PASSIVE SOLUTIONS TO INCREASE ENERGY EFFICIENCY

In the Design of a Shopping Mall Abuja, Federal Capital Territory, Nigeria

HANNATU ABDULLAHI IDRIS

M. Sc./ENV-DES/ 03512/ 10-11

A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL,

AHMADU BELLO UNIVERSITY, ZARIA

IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD

OF THE DEGREE OF MASTER OF SCIENCE (M.Sc) IN ARCHITECTURE

DEPARTMENT OF ARCHITECTURE

FACULTY OF ENVIRONMENTAL DESIGN

AHMADU BELLO UNIVERSITY, ZARIA

DECEMBER, 2014.

DECLARATION

I declare that the work in the dissertation entitled 'PASSIVE SOLUTIONS TO INCREASE ENERGY EFFICIENCY IN THE DESIGN OF A SHOPPING MALL ABUJA, FEDERAL CAPITAL TERRITORY, NIGERIA' has been performed by me in the Department of Architecture under the supervision of Arc. E.O.A Eneh and Dr. S.N. Oluigbo. The information derived from the literature has duly been acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at any university.

HANNATU ABDULLAHI IDRIS		DECEMBER, 2014.
----------------------------------	----------------------	----------------------------
Name of Student	Signature	Date

CERTIFICATION

This dissertation entitled **"PASSIVE SOLUTIONS TO INCREASE ENERGY EFFICIENCY IN THE DESIGN OF A SHOPPING MALL ABUJA, FEDERAL CAPITAL TERRITORY, NIGERIA"** by Hannatu Abdullahi Idris 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.

______________________________ ______________________________

Arc. E.O.A Eneh

Chairman, Supervisory Committee **Date**

______________________________ ______________________________

Dr. S.N. Oliugbo

Member, Supervisory Committee **Date**

______________________________ ______________________________

Arc. (D.r.) M.D Ahmed

Head of Department **Date**

______________________________ ______________________________

Prof. A.Z. Hassan

Dean, Postgraduate School **Date**

DEDICATION

This research is dedicated to the Almighty Allah for my existence and providing the zeal in all affairs, Alhamdulillah.

To my parents Alhaji Abdullahi M. Idris and Hajia Adama J. Idris for always being there for me. My siblings Idris, Bello, Abbas for believing in me; and how can I forget the very first grandchild of the family baby Abdallah Idris Abdullahi and his mum Rabia Wanka Idris.

HANNATU ABDULLAHI IDRIS DECEMBER, 2014.

-------------------------- ------------------------- -----------------------

Name of Student Signature Date

ACKNOWLEDGEMENT

I believe 'Alhamdulillah' always says it all. My deepest appreciation goes to Arc. E.O.A Eneh and Dr. S.N. Oliugbo, thank you very much for accepting to supervise this research, you have both given me the best of guidance in excess to spare for even my future pursuits. Internal Examiners assigned to me Dr. M.D. Ahmed and Dr. Ken Okoli. I also appreciate the effort of all my lecturers who have mentored me to this stage and gave moral advice and encouragement to me as a student of this great department Architects and Lecturers who found time to slot me into their busy schedules ; Dr. M.L. Sagada, Arc. Babayo, Arc. Mai, Dr. Ango, Dr. Abdullahi, Arc. Shehu, Arc. Sarkile. Q. Surveyor M.K. Bello for being patient with me. Engr. M. Goni.

A profound gratitude goes to my family. The best one can ever have and hope for: Dad, Mum, Mainasara, Lala, Autan mamanshi, Jnr., Maama, Hajia karama. More family members Engr. Isa bello, Aunt Maryam, Adama, Ali, Jidda, Ummi for the positive company and support; Uncles K.B, Hassan, Ibrahim, Gambo, Wives Suwaiba, Hadiza, Jamila; Aunt Mairo. Grannies Hannatu and Rahama for lots of prayers. Aunties Gimbia, Hauwa, Hajara, Salam. The families of Late Sergent Idi, Late Sergent Bello , Alh. Yahaya Tanko, .Mal. Adam Zeze, Alh. Ali Dikwa, Aunt Ramatu Samaru.

Abdulrazak B., Rabiu Ado, Steve Achile, Aisha Auwab, Halima Zorro, Basharia Zorro, Hadiza Sallau, Abu Sadeeq Ali, Aisha Tanko, Khadija Alkali, Jennifer Garnvua, Mubarak Bala, Ama Busari, Albert Igenus, Ahmed Fika, friends I can't do without, thank you all.

Staff of Offices and firms consulted who provided assistance: AGIS, National Archives, Grand Towers, Unity Bank, A.B.U Zaria, Fed. Poly Nas, A.T.B.U.

My pet dog Domingo. Those not mentioned are in my mind and thoughts, thank you all.

TABLE OF CONTENTS

CHAPTER ONE

CHAPTER TWO

CHAPTER THREE

CHAPTER FOUR

CHAPTER FIVE

CHAPTER SIX

CHAPTER SEVEN

Figure **Page**

Plate	**Page**

Table **Page**

ABSTRACT

The idea that shopping malls exists for all intents and purposes solely for buying and selling has long passed, Malls now boast of far greater scale in terms of both sizes and activities carried on within; and with such transcendence comes also the need to make it as affordable, comfortable and functional as possible, this is where energy comes into play. Energy efficiency as the name implies looks at how to reduce its demand, measures on how to both recycle and exploit renewable resources. The shopping mall is a high energy demand building to be built, maintained up to its estimated lifespan; which brings about the need to cost effectively enhance and lower fuel cost, curb environmental pollution, reduce demand on non-renewable fuels. However it is a fact well established that barriers do exist which could be a deterrent to said goal actualization and they appear in forms of economic backing not feeling the payback in a short span of time due to lack of adequate information on its importance and decay of approval of implementation, then access to compatible measures which can compromise on appearance of buildings with all the barriers and constraints visible so also are the therapies and this is where the passive measures come into play by applying techniques such as day lighting, cooling, building envelop, landscaping, so also having a grip on total energy usage and the services within the building. This research looked at energy as a global issue via energy efficiency adopting passive solutions in the design of shopping mall. A method of approach was sampled shopping malls in the choice location Abuja; interviews held helped shed light on their observations. So also were literature gathered, analyzed and summarized to determine energy savings. Time posed as both a limitation and delimitation which formed part of hindrances as choice of site location and number of cases to be studied form basis of analysis. Passive solutions looked at here includes general planning and or orientation of the shopping mall design, how accessibility and flow of traffic affects energy within and micro climate by providing separate routes for pedestrian and vehicular movement; so also site planning and landscape using plantation of trees, shrubs, hedges and stone paving to curb external heat flow into the building. Day lighting use was natural due to the topography and as such use of photovoltaic panels, skylights, double paned glazing on windows and lots of windows to aid natural lighting and also ventilation aided by patterns of wind circulation afforded by the placement of the openings strategically. Building materials and techniques applied are highly influential factors as such compressed earth bricks will be used in some parts of the building due to their natural characteristics of strength, cooling and also double paned pressurized glass. An expectation is that energy efficiency can be achieved using available resources optimally and providing a model for subsequent applications in shopping malls and any other public building. Use of material and construction techniques to assist designers, builders, clients in creating designs for less cost and higher yield driving the building industry to greater heights. Passive strategies applied are to be environmentally friendly and trendy which invariably are responsible for space, form, and surfaces of the building.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND STUDY

Historically, shopping places and the shopping activities took place in open public spaces within urban and public functions and activities of the city, like ancient Greek Agora or Roman Forum. After centuries, the enclosed shopping mall separated urbanity and shopping activity from each other. These fully-enclosed and environmentally controlled consumption spaces reinterpreted the urban fabric to simulate a city image and a street-like atmosphere indoors. According to International Council of Shopping Centres (ICSC, 2008), 'A shopping mall is an enclosed collection of a variety of independent retail units, services and parking spaces, which were built and maintained by a separate management.

Inside the walls, a new city was created, where people shop, eat, entertain, sleep, get married or have college education. An example of the Mall of America in Bloomington, Minnesota. All these activities are integrated under one roof, with interconnecting walkways to enable people to easily move from one unit to another. They also provide an atmosphere for the people to socialize. Open space and sustainable design for shopping malls are raising trends in the world. So, the existing shopping malls are opening, integrating with urban fabric and continually updating themselves to compete with emerging shopping places. The use of new building materials gives shopping malls new forms and overall looks.

Nigeria has a peak demand of 2,000GWH of electricity per day. Out of this, 65% is consumed by the residential sector, 20% in the commercial sector and 10% in the industrial sector while the remaining 5% is exported to Niger, Togo and Benin

Republic. For a population of over 140 million people in Nigeria, only about 40% of these people have access to electricity, and a very large majority of these people live in the urban areas. In places where there is access to electricity, consumers suffer from frequent power outages which last for several hours. In a recent survey conducted in three large cities in Nigeria-Abuja, Lagos and Benin city, the survey from 150 respondents revealed that over 80% of those interviewed do not get electricity supply for up to 24 hours a day CREDC, (2009). Majority of respondents get electricity from zero to about six hours a day. This is a likely reflection of the power supply scenario in all urban areas in Nigeria. The power currently generated in Nigeria is inadequate and unstable, forcing a large portion of the industry, businesses and households to rely on diesel and petrol generators as a primary or back-up source of electricity, which can be expensive and a source of noise and air pollutions. The Power Holding Company of Nigeria(PHCN), like numerous utility companies in Africa, is facing difficulties to keep up with electricity demand Toure, (2010). Global energy demand will grow 45% by 2030, requiring US$26 trillion investment.

1.2 STATEMENT OF THE PROBLEM

Due to the rising cost of energy worldwide, it is a growing issue accounting for a high percentage of greenhouse emission contributing significantly to global climate change; and its peculiarity to Nigeria is far greater and rising higher Ecree, 2010; it affects man and environment. Expenditure on energy as an economic factor is high; as such creating a need to look into possible means of reducing these costs on building like shopping malls.

The hot-dry climate that is characterized by excessive heat and sun glare requires a sustainable approach to building designs especially those that consume a lot of energy, specifically shopping malls. In order to reduce the energy consumption and increase indoor thermal comfort, there is the need to design for bioclimatic comfort.

In this study, the notion exists that shopping malls are high energy users and that the hot-dry nature of the climate of the study area, Abuja remains an issue. The research seeks to study and use Energy efficient design principles in the design of shopping malls in hot-dry climate and whether to address this notion. The passive approach can be adopted as an appropriate means of designing buildings that consume high energy. The outcome will determine if the research approach will encourage a sustainable approach to similar and/or the same category of buildings.

1.3 JUSTIFICATION

Shopping malls have high energy efficiency consumption as such the cost of energy demand is generally transferred back to the consumer thereby increasing the cost of patronage which in turn affects the consumer ICSC, 2000, in terms of paying more for goods and services that could be obtained cheaper; There is the need for the study to look at indigenous solutions in improving energy efficiency in the building, thereby eliminating the cost that will eventually be borne by consumers. Most modern buildings in cities and towns both residential and public buildings are highly energy inefficient as well as not being environment friendly.

1.4 AIM AND OBJECTVES

AIM:

The aim of this thesis is to apply passive design ideas to achieve energy efficiency in a shopping mall; in a tropical setting like Abuja Federal Capital Territory.

OBJECTIVES:

i. To identify the basic design issues tied to shopping mall design in Abuja.

ii. To identify passive solutions applicable to shopping mall design problems.

iii. To assess passive design parameters that will help achieve energy efficiency in a shopping mall to provide thermal comfort with less energy.

1.5 RESEARCH QUESTIONS

The research question of this research is:

i. What are the basic design issues in shopping mall designs in Nigeria?

ii. What passive architectural solutions are relevant to shopping mall design?

iii. What are energy efficient design principles?

1.6 SCOPE AND DELIMITATION:

Jones (1998) has concluded that energy use in modern buildings occur in five phases, namely, manufacture of building materials, transportation of building materials to the site, on-site construction activities, the operational phase, (running of the building) and finally, the demolition process of buildings and recycling of building materials. This study confined itself in considering energy use at the operational phase of the building. A choice location of Abuja is chosen based on the rising trend of plazas which used to be common but gave way recently to shopping malls as commonly seen in Abuja. Area of study is wide and as such a selection of a few case studies would be made to review their current state of energy efficiency.

The study is restricted to making new commercial buildings energy-efficient and does not consider the existing mall stock because of two reasons. First, Abuja is rapidly urbanizing and the construction of new buildings is extensive. Second, better design of new buildings could result in a 50% reduction in energy use, whereas, appropriate design intervention in the existing stock of buildings could yield an energy reduction of 25% (Clarke and Maver, 1991).

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

Until the early 20th century, the only way to control the indoor climate was through passive strategies. With the introduction of mechanical building services, it became a separate profession (Hartog, 2004). The evolution of technology and the development of new artificial systems for lighting and air conditioning, for example the air conditioning equipment developed by Willis H. Carrier in 1902 (Turner et al., 2002), were great contributions for the internal thermal comfort of buildings. However, for some time, these new systems and the availability of cheap energy made the architects ignore the climatic characteristics of each region, resulting in dependence and indiscriminate use of such systems. Therefore, the majority of global energy use is employed in reducing the impact of the natural environment on us.

Recognizing the worldwide impact that buildings and their construction have on the environment, governments have been exploring ways to achieve greater sustainability of the built environment. It is far more cost-effective to build energy efficiency into the design of a new building than to retrofit an existing building, because a new building offers flexibility in all its construction parameters. (Wen, 2007). For new building design, the choices of which kinds of building components and systems to use can either enhance or degrade the energy efficiency of a building.

The building envelope is a major component in determining a building's energy use. It includes everything that separates the interior of the building from the outdoor environment: the doors, windows, walls, foundation, roof, and insulation. Various approaches can help improve the building envelope. For example, storm windows and doors can reduce heat loss when temperatures drop. In warm regions, windows with special glazing can let in daylight without raising the temperature as seen in Figure 2.1.

