spatial qualities of a space. light can accentuate, direct attention, create an atmosphere of contemplation and composure, foster togetherness in prayer, or underline the solemnity or festiveness of an occasion" (Steger, 2010) discusses the issue of human biorhythms, and the importance to human wellbeing of maintaining the 24-hour pattern. The quality and quantity of natural light plays a central role in this, and she refers to evidence indicating those seasons as physiological and psychological

2.3.5 The negative effects of artificial light on vision

According to (ACTION, 2010), spending too much time in buildings with fluorescent lighting can cause headaches and eye strain. This is because of the flickering that occurs with fluorescent lighting. Other forms of artificial lighting aren't free of health consequences. Incandescent light – the most popular form of lighting in homes – can also produce serious eye issues. Because incandescent bulbs produce areas of bright light, focusing on one source of light can lead to eye strain for people whose eyes can't easily adjust. Then there's the heat issue. Many forms of artificial lighting, particularly halogen and incandescent lights, produce a massive amount of heat. Halogen lighting, in particular, produce so much heat when used for extended periods of time that a number of local governments consider them a fire hazard (Bristolite, 2012).

2.3.6 Daylighting and visual comfort

Daylighting and visual comfort work hand in hand to achieve the needed outcome for the viewer when clearly defined:

2.3.6.1 Visual comfort

Daylight 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). Poor lighting can cause eyestrain, fatigue, headaches and irritability, to say nothing of mistakes and accidents (ACTION, 2010). The components of a daylighting system are designed to bring natural light into a building in such a way that electric lights can be dimmed or turned off for a portion of the day, while preventing occupant discomfort or other building loads from increasing. For example, direct sun in the eye of a building occupant can cause disability glare, which interferes with the occupant's ability to see and perform work and should be avoided. Depending on the building construction and prevailing climate, excessive window area could also increase the cooling load in summer or accelerate heat loss in winter. An optimized building footprint is a foundational element of a daylight building design. Maximizing the amount of south- and north-facing facade area and minimizing east and especially west exposure allows for the easiest controllable daylight fenestration. Restricting the floor plate depth (north-to-south) also helps to daylight as much floor area as possible, as there are practical limitations to how far one can transmit daylight in side lighting applications (Barret, 2014). The primary objective in the design of any lighting system (daylight or electric light) is to provide the Illuminance levels required for visual performance at the task, using a system that enhances visual comfort in the work environment. Both ceiling-mounted electric lights and skylights have the potential to cause visual discomfort, and the techniques for avoiding this are the same. There are two basic areas of concern:

1. Avoid excessively bright sources within the occupants field of view
2. Avoid reflections from bright sources on the work surface i.e. Fig 2.16

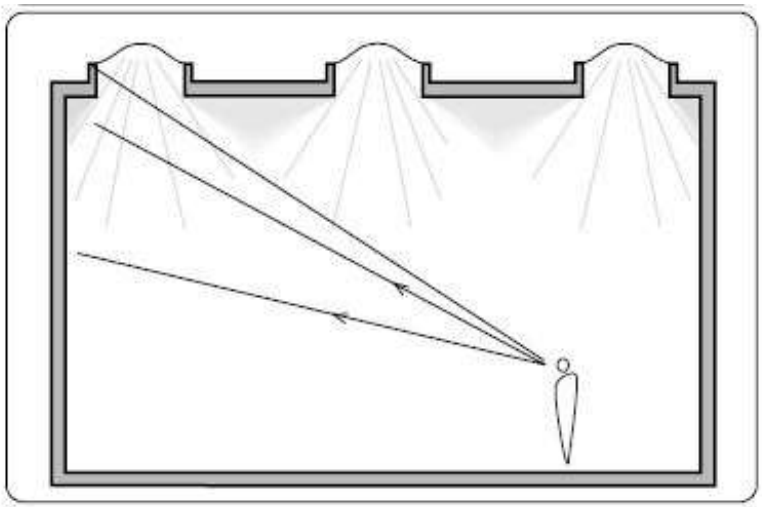


Fig 2. 16: Cause of visual dis-comfort
Source: illuminance source.com.

The surface of diffusing skylights can become very bright in sunlight, and is a potential source of glare to people working in the space. If the skylight is directly in their line of vision, it may cause visual discomfort, as their eyes try to adjust between the extremely bright skylight and less bright room surfaces. The height of the ceiling in relation to the proportions of the room affect the probability that the skylight may cause glare. If a room has a very low or very large ceiling, it is more likely that the skylights will be within the occupants' field of view. The higher the ceiling, the less likely this is to be a problem i.e. Fig 2.17. Using a section drawing of the building to understand the angles of sight within the room is the best way to determine if there may be a potential problem.

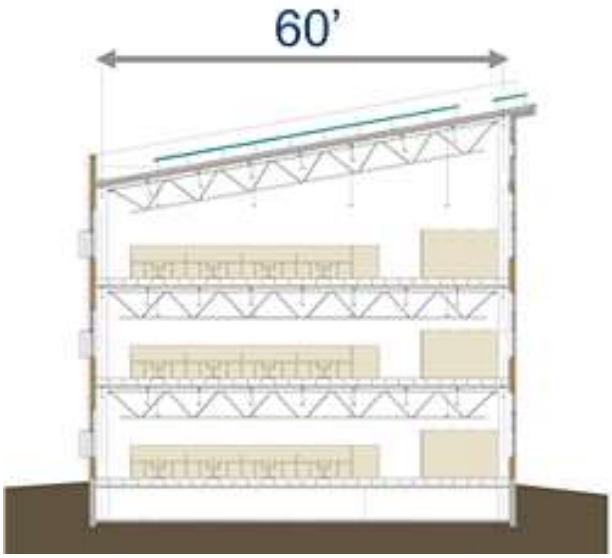


Fig 2. 17: Optimal day lit building section
Source: RNL Design.

As daylight penetration is limited by the siting and facade design, the circuiting of the electric light fixtures is critical in gauging success of a daylighting strategy. Ideally, the light fixtures should be circuited in groups, or zones, that relate to the predominant daylight distribution in the space. In general, the first 10 to 15 feet from the building perimeter receives adequate daylight illumination to allow for light dimming or switching. By zoning the lighting accordingly, there's a greater chance of ensuring maximum dimming of the lights i.e. table 2.1.

Table 2. 1: Level of Illuminance required in Day-to-day tasks

Class of visual task	Typical examples	Recommended Horizontal Illuminance
Difficult	Colour matching, inspection of fine work (e.g precision instrument)	800 lux
Moderately Difficult	Office work with poor contrast: Drawing office	600 lux
	Routine office work: typing, reading, writing	400 lux
Simple	Waiting room, social activities	200 lux
Orientation	Corridors, Stairs, Restrooms	100 lux

Additionally, it is important for the daylighting design process to involve the integration of many disciplines including mechanical, electrical, and lighting. Design team members need to be brought into the process early to ensure that daylighting concepts and ideas are carried throughout the project.

1. Awareness of basic visual acuity and performance issues is essential to an effective daylighting design, including:

2.3.6.2 Veiling reflections.

Veiling reflections can occur when the angle of incidence of light on the horizontal work surface is within the observers viewing zone. The offending zone of potential veiling reflection light source is seen if a mirror is substituted for the surface of the reading task. The most frequent viewing angle for reading and writing task on flat surface is 25º.

2.3.6.3 Glare.

Glare can cause visual discomfort, for example, excessive reflection form shiny white paper can cause glare while reading. Such conditions also occur when a person has a direct line of view to a bright light object such as a window or a light fixture. The eye must constantly adjust from the task to the higher luminance and result in eye fatigue

2.3.6.4 Design Recommendations

During the design process, the following design strategies should be understood and explored:

1. Increase perimeter daylight zones—extend the perimeter footprint to maximize the usable daylighting area.
2. Allow daylight penetration high in a space. Windows located high in a wall or in roof monitors and clerestories will result in deeper light penetration and reduce the likelihood of excessive brightness.

3. Reflect daylight within a space to increase room brightness. A light shelf, if properly designed, has the potential to increase room brightness and decrease window brightness.
4. Slope ceilings to direct more light into a space. Sloping the ceiling away from the fenestration area will help increase the surface brightness of the ceiling further into a space.
5. Avoid direct beam daylight on critical visual tasks. Poor visibility and discomfort will result if excessive brightness differences occur in the vicinity of critical visual tasks.
6. Filter daylight. The harshness of direct light can be filtered with vegetation, curtains, louvers, or the like, and will help distribute light.
7. Understand that different building orientations will benefit from different day lighting strategies; for example, light shelves—which are effective on south facades—are often ineffective on east or west elevations of buildings.

2.4 Exposition

Expo, or Exposition, is somewhere in the middle between a Trade Show and an Exhibition. Expo is open to the public, but focuses very much on business networking as well, especially export opportunities. Expositions are very large scale events, usually international and covering many industries; they may have Government support and a lot of Government organisations as exhibitors. When a specific business sector will expose and market their own products. For example, a mobile phones fair. Usually you get to see some of the most popular manufacturer brands of mobile phones, with their displays in booths. They showcase their latest products and services offered. When you engage yourself in a trade fair, you are exposing the new services and products of your business. It is important for you to consider factors such as the placement of your booth and the

type of booth you are getting. In practice, all of those types blend into one and differences if they still exist may be very hard to notice. Nowadays it would be very hard to find a Trade Show which is not open to the public, or a Trade Fair without a “trade day”, when only industry professionals and media are allowed to attend. The same can be said about focus on export: although traditionally attributed to Expos, it is hard to imagine any Trade Show or Fair where participants would not be interested in finding clients from abroad (Beier, 2005).

2.4.1 Types of exposition

There are different types of exposition as follows:

2.4.1.1 World fair

Is the generic name for various large expositions held since the mid-19th century? The official sanctioning body is the Bureau International des Expositions or BIE. Expositions approved by BIE are universal, and international or specialized, lasting from 3 to 6 months in duration. Universal expositions encompass universal themes that reflect the full range of human experience. These Universal Expos usually have themes based upon which pavilions are made to represent the country's interpretation on that theme. For example, the theme for the Expo at Lisbon (1998) was "water" and the theme for the 2005 Expo hold in Japan is "nature's wisdom”. To distinguish them from other fairs, expos require total the design of pavilion buildings from the ground up. As a result, nations compete for the most outstanding or memorable architectural structure.

2.4.1.2 Trade fair

This have been the primary marketing medium of exporting countries. The exhibits are confined to one industry or a specialised segment of a special industry. They are more commonly known as trade fairs. Historically, trade fairs have been the primary marketing

medium of exporting countries. Initially, trade fairs were horizontal in their organization, with various products and/or services in specified industry groupings.

2.5 Summary

Chapter two of this dissertation elucidated and gave a literature review of what daylighting is all about, history and sources of daylighting where discussed. Furthermore the advantages and disadvantages of daylighting where expatiated including the indicators that characterise a good daylighting, the different strategies used in enhancing daylighting, the potential drawbacks to daylighting, factors affecting the use of daylighting, the basic principles of daylighting and the control of daylighting through design approach. In addition approaches to improving visual comfort and the importance of daylighting in exposition centres where analysed including health and wellbeing and the negative effect of artificial lighting on vision including daylighting and visual comfort. It also highlight the meaning and different types of exposition and the various lighting requirements for different activity types in exposition and exhibitions centres. The difference between exposition and exhibition centres where highlighted and expatiated in this chapter.

3.0 RESEARCH METHODOLOGY

3.1 Theoretical and Conceptual Framework

From the literature review it is imperative to be able to draw a distinctive approach for a project design which is one of the reasons for carrying out literature review besides establishing acknowledge gap. To be able to draw a concept for that will enable the objectives of the research be achieved successfully (Maina, 2013). The theoretical concept is based on five concept that covers the various objectives of these research work they are daylighting design, daylighting design principles, daylighting strategies, daylighting control and exposition centres. The operational definitions of the five aspect for this research work are given base on the in-depth understanding gotten from the literature that was reviewed. The research methods are based on; the review of relevant data and existing literature in terms of daylighting optimization.

1. Case study methodology using sketches, interview, visual survey and check list.
2. Experimentation through the use of a recognised and appropriate software for simulation i.e. ECOTECT, RADIANCE® AND DAYSIM.
    - Ecotect: for looking at the quality of daylighting.
    - Radiance: for looking at the degree and quantity of daylighting.
    - Daysim: for looking at the evaluation and validation of the quality and quantity of daylighting.
3. Analysis carried out by comparing standard daylighting requirements with results from Simulations carried out.
4. Exploring ways of improving daylighting requirements from simulation models.

3.1.1 Daylighting design principles.

The science of daylighting design is not just how to provide enough daylight to an occupied space, but how to do so without any undesirable side effects. Beyond adding

windows or skylights to a space, it involves carefully balancing heat gain and loss, glare control, and variations in daylight availability.

3.1.2 Daylighting design strategies.

Daylighting design strategies refers to the consideration of key space design parameters that affect daylight performance, such as orientation and massing, size and placement of apertures, glazing and shading systems, and geometry and reflectance of interior surfaces.

3.1.3 Daylighting control.

These controls reduce the general lighting in response to sunlight coming in through windows and skylights. This can also be achieved by simulating the buildings and finding out how lighting affects the building envelope.

3.1.4 Exposition

Expositions are one of the most powerful, versatile and cost-effective marketing tools available. With years of experience, it helps to generate sales leads, build relationships with prospects, advance the sales cycle, cross-sell existing ,increase awareness, survey market awareness, launch new products, keep up on industry trends, meet with key clients, meet with key business partners, to make appointments in the future and find potential investors. In view of this a model for achieving daylight have being designed as shown in Fig 3.1 as conceptual frame work for this project.



Fig 3. 1: Derived theoretical and conceptual framework
Source: author/researcher 2016.

3.2 Case study methodology

One of the research methods is consulting literature on Exposition centres. And also no research is complete without a close examination of other works of similar nature. In approaching the solution to any design, it is imperative to consult existing structures for an insight into the basic requirement of the design. The case studies may not have a direct relationship but may contain some aspects which are relevant. For the purpose of this study, the case studies consist of Exhibition with in the building, analysis of the case

studies, a brief history, the function of the building, the facilities available, the materials used in construction and other special features are considered (Oluibo, 2010). A case study approach is adopted for this research to evaluate the passive daylighting design features used in Exposition. According to (Mayer, 2001), the approach enables the researcher to study many different aspects, examine them in relation to each other and view the process within its total environment. (Yin, 2003) argues that a case study is an empirical inquiry that investigates a contemporary phenomenon within its real life context, especially when the boundaries are not clearly stated. Unlike many other forms of research, the case study approach makes use of multiple methods of data collection such as interviews, document reviews, direct and participant observations etc. (Yin, 2003). However to be seen in its full sense, the study should include detailed documentation of information on the history and environment of study (Oluibo, 2010). Hence, the case study to be carried out on this research will be documented based on the following headings: Introduction, The envelope Shape of building the geometry, location and orientation of aperture, Surface characteristics, Spatial distribution of light, IL luminance ratio, Shape from shadows, Colour rendition, Glare, Visual noise. This will then be followed by the application of general data collection technique.

3.3 Study Sample

Population of study comprises the totality of all subjects that have a set of specifications and characteristics that are of interest to the researcher and to whom the research results can be generalized (Polit & Hungler, 1999). The research population for this study are three selected exposition centres selected within Nigeria.

3.4 Case Study Selection

The selection criteria for the exposition used as case study in this research based on the current thinking of space norms and standards for physical facilities. This study is relevant

to the design strategies priorities which is aimed at improving daylighting and well-being of the interior space in exposition centres.

Each case study has been analysed based on two aspects.

1. A general documentation.
2. An assessment of the use of passive lighting technique which are presently being re-thought and provided for in contemporary exposition centres.

From the listed criteria above, the following cases were selected due to their inherent qualities which were in consonance with the phenomenon under investigation;

1. Shehu Musa Yar Adua centre Abuja.
2. International conference centre Abuja.
3. Ceddi plaza Abuja.

The above case studies were also chosen deliberately to increase the likelihood of showing or expressing important variations of several features of the facility. This type of case study is illustrative. It is information-rich and can be used to illustrate an architectural style or issue.

3.5 Instruments of Data Collection

Various sources were selected for this research including: field/visual survey, interview, checklist, photographs, sketches and notes.

3.5.1 Field/Visual survey

This is a method of data collection in which the eyes is used to study and observe. This survey must be guided by critical literature review guidelines. E.g. checklist. Visual survey can be documented through tabulation, sketches, plates, figures, written reports, etc.

3.5.2 Interview

This is a method of data collection which involves preparing a list of interview schedule and laid down questions to ask the interviewee. It is grouped into three main types namely: structured, semi-structured and unstructured interview (Neville, 2007).

3.5.3 Checklist

This is in form of field forms outlining the variables of passive design feature. It contained the list of variables which were observed and noted during the survey.

3.5.4 Photographs

Photographs were taken to support the notes taken during the visit and for record. The photographs also provided a significant source of visual data about the case to outside observers. The photographs of relevant areas were taken in order to show the passive design features on the cases possessed as well as the extent to which they were applied.

3.5.5 Sketches

Sketches showing the selected case studies were made during the field survey. These sketches were considered vital to form an opinion on the physical setting and spatial organization of the case studies in order to explain the research.

3.5.6 Simulation

Design and building materials information obtained from the survey was used to create a 3D model for a space representing the various expositions; this model was used in the simulation runs to determine the lux value and other relevant information for simulation purposes.

Notes: This instrument of data collection was adopted to back-up information discussed during the interview and what was observed during the field survey. Comprehensive notes were prepared as an ongoing record of what was happening as the research progressed.

3.6 Daylighting analysis and design tools

3.6.1 Physical Modelling

According to (Ander, 2010) the physics of illumination are such that light behaves exactly the same way in a scaled model as it does in a full-size room. Physical models can be built inexpensively and at various stages of the design process as seen in Fig 3.2 and Fig 3.3. A number of issues can be accomplished with physical models.

1. Photographs of the model interior can be taken to record and study various design Alternatives.
2. The effect of different glass areas and locations can be studied.
3. Using photometers, illumination levels resulting from different daylighting schemes can be compiled and used to project energy savings.

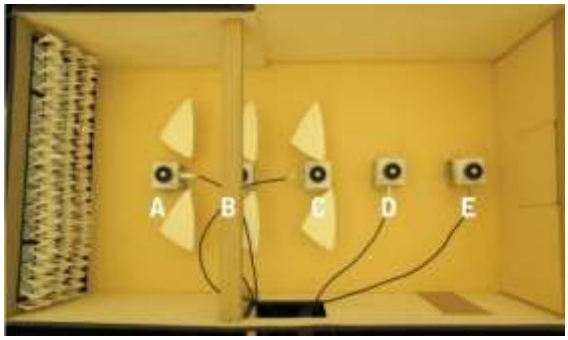


Fig 3. 2: Model simulation
Source: shaping Lights.



Fig 3. 3: Physical model simulation
Source: shaping Lights.

3.6.2 Computer and Calculation Tools

Over the past 50 years many daylighting calculation tools have been developed. These include hand methods, monographs, and computer models to simulate both daylighting design and its impact on the overall thermal performance of buildings i.e. Fig 3.4 and Fig 3.5 respectively.



Fig 3. 4: Actual photograph showing lux
Source: author/researcher, 2015

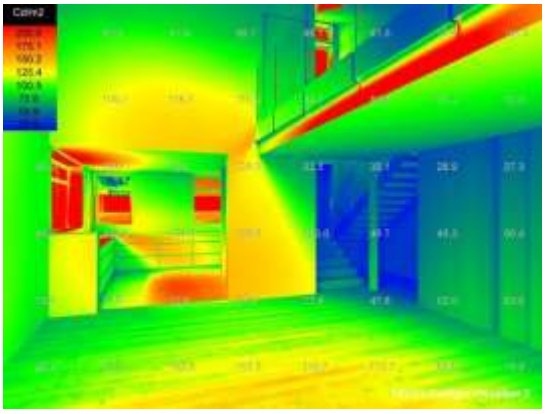


Fig 3. 5: Computer simulated image value of daylighting
Source: author/researcher, 2015

3.7 Daylight in exposition centres

In the push towards sustainability and green design, daylighting is becoming critical to energy efficient design. In most situations daylight can be easily incorporated into building designs; however Exhibition centres provide a special challenge. Unlike most building situations, where can spread within the building envelop, light need to be directed toward where it will be useful the most without causing mush problems to other users as seen in plate I.



Plate I: Daylighting exposure
Source: (AMCLighting.com).

The following guide compiled by (Schaft, 2013) will highlight the specific issues associated with daylighting exposition will provide some basic rules of lighting.

1. Exhibit lighting uses hard-edged directional light to accentuate individual items on display. As a general rule, it needs to be supplemented by softer room lighting. Exhibit lighting based on spots alone is advisable only where a particularly dramatic effect is required. Otherwise, a stimulating spatial experience is obtained with a mix of diffuse (room) and directional (exhibit) lighting.
2. Daylighting additionally provides energy savings for the exhibition by minimizing the amount of electric lighting required during the day to illuminate the museum. Over a period of time, these savings can help pay back the potential additional cost of construction from daylighting.
3. Finally, daylighting improves the quality of experience of the visitor by providing a connection to the outside and showing the passage of time as the light changes throughout the day (Schaft, 2013).

3.8 Simulation

After collection of data and analysis of design, planning the simulation runs and determining the simulation conditions was required. This included the following.

1. Design and building materials: the design information obtained from the survey was used to create a 3D model for a space representing the various expositions; this model was used in the simulation runs.
2. Sky conditions Clear sky with sun conditions are used based on Abuja's (location Coordinates (latitude 9.10 degree north and 7.40 degree east). Simulating the entire year would be very costly, and yet it is probably not necessary if one can decide on important dates and hours. In this aspect a model of the case studies in Abuja is simulated for daylighting characteristics of the building as it where to

determine the visual comfort under normal circumstance and data analysed using Ecotect with Abuja metrological data inputted.

Using the same model, but with different materials a simulation test was run to determine the visual comfort in the same exposition to determine the improvement in visual comfort which will letter be used as the model for the final design. In order to become usable for design, this massive amount of data has to be converted into an intuitive metric. The first step in this conversion process is to decide on which times of the year the analysis should be based. A common choice is to concentrate on the times when the investigated space will be occupied since daylight 'needs witnesses' to have an effect (Reinhart.c, 2006). This approach goes hand in hand with the one taken by energy simulation programs that also assume typical usage patterns. In cases where were no documentation available for the architectural drawings, the buildings were surveyed and the drawings were prepared by the researcher through sketches, photographs and notes. All photographs were taken either by the author or with help of relatives and friends. Photographs of relevant areas of the case studies were taken in order to highlight the observed passive design features. Sketches showed the spatial organization of some of the study cases while notes explained the observed passive daylight design features in each of the selected cases. The table 3.1 below shows the research method schedule.

Table 3. 1: Research method schedule

s/no	Study	Investigation	Research and data analysis
1.	Building structure	1.General information 2.material types 3.building morphology 4.historical background	Field survey Interviews Checklist Photographs sketches
2.	Actual/existing	1. Daylight quality 2.Useful day light Illuminance (average) UDI. 3.Glare Level 4. Daylight level distribution quality.	Graphs and tables from field survey.
3.	Validation of actual tool and assessment of models	1. Validation of result by the researcher 2. Assessment of light Light level illuminance 3. Assessment of visual Comfort form recommended lighting requirement.	1. Simulation. 2.Visual Analysis 3. Correlation test 4. average illumin -nance Calculations.

3.9 Variables of Study

According to (Nick, 2013) although we have day light as our principal source of light, we must remember that especially in southern countries.it may be difficult to use daylight directly in every day working life because of its high intensity and content variation due to:

1. Sun path.
2. Metrological changes. Taking advantage of different surface configuration and number of physical phenomena, such as;

1. Reflection
2. Refraction
3. Diffusion
4. Absorption etc.

Daylighting should be used in diffused form, ideally as an indirect light. Variables are parameters that scholars investigate. For the purpose of this research, the variables to be considered are design dependent and independent variables which will point out which of the elements of daylighting had been applied in the cases and their effect in visual comfort. They are;

3.9.1 Dependent variables (Day light parameters).

These are the most common controllable causes influencing daylighting within a room for a specific building type this include.

1. The envelope shape
2. The geometry, location and orientation of aperture
3. Surface characteristics
    - Surface texture
    - Surface reflectance
    - Surface colour

3.9.2 Independent variables (Visual comfort parameters)

Despite the common misconception that surface luminance is the only relevant parameter for visual comfort, a more comprehensive attitude to visual comfort is needed this include:

1. Spatial distribution of light
2. IL luminance ratio
3. Shape formed from shadows
4. Colour Rendition
5. Glare
6. Visual noise

3.9.3 The Envelope shape.

The higher the skin-to volume ratio, the greater percentage of floor space available for daylighting. Long and narrow footprints are preferable to square ones, up to a limit, although a high skin-to-volume ratio may mean a heating or cooling penalty. North and south exposures are generally preferred compared to east or west (Kramer, 2012). The following can help achieve daylighting:

1. Shape building for self-shading**:** Building form can assist cooling by providing self- shading through wings i.e. Fig 3.6 below with other mass articulations, balconies, and deep reveals, or arcade.

