AN EVALUATION OF SUSTAINABLE DESIGN STRATEGIES TO ENHANCE ENERGY EFFICIENCY IN CONFERENCE CENTRES.

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DECEMBER, 2014.

DECLARATION

I declare that the work in the thesis entitled '**EVALUATION OF SUSTAINABLE DESIGN STRATEGIES TO ENHANCE ENERGY EFFICIENCY IN CONFERENCE CENTRES** has been carried out by me in the Department of Architecture under the supervision of Dr. Stephen Oluigbo and Dr. R. B. Tukur.

The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any institution.

_____ _____

SARATU ENEOJO BALA **DATE**

CERTIFICATION

This thesis entitled "**AN EVALUATION OF SUSTAINABLE DESIGN STRATEGIES TO ENHANCE ENERGY EFFICIENCY IN CONFERENCE CENTRES** " by **SARATU ENEOJO BALA** 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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ABSTRACT

Sustainable design strategies are strategies that seek to promote the quality of indoor and outdoor environment by reducing negative impact on building and the natural environment. Energy efficiency which is a key factor of sustainable design is especially critical for conference centres with their typically large volumes of space and great variation in numbers of occupants. This has made the focus on sustainability in the design, construction, and operation of conference centres grow more intense. Studies show that one third of the energy used in existing conference centres in Nigeria is generated via electricity, but due to epileptic power supply, high cost of energy and high carbon emission, there is a need to minimize energy demand in the facility. This research evaluated sustainable design strategies and their effects on energy efficiency in conference centres in warm humid climates of Nigeria. The climate, building envelope, heating, ventilation and air conditioning (HVAC) and lighting systems working together as an integrated system are the principal factors responsible for energy consumption of a building. The research was based on case study approach and data was collected through visual survey and interview of Architects/ designers of conference centres in the field of energy as well as analysis of the environmental climate data of the proposed site. The case study revealed that the centres as at the time of their construction did not consider sustainable design strategies in terms of materials of the building envelope, wall and window shading as well as natural means of cooling and lighting. In order to apply and achieve a sustainable design, effort was put into understanding the local climate and integrating appropriate strategies such as appropriate orientation, landscaping, fenestration, shading devices and appropriate use of materials into the architecture. The key factors which are local climate, building envelope, lighting, and cooling systems affecting the

energy efficiency of the building were analyzed and the strategies to improve its sustainability were examined. Innovative building materials and technology such as clay bricks in concrete render, precast concrete panels and solatube daylighting system effectively utilized on a model in managing the problem of lighting and cooling energy loads were carefully investigated and these were used to arrest the energy efficiency challenges in the study area.

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GLOSSARY

Building envelope known as the "skin" consists of the roof, exterior and interior walls, windows, doors and floor of a structure; it serves as a barrier that separates the interior of the building from the outdoor environment.

Daylighting Daylighting is the use of direct, diffuse, or reflected sunlight to provide full or supplemental lighting for building interiors.

Heat gain Inside heat generated from internal heat sources such as lights, appliances, machinery, and human bodies, thermal mass, and air temperature (sun).

Low-emissivity Emissivity is a measure of an object's ability to emit long-wave infrared radiation or room temperature radiant heat energy. Surfaces with low-emissivity reduce heat flow and allow light through.

Photovoltaic Photovoltaic (or PV) systems convert light energy into electricity. Also commonly known as "solar cells." The simplest systems power many small calculators and wrist watches. More complicated systems can provide electricity for pumping water, powering communications equipment, and

R-value Standard rating system used to label insulation value of materials. Also, an energy efficiency rating designed by the Efficient Windows Collaborative system. The higher the r-value, the less heat loss.

Solar gain Heat from the sun.

Sustainable design The ability to meet "today's energy needs without compromising the ability of future generations to meet heirs." The use of energy-efficient designs, building materials, appliances, as well as reusing and recycling materials, including the building at the end of its life.

Thermal resistance The opposition of materials and air spaces to the flow of heat conduction, convection, and radiation.

U-factor: The American Architectural Manufacturers Association (AAMA) specifications for glass windows, doors, and framing materials. The lower the u-factor, the higher the insulation value.

1.0 INTRODUCTION

1.1 Background of Study

Sustainability has increasingly become an important aspect of architecture and construction. Hence architects and their clients have integrated both their functional requirements and a wide range of sustainable strategies into the architecture (Moskow, 2008). The concept of sustainability is widely used in many areas but the main idea is to provide benefits for current generation, without neglecting the effects that it would bring to the future society (Zamzuri et al, 2011). Sustainability involves addressing a wide spectrum of issues, sometimes, seemingly conflicting ones, therefore acquiring a basic knowledge of these issues is the first step towards establishing or clarifying personal values and moving towards a more sustainable future (Sassi, 2006). Several factors, which are interactive in nature, are affecting as well as threatening the existence of our planet Earth. They include overpopulation and urbanization (which have multitude of effects), transportation in cities, energy use and global warming, excessive waste generation and subsequent pollution of air, water and soil, and limited supply of resources (Subramanian, 2007). According to Sassi (2006), issues to consider for sustainability design include land and ecology, community, health, material, energy and water. Doyle (2011) stated that sustainability is more than using environmental friendly materials; it is having a facility that works well with the local environment and community and supports many different activities.

Conference centres are remarkably effective environments for meetings, seminars, conferences and exhibitions (Doyle, 2011). They are public facilities (Moh'd, 2010) which are often located in urban centres. It's most interesting trend is the growing desire for functional outdoor spaces, these outdoor spaces provide visitors a more

direct physical and visual connection to the city and allow for meeting planners the ability to program outdoor space as part of their event (Lockwood, 2012). Talking about sustainability, (Jhaveri et al, 2010) stated that energy efficiency is a particular challenge for conference centres due to their typical large volumes of space and great variation in the number of occupants. He also ascertained that one of the unsung heroes of sustainability is adaptive reuse-green on a grand scale. Murphy (2010) opined that reducing the consumption of electricity in conference centres is especially important especially on air conditioning and lighting systems. As conference center space becomes more multi-use, the spaces provided should adapt to the need of the users (Doyle, 2011). This thesis tends to address this issue of energy efficiency which poses as a challenge in conference centres through the use of sustainable design strategies.

1.2 Problem Statement

Studies have shown that the focus on sustainability in the design, construction, and operation of buildings and facilities is growing more intense and energy efficiency is especially critical for conference centres due to their typically large volumes of space, great variation in numbers of occupants and range of activities that take place in them. This results in high energy demand which has not been adequately met since the country faces constant power disruption due to inefficient use of power resources.

It has also been observed from studies of existing conference centres in Nigeria that one third of the energy used is generated via electricity. Hence to achieve a sustainable center, there is a need to reduce energy use thereby reducing energy emissions carbon foot print and energy costs which in turn may result in financial cost saving to consumers if the energy savings offset any additional cost of implementing an energy efficient technology. As such, sustainable design strategies are taken to

ensure that energy efficiency in conference centres is maximized in order to create a comfortable environment where meetings, seminars, conferences and exhibitions can take place conveniently.

1.3 Justification of Study

With global warming becoming a major threat to our ecosystem, architects are encouraged to design sustainable buildings in order to reduce the extensive energy consumption by the building industries. The high energy demand required in conference centres has not been met due to epileptic power supply in the country; therefore, there is a need to carry out a study on how to improve the energy efficiency of conference facilities without depending totally on electricity. As energy efficiency has proved to be a cost effective strategy for building economics without necessarily increasing energy consumption, the introduction of passive energy sources especially in a country with poor electrical and water supply gives an added advantage to the running process of the facility while creating an awareness of energy efficiency in all types of buildings.

The project's dealings with the evaluation of sustainable design strategies will help to implement the policy on design of sustainable buildings for the purpose of preventing further environmental degradation.

1.4 Aim and Objectives

The aim of this study is to explore the concept of sustainable design strategies in an attempt to achieve energy efficiency in conference centres.

The objectives include;

I. To conduct a review on sustainable design strategies and those related to energy efficiency.

II. To examine and study energy efficiency factors and their application in conference centres.

III. To determine to what extent these strategies have been applied in existing conference centres

IV. To demonstrate the use of sustainable design strategies for the achievement of energy efficiency in conference center design.

1.5 Research Questions

I. What are the sustainable design strategies related to energy efficiency?

II. What sustainable design strategies can be applied in conference centres to maximize its energy efficiency?

III. To what extent have sustainable design strategies been applied in the design of existing conference centres in Nigeria?

IV. In what way can sustainable design strategies be applied in the design of a conference centre?

1.6 Scope of Study

This research tends to study related issues/literatures concerning existing conference centres in the hot humid regions of Nigeria, this is essential in order to achieve the standards provided and possible additions to improve the existing ones. Information will also be gathered through field work carried out in related buildings with emphasis on the relationship between sustainability, alternative sustainable design strategies and energy efficiency strategies in conference centres.

2.0 LITERATURE REVIEW

2.1 Sustainable Design

Sustainable design has emerged as a guiding paradigm in the creation of a new kind of built environment: one that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). According to Iwaro and Mwasha (2013), sustainable design is a design approach put in place to promote the building indoor and outdoor environment by reducing negative impacts on building and the natural environment. Sustainable design according to Eubanks (2007) means integrating architecture with electrical, structural and mechanical systems, taking advantage, whenever possible, of other renewable energy sources such as photovoltaic, wind, geothermal, etc. The use of native building materials, energy-efficient appliances, as well as reusing and recycling materials (including the building at the end of its planned life) are all facets of sustainable building design principles.

Sustainable design involves buildings that need fewer resources and materials to build, occupy and maintain, and are more comfortable and healthy to live and work in. They result in durable, attractive buildings, reduced operation and maintenance costs, improved comfort and convenience and low environment impact.

Built form has a significant impact on the greater environment and that most current common development practices are not environmentally sustainable in the long term. For this purposes, Palich et al (2011) defines sustainable design as an approach to building procurement and other urban development which works towards achieving zero net environmental impact. This includes but not limited to the following:

1. Eliminating the use of non-renewable resources.
2. Eliminating air, soil and water pollution.

3. Creating healthy and accessible indoor and urban environments.
4. Protecting and enhancing natural eco-systems and cycles.
5. Supporting the conversion of ‘waste’ into useful resources.
6. Creating a built environment that is resilient, flexible and adaptive to climate change.
7. Supporting decentralized electricity and water systems.
8. Supporting a move towards understanding and implementing ‘positive development’
9. Supporting sustainable modes of travel (Palich et al, 2011).

The goal of sustainable design for the built environment is to integrate local ecology into design and construction, to reduce natural resource impacts, minimize non-renewable energy consumption, use environmentally preferable products, protect and conserve water resources, enhance indoor environmental air quality, and improve operation and maintenance practices (U.S. protection Authority, 2010).

2.1.1 Basic principles and strategies of sustainable design

Hui (2002) stated that sustainable design principles involves understanding place, connecting with nature, understanding natural processes, understanding environmental impacts, embracing co-creative design processes and understanding people. Similarly, Guyer (2009) opined that sustainable design principles involves optimization of site potential; optimizing energy use; protection and conservation of water; selection and use of environmentally preferable products; enhancement of indoor environmental quality; and optimization of operations and maintenance practices. Sustainable design is a discipline in which in addition to the environment, strives to at least acknowledge the social and economic ramifications of a project

(Nicholson, 2005). Hence, the principles of sustainable design can be summarized as follows;

1. To mitigate against diminution of natural resources such as energy, water, and raw materials;
2. To prevent environmental degradation caused by building projects throughout their life cycle;
3. To construct buildings that is livable, healthy, secure, and positively usable (Samuel, 2011).

Sustainable design should be achieved at three levels; ecological, economic, social and cultural levels (clausen et al, 2003). These three levels of sustainability are interwoven in order to maximize human well being and comfort as seen in figure 2.1.

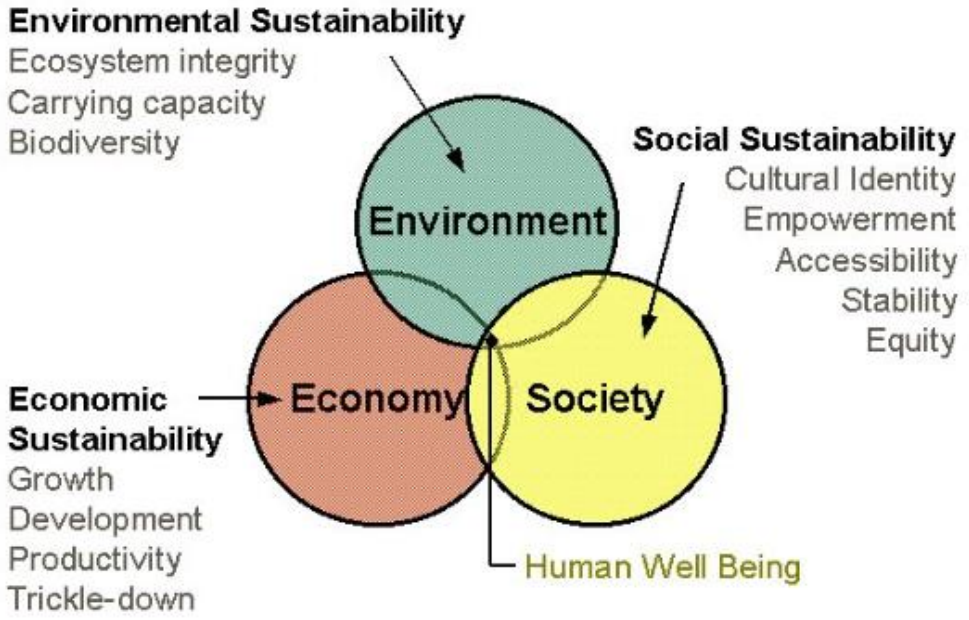


Figure 2.1: The three levels of sustainability.
Source: Hui (2002)

The ecological sustainability mainly aims to preserve resources, including energy and materials and protect the ecosystem from existing and possible future problems. The economic sustainability may be achieved by a better exploitation of resources and a decrease of the overall cost that may be achieved by minimizing the energy cost, the

cost of operation and maintenance as well as the cost of a possible rehabilitation of buildings. Finally, sustainability at the social and cultural level aims mainly to provide shelter to human beings, optimize comfort and health for the building occupants and builders, discourage social exclusion, as well as to protect and preserve the social and economic values including measures aiming to protect the existing building stock, the local networks as well as the local knowledge (Clausen et al, 2003). However the 'triple bottom line' of sustainability is open-ended and a current significant focus is being placed on the energy and environmental performance of buildings, with specific key goals involving the reduction of associated carbon emissions and energy costs (Grierson and Moultrie, 2011).

Sustainable building design makes use of the best commercially available materials and technology to minimize consumption of energy resources and maximize use of non-exhaustive and non-toxic materials. In this manner they achieve a level of human comfort and usability that conventional buildings may not (Samuel, 2011). To assist in making appropriate sustainable design decisions, the following design strategies and actions are recommended;

1. Resources should be used only at the speed at which they naturally regenerate and discarded only at the speed at which local ecosystems can absorb them.
2. Site planning should incorporate resources naturally available on the site such as solar and wind energy, natural shading and drainage.
3. Resource efficient materials should be used in the construction of buildings and in furnishings to lessen local and global impact.
4. Energy and material waste should be minimized throughout the building's life cycle through reuse.

5. The building shell should be designed for energy efficiency considering factors such as day lighting, passive ventilation, building envelope, internal load, local climate, etc.
6. Material and design strategies should produce excellent indoor environmental quality
7. The design should maximize occupant health and productivity.
8. Operation and maintenance systems should support waste reduction and recycling.
9. Water should be managed as a limited resource.
10. Location and systems should optimize employee commuting and customer transportation options and minimize the use of single-occupancy vehicles. These include using alternative work modes such as telecommuting and teleconferencing (Subramanian, 2007).

The above design considerations show that there should be effective interaction among all the persons involved in a project (client, architect structural engineer, electrical and mechanical engineer, landscape architect, and others) at all the stages of the project.

2.1.2 Sustainable building design and energy

The energy associated with buildings includes the operational energy and the construction energy. The construction energy, known as the embodied energy, is energy required to transport the material to site, maintain it and finally dispose of it. The operational energy is the energy used to heat, cool, ventilate and light the building, provide hot water, and run appliances and equipment. The operational energy varies depending on building location, climate and season, and the building use (Sassi, 2006). Climate and seasons have the biggest impact on the building's

requirements for heating and cooling, but all factors have to be considered. Designing buildings to minimize energy needs means adopting measures that primarily affect the building envelope and the spatial design. These are passive measures that include: orientating the building in relation to the sun, the wind and the site characteristics; insulating the building and providing heat storage according to climatic needs; integrating systems to passively cool and ventilate the building; and providing appropriate natural light to minimize the need for electrical lighting (Sassi, 2006). Buildings gain heat from internal incidental sources, such as people and equipment; external sources, such as the sun; and auxiliary sources, such as heating and ventilation systems. To minimize the need for auxiliary heating or cooling, requiring energy, buildings have to be designed to harness solar radiation and to keep out heat from the building.

2.2 Energy Efficiency

Energy is fundamental to all human activities (Uyigue et al, 2007). Efficient energy which is simply known as energy efficiency is using less energy to provide the same level of energy service. It is any action that reduces energy use per unit output without affecting the level of service provided. For example, insulating a home allows a building to use less heating and cooling energy to achieve and maintain a comfortable temperature. Another example would be installing fluorescent lights and/or skylights instead of incandescent lights to attain the same level of illumination. Compact fluorescent lights use two-thirds less energy and may last 6 to 10 times longer than incandescent light bulbs. Energy efficient buildings, industrial processes and transportation could reduce the world's energy needs in 2050 by one third, and help control global emissions of greenhouse gases, according to the International Energy Agency.

Basically Energy efficiency covers the efficiency of power generation, transmission and distribution of electricity as well as various end uses of energy. It has been identified as one of the criterion to ensure sustainability of energy supply. The key emphasis is to encourage the use of new and alternative energy sources as well as efficient utilization of energy (Ching Sin et al, 2011). The author also opines that energy efficiency is an important means towards the development of sustainable energy and reducing the impact of the energy sector on the environment.

The energy consumption of buildings can be reduced in three different ways: reducing the demand for energy services, increasing 'technical' energy efficiency, and integrating renewable sources of energy in the building system to reduce the use of fossil fuels for heating, cooling, ventilation, lighting or electricity (Schwarz, 2009). Actions can be targeted at improving the building design and construction which will improve the overall sustainable performance of the facility. Examples include improved access to daylight and views, improved indoor air quality, and improved occupant comfort. The building design includes choice of location, orientation, structure, and layout as well as choice of building materials and equipment which largely determines the energy consumption required during the building's operation. Large savings can be achieved by optimizing the entire building system rather than improving elements individually. This can only be done at the beginning of the building's life or during major renovations. The rest of the energy consumption is linked to the building use, through the performance of equipment used in the building (for example, boilers, A/C units, lighting, electrical appliances,) and the behavior of the people who use it (choice of temperature, turning off unused lights and appliances, etc.). However, buildings can be designed to meet occupant's need for thermal and visual comfort at reduced energy levels & resources consumption. Energy resource

efficiency in new constructions can be affected by adopting an integrated approach to building design. The goal of energy efficient building is to use resources more efficiently and reduce a building's negative impact on the environment (US Environmental Protection Agency, 2008). It's benefits include;

1. Reduced cost
2. Enhancing comfort condition within buildings thereby improving health and productivity
3. Curbing environmental pollution
4. Improved building design and operation
5. Life-cycle cost savings
6. Added market value of buildings
7. Reduced carbon-dioxide emissions and consumption of finite fossil fuels
8. Reduced capital cost by better integration of building fabric and systems
9. Reducing demand on non-renewable fuels
10. Energy buildings achieve one key green-building goal of completely or very significantly reducing energy use and greenhouse gas emissions for the life of the building (Hui 2007)

2.2.1 Factors that affect energy efficiency in buildings

Factors that affect energy efficiency in buildings include; day lighting, natural ventilation, building envelope, internal load, site and external space, orientation and planning, building shape and form, wall shading, as well as local climate amongst others (Subramanian, 2007).

A. Daylight in buildings

Natural daylighting is the controlled entry of natural light into a building through windows, skylights, atria, and other building envelope components (Swindon

Sustainable Building Design and Construction Supplementary Planning Document, 2007). Daylight not only replaces artificial lighting, reducing lighting energy use, but also influences both heating and cooling loads. It starts with the selection of a building site and continues as long as the building is occupied (Hernandez, 2011). Day lighting requires the correct placement of openings in the building envelope to allow light penetration while providing adequate distribution and diffusion of the light, well-designed day lighting delivers more useful light with less heat gain than even the most efficient fluorescent lights, resulting in reduced electrical requirements for cooling (Eubanks, 2007). Day lighting is one sustainable building strategy that can help achieve low energy bills, high quality indoor environment and low construction costs (Nicklas, 2008). Similarly, optimal use of natural daylight in buildings makes significant contributions to energy efficiency (Kwok and Grondzik, 2007). A well designed light shelf or lowered ceiling from a window will add to the physical and visual comfort of a space and reduce the use of electric lighting thereby enhancing energy efficiency (Nicklas, 2008). This is shown in Figures 2.2 and 2.3 respectively.

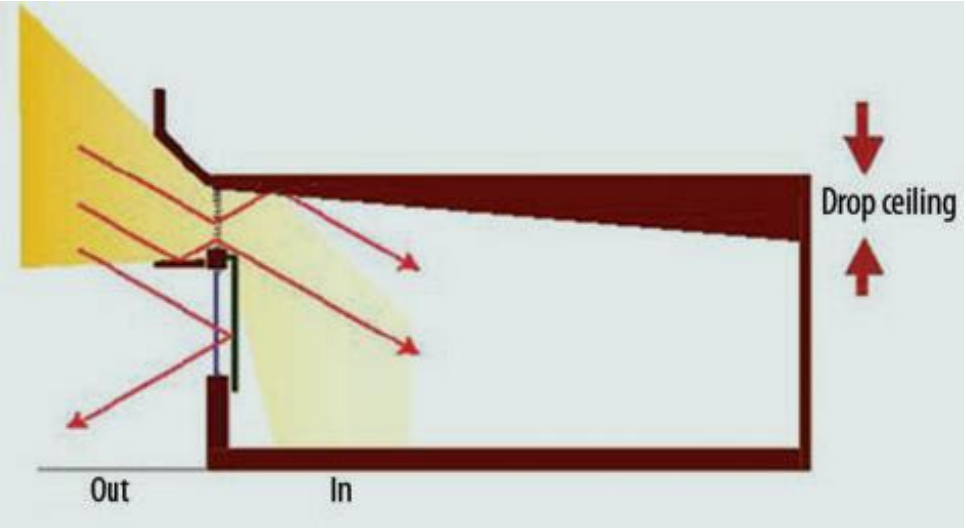


Figure 2.2: Sloping the ceiling downward from the head of the window
Source: Nicklas (2008).

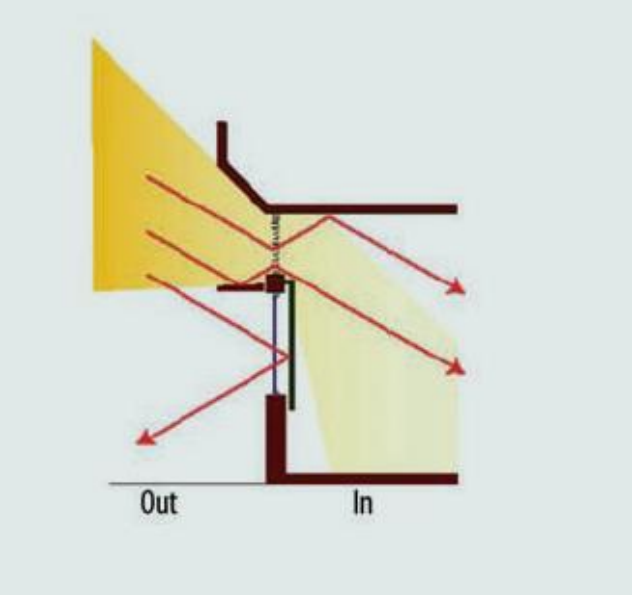


Figure 2.3: light shelf with blinds between the glasses
Source: Nicklas (2008).