According to Randall (2006) what is important in achieving this, solar energy drives the processes we live in; Building envelopes obviously need to be durable, economical, aesthetically pleasing, weather tight, structurally sound and secure. Likewise Kosny et. al 2006 says that psychologically, views out are very important. In certain climates, massive building envelopes-such as masonry, concrete, earth, and insulating concrete forms (ICFs)-can be utilized as one of the simplest ways of reducing building heating and cooling loads. Very often such savings can be achieved in the design stage of the building and on a relatively low-cost basis.

While designing the volume of a building, architectural solutions can be employed to achieve greater energy efficiency for the entire lifecycle of the building. However, currently this possibility is not sufficiently utilised. (Josifas, et al 2011). Efficient energy resource utilisation during the lifecycle of a building is in part determined by the use of rational architectural and layout measures at the time of planning the building volume. (Josifas ,et al 2011), As well as the ability of a building to save energy – aside

from thermodynamic and heat retention qualities of materials – depends on its shape, orientation, layout of transparent envelopes, size, measures of protection from the sun, and the facade colour.

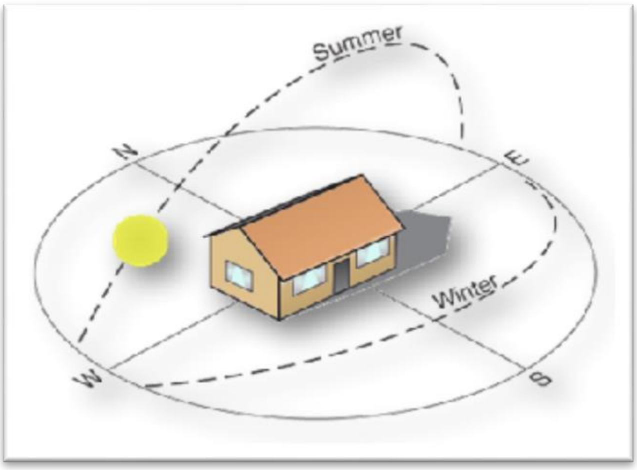


Figure 2.1: Sun path and Building Orientation
Source: www.nachi.org

2.2 BUILDING FORM AND ORIENTATION

A compact building form of minimum surface-to-volume ratio is best for reducing heat loss. However, as Figure 2.2 shows a rectangular building with one of the longer facades facing south can allow for increased passive solar heating, day-lighting and natural ventilation. As well as reducing energy costs, sunny south-facing rooms also have high amenity value.

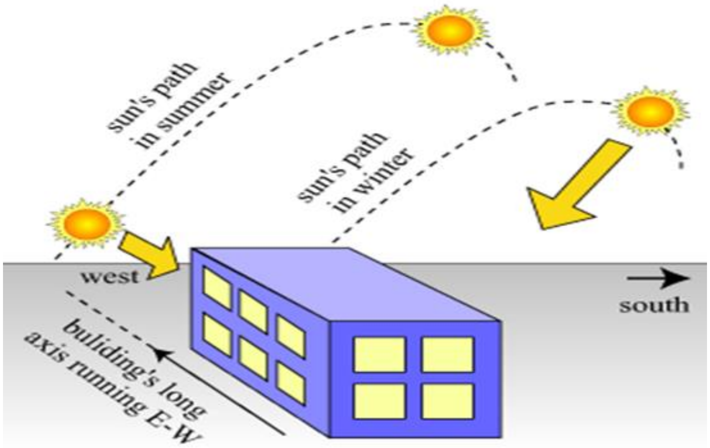


Figure 2.2: Building Orientation
Source: www.hk-phy.org(2013)

The influence of architectural and layout solutions on the energy balance of a building Compactness – an ability of a building volume to fit as much useful area into the external envelope (the totality of external walls, windows, roof and lower heated floor areas) as possible – is one of architectural and layout characteristics of a building. Projections such as bay and dormer windows should be kept to a minimum, since by increasing the surface-to-volume ratio of the building, they will increase heat loss. They also tend to be more difficult to insulate effectively. Pitched roofs should have one slope oriented south to allow for optimum performance of a roof-mounted or roof-integrated active solar heating system, Even if such a system is not planned during construction. The energy efficiency potential of buildings, which depends on the chosen architectural and layout solution. (Josifas et al, 2011).

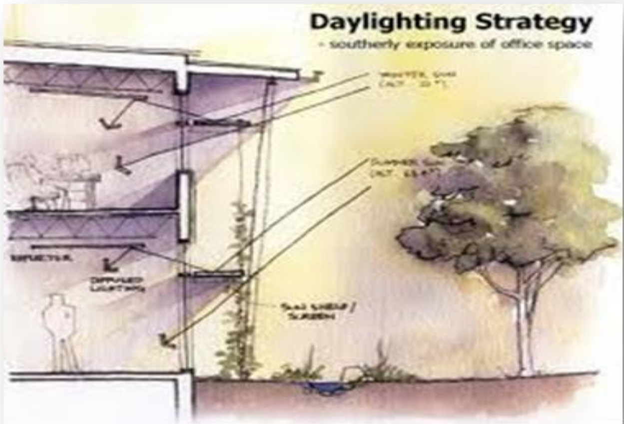


Figure 2.3: Day lighting
Source: www.hk-phy.org

Energy efficiency is one of the quickest, cheapest, cleanest ways to address energy and environmental challenges Wen, (2007).

2.3 KEY BARRIERS AND CHALLENGES

Contrary to popular perceptions, industry interviews and research confirm that many energy savings initiatives can be achieved with little or no cost through careful building design mandated by project developers and good management practices of building operators and occupants. Some factors perceived to have slowed down Energy efficiency measures in designing and constructing of new buildings such as:

i. Increased capital costs for construction;

ii. Compressed development schedules in most of the region's rapidly developing countries;

iii. Excess capacity of HVAC systems because of insufficient expertise by designers;

iv. Poor quality of commissioning;

v. Lack of life-cycle cost thinking;

vi. Lack of trusted energy-efficiency rating and verification systems; and

vii. Limited awareness or skills leading to efficient energy use in new buildings.

2.3.1 ENVIRONMENTAL IMPACT

Until the early 20th century, the only way to control the indoor climate was through passive strategies. With the introduction of mechanical building services, it became a separate profession (Hartog, 2004). The evolution of technology and the development of new artificial systems for lighting and air conditioning, as for example the air conditioning equipment developed by Willis H. Carrier in 1902 (Turner, 2002) were great contributions for the internal thermal comfort of buildings. However, for some time, these new systems and the availability of cheap energy made the architects ignore the climatic characteristics of each region, resulting in dependence and indiscriminate use of such systems. Therefore, the majority of global energy use is employed in reducing the impact of the natural environment on us.

Firstly, to make buildings comfortable, they should be kept within a suitable temperature range which is not as wide as that in an uncontrolled external environment. Secondly, human bodies are capable of maintaining a very stable core temperature with a fairly constant metabolic heat output over a wide range of external temperatures. This is done, with little or no additional energy expenditure, by a combination of control processes including sweating, altering the blood flow (and therefore the heat loss to the skin) and changing clothes to suit conditions.

2.4 WHAT MAKES BUILDINGS ENERGY EFFICIENT?

Experts have outlined that the basic tenet of building energy efficiency is to use less energy for heating, cooling, and lighting, without affecting the comfort of those who use the building. High-performance buildings not only save energy costs and natural resources, but also mean a higher-quality indoor environment. The benefits of building energy efficiency include:

2.4.1Reduced Resource Consumption

Improving building energy efficiency as a new energy supply significantly reduces demand

2.4.2 Minimized Life-cycle Costs

Improving building energy efficiency reduces the amount of energy required to operate a building, and reduces costs for building occupants.

2.4.3 Reduced Environmental Impact

Buildings contribute to the discharge of four primary pollutants--- mono-nitrogen oxides (NOX), sulphur oxide (SOX), Carbondioxide(CO2), and particulates. Improving building energy efficiency reduces the need for fossil fuels and reduces greenhouse gas emissions.

2.4.4 Healthier Indoor Environment

Efficient buildings also mean a healthier indoor environment for the people who live and work in them by, for example, using pleasing architectural designs to brighten up work areas using sunlight rather than electricity, without causing excess glare. Comfortable temperatures and a quiet work environment are also features of high-performance buildings.

2.4.5 Increased Employee Productivity

Improved comfort of building occupants contributes to increased employee productivity. Recent studies have shown an increase in employee productivity when buildings have features such as natural light, better control of temperature, and more intelligent use of space.

By following a careful design process, it is possible to produce buildings that use substantially less energy without compromising occupant comfort or the building’s functionality. Whole-building design considers the energy-related impacts and interactions of all building components, including the building site; its envelope (walls, windows, doors, and roof); its heating, ventilation, and air-conditioning (HVAC) system; and its lighting, controls, and equipment.

2.4.6 Integrated and Passive Design Key to Energy-Conscious Buildings

Developers who take the energy performance of new construction seriously are using integrated and passive design techniques to maximize energy efficiency(Wen et.al 2007).

2.5 PASSIVE DESIGN

Passive design is design that takes advantage of natural energy flows to maintain a building's thermal comfort, and reduces the need for mechanical heating or cooling. Buildings that are passively designed maximize cooling air movement and exclude sun in summer, and trap and store heat from the sun and minimize heat loss to the external environment in winter.

ELEMENTS OF PASSIVE DESIGN

2.5.1 Analysing Climate and Site:

The key to passive design is to make the most use of the natural environment. Passive design responses for buildings vary in accordance with the climate and site conditions.

2.5.2 Orientation:

A building that is well-positioned on its site delivers significant lifestyle and environmental benefits. Appropriate orientation assists passive heating and cooling, resulting in improved comfort and decreased energy bills.

2.5.3 Passive Solar Heating:

Passive solar heating keeps heat from the summer sun out and let's heat from the winter sun in. A balanced ventilation system involving fans, ductwork and a heat exchanger can transfer heat from warm stale outgoing air to incoming fresh air (this is called “Mechanical ventilation with heat recovery”).

2.5.4 Passive Cooling:

Passive cooling uses design and modification of buildings to achieve summer comfort and minimize or eliminate energy use for cooling.

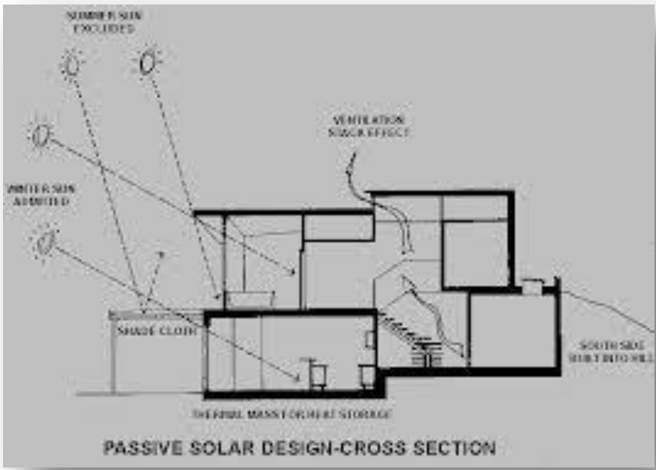


Figure 2.4 passive solar sketch
Source:www.nachi.org(2013).

2.5.5 Insulation Installation:

Insulation is an essential component of passive design. It improves building envelope performance by minimising heat loss and heat gain through walls, roof and floors.

2.5.6 Thermal Mass:

Externally insulated, dense materials like concrete, bricks and other masonry are used in passive design to absorb, store and re-release thermal energy. This technique moderates internal temperatures by averaging day/night (diurnal) extremes, therefore increasing comfort and reducing energy costs.

2.5.7 Windows and Glazing:

Windows and glazing are very important because heat loss and gain in a well-insulated building occurs mostly through the windows. For the design of windows, cooling breezes and air movement are encouraged in summer and cold winter winds are excluded. Glazing is used to trap winter heat whilst excluding summer sun.

2.5.8 Shading:

Shading of glass is also critical, since unprotected glass is the single greatest source of heat gain in a well -insulated space. Shading requirements vary according to climate and house orientation. In climates where winter heating is required, shading devices should exclude summer sun but allow full winter sun to penetrate. In climates where no heating is required, shading of the whole building and outdoor spaces will improve comfort and save energy.

2.5.9 Skylights:

Well-positioned and high-quality skylights can improve the energy performance of the building and bring welcome natural light to otherwise dark areas.

2.5.10 Material use:

Historical developments have shown that materials consumed in bulk quantities, the Common building materials are Burnt clay Bricks, Stones, Concrete , blocks, Cement, Steel, Concrete, Aluminium, Zinc, Glass, Tiles(ceramic/burnt), Plastics/PVCPaints, Timber, Mud, Unburnt bricks, Lime, Wood/bamboo/reeds, Country tiles, Stone boulders, Thatch (Reddy, 2006).

2.6 GENERAL PRINCIPLES OF ENERGY EFFICIENCY

The principles for both energy efficiency and water conservation are basically the same: reduce demand, recycle and exploit renewable supplies (Edwards, 1998).

The principles are divided into three namely:

Principle i: Climate and site-

A building is not just a shell but a complex system which responds to its climatic environment.

Principle ii: - Building envelope-

A building envelop responds enthusiastically to changing ambient conditions.

Principle iii :- Building systems-

The tactical analysis of building systems achieves ideal energy efficiency.