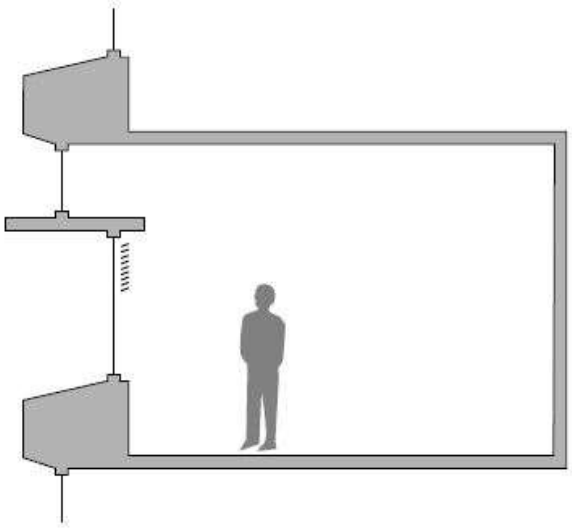


Fig 3. 6: Deep wall section provides self-shading
Source: viewers.com

2. Take a deep facade approach**:** A facade with some depth creates a buffer zone that can contain shading elements and other modifiers to filter glare and block sun.
3. Capitalize on other building elements to integrate shading**:** For example, overhangs, Louvers, fins, and light shelves can be integrated both structurally and visually with the exterior structural system.
4. Incorporate envelope features that improve daylighting**:** Deep reveals, splayed

reveals, exterior fins, and similar characteristics of the envelope structure improve daylight distribution and control glare. These facade projections can also attenuate noise. Rounded edges soften light contrasts. Effective reveals are 9 to 12 inches (23-30 cm) deep, at an angle of 60° to the window plane.

5. Balance daylight admittance**:** Spaces with windows onto sides often have better daylighting distribution.
6. Keep private offices somewhat shallow: Keep depth of rooms within 1.5-2.0 times window head height for adequate illumination levels and balanced distribution.
7. Consider colour and texture of exterior surfaces**:** Light-coloured surfaces will reflect more daylight than dark surfaces. Specular surfaces (e.g., glazed tile or mirrored glazing) may create glare if viewed directly from an office. Diffuse ground-reflected daylight can increase daylight availability.

3.9.4 The geometry, location and orientation of aperture.

Geometrical Massing is deciding on the overall shape and size of the building. Will the building be tall or short? Long and thin? Will it have significant cutouts, or be more solid? Successful massing uses the general shape and size of the building to minimize energy loads as much as possible and to maximize free energy from the sun and wind (Peter T. , 2011) i.e. Fig 3.7 below.

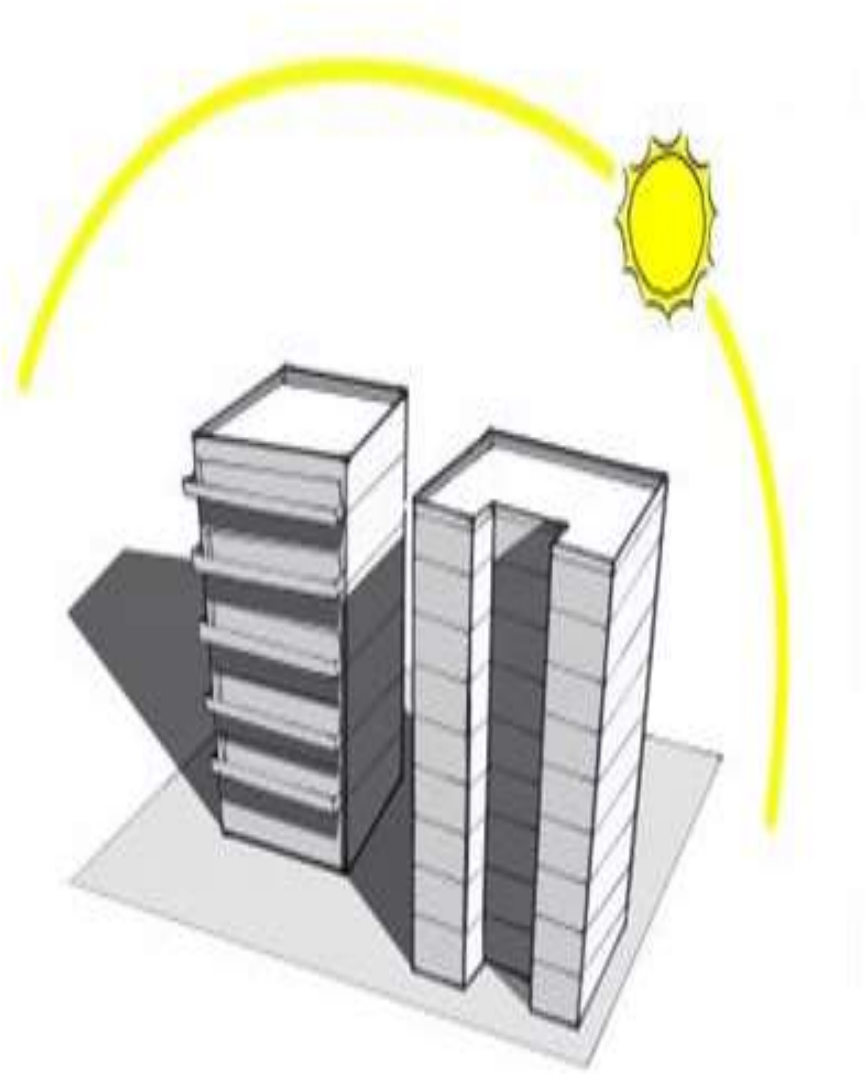


Fig 3. 7: Deep wall section provides self-shading
Source: designforms.com

Orientation is simply what compass direction the building faces as seen in Fig 3.8, does it face directly south? 80° east-northeast? Along with massing, orientation can be the most important step in providing a building with passive thermal and visual comfort. Orientation should be decided together with massing early in the design process, as neither can be truly optimized without the other.

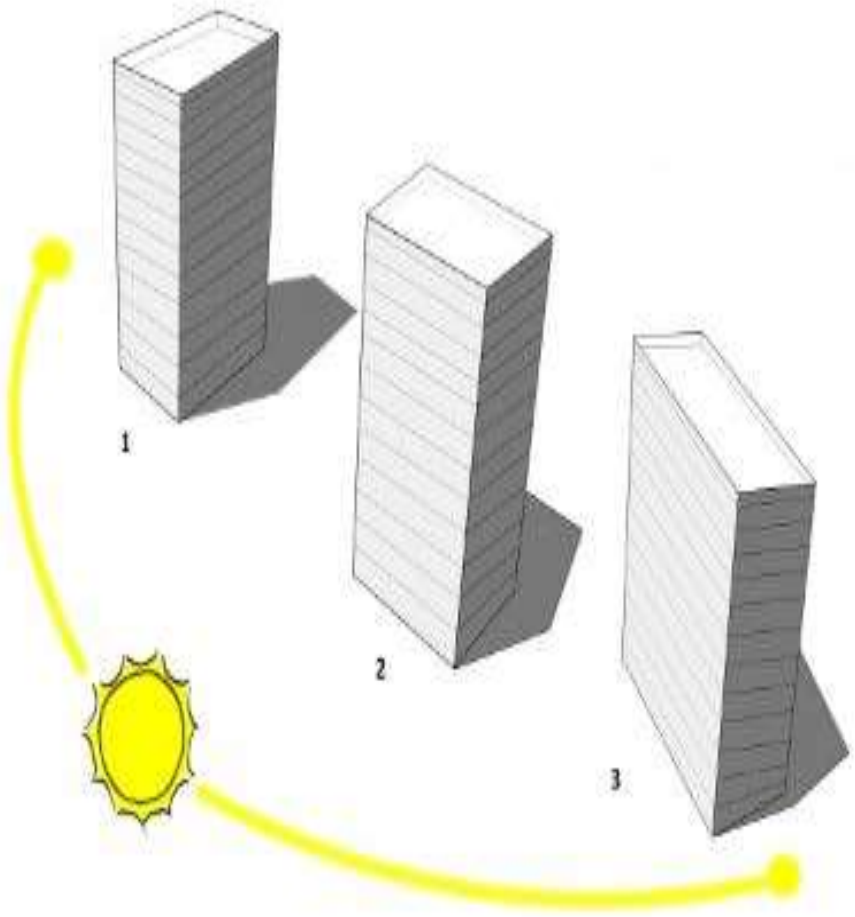


Fig 3. 8: Building orientation effect on daylighting
Source: designforms.com

3.9.5 Surface characteristics

Colour appearance of an object is significantly influenced by the colour of the illumination. When the illumination colour changes, the colour appearance of the object change accordingly, causing its appearance to be inconsistent further light is absorbed by a more textured surface when it falls on the object than a smooth surface.

Special distribution of light

A smoother surface is more likely to reflect light that falls on it the table below 3.2 shows the special distribution of light.

Table 3. 2 a Shows the different lighting distribution in activity space. Lighting recommendation in work space

Activity/space	**Building type**	**Artificial Lighting:**		**Daylighting:**		
		Illuminance (lux)	**Glare index**	**Type of Daylighting***	**Average daylight factor (%)**	**Glare Index**
Formal teaching and seminar space	Schools Colleges Hospitals, etc.	300 to 500 (300 on desk, in hospitals	16 formal 19 seminar	A B	5 2	21 formal 23 seminar
Deep (Open) plan teaching space	Schools Colleges	300 to 500	19	A B	5 2	23
Lecture theatres and examination halls	Schools Colleges Hospitals	500 (300 on desk, In hospitals)	16	A B	5 2	21
Musical rooms and music practice rooms	Educational and recreational buildings	300	19	A B	5 2	23
Art Craft Needlework (studios)	Schools Colleges Factories Offices Recreational buildings	300 to 500	16	A B	5 2	21
Wood work Metal work Engineering (teaching)	Schools Colleges Training centres Recreational building	500	16	A B	5 2	21
Laboratories	Educational buildings Hospitals Offices Research establishments Factories	500 to 750 (300 to500 on bench, in hospitals)	16	A B	5 2	21
Staff rooms Common rooms	Educational buildings Hospitals Offices Factories	150 to 300 (100 average in hospitals)	19	A B	5 2	23
Offices (enclosed)	Offices Educational buildings Factories Hospitals Banks Insurance buildings Post offices Libraries	500 (300 on desk, In hospitals	19	A B	5 2	23
Deep (open) plan office Landscape office	Offices Colleges Banks Insurance buildings, etc.	500 to750	19	A B	5 2	23

Table 3.2 b Shows the different lighting distribution in activity space. Lighting recommendation in work space

Activity/space	Building type	Artificial Lighting:		Daylighting:		
		Illuminance (lux)	**Glare index**	**Type of Daylighting ***	**Average daylight factor (%)**	**Glare Index**
Typing Business machines Punch card	Offices Colleges Banks Post offices, etc.	500 to 750	19	A B	5 2	23
Computers	Offices Banks Educational buildings Hospitals	500 to 750 Limited illuminance where VDUs are used	19	A B	5 2	23
Drawing offices Design offices	Educational buildings Offices Factories	500 to 750 plus local lighting to 1000 on board	16	A B	5 1 (in suppl-emented area).	21
Workshops Machine shops Processing Production plane	Factories Offices Hospitals	Rough work 300 Medium 500 Fine 750 to 1000 Very fine 1000 to 1500 (300 to 500 on bench, in hospitals).	19	A B	5 1 (in suppl-emented area).	23

Source: daylight drafting, DD73, British standards
*A- Full day light *B Supplemented daylighting

3.9.7 Illuminance ratio

The achievement of comfortable luminance ratio in any space requires a careful study of all factors involved, including not only the light source but also the reflectance of wall, floors and furniture's, for best result it is necessary to create a balance between the luminance of the immediate task and the adjacent surface in the field of view avoid both excessive dark background and distracting bright colours. Ideally the following brightness ratios within the field of view should be aimed at:

1. Between task and darker surrounding 3:1
2. Between task and remote darker surface 10:1
3. Between light surface and surroundings 20:1
4. Maximum contrast (exception of decorative) 40:1

5. High lighting objects for emphasis 50:1

3.9.8 Shape from shadows

Shadows are important in determining the shapes and position of an object in space, if there are no other references. Directional light accentuates the three dimensional qualities of an object more clearly than diffused shadow less light. However, shadows created by obstruction between the light source and the task are bad for visibility, since contrast is drastically reduced.

3.9.9 Colour rendition

Daylighting is considered the best source of light for good colour rendering. Many people have had the experience of matching cloths of different colours under electric light only to discover that they do not match when seen in daylight. This is because a light source may alter the perception of colour spectral composition of the light. Therefore object may vary in colour appearance depending upon the light source. Daylighting may cause object to fade due to ultraviolent light (UV Light).

3.9.10 Glare

Glare is defined as the condition of vision in which there is discomfort or a reduction in the ability to see details of object caused by an unsuitable distribution or range of luminance or extreme contrast. (Hopkinson R. , 1966 B), defines glare as a general term as a condition of eye adaptation that is un favourable to good sight it causes discomfort or impairment of vision. Table 3.3 shows the relative glare index of various building types.

Table 3. 3: Limiting values of Glare index

Building types	Limiting Glare Index
Factories	25
Engine assembly	25
Fine assembly	22
Instrument assembly	19
Farm building (where people work)	25
Jewellery assembly	10
Laboratories	19
Museums	16
Art Galleries	10
Offices	
General	19
drawing	16
Schools	
Classrooms, etc.	16
Needlework rooms	10
Hospital wards	13

3.9.11 Visual noise

Although we tend to think of the word noise in terms of sound, the word is just as applicable to vision. Visual noise is anything that may distort, transform, block or add to what we see. Dirt, creases, wrinkles and irregularities in the weave are all forms of background noise on the Shroud. By photographing additional forms of visual noise and accentuate can be noticed to be existing as background noise. (GreatshroudturinFAQ, 2009).

3.10 Data Analysis

According to (Polit & Hungler, 1999), analysis of qualitative data is an active and interactive process of data analysis which seeks to provide a structure and elicit meaning to the data obtained. The theoretical background of the study provides the basis of the method used for analyzing the content. For this research, the analysis was first focused on the individual interviews, then the field survey carried out. The data is then analysed and compared with the results to identify the application of passive design principles in

each selected cases**.** Data analysis was based on descriptive, visual and ranking system as seen in Table 3.4

Scale Factor: Very inadequate=1, Inadequate=2, Average=3, Adequate-4 and Very adequate=5**.**

Table 3. 4 a: Sample of the Checklist of the Case Study Variables.

S/N	*Variables*	*Check list*	*Scale Factor*					*Remark*
			1	2	3	4	5	
1.	**Dependent variables**							
	• The envelope Shape of building	skin to volume ratio of the building						
		Architectural expression						
		Architectural design in relation to locality Complexity and design morphology of structures.						
		Compatibility of building Open is the form of the building envelop						
		Harmonic composition of shapes and materials Absence of visual barriers						
		Shading device and overhangs						
	• The geometry, location and orientation of aperture	Position in relation to environmental or visual field						
		Pedestrian means of circulation						
		Space utilization						
		Social interaction and sense of community						
		Security from crime						
		Visual inertia Stability and symmetry						
		Local character/history						
		Easy identification						
		Way finding system						
		signals						
		Absence of visual barriers						
	• Surface characteristics	Acoustic qualities						
		Thermal conductivity of surface						

Table 3.4 b: Sample of the Checklist of the Case Study Variables

S/N	*Variables*	*Check list*	*Scale Factor*	*Remark*
			1 2 3 4 5	
		Resistance /strength/cleanliness Uniform surface structure		
		Homogeneous and water retention		
		Resistance to weather and external influence		
2.	**Independent variables**			
	• Spatial distribu-tion of light	Luminaire efficiency		
		Colour of light Glare control Directional characteristics of light		
		Shadows and reflections		
		Level of lightness		
	• IL luminance ratio	Stimulating surroundings Adequate visibility of retailed information Opportunity of individual adjustment Daylighting percentage Running cost and energy Rough surface characteristics shadows		
	• Shape from shadows	Binocular Disparity Shadow inversion		
		colour		
		Day time variation		
		Propagation speed Presence of high objects ➢ Work space		
		➢ circulation		
	• colour rendition	Reading task Lighting source Fighting colours incandescent		
		preference		
		Faded items		
	• glare	Instinctive desire to look away Difficulty task Impairs vision Inter reflection of light Distinguishing task contrast dazzle		

Table 3.4 c: Sample of the Checklist of the Case Study Variables

S/N	*Variables*	*Check list*	*Scale Factor*	*Remark*
			1 2 3 4 5	
	• visual noise	Dirt percentage Colour particles Waves Level of adaptation		

3.11 Summary

Chapter three gave an overview of the research method that was adopted for the purpose of the expected outcome of the research study and a theoretical frame work was established within the concept of daylighting, exposition centres, simulations, principles, strategies and control used. The research design was stated and method of data collection and the research variables where also outlined with the various simulation soft wears used i.e. Ecotect, radiance and Daysim software's in line with the type of data required to achieve the purpose of the desired outcome from the research work done.

4.0 CASE STUDIES

4.1 Case Studies Introduction

Case studies are avenues of getting first-hand information about similar buildings structures that have been designed and learning from the successes and mistakes others have made.

4.2 Case Study Selection Criteria

The criteria for selecting the case studies were;

1. The presence of daylighting architectural elements in the building i.e. sky light
2. Building should be located in a climatic region similar to the climate of the proposed site for the research.
3. A show case of exposition.
4. Architectural identity
5. Innovation

4.3 Case study Methodology

The methodology of carrying out the case studies was threefold. The first was by physically visiting the case study sites and practically accessing the architectural design parameters that are important in exposition design. The second was by assessing the means in which daylight is admitted in the buildings and the thirdly was by optimizing energy conservation through various means.

The case studies were assessed using both depended and independent variables. The variables considered for assessing the buildings selected are listed below.

1. **Dependent variables** (Day light parameters)
    2. The envelope shape
    3. The geometry, location and orientation of aperture
    4. Surface characteristics

5. Surface texture
6. Surface reflectance
7. Surface colour

2. **Independent variables** (Visual comfort parameters)

1. Spatial distribution of light
2 Illuminance ratio
3. Shape formed from shadows
4. Colour rendition
5. Glare
6. Visual noise

4.3.1 Simulation of Daylighting in Virtual Case study.

This study was based on the Climate-Based Daylight Modelling (CBDM) methodology which is dependent on meteorological data, locality and building orientation the daylight simulation of the measured virtual case study were carried out in *Radiance* ported through *Ecotect Analysis* 2011. The models were first created in *Ecotect Analysis* with the following inputs

4.3.2 Weather Data

To execute a daylighting simulation of a building in any location for a day or a year, there is a need to source for the weather data representative of that location (Salisu, 2015).

Comprehensive weather data files using high powered computers should be generated to produce a synthetic year to represent a typical weather file rather than using an actual single year measured data. Typical weather data used can be in various formats such as Typical Meteorological Year (TMY) or (TMY2), *Meteonorm*, *EnergyPlus* weather (EPW). Weather data should be obtained from National Renewable Energy Laboratory (NREL), Chartered Institution of Building Services Engineers (CIBSE), Energy

Efficiency & Renewable Energy (EERE) or any of their affiliates. Climatic data for Abuja were obtained from an affiliate - *Weather Analytics - affiliated to EERE* (Salisu, 2015).

4.3.3 Radiance Rendering Parameters

There are many rendering settings in the *Radiance* rendering toolbox, but *Ecotect Analysis* simplifies the choice based on how complicated the model is (geometric complexity, materials type, objects and luminaires)

4.3.4 Physical and Environmental Parameters

Parameters of time, date, dimensions, types of skies, reflectance of materials, transmissivity of glazing, sensor points and work plane are fed into the software as the ones measured in the existing buildings. The computer simulations were carried out on an HP PC with 2.4 GHz CPU 6:00GB RAM; 64-bit *Windows* 8 pavilion Operating system.

4.4 Some daylighting Simulation tools

4.4.1 Velux

Daylight Visualizer is a validated simulation and visualization tool for daylighting design and analysis. It is intended to promote the use of daylight in buildings and to aid professionals by predicting and documenting daylight levels and appearance of a space prior to realization of the building design. The Daylight Visualizer intuitive modelling tool permits quick generation of 3D models in which roof and facade windows are freely inserted. The program also permits users to import 3D models generated by CAD programs in order to facilitate a good workflow and provide flexibility to the model geometry.

4.4.2 Radiance

Radiance is programs for the analysis and visualization of lighting in design. Input files specify the scene geometry, materials, luminaires, time, date and sky conditions.

Calculated values include spectral radiance (ie. luminance + colour), irradiance (illuminance + colour) and glare indices. Simulation results may be displayed as colour images, numerical values and contour plots. The primary advantage of Radiance over simpler lighting calculation and rendering tools is that there are no limitations on the geometry or the materials that may be simulated. Radiance is used by architects and engineers to predict illumination, visual quality and appearance of innovative design spaces, and by researchers to evaluate new lighting and daylighting technologies.

4.4.3 Daysim

Daysim is a lighting analysis software based on the Radiance developed by the National Research Council, Canada and the Fraunhöfer Institute for Solar Energy Systems, Germany. Theoretically it is possible to use the standard Radiance software to calculate annual ill luminance profiles for a year for any location, but this is very impractical because it could literally take hours to produce an IL luminance measurement for a one 5-minute step sky condition of the location (Salisu, 2015). Daysim algorithms also is a validated, radiance-based daylighting analysis software that models the annual amount of daylight in and around buildings. DAYSIM allows users to model dynamic facades systems ranging from standard venetian blinds to state-of-the-art light redirecting elements, switchable glazing and combinations thereof. Users may further specify complex electric lighting systems and controls including manual light switches, occupancy sensors and photocell controlled dimming.

4.4.4 DIALux

DIALux can calculate electric light, daylight and the energy performance of electric light. The program is oriented towards the European market, and is widely used for calculation of indoor and outdoor electric lighting systems. It follows different national standard lighting calculations, and can import photometric databases directly from manufacturers.

The daylight calculation capabilities within DIALux make use of German standard DIN 5043 and CIE Publication 110. Geometric input is limited to certain shapes. Sky choices are somewhat limited but acceptable for diverse ranges of weather conditions. There is an external radiosity and ray-tracing model, POV-Ray (Persistence of Vision 2010). It is used to produce images from calculation results and for presentation renderings.

4.4.5 Ecotect

Ecotect "Autodesk® Ecotect® Analysis sustainable design analysis software is a comprehensive concept-to-detail sustainable building design tool. Ecotect Analysis offers a wide range of simulation and building energy analysis functionality that can improve performance of existing buildings and new building designs." These simulations and analysis include energy performance of buildings, thermal simulations, solar radiation, daylight levels and shadow diagrams.it is also a sustainable design analysis solution that helps measure the impact of environmental factors on building performance. A wizard based easy to use solution that makes it easier for building designers to conduct simulation and visualize the result (Webinar, 2011).

Basically it performs the following:

1. Shadows and reflections: display the sun position and path relative to the building at the date, time and location.
2. Daylighting: calculate daylight factors and illuminance level at any point in the model.
3. Solar radiation: visualize incidence solar radiation on surface over any period.
4. Thermal performance: calculate heating and cooling load for models and analyse effects of occupancy, internal gains.
5. Visual impact: analyse projection angels, determine obstructions and visualize right to light (Webinar, 2011).

4.4.6 3ds Max®

3ds Max Design software provides a comprehensive 3D modeling, animation, and rendering solution used by architects, designers, civil engineers, and visualization specialists. Validate and sell designs before they are built, and get rapid iteration of designs, accurate daylight analysis, and high-impact visuals and animations. The software has been validated for the simulation and analysis of diffuse light and daylight effects.

4.5 Adopted daylighting Simulation research tools

The adopted simulation tool for this research shall be a combination of some of the above mentioned simulation tools due to their unique qualities and characteristics which will include:

1. Ecotect
2. Radiance
3. Daysim

The model was first carried out in Autodesk Revit 2011 and then imported into ecotect 2011 as a (*gbsml)* file where it then simulated using the Abuja weather data.

Human subject studies suggest that luminance above 2500 to 3000 candela/m2 in the field of view of an office worker may start causing discomfort glare (Clarkson, 2016).

4.5.1 Recommended light levels - IL luminance - for some types of working activities

Light Level or illuminance is the total luminous flux incident on a surface per unit area have a relationship as shown in the plate ii below - the work plane - is where the most important tasks in the room or space are performed (Design, 2014).

Plate II show the relationship between luminous flux, luminous intensity, illuminance and luminance.