The selection of glazing for warm humid climates shall be based on its capacity to block heat gain from the sun and reduce infiltration. The main energy parameters of a window are its insulation value, transparency to solar radiation, SHGC (solar heat gain coefficient), visible light transmittance (VT) and air tightness as illustrated in Figure 2.4.

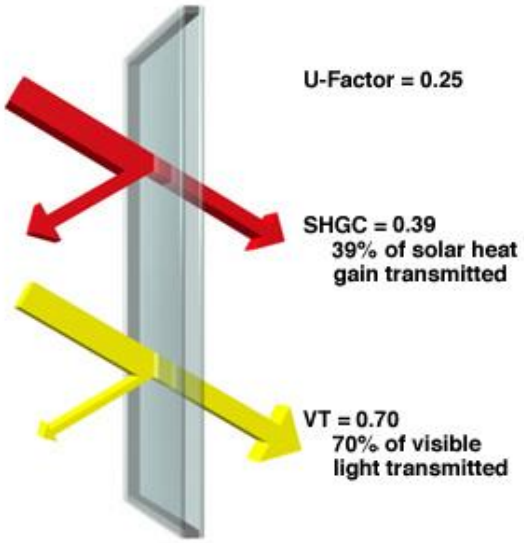


Figure 2.4: window performance parameter
Source: Zhivov et al (2010).

The U-factor expresses a window's insulation value, its resistance to heat flow when there is a difference between inside and outside temperature. The U-factor is measured in Btu/hr-sq ft-°F (W/sq m-°C). The lower the U-factor, the greater a window's resistance to heat flow.

A window's transparency to the heat carried by solar radiation is expressed in the solar heat gain coefficient (SHGC). The SHGC is the fraction of solar heat admitted by the window on a range of 0 to 1.

A window's transparency to visible light is expressed as its visible transmittance (VT) on a range of 0 to 1.

The air-leakage (AL) rating of a window indicates its air tightness. It expresses the rate of air-leakage around a window at a specific pressure difference in units of cubic feet per minute per square foot of frame area (cfm/sq ft) or cubic meters per minute per square meter of frame area.(cmm/sq m).

B. Natural ventilation

Natural ventilation, also called passive ventilation, uses natural outside air movement to both passively cool and ventilate a building. Natural ventilation is important because it can provide and move fresh air without fans. Maximizing the amount of space to be naturally ventilated is another strategy towards reducing energy demand since natural ventilation requires little energy use as compared to air-conditioning. (Green Building Platinium Series, 2010). For warm and hot climates, it can help meet a building's cooling loads without using mechanical air conditioning systems. This can be a large fraction of a building's total energy use. Successful natural ventilation is determined by having high thermal comfort and adequate fresh air for the ventilated spaces, while having little or no energy use for active HVAC cooling and ventilation. Enhancing natural ventilation within the built environment aids in:

1. Removing heat build-up from dense urban areas.
2. Reducing energy consumption especially from mechanical ventilation means.
3. Improving human comfort within occupied spaces.
4. Increasing controllability of thermal comfort controls.
5. Improving indoor air quality (Green Building Platinium Series, 2010).

Natural ventilation is also the most energy-efficient way of supplying essential fresh air to a building (Sassi, 2006). The most common methods of natural ventilation are single sided ventilation, cross flow ventilation and stack ventilation (Bahrami, 2008). The single sided ventilation has opening only on one side of the wall through which outdoor air enters the building and leaves through the same opening or another opening on the same wall as shown in figure 2.5. This method is inexpensive and suitable for moderate climates and small internal spaces. Double opening can be used to enhance the efficiency of this type of ventilation. See figure 2.6.

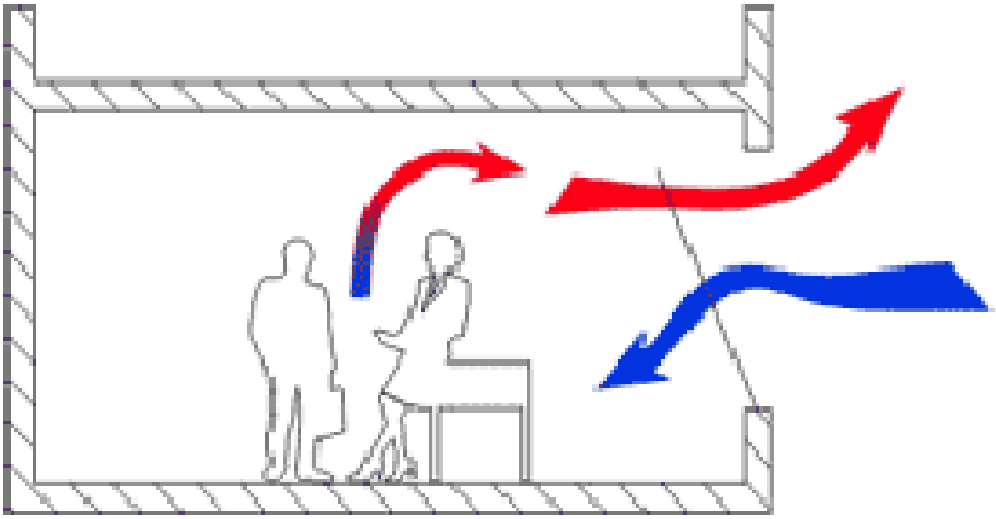


Figure 2.5: Single sided ventilation (One opening)
Source: Dyer Environmental Controls (2008)

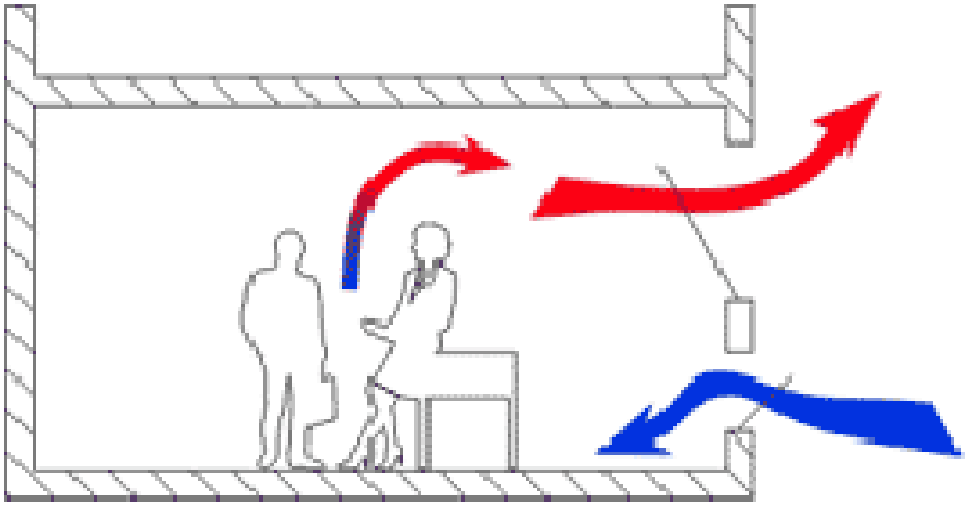


Figure 2.6: Single sided ventilation (Double opening)
Source: Dyer Environmental Controls (2008)

Cross flow ventilation provides more airflow rates and thus is effective in larger internal spaces as shown in Figure 2.7. In this kind of ventilation, cool fresh air enters into the building from openings on a wall while warm and foul air moves out of the building from openings on the opposite walls.

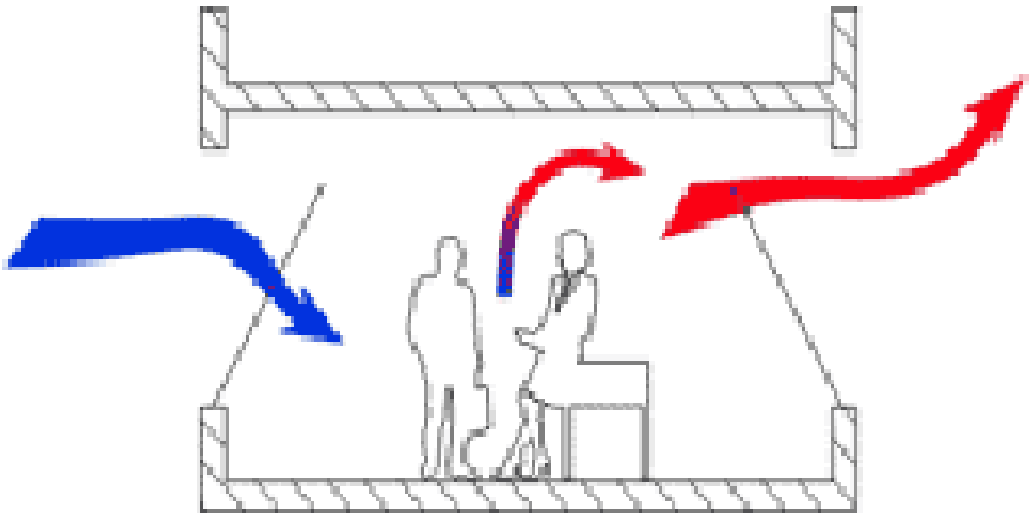


Figure 2.7: Cross flow ventilation
Source: Dyer Environmental Controls (2008)

Stack ventilation is a method where by hot air which naturally flows upward is vented through high-level openings and replaced by fresh air entering from lower openings.

Figure 2.8 shows an advancement of this method, which includes the integration of both stack and cross ventilation using a double façade.

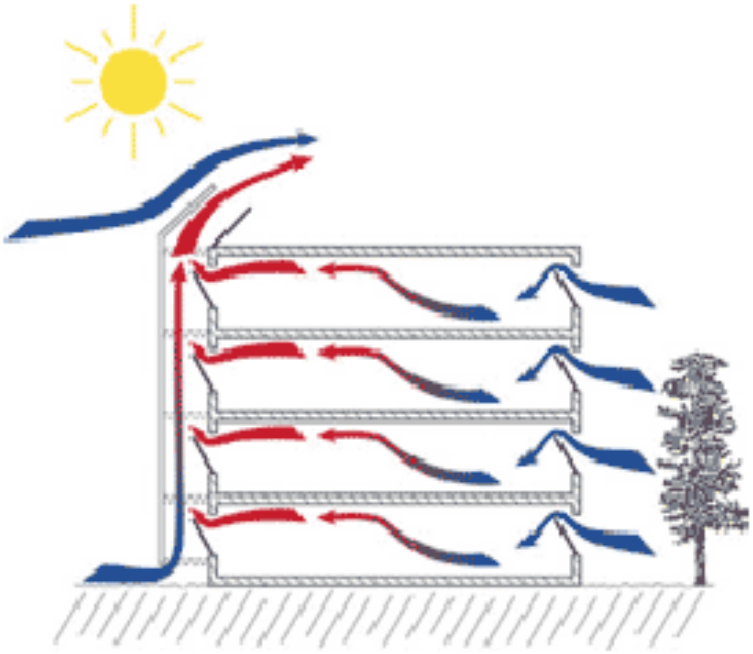


Figure 2.8: Combination of cross and stack ventilation
Source: Dyer Environmental Controls (2008)

The red and blue arrows represent outflow and inflow of air respectively.

C. The building envelope

The building envelope also known as the "skin" consists of the roof, exterior and interior walls, windows, doors and floor of a structure; it serves as a barrier that separates the interior of the building from the outdoor environment. This envelope controls heat gain and heat loss from the building. By definition, the envelope's purpose is to provide protection from external elements, which, in building construction, means protection from moisture, air, and temperature ingress and egress (Howell, 2008). Concerns for sustainability demand that we consider the fundamental requirements of buildings and re-examine our current approaches to building envelopes and environmental separation (Kesik, 2002). The design of the envelope of a building is a major task of the architect and involves a number of considerations

including strength and stability, control of air flow, rain water, fire, aesthetics and cost, with some opposing others in their requirements. For control of heat flow through the building envelope, thermal properties of the wall and its components is considered through the use of glass; insulation materials; choice of colour and surface texture; and natural ventilation. Figure 2.9 shows the connection between the building envelope and sustainability.

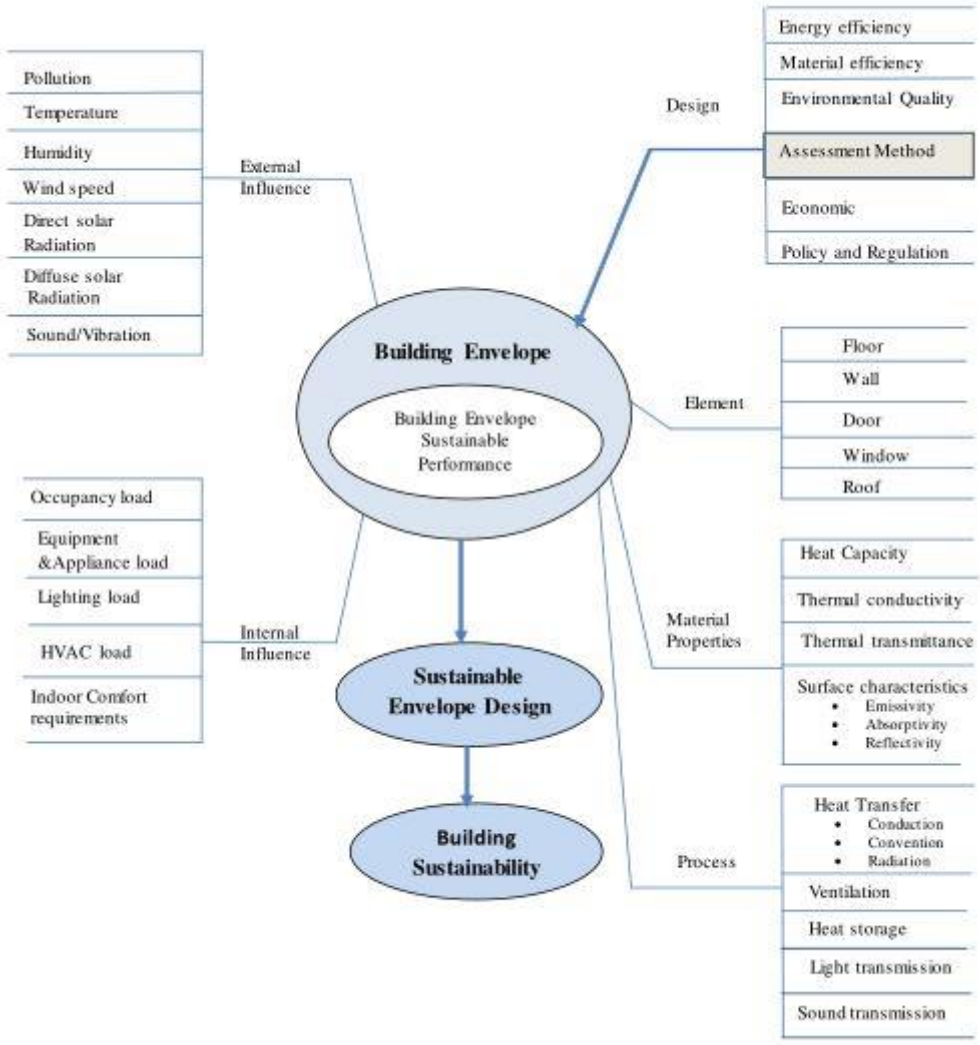


Figure 2.9: The connection between the building envelope and sustainability.
Source: Iwaro and Mwasha (2013)

The envelope must balance the requirement for ventilation and daylight while providing thermal and moisture protection appropriate to the climatic condition of the site. Envelope design is a major factor in determining the amount of energy a building

will use in its operation. It is the integrated design of building form and material as a total system to achieve optimum comfort and energy savings. Good envelope design respond to climate and site conditions to optimize the thermal performance. It can lower operating cost, improve comfort and lifestyle and minimize environmental impact (Binggeli, 2003).

D. Site and external spaces

Sunshine on the grounds surrounding a building is often ignored when considering heat flow into buildings. Thus, there is the need to assist in the cooling of streetscapes and buildings by a reduction in the paved areas and an increase of grassed areas and of trees (Hernandez, 2011) this is illustrated in figure 2.10. Planting and interwoven tiles between the facilities of buildings can be used to reduce the ambient air temperature of that building and also external landscaping and excessive greening can help mitigate urban heat island (Green building platinum series, 2010).



Figure 2.10: Walkpath and grassed areas
Source: Passive Design Toolkit - Best Practices (2008)

It is also important to note that landscaping and wall shading of the immediate environment of the building can help to cool its surrounding, therefore with proper landscaping and wall shading, heat flow into the building will be reduced and in turn

the need for cooling through mechanical systems will also be reduced thereby reducing demand on energy use. See figure 2.11.

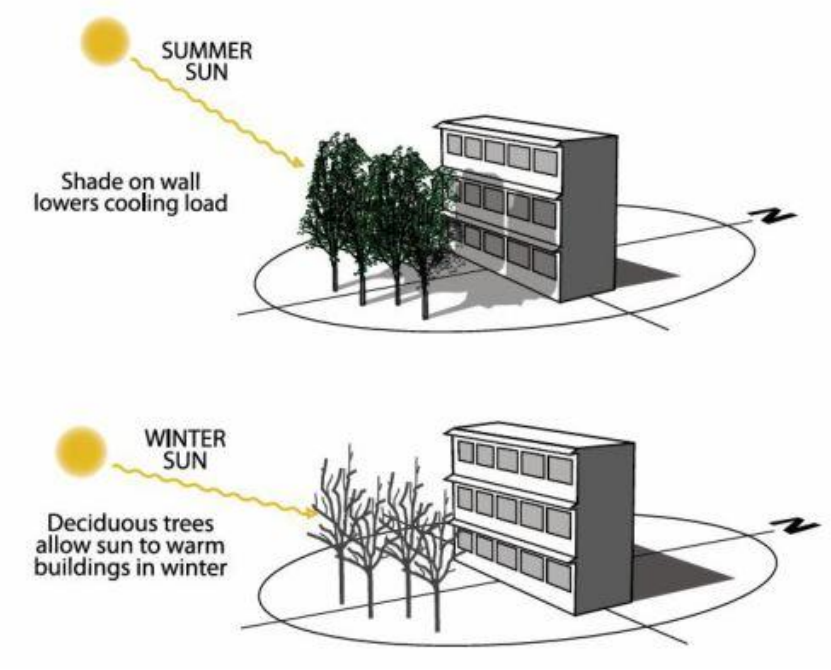


Figure 2.11: Landscape strategies for passive solar heating and day lighting control
Source: Passive Design Toolkit - Best Practices (2009)

E. Orientation and planning

Orientation and planning for reducing solar entry into buildings is dependent on the location (that is, the latitude) of the site. The main objective in deciding upon a given orientation in hot climatic regions is to minimize the impact of the sun on the building (Hernandez, 2011). With good orientation, the need for cooling is reduced resulting in lower energy bills and reduced green house emission (Reardon, 2008). Buildings should be made to maximize the site's potential and to achieve the best possible orientation for functional areas as illustrated in figure 2.12. In hot humid climates, orientation should aim to exclude the sun all year round and maximize exposure to cooling breeze. Building orientation related to the sun and prevailing winds will have a significant impact on the required heating and cooling systems and thus the overall energy efficiency of the project (Department of Veterans Affairs, 2007).

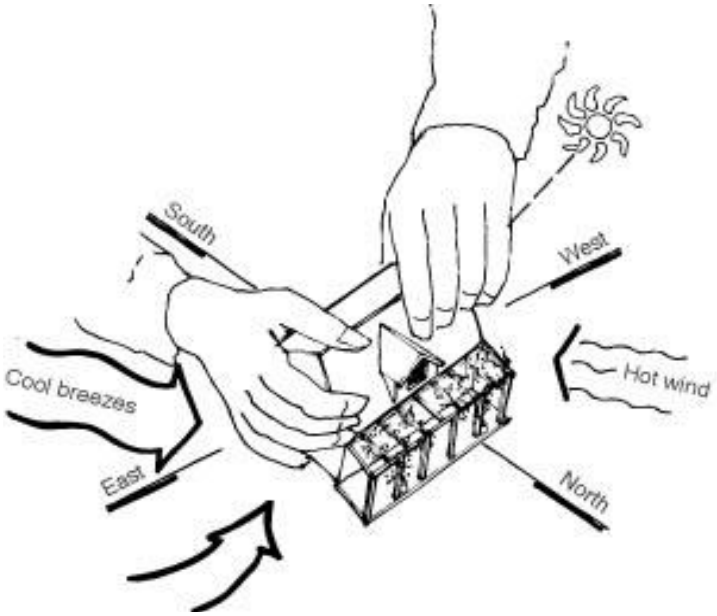


Figure 2.12: Good orientation
Source: Reardon (2008)

F. Building shape and form

Building shape and form are also basic determinants of the energy required to cool a building. For example, a compact building shape reduces the area of a building's envelope through which solar heat may be gained (Hernandez, 2011). Research elsewhere has shown that for air-conditioned buildings, considering the relationship of external surface area, volume, and floor area of buildings in the design can result in energy efficiency. Additionally, the size of the building is also related to building shape/form as a factor in energy-conserving. Calculations for energy conservation in buildings can even determine the number of storeys that would be the optimum for energy efficiency, for a given total floor area.

G. Wall shading

Shading of a building refers not only to shading of its windows, but to the walls themselves. The shading of walls will do much to reduce the total heat that enters the building and therefore drastically reduce the amount of heat to be later emitted into the building as shown in figure 2.13. Canopies, louvres, awnings, and external sun

shading devices are examples of shading elements that can be used to great effect in building. It is important to note that wall shadings are only necessary under extreme conditions (Hernandez, 2011).

Shading of windows can be achieved in two ways which are external and internal shading. External shading devices intercept, absorb and/or reflect solar radiation before it reaches the exterior surface of the building envelope while, internal shading blocks solar radiation from penetrating into the interior space; however the solar energy is still transmitted through the window assembly (Labrie, 2009).

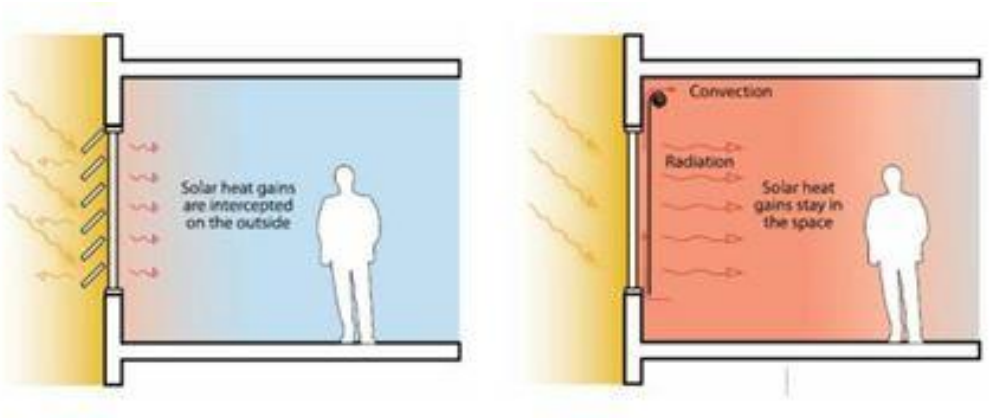


Figure 2.13: Effect of external(left) and internal(right) Shading
Source: Passive Design Toolkit - Best Practices (2009)

H. Local climate

Climate is a reoccurring pattern of generalities and averages that relate to temperature, humidity, precipitation, and air movement. It can be defined as how hot or cold it is in a certain place over a long period of time. It is specific to conditions driven by solar and lunar cycles in concert with water, soils, and geology. Its location is affected by its latitude, terrain, altitude, ice or snow cover, as well as nearby water bodies and their currents. Within any climate, there are times when human comfort can be achieved without mechanical intervention and times when it cannot (Williams, 2007). It is the consideration of the climate that prescribes the form, shape and placement of

a building within a site. In hot and humid climates, cooling loads can be reduced by addressing the building envelope, including window coatings and shading and by employing energy-efficient lighting (which produces less waste heat). In many cases, low-technology options, such as incorporating traditional design features or painting flat rooftops white to increase their reflectivity; can produce substantial reductions in cooling loads (IAC Report, 2009).

2.2.2 Energy flow and consumption in conference centres

The present energy source in Nigeria is hydro electricity through the use of dams and nuclear energy through the use of nuclear power plants especially in more developed countries as seen in figure 2.14. This energy is distributed to various buildings through the central power grid consisting of a series of high and low tension cables, transformers and distribution boxes to the appliance (Ahmed, 2012). Electricity flows from the extraction and treatment of natural gas down to the satisfaction of human needs.