2.6.1 BASIC PRINCIPLES IN ENERGY EFFICIENT BUILDING DESIGN

It is evident from the above section that energy efficiency in buildings is vital for many reasons. Having justified the needs for energy efficiency it is important to focus on the basic principles that can bring about energy efficiency in commercial buildings of Abuja.

i. **Planning aspects:**

i. Site analysis

ii. Building form

iii. Building orientation

iv. Room orientation

v. Landscaping

ii. Building envelope:

i. External wall

ii. Thermal insulation

iii. Building material

iv. Roof

v. Windows

vi. Shading device

vii. Natural ventilation

Further breakdown of passive strategies in energy efficient principles in building design made below

I. Planning aspects

Analysis of the building site should be made to determine the following:

i. **Site analysis**

Analysis of the building site should be made to determine suitability in respect to certain factors such as topography to check if it can be used for a building type; accessibility to check routes to get to site whether via roads or waterways; usability if the site could be buildable.

ii. Building form

Gut and Ackerknecht (1993) have suggested forms with large surfaces rather than compact buildings as large surfaces favour ventilation and heat emission at night-time. The building forms should thus be open, outward oriented and built on slits. Givoni (1998) states that building form largely depends on whether the building is planned to be air-conditioned or if it is intended to rely on natural ventilation. He recommends a compact shape for the building dwelled by people who are determined to use air conditioners and open forms for naturally ventilated buildings.

Compactness of the building minimizes the surface area of the building envelope, resulting in a reduction of the heat gain through the envelope.

iii. Building orientation

Properly oriented buildings take advantage of solar radiation and prevailing wind. According to Gut and Ackerknecht (1993), the longer axis of the building should lie along east-west direction for minimum solar heat gain by the building envelope. Openings should be avoided on the west and if they cannot be avoided, they should be adequately shaded by using verandahs and tall trees.

iv. **Landscaping**

Raeissi and Taheri, (1999) acknowledged the beneficial effects of trees. They state that planting of trees can result in energy saving, reduction of noise and pollution, modification of temperatures and relative humidity and psychological benefits on humans. They also noted that trees can act complementary to window overhangs, as they are better for blocking low morning and afternoon sun, while overhangs are better barriers for high noon sunshine. Simpson and Macpherson (1996) have shown that tree shades can reduce annual energy for cooling by 10% -50%.

II. Building Envelope

i. External wall

As the main goal in building design of tropical climates is reduction of direct heat gain by radiation through openings and reduction of internal surface temperature, the building should be designed with protected openings and walls (Gut and Ackerknecht, 1993). The walls can be protected by designing the roof so that it extends far beyond the line of walls and has broad overhanging eaves. Gut and Ackerknecht, (1993) argue that the outer surface of the external wall should be reflective and light coloured.

Wong and Li (2007) from their study concluded that the use of thicker construction on east and west external walls can reduce the solar radiation heat gain and hence, the cooling load can be reduced by 7%-10 % when the thickness of external wall is doubled (229 mm concrete hollow block instead of 114 mm concrete hollow block).

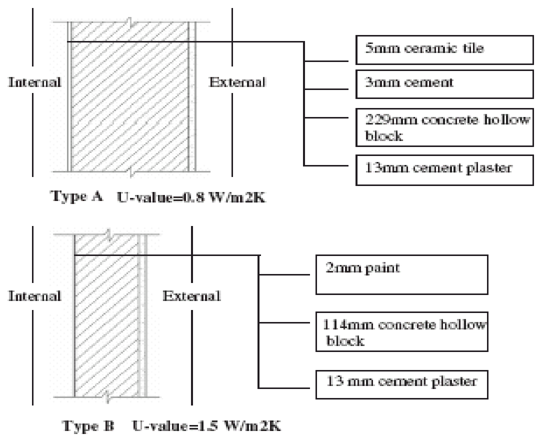


Figure 2.5 External wall construction
Source: Wong, N.H and Li, S. (2007)

ii. Thermal insulation

According to Bolatturk, (2008), thermal insulation is one of the most effective energy conservation measures for cooling and heating in buildings because it reduces heat transfer to and from the buildings. However, this view portrayed by Bolatturk, (2008) seems to conflict with those of Gut and Ackerknecht, (1993) and Yang and Hwang, (1993). Yang and Hwang (1993) have added that in warm and humid regions, condensation might occur and this would demean the thermal performance of the building envelope and cause mildew problems. Moreover, Gut and Ackerknecht, (1993) also note that thermal insulation has a dual nature. It reduces daytime excess heat entering a building, but averts the building from cooling down at night. According to them, this dual nature makes insulation unsuitable for buildings with natural climate control.

iii. Building material

Gut and Ackerknecht, (1993) recommend using the following building materials in tropical climates:

1. Burnt clay bricks can be used in tropical climates because they have good thermal resistance and good regulating property against humidity.

2. Timber has good thermal resistance and is a good regulator of humidity.

3. Matting of bamboo, grass and leaves are good because they are not airtight and allow proper ventilation.

Though timber was once used as a vernacular building material, it is no longer used because of the costs involved in seasoning timber. Bamboo, grass and leaves are temporary building materials and are not used in urban settings.

iv. Roof

The roof is an important element of design when it comes to conserving energy because this part of the building receives most of the solar radiation and its shading is not easy. Vijaykumar et al. (2007) and Alvarado and Martinez , (2008) conclude that the heat entering into the building structure through the roof is the major cause for discomfort in case of non-air-conditioned building or the major load for the air-conditioned building. However, Gut and Ackerknecht, (1993) argue that this is true for single storied buildings and the top floor of multi-storied buildings.

v. Windows

Openings are important design elements for admitting daylight, air flow, providing cross ventilation and views. Liping *et al.* (2007) claim that ventilation and indoor air quality can be improved by increasing the window to wall ratios (WWR), but it would also increase solar heat gain. As seen in Plate 2.1 below

Plate 2.1: view of window type
Source: Researcher's work, 2014.

vi. Size

Openings sizes are relevant also in that they regulate movement of light, heat, cold, airflow.

vii. Shading device

Watson and Labs, (1983) categorized shading devices into three categories namely solar transmittance of glazing materials, interior shading and exterior window shades. Solar transmittance is defined as the heat admitting or rejecting characteristic of the glazing materials. Watson and Labs (1983) and Gut and Ackerknecht, (1993) advice against heat absorbing, heat reflecting and tinted glazing. According to Watson and Labs, (1983) heat absorbing clear and tinted glazing reduces solar transmission by absorbing heat within the material itself. They state that the absorbed heat can be uncomfortable to occupants because it adds heat to the interior by conduction and thermal radiation.

viii. Natural ventilation

Ventilation is the movement of air. According to Watson & Labs (1983), ventilation has three useful functions in the building sector. It is used to:

i. Satisfy the fresh air needs of the occupants

ii. Increase the rate of evaporative and sensible heat loss from the body

iii. Cool the building interior by an exchange of warm indoor air by cooler outdoor air.

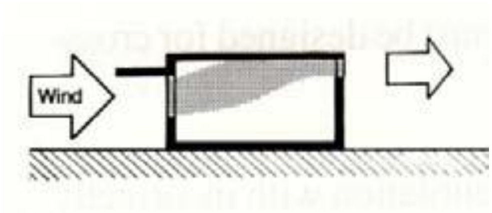


Figure 2.6: A canopy over a window directs the airflow upwards
Source: Gut, P. &Ackerknecht, D. (1993)

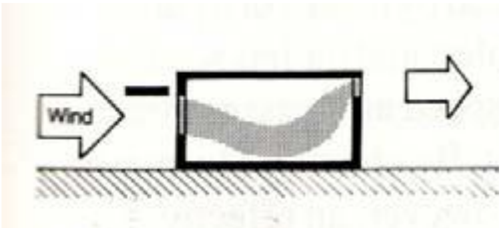


Figure 2.7: A gap between it and the wall ensures a downward flow
Source: Gut, P. &Ackerknecht, D. (1993)

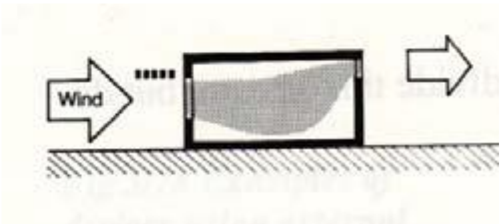


Figure 2.8: This is further improved in the case of a louvered sunshade
Source: Gut, P. &Ackerknecht, D. (1993).

2.6.2 CONCEPT OF ENERGY EFICIENCY

i. Energy:

Is defined as a quantity that gives the ability to do work, Encarta (2010).

• Energy is a quantifiable state function of every physical system.

ii. **Energy Consumption:**

Is the measured site energy used by a building or equipment over a stated period (kWh) (Encarta 2010).

Energy unit: kWh = Joule (J)) = Calories = BTU

iii. **What is Energy Efficiency- EE?**

EE refers to the ratio of energy output to input of equipment. The unit is %.

In physical term, EE may relate to equipment in a large system,

Example: Energy to heat a building:

i. The use of less energy without impairing comfort level of occupant, productivity and quality of life.

ii. Reducing the energy used by specific end-use devices and systems, typically without affecting the services provided.

Energy efficiency is said to be changing or moving the most efficient matter with the least amount of energy and it saves earth's precious resources, helps the environment and reduces building energy costs (EIA, 2009). This means using less energy to provide the same level of energy. It is therefore one method to reduce human greenhouse gas emissions (Piebalgs, 2008).

2.6.3 ENVIRONMENTAL BENEFITS

Every new development ideally should have an explicit energy strategy.

The benefits of greater energy efficiency therefore are not hard to identify. They can be summarized as follows:

i. Lowering fuel costs;

ii. Reducing demands on non-renewable fuels;

iii. Enhancing comfort conditions within buildings, and thereby improving health and productivity;

iv. Curbing environmental pollution;

v. Delaying if not mitigating the greenhouse effect;

vi. Creating jobs in energy conservation.

Energy efficiency is not an alternative to energy security; it is a vital component in achieving it (Piebalgs, 2008).

EE design elements that affect thermal comfort conditions and energy consumption in **a** building expressed in Figure 2.9 below

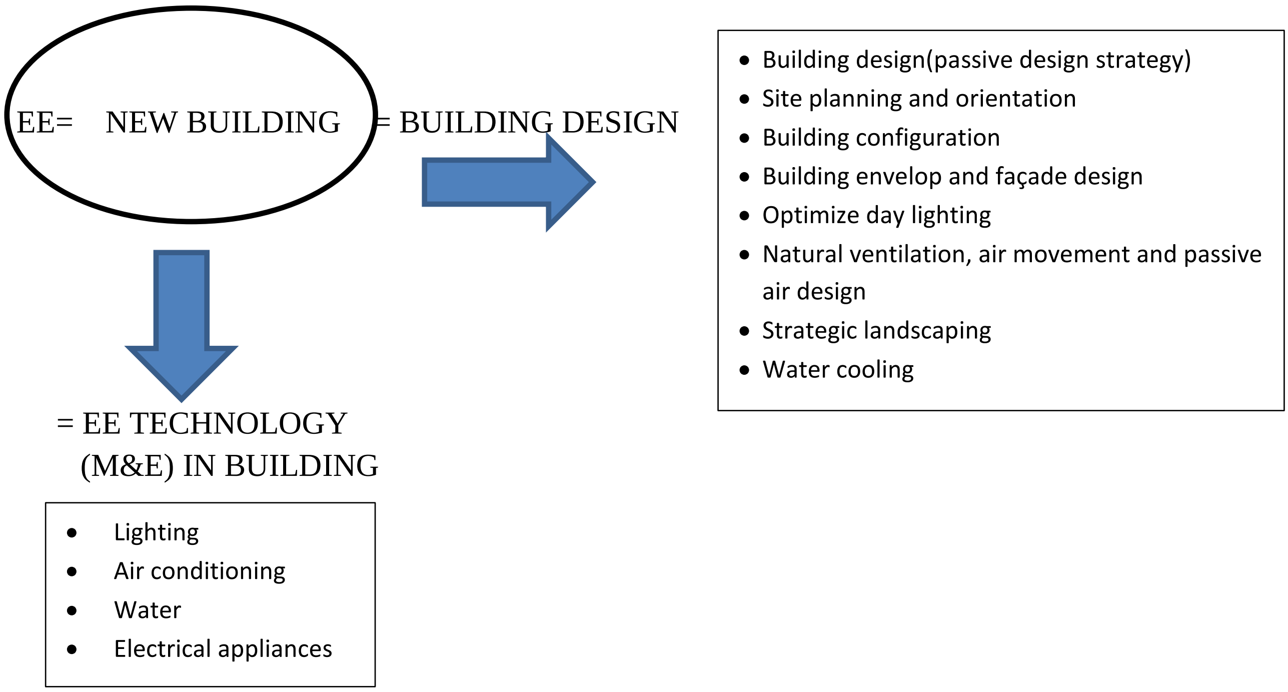


Figure 2.9: EE design elements that affect thermal comfort conditions and energy consumption in **a** building.

Source: Researchers work, 2014.

2.7 INTRODUCTION TO THE SHOPPING MALL

In a society where buying everyday goods has increasingly become linked to driving to a mall or shopping centre, and where more and more time is spent in such places, (claimed to be on the cost of life on the streets), it has become important to question how public, shopping malls in fact are. Retailing is one of the major economic activities all over the world. Shopping malls have been taken on a distinct role in the retail structure. The term "Shopping mall" has been evolving since the early 1950s (1CSC, 1999). It evolves from the street-side stores, Public Square, seaport, wet market, department stores then the shopping malls. There are various types of shopping mall depending on the sizes, tenants, facilities availability, etc. The Urban Land Institute had in 1977 referred shopping Centre as "a group of architecturally unified commercial establishments built on a site which is planned, developed, owned and managed as an operating unit related in its location, size and types of shops to the trade area that the units serves. The unit provides on-site parking in definite relationship to the types and total size of the stores "(Urban Land Institute, 1977). The International Council of Shopping Centre (ICSC) had in 1999 defined shopping mall as "A group of retail and other commercial establishments that is planned, developed, owned and managed as a single property. On-site parking is provided. The Centre's sizes and orientation are generally determined by the market characteristics of the trade area served by the mall. (Kwatu, 2012).