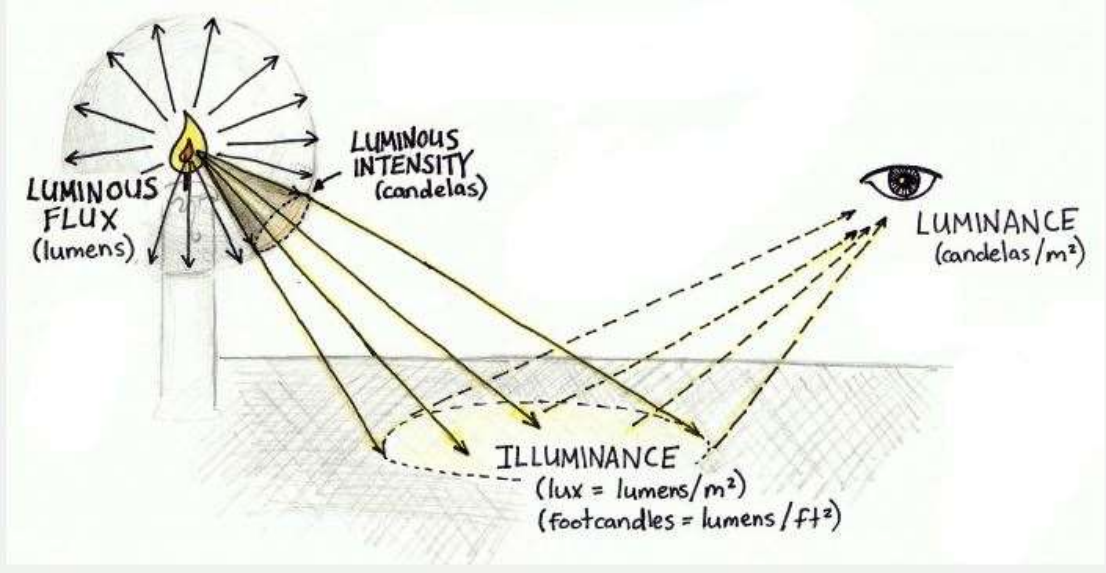


PLATE II : Diagram showing relationships between luminous flux, luminous intensity, luminance and illuminance
Source: windowsfcm.com

Lighting condition that occur at various time of the day and year have their standard value of illumination in foot per candelas and lux Values as seen in table 4.1 and table 4.2.

Table 4.1: Ftcd/lux value for various lighting conditions

Condition	**Illumination**	
	(ftcd)	(lux)
Sunlight	10000	107527
Full Daylight	1000	10752
Overcast Day	100	1075
Very Dark Day	10	107
Twilight	1	10.8
Deep Twilight	0.1	1.08
Full Moon	0.01	0.108
Quarter Moon	0.001	0.0108
Starlight	0.0001	0.0011
Overcast Night	0.00001	0.0001

Source: lighlumania.com, 2010

Table 4. 2: Activity and their lighting requirement

Activity	Illumination *(lux, lumen/m^2)*
Public areas with dark surroundings	20 - 50
Simple orientation for short visits	50 - 100
Working areas where visual tasks are only occasionally performed	100 - 150
Warehouses, Homes, Theatres, Archives	150
Easy Office Work, Classes	250
Normal Office Work, PC Work, Study Library, Groceries, Show Rooms, Laboratories	500
Supermarkets, Mechanical Workshops, Office Landscapes	750
Normal Drawing Work, Detailed Mechanical Workshops, Operation Theatres	1,000
Detailed Drawing Work, Very Detailed Mechanical Works	1500 - 2000
Performance of visual tasks of low contrast and very small size for prolonged periods of time	2000 - 5000
Performance of very prolonged and exacting visual tasks	5000 - 10000
Performance of very special visual tasks of extremely low contrast and small size	10000 - 20000

4.6 Case Study one: Shehu Musa Yar adua Centre Abuja



Plate III: Shehu Musa Yar' Adua centre Abuja
Source: field work, September, 2015



Plate IV: Side view of Shehu Musa Yar' Adua centre Abuja
source: field work, September, 2015

Architect: Julius Berger

Client**:** Federal Government of Nigeria

4.6.1 Historical background

Established in honor of one of Nigeria's leaders, the center provides news and information about conference services, the library and exhibition hall. The building was dedicated to Shehu Musa Yar´ adua a patriot with courage and compassion who sacrificed his freedom and ultimately his life for Nigeria on the 1st of March 2000 by the then president of Nigeria Olusegun Obasanjo, Vice-President Atiku Abubakar and His Excellency Nelson Mandela of South Africa and was letter commissioned by his excellency John Kufor the president Republic of Ghana on the 9th of march 2002.

Sample of the Checklist of the Case Study Variables.

Scale factor: Very inadequate=1, Inadequate=2, Average=3, Adequate-4 and Very adequate=5**.**

Table 4. 3 a: Table showing variable/checklist of Musa Yar Adua centre

S/N	Variables	Check list	Scale Factor 1 2 3 4 5	Remark
1.	**Dependent variables**			
	The envelope Shape of building	skin to volume ratio of the building	■	
		Architectural expression	■	
		Architectural design in relation to locality	■	
		Complexity and design morphology of structures.	■	
		Compatibility of building Open is the form of the building envelop	■	
			■	
		Harmonic composition of shapes and materials	■	
		Absence of visual barriers	■	
		Shading device and overhangs	■	
	The geometry, location and orientation of aperture	Position in relation to environmental or visual field	■	
		Pedestrian means of circulation	■	
		Space utilization	■	
		Social interaction and sense of		

Table 4. 4 b: Table showing variable/checklist of Musa Yar Adua centre

S/N	Variables	Check list	Scale Factor 1	2	3	4	5	Remark
		community						
		Security from crime				■		
		Visual inertia		■				
		Stability and symmetry				■		
		Local character/history		■				
		Easy identification	■					
		Way finding system		■				
		signals		■				
		Absence of visual barriers			■			
	Surface characteristics	Acoustic qualities						
		Thermal conductivity of surface	■					
		Resistance /strength/cleanliness			■			
		Ease of maintenance				■		
		Uniform surface structure					■	
		Homogeneous and water retention			■			
		Resistance to weather and external influence				■		
2.	**Independent variables**							
	Spatial distribu-tion of light	Luminaire efficiency						
		Colour of light			■			
		Glare control				■		
		Directional characteristics of light				■		
		Shadows and reflections		■				
		Level of lightness	■					
	ILluminance ratio	Stimulating surroundings				■		
		Adequate visibility of retailed information	■					
		Opportunity of individual adjustment					■	
		Daylighting percentage			■			
		Running cost and energy				■		
		Rough surface characteristics		■				
		shadows				■		
	Shape from shadows	Binocular Disparity		■				
		Shadow inversion		■				
		colour			■			
		Day time variation		■				
		Propagation speed			■			
		Presence of high objects						
		➢ Work space	■					
		➢ circulation		■				

Table 4. 5 c: Table showing variable/checklist of Musa Yar Adua centre

S/N	Variables	Check list	Scale Factor 1 2 3 4 5	Remark
	colour rendition	Reading task		
		Lighting source		
		Fighting colours		
		incandescent		
		preference		
		Faded items		
	glare	Instinctive desire to look away		
		Difficulty task		
		Impairs vision		
		Inter reflection of light		
		Distinguishing task		
		contrast		
		dazzle		
	visual noise	Dirt percentage		
		Colour particles		
		Waves		
		Level of adaptation		

Source: Author/researcher, 2015

Table 4.6 below shows the frequency and variable occurrence from the case study conducted.

Table 4. 6: Table showing frequency against variables

		Variables									
value	scale factor	ES	GL&O	SF	SDL	IR	SS	CR	G	VN	Total frequency
very inadequate	1	0	1	1	1	1	1	2	3	3	13
inadequate	2	2	4	0	1	2	4	1	3	0	17
average	3	3	2	3	1	1	2	1	1	0	14
adequate	4	4	5	2	3	2	0	2	0	1	19
very adequate	5	0	0	1	0	1	0	0	0	0	2
TOAL		**9**	**12**	**7**	**6**	**7**	**7**	**6**	**7**	**4**	**65**
PERCENTAGE		13.85	18.46	11	9.23	10.8	10.77	9.23	10.8	6.15	

The variables used in this research work where abbreviated i.e. envelop shape of the building to mean (ES) and the various percentage of each variable was represented in percentage i.e. the pie chart shown below in Fig 4.1. The highest is geometry location and orientation of aperture represented as GL&O with 18% and the lowest is visual noise represented as VN with 6% and the total frequency occurrence remain 65.

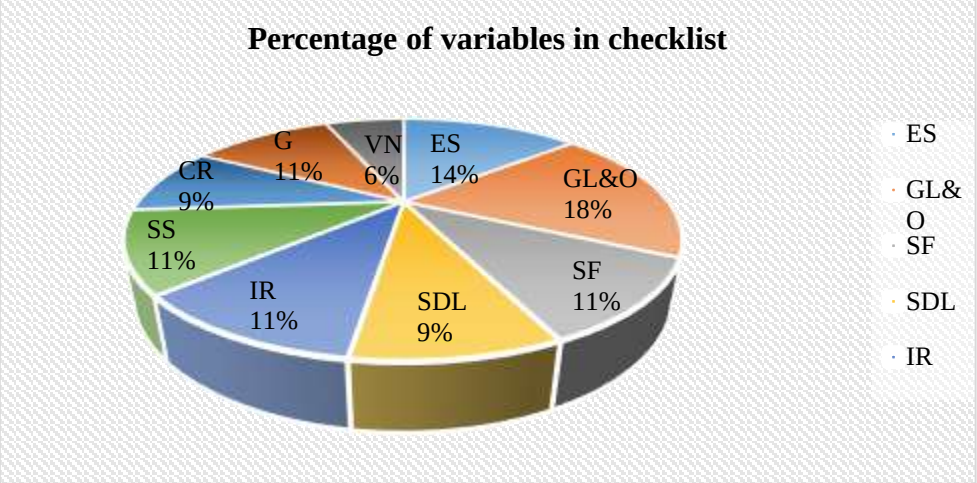


Fig 4. 1: Pie chart showing percentage of each variable
Source: Author/researcher, 2015

Bar chart are known to give a pictorial representation based on the frequency of occurrences the highest frequency in this regard is adequate with 19 followed by in adequate with 17, average with 14, very adequate with 13 and the least is very adequate with 2 as frequency respectively as shown in Fig 4.2.

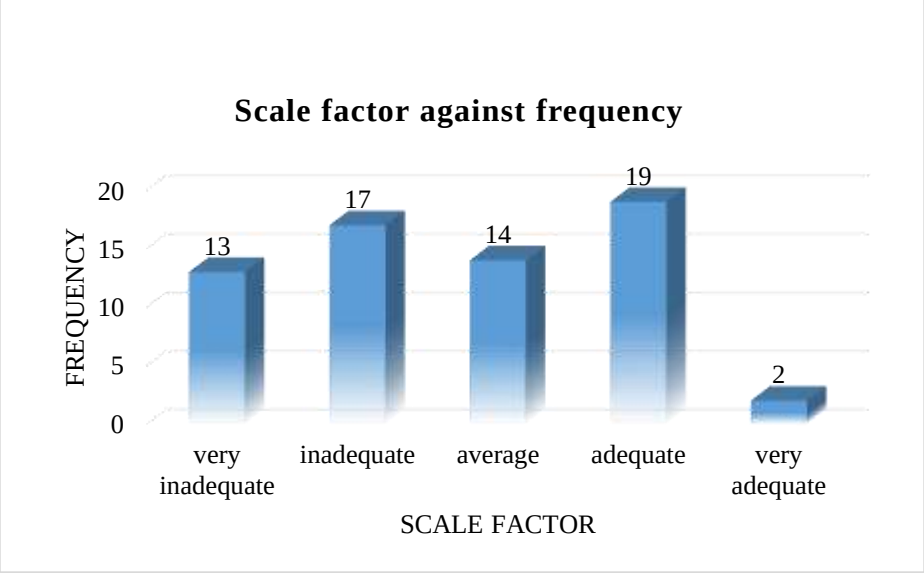


Fig 4. 2: Bar chart showing frequency against scale factor
Source: Author/researcher, 2015

A clear latitudinal cut through the simulated Musa Yar Adua building that was modelled with the same material used in the existing building, as seen from the simulation data.

The main exhibition hall is not having the adequate lighting requirement i.e. Fig 4.3, weather date from Abuja metrological department was used.

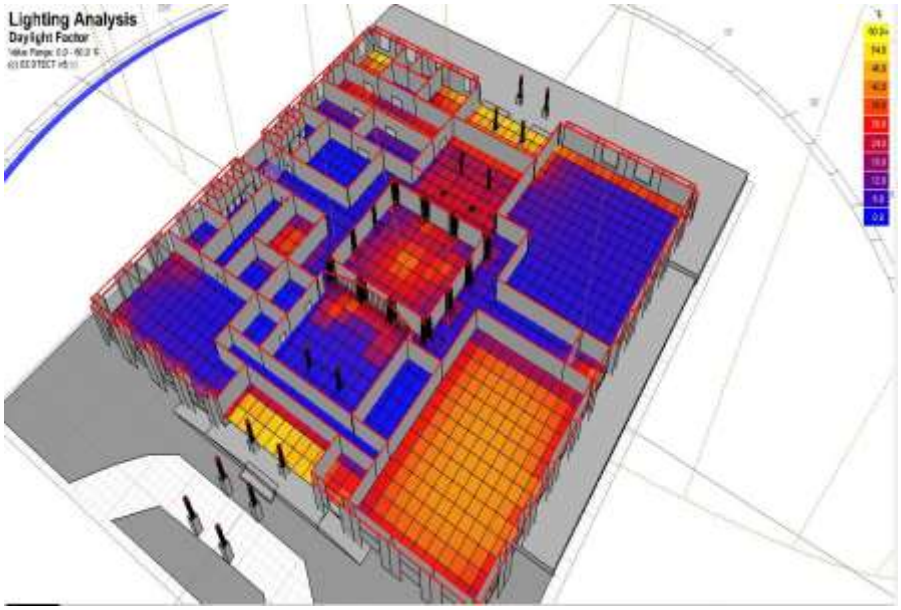


Fig 4. 3: Daylight level of the Musa Yar adua centre.
Source: Author/researcher, 2015

Fig 4.4 shows the exact model of Musa Yar adua centre Abuja in Revit architecture using the exact measurement and material used before it was transported to Ecotect for simulation. The model was carried out in Revit 2011 and transferred to Ecotect 2011 version as the two soft wears have to be from the same year.

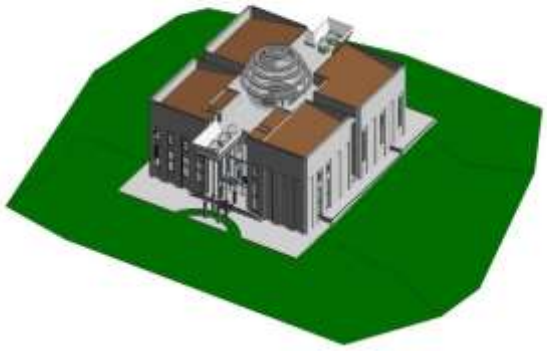


Fig 4. 4: Arial view of the modelled centre.
Source: author/ Researcher.2015

The daylighting level in the exposition hall of Musa Yar adua centre shows that the highest points of lighting level which is represented in a graphical form as shown in fig 4.5. The major disadvantage of the exposition hall is the fact that the lighting are majorly from the side with little or no top lighting.

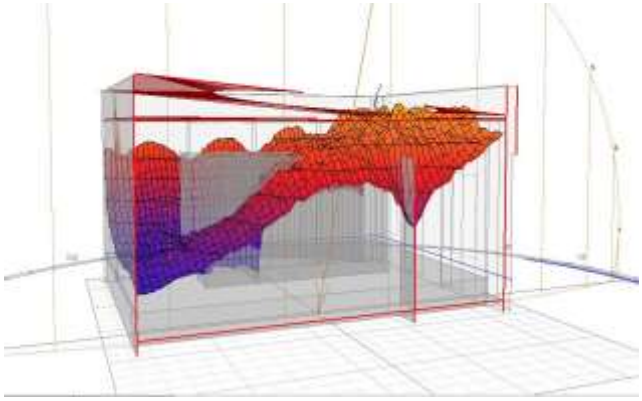


Fig 4. 5: Daylight level in exhibition
Source: Author/researcher, 2015

Fig 4.5 shows isolated portion of the exposition before the various daylight materials were applied in other to discover what changes will be obtained.



Fig 4. 6: Showing model of exhibition space
Source: Author/researcher, 2015

Shehu Musa Yar adua centre is known for skylight which have a shading device attached to the exterior of a dome shaped lighting aperture. This serves to protect the interior from

the adverse effect of the sun while allowing light to penetrate into the building ad shown in plate V. this design approach will be utilised in the proposed design as a close look at the dome shows it is structurally stable to withstand stress as shown in Plate VI.



Plate V: Sky light illuminance.
Source: field work, September, 2015



Plate VI: Daylight from skylight.
source: field work, September, 2015

Furthermore a closer look at the entrance of the exhibition hall shows that the door is close to where the dome shapes sky light is situated thereby allowing more of the natural lighting into the building as seen in plate VII. A proper display of exhibits and other pictorial items of the late Shehu Musa Yar adua can be seen clearly even without the artificial lighting as seen in plate VIII. Tis shows the importance of proper use of daylight in a building which should be a part of the design process.



Plate VII: Exhibition Entrance
Source: field work, September, 2015



Plate VIII: Day light Illuminance in the hall
Source: field work, September, 2015

simulation was carried out on a work place in the simulated building as this will serve a typical working environment which will be used as a basis for analysing the building as seen in fig 4.7 there is no work plane modelled on the window side an d no work place bur just a model with no obstruction while in fig 4.8 shows a window level with work plane.



Fig 4. 7: Window and shadow from Radiance
Source: Author/researcher, 2015



Fig 4. 8: Window work plane from Radiance
Source: Author/researcher, 2015

Fig 4.9 shows the radiance simulation in lux and cd/m2 value equivalent in the building with the highest of 4750lux and minimum of 150 lux while fig 4.9 shows the daylight factor equivalent with the minimum of 10 % and 190% DF.

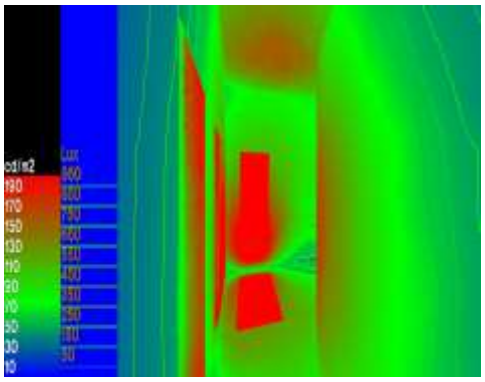


Fig 4. 9: Radiance simulation in lux and Cd/m2 values and equivalent.
Source: Author/researcher, 2015

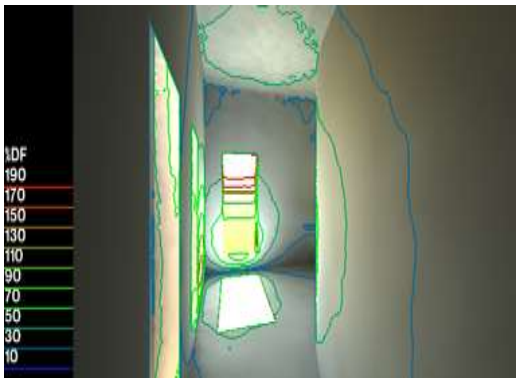


Fig 4. 10: Daylight factor.
Source: Author/researcher, 2015

The different colour indicators shows the different lighting hierarchy as shown in Fig 4.11 show the lighting level at random points. It is imperative to know that lighting levels cannot be the same at all points in a room therefore an average was taken of the deferent lighting cells in the simulation work in the case of this study. Furthermore Fig 4.12 shows lighting level at random points.

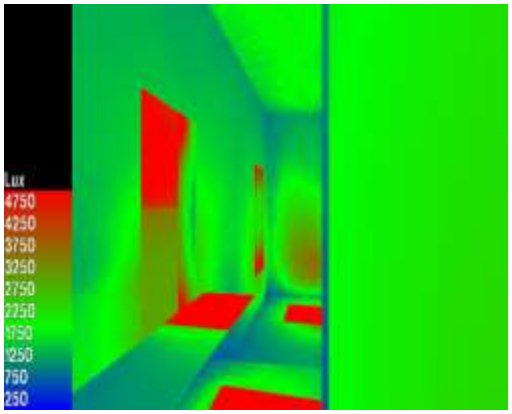


Fig 4. 11: Lux value of work plane.
Source: Author/researcher, 2015

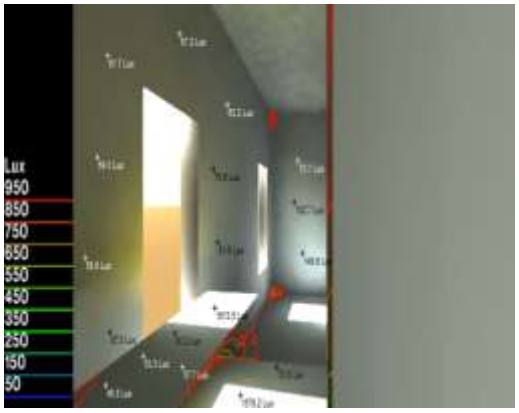


Fig 4. 12: Lux value of various points.
Source: Author/researcher, 2015

Result findings from daysim simulation

1. Daylight Factor (DF) Analysis: 26% of all IL luminance sensors have a daylight factor of 2% or higher. If the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zone would not qualify for the LEED-NC2.1 daylighting credit 8.1 as the area ratio of sensors with a daylight factor over 2% would need to be 75% or higher.
2. Daylight Autonomy (DA) Analysis: The daylight autonomies for all core work plane sensors lie between 0% and 100%.
3. Useful Daylight Index (UDI) Analysis: The Useful Daylight Indices for the Lighting Zone are UDI<100=100%, UDI100-2000=0%, UDI>2000=0%.

4. Continuous Daylight Autonomy (DAcon) and DAmax Analysis: 55% of all IL luminance sensors have a DAcon above 40%. 16% of all IL luminance sensors have a DAmaxabove 5%.

Simulation Assumptions

1. Site Description: The investigated building is located in Abuja (9.10 N/ 7.40 E). Daylight savings time lasts from April 1st to October 31st.
2. User Description: The zone is occupied Monday through Friday from 8:00 to 17:00. The occupant leaves the office three times during the day (30 minutes in the morning, 1 hour at midday, and 30 minutes in the afternoon). The total annual hours of occupancy at the work place are 1569.0.The occupant performs a task that requires a minimum IL luminance level of 3500 lux.
3. Lighting and Blind Control: The office has no dynamic shading device system installed.

NB: LEED (leadership in energy and environmental design) stands for green building leadership and is the world premier bench mark for high-performance green building,

Its objective include:

1. A focus on materials that goes beyond how much is used to get a better understanding of what is in the materials we spec for our building and the effect those component have on human health and the environment.
2. Takes a more performance-based approach to indoor environment quality to ensure improved occupant comfort.
3. Bring the benefits of smart grid thinking to the for-front with a credit that rewards project for participating in demand response.
4. Provide a clear picture of water efficiency by evaluating total building water in use (Council, 2016). The building design categorization have their different

ranking and percentage of energy to be consumed especially in developed LEED building categorization which include building design construction, interior design and construction, building operations and maintenance, neighbourhood development and homes as seen in Fig 4.13.



Fig 4. 13: LEED Building categorization
Source: www.usgbc.org/LEED/

There are four levels of certification, the number of points a project earns determine the level of LEED certification that the project will receive. Typical certification thresholds as seen in Fig.14 shows the different range of building certification 40-49% for certified, 50-59% for silver, 60-70 % for gold and 80-100% for platinum.

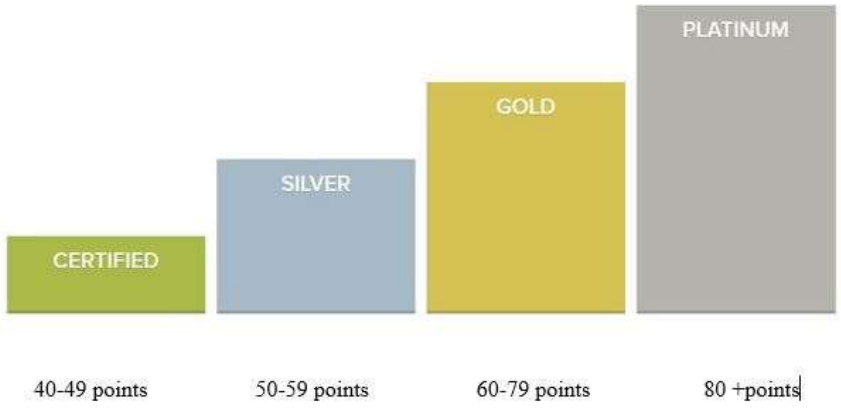


Fig 4. 14: LEED Certification Points
Source: www.usgbc.org/LEED/

Table 4.5 shows the different materials used in the building and there various components which were used in construction. This material components where altered to have a more daylight friendly material. Energy consumption can be estimated based on the artificial and natural lighting consumption as seen in tale 4.7, 4.8 and 4.9 respectively.