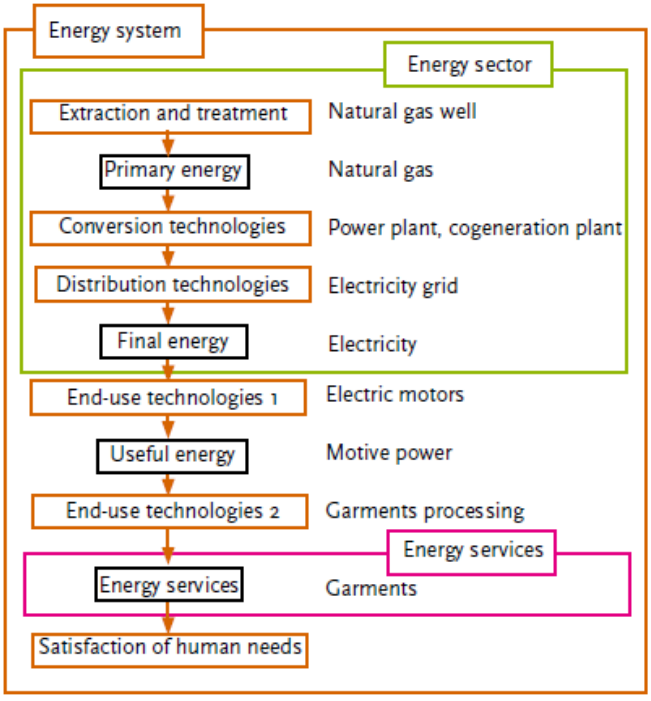


Figure 2.14: Energy flow
Source: IAC Report (2009).

Energy consumption is beyond just electricity used in the building for its operation but also branches into net area of material used for the construction of that building. The two most important ways in which commercial buildings consume energy, as illustrated in Figure 2.15, are air conditioning (HVAC) systems, which account for 46 percent of total building primary energy use; and lighting, which accounts for 33 percent of total building primary energy use. The sophistication of the electrical appliances in a building depends on the scale of the operation carried out in the building as well as the size of the building itself.

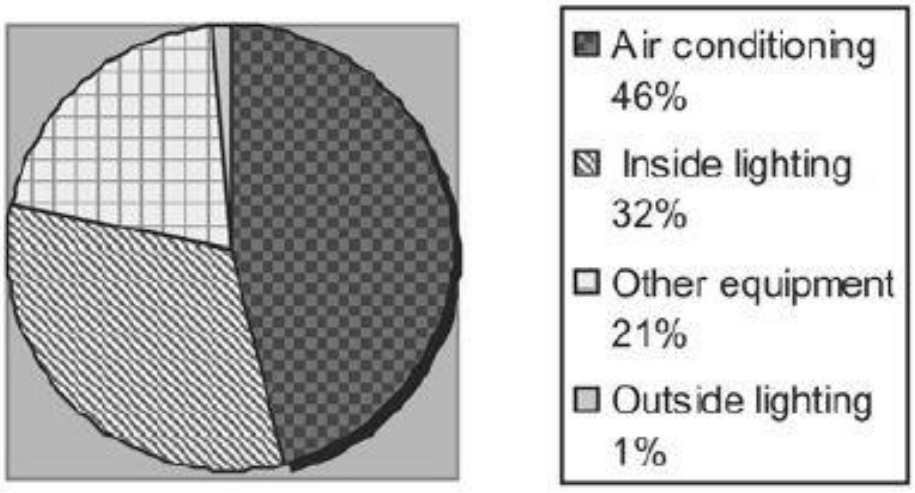


Figure 2.15: Shares of primary energy use in commercial buildings.
Source: Sosa (2007)

The results for large commercial buildings in many other countries are similar to those for the United States, although no such statistical breakdown is available for other IEA member nations or for the developing world, The term ‘commercial buildings’ covers a wide range of structures, including government buildings, commercial office buildings, schools, hospitals, houses of worship, shops, warehouses, restaurants, and entertainment venues. Large energy-saving opportunities exist in the commercial-building sector.

2.2.3 Architectural design requirement for energy efficiency in conference centres

The most energy efficient and environmentally friendly buildings must be functional, durable and aesthetically pleasing (Grierson, 2011). Hence, architectural design requirements available to designers and building owners for energy-efficient building design are summarized under the following; siting and planning; concept design; resources – material selection, energy and water.

A. Siting and planning

This has to do with developing an understanding of the opportunities and constraints of the site and utilizing the knowledge to appropriately plan at the macro level. It involves evaluating the site and local ecosystems to ensure that buildings are positioned to allow for optimum passive design opportunities considering prevailing winds, solar access, water supply, and others.

B. Concept design

This has to do with employing a well considered knowledge about environmentally responsive design to appropriately plan and design to maximize building and siting orientation for appropriate solar access and ventilation through all seasons and for specific climate and location area at the micro level.

C. Resources: Material Selection

This considers issues regarding the life cycle of materials in order to ensure most appropriate and least damaging selection and design.

D. Resources: Energy

This ensures that the detail design, selection of appliances and energy sources results in a reduction in the building's operational energy impact across all seasons.

1. Encourage reduction of power consumption through design by selecting high efficiency lights and sensor systems.

2. Operation and high efficiency equipment especially for heating and cooling throughout.
3. Select energy efficient appliances and operating systems.
4. Employ smart building management systems to minimize energy requirements.
5. Encourage inclusion of appropriate renewable energy forms:
6. Encourage use of alternative and low impact power sources.
7. Encourage use of gas in preference to electricity.

E. Resources: Water and others

This involves understanding and acknowledging the opportunities to sustainably harvest, use, re-use or recycle on-site resources during the life of the building.

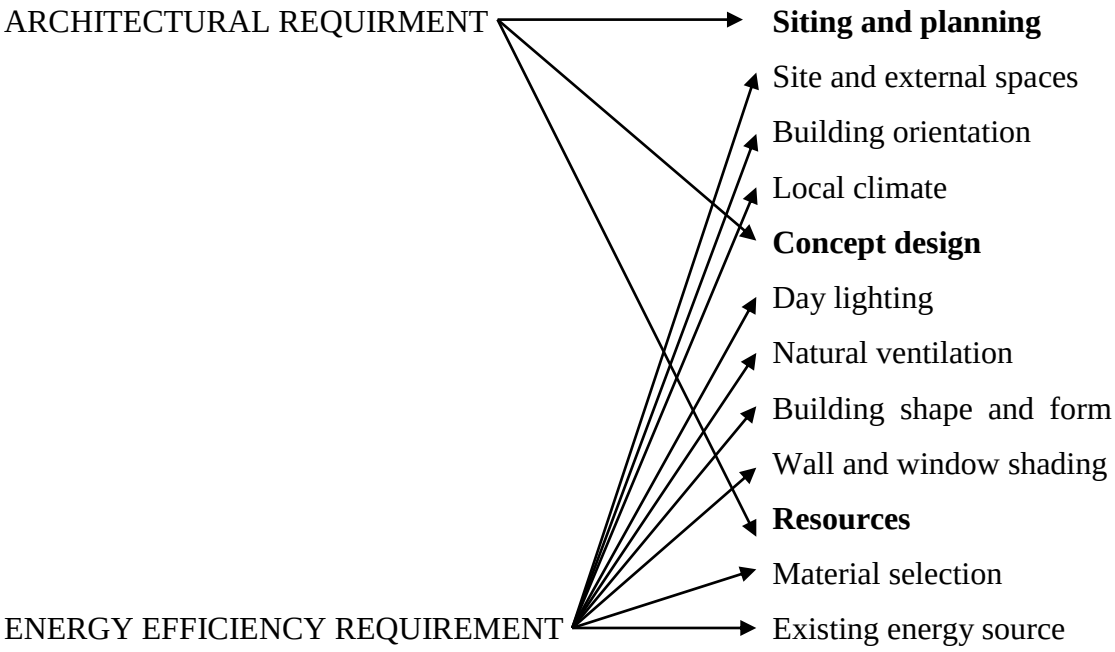


Figure 2.16: Conceptual frame work of energy efficiency and architectural requirement.
Source: Author (2014)

2.2.4 Challenges in achieving energy efficiency in conference centres

The steps towards achieving a sustainable conference centre has to consider the climate of the site, different climatic zones have different design considerations with respect to the climate. Hence a conference centre design should have features to reduce solar heat gain, increase natural lighting and ventilation and materials of high energy performance should be used. According to Agboola (2011), the selection of material for construction is very vital in hot-humid climatic region of Nigeria, this has to consider;

1. Thermal conductivity: this is the ability of materials to conduct heat.
2. Thermal stability: the ability of materials to retain its basic physical and mechanical properties and inner structure when heated.
3. Thermal resistance: this is the ability of material to resist heat flow.
4. Heat capacity: this is the ability of material to absorb heat when its temperature is raised.
5. Surface coefficient: this determines the rate of heat exchange between the surface and the surrounding air.
6. Surface characteristics: this determines reflectivity, absorptive and emissive of a material, for example, colour, texture, etc hence in choosing materials for this region, their thermal properties has to be of high performance.

2.3 Conference Centres

A conference center is a specialized facility usually in a less busy but accessible location designed and built almost exclusively to host conferences, exhibitions, large meetings, seminars, training sessions, etc. They often make provisions for office facilities and a range of leisure activities (Doyle, 2011). Similarly, Steve (2006)

opined that conference center is a comprehensive facility dedicated to facilitating business meetings, planning sessions, day retreats, luncheons, and receptions.

According to Harris (2006), convention centres (American) are air-conditioned multipurpose facilities generally used for meetings, conventions, and the display of merchandise by a wide variety of industrial groups, professional groups, and trade organizations. The size of the facility ranges from small to very large, sometimes over more than 2 million square feet (approximately 18 hectares). The interior must be flexible so that it can be divided into various sized spaces. Regardless of size, a conference center requires meeting spaces, movable partitions to subdivide these spaces, sanitary facilities, loading docks, adequate heating, cooling, electrical and communications equipment, and trained maintenance staff.

Lockwood (2012) stated that conference centres are often located in urban centres they incorporate functional outdoor spaces to provide visitors a space for more intimate socializing and an opportunity to break away from the conference momentarily to enjoy a more direct physical and visual connection to nature. An outdoor meeting space or functional plaza can provide another unique outdoor experience that attracts conference or exhibition attendees and provides them with a welcome break from the indoor exhibition space. As conference center space becomes more multi-use, these outdoor spaces also provide a selling point for conference center executives looking to rent space for private parties or corporate events, making them a viable alternative to other event spaces in a city.

2.3.1 Types of conference centres

Conference centres are of different types. They can be classified based on their function, capacities, facilities and sizes. Skelton (2010) classified conference centres based on their functionality and facilities. These centres are; executive conference

centres, corporate conference centres, Resort conference centres, University conference centres and Not-for-profit conference centres.

Executive conference centres, are developed primarily to satisfy the requirements of specialized executive level meetings and are staffed with conference center coordinators;

Corporate conference centres are designed by a corporation primarily for in-house use, they are typically available on a limited basis to outside users. The size of the facility varies depending on companies' needs and emphasis is primarily to satisfy the companies'/owners' training and development as well as internal communication needs.

Resort conference centres accommodate events that are similar to those held at either executive or corporate centres but emphasis is more toward incentive, recreation, and socially-oriented objectives.

University conference centres which are developed by and associated with a major educational institution. The facilities are typically managed by university personnel.

Not-for-profit conference centres are those owned by religious or educational organization, association or foundation, research center or a private humanitarian or art group.

Some similar characteristics of these various conference centres include adaptability and sustainability of meeting spaces provided, (Doyle, 2011). They devote at least 70% of meeting space to conferences and generate at least 60 percent of occupied room nights for conferences. They have flexible column free spaces used for variety of exhibition, trade, conferences, meeting events and sometimes sporting events, they may also include a variety of configurations and meeting options such as break-out space, auditorium, theatres, sport arenas and others (Moh'd, 2010).

2.3.2 Conference centre facilities

Conference centres have a wide range of facilities based on their types and functions. Typically, they should provide lobby, guest rooms, meeting rooms, auditorium, foyer and gallery, seminar rooms and conference services. It should also provide Leisure facilities such as swimming pools, bars, and restaurants; dining facilities and parking facilities are also regarded as the essential elements for a successful conference center design. For a successful conference facility, it should be furnished with ergonomic chairs, tables, appropriate lighting and acoustics, etc. Guest rooms should have desks, wireless high-speed internet access, and appropriate lighting and seating (Valentino, 2006).

Auditorium should have tiered seats; excellent acoustics; air conditioned with black out facilities; state-of-the-art audio visual equipment; wheelchair access and induction loop hearing system.

Foyer and Galleries should be a stuning, interesting and versatile space containing display and exhibition facilities with reception desk and closed circuit televisions to monitor event proceedings.

Seminar rooms can be in form of theatre style which can be opened up to create a larger facility accommodating larger number of people. They should have provision for LCD projector, white boards, 35mm and overhead projector.

Meeting rooms should make provisions for Plasma screens, traditional hanging screens, and overhead projectors.

Ample free car parking spaces should be available within easy reach of all conference centre facilities.

For the purpose of this research, a resort conference centre is considered. This is because it provides and accommodates facilities for variety of activities and events.

2.3.3 Current trends in conference center design

Most conference centres respond to a fairly typical set of requirements and constraints: location within or in proximity to the client's offices, flexibility and adaptability to varying functions, sophisticated technologies, and a variety of amenities (Jhaveri, 2010). Similarly, some other trends include sense of environment; new form and new function; small is the new big; package appeal; and green (PCMA, 2007). However some new developments influencing decisions and design solutions for conference centres are discussed below.

A. Sense of environment

Conference centres are incorporating local features and culture; they have a reputation of being big boxes. However that aspect is fast becoming a myth. For example the Palm Springs Convention Center, Califonia, has native American and desert-inspired architectural details. During its 2005 renovation, the building's entrance was re-oriented to face the surrounding mountains (PCMA, 2007). **A**esthetics are important to attendees (Lenhart, 2007). Hence, Conference centres are paying attention to interior and exterior architecture that reflects the culture of the community and the natural environment they are surrounded by.

B. Adaptive reuse

This is one of the unsung heroes of sustainability on a grand scale. As compared with new construction, it is faster to market, has a lower cost, and revitalizes the urban fabric while preserving important aspects of local architectural character. Adaptive reuse also creates unique opportunities for creative design solutions. It is often an attractive option, especially given the availability of urban retail properties, with their higher overall ceiling heights and proximity to hotels and restaurants.

C. Technology

Technology as a trend warrants its own section. Meetings today are driving the demand for conference centres to have high-tech equipment and services to meet the needs of groups. Technological amenities are no longer an exception, but rather the rule. Current technology for conference centres includes:

1. High-speed Internet access
2. Video teleconferencing capability
3. Communication infrastructure capable of moving voice, video and data
4. 24-hour technical support staff
5. Plasma screens
6. Digital electronic signage (PCMA, 2007)

Organizations adopt more timely, inclusive, and geographically unfettered ways to reach their constituencies and the public due to these changes in technology and its uses. As a consequence, conference centre design now must take into account on-screen effects and different acoustic requirements, because broadcast capabilities are critical for the users. They should incorporate lighting, acoustics, backdrops, and furniture specifically suited to a broadcast-ready set.

D. Package appeal

Conference centres which are purpose-built space for meetings make their money on meeting space. And in most cases that is all they control – their meeting space. However, conference center staff recognizes the importance of destination appeal, hotel pricing, attached hotels, hotel proximity to convention/conference center and shopping facilities and restaurants in the area. This has led convention/conference centres to focus on creating a more appealing meeting and trade show environment through attention to loading efficiency, building access, traffic separation, better

sound and lighting systems and full-service business centres. For example, the Georgia International Convention Center (GICC) has installed a high-tech project that will allow convention/conference-goers to fly into the airport, disembark their plane and arrive at the GICC without ever getting into a taxi, bus or shuttle.

E. Branding and privacy

Branding and privacy are critical to enabling conference centre owners to make their facilities available to outside organizations, this has added to the functionality of the centres. To make that objective viable, the conference centres must meet two criteria: visual independence - a clear, compelling, distinct image; and physical independence - ability to separate public and private space to ensure privacy and security. In difficult economic times, this new wave of conference centres has great potential for organizations and architects alike.

F. Energy efficiency

Energy efficiency is especially critical for conference centres with their typically large volumes of space and great variation in numbers of occupants. This has made the focus on sustainability in the design, construction, and operation of the buildings and facilities grow more intense. Energy efficiency in conference centres is evaluated from three aspects;

i. Energy for Environmental Control in the work spaces; air-conditioning and ventilation ,
ii. lighting and
iii. Energy for other building equipment like computers, public address systems, and others.

These three calls for separate strategies. For the purpose of this research, the first two being greater consumer of energy, require more attention.

Cooling Energy: If the architectural solution of a building has disregarded the climatic aspect as fundamental criteria of design, the thermal quality of the spaces is affected. The most expeditious solution to this problem, which is considered later on, constitutes the installation of high capacity air conditioning systems. An important criterion to consider is the energy consumption required for the air conditioning system. This is because it represents increase in energy use and economical costs of the building throughout its lifecycle. The indicators proposed to evaluate the strategies are: Percentage reduction of solar heat gain and percentage reduction of cooling load. (Sosa, 2007)

Lighting Energy: The architectural response should be dedicated to taking advantage of the potential of natural lighting to illuminate the interior spaces and to diminish the necessity to illuminate by means of electric lighting. For each kW saved in the electric lighting system there is a decrease by approximately 0.28 tons of refrigeration in the capacity of the air conditioning system. The proposed indicators are: Solar Heat Gain Coefficient (SGHC) and Visible Light Transmission Coefficient (VLTC) (Ibid). Figure 2.17 shows a schematic representation on the energy efficiency indicators proposed to evaluate in the building envelope.

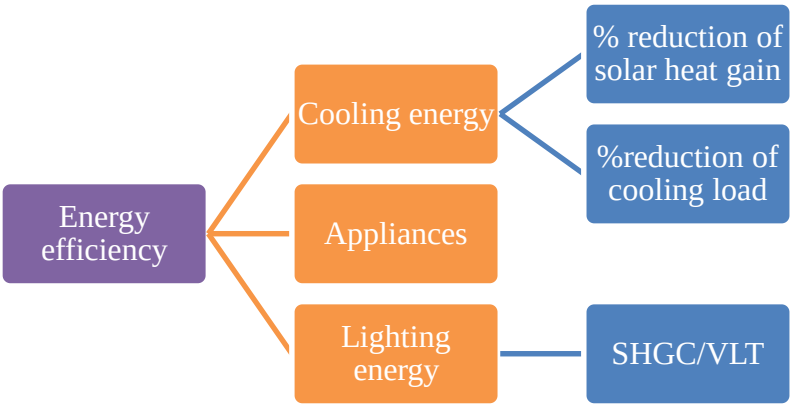


Figure 2.17: Energy efficiency indicators
Source: Sosa (2007)

To maximize energy efficiency in the conference centres, 'demand controlled ventilation' can be adopted as demonstrated in Washington, D.C. conference center. This was achieved by installing a system of CO2 monitors that determines the need for air changes on conference floors. Whereas, without the sensors, the system would be conservative, demanding a higher level of ventilation at all times, this approach allows greater levels of ventilation when the space is fully occupied and code minimums when it is not. Monthly monitoring and analysis of the electrical load data and comparison of the actual operations with the design intent will reveal further opportunities for efficiency (Jhaveri et al, 2010).

Other significant contributors to the building's energy savings and sustainability include a new, high-performance glass curtain wall; modifications to the existing exterior skin assembly for infiltration and vapor control; a continuous dimming system for all light fixtures within 15 ft. of the building perimeter; and green power offsets (Ibid).

2.3.4 Spatial organization of conference centre designs

This has to do with the general planning of the site and facilities in such a way that the activity relationship are well co-ordinated to create a harmonious grouping and ease of circulation. In a conference centre, there are a wide range of activities taking place. Hence it is important to have a good circulation pattern to ease movement within the facility and avoid rowdiness.

A. The Greenville Conference Center

The Greenville Conference Center is built around a 30,000-square-foot exhibit hall with 28-foot ceilings. The space can be subdivided into five individual sections. The facility can accommodate 160 10'X10' exhibit booths, 2,450 guests banquet-style, or 3,000 guests theater-style.



Figure 2.18: Spatial arrangement of greenville conference centre

B. New Bern Riverfront Conference Center

The 45,000-square-foot New Bern Riverfront Convention Center is built around a 12,000-square-foot Grand Ballroom that can be subdivided into three separate spaces of 6,000, 3,500 and 2,500 square feet. The facility also features: three meeting rooms ranging from 930 to 2,030 square feet; a 450-square-foot executive board room; 8,000 square feet of pre-function/exhibit space, and; a 3,740-square-foot veranda verlooking the Trent River.



Figure 2.19: Spatial arrangement of New Bern Riverfront Conference Centre

3.0 RESEARCH METHODOLOGY

Evaluative research aims at testing effectiveness of projects, policies or programs to determine how they have failed against stipulated standards or targets in order to suggest modifications and alternatives (Veal, 2006). This approach was adopted for this study. It will require basic tools for data collection and analysis which include interview, visual survey which is incorporated into case studies in order to provide the researcher with first hand information on the subject matter, secondary data from the cases visited and calculations/simulation. This is necessary in other to deduce the appropriate and practicable guideline needed in the design of the proposed facility.

The case study method ensures an accurate description on similar problems stated in the research and the existing solutions applied.

3.1 The Case Study Approach

Case study is a dominant approach in architectural research. It may be referred to as a research method or a unit of analysis which involves the study of an example or a case of the phenomenon being researched (Veal, 2006).

According to Yin (2004) case study can be seen as an empirical inquiry that investigates a contemporary phenomenon within its real life context using multiple source of evidence.

Case study approach is characterized by a purposeful selection of the cases to study and triangulation, which is normally conducted by means of multiple methods of data collection (Johansson, 2010). However to be seen in its full sense, the study should include detailed documentation of information on the history and environment of study (Oluigbo, 2010). Hence, the case study to be carried out on this research will be documented based on the following headings: history and background; site planning and landscaping; spatial organization of buildings; structure and materials; and

building services. This will then be followed by the application of general data collection technique.

3.2 Case Study Selection

Oluigbo (2010) mentioned that for cases to be identified, they have to possess some intrinsic virtues which are in relation with the phenomenon under consideration. Hence, to properly select case studies best suited for this research, the following criteria are considered.

1. Its function
2. The climatic zone to which the case belongs
3. The scope of facility provided: this is to check the services, facilities, climatic zone, architectural characteristics, etc provided and its correlation to the proposed facility.
4. Their adaptation to sustainable design strategies: this is to check its success as it relates to energy conservation/efficiency (in materials used, energy sources, passive design application, etc.). Hence, the selected case studies are required to strongly satisfy the listed criteria.

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. NECA Conference Centre, Lagos
2. LCCI Conference Centre, Lagos
3. Shehu Musa Yar'adua Conference Centre, 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.

3.3 Instrument of Data Collection

The instrument used for data collection in this research include;

1. **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.
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. **Secondary Data:** this involves data gotten from the management such as electrical design drawings and records of energy consumption. This will help to carry out statistical analysis on the cases.

3.4 Procedure of Data Collection

Visitations will be made to each of the cases selected, visual survey inform of walking tours will be made around the site observing and identifying architectural features will be made taking note of materials, finishes and spatial arrangements of their floor plans in order to analyze the collected data. Documentation will be made on;

1. Sustainable design features of the centres;
2. Energy efficiency strategies applied in the design;
3. Architectural design requirement used to achieve energy efficiency and
4. Facilities provided and spatial organization of the design.

Visual survey will be reflected using photographs which were taken of relevant case studies to ascertain the features of sustainable design, sketches will also be made of

some parts of the selected cases. These sketches will show the spatial organization of the facilities.

3.5 Variable of Study

Variables are parameters that scholars investigate. For the purpose of this research, the variables to be considered are design dependent variables which will point out which of the elements of sustainable design had been applied in the cases and their effect in energy reduction. They are;

1. The building envelope
2. Daylight in the building
3. Natural ventilation
4. Site and external spaces
5. Orientation and planning
6. Building shape and form
7. Wall shading
8. Local climate
9. Existing energy source

3.6 Data Analysis

Data analysis was based on descriptive, visual and ranking system. A checklist was also employed to assess and record the extent to which sustainable design strategies were employed in the three centres based on a 5 point scale ranking system ranging from very inadequate-1point to very adequate-5point.