Encyclopaedia Britannica, (2009) defines a shopping mall as "a collection of independent retail stores, services, and a parking area conceived, constructed, and maintained by a management firm as a unit. And may include a whole list of other establishments within. Cyril,(2006) defines a shopping mall as "A shopping Centre enclosed within a large structure; often two or three stories high, often designed around a central atrium; may have numerous stores, as well as entertainment facilities such as movie theatres, fast-food outlets, restaurants, and public areas" . A shopping mall, as defined in this study, is a large shopping centre entirely within a roofed structure, controlled by a limited number of entrances. Stores and other services are only accessible via interior corridors (Antal, 2010).

2.7.1 TRENDS IN SHOPPING MALL

Current trends in shopping mall design

The changing trends that can be experienced in many Nigerian malls of today are as follows:

i. Emphasis on the integration of shopping and entertainment: the integration of shopping and entertainment is fast growing in the world today. To enhance patronage, shopping malls of today include other activities that tend to attract people to the shopping area. These activities may include: cinemas, games etc.

ii. Application of energy efficient design features.

iii. Use of modern vertical transportation systems like panoramic lifts and escalators.

iv. Use of aesthetically pleasing materials.

v. Maximum customer attraction parallels high sales

2.8 PRINCIPLES OF MALL DESIGN AND PLANNING

In the design of shopping malls, there are some very crucial factors that need to be critically addressed. These factors are likely to make or mar the success of the shopping mall. The idea behind every mall is to attract as many customers as possible and to sell as many goods as possible. This can only be achieved if the atmosphere suits the shoppers needs like the provision of adequate parking, security and so on.

2.8.1 Economic survey

In the design of a shopping mall, it is important to understand the current economic status of the area. The development of a shopping mall in any location should improve its economic state in the long run. A mall should have a positive impact on the society as a whole. The combination of consumer satisfaction and societal well-being make up the core concepts of society marketing. The economy of a community gains benefit from any commercial activity, the shopping mall included, by generating jobs for the community and improving its technological progress and providing more goods to the customer.

2.8.2 Site selection

For any commercial establishment like a shopping mall, the choice of selecting a site is very important. The site should be located in the commercial area of the city. The site should be located to allow ease of access by both pedestrians and vehicles. The site should have an area large enough to provide for future expansion.

2.8.3 Vehicular survey

Since the vehicular access to a site is important, it is necessary to study the vehicular pattern of movement. This would help in locating the access points within the site. It is important to survey the approach of the vehicles from the various directions, the major routes that would lead to the site and the traffic loads on the routes. The main idea behind this survey is to minimize traffic congestion on the road leading to the site so as to make access easy and convenient. Also access for delivery services should be separated from the customer's access.

2.8.4 Climate control

A fully enclosed space housing a lot of activities, goods and people needs to have well controlled internal climate. The activities of people, generation of heat by electrical and mechanical installations and the like can greatly affect the climate in the building. Measures have to be taken, therefore, to ensure that the right internal climate is achieved to make the place comfortable enough for the people and the installations to carry out their functions properly. Factors such as dehumidification of the internal environment, ventilation and lighting have to be properly addressed in the design so as to create a conducive environment for people to shop comfortably.

2.8.5 Services

The services in a shopping mall include service areas for delivery of goods, storage facilities for the goods, refuse disposal, facilities for accommodating the electrical and mechanical equipment and so on. The location of these services is very important; they should be located out of the customer's sight. Their locations should not tamper with the movement of the customers and vehicles. These services are provided for the safety and convenience of the shoppers, they should therefore be properly planned based on the needs of the customers.

2.8.6 Security considerations

A shopping mall is a public establishment; it is therefore open to a wide range of people. This makes it a target for criminal activities. To avoid this, provision has to be made for security right from the parking to the main building. The incorporation of security gadgets such as surveillance cameras, security guards and burglar alarms are necessary. Also the design should allow for openness in plan and avoid niches to prevent criminals from carrying out their activities and with the building acting as cover.

2.8.7 Fire precautions

In shopping malls where there are a great number of people and goods, precautions have to be taken to minimize the risk of fire outbreak. This involves the use of fire fighting equipment and the provision of emergency escape routes. This should be properly planned and designed to ensure the safety of people in times of fire outbreak taking into cognisance availability of water hydrants and vans to be able to get close to buildings.

2.8.8 Landscaping

Landscaping is an important aspect of any type of building, whether residential, commercial and so on. Landscaping should be properly addressed in the site planning as well as the design of the mall. It is important to plant trees because they provide shade for the pedestrians, and the vehicles. They also serve as windbreakers and they buffer sound from the mall to its neighbouring buildings. Also, the pedestrian areas should be well planned and demarcated from vehicular circulation areas by the use of bollards, hedges and so on.

These are the major end user groups in a shopping mall are Management, Security, private and police, Tenants, Shoppers, and Non-shoppers.

CHAPTER THREE

3.0 METHODOLOGY

3.1 RESEARCH METHODOLOGY

The study was extended to three main phases. The first and third phases consisted of theoretical studies that were conducted in Zaria. The second phase was a field research that was held in Abuja.

The first phase defined the theoretical framework for this study. In addition, it aims to identify the methodology of analysis and issues that are to be investigated in the case study. This phase, mainly encompassing extensive literature reviews of books, journal papers, researches and documents to identify energy efficient design principles that could be used for the context of the research.

The second phase will involve a field trip to Abuja. The fieldwork consisting of visits to the instrumental case study with embedded units and interviews with the staff, and customers of the case study building. The case study is commercial buildings that are representative of inefficient energy buildings in Abuja city. Quantitative and qualitative data were collected from the case study building. All the information that was analysed during this phase was intended to fulfil the structure outlined in theoretical framework formed in the first phase.

The third phase comprised of a desk study for the second time to analyse and evaluate the data from the first and second phase studies using quantitative and qualitative methods. Energy efficient principles that were identified through literature review were summarized and analysed quantitatively to determine the energy savings of features that could be applied in the context of Abuja.

3.2 RESEARCH DESIGN

Yin (2009) defines case study research as an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and the context are not evident. According to Yin, the method is the most important characteristic of a case study. Stake (1998) on the other hand argues that case study is not a methodological choice, but a choice of object to be studied. This object of study as Stake puts it is a case. In accordance with Stake's definition, every study that has a case as the object of study is a case regardless of the methods used. Case study can be regarded as a research that incorporates several different methods for the collection of data and for the analysis and processing of findings.

Yin (2009) differentiates between two types of case studies: holistic and embedded. The holistic case study focuses on the case as a unit of analysis. On the other hand, embedded case study is one in which the case still functions as the unit of analysis; however, there are also subunits of analysis within the case. In this research, the shopping mall is the unit of analysis. The case study performed in this research is that of a holistic case study.

Yin (1999) also distinguishes between a single-case design and a multiple-case design. Single-case design uses only one case to deal with the research questions and in multiple-case design, two or more cases are studied. The research undertaken uses a multiple case.

Stake (1998) makes a distinction between three types of case study: intrinsic, instrumental and collective. In an intrinsic case study, study is undertaken because one wants better understanding of that particular case. An instrumental case study is one in which a particular case is examined to provide insight into an issue or refinement of theory. A collective case study is an instrumental study that is extended to several cases. The case study in this research is instrumental in nature.

3.2.1 SELECTION OF CASE STUDY

In this research, the shopping malls surveyed are the holistic units of analysis.

The selection of the case study building was based on the following criteria:

i. It is representative of typical commercial building in Abuja.

ii. Some of the architectural drawings of the malls were available

iii. It was accessible

iv. The staff and consumers were cooperative.

3.2.2 Case Study Selection Criteria

The selection criteria for the case studies on this research is based primarily on commercial building type shopping malls in particular; buildings that have applied the principles of energy efficiency within them.

The selected cases have been analyzed via two categories:

i. An overview documentation of commercial design
ii. An assessment of the application of energy efficiency principles

ACCESSIBILITY: A strategic location should be chosen which provides the greatest public access.

IMAGE: Commercial buildings should be located in order to maximize the potential for patronage.

CONTEXT: Commercial buildings should be located where the area uses its physical scale.

PROXIMITY: Commercial buildings should be located close to support facilities so as to ease users.

3.2.3 ISSUES INVESTIGATED/ UNITS OF ANALYSIS

Apart from the design aspects that were identified in the theoretical framework, the following

Issues in the case study building have also been investigated:

i. Energy use practices of the building (appliances used, energy used by those appliances)

ii. Energy use for cooling and lighting in commercial buildings in Abuja.

iii. Role of architects, developers and interior designers in designing energy efficient buildings

iv. Role of architects, developers, interior designers and clients (land owners) in creating barriers for designing energy efficient residential buildings

v. Common amenities provided by the developers in typical commercial building of Abuja.

3.2.4 CASE STUDY ASSESSMENT CRITERIA

Case study research in Architecture goes beyond the documentation and description of the physical characteristics of the built environment (Oluigbo, 2010). Hence, the findings and results gotten have to be assessed based on specific approaches addressing the research question or issue directly and listing out how the findings have been able to be of help to the research question. This can be in the form of variables that seek to point out certain features as identified in the visual survey.

3.2.5 DATA GATHERING STRATEGIES

Data gathering strategies were divided into a mixture of qualitative and quantitative approaches called mixed method and collectively known as Triangulation method.

The following different combinations of parameters were adopted:

i. Qualitative and quantitative physical survey of the case study building
ii. Qualitative and quantitative semi-structured interviews that have open and closed questions
iii. qualitative and quantitative architectural drawings of the case
iv. photographes (qualitative and quantitative).

3.2.6 EVALUATION AND ANALYSIS OF THE DATA

To capture complexity of cases the use of multiple sources of data collection will be used in defining characteristics in carrying out case study methodology (Yin, 2004; Veal, 2006; Johansson, 2010). For the purpose of this research, the visual survey can be reflected in various formats which include:

i. Physical observation and photographs

ii. Sketches

iii. Checklist

iv. Structured interview

The data gathered called for a number of different methods of analysis in order to find linkages between the research object and the outcomes with reference to the original research questions. Throughout the evaluation and analysis process, options were kept open to new opportunities and insights. Data has been categorized, tabulated, and recombined to address the initial purpose of the study.

3.2.7 Data Collection Methods

The research is basically mixed. Methods employed include:

i. **Participant observation:** Being physically on the premises of the building and going round available facilities on site.

ii. **Interview:** Being able to ask the relevant questions and gather responses for use.

iii. **Review of exiting literature:** Documents, books, journals, within context.

iv. **Analytical and comparative study:** Comparisons of a few commercial building types.

Variables of study will be deduced from the principles of energy efficiency namely:

i. Principle I: - Climate and site- a building reacts naturally to its environment climatically.

ii. Principle II :- Building envelop responds dynamically to ambient conditions.

iii. Principle III :- The building systems achieves optimum energy efficiency strategically.

Variables of study will be based on the below listed dependent variables:

i. Major facilities
ii. Construction system
iii. Building concept
iv. Building orientation
v. Ventilation system
vi. Day lighting attributes
vii. Primary sources of energy

3.2.8 ASSESSMENT OF THE PRINCIPLES OF ENERGY EFFICIENCY

The following design criteria is focused on the tropical zone namely Abuja Nigeria.

Principle i: (Climate and Site):-

i. Design should be integrated from the site.
ii. Design for thermal comfort

VARIABLES

i. **Topography:** Designing according to the slopes, valleys, hills and their surface conditions.

ii. **Vegetation:** Preservation of trees, plant type, mass, texture and other natural features within the site.

iii. **Built forms:** Large spacing of building or staggered arrangements is required to a low adequate flow around the building.

iv. **Water bodies:** Use of water permeable landscape features, use of gardens, lakes, ground water for cooling effect.

v. **Orientation:** Longer walls should be facing north-south axis.

Principle ii: (Building Envelop and Fenestrations)

1. Design for thermal comfort(for the Tropical Zones)

VARIABLES

i. Building materials: materials used should be of low thermal capacity to enhance heat loss efficiently via walls, roof and flooring.

ii. Size of openings: opening should be large and wide on the north and southern sides of the building.

iii. Site planning and layout of buildings: spacing and arrangement of buildings should be done strategically to allow adequate and controlled air flow around.

iv. Floor plans: single banking of should be used to facilitate cross-ventilation.

v. Shape of roof: pitched roofs with adequate eaves projection to exclude rain and solar radiation. Roof gutters should be large enough and well drained.

vi. Shading devices: trees, vertical shading devices, horizontal shading devices and egg crate shading devices.

vii. Use of day lighting: south facing glass admits solar energy into the interior of buildings.

Principle iii :(Renewable energy):-

1. Use of renewable energy.

VARIABLE

a) Renewable energy: Renewable energy such as photovoltaic cells, solar energy, biomass, wind turbines.

3.2.9 VALIDATION OF RESULTS

The data obtained from the instrumental case study have been validated by triangulation. Triangulation, as Johansson (2003) says, is the most important way of making the results of a case study valid. Stake (1998) defines triangulation as a process of using multiple perceptions to clarify meaning by identifying different ways in which the phenomenon is seen. According to Garson (2002), the case study method, with its use of multiple data collection methods and analysis techniques, provides researchers with opportunities to triangulate data in order to strengthen the research findings and conclusions.

According to Patton (1990), there are four different methods of triangulation in connection with qualitative methods:

i. **Data triangulation:** Several sources are used to collect data about the same phenomenon.

ii. **Researcher triangulation:** Several researchers study the same phenomenon.

iii. **Theory triangulation:** The same data is analysed using different principles.

iv. **Method triangulation:** Several methods are used to gather data about the same phenomenon.

Among the different methods of triangulation described above, data triangulation and method triangulation were used in this study. That is in the case study building were used for data triangulation to investigate the issues or attributes of interest mentioned. Data triangulation was also used to investigate the usage of air conditioners a number of staff and users have been asked individually). Lighting conditions were crosschecked through method triangulation (interview, observation, photographs). Cross ventilation inside the spaces is triangulated by employing Triangulation method (interview, observation).