Table 4. 7: Building Materials used for case study 1

Building Component	**Type of Materials**
Walls	Hollow Block Render
Windows	Double Glaze Aluminium Frame
Roof	Roof decking
Floors	Terrazzor

Table 4. 8 Dailly lighting energy consumption of case study 1

Compact Florescent lamp type (watts /hr)	**Number**	**Working hours (Average) Hr**	**TOTAL (Watts)**
17 (watts) CFL	60	8	8160 W
30 (watts) CFL	65	8	15600 W
			23760W

Table 4. 9 yearly artificial lighting consumption of case study 1

Month	**Number of days**	**Monthly lighting energy consumption (W)**
January	31	736560
February	28	665280
March	31	736560
April	30	712800
May	31	736560
June	30	712800
July	31	736560
August	31	736560
September	30	712800
October	31	736560
November	30	712800
December	31	736560
Total	365	**8672400W**

For the purpose of this research the overcast day of 1075 lux is adopted as it is the normal lighting under normal circumstances. Which gives an approximate of 53.75 watts equivalent per hour 53.75*8 = 430watts every day * 365= **156950 W.**

Total energy = 8672400 + 156950= 8829350W

Lumens to watts calculation formula

Energy saving lamps have high luminous efficacy (more lumens per watt). The power P in watts (W) is equal to the luminous flux ΦV in lumens (lm), divided by the luminous efficacy η in lumens per watt (lm/W): P (W) = ΦV (lm) / η (lm/W). Source: (Rapid table). Materials Visible transmittance is the amount of light in the visible portion of the spectrum that passes through a glazing material. A higher VT means there is more daylight in a space which, if designed properly, can offset electric lighting and its associated cooling loads. Visible transmittance is influenced by the glazing type, the number of panes, and any glass coatings. Visible transmittance of glazing ranges from above 90% for uncoated water-white clear glass to less than 10% for highly reflective coatings on tinted glass. A typical double-pane insulated glass unit IGU had a VT of around 78%. This value decreases somewhat by adding a low-E coating and decreased substantially when adding a tint (see figure to the right). VT values for the whole window are always less than centre-of-glass values since the VT of the frame is zero (buildings, 2015). The various materials (E-glazing) used in this research are the clear double glazing i.e. Fig 4.15, low solar gain low-E double glazing i.e. Fig 4.16 and the double glazing with bronze tint i.e. Fig 4.17 which has the lowest U-factor.

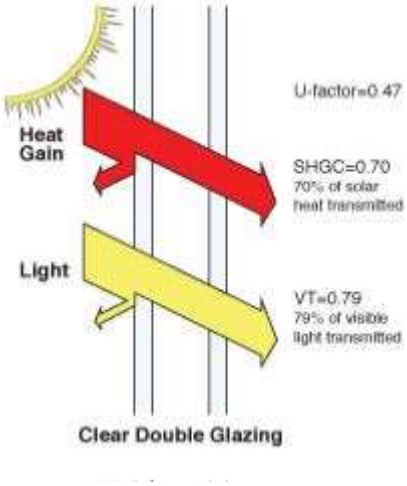


Fig 4. 15: Material sample 1
Source: INC, 2014.

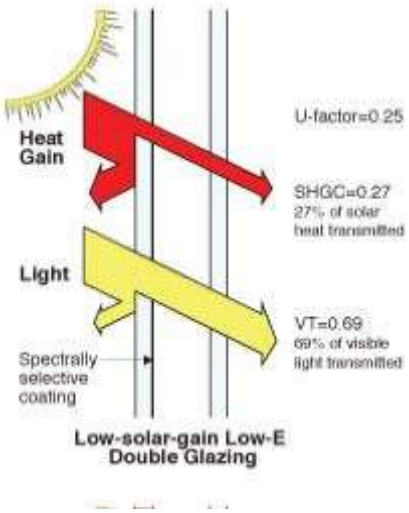


Fig 4. 16: Material sample 2
Source: INC, 2014

The E- glazing type that was found to have the lowest 'U' i.e. in Fig 4.17 was the best glazing type that will be used for the propose design, therefore it can be implied that the lower the 'U' factor the greater the chances of the material to be a daylight transmittance material.

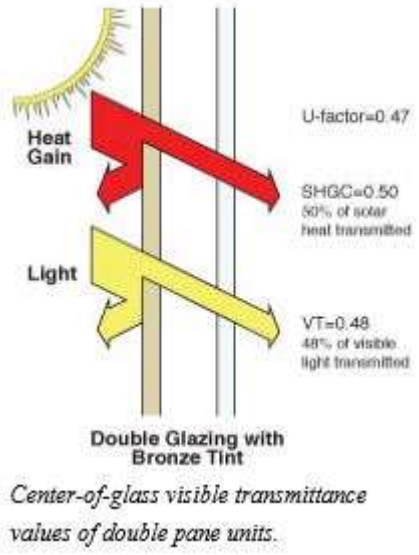


Fig 4. 17 Material sample 3
Source: INC, 2014

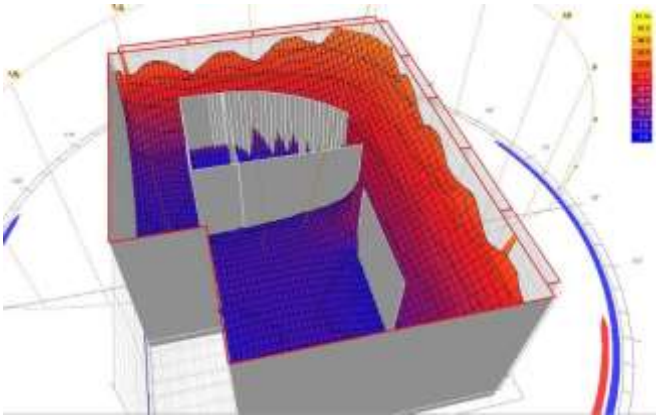
Material sample 1 (*Low-E Glazing)*

U value =0.47

SHGC (solar heat gain coefficient) =0.70

Visible Transmittance (VT) =0.79

With the increase in the visibility transmittance and the reduction in 'U' factor of the materials used in case study one shows an increase in the daylight level of the exterior wall as shown in Fig 4.18 which is a view from the top of the exposition hall



Plan perspective
Fig 4. 18: Views showing radiance level increase
Source: Author/researcher, 2015

Fig 4.19 shows the lux value of the interior which has a highest of 2850 lux and a lowest value of 1500 lux which show an increase in the lighting condition of the interior.

The daylighting factor of the interior shows a highest value of 950 and a lowest value of 150 in the Fig 4.20.

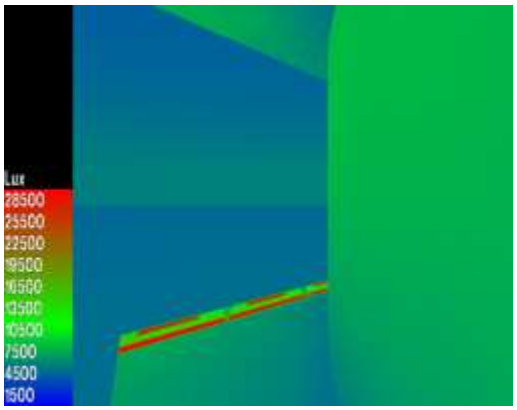


Fig 4. 19: Lux level increase
Source: Author/researcher, 2015

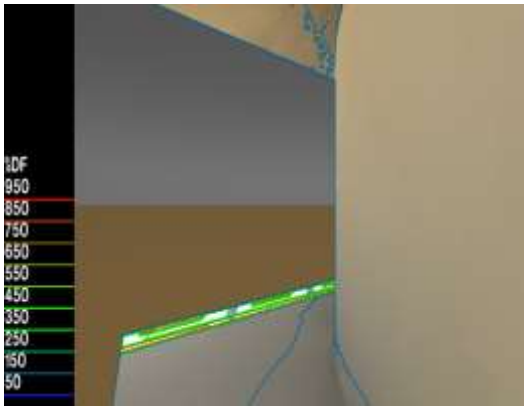


Fig 4. 20: Daylighting level increase
Source: Author/researcher, 2015

Result findings from daysim simulation

1. Daylight Factor (DF) Analysis: 75% of all IL luminance sensors have a daylight factor of 2% or higher. If the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zone should qualify for the LEED-NC 2.1 daylighting credit 8.1.
2. Daylight Autonomy (DA) Analysis: The daylight autonomies for all core work plane sensors lie between 0% and 59%.
3. Useful Daylight Index (UDI) Analysis: The Useful Daylight Indices for the Lighting Zone are UDI<100=90%, UDI100-2000=0%, UDI>2000=10%
4. Continuous Daylight Autonomy (DAcon) and DAmax Analysis: 96% of all IL luminance sensors have a DAcon above 40%. 53% of all IL luminance sensors have a DAmax above 5%.

Simulation Assumptions

1. Site Description: The investigated building is located in Abuja (9.10 N/ 7.40 E).

2. User Description: The zone is occupied Monday through Friday from 0:00 to 19:00. The occupant leaves the office three times during the day (30 minutes in the morning, 1 hour at midday, and 30 minutes in the afternoon). The total annual

hours of occupancy at the work place are 2376.0.The occupant performs a task that requires a minimum IL luminance level of 350 lux.

3. Lighting and Blind Control: The office has no dynamic shading device system installed.

Material sample 2 (*Low-E Glazing)*

U value =0.25

SHGC (solar heat gain coefficient) =0.27

Visible Transmittance (VT) =0.69

Result findings from daysim simulation

1. Daylight Factor (DF) Analysis: 75% of all IL luminance sensors have a daylight factor of 2% or higher. If the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zone should qualify for the LEED-NC 2.1 daylighting credit 8.1 (see www.usgbc.org/LEED/).
2. Daylight Autonomy (DA) Analysis: The daylight autonomies for all core work plane sensors lie between 0% and 59%.
3. Useful Daylight Index (UDI) Analysis: The Useful Daylight Indices for the Lighting Zone are UDI<100=90%, UDI100-2000=0%, UDI>2000=10%.
4. Continuous Daylight Autonomy (DAcon) and DAmax Analysis: 96% of all IL luminance sensors have a DAcon above 40%. 53% of all IL luminance sensors have a DAmax above 5%.

Simulation Assumptions

1. Site Description: The investigated building is located in Abuja (9.10 N/ 7.40 E).
2. User Description: The zone is occupied Monday through Friday from 0:00 to 19:00. The occupant leaves the office three times during the day (30 minutes in the morning, 1 hour at midday, and 30 minutes in the afternoon). The total annual

hours of occupancy at the work place are 2376.0.The occupant performs a task that requires a minimum IL luminance level of 350 lux.

3. Lighting and Blind Control: The office has no dynamic shading device system installed. A comparison between concrete and the various E-glazing shows that the e- glazing 3 as the highest as seen in Fig 4.21.

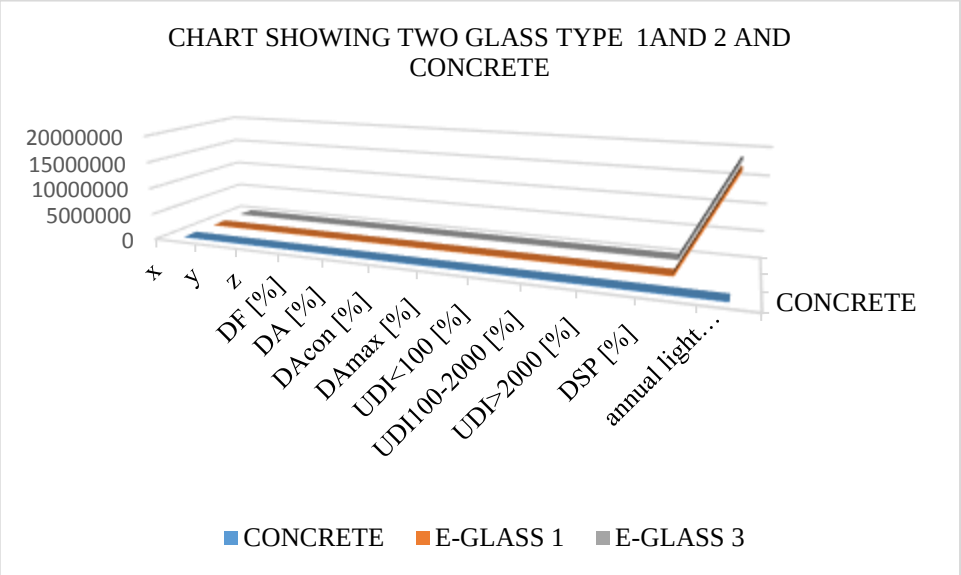


Fig 4. 21: Comparison of concrete and the two E –Glazing 1 and 2
Source: Author/researcher, 2015

Material sample 3 (*Low-E Glazing)*

U value =0.47

SHGC (solar heat gain coefficient) =0.50

Visible Transmittance (VT) =0.48

Result findings from daysim simulation

1. Daylight Factor (DF) Analysis: 52% of all IL luminance sensors have a daylight factor of 2% or higher. If the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zone would not

qualify for the LEED-NC 2.1 daylighting credit 8.1 as the area ratio of sensors with a daylight factor over 2% would need to be 75% or higher .

2. Daylight Autonomy (DA) Analysis: The daylight autonomies for all core workplane sensors lie between 0% and 87%.
3. Useful Daylight Index (UDI) Analysis: The Useful Daylight Indices for the Lighting Zone are $UDI_{<100}$=100%, $UDI_{100-2000}$=0%, $UDI_{>2000}$=0%.
4. Continuous Daylight Autonomy (DA_{con}) and DA_{max} Analysis: 92% of all Illuminance sensors have a DA_{con} above 60%. 31% of all IL luminance sensors have a DA_{max} above 5%.

Simulation Assumptions

1. Site Description: The investigated building is located in Abuja (9.10 N/ 7.40 E).

2. User Description: The zone is occupied Monday through Friday from 9:00 to 19:00. The occupant leaves the office three times during the day (30 minutes in the morning, 1 hour at midday, and 30 minutes in the afternoon). The total annual hours of occupancy at the work place are 2077.0.The occupant performs a task that requires a minimum IL luminance level of 350 lux.

3. Lighting and Blind Control: The office has no dynamic shading device system installed.

The lighting level index of the three glazing types when compared is shown in Fig 4.22

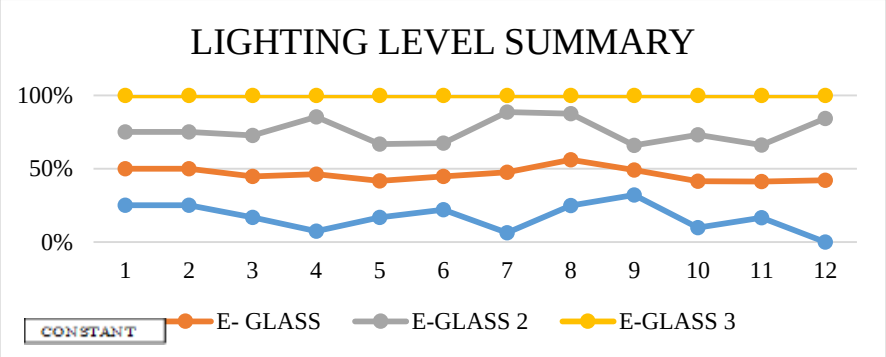


Fig 4. 22: Reduction in energy consumption
Source: Author/researcher, 2015

4.7 Case Study two: International Conference Centre Abuja.

The Abuja international conference centre as it is also known as ICC is a public structure that is used for conferences and expositions with a very large entrance i.e. in Plate IX and a very large interior hall and a gallery as seen in Plate X below.



Plate IX: Approach view of ICC
Source: Copyright (c) 2005, ICC



Plate X: Interior display items at ICC
source: Copyright (c) 2005, ICC

The Abuja International Conference Centre (AICC) provides an ideal location for exciting themed and large events. Ideal for, concerts, consumer and trade shows, large receptions or galas and other special events, the AICC can accommodate up to 3,000 guests. In the last decade and a half the Centre has played host to several International, Regional and National political, social, cultural, economic and religious conferences, summits, meetings, seminars, ceremonies and programmes. A magnificent edifice

overlooking the Radio House, 'moulded' and lying in its own lovely garden filled with historic shady pine trees and well paved driveway. Options that the interior of this architectural masterpiece maybe put to are endless function Such as;

1. banquet setting,
2. as an in-door exhibition hall
3. Or set for a concert (LTD, 2005).

Ecotect simulation softer ware is used to simulate the Abuja international conference centre ICC but it has to be transported from Revit to Ecotect as seen in Fig 4.23.

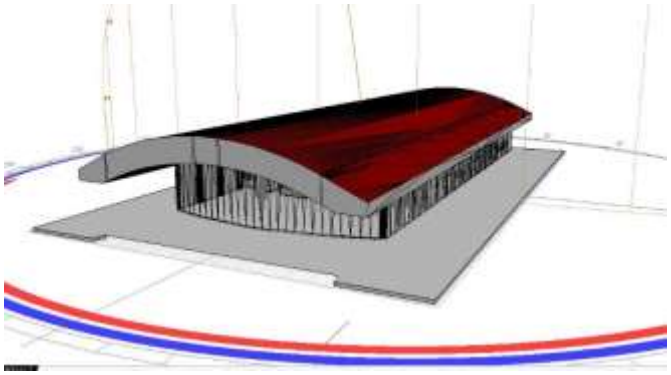


Fig 4. 23: Ecotect model of ICC Abuja.
Source: Author/researcher, 2015

The table 4.6 below is a sample check list for the case study.

Scale factor: Very inadequate=1, Inadequate=2, Average=3, Adequate-4 and Very adequate=5**.**

Table 4. 10 a: Sample of the Checklist of the Case Study Variables international conference centre Abuja.

S/N	Variables	Check list	Scale Factor 1	2	3	4	5	Remark
1.	**Dependent variables**							
	• The envelope Shape of building	skin to volume ratio of the building					■	
		Architectural expression				■		
		Architectural design in relation to locality			■			
		Complexity and design morphology of structures.		■				

Table 4. 11 b: Sample of the Checklist of the Case Study Variables international conference centre Abuja.

S/N	Variables	Check list	Scale Factor 1	2	3	4	5	Remark
		Compatibility of building					■	
		Open is the form of the building envelop				■		
		Harmonic composition of shapes and materials				■		
		Absence of visual barriers		■				
		Shading device and overhangs				■		
	The geometry, location and orientation of aperture	Position in relation to environmental or visual field				■		
		Pedestrian means of circulation		■				
		Space utilization				■		
		Social interaction and sense of community		■				
		Security from crime	■					
		Visual inertia	■					
		Stability and symmetry				■		
		Local character/history		■				
		Easy identification				■		
		Way finding system		■				
		signals	■					
		Absence of visual barriers		■				
	Surface characteristics	Acoustic qualities				■		
		Thermal conductivity of surface		■				
		Resistance /strength/cleanliness				■		
		Ease of maintenance			■			
		Uniform surface structure				■		
		Homogeneous and water retention			■			
		Resistance to weather and external influence				■		
2.	**Independent variables**							
	Spatial distribu-tion of light	Luminaire efficiency						
		Colour of light		■				
		Glare control			■			
							■	

Table 4. 12 c: Sample of the Checklist of the Case Study Variables international conference centre Abuja.

S/N	Variables	Check list	Scale Factor 1	2	3	4	5	Remark
		Directional characteristics of light				■		
			■					
		Shadows and reflections						
		Level of lightness			■			
	IL luminance ratio	Stimulating surroundings						
		Adequate visibility of retailed information		■				
						■		
		Opportunity of individual adjustment			■			
		Daylighting percentage						
		Running cost and energy		■				
		Rough surface characteristics						
		shadows	■					
						■		
	Shape from shadows	Binocular Disparity						
		Shadow inversion		■				
				■				
		colour			■			
		Day time variation						
				■				
		Propagation speed						
		Presence of high objects	■					
		➢ Work space						
			■					
		➢ circulation						
				■				
	colour rendition	Reading task			■			
		Lighting source		■				
		Fighting colours						
		incandescent	■					
						■		
		preference			■			
		Faded items						
			■					
	glare	Instinctive desire to look						
		away	■					
		Difficulty task						
				■				
		Impairs vision						
			■					
		Inter reflection of light						
				■				
		Distinguishing task						
		contrast	■					
				■				
		dazzle			■			
	visual noise	Dirt percentage						
				■				
		Colour particles						
			■					
		Waves						
				■				
		Level of adaptation						
						■		

Table 4.9 shows the relationship between variables and frequency occurrence.

Table 4. 13: Variables against Frequency Table

		variables									
value	scale factor	ES	GL&O	SF	SDL	IR	SS	CR	G	VN	Total
very inadequate	1	1	3	0	0	1	2	2	3	1	13
inadequate	2	1	5	1	2	2	4	1	3	2	21
average	3	1	0	2	2	1	1	2	1	0	10
adequate	4	4	4	4	1	3	0	1	0	1	18
very adequate	5	2	0	0	1	0	0	0	0	0	3
Total		**9**	**12**	**7**	**6**	**7**	**7**	**6**	**7**	**4**	**65**
Percentage		13.85	18.46	11	9.23	10.8	10.77	9.23	10.8	6.15	

Source: Author/researcher, 2015

The bar chart below shows the level of frequency occurrence in the different variable with inadequate of 21%, followed by adequate with 18%, very inadequate with 13% average with 10% and very adequate with 3% as shown in Fig 4.24.

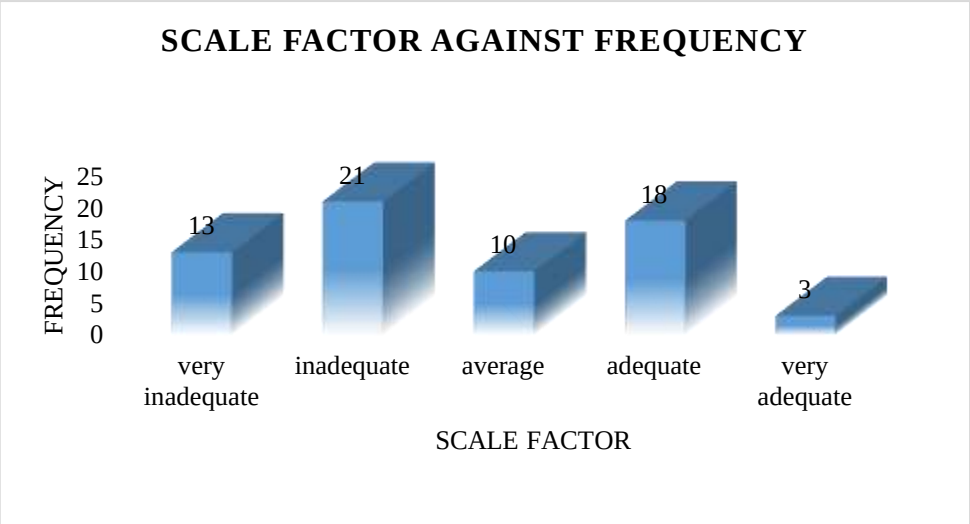


Fig 4. 24: Scale Factor against Frequency Table
Source: Author/researcher, 2015

The interior shows the lux values of the different lighting zones of the interior space with the highest of 950 lux and the lowest average of 150 lux as seen in Fig 4.25. The major challenge to this is the Glare intensity that is begin display at the lower corner of the exposition hall which suggest an increase in the factors that enable visibility transmittance.

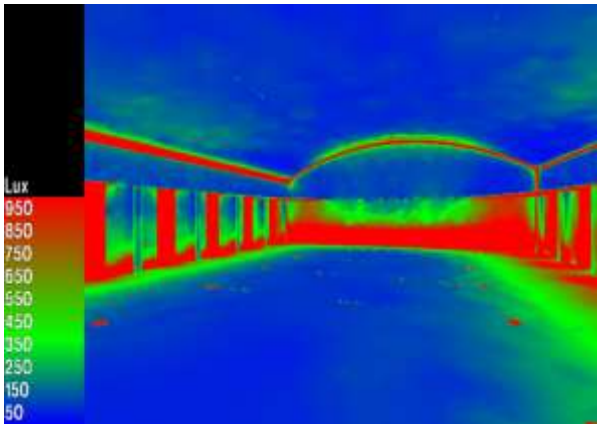


Fig 4. 25: Lux value and lighting levels.
Source: Author/researcher, 2015.

Result findings from daysim simulation

1. Daylight Factor (DF) Analysis: 15% of all luminance sensors have a daylight factor of 2% or higher. If the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zone would not qualify for the LEED-NC 2.1 day lighting credit 8.1 as the area ratio of sensors with a daylight factor over 2% would need to be 75% or higher.

2. Daylight Autonomy (DA) Analysis: The daylight autonomies for all core work plane sensors lie between 0% and 87%.

3. Useful Daylight Index (UDI) Analysis: The Useful Daylight Indices for the Lighting Zone are UDI<100=100%, UDI100-2000=0%, UDI>2000=0%.

4. Continuous Daylight Autonomy (DAcon) and DAmax Analysis: 55% of all IL luminance sensors have a DAcon above 40%. 14% of all IL luminance sensors have a DAmax above 5%

Simulation Assumptions

1. Site Description: The investigated building is located in Abuja (9.10 N/ 7.40 E). Daylight savings time lasts from April 1st to October 31st.

2. User Description: The zone is occupied Monday through Friday from 9:00 to 19:00. The occupant leaves the office three times during the day (30 minutes in the morning, 1 hour at midday, and 30 minutes in the afternoon). The total annual hours of occupancy at the work place are 2077.0.The occupant performs a task that requires a minimum IL luminance level of 350 lux.
3. Lighting and Blind Control: The office has no dynamic shading device system installed.