4.0 FINDINGS AND DISCUSSION

4.1 Introduction

In this chapter, the third objective which is to find out the extent to which sustainable design strategies were applied in the design of conference centres was carried out. Here, the data gotten from the cases studied are described and a checklist was employed to access and record the level of application based on a 5-point scale ranking system ranging from very inadequate-1point, inadequate-2points, average-3points, adequate-4points to very adequate-5points.

4.2 Case Study One: Findings at NECA Conference Center

4.2.1 Background

The Nigerian Employers' Consultative Association (NECA) is the umbrella body of the organized private sector of Nigeria. It has a conference/event centre which is strategically located within the Ikeja Central Business District at Plot A2, Hakeen Balogun Street, Alausa, Ikeja, Lagos. The centre is in a functional state and it is made up of five floors and a basement, It consists of;

1. An auditorium that has a capacity of 700 seats without tables and 500 with banquet tables.
2. Two mini halls; one has a capacity of 250 without tables and 180 with banquet tables and the other has a capacity of 200 without tables and 140 with banquet tables.
3. Two elegantly finished restaurants capable of seating 80 guests each.
4. Waiting room
5. Four seminar rooms, each having various capacities
6. Foyer for exhibition and other services

7. Library and offices
8. Parking spaces.

The auditorium, mini halls, and seminar rooms are well equipped with projector and screens, public address systems, flip chart boards, markers and superb air conditioning system.

4.2.2 Findings from visual survey

At the NECA conference centre, it was observed that the source of energy consumption within the building are:

i. Lighting fixtures
ii. HVAC systems
iii. Projectors and Computers
iv. Public address systems
v. Printers
vi. Television
vii. Refrigerator and
viii. Elevators.

Some sustainable design strategies were applied to the building elements, these elements are described below;

A. Building envelope

The building envelope and its components are key determinants of the amount of heat gain/ loss and wind that enters into a building. The dominant building material used are concrete and glazing (reflective glasses) for walls, marble tiles for floor, white patterned suspended ceiling and plaster of Paris (POP) ceiling in some spaces as shown in plate I. Variety of colours were used in different spaces within the building; milk coloured walls for the library, auditorium, and seminar rooms respectively, dark

and light blue coloured walls for the mini halls, orange and milk coloured walls for the foyer and light and dark shades of green coloured walls for the restaurants as shown in plates II to IV. The external finish of a surface determines the amount of heat absorbed or reflected by it. Table 4.1 show the thermal properties of the building envelope materials used.



Plate I: External view of center



Plate II: Auditorium



Plate III: Foyer/circulation



Plate IV: Restaurant 1

Table 4.1: Thermal properties of materials used at NECA centre

Elements	Materials	Thermal properties						
		Colour	U-value (W/m2k)	Admittance	Solar absorbtion	Emissivity	Relectivity	Conductivity
Wall	Concrete block wall	Sandy brown	1.800	3.360	0.506	0.90	0.549	0.431
Floors	ConcSlab -Tiles	Grey	0.880	6.100	0.475208	0	0.573	0.837
Roof	Corrugated metal roof	Red	7.140	7.100	1.000	0.89	0.624	0.075
Ceiling	Suspended ceiling	White	0.500	0.900	0.368	0.90	0.702	0.431
Doors	Glass door	Transparent	5.356	5.360	1.000	0.86	0.967	1.046
Windows	Single glazed alumframe _blinds	Tinted blue	6.000	6.000	SHGC 0.56	VT 0.725	0.725	1.046 RI=1.74

Source: Author's case study research (2014)

B. Natural lighting

The interior of each of the spaces had access to natural daylight through the use of large windows which spans the whole length of the space as shown in plates V to X. Due to inadequate natural lighting, fluorescent bulbs are used to enhance the brightness of the rooms.



Plate V: Reception



Plate VI: Restaurant 2



Plate VII: Seminar room 1



Plate VIII: Seminar room 2



Plate IX: Seminar room 3



Plate X: Seminar room 4

C. Natural ventilation

Natural ventilation was provided for through the use of large windows some of which are openable as seen in plates VI to X, however it was not adequate, hence the functional spaces within the conference centre made use of air conditioning systems.

D. Site and external spaces

The building environment is surrounded by hard and soft landscape. Interlocking tiles were used for walkways and drive ways as seen in plates XI to XIII respectively. Grassed areas and plants were also used to beautify as well as cool the environment.



Plate XI: landscape



Plate XII: landscaped walk path

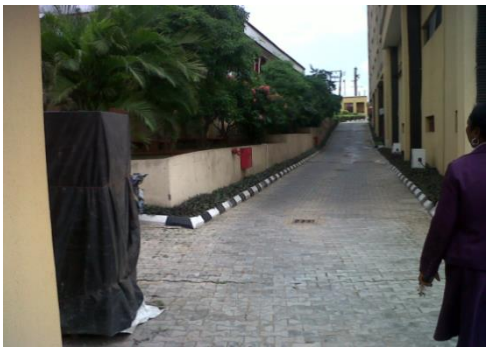


Plate XIII: driveway

E. Wall shading

There are eave projections in some areas especially along the restaurant extension, but they don't shade the windows, venetian blinds do from within. No horizontal or vertical shading device as shown in plates XIV and XV respectively.



Plate XIV: Exterior view



Plate XV: Exterior view

F. Existing energy source

The existing energy source is municipal power from PHCN which is not reliable so they depend mainly on generators. These generators as seen in plate XVI use about 10000 litres (average) of diesel per month. They have two fuel dumps (tanks) buried underground.



Plate XVI: Power Generating Set

4.2.3 Findings from the interview

According to Architect D. Dedeke, the designer of the NECA centre, some of the sustainable design considerations made on the building envelope was the use of light colours on the walls and reflective glass to help reflect light, the shape and direction of the building. Efforts were made to have adequate lighting through the use of large windows which spans from one end to the other in the various functional spaces and the depth of the building was also reduced in order to allow adequate coverage of natural light in the spaces.

Natural ventilation was also achieved through the use of large windows, some of which were openable.

In the orientation of the building, the design considered the direction of the sun path and the four cardinal points, windows were placed on areas that are less exposed to the sun.

According to the architect, the building was not about energy efficiency alone, the design was a combination of a rectilinear and curvilinear form, this was determined by the nature of the site to get the maximum. On the issue of sustainability of energy source of the facility, he said that solar panel was not used as at the time of construction because they were too expensive (limited budget) and they had not understood its maintenance aspect so two 500Kv generators were purchased as back up.

4.2.4 Extent of sustainable strategies applied on the building element

This section will evaluate the extent to which sustainable design strategies were applied on the building element as shown on table 4.2. It shows that the building envelope made use of medium range embodied energy materials. The design has inadequate daylighting and natural ventilation, no shading devices and no alternative source of energy was used. Table 4.2 is ranked using a 5-point scale ranking system ranging from very inadequate-1point, inadequate-2points, average-3points, adequate-4points to very adequate-5points.

Table 4.2: Sustainable design strategies applied at NECA centre

S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
1	Building envelope	Suitability of the materials to the climate				✓		No insulation material was used on the external walls. Use of light colours and the entire exterior surface of the building envelope was rough.
		Use of external insulation	✓					
		Use of smooth surface finishes		✓				
		Use of light colours		✓				
2	Natural lighting	Wall to window ratio (40%)					✓	Use of extensive large windows made of single clear glass cause heat gain.
		Use of spectrally selected glass	✓					
3	Natural ventilation	Use of openable windows				✓		Natural ventilation was provided for but was inadequate.
4	Site and external spaces	Use of interwoven landscape		✓				Presence of soft and hard landscape, but not interwoven.
		Use of impervious surfaces		✓				
5	Building form	Large building surface area				✓		Appropriate building form based on climate
6	Building orientation	Sun orientation; E-W				✓		The optimum orientation is NW-SE
		Wind orientation; SW-NE		✓				
7	Wall/Window shading	Use of horizontal and vertical shading devices	✓					Building was not properly shaded, only the use of fixed overhangs at some point, this exposes it to direct solar radiation
		Use of interior blinds					✓	
		Use of recessed walls	✓					
		Use of overhangs			✓			
		Use of plants	✓					
8	Existing energy source	Use of PV cells	✓					Extensive use of PHCN, however, energy was totally reliant on fossil fuel due to epileptic power supply.
		Use of natural gas	✓					

4.3 Case Study Two: Findings at LCCI Conference Center

4.3.1 Background

The Lagos Chamber of Commerce and Industry (LCCI) has a conference and exhibition centre located at N0 10, Bola Ahmed Tinubu way (Behind MKO Abiola Gardens) Alausa, Ikeja, Lagos. This centre has facilities for trainings, meetings, seminars and exhibitions. It is currently in a functional state and it is made up of five floors which consist of;

1. An auditorium/gallery which has a capacity of 700 without tables.
2. Two conference rooms; one has a capacity of 40 without tables and 36 with banquet tables and the other has a capacity of 60 without tables and 40 with banquet tables. Both rooms are equipped with screens, flip chart boards, markers and superb air conditioning system.
3. Four meeting/seminar rooms, these rooms are used interchangeably (multipurpose).
4. They have offices and spaces rented out for other conference supporting activities.
5. Parking spaces.

4.3.2 Findings from visual survey

At the LCCI conference centre, it was observed that the source of energy consumption within the building are:

i. Lighting fixtures
ii. HVAC systems
iii. Projectors
iv. Computers
v. Public address systems

vi. Television

vii. Printers

viii. Refrigerator and

ix. Elevators.

Some sustainable design strategies were applied to the building elements, these elements are described below;

A. Building envelope

The dominant building material used on the building envelope are concrete walls, glass windows, blue paint on the outside as shown in plates XVII and XVIII, and white on the inside, white patterned suspended ceiling and vitrified glazed tiles for the floors as shown in plate XXI. The openings are made up of transparent openable glass windows and doors. Table 4.3 show the thermal properties of the building envelope materials used.



Plate XVII: Approach view



Plate XVIII: Rear view

Table 4.3: Thermal properties of materials at LCCI centre

Elements	Materials	Thermal properties						
		Colour	U-value (W/m2k)	Admittance	Solar absorbtion	Emissivity	Relectivity	Conductivity
Wall	Concrete block wall	Blue	1.800	3.360	0.506	0.90	0.549	0.431
Floors	ConcSlab -Tiles	White	0.880	6.100	0.475208	0	0.573	0.837
Roof	Corrugated metal roof	Blue	7.140	7.100	1.000	0.89	0.624	0.075
Ceiling	Suspended ceiling	White	0.500	0.900	0.368	0.90	0.702	0.431
Doors	Glass door	Transparent	5.356	5.360	1.000	0.86	0.967	1.046
Windows	Single glazed alumframe	Tinted blue	6.000	6.000	SHGC 0.94	VT 0.753	0.725	1.046 RI=1.74

Source: Author's case study research (2014)

B. Natural lighting

Provision was made for natural lighting through the use of windows but interiors spaces made use of artificial lights this is because the use of windows did not provide adequate natural lighting as seen in plates XIX to XXII.



Plate XIX: Seminar room 1



Plate XX: Conference room



Plate XXI: Seminar room 2



Plate XXII: Auditorium

C. Natural ventilation

Based on the orientation of the building, proper placement of the openings was achieved and majority of the spaces are cross ventilated, but the air flow within the building is not adequate. This is due to large spaces with small windows as shown in plate XIX.



Plate XXIII: Auditorium

D. Site and external spaces

Plants and sustainable landscaping was not considered in the design of the site, the environment was made up of hard landscape, no soft landscaping as seen in plates XXIV, XXV and XXVIII respectively.



Plate XXIV: Landscape



Plate XXV: Parking space

E. Wall shading

No defined use of shading devices (horizontal or vertical), no plants too, but eave projections of 1200mm (plates XXVI and XXVII) were used on both sides of the building and venetian blinds were used to shade the windows from within.



Plate XXVI: East view



Plate XXVII: West view

F. Existing energy source

The existing energy source is municipal power from PHCN which is not reliable so they depend mainly on generators (plate XXVIII) which have an output of 240 – 260 KVA and about 6000 litres (average) of diesel is used in a month.



Plate XXVIII: Power Generating Set

4.3.3 Findings from the interview

From the interview carried out with Arc. Odeyemi, it was pointed out that the brief did not give much room for design adventure. However, some sustainable strategies were employed. For the building envelope, he said the number and size of windows per square meter of space was calculated and window types chosen to ensure that energy loss is minimal.

In order to achieve adequate daylight, atrium was provided to cope with the needed depth of the building. The site is narrow relative to getting economic space to amortise investment. Here it was stated that the issue of natural 'ventilation' does not really arise for consideration because design cannot consider cross ventilation in this type of brief and the available site. Hence, mechanical door closing device was essentially employed to avoid losing cold air from air conditioning installation.

In the orientation and planning of the building, efforts were made to reduce the area of fenestration on walls that face severe heat collection from the sun path. This was done to reduce the amount of heat collected into the building. The design had no much room for design adventure because of the need for meeting the requirement of the brief so the building is just a straight rectangular block dictated by the geometry of the

site and power was supplied to the building through PHCN and availability of diesel fuel for generator.

4.3.4 Extent of sustainable strategies applied on the building elements

This section will evaluate the extent to which sustainable design strategies were applied on building elements. Here the building was cooled mechanically, had inadequate daylighting, no landscaping, no shading devices only eave projections at some areas and no alternative use of energy. Details are seen on table 4.4 using a 5-point scale ranking system ranging from very inadequate-1point, inadequate-2points, average-3points, adequate-4points to very adequate-5points.

Table 4.4: Sustainable design strategies applied at LCCI centre

S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
1	Building envelope	Suitability of the materials to the climate				✓		No insulation material was used on the external walls. Blue colour was used extensively on the exterior of the building with a rough surface finish.
		Use of external insulation	✓					
		Use of smooth surface finishes		✓				
		Use of light colours		✓				
2	Natural lighting	Wall to window ratio (40%)			✓			Interior spaces were lit through windows, however this appears inadequate due to use of small windows for large spaces.
		Use of spectrally selected glass	✓					
3	Natural ventilation	Use of openable windows			✓			The use of openable casement windows, but inadequate ventilation
4	Site and external spaces	Use of interwoven landscape	✓					No soft landscaping.
		Use of impervious surfaces	✓					
5	Building form	Large building surface area				✓		Appropriate building form based on climate
6	Building orientation	Sun orientation; E-W				✓		The optimum orientation is NW-SE
		Wind orientation; SW-NE		✓				
7	Wall/Window shading	Use of horizontal and vertical shading devices	✓					No wall shading, no tall trees, no plants only overhangs at some areas of the building. Venetian blinds were used on windows. This exposes it to direct solar radiation
		Use of interior blinds					✓	
		Use of recessed walls	✓					
		Use of overhangs			✓			
		Use of plants	✓					
8	Existing energy source	Use of PV cells	✓					Extensive use of PHCN, however, due to epileptic power supply, standby generator was used.
		Use of natural gas	✓					

4.4 Case Study Three: Findings at Shehu Musa Yar'adua Conference Centre

4.4.1 Background

Shehu Musa Yar'adua Conference centre is a privately owned conference facility located within the central business district at one memorial drive, Abuja, Nigeria. The centre offers facilities for a wide range of events such as conferences, wedding receptions, seminars, exhibitions and meetings. It is in a functional state and consists of two floors with the following facilities;

1. An auditorium that has a theatre style capacity of 450 seats and working conference capacity of 250.
2. In-house Exhibition hall show casing "A life of service" of Shehu Musa Yar'adua.
3. Foyer for exhibition and other activities
4. Library and offices
5. Parking spaces
6. Other facilities include the unfinished bridge and the garden pavilion.

The auditorium is well equipped with projector and 6m x 4.5m screen, cordless infrared head sets, three simultaneous translator booths, and others.

4.4.2 Findings from the visual survey

At the Shehu Musa Yar'adua Conference centre, it was observed that the source of energy consumption within the building are:

i. Lighting fixtures
ii. HVAC systems
iii. Projectors
iv. Computers
v. Public address systems

vi. Television

vii. Printers

viii. Refrigerator and

ix. Elevators.

Some sustainable design strategies were applied to the building elements, these elements are described below;

A. Building envelope

The dominant building materials used are concrete walls and glazing, marble tiles for floor and concrete for ceiling. White is the major colour used in and outside the building with touches of grey on the inside and touches of green and grey on the outside respectively. The walls and ceilings of the library, auditorium, and offices are a combination of white and grey in colour and the floors made of grey marble tiles as seen in plates XXIX and XXX. Table 4.5 show the thermal properties of the building envelope materials used.



Plate XXIX: Approach view



Plate XXX: Rear view

Table 4.5: Thermal properties of materials at Yar'adua centre

Elements	Materials	Thermal properties						
		Colour	U-value (W/m2k)	Admittance	Solar absorbtion	Emissivity	Relectivity	Conductivity
Wall	Concrete block wall	White Grey	1.800	3.360	0.506	0.90	0.549	0.431
Floors	ConcSlab -Tiles	Grey	0.880	6.100	0.475208	0	0.573	0.837
Roof	Corrugated metal roof	Green	7.140	7.100	1.000	0.89	0.624	0.075
Ceiling	Suspended ceiling	White	0.500	0.900	0.368	0.90	0.702	0.431
Doors	Glass door	Transparent	5.356	5.360	1.000	0.86	0.967	1.046
Windows	Single glazed alumframe _blinds	Transparent	6.000	6.000	SHGC 0.56	VT 0.725	0.725	1.046 RI 1.74

Source: Author's case study research (2014)

B. Natural lighting

The modes of admission of daylight into the building are windows and a central atrium as seen in plates XXXI to XXXIII. However some spaces still made use of artificial lighting as seen in plates XXXIV and XXXV respectively.



Plate XXXI: Atrium



Plate XXXII: interior view



Plate XXXIII: foyer



Plate XXXIV: Exhibition hall

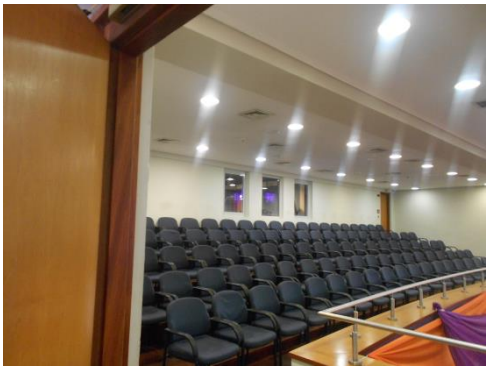


Plate XXXV: Gallery

C. Natural ventilation

Windows were provided in the various functional spaces some of which are openable and others fixed. This however did not provide adequate ventilation therefore, most spaces are artificially ventilated.

D. Site and external spaces

Presence of hard and soft landscape within the environment. Driveways were tarred and interlocking tiles were used for walkways. Grassed areas and plants were also used to beautify as well as cool the environment.



Plate XXXVI: landscape



Plate XXXVII: Driveway

E. Wall shading

The walls were not shaded but areas carrying windows and doors were recessed as seen in plates XXXVIII and XXXIX respectively. No eave projection and overhangs. Venetian blinds were also used inside the building.



Plate XXXVIII: Side view



Plate XXXIX: Recessed wall

F. Existing energy source

The existing energy source is PHCN which is not reliable so they depend mainly on generators and to minimal extent solar cells.

4.4.3 Findings from the interview

From the interview carried out on Arc. F. Uwanya of the Shehu Musa Yaradua conference center, he stated that the building envelope consisted of a central roof light which is used to harness daylight during the day and equally used to improve the ventilation of the centre as well as save cost of lighting. High illumination level was

achieved in the complex due to the use of large windows. The design of the complex is very western and is artificially ventilated especially the multipurpose halls and offices, hence the use of special doors were used to ensure that less money is used to cool or heat the spaces.

It was stated that the centre was not about energy efficiency but was designed in the memory of one of the notable sons of the country, therefore major consideration was to make sure that the complex was very imposing and iconic so the iconic impression supercedes energy efficiency in terms of the orientation.

Other energy efficiency factors employed was the use of energy saving bulbs, introduction of special concepts that decreases the inflow of water while increasing its pressure, and the use of solar heating systems for the heaters (most of the heaters were isolated and were not powered by electricity but by solar cells). Wind shadow effect was very primary in choosing the location of the windows and wind corridors were analysed. The results of the analysis informed the shape, location of the dome and orientation of the complex. The power sources are PHCN, standby generator and to a minimal extent, solar power.

4.4.4 Extent of sustainable strategies applied on the building envelope

This section will evaluate the extent to which sustainable design strategies were applied on the building elements. Here it was noted that the building is iconic. Table 4.6 shows more details using a 5-point scale ranking system ranging from very inadequate-1point, inadequate-2points, average-3points, adequate-4points to very adequate-5points.

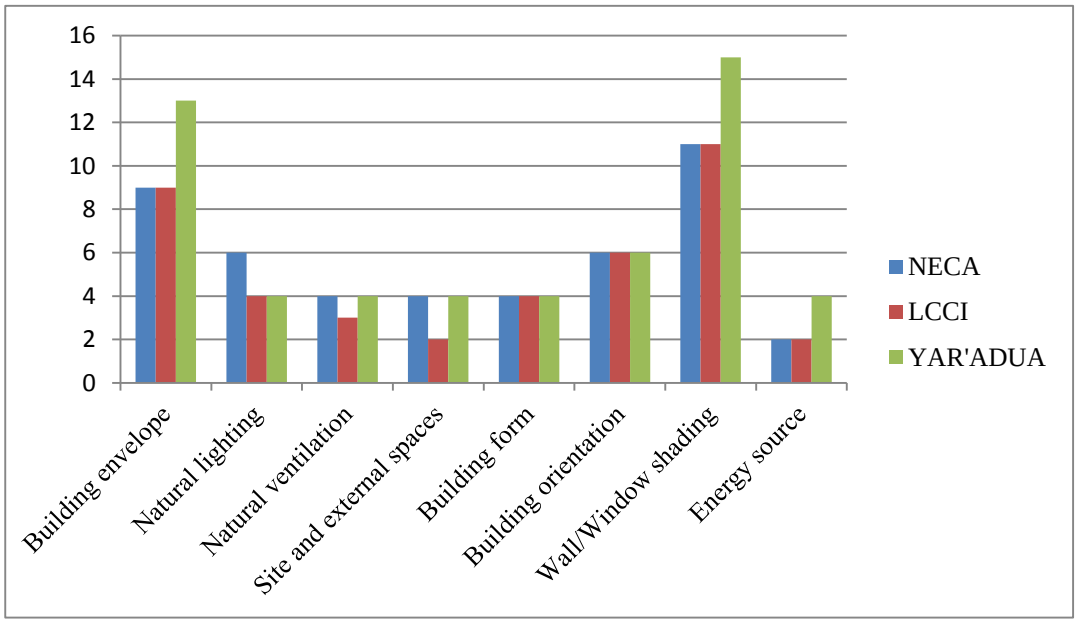
Table 4.6: Sustainable design strategies applied at Yar'adua centre

S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
1	Building envelope	Suitability of the materials to the climate				✓		No insulation material was used on the external walls. Use of light colours and the entire exterior surface of the building envelope has a smooth surface finish.
		Use of external insulation	✓					
		Use of smooth surface finishes				✓		
		Use of light colours				✓		
2	Natural lighting	Wall to window ratio (40%)			✓			Daylighting was provided through the use of windows and central atrium however, artificial lighting fixtures were used
		Use of spectrally selected glass	✓					
3	Natural ventilation	Use of openable windows				✓		Natural ventilation was provided for but was inadequate.
4	Site and external spaces	Use of interwoven landscape		✓				Presence of soft and hard landscape, but not interwoven.
		Use of impervious surfaces		✓				
5	Building form	Large building surface area				✓		Appropriate building form based on climate
6	Building orientation	Sun orientation; E-W				✓		The optimum orientation is NW-SE
		Wind orientation; SW-NE		✓				
7	Wall/Window shading	Use of horizontal and vertical shading devices	✓					Use of recessed walls on areas with windows, walls were not shaded, this exposes it to direct solar radiation
		Use of interior blinds					✓	
		Use of recessed walls					✓	
		Use of overhangs			✓			
		Use of plants		✓				
8	Existing energy source	Use of PV cells			✓			Extensive use of PHCN and generators. Minimal use of PV cells.
		Use of natural gas	✓					

Table 4.7 shows a summary of findings from the three centres and are ranked using information gotten from literature review.