3.2.10 GENERALIZATION

Flyvbjerg (2006) has addressed the misunderstanding that one cannot generalize based on an individual case and therefore the case study cannot contribute to scientific development. He has revised this misunderstanding, so that it now says:

'One can often generalize on the basis of a single case, and the case study may be central to scientific development via generalization as supplement or alternative to other methods. However, formal generalization is overvalued as a source of scientific development, whereas "the force of example" is underestimated.'

According to Svane (2005), architects customarily use a form of systematic generalization known as naturalistic generalization. Architects, based on their knowledge, professional training and experience are able to make systematic comparisons from similar examples; chose what is relevant to the specific context and design something unique. In naturalistic generalization, the reader or the user of the findings is confronted with uncontrollable generalizations, taking place in his or her mind. In this type of generalization, it is the reader who does the generalization by reflecting and relating to the results based on his or her experience or lack of it. It is thus left up to the reader or the user of the findings in this study to compare the examples and accept this study as one case in her or his compilation of related cases.

CHAPTER FOUR

4.0 CASE STUDIES

4.1 Findings from the case studies

4.2 CASE STUDY ONE: CEDDI PLAZA

Plate 4.1: External view of Ceddi plaza
Source: Researchers work, 2014.

4.2.1 Background

Ceddi Plaza is located at no 264, Tafawa Balewa way in the central business district of Abuja the capital of Nigeria adjacent to the Federal Mortgage Bank of Nigeria and it is owned by Ceddi cooperation. Construction of the building started in 2001 and not until November 2005 was the plaza officially opened. The plaza is celebrated as the premiere plaza for shopping and entertainment in the city of Abuja.

4.2.2 Application of passive strategies in case study

i. **Building Orientation**-

The building is oriented on a North- East axis, its longer side facing the North and shorter side the East.

ii. **Climate**-

Climatic conditions of the area are Hot with Dry prevailing winds.

iii. **Windows-**

Fenestration is used by Non operable curtain wall windows primarily for light.

iv. **Size of openings**-

Awning windows along the south façade

v. **Usability**-

Provision is mainly mechanical but an alternative through use of atriums.

vi. **Day lighting**-

Natural ventilation through mechanical, atriums and windows placed strategically.

vii. **Natural ventilation-**

Provided through atriums, and windows

viii. **Building materials**-

The material composition used includes Concrete, steel, aluminium and glass.

ix. **Building forms**

-the building form takes on a Simple rectangular form.

x. **Interior spaces-**

A tenant mix of three floors of retail space which consists of eateries, fashion boutiques, entertainment and services, corporate office spaces. Thus the mall consist of 59 shops, offices and service providers consisting of movie theatres, a supermarket, champagne lounge, restaurants, cafe, fashion boutiques, shoe accessories ,home interior design stores, spa, furnishing, telecoms, banking and ATM, dry cleaning service, dental office, pharmacy, photo studio, children entertainment, event's hall.

xi. **Energy-**

Energy source is from the national grid and a standby power plant.

Plate 4.2: View of Openings
Source: Researchers work, 2014.

Plate 4.3: View of Staircase
Source : Researchers work, 2014.

Plate 4.4: View staircases

.

Plate 4.5: View of Light fittings
Source : Researchers work,2014.

Plate 4.6: Light fittings
Source: Researchers work,2014.

Plate 4.7: Views of lift openings
Source: Researchers work, 2014.

Plate 4.8: View of spaces between headroom
Source: Researchers work, 2014.

Table 4.1: VARIABLE 1. ASSESSMENT OF THE APPLICATION OF ENERGY EFFICIENCY PRINCIPL

ENERGY EFFICIENCY PRINCIPLE i : CLIMATE AND SITE		
VARIABLES	DESCRIPTION	CONCLUSION
Building materials	Use of concrete and heavy massing of high thermal capacity doesn't reduce heat penetration.	Negative
	Use of glazing around doesn't reduce the heat into the building.	Negative
Size of openings	Use of windows to face the east and west axis reduces passive cooling.	Positive
Building footprint	The building size and form creates minimal interference with site topography	Positive
Site planning and layout of building	The building enhances passive cooling	Positive
Floor plans	Placement of atriums increases cross ventilation	Positive
Preservation of site characteristics	Minimal availability of trees within site	Negative
Landscaping	Use of natural landscaping elements was minimal	Negative
Building form and aesthetics	The building is rectangular in shape is conducive for the tropical climate	Positive

ENERGY EFFICIENCY PRINCIPLE ii : BUILDING ENVELOP AND FENESTRATION		
VARIABLES	DESCRIPTION	CONCLUSION
Building materials	Use of concrete and heavy massing of high thermal capacity doesn't reduce heat penetration.	Negative
	Use of glazing around doesn't reduce the heat into the building.	Negative
Shading devices	Use of horizontal devices	Positive
ENERGY EFFICIENCY PRINCIPLE iii : RENEWABLE ENERGY		
VARIABLES	DESCRIPTION	CONCLUSION
Renewable energy	The building is powered with use of generators.	Negative

Source: Researchers work, 2014.

4.3 CASE STUDY TWO: NEXT Cash And Carry

Plate 5.1: Exterior views of Next: cash and carry

Source: Researchers work, 2014.

4.3.1 Background

Next International Nigeria Limited with its wholly-owned subsidiaries, Next International (UK) Ltd, Next Foods (Nigeria) Ltd, Next Direct Ltd, Next Cash 'N' Carry Ltd, is a first class brand market development and management company, the first of its kind in sub-Saharan Africa. Next C & C is based on the successful Cash 'n' Carry operations/Warehouse Clubs/Hypermarkets in South Africa.

4.3.2 Application of passive strategies in case study

i. **Building orientation-**

The building is located on a North-East axis, its longer side facing the North and shorter side the East.

ii. **Climate-**

A climatic condition of the area is Hot and Dry prevailing winds.

iii. **Windows-**

Fenestration is use by non-operable curtain wall windows primarily for light.

iv. **Size of openings-**

Awning windows along the south façade

v. **Usability-**

Mainly mechanical

vi. **Day lighting-**

Mechanical, windows

vii. **Natural ventilation**-

Mechanical, windows

viii. **Building materials**-

Concrete, steel, cladded bricks, aluminium and glass

ix. **Building forms**-

Simple rectangular

x. **Interior spaces**-

A tenant mix

xi. **Energy**-

Electricity and standby power plant.

Table 4.2: VARIABLE 1. ASSESSMENT OF THE APPLICATION OF ENERGY EFFICIENCY PRINCIPLES

Energy efficiency principle1 : climate and site		
VARIABLES	DESCRIPTION	CONCLUSION
Building materials	Use of concrete and heavy massing of high thermal capacity doesn't reduce heat penetration.	Negative
	Use of glazing around doesn't reduce the heat into the building.	Negative
Size of openings	Use of windows to face the east and west axis reduces passive cooling.	Positive

Building footprint	The building size and form creates minimal interference with site topography	Positive
Site planning and layout of building	The building enhances passive cooling	Positive
Floor plans		Negative
Preservation of site characteristics	Minimal availability of trees within site	Negative
Landscaping	Use of natural landscaping elements was minimal	Negative
Building form and aesthetics	The building is rectangular in shape is conducive for the tropical climate	Positive

ENERGY EFFICIENCY PRINCIPLE2 : BUILDING ENVELOP AND FENSTRATION		
VARIABLES	DESCRIPTION	CONCLUSION
Building materials	Use of concrete and heavy massing of high thermal capacity doesn’t reduce heat penetration.	Negative
	Use of glazing around doesn’t reduce the heat into the building.	Negative
Shading devices	Use of horizontal devices	Positive
ENERGY EFFICIENCY PRINCIPLE3 : RENEWABLE ENERGY		
VARIABLES	DESCRIPTION	CONCLUSION
Renewable energy	The building is powered with use of generators.	Negative

Source: Researchers work, 2014.

4.4 CASE STUDY THREE: Shoprite

Plate 4.17: Exterior views of shoprite

Source: Researchers work, 2014.

4.4.1 Background

The building is located along the outskirts of the metropolitan along Apo, owned by Grand Towers a South African company.

4.4.2 Application of passive strategies in case study

i. **Building Orientation**

North- east

ii. **Climate**

Hot and dry

iii. **Windows**

Non operable curtain wall windows

iv. **Size of openings**

Awning windows along the south façade

v. **Usability**

Mainly mechanical

vi. **Type of ventilation**

Single sided and stacked

vii. **Day lighting**

Mechanical, windows

viii. **Natural ventilation**

Mechanical, windows

ix. **Building forms**-

Simple rectangular

x. **Interior spaces**-

A tenant mix

xi. **Energy**-

Electricity and standby power plant.

Table 4.3: VARIABLE 1. ASSESSMENT OF THE APPLICATION OF ENERGY EFFICIENCY PRINCIPLES

ENERGY EFFICIENCY PRINCIPLE1 : CLIMATE AND SITE		
VARIABLES	DESCRIPTION	CONCLUSION
Building materials	Use of concrete and heavy massing of high thermal capacity doesn't reduce heat penetration.	Negative
	Use of glazing around doesn't reduce the heat into the building.	Negative
Size of openings	Use of windows to face the east and west axis reduces passive cooling.	Positive
Building footprint	The building size and form creates minimal interference with site topography	Positive
Site planning and layout of building	The building enhances passive cooling	Positive
Floor plans		Negative
Preservation of site characteristics	Minimal availability of trees within site	Negative
Landscaping	Use of natural landscaping elements was minimal	Negative
Building form and aesthetics	The building is rectangular in shape is conducive for the tropical climate	Positive

ENERGY EFFICIENCY PRINCIPLE2 : BUILDING ENVELOP AND FENESTRATION		
VARIABLES	DESCRIPTION	CONCLUSION
Building materials	Use of concrete and heavy massing of high thermal capacity doesn’t reduce heat penetration.	Negative
	Use of glazing around doesn’t reduce the heat into the building.	Negative
Shading devices	Use of horizontal devices	Positive
ENERGY EFFICIENCY PRINCIPLE3 : RENEWABLE ENERGY		
VARIABLES	DESCRIPTION	CONCLUSION
Renewable energy	The building is powered with use of generators.	Negative

Source: Researchers work, 2014.

Table 4.4: The need for energy efficiency: analysis of case studies

BUILDINGS	**CEDDI PLAZA**	**NEXT**	**SHOPRITE**
VARIABLES			
Day lighting	Mechanical,atrium, window	window	Window
Natural ventilation	Mechanical, atrium, window	window	Window
Building height	6 storey	1 storey	1 storey
Building material	Concrete,steel,alumnium ,glass	Concrete,steel,alumnium ,glass	Concrete,steel,aluminium, glass
Building form	Rectangular	rectangular	Rectangular with afew distortions
Interior space	Offices,tenant spaces,eateries	Tenant spaces	Teneant spaces
Energy	Eletricity and generators	Electricity and generators	Electricity and generators

Source: Researchers work, 2014.

4.5 CASE STUDY FINDINGS

The findings of this study indicates that the shoppers, tenants and staff working within these buildings barely take note of effects of the building; its material use by them directly, they rather go on with their businesses irrespective; though power is an issue appreciated although. Therefore a look at energy is paramount and its application is needed in commercial like buildings which consume relatively high portions of energy in running them.

CHAPTER FIVE

5.0 The Site

5.1 Site

The site for the proposed Shopping mall is located in the outskirts of Abuja. The federal capital territory is centrally located in between surrounded by Nasarawa to the west, Kaduna to the North, Kogi to the South, Niger to the West.

Abuja is located in the Savannah region of Nigeria between Latitudes 8’25’’ and 9’20’’ North of the equator and Longitudes 6’45’’ and 7’30’’ east of Greenwich Meridian. The total landmass is 8000square kilometers.

Plate 5.1: Map of Africa

Source: www.nigerianarchives.com

Plate 5.2: Map of Nigeria with situation of Abuja

Source: www.nigerianarchives.com

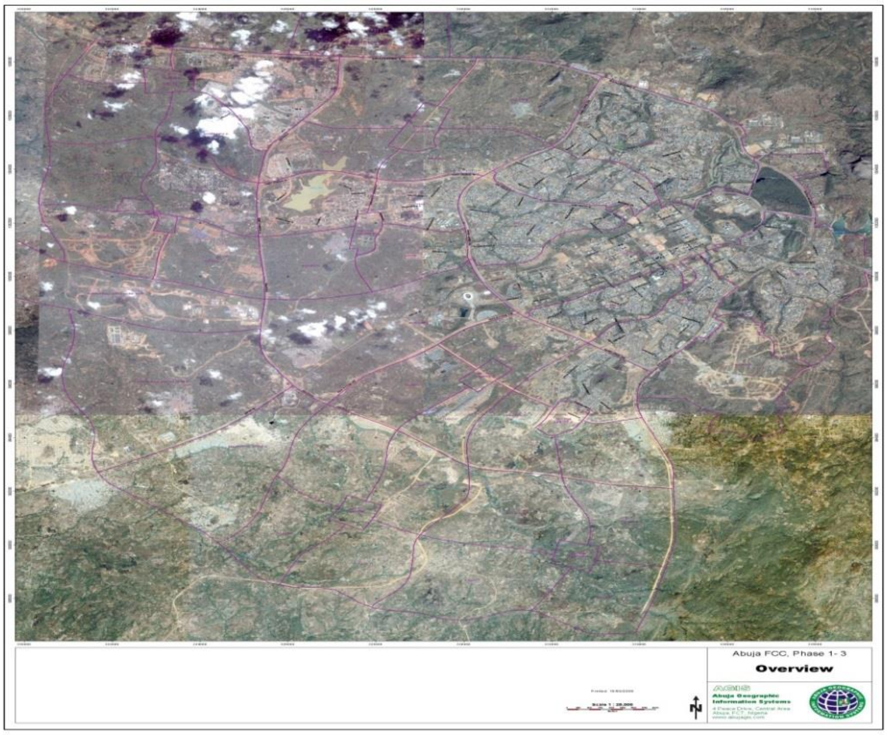


Plate 5.3: Satellite image of Site Location

Source: Abuja Geographic Information Systems

5.2 SITE SELECTION CRITERIA

The mall site is been carefully and strategically selected bearing the following criteria in mind. They are as follows:

Two sites were compared and a table of comparison provided below:

Table 5.1: Table showing comparison of proposed sites

SITE CRITERIA	SITE A	SITE B
Proximity to residential areas	Site is convenient	Site is convenient
Location/accessibility; traffic issues (pedestrian, passenger vehicles);	Site is not convenient	Site is convenient
Proximity to airport, major roads	Site is close by	Site is far
Land-use compliance	Suitable	suitable
Visual and aesthetic potential	suitable	suitable

Source: Researcher's work, 2014.