4.8 Use and types of Insulating glass

Insulating Glass Units are used in a variety of applications including windows, doors and skylights for commercial buildings and residential construction as well as in refrigeration units, control towers, rail transportation, cars and busses, marine applications and many other areas where energy conservation and comfort are part of the design.

1. Insulating Glass Units are sealed combinations of two or more lights of glass separated by a dry air space.
2. Insulating Glass Units save energy, save money, reduce pollution and greatly improve the comfort inside a building.

Glass types

1. Clear Glass: soda lime, low iron
2. Tinted Glass: green, grey, bronze, blue, blue green
3. Reflective Glass: pyro lytic, sputtered
4. Low Emissivity Glass: pyro lytic, sputtered
5. Laminated Glass: monolithic, insulating, PVB interlayer, ionoplast interlayer, urethane interlayer, silicone interlayer, resin interlayer
6. Patterned Glass: sand blasted, chemically etched, rough Rolled

7. Spandrel Glass: ceramic frit opacification, film opacification, silicone opacification
8. Hydrophilic Coated Glass: self-cleaning, easy to clean
9. Fire Rated Glasses
10. Wired Glasses
11. Electrochromic coatings

4.8.1 Energy concepts for insulating glass

4.8.1.1 U-factor (U-value)

The measure of the rate of non-solar heat loss or gain through a window system in terms of Btu/ hr-sq ft·ºF (W/sq m·C). The lower the U-factor the greater the resistance to heat flow as a better insulator.

4.8.1.2 R-value

The measure of the resistance of a glazing material or fenestration assembly to heat flow. Basically the inverse of the U-factor or R = 1/U

4.8.1.3 Solar Heat Gain Coefficient (SGHC)

The fraction of the solar radiation admitted through a window or skylight both transmitted and absorbed and released inward (A William Lingnell, 2011).

U value =0.65

SHGC (solar heat gain coefficient) =0.27

Visible Transmittance (VT) =0.36

Result findings from daysim simulation

1. Daylight Factor (DF) Analysis: 90% of all IL luminance sensors have a daylight factor of 2% or higher. If the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zone should qualify for the LEED-NC 2.1 daylighting credit 8.1

2. Daylight Autonomy (DA) Analysis: The daylight autonomies for all core work plane sensors lie between 75% and 87%.
3. Useful Daylight Index (UDI) Analysis: The Useful Daylight Indices for the Lighting Zone are UDI<100=15%, UDI100-2000=0%, UDI>2000=85%.
4. Continuous Daylight Autonomy (DAcon) and DAmax Analysis: 100% of all IL luminance sensors have a DAcon above 80%. 94% of all IL luminance sensors have a DAmax above 5%.

Simulation Assumptions

1. Site Description: The investigated building is located in Abuja (9.10 N/ 7.40 E).
2. User Description: The zone is occupied Monday through Friday from 9:00 to 19:00. The occupant leaves the office three times during the day (30 minutes in the morning, 1 hour at midday, and 30 minutes in the afternoon). The total annual hours of occupancy at the work place are 2077.0.The occupant performs a task that requires a minimum IL luminance level of 350 lux.
3. Lighting and Blind Control: The office has no dynamic shading device system installed. The table 4.8 shows the comparison between normal glazing and insulated glazing simulation.

Table 4. 14: Comparison of actual and insulated glass materials

	Actual glass	**Insulated glass**
x	19.86298	19.86298
y	-42.0237	-42.0237
z	1.3	1.3
DF [%]	21.99174	21.99174
DA [%]	32.60556	86.45104
DAcon [%]	50.41007	86.86493
DAmax [%]	6.744097	52.66944
UDI<100 [%]	44.87083	13.00417
UDI100-2000 [%]	46.70069	15.79201
UDI>2000 [%]	8.418056	71.22049
DSP [%]	29.07951	29.07951
annual light exposure [luxh]	13939263	53847819

From the chart in Fig 4.26 it shows an n increase in daylight transmittance for insulated glazing.

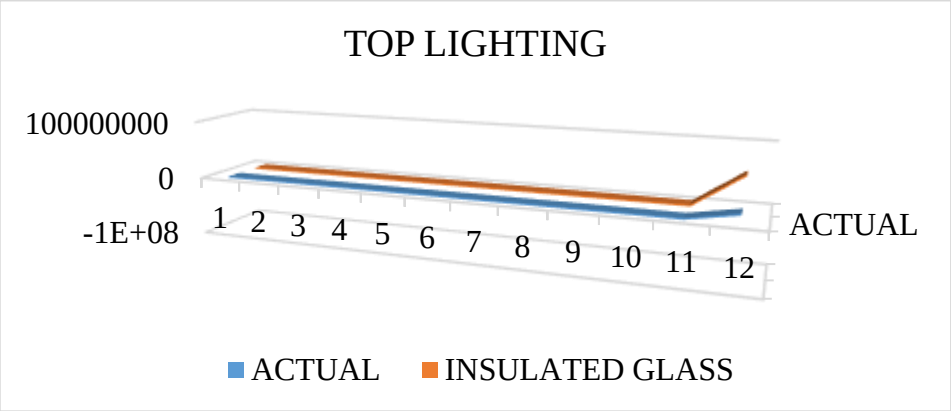


Fig 4. 26: Increase in lighting level
Source: Source: Author/researcher, 2015

Table 4. 15: Daily lighting energy consumption of case study 2 Artificial lighting

Compact Florescent lamp type watts /hr.	**Number**	**Working hours**	**Total (Watts)**
30 (watts) CFL	60	8	14400 W
60 (watts) CFL	100	8	48000 W
			62400 W

Source: Author/researcher, 2015

Table 4. 16: Monthly lighting energy consumption of case study 2 (validation)

Natural lighting

Month	**Number of days**	**Monthly lighting energy consumption (w)**
January	31	1934400
February	28	1747200
March	31	1934400
April	30	1872000
May	31	1934400
June	30	1872000
July	31	1934400
August	31	1934400
September	30	1872000
October	31	1934400
November	30	1872000
December	31	1934400
Total	365	22776000W

For the purpose of this research the overcast day of 1075 lux is adopted as it is the normal lighting under normal circumstances. Which gives an approximate of 53.75 watts equivalent per hour

53.75*8 = 430watts every day * 365= **156950W.**

Total energy = 22776000 + 156950= <u>22932950W</u>

4.9 Case study three: Ceddi plaza Abuja.

Ceddi Plaza is owned by Ceddi Corporation and is located in the Central Business Area of Abuja. The Plaza consists of 10,000 square meters of retail and office space. The Nigerian owned and designed, the mixed use facility is managed by Broll Property Services Nigeria. Opened officially in November 2005 as seen in plate XI. It has a very large sky lighting feature that makes it stand out and to be chosen as one of the case study for this research as seen in plate XII.



Plate XI: Ceddi plaza Abuja.
Source: Author/researcher, 2015.



Plate XII: Interior atrium daylighting
Source: Author/researcher, 2015.

the Plaza is celebrated as the premiere Centre for Shopping & Entertainment in the City of Abuja Ceddi Plaza is made up of 55 specialty shops, offices & service providers consisting of movie theatres, a bookstore, champagne lounge, the Atrium at Ceddi Plaza, restaurants, cafes, fashion boutiques, shoes, accessories, home interior design stores,

furnishings, health & beauty salons, gift shops, telephones, banking and automated teller machine (ATMs), dry cleaning services, a dental office, pharmacy, photo studio, children's entertainment, events hall. The tenant mix is made up of three floors of retail (eateries, fashion boutiques, entertainment and services) and three floors of corporate office space and much more. It was modelled also and transported to Ecotect as seen in Plate XIII.

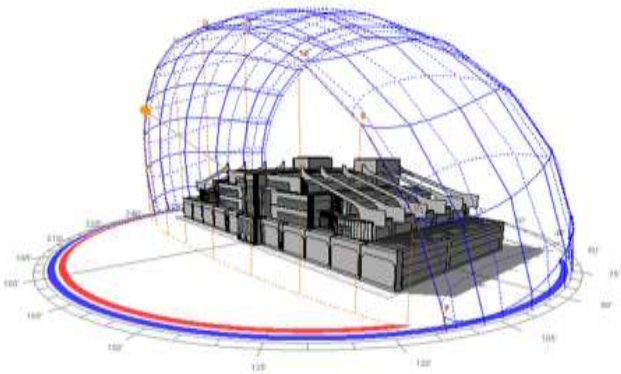


Plate XIII: Ecotect model
Source: Author/researcher, 2015

SCALE FACTOR: Very inadequate=1, Inadequate=2, Average=3, Adequate-4 and Very adequate=5**.**

Table 4. 17 a: Sample of the Checklist of the Case Study Variables. Ceddi Plaza

S/N	Variables	Check list	Scale Factor 1	2	3	4	5	Remark
1.	**dependent variables**							
	The envelope Shape of building	skin to volume ratio of the building			■			
		Architectural expression				■		
		Architectural design in relation to locality			■			
		Complexity and design morphology of structures.				■		
		Compatibility of building				■		
		Open is the form of the building envelop		■				
		Harmonic composition of shapes and materials			■			
		Absence of visual barriers				■		

Table 4. 18 b: Sample of the Checklist of the Case Study Variables. Ceddi Plaza

S/N	Variables	Check list	Scale Factor 1 2 3 4 5	Remark
	The geometry, location and orientation of aperture	Position in relation to environmental or visual field		
		Pedestrian means of circulation		
		Space utilization		
		Social interaction and sense of community		
		Security from crime		
		Visual inertia		
		Stability and symmetry		
		Local character/history		
		Easy identification		
		Way finding system		
		signals		
		Absence of visual barriers		
	Surface characteristics	Acoustic qualities		
		Thermal conductivity of surface		
		Resistance /strength/cleanliness		
		Ease of maintenance		
		Uniform surface structure		
		Homogeneous and water retention		
		Resistance to weather and external influence		
2.	**Independent variables**			
	Spatial distribu-tion of light	Luminaire efficiency		
		Colour of light		
		Glare control		
		Directional characteristics of light		
		Shadows and reflections		
		Level of lightness		
	ILluminance ratio	Stimulating surroundings		
		Adequate visibility of retailed information		
		Opportunity of individual adjustment		
		Daylighting percentage		
		Running cost and energy		
		Rough surface characteristics		
		shadows		
	Shape from shadows	Binocular Disparity		

Table 4. 19 c: Sample of the Checklist of the Case Study Variables. Ceddi Plaza

S/N	Variables	Check list	Scale Factor 1 2 3 4 5	Remark
		Shadow inversion		
		colour		
		Day time variation		
		Propagation speed		
		Presence of high objects		
		➢ Work space		
		➢ circulation		
	colour rendition	Reading task		
		Lighting source		
		Fighting colours		
		incandescent		
		preference		
		Faded items		
	glare	Instinctive desire to look away		
		Difficulty task		
		Impairs vision		
		Inter reflection of light		
		Distinguishing task		
		contrast		
		dazzle		
	visual noise	Dirt percentage		
		Colour particles		
		Waves		
		Level of adaptation		

Table 4. 20: Variables against frequency table

		variables									
value	scale factor	ES	GL&O	SF	SDL	IR	SS	CR	G	VN	Total frequency
very inadequate	1	0	3	0	0	2	1	1	3	2	12
Inadequate	2	1	3	2	1	2	4	3	3	1	20
Average	3	3	3	0	1	1	1	1	0	0	10
Adequate	4	5	3	4	3	2	1	1	1	1	21
Very adequate	5	0	0	1	1	0	0	0	0	0	2
Total		**9**	**12**	**7**	**6**	**7**	**7**	**6**	**7**	**4**	**65**
Percentage		13.85	18.46	11	9.23	10.8	10.77	9.23	10.8	6.15	

The bar chart below shows the level of frequency occurrence in the different variable with inadequate of 21%, followed by adequate with 18%, very inadequate with 13% average with 10% and very adequate with 3% as shown in Fig 4.27.

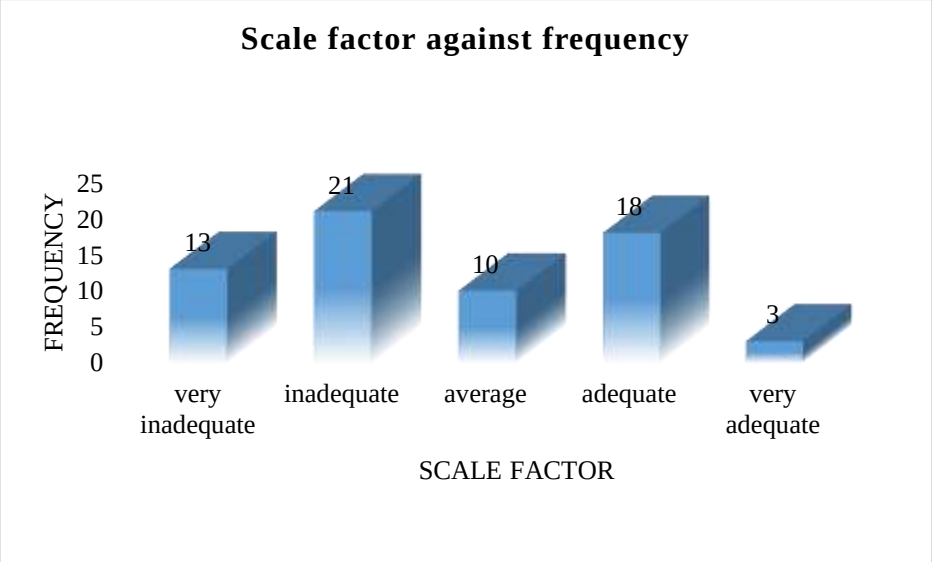


Fig 4. 27: Scale factor against frequency
Source: Author/researcher, 2015

Table 4. 21 Types of materials used for each building component (Case Study3)

Building Component	**Type of Materials**
Walls	Alluminium sheets
Windows	Single Glaze Aluminium Frame
Roof	Curved Alluminium roofing sheets
Floors	Terrazzor

Table 4. 22 Artificial Daily lighting energy consumption of case study 3

Compact Florescent lamp type watts /hr	Number	Working hours (Average) hr.	Total (Watts)
30 (watts) CFL	80	8	19200 W
60 (watts) CFL	100	8	48000 W
			67200 W

Monthly lighting energy consumption of case study 3

Table 4. 23 Natural lighting

Month	Number of days	Monthly lighting energy consumption (w)
January	31	2083200
February	28	1747200
March	31	2083200
April	30	2016000
May	31	2083200
June	30	2016000
July	31	2083200
August	31	2083200
September	30	2016000
October	31	2083200
November	30	2016000
December	31	2083200
Total	365	24528000w

Natural lighting

For the purpose of this research the overcast day of 1075 lux is adopted as it is the normal lighting under normal circumstances. Which gives an approximate of 53.75 watts equivalent per hour

53.75*8 = 430watts every day * 365= **156950W.**

Total energy = 24528000 + 156950= 24684950W

Result findings from daysim simulation

1. Daylight Factor (DF) Analysis: 13% of all luminance sensors have a daylight factor of 2% or higher. If the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zone would not qualify for the LEED-NC 2.1 day lighting credit 8.1 as the area ratio of sensors with a daylight factor over 2% would need to be 75% or higher.
2. Daylight Autonomy (DA) Analysis: The daylight autonomies for all core work plane sensors lie between 0% and 87%.
3. Useful Daylight Index (UDI) Analysis: The Useful Daylight Indices for the

Lighting Zone are UDI<100=100%, UDI100-2000=0%, UDI>2000=0%.

4. Continuous Daylight Autonomy (DAcon) and DAmax Analysis: 55% of all IL luminance sensors have a DAcon above 40%. 14% of all IL luminance sensors have a DAmax above 5%

In all the case studies so far a summary was arrived as seen in table 4.24

Table 4. 24: Summary of findings from case studies

	Case studies summary				
	Major facility	**Dominant building materials**	**Daylighting element**	**Use of artificial light**	**Architectural features and characteristics**
			Musa Yar Adua centre Abuja.		
1	The centre has the necessary facility for exhibition.	Dominant building material include concrete, steel and glass.	This include sky light doors and windows and glassed partition	Incandescing and florescent lighting tubes.	Contemporary architecture with the use of decorative walls and claddings.
			International conference center Abuja.		
2	The centre has a vast area space for exhibition and circulation which can be muti-used for different functions	steel, concrete, wood and glass	Large open space windows, partitioned glazing.	Florescent lighting tubes. And halogen tubes.	The building consist of self-supporting columns spaced at 10m apart with steel portioning and a curved steel roofing
			Ceddi plaza Abuja		
3	The plaza has a vast floor space that can be portioned for various activities like for commercial and recreational activities	Concrete blocks. Precast concrete steel aluminum	Atrium glazed windows and doors	Florescent tube and low energy consumption bulbs.	Framed structure that is easily partitioned for various purposes and the collections of over hangs as shedding device

4.10 Case study findings

1. it have been noticed from the various case studied that there has been a deliberate attempt to provide daylight through top lighting and side lighting in exhibition centres in Nigeria.
2. the use of materials that enhances daylight visualization in the interior space have been utilized to a greet extend
3. Architectural forms from the case studies shows that those form where meant to deliver maximum daylighting to the interior of the building envelop.
4. Exhibition centre from the case studies display a brilliant showcase of exhibits.
5. From the case studied, in case of power outage, the interior of exhibition becomes dark and it becomes difficult to see due to power failure.
6. The Nigerian case studies make an attempt to incorporate exhibition and other commercial and recreational activities at the same time.

4.10.1 Case study Inferences

1. A good daylighting design, requires daylighting to be an integral part and not just an addition via windows or glazing.
2. Use of reflected light in the exhibition spaces and galleries will to a great extend illuminate the interior space especially where light cannot extent to those spaces'.
3. A careful selection of building materials can enhance day light in the interior environment of buildings such as paint and colour.
4. from the simulation result top lighting is more efficient than the side lighting
5. A good selection of building materials should not affect the comfort of the interior environment.

6. A combination of daylighting elements and artificial lighting will ensure well day lit spaces during the day and a smooth transition to artificial lighting during the night.
7. Good and careful use of top lighting and side lighting is recommended for the design of Exposition centres table 4.25 shows a summary of case studies.

Table 4. 25: Summary table of case study

	case study 1	**case study 2**	**case study 3**
ES	29	32	31
GL&O	35	29	30
SF	23	24	25
SDL	18	19	22
IR	21	20	17
SS	15	13	16
CR	15	14	14
G	12	12	13
VN	7	9	8
TOTAL	175	172	176

4.11 Summary

Three case studies where selected, discussed and accessed in Abuja the federal capital territory of Nigeria, in chapter four. The basics for the selection of the case study was explained alongside the variables that where studied. Features like the presence of daylighting architectural elements in the building, i.e. skylight, building location in in a climatic similar region of the proposed site of research, showcase of exposition, architectural identity and innovation, daylight level. an assessment of existing building was carried out and alteration of the “U” factor and the “V” values of the different materials types that where used including the solar heat gain coefficient and visibility transmittance where altered and compered to achieve maximum daylighting requirement. From the daysim simulation result the overall lighting load required for each building when the three various law emissivity glazing where used on a case study exposition building. All this where discussed in this chapter

5.0 DESIGN CRITERIA

5.1 Design Introduction

The main purpose of this chapter is on the design as it seeks to provide information and data which would eventually form the benchmark for the design of an exposition centre. The Fig 5.1 show the map of the world and a direction on how to locate the site.

5.2 Site location

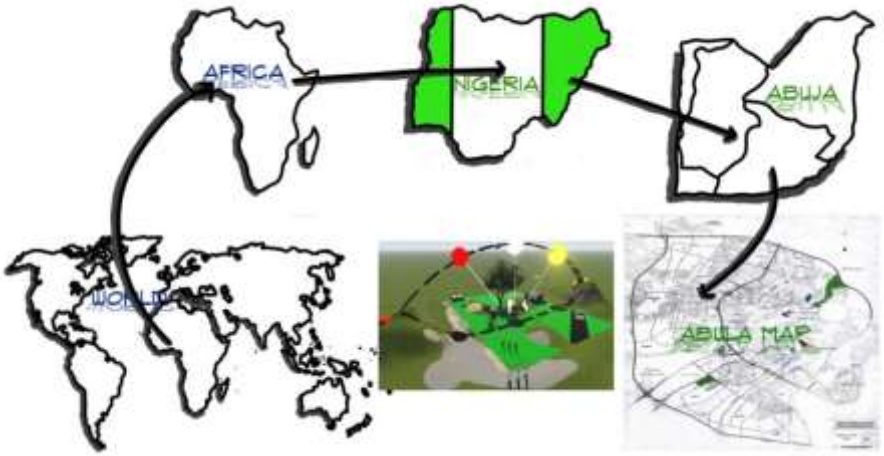


Fig 5. 1: Map of world showing the direction to the site in F.C.T Abuja
Source: Author/researcher, 2015

Furthermore the Fig 5.2 shows the map of Nigeria and the thirty six state of the federation of which the exposition center will be located at the center.



Fig 5. 2: Map of Nigeria showing F.C.T Abuja and States boundaries
Source: Author/researcher, 2015

5.2.1 Brief description of F.C.T Abuja.

The Federal Capital Territory is located in the geographical centre of Nigeria. It has a land area of 8,000 square kilometres. It is bounded on the north by Kaduna State, the west by Niger State, the east and southeast by Nasarawa State and the southwest by Kogi State. It falls within latitudes 70 20′ North of the Equator and longitudes 60 45′ and 70 39′. The FCT's natural endowments such as; its rolling hills, isolated highlands and other endearing features make it a delight. The savannah grassland of the North and the Middle Belt, the richness of the tropical rain forests of the south and an equable climate all combined to make the FCT a soil-rich agricultural haven. The land now called Abuja was originally the south-western part of the ancient Habe (Hausa) kingdom of Zazzau (Zaria). It was populated for centuries by several semi-independent tribes. The largest of the tribes was Gbagyi (Gwari), followed by the Koro and a few other smaller tribes. In early 1800′s when Zaria fell to Fulani invaders, Muhammed Makau, fled south with some followers and his brothers- Abu Ja and Kwaka. Abu Ja succeeded Makau in 1825. The full name of the king was Abubakar, Abu was his nickname. By some accounts his fair complexion earned him the nickname Ja which means red or fair-skinned in Hausa. He became known as Abu-Ja meaning Abu the red or Abubakar the fair one. Other sources say that the Ja is a shortened form of lshaku Jatau, his father's name. King Abubakar founded the kingdom of Abuja. Abuja became a major commercial center where goods were exchanged by long distance traders. The inhabitants successfully fought off the Fulani and were not conquered as the neighbouring lands were. In 1902, Abuja was occupied by the British colonial army The British reorganized the kingdoms and called them emirates which means kingdoms in Arabic. Until 1975, it remained a quiet part of Nigeria. The problems associated with the capital being in Lagos, led to the search for a new capital that year. Abuja was selected from amongst 33 possible sites. The criteria used for selection

included: centrality, health, climate, land availability and use, water supply, multi-access possibilities, security, existence of resources, drainage, good soil, physical planning convenience and ethnic accord. The Emir of Abuja at the time, Altai Suleiman Bara, was asked to meet with his Emirate Council to approve contributing four of the live districts to Abuja to become the new capital. The council was divided as some districts considered it too much of a sacrifice; but at the end, they approved the request from the Federal Government. Thus, the Abuja in Niger State contributed 80% of the land of the territory Plateau State (Now Nassarawa State) contributed 16% of the South east territory and Kwara State (now Kogi State) contributed about 4% of the s0uth—west territory. The Emirate was then asked to give up the name Abuja for the Federal Capital Territory. Again the council was divided. In the end, they agreed believing that the name of the emirate would become famous throughout the world. The previous town of Abuja was renamed Suleja after the then Emir of Suleiman Barau and Ja the last syllable of the first emirate's name. Another interesting historical fact is that in the Gbagyi (or Gwan) language, the word Aso means success or victory.