Table 4.7: Summary of findings.

S/N	VARIABLES	CONFERENCE CENTRES			TOTAL
		NECA	LCCI	YAR'ADUA	
1	Building envelope	9	9	13	20
2	Natural lighting	6	4	4	10
3	Natural ventilation	4	3	4	5
4	Site and external spaces	4	2	4	10
5	Building form	4	4	4	5
6	Building orientation	6	6	6	15
7	Wall/Window shading	11	11	15	25
8	Energy source	2	2	4	10
	TOTAL	46	41	54	100



4.5 Discussions

Research has shown that the building envelope, HVAC and lighting systems working together as an integrated system are the principal factors responsible for the energy consumption of any building and these affects its efficiency. However, as established in the literature review, orientation, site and external spaces, day lighting, wall shading, natural ventilation and existing energy source are all factors to be considered in a building in order to achieve an energy efficient design.

The building envelope affects the building energy consumption which in turn affects its efficiency. It controls the amount of light and heat that gets into the building thereby affecting the lighting and HVAC systems. The thermal properties of the building envelope materials/ finishes determine how well a building conducts, emits, transfers, absorbs and reflects heat away from its surfaces. However, studies show that the lower the conductivity and transmittance values of a material, the better the material for insulation and reduction of heat transfer and the cooler the surfaces and the higher the emittance values the cooler the surfaces. Table 4.8 shows the required reflectivity of building elements. In addition to the information in table 4.8, it is important to note that roofs with slopes less than 20 degrees shall have an initial solar reflectance of not less than 0.70 and an initial emittance of not less than 0.75.

Table 4.8: Desirable reflectance level

Surface	Desirable reflectance	Typical finish to achieve reflectance
Ceiling	0.7—0.8	White colour
Wall	0.5—0.6	Cream, light green
Table top	0.35-0.5	Brick colour
Floor	0.15-0.3	Medium Grey

Source: Energy Conservation Building Code User Guide, BEE, ECO-III ( )

Windows, curtain walls and other translucent surfaces offer a view to the exterior and they allow natural lighting and possibly natural ventilation. Their main energy related parameters are their insulation value, transparency to solar radiation, and air tightness. The lower the insulation value, the greater a window's resistance to heat flow. The SHGC is the fraction of solar heat admitted by the window on a range of 0 to 1, the lower the SHGC, the lower the heat transfer, the better the window is at preventing solar gain (Sosa, 2007; Zhivov et al, 2010). For a warm humid climate, the SHGC value should be less than 0.40. A window's transparency to visible light is expressed as its visible transmittance (VT) on a range of 0 to 1. Windows with a high value of Coefficient Visible Light will maximize the natural light inside the space. The rate of heat flow (U-factor) through the unit area of glass is another property that should be considered. A low U-Factor is useful when it is important to maintain the heat outside, but it is less important than the SGHC in warm climates, hence, windows and skylights with a U-Factor less than 4.00 is appropriate. Table 4.9 shows a range of window options and their energy related characteristics and table 4.10 show the percentage reduction in solar heat gain by applying different strategies.

Table 4.9: Glazing types and energy related parameters.

CODE	WINDOW WITH GLASS	Coefficients		
		SHGC	VLTC	Factor U
a	Simple clear	0.86	0.90	6.59
b	Simple bronze or grey tint	0.73	0.68	2.09
c	Double simple clear	0.76	0.81	4.48
d	Double bronze or grey tint	0.62	0.62	3.41
e	Double high technology Low-e	0.48	0.69	2.04
f	Double high solar gain Low-e	0.71	0.75	1.82

Source: Sosa & Siem, (2004).

Table 4.10: Percentage comparison of the reduction of the solar gain of a window of simple clear glass when applying solar shades and curtain.

Strategies	Reduction of the solar gain vs. window of simple clear glass of 1/4´´
External solar shade	80%
Paper or reflective layer in glass	37 - 68%
Spectrally selective glass	37 - 58%
Glass of bronze or grey tint	26 - 37%
Interior blind of clear colour	30%
Interior blind of medium colour	22%
Curtain inside translucent	54%
Curtain inside white colour	59%
Curtain inside dark colour	15%

Source: ASHRAE handbook of fundamentals (2001)

Every material used in an envelope assembly has fundamental physical properties that determine their energy performance. The higher the energy performance of a building envelope design, the higher the sustainable performance of that envelope design Iwaro et al (2013).

The design of any shading device depends greatly on the exact path of the Sun through the sky. Thus, shading device strategies need to be tailored to the orientation of each window. Whilst some orientations are easy to shade, others are much more difficult as the Sun can be almost direct-on at certain times of the day (Reardon, 2008). Table 4.11 shows the appropriate types of shading device for use on each orientation of a building. These are intended as guidelines only as there are many variations to these basic shading types and some significant room for innovation in the detailed design of shading.

Table 4.11: Simple shading strategies for different orientation.

ORIENTATION	EFFECTIVE SHADING
Equator-facing	Fixed Horizontal Device
East	Vertical Device/Louvres (moveable)
Pole-facing	Not required
West	Vertical Device/Louvres (moveable)

Source: Reardon (2008)

5.0 DESIGN CRITERIA

5.1 Site Location

The conference centre is to be located in Lokoja, the Kogi State capital. Its coordinates are 7°49'02"N and 6°44'14"E with a total area of 3180 km². Kogi state is found in the central region of Nigeria and it lies in the warm humid zone, it occupies 29833km² and shares common boundaries with Niger, Kwara, Nasarawa and the Federal Capital Territory to the north, Benue to the east, Enugu and Anambra to the south and Ondo, Ekiti and Edo to the west. Plate XL shows the map of Nigeria showing map of lokoja, Kogi state in red.



Plate XL: Map of Nigeria
Source: www.ngex.com

5.2 Climatic Data of Site

Lokoja is found in the warm humid zone of Nigeria which lies within the sub-equatorial rainforest. It encompasses the coastal region, forest and the transitional regions and has the low-wet climate of the tropics. This zone experiences heavy rainfall usually between 1000mm and 1250mm. The climate is characterized by high humidity and is associated with hot discomfort for about eleven months in a year. The

main rain occurs between April and October, and the maximum temperature never falls below comfort limit. Plate XLI shows this data.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C (°F)	28 (82)	31 (87)	32 (90)	32 (90)	31 (87)	28 (83)	27 (81)	27 (81)	27 (81)	28 (82)	29 (84)	29 (84)	29.1 (84.3)
Average low °C (°F)	26 (79)	31 (87)	31 (88)	31 (87)	29 (84)	27 (80)	26 (78)	26 (78)	26 (79)	26 (79)	27 (81)	27 (81)	27.8 (81.8)
Precipitation mm (inches)	5 (0.2)	10 (0.4)	41 (1.6)	97 (3.8)	150 (5.9)	155 (6.1)	168 (6.6)	170 (6.7)	211 (8.3)	122 (4.8)	13 (0.5)	3 (0.1)	1,145 (45)

Plate XLI: Climatic data for Lokoja
Source: Weather base, 2011

5.3 Site Selection Criteria

Lenhart (2007), states that in present times, conference centres are built in prime areas and on prime site near hotels and attractions. They are part of an overall down town package that makes the destination competitive. He also stated that conference centres should have relative proximity to commercial accommodation. Other key considerations include size of site, room for future expansion, availability of iconic views and consentability under the resource management act (ibid). The choice of location should be within an area reserved for institutional facilities and public utilities, a location that is easily accessible by good roads to aid smooth traffic flow and encourage patronage and which is far away from industrial zones to avoid all forms of industrial pollution.

Lokoja has limited land areas due to the presence of hills and water ways. It is a developing state that has no detailed or structured land use map. But plate XLII shows lokoja's urban area within the perimeter circle.

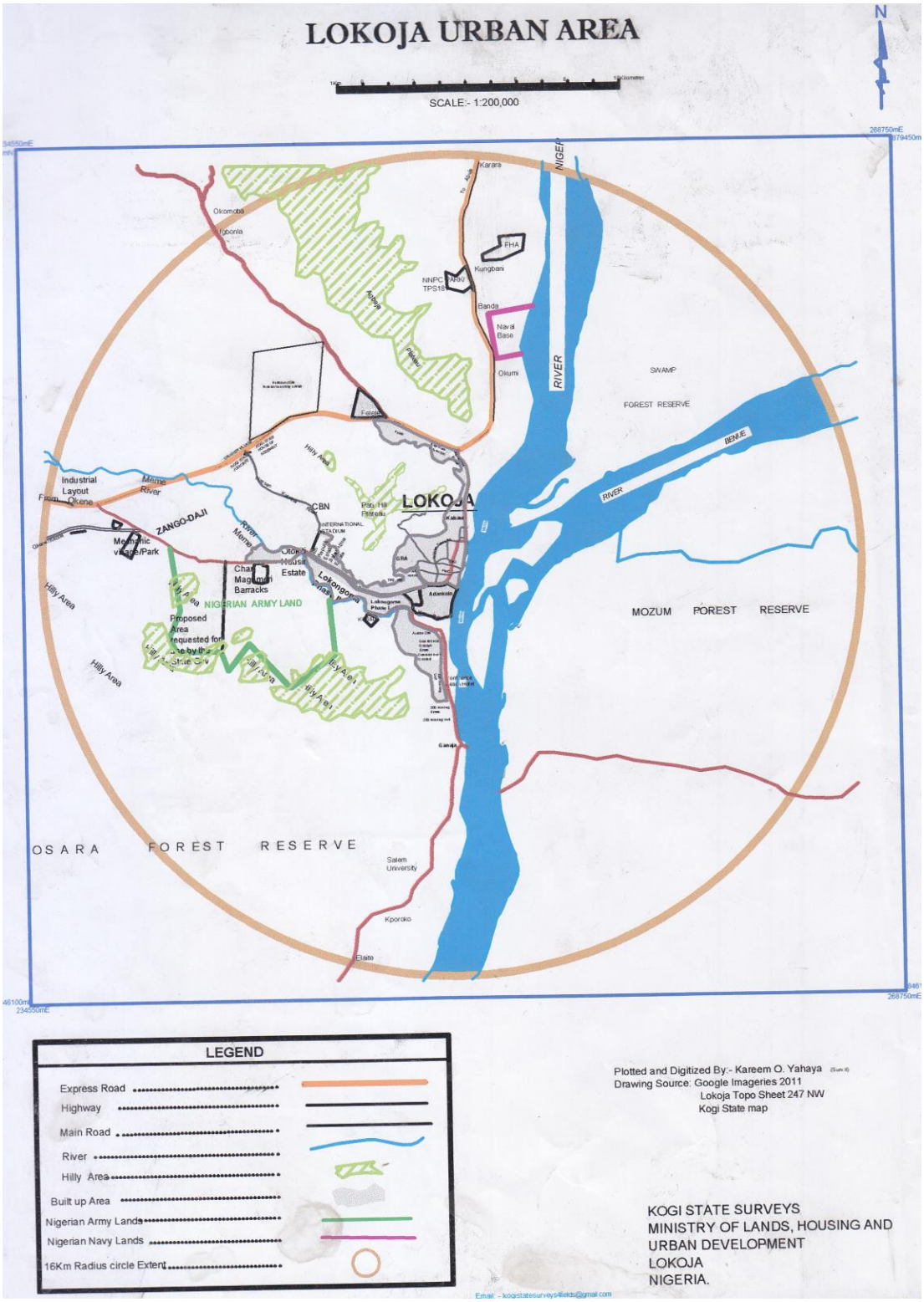


Plate XLII: Lokoja urban area
Source: Kogi State survey, Ministry of Lands, Housing And Urban Development, 2013

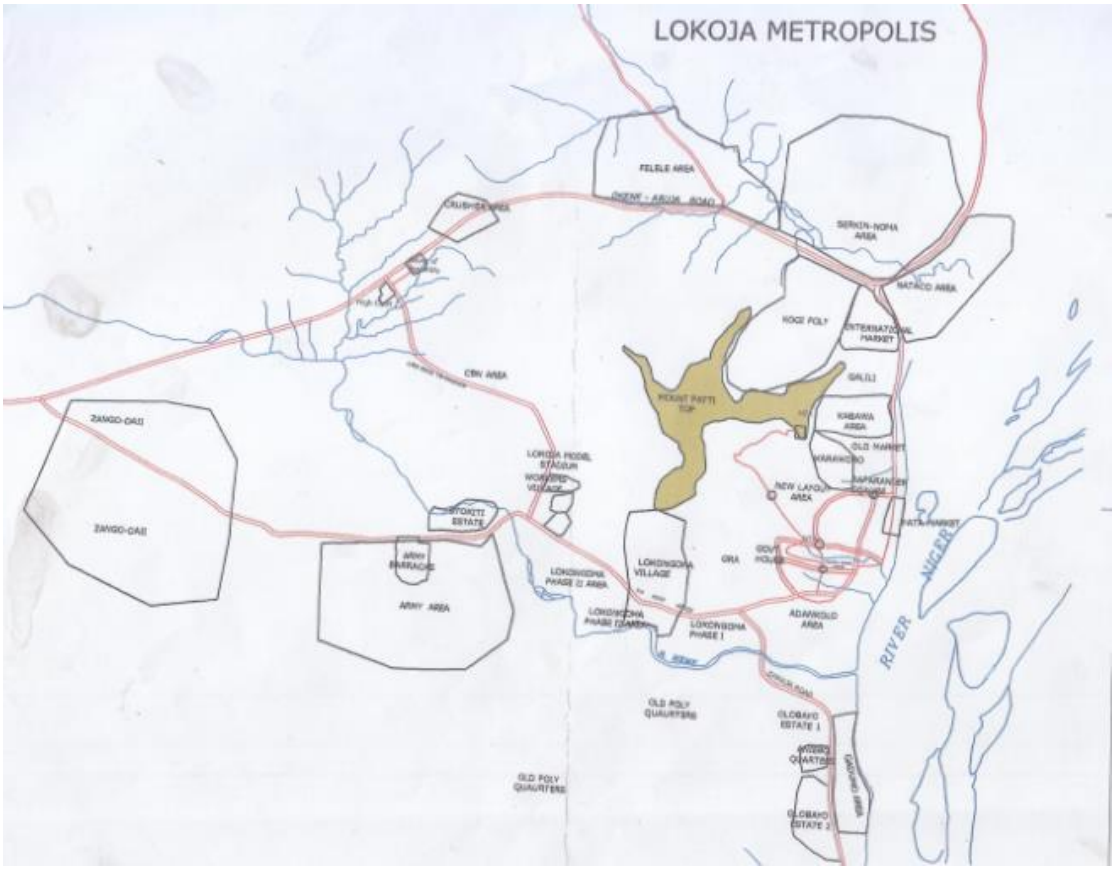


Plate XLIII: Lokoja urban area
Source: Kogi State survey, Ministry of Lands, Housing And Urban Development, 2013

Within the perimeter circle, the shaded area in Plate XLIII is the proposed central business district of lokoja which is suitable for the location of a conference facility, hence three sites were chosen from this area as seen in Plate XLIV and will be weighed based on the above considerations in order to select the most appropriate site.

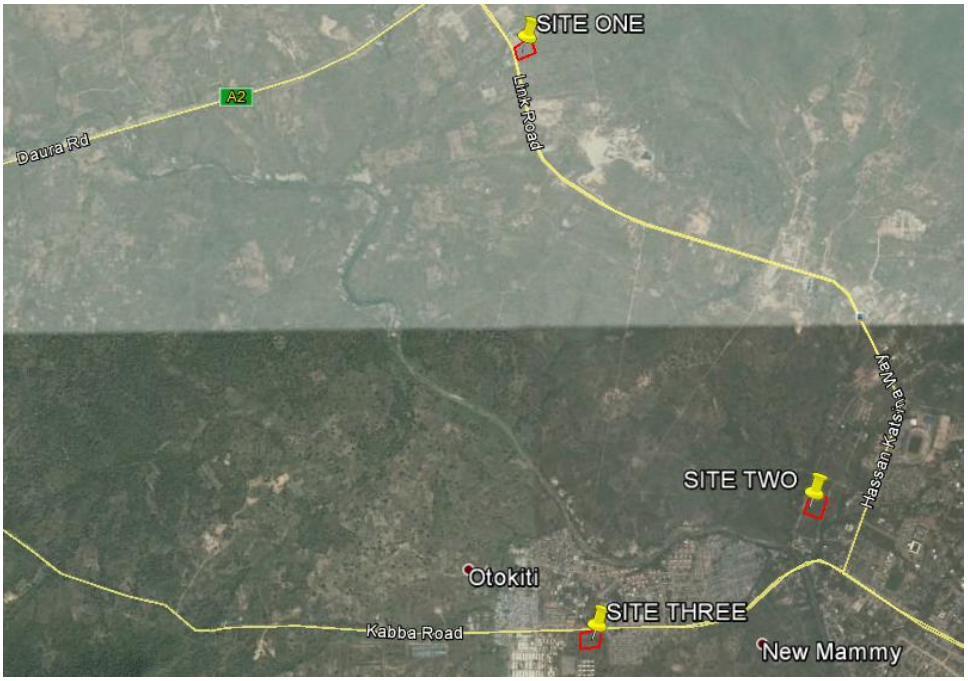


Plate XLIV: The selected sites
Source: Google earth, 2014

5.3.1 Site one

This area is located along Hasssan Katsina Way, Zone 8. It is in close proximity to the state judiciary, Federal High Court, Federal Inland Revenue Service (FIRS), and Aloma hotel and resort off the Abuja - Okene express way. The site is accessible by road through the route that branches off the Hassan Katsina express way as shown in Plate XLV



Plate XLV: Proposed site one
Source: Google earth, 2014

5.3.2 Site two

This area is also located along Hasssan Katsina Way, Zone 8. It is in close proximity to the international stadium and the Central Bank of Nigeria (CBN). The site is accessible by road through the route that branches off the "crusher junction" express way as shown in Plate XLVI.



Plate XLVI: Proposed site two
Source: Google earth, 2014

5.3.3 Site three

This area is located along Kabba road. It is in close proximity to the chari maigumari barracks and otokiti housing estate. It has no link to the road as shown in Plate XLVII.



Plate XLVII: Proposed site two
Source: Google earth, 2014

Based on the listed criteria, a quantitative result was derived and the best site was selected. The rating is as follows: 5 for most appropriate; 4 for appropriate; 3 for moderately appropriate; 2 for not appropriate; and 1 for least appropriate.

Table 5.1: Site selection criteria

CRITERIA	**SITE ONE**	**SITE TWO**	**SITE THREE**	**REMARKS**
Accessibility	4	4	4	Both sites are accessible by good roads.
Proximity to conference support facilities	5	3	2	Site one has a closer proximity to hotels and attractions.
Proximity to attractions (scenic views)	5	3	2	Site one has more proximity to scenic views.
Distance from heavy traffic	4	3	3	Site two faces more traffic due to its closeness to residential and commercial areas.
Expansion possibilities	4	3	3	Site one has more expansion possibilities.
Land use compliance	5	5	3	Both sites are indicated for public facilities and are centrally located.
TOTAL	27	21	17	Results shows that site one is more suitable.

From table 5.1, the most appropriate location for the conference centre is site one.

5.4 The Proposed Site

The site is located within the proposed central business district in close proximity with other public buildings. It is approximately 12 acres which is within the recommended guideline for the size of a conference centre. Plate XLVIII shows a site location map from Africa to Lokoja.

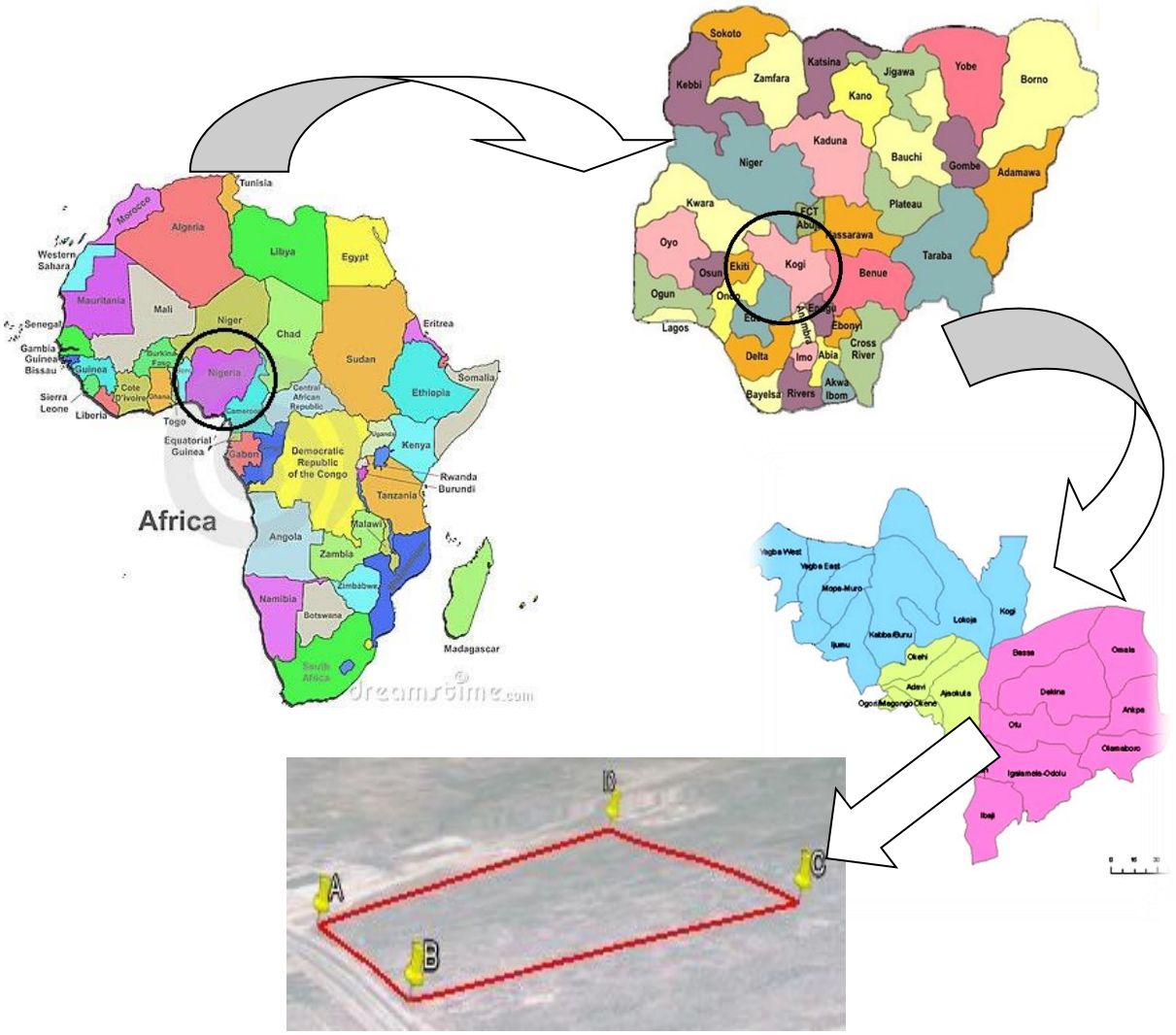


Plate XLVIII: Site location map
Source: Google earth, 2014

The proposed site is moderately undulated, it slopes gradually downwards from the North-East to the South-West. It is underlain by rocks of the basement complex, the main rock type is migmatite with pockets of gneiesses. The soil is very sandy, specifically, sandy loam but it is interspersed with minor outcrops that have undergone weathering showing fragments of quartz and feldspars. The soil is well drained.



Plate XLIX: Proposed site
Source: Google earth, 2014

The site is easily accessible through the use of good roads and has a lodging facility within walking distance as indicated alphabet 'A' in plate XLIX.

5.5 Features Present on Site

The features present on the site are natural and manmade. The information of the natural features are seen from the climate and topography of the site. These include; the contours, the geology of the site and drainage problems as well as existing natural features such as trees, ground cover, ground texture, and soil conditions as shown in fig 5.1. The manmade features are the road system, existing infrastructures (buildings, walls, fences, patios, plazas, bus stop) and services. This is seen in figs 5.2 and 5.3.