Site B was chosen based on Researcher's conclusions.

5.3 LANDUSE

Abuja is demarcated by districts zoned accordingly for their intended land uses such as commercial, residential, industrial sectors.

5.4 SITE ANALYSIS

5.4.1 SITE CLIMATE

The climate of the FCT is typical of the Savannah. Lists of the conditions are broken down in tabular form provided below:

I. Temperature

Temperatures rise as high as 18' in the dry season being recorded and lowest in rainy season in the months of august.

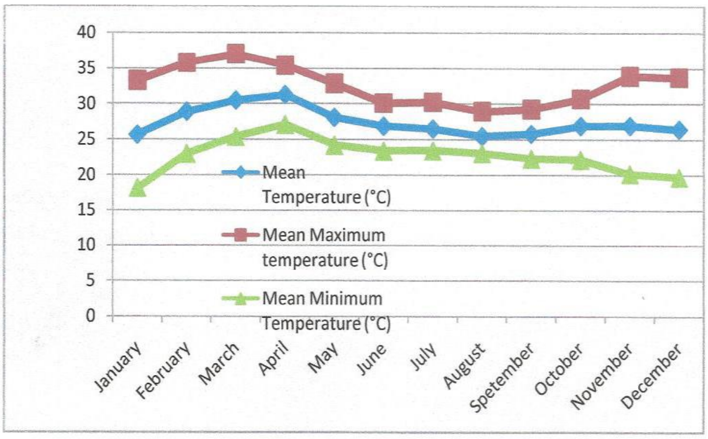


Figure 5.1: Temperature chart
Source: www.gaisma.com

II. Humidity

Humidity levels rise high during rainy season and are low during the dry season between months of November to march

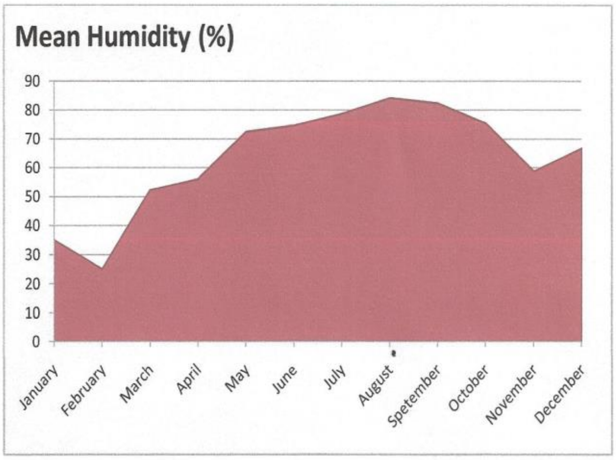


Figure 5.2: Humidity chart
Source: www.gaisma.com

III. Rainfall

Rainy months fall in-between April and October with an average duration of 185 days.

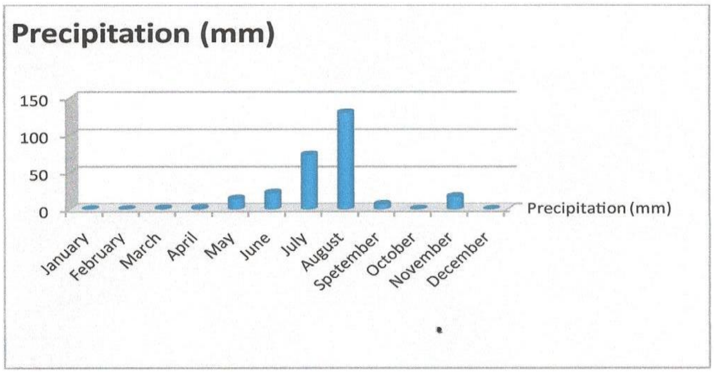


Figure 5.3: Precipitation chart
Source: www.gaisma.com

IV. Wind speed

Tropical maritime and tropical continental air masses are the two dominant masses domineering the Abuja air mass. The tropical continental air mass comes with the dry season and is developed over the Sahara desert and the tropical maritime air mass the wet season and is therefore warm and moist.

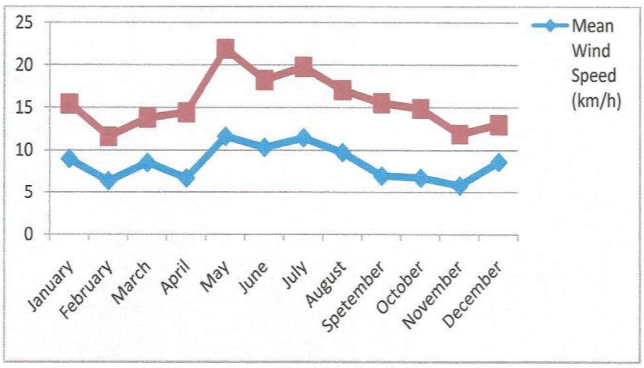


Figure 5.4: Wind speed chart
Source: www.gaisma.com

V. **.Sun and cloud cover:** Sunshine ranges from a minimum of 130 hours in the Niger Delta to over 3200 hours in the extreme north-east of the country.

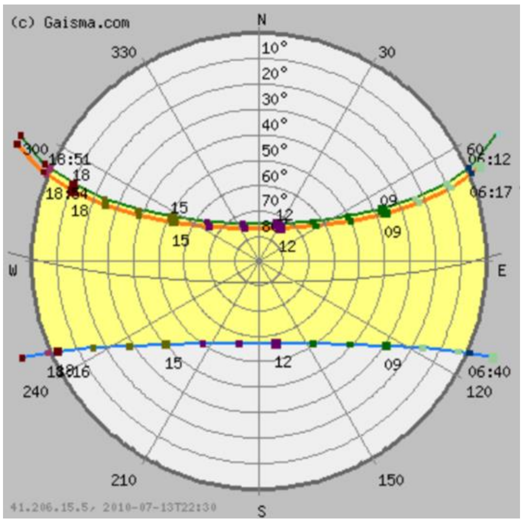


Figure 5.5: Solar chart
Source: www.gaisma.com

5.5 Design Philosophy

Access:

The site is accessible on road

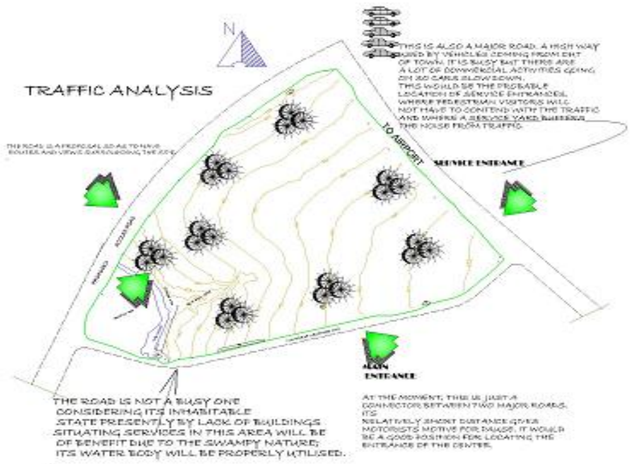


Figure 5.6: Access to the site

Source: Researchers field work, (2014).

Utilities:

Existing electricity, sewage, water and telecommunication network availability on site

Air movement:

Availability of trees and shrubs on site assists as shield to the passing north east trade winds bringing dry humid desert winds sweeping south west ; and south west trade winds blowing north east across the site with rain and humid air from the Atlantic ocean.

Vegetation:

Dense vegetation on site to be well landscaped and trees planted to reduce ambient temperatures.

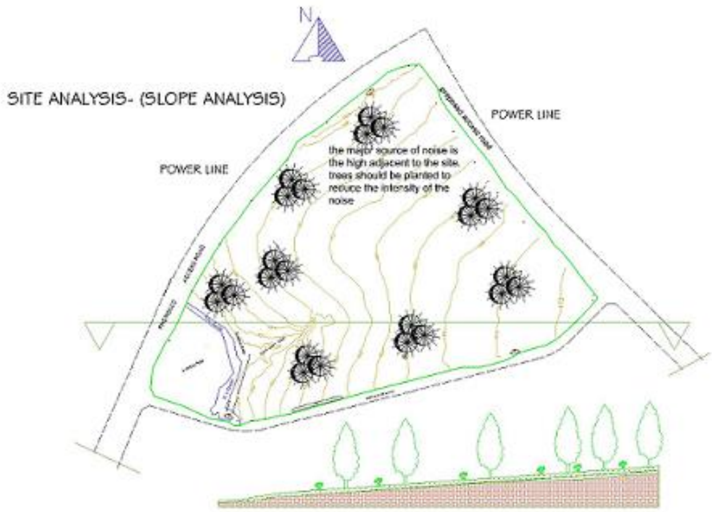


Figure 5.7: Site vegetation
Source: Researchers field work (2014)

Topography:

The site slopes towards the west; this would be harnessed for parking

Figure 5.8: Topography view
Source: Researchers field work 2014

Soil:

Soil strength durable to a reasonable capacity; would not pose much structural allenges.

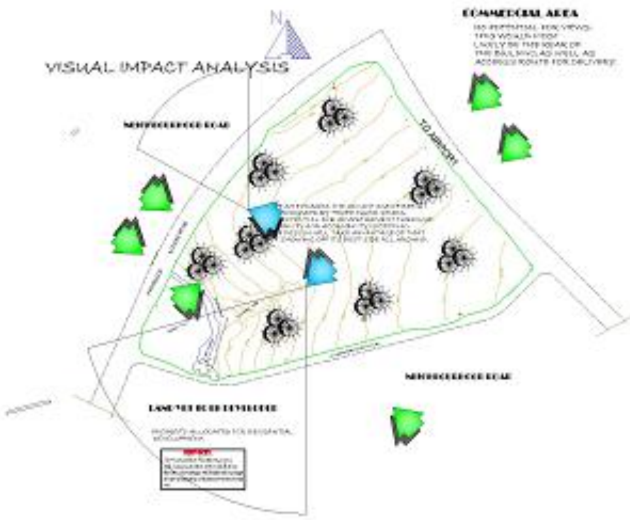


Figure 5.9: site view
Source: Researchers field work 2014.

View:

The site offers views

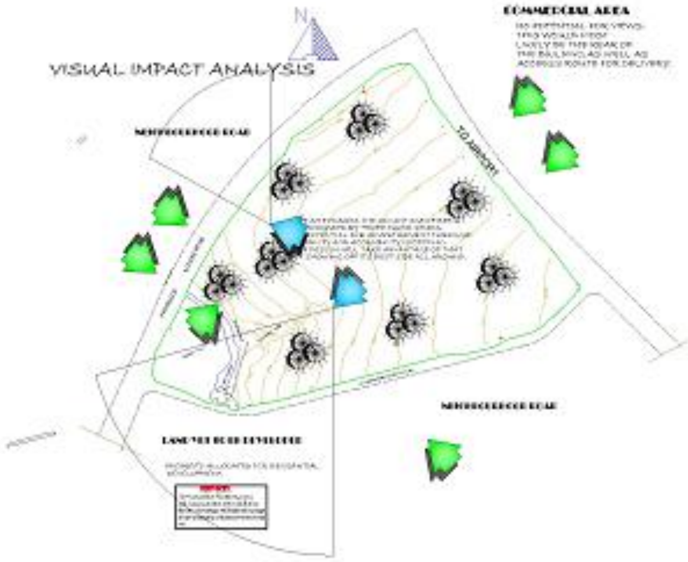


Figure 5.10: site view
Source: researchers field work, 2014

5.5 DESIGN PHILOSOPHY

The concept of the building is borne out of the reliance on natural ventilation, lighting and use of site for harmony of functional requirements and human needs.

5.6 DESIGN PROPOSAL

Considering Abuja a fast paced growing city economically and the trends of shopping on the increase, this led to the idea of a proposal sited along a new development area springing up.

5.6.1 DESIGN CONSIDERATIONS

i. **General planning: orientation/ spatial arrangement**

The facility is designed to align around the central core which is the departmental store. This makes accessibility easy and fast. The parking lots are arranged as wings so one approaches the building this allows easy flow of traffic ; and an incorporation of greenery in-between helps with enhancing the micro climate.

ii. **Circulation**

A wide and spacious circulation space arranged along row of spaces are provided and a provision of taxi drop off and bus stop helps curb traffic and a clear demarcation between pedestrian and vehicular movement is made outside the building within the premises.

iii. **Day lighting**

Natural light is readily available to most if not all spaces in the design by providing rows of skylights and windows a provision of multiple openings around the building.

iv. **Ventilation**

The provision of skylights and high level windows, artificial ventilation by the use of displacement air-conditioning systems in the interior of the building increases its energy efficiency and the patterns of circulation which is in a chronological succession allows air to come in freely from beneath, cool the buildings and escape through the top of the openings in a stack-effect pattern, thus, allowing the building to be moderately cool.

v. **Site planning and landscaping**

Use of trees, shrubs, hedges as plantations around the structure, as well as use of stone paving to help curb external heat and minimizes the inflow to the building.

vi. Building materials and technology

Compressed earth bricks, aluminum, double paned pressurized glass shall be the dominant building materials.

vii. Compressed earth bricks

The ability of the material to lower internal heat by absorption and re-radiate cool temperatures at night as well as its locally sourced and compatible to the tropical climate like Abuja.