5.3 Site selection criteria

Site selection is an important aspect of daylighting design because the site must provide the adequate resources from which daylighting can adequately be harnessed and utilized. Therefore, two sites are considered below and the one with the better resources will be considered for development. Below is a list of site selection criteria that will be used for the selection of site.

a. Climate.
b. Topography
c. Legal property description
d. Geotechnical /soil

e. Utilities

f. Immediate surroundings

g. Cultural factors

h. Economic values

i. Regulatory factors

These site selection checks have been used to compare and evaluate the appropriateness of site one to site two for usage and are summarized in table 5.1. The rating is represented as such;

Excellent = 5

Good = 4

Average = 3

Fair = 2

Poor = 1

Very poor = 0

Here the selected site is being analysed to see how best it can be utilized for the proposed project using the factors in table 5.1

Table 5. 1 a: Checklist for site selection

			Site A	**Site B**
Climate	•	Prevailing wind	4	2
	•	Solar Radiation	3	3
	•	Temperature	2	1
	•	Humidity	4	1
	•	Precipitation	3	2
	•	Legal property description	5	4
Topography	•	Topographic map and	4	2
		aerial photos	3	1
	•	Analysis of physical features	2	3
	•	Existing access and circulation	4	3
	•	Vegetation	3	4
	•	Existing water bodies	4	5
	•	Drainage canals	5	2
	•	Existing water way easement	3	3
	•	Surface Drainage	4	2
	•	Unique site factures	5	3

Table 5. 2 b: Checklist for site selection

			Site A	Site B
Geotechnical /Soil	•	Basic surface soil type	5	5
	•	Rock surface type	4	3
	•	Bedrock	5	3
	•	Seismic Conditions	4	4
	•	Environmental Hazards	3	5
Utilities	•	Portable water	5	4
	•	Electricity	4	3
	•	Gas	4	3
	•	Telephone	3	3
	•	Cable Television	2	3
	•	Sanitary Sewer Service	2	3
	•	Storm water drainage	3	3
	•	Fire protection	4	2
Immediate	•	Fire and police protection	5	1
surroundings	•	Trash/refuse removal	4	3
Cultural factors	•	Site history	5	4
	•	Hazardous dumping	4	5
	•	Type of land ownership	4	3
Economic values	•	Future potentials	4	2
	•	Political jurisdiction	4	3
	•	Land cost	3	1
Regulatory factors	•	Zoning codes	4	3
	•	Site plan reviews	3	2
	•	Environmental regulations	3	1
Total			**149**	**113**

5.4 Site analysis

For a design to be in proper consonance with the environment in which it is located a proper site analysis need to be conducted as seen in Fig 5.3which shows the topographical nature of the site, of which the highest point is located at the north western part. The north eat trade wind blows from the north eastern part while the south west trade wind blows from the southern part which brings hammer tern.

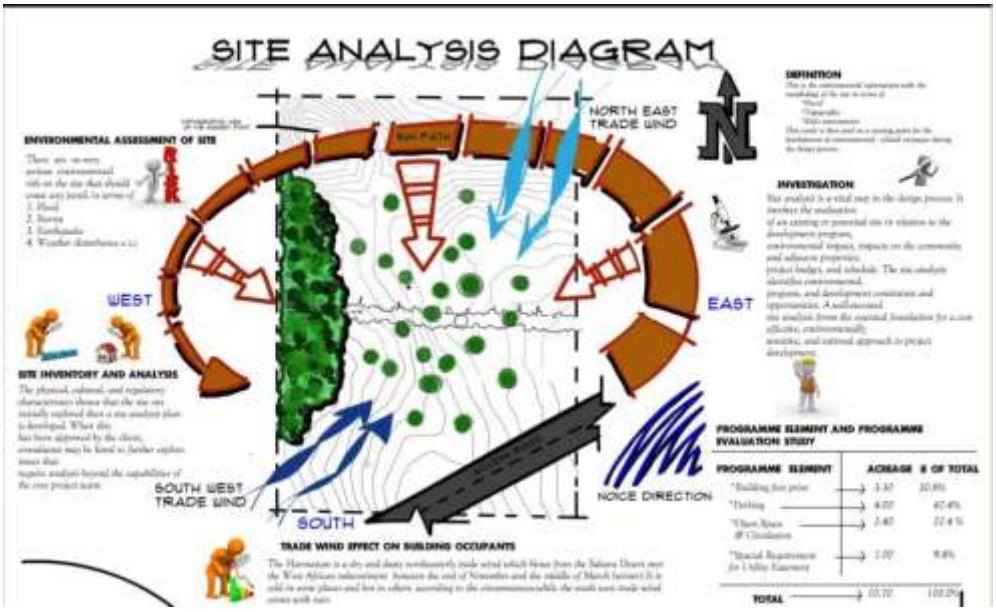


Fig 5. 3: Site Analysis showing features of the site
Source: Author/researcher, 2015

5.5 Summary

Chapter five was dedicated for design criteria ranging from site location, site selection, weather analysis, site analysis, infrastructural analysis of the site in Abuja so as to find a suitable site that information from previous chapters where translated into the design of proposed Abuja exposition centre.

6.0 DESIGN BRIEF

6.1 Brief development

6.1.1 Client

Nigerian investment promotion commission under the federal ministry of industry, trade and investment.

6.1.2 Brief

The Nigerian investment promotion commission wishes to have an exposition centre located in F.C.T Abuja the nation's capital. The proposed Exposition centre is to cater for activities such as exhibitions, Educational functions, and conferences, Performing Theatre, and other social activities for the Smooth running of the centre; thus the spaces and facilities proposed are designed to comply with the scope of the project. The site is located at the Abuja airport road off the express road. This brief aims to encompass the following:

1. The Project is to provide the city centre with an Entertaining exposition and Exhibition Centre with a facility of high quality capable of serving the region.
2. The facility will be emblematic of the civic ambitions of Nigeria and reflective of the unique architecture for Nigeria.
3. The design must create an Entertainment Convention and Exhibition Centre that takes advantage of its central location so that the area can be marketed and experienced as a world-class convention and entertainment precinct.
4. The Centre shall be economically viable and sustainable.
5. The design will allow for interaction on all the aforementioned levels. It is believed

   that interaction shall enhance learning within the centre; especially the youths.

6. A provision of avenue for art exhibitions and symposia

7. Circulation spaces within the premises will be defined and provide natural access Control to avoiding interfering with the landscape
8. The use of highly durable and low maintenance building materials
9. The venues to be a vibrant integrated public resource.
10. Layout should follow the site slope.
11. The design should be embraced by the community and be a focus for celebration and civic events.
12. Should fit with Nigeria's community values and aspirations.
13. The Exhibition Spaces are intended as a combination of indoor and open-air exhibition space in order to create a strong relation between covered and green open spaces through thematic content.
14. The Exposition intention is to avoid any conflict between open space and the content of the Exposition.
15. The architectural and landscape design of Exhibition Spaces shall be an important component of the exhibition proposal to create a truly unique and multi-faceted experience

The proposed spaces are based on specific activity types as well as the staffing system or organogram of an Exposition centre.

6.2 Proposed facilities to be included in the design

1. **Exposition**
    1. Arena
    2. Exhibition halls
    3. Inspirational idea shearing
2. **Exhibition**
    1. Multipurpose Halls

2. Sculpture

3. Arts

4. Boulevards

5. Galleries

3. **Supporting services**

1. Conferences

2. Meetings

3. Performance Theatre

4. Reception

5. Foyer

6. Car expo

7. Events

8. Lecture Hall

9. Café

10. Let able Space

11. Circulation

12. Symposium

13. Banquet

14. Concert halls

15. Restaurants e.tc

6.3 Description of space

1. Exposition or Trade fair

The Exposition will include halls and spaces, show rooms and museum spaces which will be located in the main building complex. These will be designed to showcase new inventions by companies and marketers. The Exposition space will

be designed as flexible open spaces the form of halls and passages whereby viewers can have a smooth and easy transition from one space to another.

2. Exhibition

   The Exhibition, will be a large building that is designed to hold a convention, where individuals and groups gather to promote and share common interests. It will include Convention centres typically that offer sufficient floor area to accommodate several thousand attendees. Very large venues, suitable for major trade shows. It will typically have at least an auditorium and may also contain concert halls, lecture halls, meeting rooms, and conference rooms

3. Supporting services

   These are spaces that will be used to serve as supporting service elements to the smooth running of the building such as toilets facilities, restaurants. Without them the smooth running of the centre may not be achieved.

6.4 Design consideration

Exposition attract large amount of people ranging from visitors, traders, investors, marketers e.tc. It is expected that all those categories of individual be properly catered for, therefore it is expected that the architect should properly design to cater for the in terms of the scale, orientation, circulation. Etc.

6.4.1 Scale

1. Buildings should be designed to be compatible in scale and proportion to buildings within their immediate context. Designs should incorporate architectural elements that relate to the human scale.
2. Lower levels of buildings should be differentiated architecturally from upper levels. Facades with a parapet should terminate in a cornice or ornamental cap.

3. Incorporate elements that give the building perceptible scale. Large buildings in particular should be designed to reduce their perceived height by dividing the building mass into smaller scale components.
4. Rhythm and repetition of building elements is strongly encouraged. This is accomplished through incorporation of regular or patterned units that are organized to provide a continuance, flow or sense of movement.
5. Organize building elements and the spaces between them in a logical sequential manner (Placeholder2).

6.4.2 Orientation

1. Rectangular floor plans elongated on an east-west axis

   Glazed south-facing wall
2. Thermal storage medium exposed to the solar radiation Light shelves/overhangs or other shading devices which sufficiently shade the south-facing elevation from the summer sun;
3. South elevation overhangs should be horizontal while east and west elevations usually require both horizontal and vertical overhangs.
4. Windows on the east and west walls, and preferably none on the north walls (Manual, 2011).

6.4.3 Circulation

1. Plan overall layout to be as logical and direct as possible.
2. Avoid changes of level within a storey
3. Maintain access routes carefully and keep them clear of potential obstructions.
4. Ensure access routes through open-plan areas are well defined
5. Incorporate handrails to both sides of walkways and provide seating at regular intervals.

6.5 Lighting

There are two major types of interior lighting, namely;

1. Natural lighting
2. Artificial lighting

For the purpose of this design, visual comfort is of significant importance. Therefore a good combination of both lighting types allows for a variety of results, thus ensuring that the interiors boast of wide array of experiences. It is for this reason that the design incorporates both types.

6.5.1 Natural Lighting

Natural lighting is essential as a result of the epileptic power supply in the federal capital territory. It is also required because lighting conditions are modulated throughout the day. Natural lighting allows for the following:

The main advantage of using natural light is the reduction of power consumption of artificial lighting during daylight hours. By ensuring that the position of the windows was facing north or were under large overhangs, the issue of glare and solar gain were addressed within the building. Glass elements also provide a more interesting and pleasing view of the building and subdued lighting allows views inside the building at night (transtore, 2012).

6.5.2 Artificial lighting

Is a means of lighting through mechanical means to generate electricity. Artificial lighting allows for wider control and array of modulation. Artificial lighting is a substitute for the sun

6.6 Climatic control

Mostly in an Exposition glazing is very essential so as to provide a clear view for visitors to see what is happening and to provide a wider range of view while minimizing the rate at which noice is being transmitted from one point to another. Those materials that are used tend to provide access to harsh weather conditions that mostly are not satisfactory when visiting an exposition therefore the main gallery spaces shall be of controlled atmospheric conditions, while auxiliary facilities shall rely on minimal atmospheric conditioning. The main exhibition halls shall be with a central conditioning system due to the large spaces created for this purpose.

1. Temperature: the temperature of Abuja ranges from 24.5°c to 30.5°c. An average Exposition centre requires a constant temperature of 18-24 °c (Fair, 2014) .
2. Relative humidity: Exposition pavilion require about 45% humidity (with a 5% variation) in order to comfort. During the rainy season, relative humidity in F.C.T Abuja can go as high 70%, but this is rather rare. The dry season is of utmost importance as it is of a longer duration. The relative humidity can go as low as 35%. Ventilation of interior exhibition and storage spaces shall be of utmost importance during the rainy season.

6.7 Noise and dust control

The level of noise exposition spaces shall be reduced to a bearable minimum, with proper zoning and use of non-reflective and sound absorbing materials. Noise sources include conversations, movement, equipment's, air conditioning plants, and human interaction within studios and from surrounding facilities around the site. The galleries and exhibition spaces shall be located along the southern part of the site that is close to the entrance that way is easier to control it from reaching other parts of the building.

Since visual contact is to be ensured, laminated glass shall be used. Laminated glass is composed of two or more layers of glass with one or more layers of a transparent/ pigmented and specially treated plastic Polyvinyl Butyral [PVB] sandwiched between the glass layers. The glass panes (layers) can be either normal glass or tempered glass.

6.8 Display techniques.

Exhibits shall remain the focal point of the design. It is important to keep the audiences' attention for as long as possible. This can only be achieved using interesting and energizing techniques and keeping the exhibits within the human visual field. The most effective display technique allows for exhibit to be viewed individually, even though a cluster of exhibits might be arousing or increase attention. Display techniques employed shall include:

1. Walls: These shall be used as major display surfaces, especially for flat exhibits such as paintings and murals. They allow for easy modification and alterations both in terms of colour and texture. This will ensure that experiences are varied over time, thereby reducing the tendency for the spaces to be redundant and boring. The use of curvilinear walls shall be employed to create a feeling of transition. The use of walls is kept to the barest minimum; as a good percentage of Nigerian art pieces exist as 3-dimensional objects that require movement around them.
2. Panels: These serve similar functions as walls, but are more flexible. They allow alteration of space composition. Panels can take various shapes and forms, with their own lighting and colour control. Suspended panels shall be provided for through the central void over all floors. For proper design of panels, consultations shall be made with exhibition experts. There shall be a significant reliance on panels as opposed to walls.

3. Cases: These are used to protect valuable and permanent exhibits from theft and damage.
4. Ceiling: These can be used to stimulate attention for short periods, in a similar way as walls.
5. Outdoor exhibits: These are lit naturally during diurnal activities. They require Support and protection and should be exhibited temporarily. Permanent outdoor exhibits should be made extremely durable; examples include concrete and steel sculptures.

6.9 Safety precautions.

Since the facility is people oriented, it is essential that the safety of lives and property be adequately catered for. The following considerations were made:

1. Fire hazards: Provision was made for stair halls that open directly into the exterior so as to ensure that such spaces allow for easy evacuation of persons and removal of smoke. Also, staircases are designed such that their treads and risers are within standard ranges for easy use. Provision of escalators and ramps that allow for easy use by all persons is provided. All areas that are prone to fire outbreaks shall be adequately catered for.
2. Accidents: All floor surfaces, ramps and stair tread shall be of rough surfaces to ensure adequate sole grip and reduce the tendency of toppling over. Also, ramp slope shall not exceed 6o^{o} to the horizontal. Details shall cater for steel railings behind the glass curtain walls. All stairs and voids shall be supported by perforated steel sheet railings properly fixed to concrete beams and floors.
3. Security: The security of exhibits and other valuable objects is of much importance.

Exhibits shall be kept in a secure store, with provision for a storage vault. This store shall be of concrete walls; located in a restricted area of the basement floor. Also, there shall be provision of security lobbies and security checks, also a curator's office shall be provided such that the entire display area is visible from within it. Double security doors shall be provided at all points of importance. Also the provision of closed-circuit cameras shall be carefully schemed during design by a services consultant, carefully integrated with the alarm system. Dead and unlit spaces shall be minimized to a bearable minimum. The plan concept allows for continuous flow from space to space.

4. Structural safety: All issues regarding structural safety (including serviceability) shall be resolved in consultation with a structural engineer.

6.10 Summary

Chapter six elucidate about the design brief, the requirements of a befitting exposition centre, space requirement, description of space and design consideration for exposition centre Abuja. Lighting requirements for the proposed design and all the necessary requirement for exposition where all discussed in this chapter.

7.0 DESIGN REPORT

7.1 Site concept

The function and personality of a building should be well reflected visually and psychologically. This visual unity should be well understandable to the human eye and the animate community. The site concept for the proposed Art centre is based on:

1. Easy Accessibility and free flow of people and goods
2. Simplicity of the building structure yet achieving maximum aesthetics
3. Provision of vehicular traffic free areas that are pedestrian intra-centre traffic devoid of cross vehicular traffic. This will help in maintaining acceptable noise level required for effective work particularly the exhibition halls.
4. Zoning and positioning of buildings
5. Multi-purpose structure, as a building entity it can be decided in the nearest future to be changed without affecting the main structural stability of the building.
6. Centre for uniting a country that has a multi-cultural identity.

7.2 Design concept

The design concept is derived from the concept of circular which allow for free circulation of visitors within the building as seen in Fig 7.1. The transition of this circular structure can see to be expressed in Fig 7.2 the court yard allow for free air and lighting into the building entity.

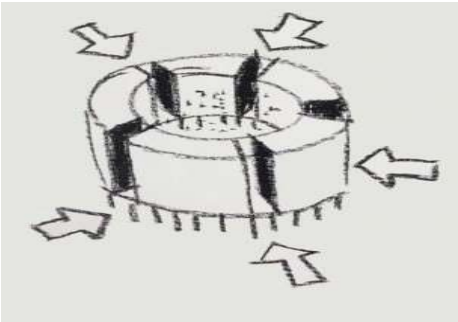


Fig 7. 1: Design concept
Source: Aquamedia.com

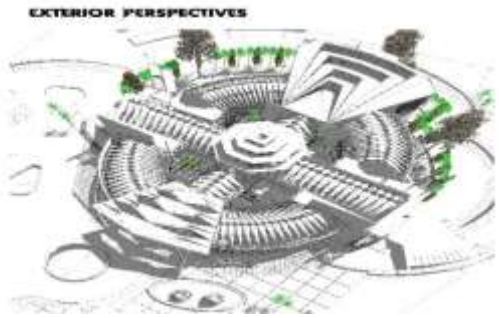


Fig 7. 2: Showing translation of form
Source: Author/researcher, 2016

7.3 Building form and openings

The building consists of circular forms with recessed areas and a central atrium. The vertical and horizontal recesses provided more surface area for glazing and made the building self-shading. There are two types of openings in buildings; vertical openings and horizontal openings. Both types were used in the building design.

1. Vertical openings.

   The distance that natural light can penetrate into a building via a vertical opening is dependent on the height of the opening in relation to the height of the room. Thus windows made of laminated glass in the form of glazing are provided. In addition to the windows, light shelves on the top of each window opening is provided to serve as a daylighting strategy but also to support 'stack effect'.

2. Horizontal openings.

   Horizontal openings are also known as roof or sky lights. For the purpose of this research, the dome (atrium) skylight was chosen to light the core of the main building

   complex. Tubular skylights also known as light tubes are used to provide light for all spaces.

7.4 Building materials

1. ETFE material

ETFE foil also known as Ethylene Tetra Flouro Ethylene is a very transparent material and transmits light across the entire visible light region (380-780m). A single layer of medium weight ETFE has an approximate 85% light transmission, although multiple layers will lead to only a small reduction.

2. Coloured laminated glass

Laminated glass is composed of two or more layers of glass with one or more layers of a transparent/ pigmented and specially treated plastic Polyvinyl Butyral [PVB] sandwiched between the glass layers.

7.5 Schedule of accommodation

Table 7. 1 a: Schedule of accommodation

Main building description	**NUMBER**	**AREA (m²)**	**TOTAL (m²)**
First floor			
Description	NUMBER	AREA (m²)	TOTAL (m²)
- Entrance porch	1	946	946
- Reception	1	796	796
- Exhibition Space	3	1115	3345
- Car Expo	1	1928	1928
- Sculpture	1	231	231
- Boulevard	4	209	836
- Painting	1	125	125
- Offices	18	16	288
- Painting studio	1	65	65
- Store	2	28	56
- Exposition	1	886	886
- Meeting	1	268	268
- Conference	1	4020	4020
- waiting	2	38	76

Table 7. 2 b: Schedule of accommodation

Main building description	**NUMBER**	**AREA (m^2)**	**TOTAL (m^2)**
- Performance theatre	1	862	862
- Washing room	4	10	40
- Restaurant	1	225	225
- Kitchenette	1	35	35
- viewing	1	225	225
- Car Expo Gallery			
- Art Gallery	1	231	231
- Office	17	16	272
- Boulevard	2	197	394
- Training	1	886	886
- Lecture Hall	1	226	226
- Back Stage	2	322	644
- Events	6	420	2520
- Cafe	1	225	225
- Rest room	2	225	450
- Wash room	2	10	20
- Toilet	20	3	60
- Photo/Graphics	1	125	125
- Utility room	1	65	65
- Architectural studio	1	28	28
- Curtain room	1	27	27
- Cafe	1	225	225
- Lit able space	2	270	270
- Gallery	1	861	861
- V.I.P	1	420	420
- Circulation	1	1444	1444
- Symposium	1	1147	1147
- Office Space	1	273	273
- V.I.P	1	278	278
- Balcony	1	55	55
- Waiting	1	64	64
- Lit Able Space	2	280	560

Table 7. 3 c: Schedule of accommodation

Main building description	**NUMBER**	**AREA (m²)**	**TOTAL (m²)**
Description	NUMBER	AREA (m²)	TOTAL (m²)
- Balcony	1	55	55
- Office Space	1	273	273
- Circulation	1	1444	1444
- Jewelleries	1	396	396
- Special Space	1	1124	1124
Inspirational hall			
Description	NUMBER	AREA (m²)	TOTAL (m²)
- Hall	1	1509	1509
- Changing rooms	2	6	12
- Backstage	2	20	40
- Stage	1	60	60
- Toilets	4	4	16

Proposed design report: proposed Abuja exposition centre

The site will be located in Abuja, the capital city of Nigeria and Abuja is in the centre of Nigeria popularly called the Federal Capital Territory (FCT). It is a planned city and was built mainly in the 1980.At the 2006 census, the city of Abuja had a population of 776,298.making it one of the ten most populous cities in Nigeria. According to the United Nations, Abuja grew by 139.7% between 2000 and 2010, making it the fastest growing city in the world. Abuja has witnessed a huge influx of people into the city; the growth has led to the emergence of satellite towns, such as Karu Urban Area, Suleja, Gwagwalada, Lugbe, Kuje and smaller settlements towards which the planned city is sprawling. The site will be served by the Nnamdi Azikiwe International Airport.

The simulation conducted on the proposed design shows a positive increse in daylightig of the interior expecially place sthat are exposed to top lighting an dwith the material changes expecially E- glazing with bronge coating which has a lowr ‘U’ factor as seen in Fig 7.3.

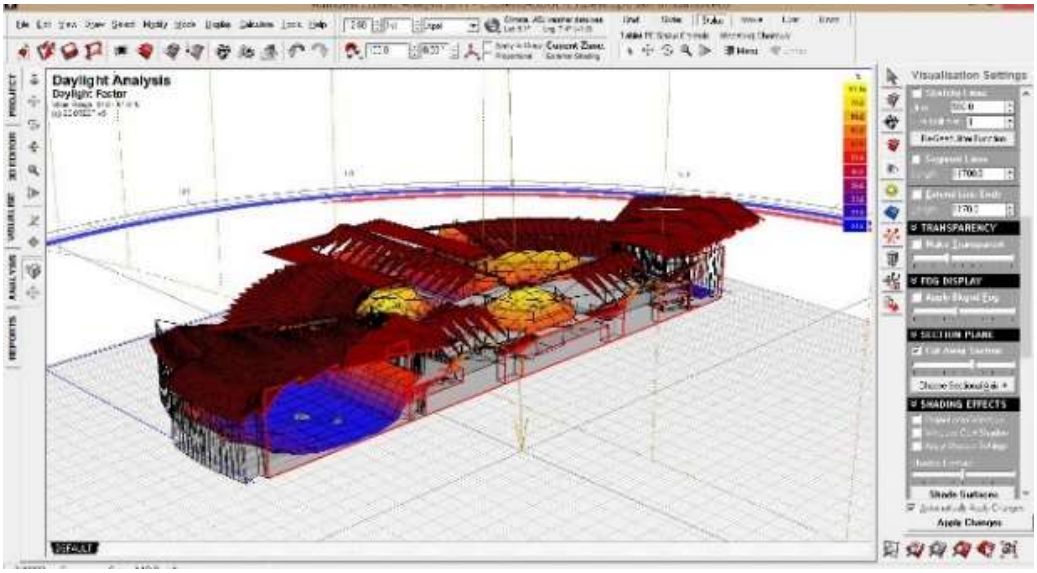


Fig 7. 3: Simulation of proposed design
Source: Author/researcher, 2016

Result findings from daysim simulation for proposed design

1. Daylight Factor (DF) Analysis: 95% of all IL luminance sensors have a daylight factor of 2% or higher. If the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zone should qualify for the LEED-NC 2.1 daylighting credit 8.1
2. Daylight Autonomy (DA) Analysis: The daylight autonomies for all core work plane sensors lie between 85% and 90%.
3. Useful Daylight Index (UDI) Analysis: The Useful Daylight Indices for the Lighting Zone are UDI<100=15%, UDI100-2000=0%, UDI>2000=85%.

4. Continuous Daylight Autonomy (DAcon) and DAmax Analysis: 100% of all IL luminance sensors have a DAcon above 80%. 94% of all IL luminance sensors have a DAmax above 5%.

Simulation Assumptions

1. Site Description: The investigated building is located in Abuja (9.10 N/ 7.40 E).
2. User Description: The zone is occupied Monday through Friday from 9:00 to 19:00. The occupant leaves the office three times during the day (30 minutes in the morning, 1 hour at midday, and 30 minutes in the afternoon). The total annual hours of occupancy at the work place are 2077.0.The occupant performs a task that requires a minimum IL luminance level of 500 lux.
3. Lighting and Blind Control: The building has no dynamic shading device system installed.