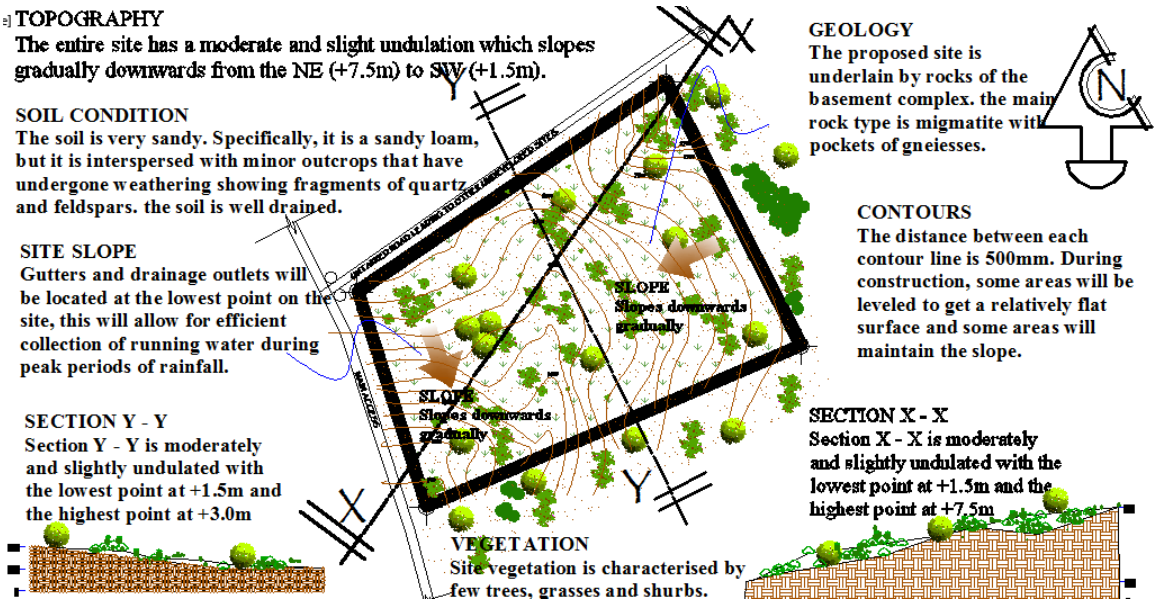


Figure 5.1: Site features
Source: Author's sketch (2014)



Figure 5.2: Site analysis(Views)
Source: Author's sketch (2014)

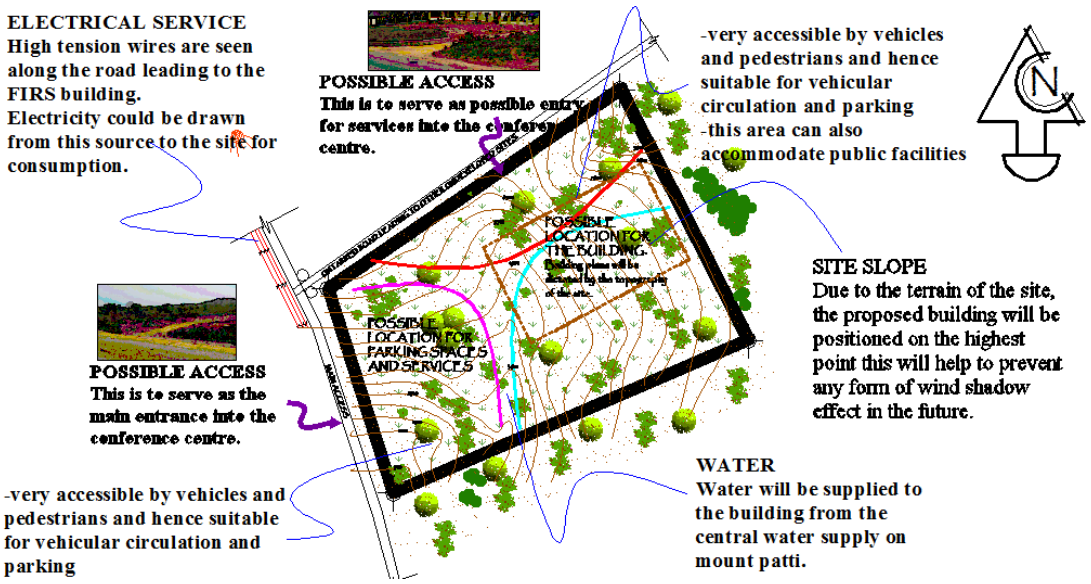


Figure 5.3: Site analysis
Source: Author's sketch (2014)

The parameters in fig 5.3 will be analyzed to determine the best planning strategy and building form to adopt in order to achieve a sustainable conference centre.

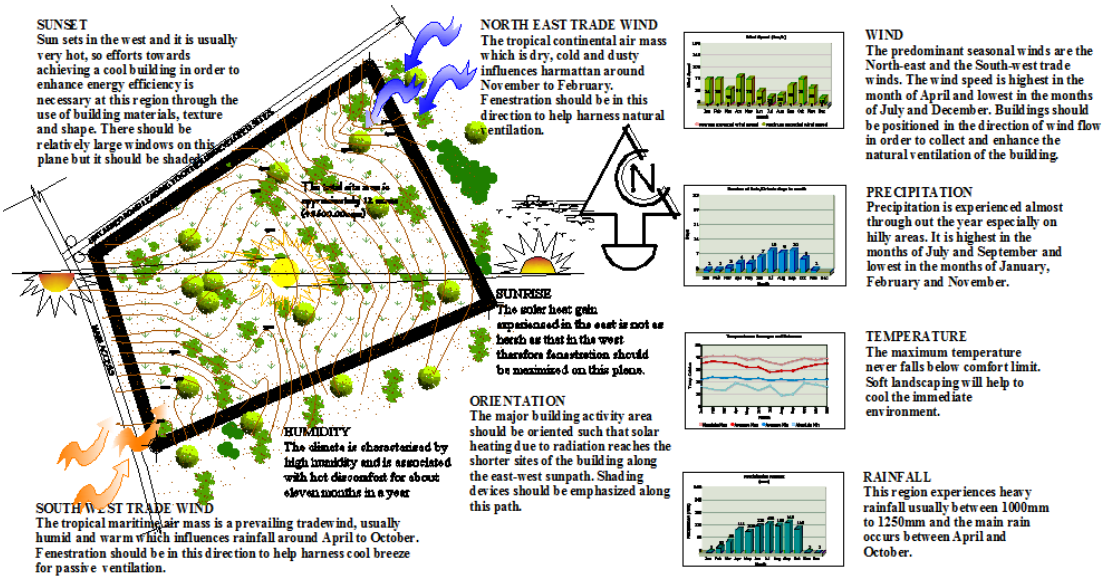


Figure 5.4: Site analysis (Climate)
Source: author's sketch (2014)

5.6 Site Zoning Concept

Zoning of the site was based on the noise surrounding the site and areas which will be proposed for various activities ranging from public areas to private areas.

Zone A is suitable for the conference facilities because of its distance from sources of noise. It is positioned on the highest point of the site to avoid any form of wind shadow effect. Zone B is suitable for functional outdoor activities and multipurpose areas for events and meetings as well as cultural shows. Zone C is suitable for outdoor meetings and break out areas and Zone D is suitable for parking spaces due to its proximity to the road (entrance).

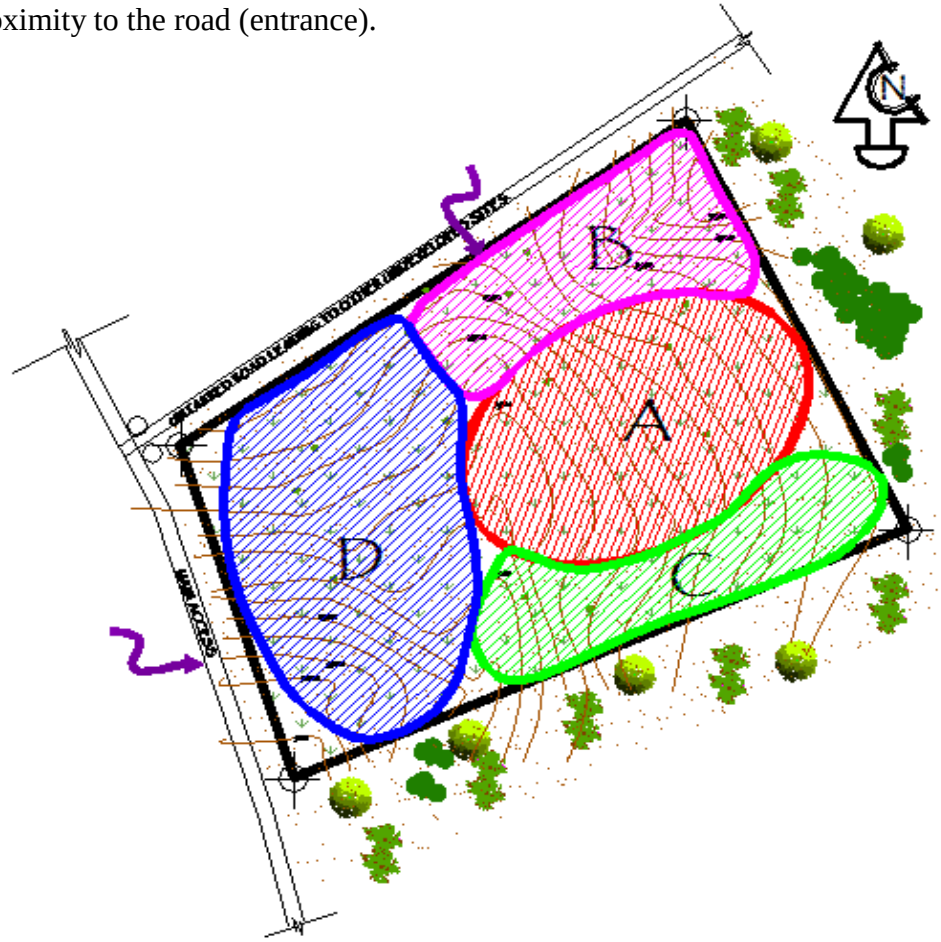


Figure 5.5: Site zoning
Source: Author's sketch (2014)

5.7 Site Development Concept

The topography of the site informed the placement of facilities within the site. This considered the ease of circulation and water drainage due to the undulating nature of the site. The climatic conditions was also considered in positioning the building in terms of building orientation.

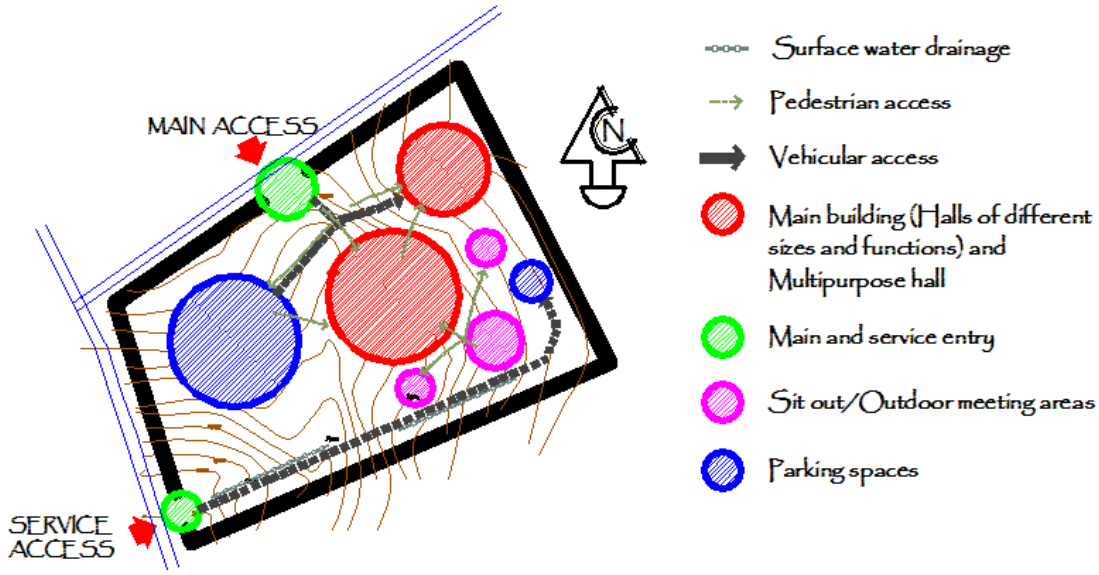


Figure 5.6: Site development concept
Source: Author's sketch (2014)

Figure 5.6 shows The general planning of the site and facilities are such that the activity relationship are well co-ordinated to create a harmonious grouping and ease of circulation. Accessibility to site is convenient and free from all obstruction. Two separate accesses were provided, The main access which is for staffs, users and visitors while the other for services. The main access is complimented with a pedestrian walkway.

6.0 DESIGN REPORT

6.1 Introduction

Lokoja with its fast increasing educational, social and economic facilities does not have sufficient and organized spaces for meetings, conferences, exhibitions, seminars as well as social gatherings, to this effect the proposed conference centre has been planned and designed to host different events of different sizes with a capacity range of two to three thousand. The facilities provided include; Auditorium, foyer and gallery, seminar rooms, exhibition hall, banquet halls and out-door meeting areas. Other auxiliary facilities include; offices, restaurants, library and parking spaces.

6.2 Design Brief

Kogi State Government needs a conference centre which is expected to meet the standards of the current trends in conference centres. This will cater for:

1. The annual educational summits held at the Kogi state university's lecture hall,
2. Training/ seminar sections for the "conquering mount patti" exercise which is held yearly,
3. Community meetings/events and weddings,
4. Source of internal revenue and
5. Activities like graduation ceremonies, tradeshows, Exhibitions and cultural display, consumer shows and banquets.

The proposed design is expected to provide facilities for various forms of gathering ranging from formal to informal gathering. The site is approximately 12 acres which is within the recommended guideline for the size of a conference centre.

Table 6.1: Schedule of accommodation

FACILITY	DIMENSIONS FROM		ADOPTED	NUMBER	TOTAL
	STANDARD (MIN)	CASESTUDY			
Auditorium	0.5 sqm/person	0.5 sqm/person	0.6 sqm/person	2000	1800sqm
Banquet hall	1.8 sqm/person	2.1 sqm/person	2.1 sqm	1500	368 sqm
Conference hall	1.2 sqm/person	1.2 sqm/person	1.5 sqm/person	150	225sqm
Exhibition hall	1.8 sqm/person	1.8 sqm/person	1.8 sqm	60	108 sqm
Meeting rooms	1.2 sqm/person	1.2 sqm/person	1.5 sqm/person	150	225sqm
Kitchen	0.8 sqm/person	1.2 sqm/person	1.2 sqm	Staff Size	
Library	0.4sqm/person	-	0.6 sqm/person	142 staff	86 sqm
Office	11sqm	-	20sqm	1	20sqm
Pre-functional area		8sqm	20sqm	1	20sqm
Store	3.5sqm		15sqm	2	30sqm
Restroom	1.2sqm/person	1.6sqm/person	1.8sqm/person	Pending on	

6.3 Design Concept

The design concept originates from a variety of sustainable symbols. These symbols stands for the building envelope which is a major component in the issue of energy consumption and the sustainable design strategies. In figure 6.1, the green plants represent sustainable design strategies while the bulb represents the building envelope and its component.



A B C

Figure 6.1: Sustainable symbols

A shows that the sustainable strategies are applied only on the outer environment of the building.
B shows that the sustainable strategies are applied only within the building, and

C shows that the strategies are applied within and on the outer environment of the building.

Option **C** is the most efficient in reducing energy consumption as demonstrated in fig. 6.2.

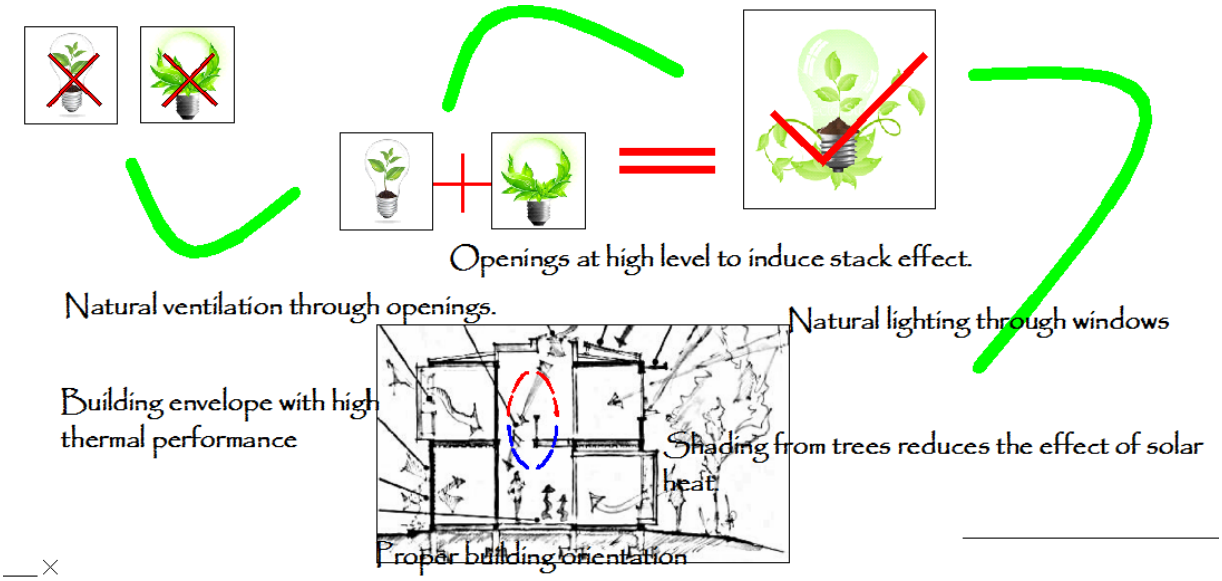


Figure 6.2: Concept

6.4 Design Considerations

This conference centre is an environmentally friendly project which has used technology and abundant natural resources to develop a model which show cases energy efficiency. The centre is dedicated and committed to sustainable design and the strategies employed based on the variables gotten from the literature review reflects this commitment. The proposed design will significantly reduce the energy it would originally consume, this will be achieved by in cooperating the sustainable strategies from the preliminary stages of the design to finish.

6.4.1 Climate

The climate of the site plays a significant role in the design of the proposed building. In a warm humid region such as lokoja which is characterized by high humidity and hot discomfort, building materials, considerations and construction techniques are

such that they should keep off heat rather than absorbing it thereby reducing the building interior temperature and running time of the air conditioning systems.

6.4.2 Site

Building orientation was with regards to solar radiation and wind, the longer sides of the building was oriented to face the south and the north direction on the east and west axis respectively. Openings on the east and west sides of the building were shaded with trees and horizontal and vertical shading devices. The proposed building was placed on the higher point of the site to avoid any form of wind shadow effect and drainages were placed on the lower points of the site, this will help for easy drainage during peak periods of rainfall. The site incorporated native plants and wild grasses to reduce direct sun from striking and heating up the building surfaces, this will prevent reflected light carrying heat into the building from the ground to other surfaces. Impervious landscaping surfaces was minimized to achieve maximum drainage.

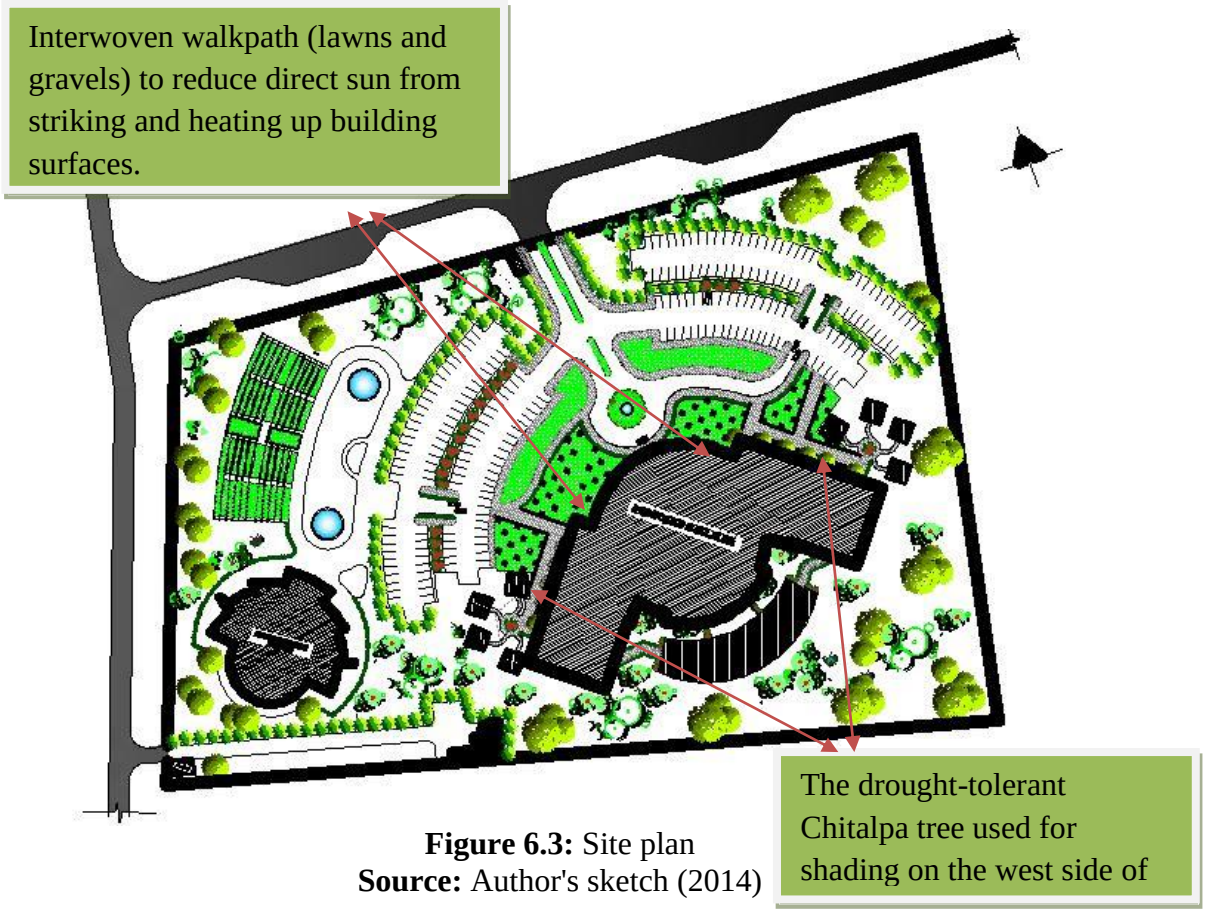


Figure 6.3: Site plan
Source: Author's sketch (2014)

Deciduous planting provided for shading during summer and allows desirable solar gains during winter and added aesthetic to the centre. The drought-tolerant Chitalpa tree (*Chitalpa x tashkentensis*) is recommended for this design, it grows several feet a year to a mature height of 25 to 30 feet. It has an open branching structure and casts a dappled shade. This heat-loving tree blooms with pink, white or lavender flowers all summer long. It requires low water usage after it is established within surrounding. Plate L illustrates this.



Plate L: Chitalpa tree
Source: http//www.ehow.com.

6.4.3 Building Envelope

The roof receives significant solar radiation and plays an important role in heat gain/ losses and daylighting, hence light colours were used on the roof to reflect light that will heat up the surface from the roof. Atrium was introduced in order to allow adequate passage of sunlight and escape of hot air from the building.

Double glazing, low emittance coatings, blue/green tints have become very important means of energy conservation in modern construction to reduce both thermal losses

and heat gain, hence it was used in this design. Figure 6.4 shows materials of the building envelope component. The depth of the spaces within the building was minimized in order to have direct access to daylight which helped to reduce the need for artificial lighting.