5.6.2 SERVICES

i. Water supply

Water will be supplied through the mains and alternatively via borehole, recycled water for the toilet system, watering of vegetation and for fire outbreaks.

ii. Power supply

Power shall be from national grid, natural daylight during the day alternatively photovoltaic and solar panels.

5.7 BRIEF DEVELOPMENT

The proposed development intends to develop into a shopping mall with the various facilities within

i. Entrance, reception, admin

ii. Security, information desk

iii. Rentable shops

iv. Stores

v. Cold stores

vi. Dry stores

vii. Butchery

viii. Departmental store

ix. Cinema

x. Conveniences

xi. Fire exits

xii. Staff Changing rooms, wc

xiii. Restaurants

xiv. Kiosks

xv. Laundry

xvi. Circulation routes

xvii. Kitchens

5.8 DESIGN BRIEF AND SPACE REQUIREMENT

Here, attempts are geared towards establishing a balance between standard requirements and peculiar variations. The importance of practical experience and knowledge gained from the case studies is of pertinence. A schedule of accommodation is given below:

SPACE	**SIZE**	**QTY**
DEPARTMENTAL STORE	45* 45= 2025 sqm	1
RESTAURANT	18*18=324sqm	2
FOOD COURT	10*10=100sqm	1
COFFEE SHOP	11*11= 121 sqm	2
FAST FOOD	5*6=30 sqm	5
SPECIALTY SHOP	9*9= 81 sqm	15
BOUTIQUE	9*9=81 sqm	5
ART GALLERY	9*9=81 sqm	3
OFFICE	5*5= 25 sqm	8
SPA	12*12=81 sqm	3
DAYCARE	12*12 sqm	1
GYMNASIUM	15*15 sqm	1
BOOKS AND STATIONARY	5*5=25 sqm	3
FASHION	8*8= 64sqm	10
FASHION BRIDAL	8*8=64 sqm	4
FASHION CHILDREN	8*8=64 sqm	3
FASHION MATERNITY	8*8=64 sqm	2
FASHION LINGERIE	8*8=64 sqm	4
FASHION SPORTS& OUTDOORS	8*8=64 sqm	3
FASHION TAILORS& TEXTILES	5*5=25 sqm	8
FOOTWEAR	5*6=30 sqm	6

GIFTS& CRAFTS	5*5=25 sqm	10
PERFUMES	5*5=25 sqm	6
COSMETICS	5*5=25 sqm	6
HOME FURNISHING	6*10= 60 sqm	4
JEWELLERY& WATCHES	5*5= 25 sqm	8
MOBILES& ACCESSORIES	8*8=64 sqm	6
MUSIC& LEISURE	8*8=64 sqm	6
LUGGAGE	6*6=36 sqm	6
SERVICES TELECOMMS	5*5=25 sqm	5
SERVICES TRAVEL	8*8=64 sqm	6
TOYS	8*8=64 sqm	3
HEALTH/ BEAUTY	7*8=56sqm	10
EXHIBITION	6*6= 36 sqm	5
ELECTRONICS	9.5* 9.5=90.25 sqm	3
COMPUTERS	10*10=100 sqm	2
SPORT EQUIPMENT	9*8=72sqm	2
TELECOM	5*6= 30sqm	3
EYEWEAR	6*6=36 sqm	3
ACCESSORIES	5*5=25 sqm	4
OPTICIAN	9*8= 72sqm	2
PHARMACY	8*8=64 sqm	3
BANK	10*10=100sqm	2
BOARDROOM	3*5= 15sqm	1
OFFICE	1.8*1.8=3.24sqm	2

CENTRAL MANAGEMENT	5*5=25sqm	1
CAMERA ROOM	2*2=4sqm	1
VAULT	1*1.5= 1.5sqm	1
CASH OFFICE	2*2=4sqm	1
MANAGER	2*2=4sqm	1
CONTROL ROOM	2*2=4sqm	1
SCANNING	2*2=4sqm	1
KIOSK	2.5*2=5sqm	6
SNACK BAR	2*3=6 sqm	4
CUSTOMER PARCELS	3*3=9sqm	1
BAKERY	10*10= 100sqm	1
FLOUR STORE	3.8*3.8=14.44sqm	1
DELI PREPARATION	6*6=36sqm	1
BUTCHERY COLDROOM	5.4*5= 27sqm	1
BUTCHERY FREEZER	4*4.5=18sqm	1
RECEIVING OFFICE	6*8= 48sqm	2
CLEANER	3*2.5= 7.5sqm	1
RETURNS	6*6= 36sqm	1
STORE	3*3=9sqm	6
MALE LOCKERS	4*4.5=18sqm	1
FEMALE LOCKERS	4*4.5=18sqm	1
REST ROOM	9*9=81 sqm	6
STAFF CANTEEN	6*8= 48sqm	1
MALE BATHROOM	6*6=36sqm	3

FEMALE BATHROOM	6*6=36sqm	3
ABLUTION	5*5= 25 sqm	1
PRAYER AREA	10*15=150 sqm	1
LAUNDRY	9*9=81 sqm	3
SALOON	8*8=64 sqm	5
BARBING	5*6= 30 sqm	3
WET REFUSE	3.5*3.5= 12.25 sqm	1
DRY REFUSE	3.5*3.5= 12.25 sqm	1
CORRIDOR	8m	
LOBBY	2m	
ESCAPE ROUTE	4m	3
LOUNGE	8*8=64 sqm	1
PARKING	2.5*3.0=7.5sqm	350
DISABLED PARKING	3.0*3.0= 9.0sqm	10
STAIRWAY		4
LIFT		4
ESCAPE STAIR		3

CHAPTER SIX

6.0 DESIGN REPORT

6.1 PRELIMINARY PROPOSAL

The aim of the project as stated in the design brief in the previous chapter is to design a Shopping mall for Federal Capital Development Authority, Abuja. The design is such that the users enjoy all the possible facilities that will help them refresh, entertain, shop and relax after a hard day's work. The shopping mall design should take into consideration all categories of likely users taken from every facet of life and should be devoid of gender, religious or be disability bias.

The design brief however included that the shopping mall design incorporate current trends and state-of-the-heart methods of design, use of materials, construction techniques and possible means devised to ensure the shopping mall can survive its desired life span without the need for frequent maintenance that may arise

.Therefore, in order to fulfil such requirements of the design brief, the principles of energy efficient architecture will be employed. This is so because of the ability of the principle to explore the walls, floors, structure and enclosure in entirety are through the use of materials and construction techniques.

6.2 DESIGN CONCEPT

The design concept as seen below is derived from the findings of the research that described the influence and what creating a shopping mall can add to the society: the end-result, which is a house or building that will contain entertainment and shopping and at the same time help to develop social interaction and integration of its host society.

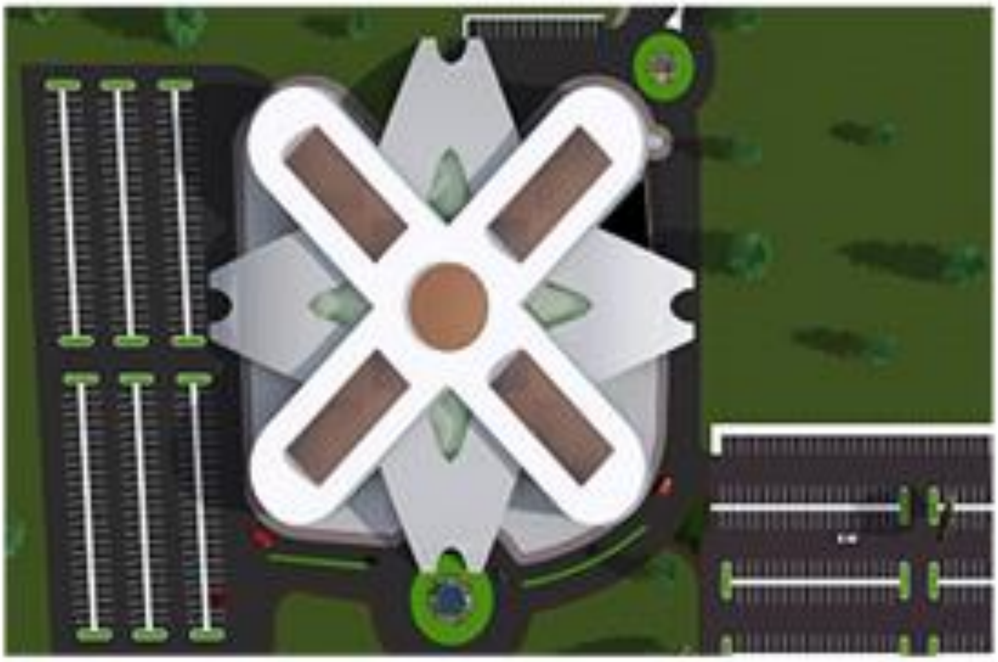


Figure 6.1: Building form/ concept
Source: Researchers work 2014.

This form ensures that the buildings‟ process functions under the principles of energy efficiency via passive strategies by enhancing ventilation, day lighting, thermal comfort and alternative energy source through the use of solar panels. The sloping edges and cylindrical form of the mass of the structure as it rises helps reduce excessive air pressure at the top by redirecting the air movements towards the base and reduces its structural load.

The design concept finds application in the site zoning, plans as well as the general form concepts as seen the figure below. The concept’s flexibility allows the application of the principles of energy efficiency architecture as well as the findings from the research variables.

6.3 DESIGN ANALYSIS

6.3.1 GENERAL PLANNING IN RELATION ORIENTATION/ SPATIAL ARRANGEMENT

The entire shopping mall is designed with the principles of energy efficient architecture hence lots of spaces mostly uninterrupted allows connections to every part of the structure so that there is a continuous flow of people, activities and services, amidst the intersections of one activity space to another and lobbies, making accessibility easy and quick. The arrangement of the building is in east-west direction maximizes the solar potentials and provides adequate solar energy for the solar panel systems. The parking lots are arranged along the stretch of the building following its form. This array provides easy and direct access to the building.

6.3.2 CIRCULATION

Pedestrian and vehicular traffic are clearly demarcated. The provision of a pick-up and drop-off area allows access to the entrance foyer and the cinema. The canopy covering this area of the entrance helps to celebrate the façade.

6.3.3 DAY LIGHTING

The glazed façade encourage the maximum use of natural light and accentuated by the provision of multiple openings around the shopping mall building. The effect of unwanted glare is controlled and reduced with the aid of the projecting roof canopy and that of the roof photovoltaic panels as well as double glazing.

Figure 6.2: Glare control
Source: Researchers work 2014.

6.3.4 VENTILATION

Highly pressured and tempered glazing systems used for the facades are efficiency windows and solar heat repellents as well as the extensive use of openings allow for effective ventilation of all spaces in the buildings.

6.3.5 SITE PLANNING AND LANDSCAPING

One of the qualities of a good design is proper planning of the spaces from the exterior to the interior. However, consideration is given to the planning and landscaping of the site to enhance a good circulation around the building. This is done in respect of the type of activities and services the entire facility is to provide and the type of intended users. Since the comfort of the users is of priority in the long run, it is essentially the key factor in the landscaping design of the site. This is done by making provision for tree canopy, gazebos, shaded or covered walkways, water fountains, sand dunes, shrubs and hedges. This is as reflected in the site shown below.

6.4 DESIGN SKETCHES: This section discusses the spatial arrangements of the design in plan sketches, elevation and sectional views and show some of the details of the building's composition in terms of envelope and materials in terms both structural and non-structural components. The shopping mall building categorized into segments: parking, Entertainment, Shopping, cinema, Administrative areas and Outdoor/Services. This is as shown below:

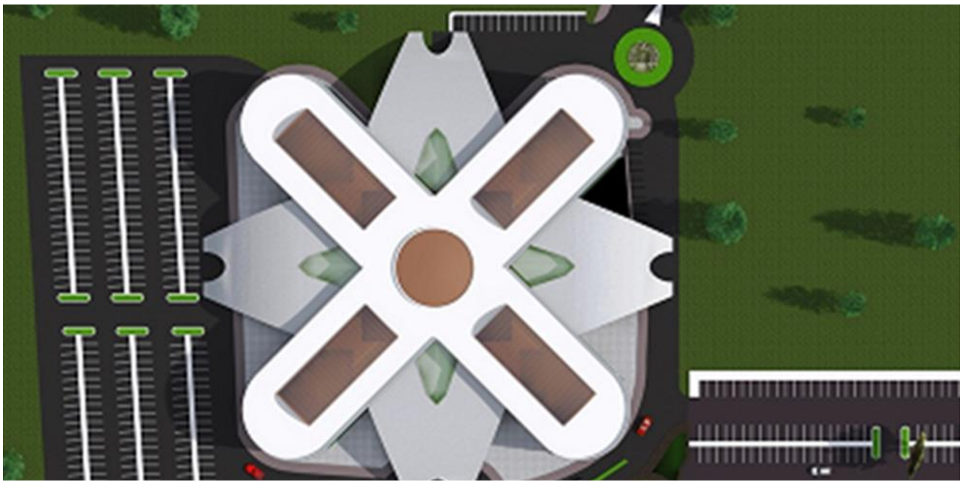


Figure 6.3: Site planning and landscape
Source: Researchers work 2014.

Figure 6.4: A series of conveniences and changing areas for staff as well as separate exits incorporated.