The table 7.4 shows the simulation result of the proposed building

Table 7. 4: Daylight analysis of proposed building

AMOUNT	FINAL DESIGN ANAYSIS OF CELLS
x	19.86298
y	-42.0237
z	1.3
DF [%]	21.99174
DA [%]	86.45104
DAcon [%]	86.86493
DAmax [%]	52.66944
UDI<100 [%]	13.00417
UDI100-2000 [%]	15.79201
UDI>2000 [%]	71.22049
DSP [%]	29.07951
annual light exposure [luxh]	53847819

Table 7. 5: Building material for proposed building

Building Component	**Type of Materials**
Walls	Hollow Block Render
Windows	Double Glaze Aluminium Frame
Roof	Double layed polystyrene membrane roof with sky light
Floors	Floor tile

Daily lighting energy consumption for proposed design

Table 7. 6: ***Daily artificial lighting energy consumption for proposed building***

Compact Florescent lamp type watts /hr.	**Number**	**Working hours (Average) hr.**	**TOTAL (Watts)**
30 (watts) CFL	30	8	7200W
60 (watts) CFL	15	8	7200W
			14400 W

Monthly lighting energy consumption (proposed design)

Table 7. 7: ***Monthly Lighting load for proposed design***

Month	**Number of days**	**Monthly lighting energy consumption (w)**
January	31	446400
February	28	403200
March	31	446400
April	30	432000
May	31	446400
June	30	432000
July	31	446400
August	31	446400
September	30	432000
October	31	446400
November	30	432000
December	31	446400
Total	365	5256000w

For the purpose of this research the overcast day of 1075 lux is adopted as it is the normal lighting under normal circumstances. Which gives an approximate of 53.75 watts equivalent per hour

53.75*8 = 430watts every day * 365= **156950W.**

Total energy = 5256000 + 156950= <u>5412950W</u>

Taking a look at all the case studies carried out in this research work we can see at there is a significant attempt to reduce the energy consumption in exposition center especially in the proposed design and taking a summary of all the amount of energy consumed we can see that the proposed building has the least energy consumption rate as seen in Fig 7.4 below.

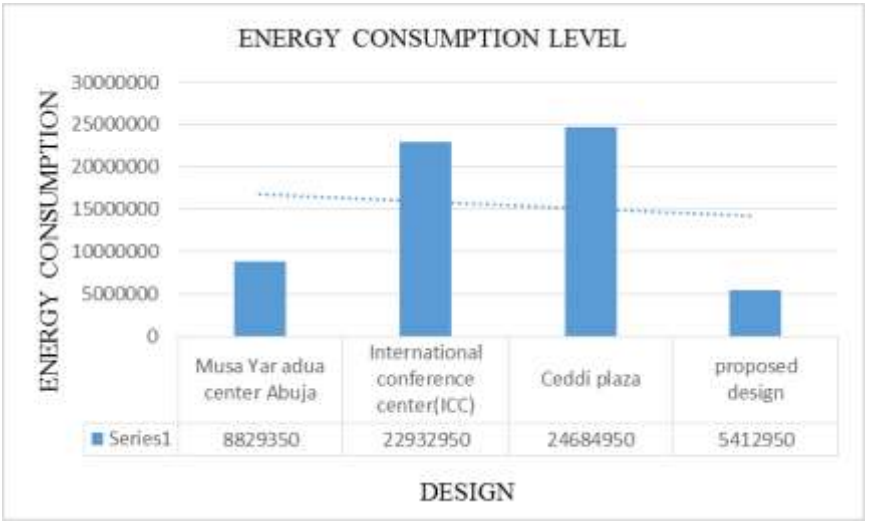


Fig 7. 4: Energy consumption level of case studies and proposed building.
Source: Author/researcher, 2016

When compared in percentage, it can be seen from the pie chart below in Fig 7.5, the proposed building has 8.75%, Shehu Musa Yar adua centre Abuja has 27.14%, ICC Abuja has 37.07% and Ceddi plaza has the highest energy consumption of 39,04%.

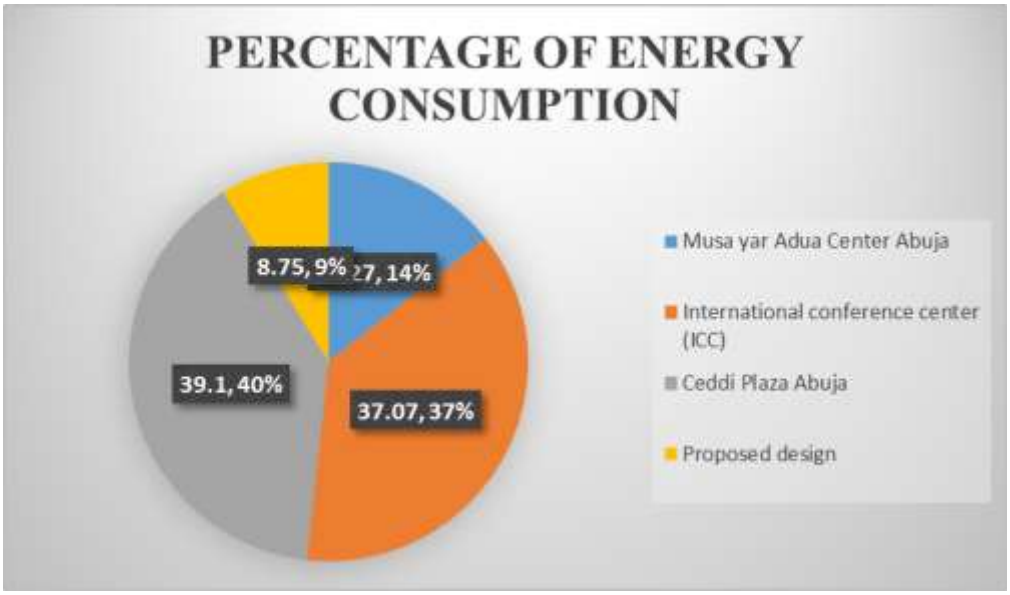


Fig 7. 5: Overall Percentage of energy consumption of the four buildings.
Source: Author/researcher, 2016

7.6 Daylight optimization in proposed building

By comparison to the case study the materials obtained it have being notices that the lesser the 'u' factor of a material the batter the material is in transmitting daylighting into the building. Therefore insulated glazing with bronze coating was adopted as the best material for glazing. It was also notices that top lighting in design approach was the best in terms of admitting light into the building what was used in the design with enough spaces for circulation and ventilation. The lower the building height the higher the chances of top lighting entering into the lower floor of the building and the wider the side glazing the more it admits lighting into the building.

7.6 Summary

Discussion on the design report was carried out in chapter seven, from the site concept according to the intent and scope of the design project, brief description, schedule of accommodation and the proposed design report. Finally the result from the proposed

design simulation whish shows a significant 35% reduction in energy consumption as a result of the design strategies used, choice and use of materials, best data results obtained from previous chapters where all discussed in this chapter.

8.0 SUMMARY, CONCLUTION AND RECOMMENDATION

8.1 Summary of Research

This research is a study of how daylighting can be optimised in exposition centres through the various strategies and principles of optimizing daylighting. The research work has comprehensively gave a background of the study, identified the stated the problem that called for the research ,justified the topic of the research, outlined the aim and objectives ,identified what the research questions are, state out the scope and significance of the study. All this where discussed in chapter one.

Chapter two of this dissertation elucidated and gave a literature review of what daylighting is all about, history and sources of daylighting where discussed. Furthermore the advantages and disadvantages of daylighting where expatiated including the indicators that characterise a good daylighting, the different strategies used in enhancing daylighting, the potential drawbacks to daylighting, factors affecting the use of daylighting, the basic principles of daylighting and the control of daylighting through design approach. In addition approaches to improving visual comfort and the importance of daylighting in exposition centres where analysed including health and wellbeing and the negative effect of artificial lighting on vision including daylighting and visual comfort. It also highlight the meaning and different types of exposition and the various lighting requirements for different activity types in exposition and exhibitions centres. The difference between exposition and exhibition centres where highlighted and expatiated in this chapter.

Chapter three gave an overview of the research method that was adopted for the purpose of the expected outcome of the research study and a theoretical frame work was established within the concept of daylighting, exposition centres, simulations, principles,

strategies and control used. The research design was stated and method of data collection and the research variables where also outlined with the various simulation soft wears used i.e. Ecotect, radiance and Daysim software's in line with the type of data required to achieve the purpose of the desired outcome from the research work done.

Three case studies where selected, discussed and accessed in Abuja the federal capital territory of Nigeria, in chapter four. The basics for the selection of the case study was explained alongside the variables that where studied. Features like the presence of daylighting architectural elements in the building, i.e. skylight, building location in in a climatic similar region of the proposed site of research, showcase of exposition, architectural identity and innovation, daylight level. an assessment of existing building was carried out and alteration of the "U" factor and the "V" values of the different materials types that where used including the solar heat gain coefficient and visibility transmittance where altered and compered to achieve maximum daylighting requirement. From the daysim simulation result the overall lighting load required for each building when the three various law emissivity glazing where used on a case study exposition building. All this where discussed in this chapter.

Chapter five was dedicated for design criteria ranging from site location, site selection, weather analysis, site analysis, infrastructural analysis of the site in Abuja so as to find a suitable site that information from previous chapters where translated into the design of proposed Abuja exposition centre.

Chapter six elucidate about the design brief, the requirements of a befitting exposition centre, space requirement, description of space and design consideration for exposition centre Abuja. Lighting requirements for the proposed design and all the necessary requirement for exposition where all discussed in this chapter.

Discussion on the design report was carried out in chapter seven, from the site concept according to the intent and scope of the design project, brief description, schedule of accommodation and the proposed design report. Finally the result from the proposed design simulation whish shows a significant 35% reduction in energy consumption as a result of the design strategies used, choice and use of materials, best data results obtained from previous chapters where all discussed in this chapter.

8.2 Contribution to knowledge

i. This dissertation research through the use of computer simulation was able to document the typical illuminance levels obtainable through the use of work planes, laminated glass windows and on days with bright design sky conditions of 900lux level in F.C.T Abuja, Nigeria Latitude:+9.06 (9°03'36"N)Longitude: +7.49 (7°29'24"E) Time zone: GMT+1hours.

ii. This research has shown proof that the use of daylighting can provide about as much good light as needed for the smooth functioning of an Exposition centre Abuja.

iii. This research was able to analyse the various daylighting strategies that can be used to replace electricity such as the use of light shelves, the use of atriums, the use laminated glass for fenestration.

8.3 Conclusion

In conclusion ,it can be emphatically stated that this research work has shown that daylighting can be optimised in the building using the various strategies and principles thereby reducing energy consumption .as discussed the use of materials especially glassing for fenestrations with higher visibility transmittance lower ‘’U’’ value and low ‘’R’’ values and with low heat gain coefficient where employed in optimizing daylighting in exposition centres and as in the case of exposition centre Abuja. The conceptualization

and the use of the various ways in which lighting can be channelled into the building, orientation, use of shading devices, strategies of optimizing daylighting, principles of daylight design and contemporary design forms was used in the design of expo exhibition centre Abuja. Furthermore the way in which the energy requirements for the various case studies where analysed with a view to making a better substitute of a more cleaner energy requirement was accessed so as to know the energy demand needed to provide lighting in watts for a whole year i.e. **8829350W** for Shehu Musa Yar Adua centre Abuja, **22932950W** for international conference centre Abuja and **24684950W** which basically reduce the energy demand by 35%. In addition the various law emissivity glazing used in this research work shows that double glazing with bronze tint with ''U'' factor of 0.47 , solar heat gain coefficient of 0.50 and visibility transmittance of 0.49 was the best glazing among the three samples used in this studies and which was adopted in the design of the proposed exposition centre. Furthermore the orientation of the shape of building aperture is a vital factor in the design of daylight building so as to optimise daylighting.

All of the above have been put together to show that daylighting should be part of building design process from inception so that architects designers and exposition owners including government bodies should be able to reduce the operational cost of their building in the long run thereby achieving a more sustainable built environment.

8.4 Recommendations

i. From the case studies performed in Nigeria, there was very little attempt to use daylighting techniques and systems in exposition centres, more studies should be done to convince and introduce designers to different means of lighting exhibition spaces other than artificial means.

ii. A study to show the operating cost of exposition space that use only artificial means of lighting and those that use both artificial and daylighting should be determine in terms of run time cost.

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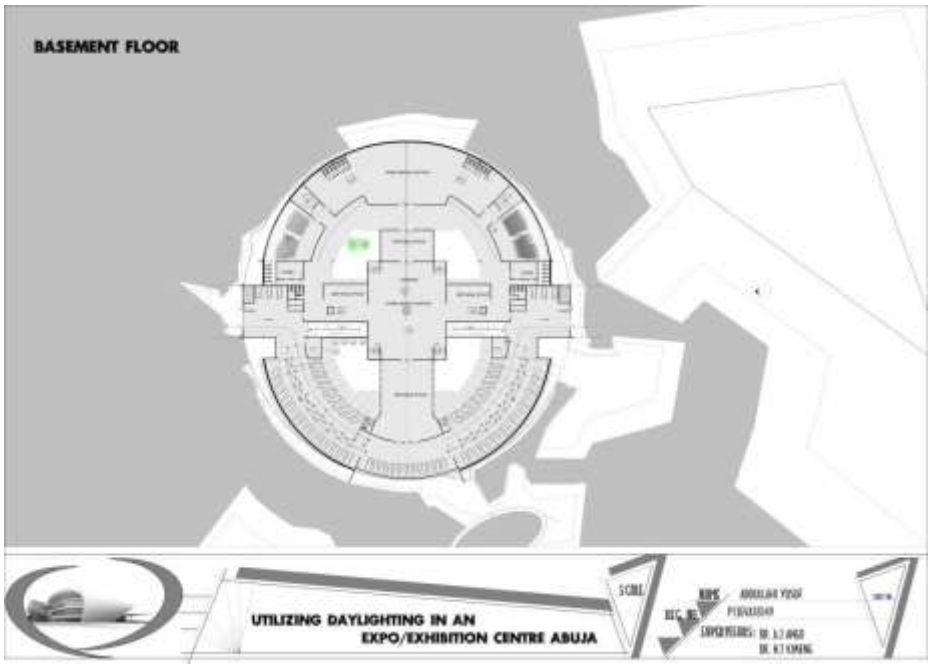
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APPENDICES

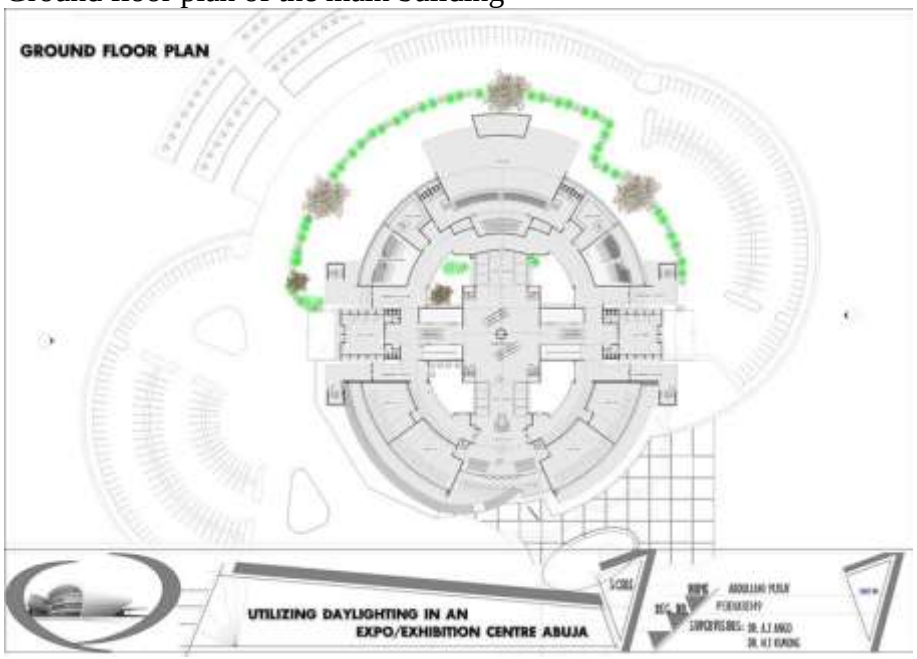
APPENDIX 'I'

Basement floor plan of the main building



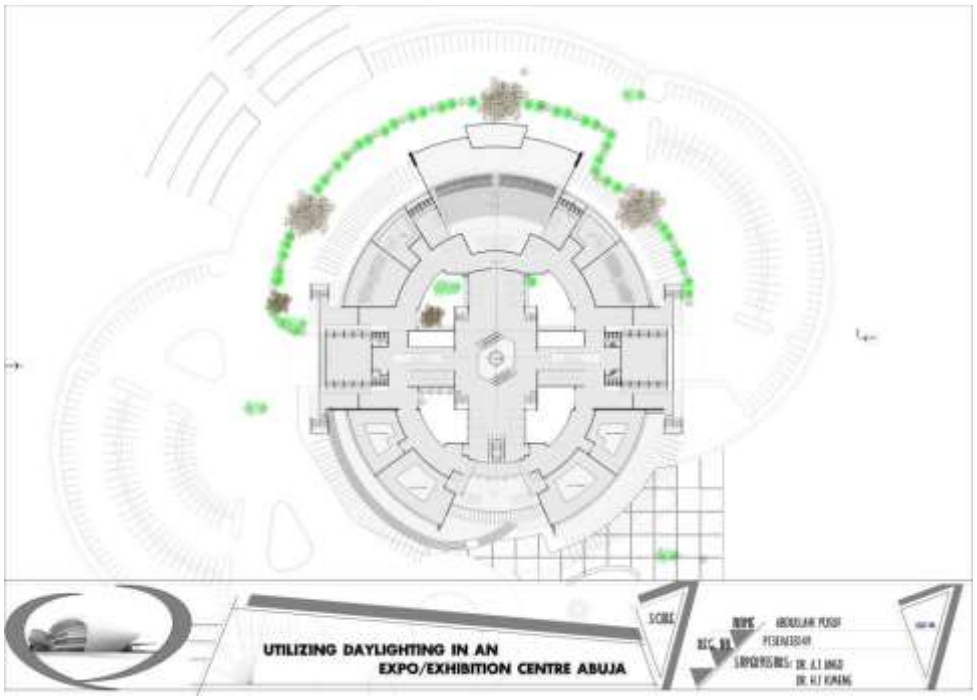
APPENDIX 'II'

Ground floor plan of the main building



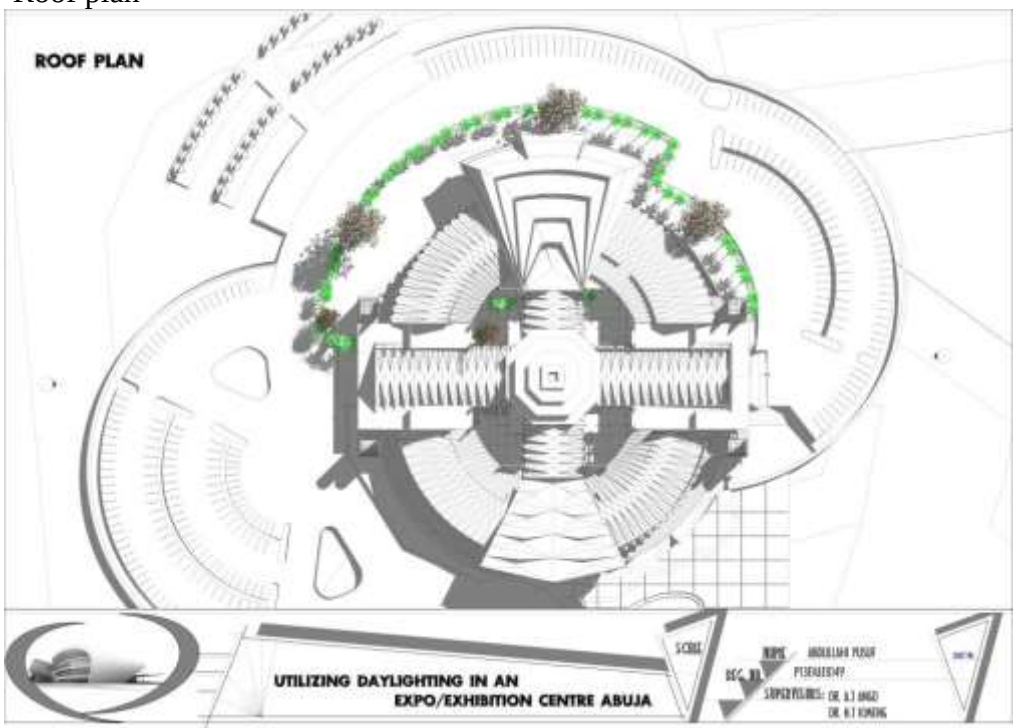
APPENDIX 'III'

First floor plan



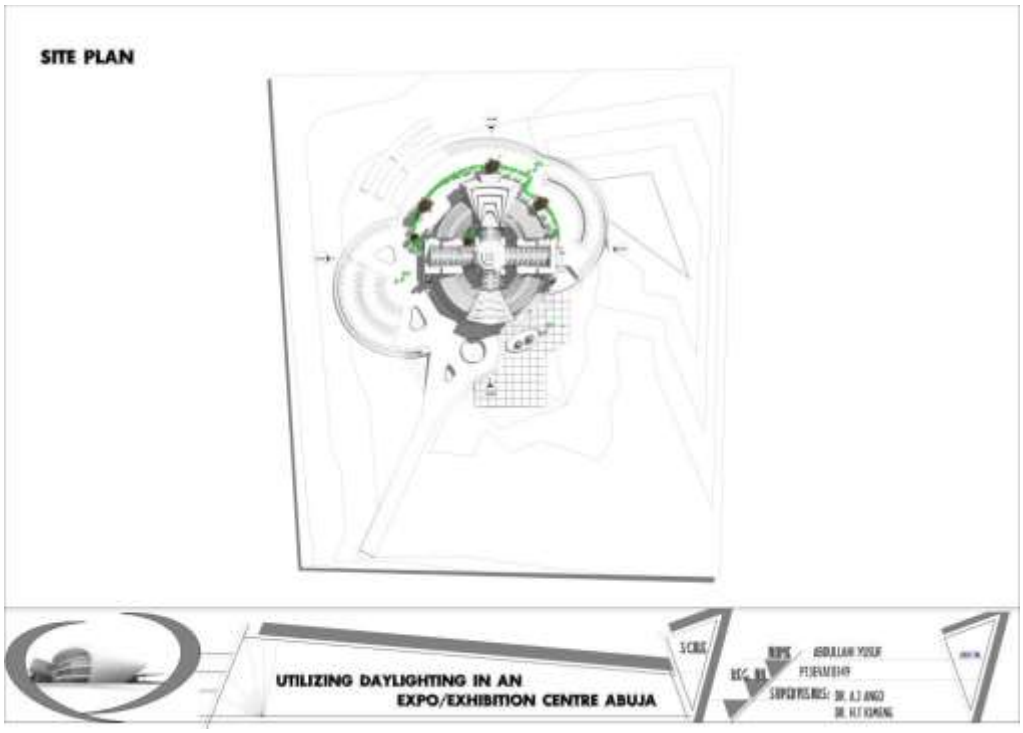
APPENDIX 'IV'

Roof plan



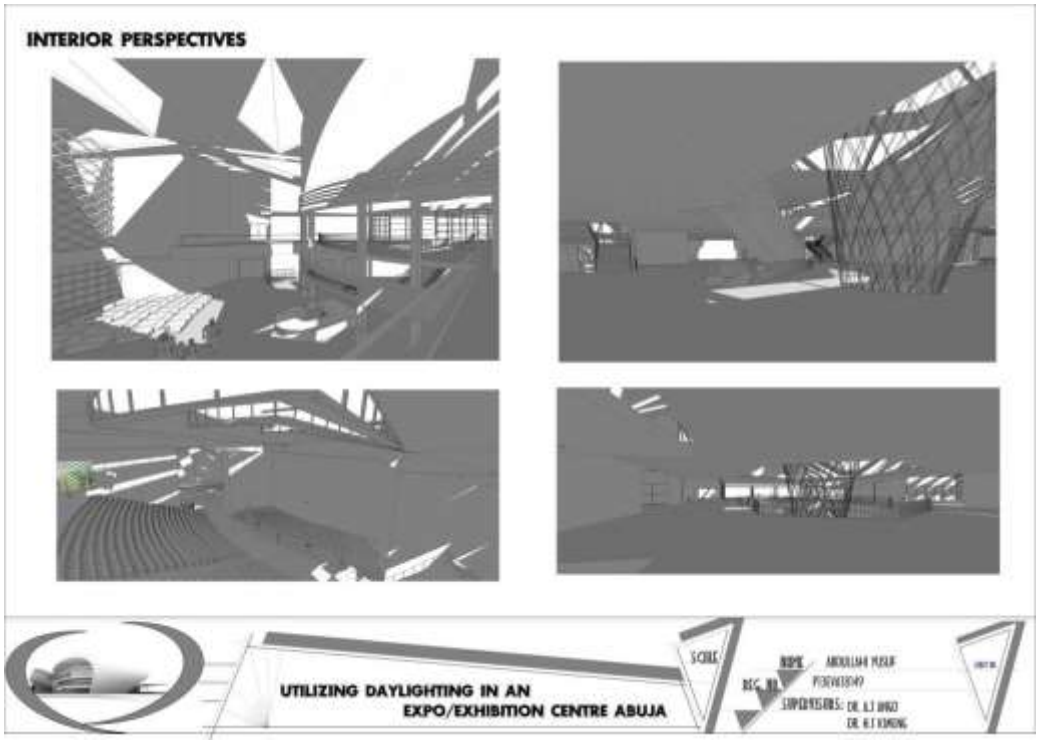
APPENDIX 'V'