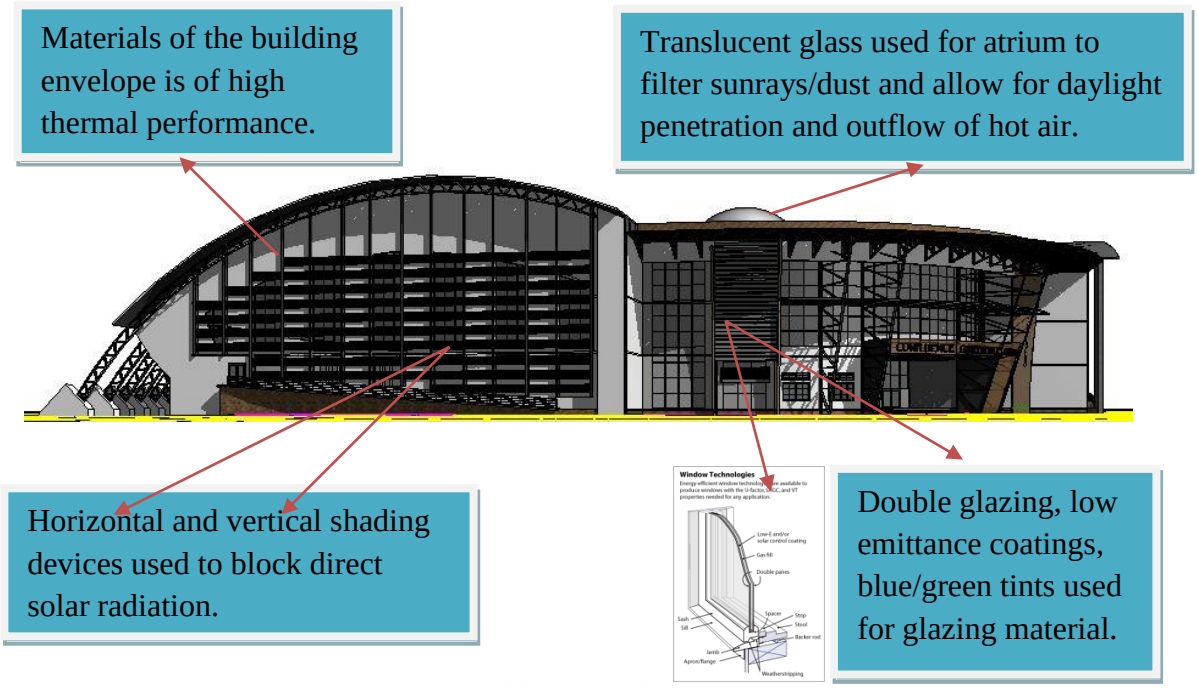


Figure 6.4: Building envelope component
Source: Author's sketch (2014)

6.4.4 Building shape and form

In warm humid climates, Forms with large surface areas facing North and South are preferred to reduce solar radiation. This influenced the shape and form of the proposed conference centre. Figure 6.5 shows the massive nature of the proposed centre.



Figure 6.5: Building form with large surface area
Source: Author's sketch (2014)

6.4.5 Spatial Organization

The general planning of the site and facilities are such that the activity relationship are well co-ordinated to create a harmonious grouping and ease of circulation.

A. Accessibility

Accessibility to site is convenient and free from all obstruction. Two separate accesses were provided, The main access which is for staffs, users and visitors while the other for services. The main access is complimented with a pedestrian walkway.

B. Site Drainage

The site drainage is positioned at the lowest point on the site, this is to allow easy flow and collection of running water during rainfall.

C. Main Facilities

This centre consist of three floors, all floors are designed to have an open plan circulation in order to encourage free movement of air and users. The entrance of the building leads to the reception desk which is directly before the central atrium. At the reception, necessary enquires are made and other spaces such as the Auditorium, Banquet hall, Conference rooms, Exhibition halls, Pre-functional areas, Meeting rooms and offices/security can be accessed as shown in figure 6.6. Stair cases are also provided for vertical movement of user.

Meeting spaces are equiped with whiteboards, projectors, sound and wireless internet, flip charts screens and special technical facilities and audio visual requirements to suit the user's needs.

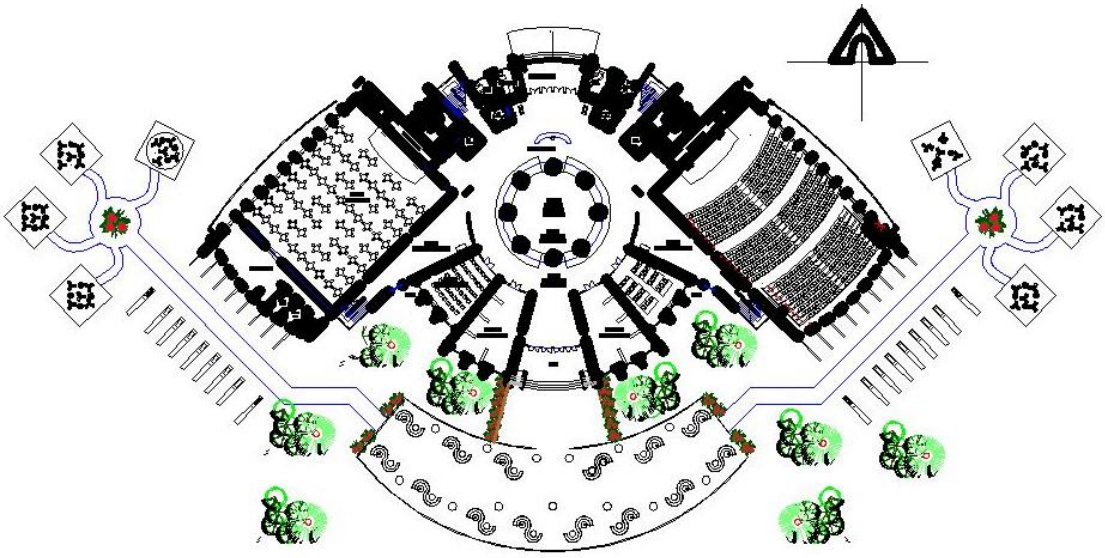


Figure 6.6: Ground floor plan of proposed conference centre

The first floor consist of the library, four meeting/seminar rooms and two conference halls. halls as seen in figure 6.7.

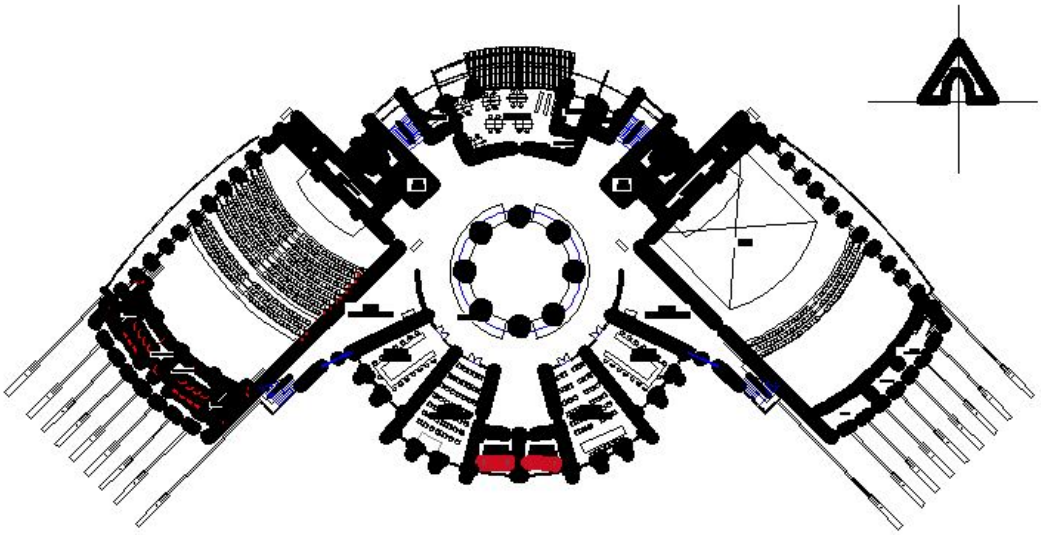


Figure 6.7: First floor plan of proposed conference centre

The second floor consist of the private lounge, manager's office, board room and four conference halls as shown in figure 6.8

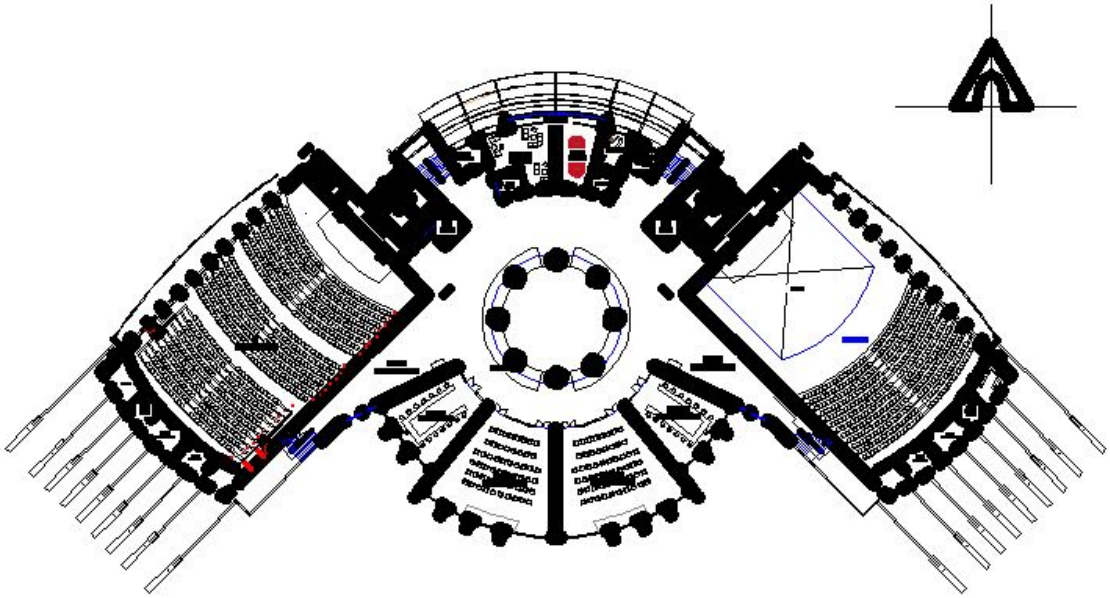


Figure 6.8: Second floor plan of proposed conference centre

Throughout the entire design of the building, day light, natural ventilation and materials of the building envelope play a vital role as seen in figure 6.9. With materials of high thermal performance, sufficient day light and good quality of air present in the building, the use of mechanical means of ventilation, cooling, and lighting is drastically reduced.

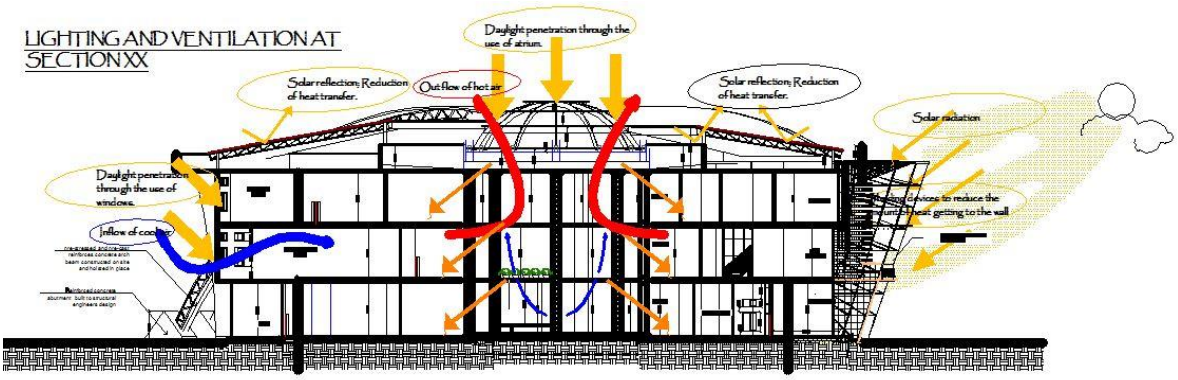


Figure 6.9: Sustainable strategies applied

D. Safety

Fire is one of the greatest risks in every building. For this reason, efforts are made to limit the fire risk with the aid of corresponding fire protection regulations and loss-

prevention measures. Fire compartments are adopted. Partition walls are made of non-combustible materials and must reach right up to the structural ceiling, doorways are sealed with tightly closing fire resistant doors.

Stairwell walls are made of fire-resistant walls of non-combustible materials installed, which will trigger a fire alerts on the buildings central control panel.

6.4.6 Acoustics

The auditorium is completely protected from any external and internal sound. Bricks in wall which is good at excluding external sound was used. High ceilings was also used in order to provide longer reverberation time. Acoustic panels were used in the ceilings to reflect sound back to the listeners without echo and use of acoustical doors equipped with heavy duty hardware and seals to prevent noise leakage. Figure 6.10 illustrates sound reflection from the ceiling shape.

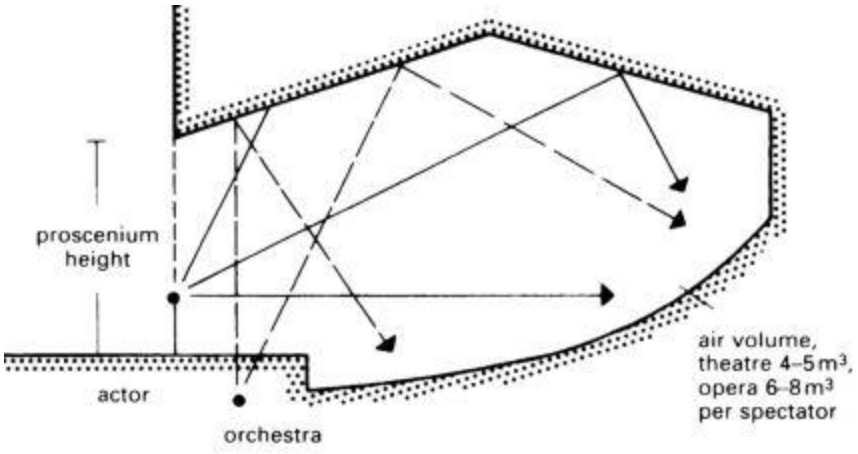


Figure 6.10: Ceiling shape and sound reflection
Source: Neufert (2000)

6.4.7 Insulation

Heat naturally flows from a warmer to a cooler space; insulation provides resistance to heat flow, thereby reducing the amount of energy needed to keep a building cool in the summer.

6.4.8 Materials and finishes

Building materials were chosen giving consideration to daylighting opportunities, solar gains, cooling loads, glare and other aspects such as efficiency, embodied energy, environmental impact and durability.

i. Clay bricks in concrete render



Plate LI: Clay bricks
Source: http://www.buildingmaterials.org

Clay bricks in concrete render is known for its good thermal qualities, it is recommended because it has a good thermal capacity, high time lag and good compressive strength. It can reduce total heating or cooling energy requirement by about 25%.

ii. Polished precast concrete and perforated precast concrete panels are used for walls

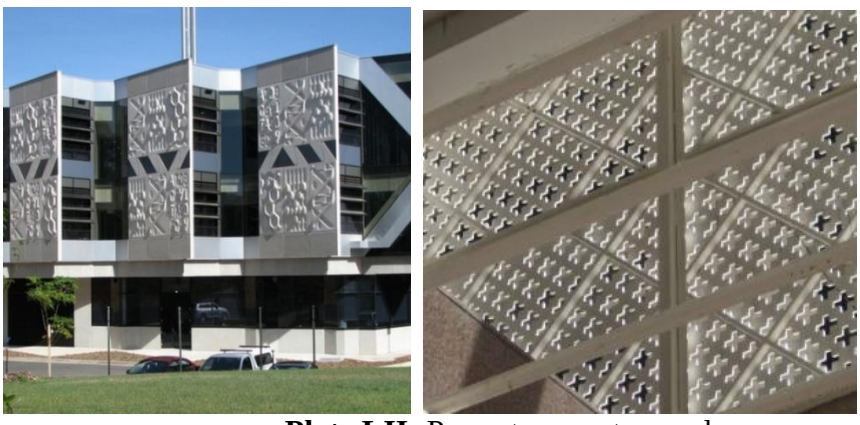


Plate LII: Precast concrete panels

The thermal mass inherent to precast concrete lends itself to energy efficiency and reduces the heating and cooling peaks and loads; often necessitating less costly mechanical system.

iii. Double glazing, low emittance coatings, blue tints aluminium frame windows

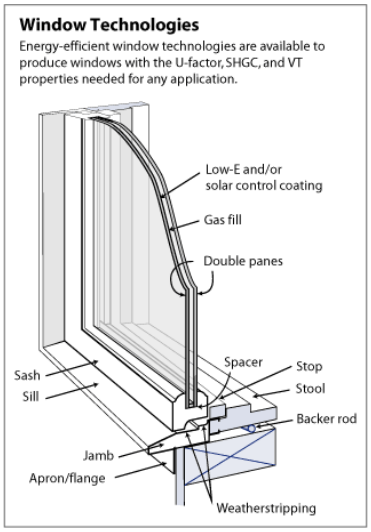


Plate LIII: Double glazing, low emittance coatings, blue tints aluminium frame windows

This glazing type allows for increased window area without sacrificing thermal and visual comfort of the interior spaces. Compared to standard windows, the high-performance model reduces heat losses and heat gains through the windows by 30 to 50% (Eubanks, 2007). Other benefits include "significant energy savings, increased thermal comfort, reduced noise transmission, reduced condensation (fogging), and reduced fading of fabrics from UV [ultra violet] radiation" (Lechner 2001).

iv. Translucent glass for atrium



Plate LIV: Translucent glass

Translucent glass is available as standard in nine colours from clear, ice and opal, orange to blue, green and bronze colours as well as grey and silver. Its nature allows for daylight penetration and outflow of hot air.

v. Solatube daylighting system



Plate LV: Solatube daylighting system

Solatube daylighting systems are devices which harness and transfer natural light from the sun. They capture sunlight on the roof top, redirect it down a highly reflective shaft and then diffuse an abundance of pure natural daylight throughout the interior space. It is naturally bright, free and, contrary to a light bulb, never burns out. This systems operate using solar energy, hence, they reduce reliance on electricity, lessen the impact on the environment, and cost little to nothing to operate. They allow for run lengths over 30feet to deliver sunlight to lower floors. This was used in my design to reduce the need for artificial lighting.

vi. Shading devices



Plate LVI: Wall and window shading

Shading of walls and windows reduces the total amount of heat that enters into a building. These shading devices intercepts, absorbs and or reflects solar radiation before it reaches the surface of the building envelope.

6.4.9 Renewable Energy Supply

Photo voltaic solar panels are used to generate electricity to help meet a portion of electricity requirement. According to Kogi (2007), the estimated peak power output of 1000mm x 670mm is 40watts. From this design the total area covered by the PV panels is approximately 1080sqm. The estimated power output is as follows;

Area of 1 module = 0.67sqm = 40w (power output)

Area of panel coverage = 1080sqm

Number of module in panel coverage area = (1080 /0.67)sqm = 1611.94 panels ≈ 1612 panels

Hence the total power output generated by the PV panels in the conference centre is

= 1612panels x 40watts = 64480w ≈ 64.48kw [± 1kw] (kilowatts).

.'. Total possible output = 64.48kw. [± 1kw]

For the purpose of this design, compact fluorescent light tubes which are energy saving are used. 45w and 23w decorative ceiling mounted light fittings are used for the halls and office spaces respectively and air conditioning systems which consume 2000w are used. Table 6.2 shows the amount of brigthness in lumes you can expect from different wattage light bulbs.

Table 6.2: Different Wattage Light Bulbs

Incandescent Watts	CFL Watts	LED Watts	Lumens (Brightness)
40	8 - 12	6 - 9	400 - 500
60	13 - 18	8 - 12.5	650 - 900
75 - 100	18 - 22	13+	1100 - 1750
100	23 -30	16 - 20	1800+
150	30 - 55	25 - 28	2780

Source: Energy efficient lighting (2014)

From the design, the estimated number of lighting and HVAC wattage is expressed in table 6.3 as follows:

Table 6.3: Estimated Number of Lighting and HVAC Systems

S/N0	FUNCTIONAL UNIT	NUMBER OF UNITS	NUMBER OF LIGHTING POINTS/UNIT	HVAC
1	Auditorium A	1	50	8
2	Auditorium B	1	40	6
3	Banquet hall	1	40	6
4	Conference hall A & D	2	6	1
5	Conference hall B & C	2	12	2
6	Conference hall E & F	2	8	1
7	Exhibition halls A & B	2	8	1
8	Meeting rooms A & B	2	6	1
9	Meeting rooms C & D	2	4	1
10	Multipurpose hall	1	60	8
11	Entrance Foyer Reception Waiting area	1	8	1
12	Circulation spaces	3	8	
13	Pre-functional areas	3	4	1
14	Kitchen	1	12	
15	Library	1	12	2
16	Utility room	6	1	
17	M/Director	1	2	1
18	Secretary	2	2	1
19	Event manager	1	2	1
20	Security	1	2	1
21	Control room	1	2	1
22	Mech. control	1	2	1
23	Projection room	2	2	1
24	Sound control booth	2	2	
25	Toilets	6	2	

Source: Author's research (2014)

Total approximate value of electricity consumed in the interior of the facility of the conference centre is 15210w (15.21Kw) for lighting and 110000w (110.00Kw) for cooling, a total of 126130w (126.13Kw).

If the peak power generated by the PV panel is 64.48Kw, then the

percentage reduction in electricity consumption based on the use of PV panels is:

(64480/126130) x 100% = 51.12% ~51%

Battery banks are also used as back up to provide electricity and generators are provided to charge these batteries.

6.4.10 Model and simulation

One of the aims of this research is to find out the extent to which sustainable design strategies were applied in conference centre design and their effect on energy efficiency. Consideration was placed on the building envelope because it has significant effects on cooling and lighting energy use. Hence from the three case studied, a comparable study applying existing and recommended materials to the building envelope was carried out on a model to determine its percentage reduction in cooling and lighting loads using ECOTECT software. Table 6.2 shows the result of the analysis.

Table 6.4: Simulation results

	SET A DEFAULT	SET B: WINDOW	SET C: WALLS	SET D: ROOF	SET E: RECOMMENDED
WALL	Concrete block plaster		Brick concrete wall plaster		Brick concrete wall plaster
FLOOR	Concrete slab on ground				Concrete slab tile on ground
WINDOW	Single glazed alumframe	Double glazed low E alumframe			Double glazed low E alumframe
ROOF	Corrugated metal roof			Clay tiled roof	Clay tiled roof
DOOR	Solid core pine				Solid core pine
COOLING LOAD (WH)	6155165	4977536	5486316	4723457	2875366
DIFFERENCE (WH)		1177629	668849	1431708	3279799
PERCENTAGE(%)		19.13	10.87	23.26	53.29

Source: Simulation and data done by self elaboration with the software ECOTECT for a cubicle of square shaped floor with the climate data of Lafia. Nigeria.

From table 6.2 The simulation was ran five times, the first one was a default analysis called SET A which comprised of the conventional building materials taking note of

the materials used in the case study. In SET B, C and D, all the materials were kept constant except the window in SET B, walls in SET C and roof in SET D. All the sets have various percentage decrease in cooling energy loads. In set E, all appropriate materials were used and a 53.29% reduction in cooling load was recorded. Hence these and other materials with higher energy performance can be recommended for a building in a hot humid climate.

CHAPTER SEVEN

SUMMARY AND CONCLUSION

7.1 Summary

The aim of this research was to explore the concept of sustainable design strategies in an attempt to enhance energy efficiency in conference centres, this was achieved by having an in-depth review of sustainable design strategies, energy efficiency factors and their application in conference centres, investigating the extent to which these strategies were applied in conference centre designs and finally, a demonstration showing the application of these sustainable design strategies on a conference centre design in a warm humid climate.

The sustainable design strategies include use of low energy materials for the building envelope and its components, full use of daylighting in all areas to eliminate the need for supplementary artificial lighting during the day time, use of open floor plan system to enhance air circulation, to avoid air conditioning in areas during periods where natural ventilation is adequate and only human comfort is required, use of shading devices where necessary and proper orientation of the building on the site. Figure 7.1 shows the relationship between architectural requirements, energy efficiency factors and the results obtained if sustainable strategies are applied appropriately.



Figure 7.1: Relationship between architectural design requirement, energy efficiency requirement and results gotten from strategies applied.

Site analysis and documentation of the study area was conducted, which forms the fifth chapter.

A design report which consist of the design brief, schedule of accommodation, design concept and design considerations form chapter six of this thesis.

7.2 Conclusion

The quest to achieve thermal comfort within a building is the primary reason why a lot of energy is consumed during the building's operational stage. This is true because most electrical and mechanical devices within the building are usually used for adjusting interior conditions to suite the users. Deductions made from various literature shows that the application of sustainable design strategies can reduce energy consumption in a building, this will maximize occupant health and comfort and minimize energy use by relying less on mechanical and electrical systems. Furthermore, it is intended to achieve higher standard of energy efficiency without sacrificing thermal comfort.