Site plan



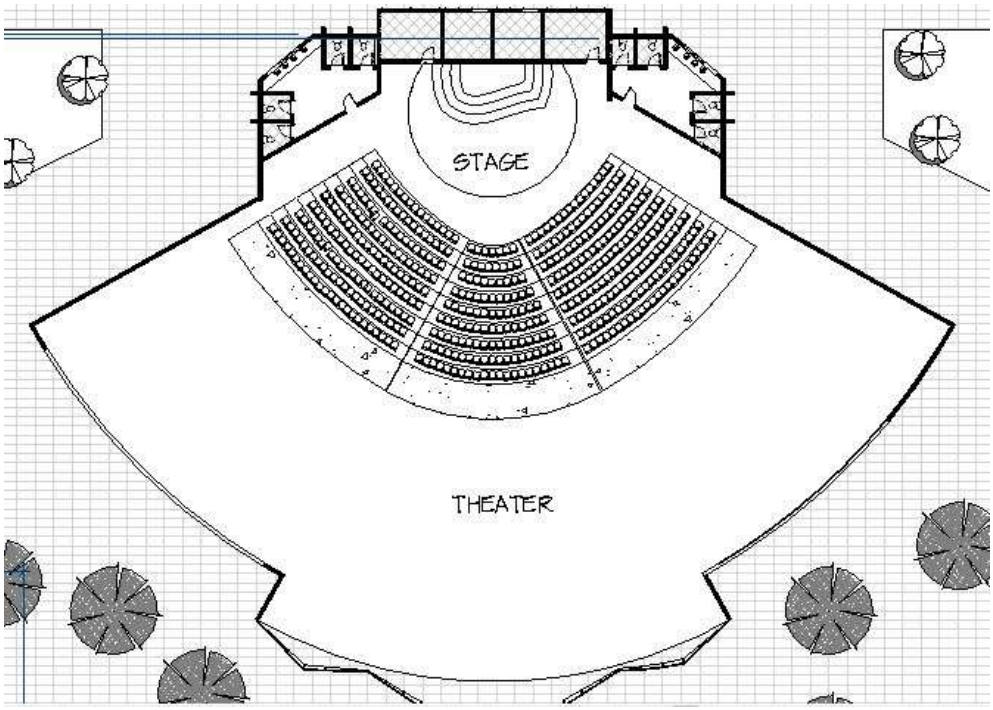
APPENDIX 'VI'

Interior perspective



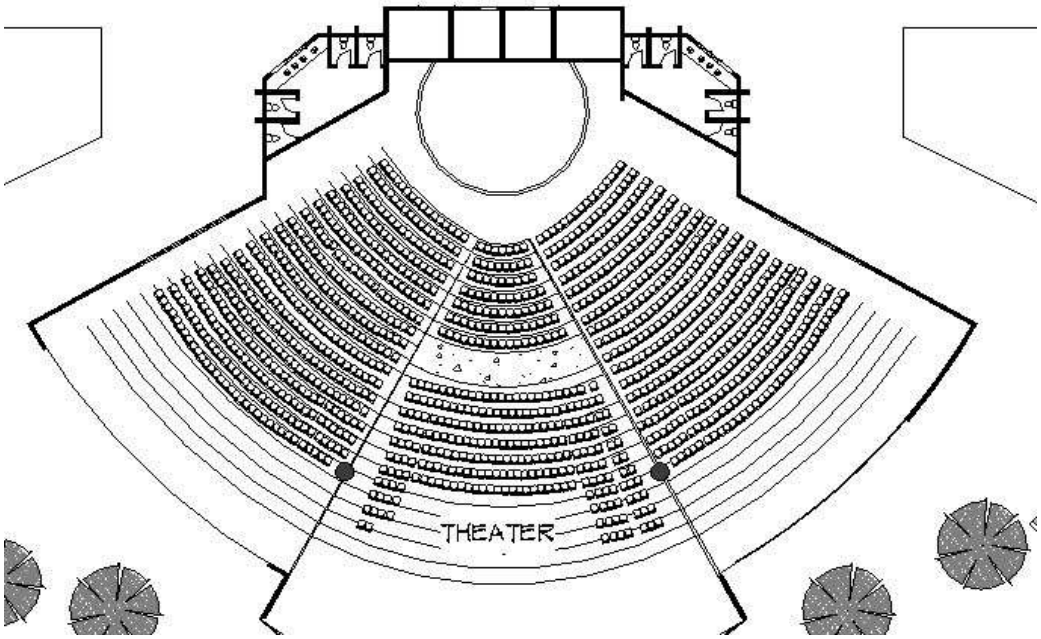
APPENDIX 'VII'

Ground floor plan of the theatre



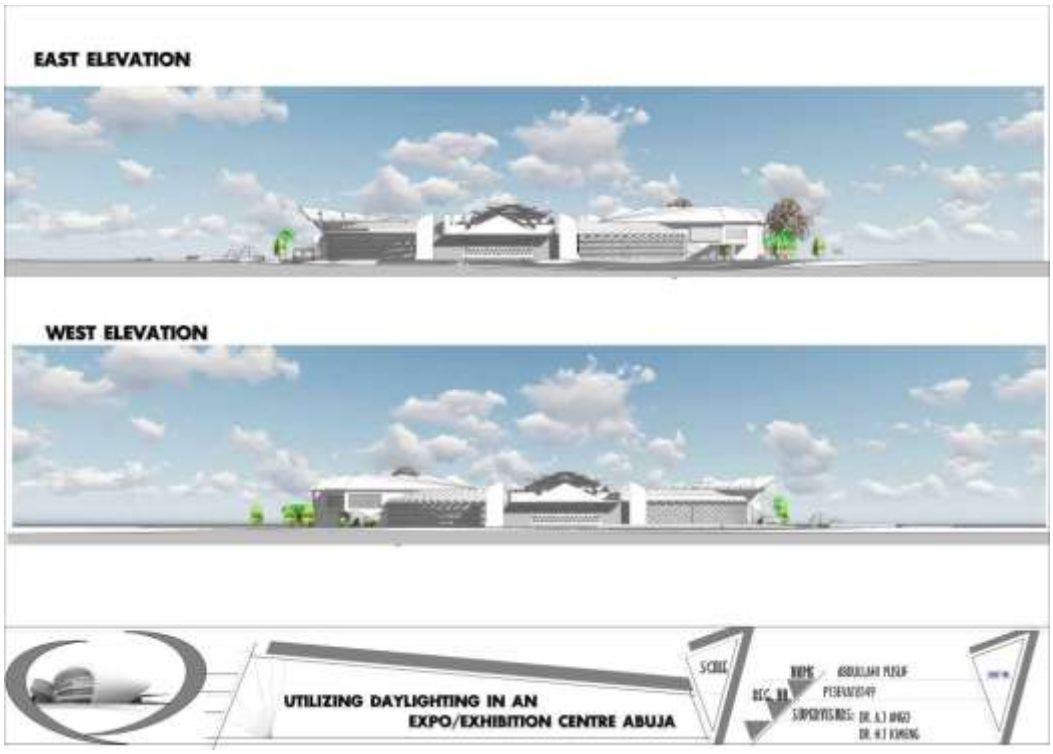
APPENDIX 'VIII'

First floor plan of the theatre



APPENDIX 'IX'

East and West Elevation



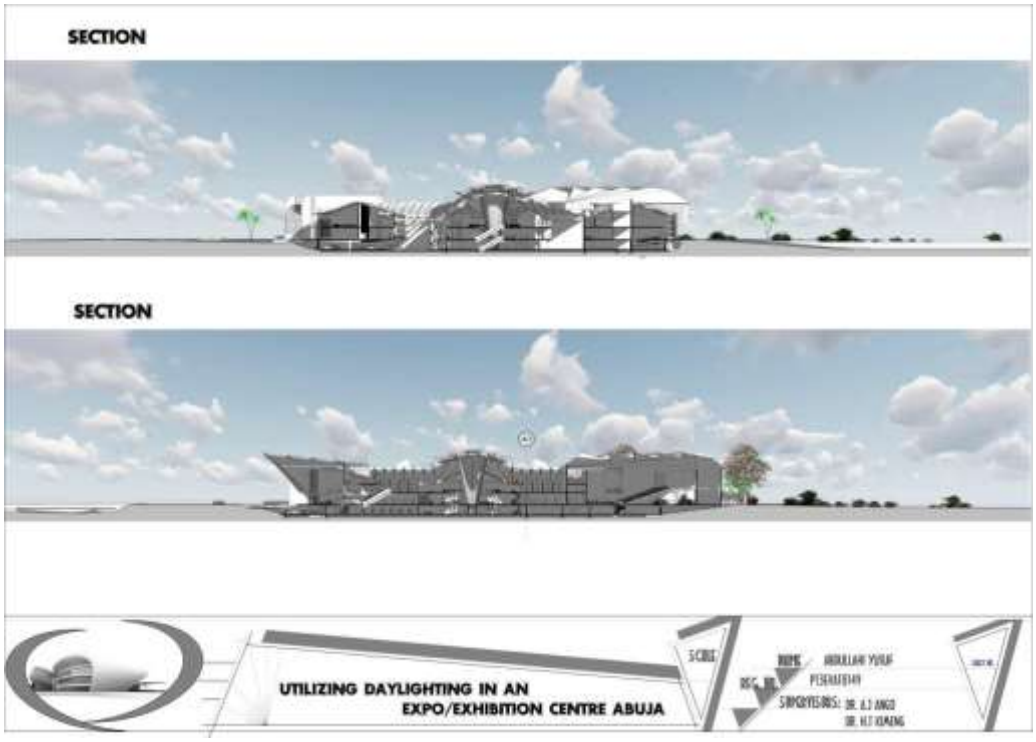
APPENDIX 'X'

South and North Elevation



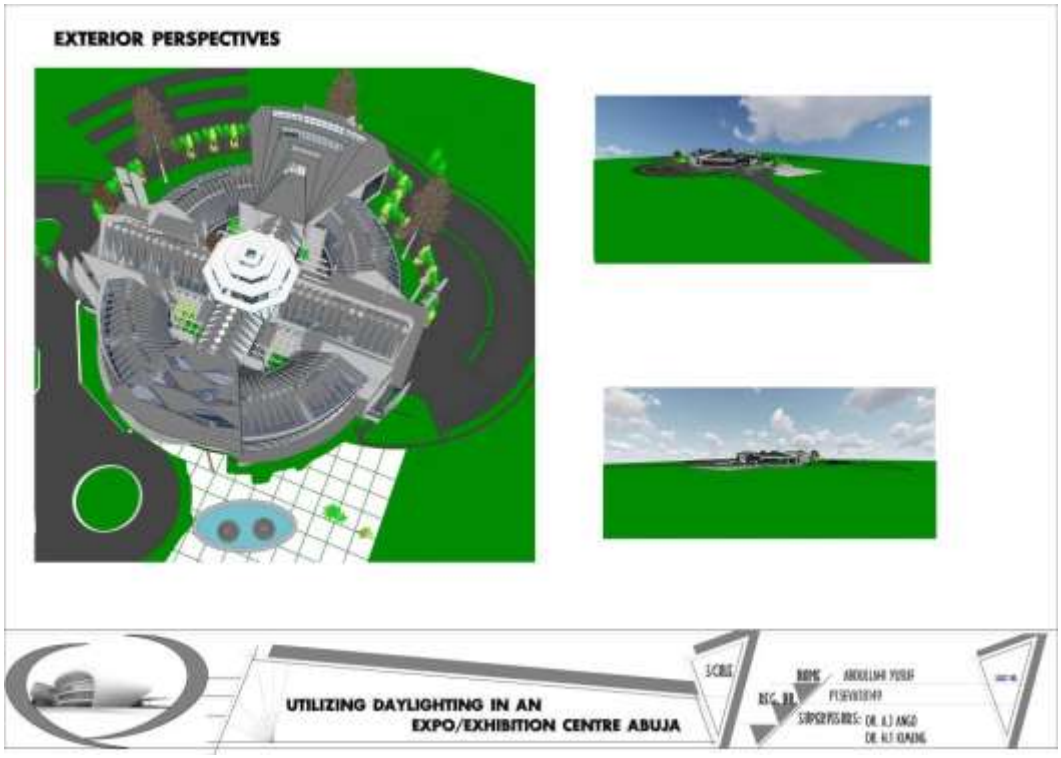
APPENDIX 'XI'

Sections A-A and B-B



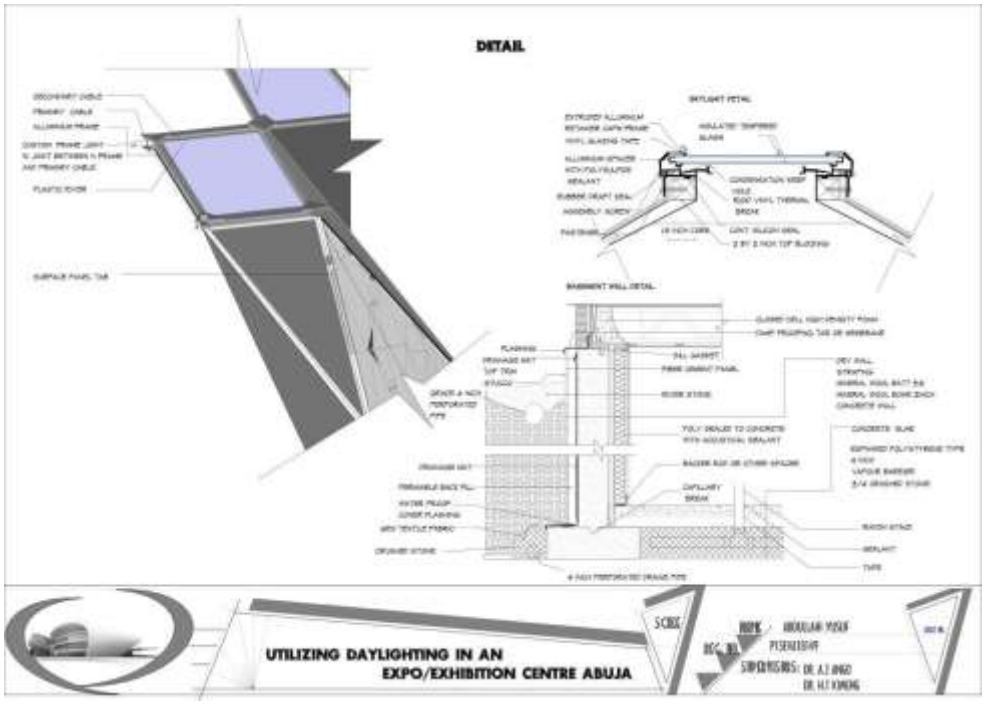
APPENDIX 'XII'

Exterior perspective



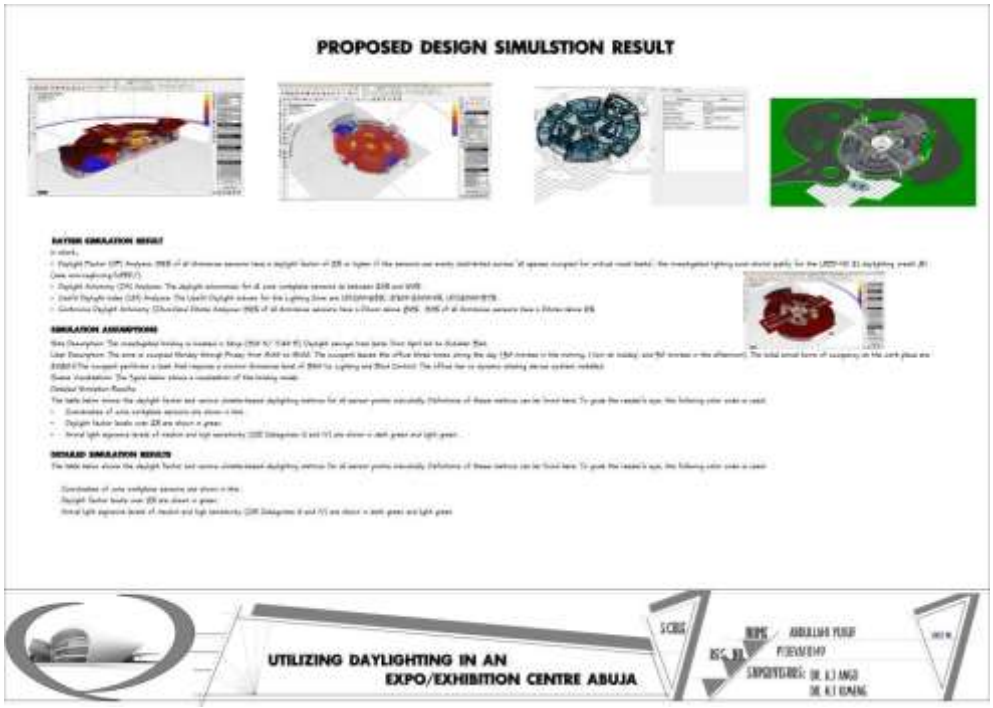
APPENDIX 'XIII'

Detail of Building



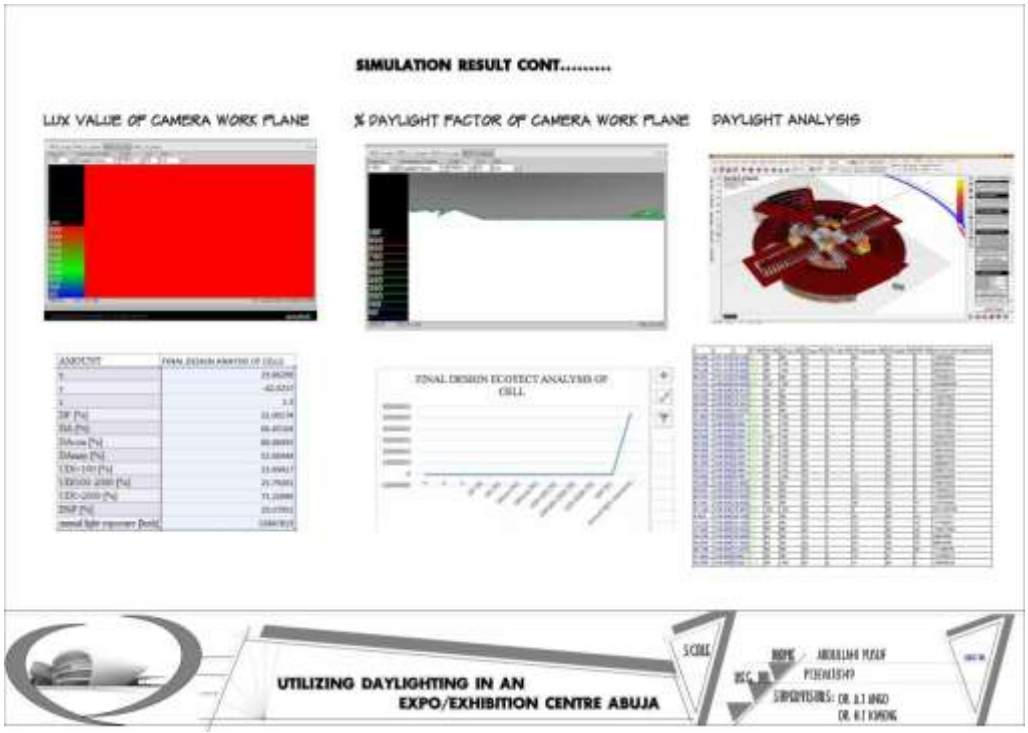
APPENDIX 'XIV'

Simulation result of the main building



APPENDIX 'XV'

Simulation result continued



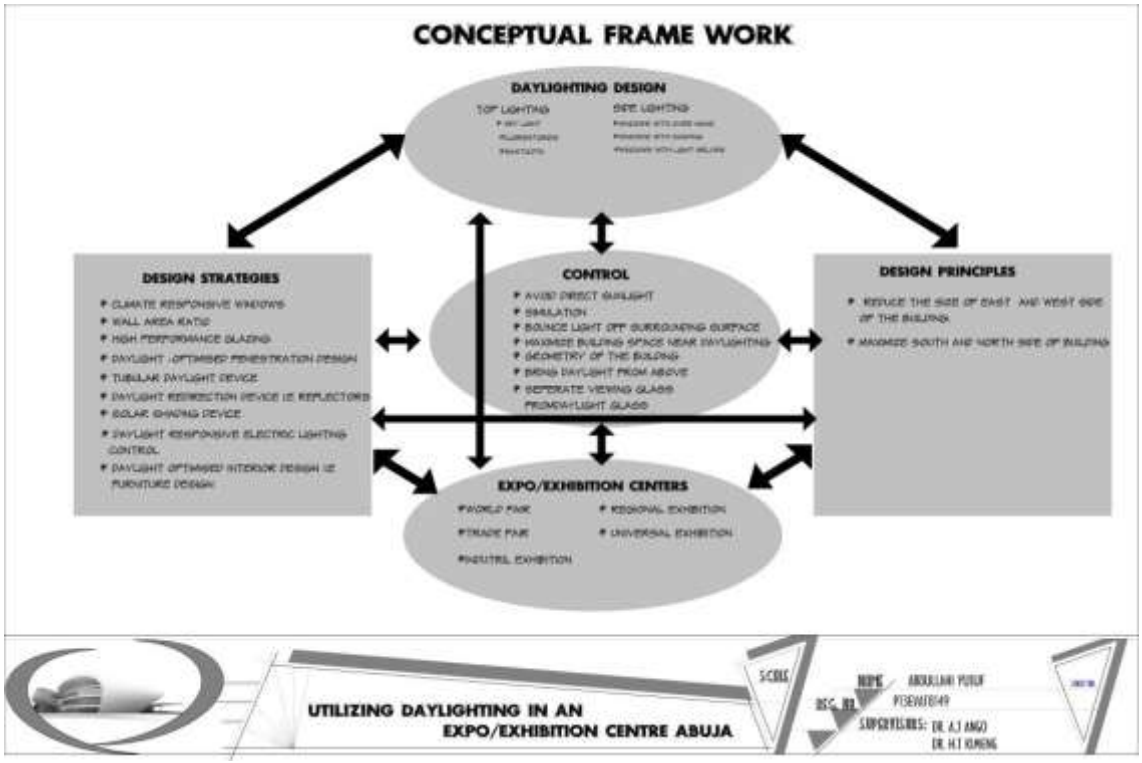
APPENDIX 'XVI'

Site Plan



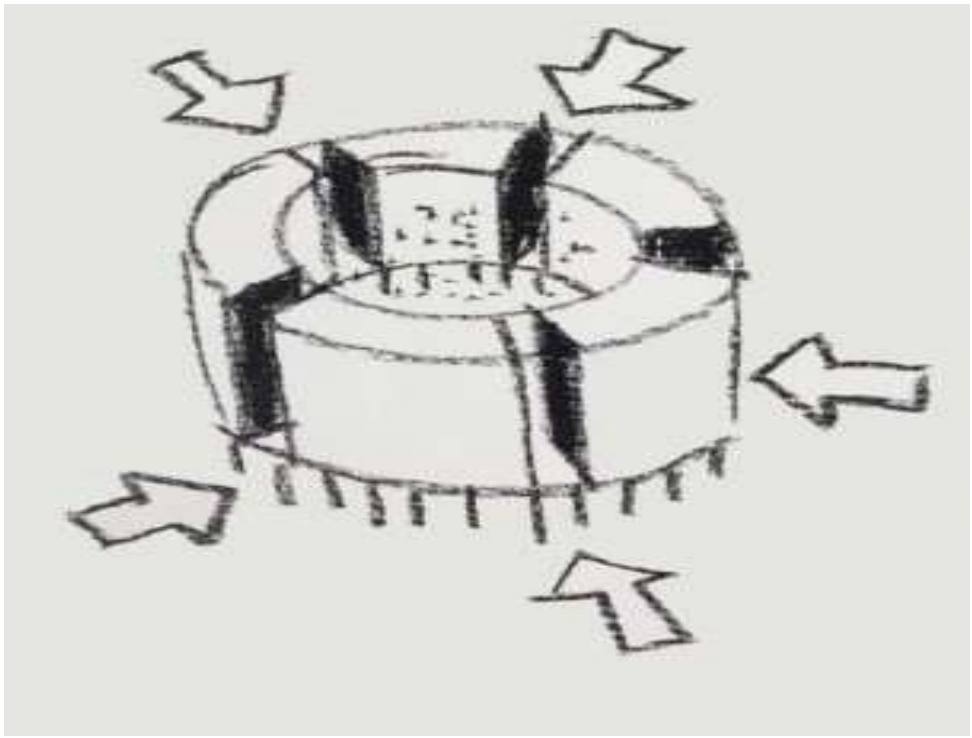
APPENDIX 'XVII'

Conceptual Framework



APPENDIX 'XVIII'

Concept Formulation



APPENDIX 'XIX'

Interior perspective of Exposition hall.



APPENDIX 'XX'

Interior perspective of circulation.



APPENDIX 'XXI'

Three Dimensional View



APPENDIX 'XXII'

Three dimensional view approach