7.3 Recommendation

Buildings should be made to maximize the site's potential and to achieve the best possible orientation for functional areas. Shading devices should be introduced to those areas that face severe heat collection from the sun path or such walls should be insulated to reduce heat emitted into the building.

Issues of sustainable planting and landscaping should be considered by planting more trees and grasses to enhance the cooling of the immediate environment. Building materials should be of high thermal performance in order to reduce heat gain.

7.4 Contribution To Knowledge

1. The study established that the application of sustainable design strategies such as proper building orientation, appropriate building envelope materials, landscaping and shading can reduce the energy of cooling loads in conference centres by 53.29%.
2. The research demonstrated that the combination of building materials such as clay bricks in concrete render and perforated precast concrete panels used effectively in a design helps to reduce a building's cooling energy load, while perforated concrete panels allows natural ventilation and lighting which in turn reduces lighting energy load in a building.

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APPENDICES

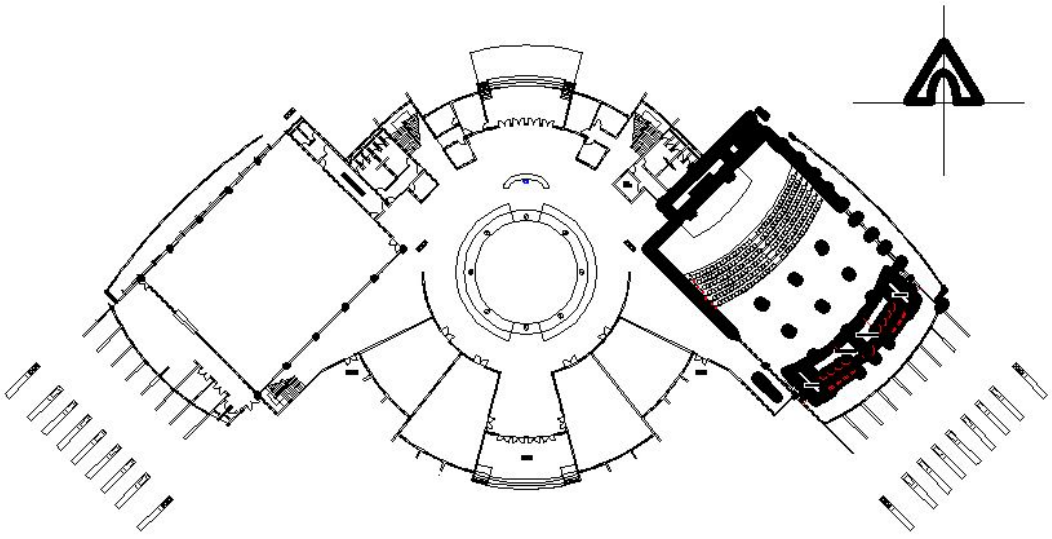
APPENDIX 1: CASE STUDY CHECKLIST

S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
1	Building envelope	Suitability of the materials to the climate						
		Use of external insulation						
		Use of smooth surface finishes						
		Use of light colours						
2	Natural lighting	Wall to window ratio (40%)						
		Use of spectrally selected glass						
3	Natural ventilation	Use of openable windows						
4	Site and external spaces	Use of interwoven landscape						
		Use of impervious surfaces						
5	Building form	Large building surface area						
6	Building orientation	Sun orientation; E-W						
		Wind orientation; SW-NE						
7	Wall/Window shading	Use of horizontal and vertical shading devices						
		Use of interior blinds						
		Use of recessed walls						
		Use of overhangs						
		Use of plants						
8	Existing energy source	Use of PV cells						
		Use of natural gas						

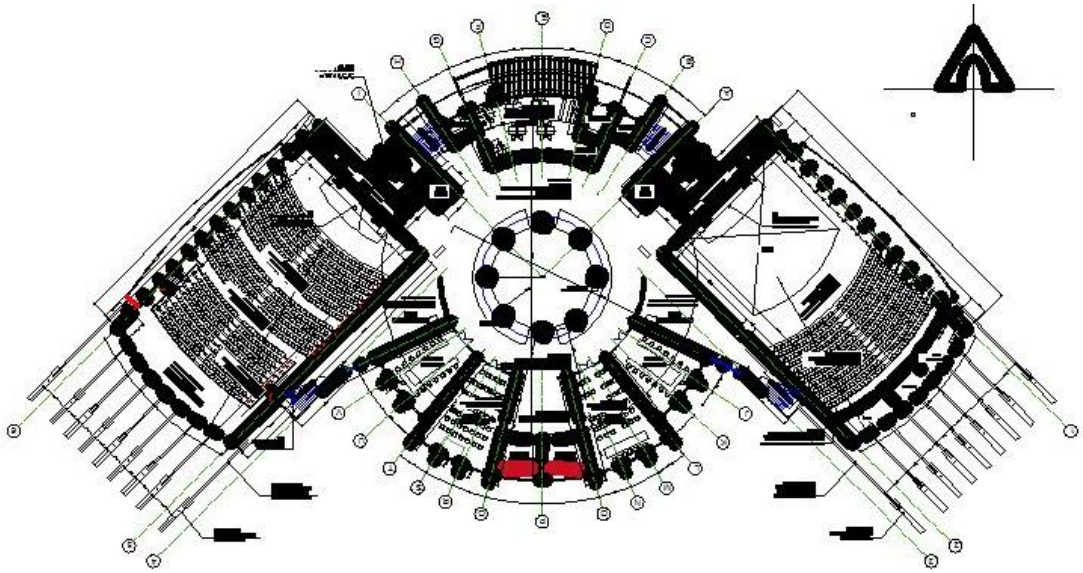
APPENDIX 2: INTERVIEW SCHEDULE

1. What considerations were made in the design of the building envelope which enhances energy efficiency?
2. Were there any considerations made to achieve adequate daylight in the center?
3. What strategies did you employ to achieve natural ventilation?
4. What strategies were employed to minimize energy consumption considering the ratio of the built area to the open spaces?
5. What considerations were made during the orientation and planning of the building to help maximize energy efficiency?
6. To what extent does the shape and form of the building help to minimize energy consumption?
7. What is the energy source of this facility and the consumption rates?
8. How sustainable is the current energy source of the facility?

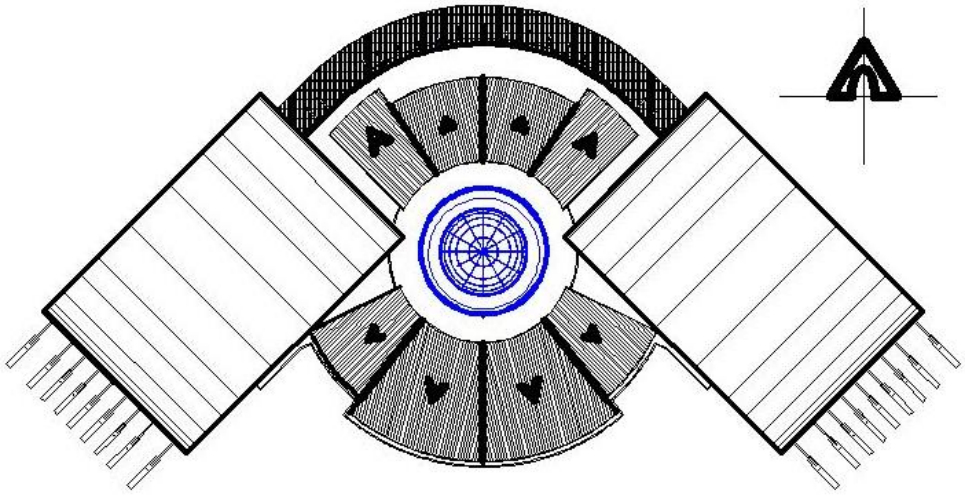
APPENDIX 3: DESIGN



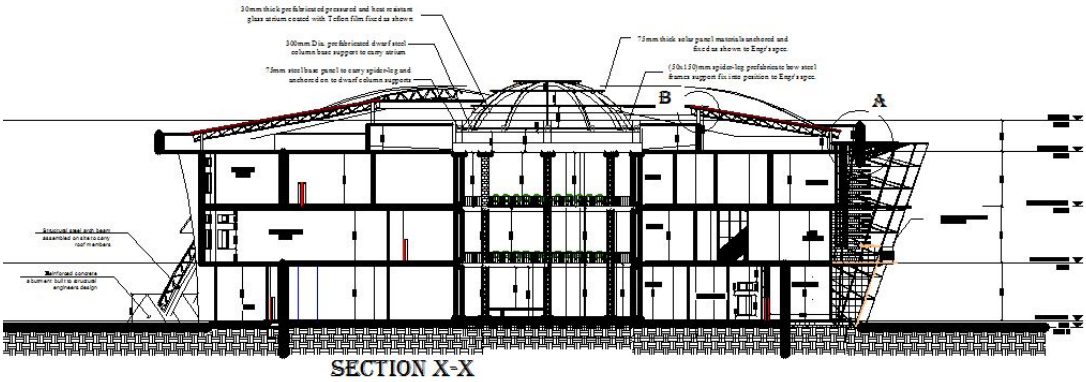
Appendix I: Basement Plan of the proposed building



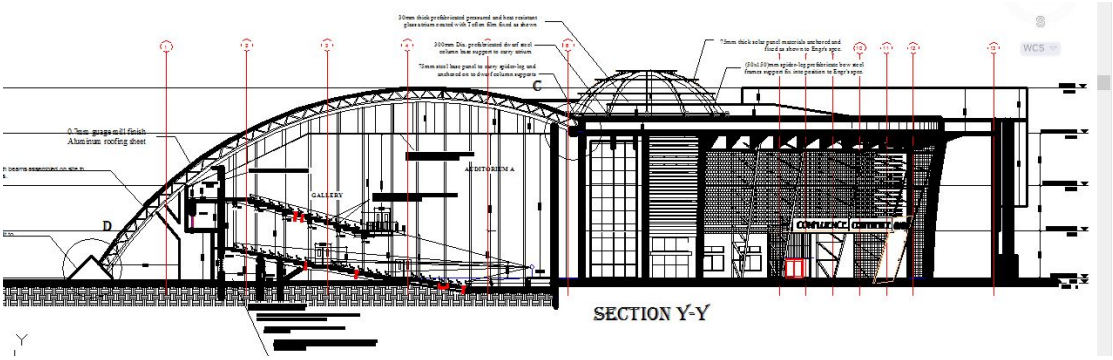
Appendix II: First Floor Plan of the proposed building



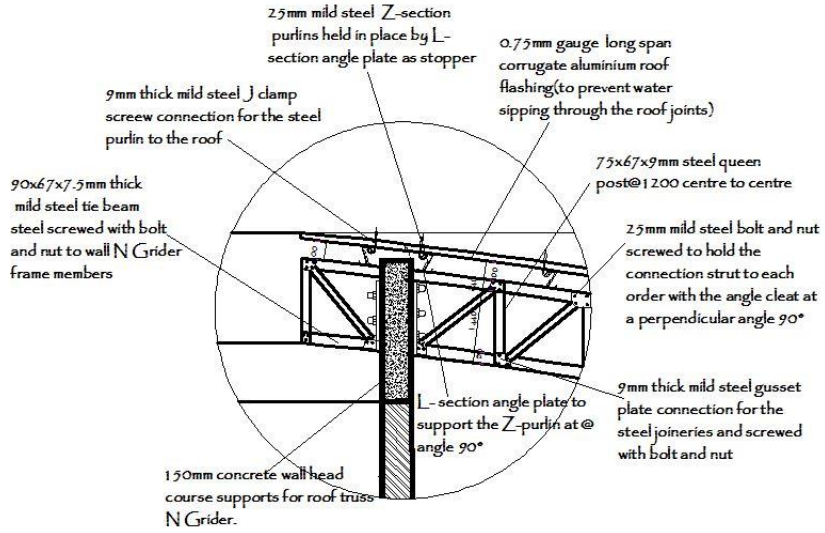
Appendix III: Roof plan of proposed building



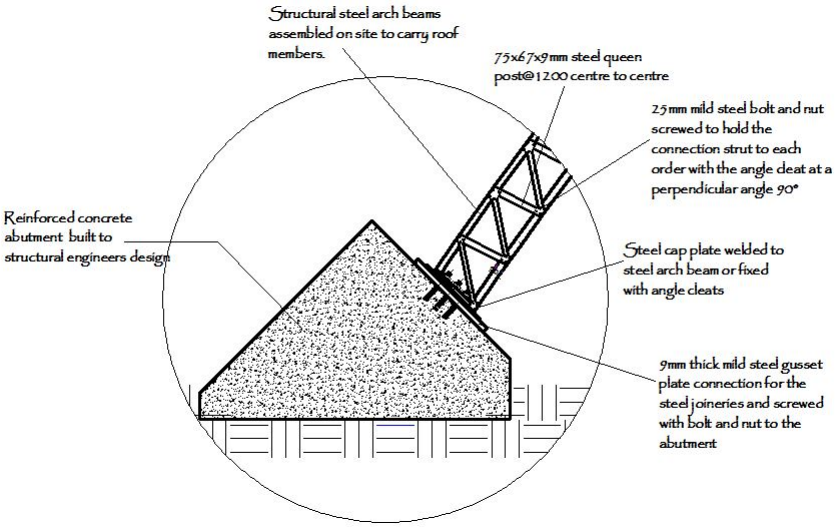
Appendix IV: Section X - X of proposed building



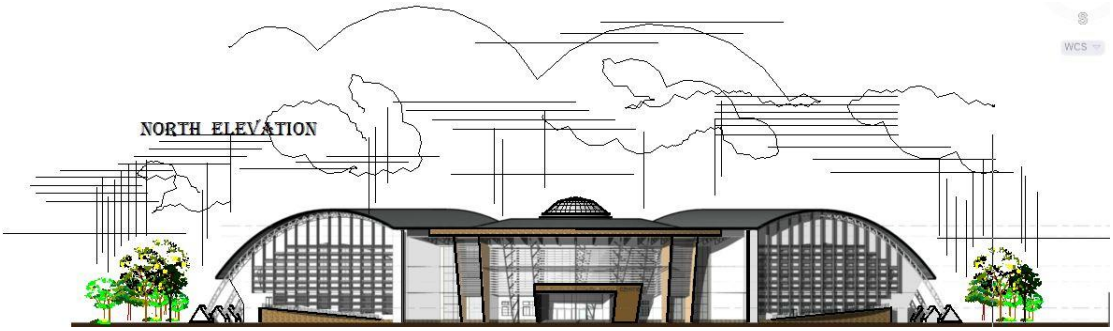
Appendix V: Section Y - Y of proposed building



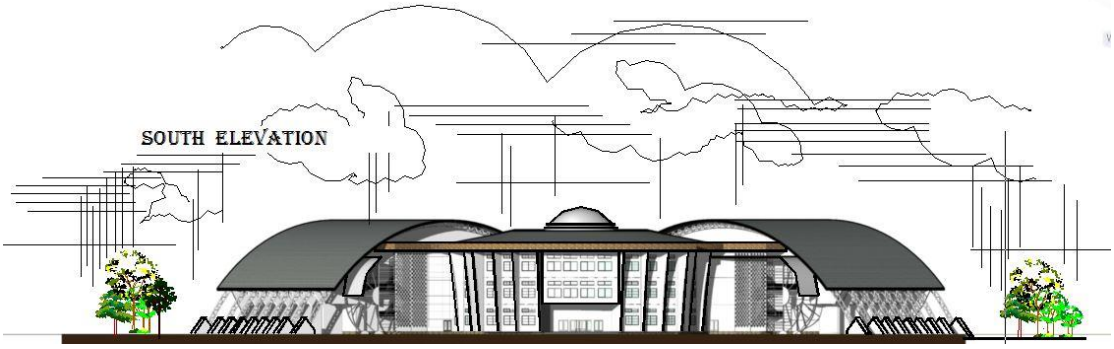
Appendix VI: Detail at B of the proposed building



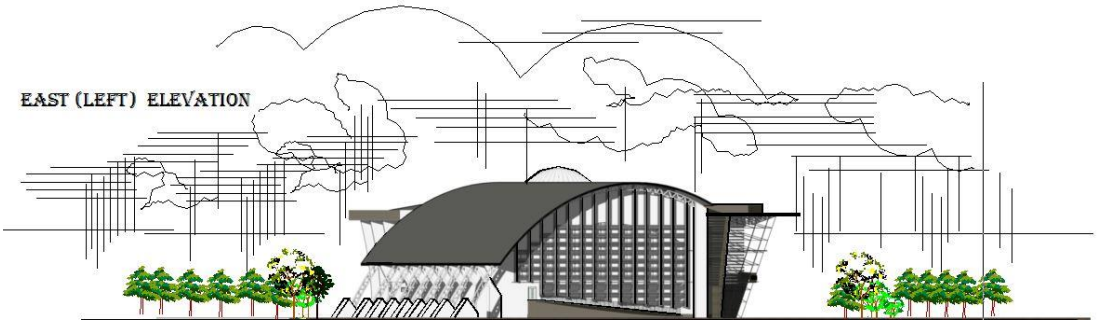
Appendix VII: Detail at D of the proposed building



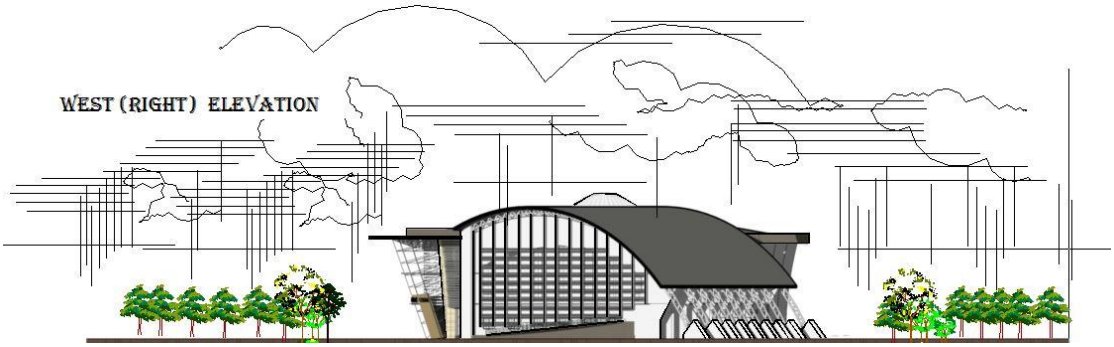
Appendix VIII: North Elevation of the proposed building



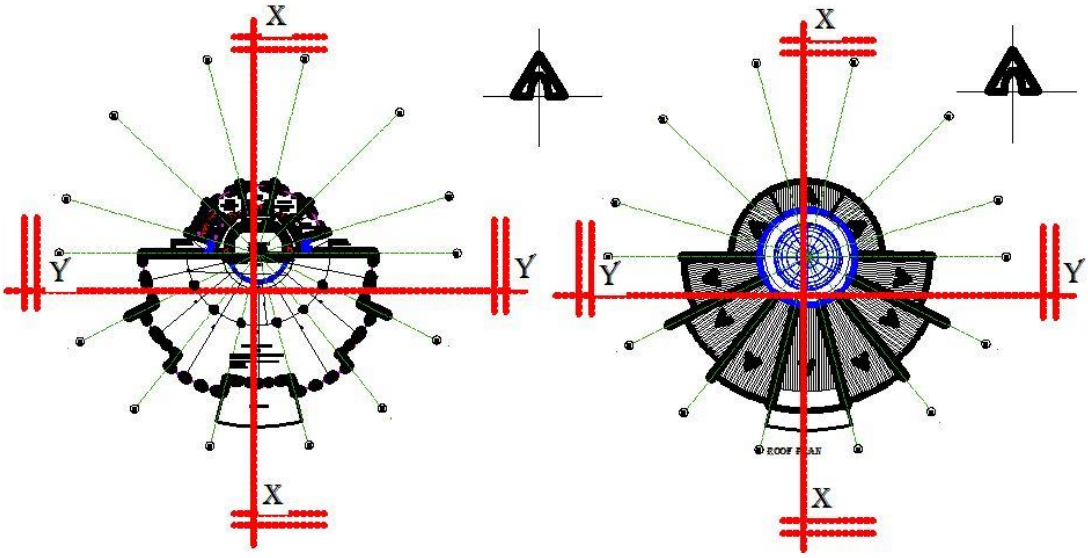
Appendix IX: South Elevation of the proposed building



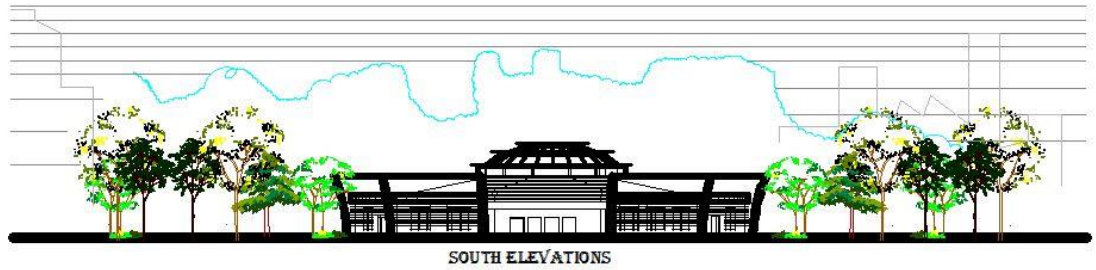
Appendix X: East Elevation of the proposed building

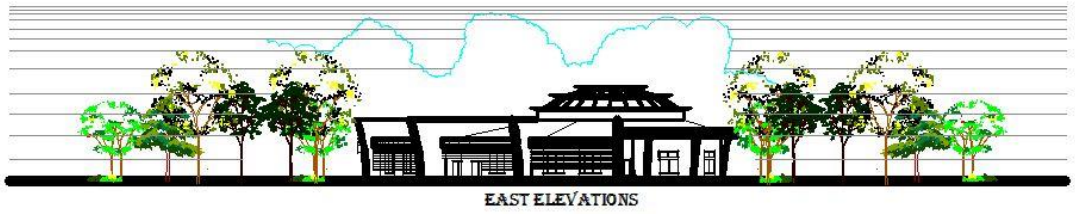


Appendix XI: West Elevation of the proposed building

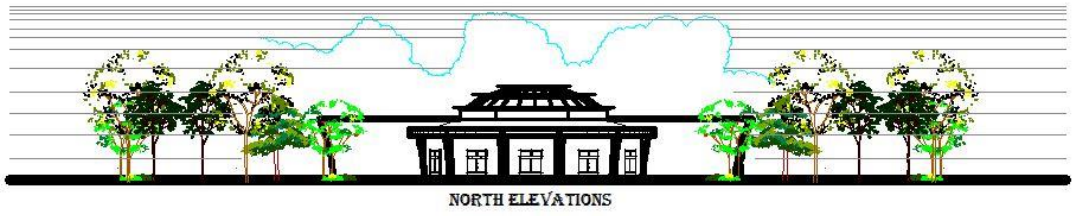


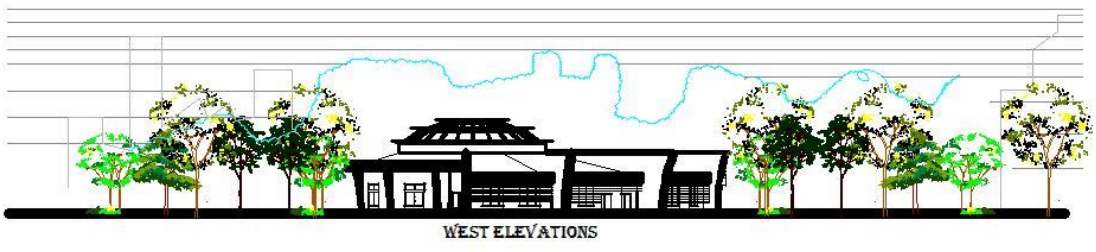
Appendix XII: Floor and Roof plan of the proposed Multipurpose Hall





Appendix XIII: Elevations of the proposed Multipurpose Hall





Appendix XIV: Elevations of proposed Multipurpose Hall

APPENDIX 4: THREE DIMENTIONAL IMAGES



Appendix I: Ariel View of Conference Centre



Appendix II: Approach View to Conference facility



Appendix III: Conference Facility



Appendix IV: Approach view to Multipurpose Hall



Appendix V: Multipurpose Hall