Source: Researchers work 2014

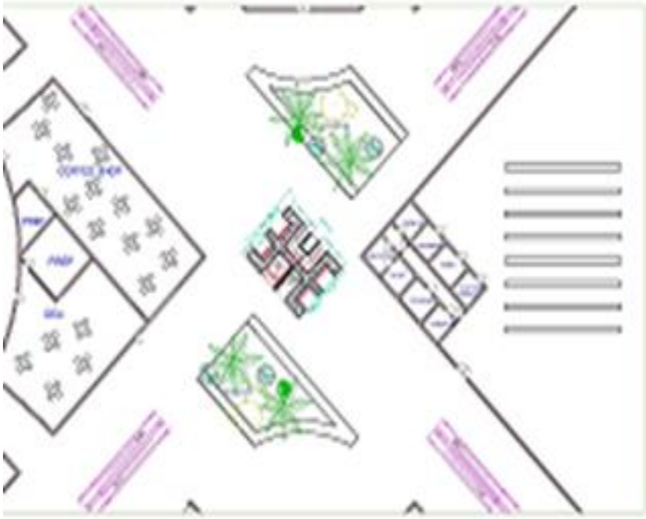


Figure 6.5: Coordinated arrangement of circulation placed centrally in clear unobstructed view.
Source: Researchers work 2014

Figure 6.6: North view
Source: Researchers work 2014

Figure 6.7: Views of buildings
Source: Researchers work 2014

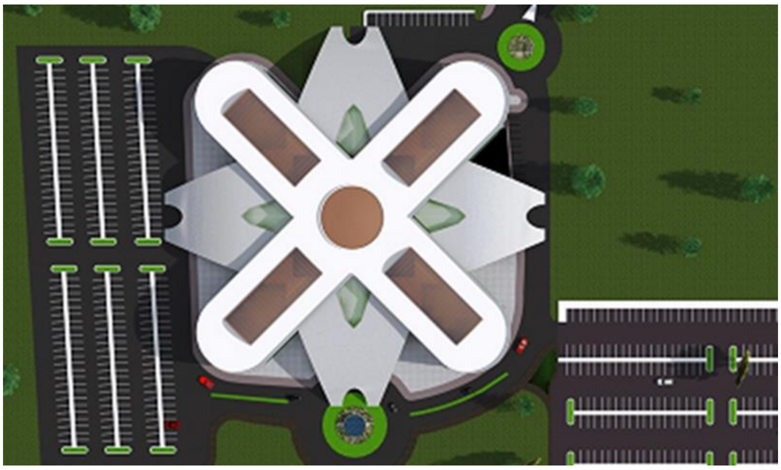


Figure 6.8: View of building showing site plan
Source: Researchers work 2014.

CHAPTER SEVEN

7.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

7.1 SUMMARY OF FINDINGS

Energy efficiency through its principles and characteristics related to Passive approach proposes the use of simple techniques and strategies that will produce balanced and comfortable buildings with ease. The research work is built on the assertion that Energy efficiency principle scan be used to provide means which are likely to lead to discoveries into the implementation of future designs and constructions using the said passive means using design methods, construction techniques, and material use.

The adoption of such is derived from a series of theoretical texts collated and accessed; case studies used as inference shed light as to the likely inclusion of the explored problem statement of the research topic. The expectation is that Energy efficient strategies be adopted in designs of shopping malls and other public buildings.

It is expected that a shopping mall designed incorporating features of passive design by Architects, planners, builders, clients those concerned in the design industry is likely to provide an adequate energy efficient building using the available resources optimally to create a conducive environment for shoppers, tenants, visitors, and the general public as a whole.

An expectation of this research is that it will provide a model for subsequent application of Energy Efficient design principles using passive methods in the design of a shopping mall and any other public building.

7.2 OBSERVATION

An overall assessment of the shopping malls we have in Nigeria has resulted in a deduction that a fundamental issue is throbbing. Power or Energy as some will put it is presently a global issue. The adoption of energy efficient principles especially in the design of a shopping mall will create both user and environment friendly design. The motive for using energy efficiency has been to explore material use and construction processes while maintaining the environment.

The use of materials and construction procedures has always been a relative aspect for designers, builders and clients over time; creating avenues for less cost and higher output and utility has always driven the industry to yet greater heights; thus can be achieved through proper implementation of design approach of the said intended facility.

7.3 CONCLUSION

i. The application of Energy efficient design principles in the design of a shopping mall or any other building

ii. Energy efficiency enhances optimum utilisation of material usage and construction which in turn reduces cost on energy values differ depending on region.

iii. Energy efficiency using passive strategies proposes environmental friendly approaches by materials and techniques; therefore reducing cost in building modification which would have otherwise arisen.

7.4 RECOMMENDATION

i. Shopping mall should be designed taking into consideration all phases from initiation to running cost which enhances reduced cost of construction.

ii. Provide source of research for both students and professionals of construction disciplines considering lack of knowledge.

iii. Reducing costs of construction since materials found locally will be used thus eliminating costs associated with manufactured products and transportation.

iv. The use of energy efficiency in shopping mall design ensures that the buildings are absolutely user friendly.

7.5 CONTRIBUTION TO KNOWLEDGE

i. The contribution of Shopping mall design as a major tool for urban development is regarded as trendy; trendy ideas are those that work towards captivating the shopper, tenant, visitor, and staff; however since energy efficiency is responsible for spaces, forms, and surfaces of the building.

ii. Creating avenue for energy efficient buildings with less dependence on energy for its full operations thereby reduce GHE.

iii. Energy efficiency by passive means will increase the exploration and knowledge of those professionals involved in the construction industry.

iv. Energy efficiency will enhance construction techniques that hold a promise of ready availability, low energy costs and simplicity of equipment requirement in the exploitation and utilisation; also have the potential to enhance a sustainable construction practice to come up with environmentally friendly and aesthetically pleasing designs.

REFERENCES

African Energy Commission AFREC's Approach to Energy Efficiency in Africa: Policy Framework & Technical Programs Dr. Hussein Elhag Executive Director / AFREC WEC Regional Workshop on Energy Efficiency 29-30 June 2009 Addis Ababa, Ethiopian august 2002 gen 14 summary.

A.K. O.A, (2002).Transforming the West African Market for Energy Efficiency Ghana Leads the Way with Mandatory Standards and Label Energy Foundation of Ghana

Ali, Z.F. (2007). Comfort with Courtyards in Dhaka Apartments. BRAC University Journal, IV (2): 1- 6.

Alvarado, J.L., Martınez E. (2008). Passive Cooling of Cement-Based Roofs in Tropical Climates. Energy and Building, 40 (3): 358-364.

Antalsidor (2010). Energy efficiency in shopping malls.Energy use and indoor climate. Technical report D - Department of Building Technology, Building Services Engineering, Chalmers University of Technology; Chalmers Publication Library (CPL).

Architectural Shaping Potential in Energy Efficiency Provision of Buildings Roberts Riekstiņš, Riga Technical University, Ivars Strautmanis, Riga Technical University RTU Publishing House

Arisa, S.A, (1997). "An unpublished M.Sc thesis report",(Department of Architecture, University of Nigeria, Enugu Campus.

Bolatturk, A. (2008).Optimum Insulation Thicknesses for Building Walls with Respect to Cooling and Heating Degree-Hours in the Warmest Zone Of Turkey. Building and Environment, 43 (6): 1055–1064.

Building Efficiency in the Tropics Low-Carbon Communities in the Caribbean Energy Workshop *KosolKiatreungwattana, P.E., LEED AP* March 1, 2011

Cheung, C.K., Fuller, R.J. & Luther, M.B. 2005. Energy-Efficient Envelope Design for High-mRise Apartments. Energy and Buildings, 37 (1): 37-48.

Cop 17 side event energy efficiency day supporting energy efficiency for access in west africa (seea-wa) mahahakappih executive director ecreeedurban, december07,2011Martin Lugmayr 2012

Cohen, Nancy, E. 2003. America's Marketplace: The History of Shopping Centers. New York: Greenwich Publishing Group.

Clarke ,J.A.,Maver, T.W.1991. Advanced Design Tools for Energy Conscious Building Design: Development and Dissemination. Building and Environment, 26(1): 25-34.

Draft Concept Note and Agenda (version 07.09.12) ECOWAS-GFSE-GEF-UNIDO High Level Energy Forum Towards Sustainable Energy For All in West Africa "Paving the Way through Renewable Energy and Energy Efficiency" 29 to 31 October 2012, Accra, Ghana

Environment design guide an introduction to energy efficiency in air conditioned tropical buildings Vin Keneally Published by The Royal Australian Institute of Architects.

Energy Efficiency In a Shopping CenterJenriquez ADSC_climatizacion_v3

Encarta Dictionary, (2005), Reference Library, Microsoft Corporation.

ECREEE & SEAD Partner to support implementation of the ECOWAS (2010).

Financing Energy Efficiency and Implementation Models in Developing Countries

Jas Singh Senior Energy Specialist ESMAP, World Bank *West African Energy Efficiency Workshop .April 12-13, 2010 –Ouagadougou, Burkina Faso*

Fatowore, E. O,(2008). "An unpublished M.Sc thesis report",Department of Architecture, University of Nigeria, Enugu Campus.

Gabrielle.D ,Sachu C., Alliance to Save Energy/CLASP Energy and Environmental Policy - 9.297

Sandy M. (2007). Hot Tips for Cool Homes in the Tropics 'Passive design techniques to reduce reliance on air-conditioning and create a cool and comfortable home in the tropics' of Eco SAVVY.

Hanna.G.B.(2011).Journal of Energy and Power Engineering 5 1134-1141 Energy Efficiency Building Codes for Egypt Housing and Building National Research Center, Cairo 12311, Egypt David publishing

Flyvbjerg,B. (2006) .Five Misunderstandings about Case-Study Research. Qualitative Enquiry, 12(2): 219-245

Garson, G.D. (2002). Guide to Writing Empirical Papers, Theses and Dissertations. New York: Marcel Dekker, Inc.

Gut, P. &Ackerknecht, D. (1993). Climate Responsive Building: Appropriate Building Construction in Tropical and Subtropical Regions. Switzerland: SKAT.

Givoni, B. (1998).Climate Considerations in Building and Urban Design. New York: Van Nostrand Reinhold.

International Council of Shopping Centers(ICSC).A Brief History of Shopping Centers.June (2000).

Josifas P., Andrius K., Diana K. (2012). The relationship between the shape of a building and its energy performance Architectural Engineering And Design Management, 2012 , VOL. 8 , 246–256. taylor and francis group

Journal Of Civil Engineering And Management, (2012).Volume 18(1): 71–80

Josifas, P., Andrius, K., Audronė, E., Diana K. Architectural Solutions To Increase The Energy Efficiency Of Buildings Vilnius Gediminas Technical University (VGTU) Press Technika

Jones, D.L. (1998). *Architecture and the Environment: Bioclimatic Building Design.* UK. London:Laurence King.

Johansson, R. (2003). Case study methodologies (Lecture III B). Stockholm: Royal Institute of Technology, Built Environment Analysis.

Klaffke, P. (2003). "*Spree: a Cultural History of Shopping".* Vancouver, B.C.: Arsenal Pulp Press.

Liping, W. &Hien,W.N.(2007). The Impacts of Ventilation Strategies and Facade on Indoor Thermal Environment for Naturally Ventilated Residential Buildings in Singapore. Building and Environment, 42 (12): 4006-4015.

Malachy, K. (2000) .ICSC- International Council of Shopping centers ,News The Impact of Shopping Centres.

Module2 The energy sector in Africa Sustainable Energy Regulation And Policymaking Training Manual 2008

Mehran J., Naghmeh Y., Masoud N. (2011).Increasing of Energy Efficiency based on Persian Ancient Architectural Patterns in Desert Regions (Case Study Of Traditional Houses In Kashan) World Academy of Science, Engineering and Technology

Mowla, Q.A. (1985). An Analytical Study of Sun-Building Interaction. Roorkee. Master's Thesis. Department of Architecture and Planning. University of Roorkee.

Mathur,V. K. & Chand, I.(200)3. Climatic Design for Energy Efficiency in Buildings. IE (I) Journal-AR, 84 (2003): 33-39.

Mallick, F.H. (1996). Thermal Comfort and Building Design in the Tropical Climates. Energy and Buildings, 23 (1996): 161-167.

Saliou T. (2011) Nigeria– EE Appliances - Project Document Nov 2010. PIMS 4122_Nigeria.

Patton, M.Q. (1990). Qualitative Evaluation and Research Methods.2nd Edition. Newbury Park, California: Sage.

Par J.Q. (2011).ECOWAS *Regional Centre forRenewable Energy and Energy Efficiency* (ECREEE). Public, Praia, Cape Verde,5-6 December West Africa and Brazil: Addressing RENEWABLE ENERGY Challenges

Raeissi,S. &Taheri, M. (1999). Energy Saving by Proper Tree Plantation. Building and Environment, 34(1999): 565-570.

Roberts.R ,Ivars,S. *(2010).*S*cientific Journal of Riga Technical University* Architecture and Urban Planning .Architectural Shaping Potential in Energy Efficiency Provision of Buildings. *V*ol. (4).

Rocky Mountain Institute RMI Solutions Fall/Winter 2003 j

Sarah V., How the world should invest in energy efficiency j u l y 2 0 0 8 economic studies Diana F., Jaana K. Remes, M, and company

Simpson, J.R. & McPherson, E.G. (1996). Potential of Tree Shade for Reducing Residential Energy Use in California. Journal of Arboriculture, 22 (1): 23-31.

S*cientific Journal of Riga Technical University* Architecture and Urban Planning *2010 Vol. 4*

Svane, Ö.(2005). Useful Concepts or Eternal Truths? Reflections on Case Study Generalization in Vestbro D U, Hürol Y &Wilkinsson N (eds): Methodologies in Housing Research. Great Britain The Urban International Press.

Stake, R. E. (1995).The Art of Case Study Research. Thousand Oaks, California: Sage

Stake, R. E. (1995).The Art of Case Study Research. Thousand Oaks, California: Sage

The New Encyclopaedia Britannica. Chicago: Encyclopaedia Britannica, 2007.“Shopping Center”

The World Book Encyclopedia. Chicago: World Book, (2008). “Shopping Center” Clausen, Meredith L. “Shopping Centers.” In *Encyclopedia of Architecture: Design,Engineering, and Construction*, ed. Jospeh A. Wilkes and Robert T. Packard, 406- 421. New York: John Wiley & Sons, 1988.

UNEP.(2006). Eco-housing Guidelines for Tropical Regions. Bangkok: United Nations Environment Programme Regional Resource Centre for Asia and the Pacific.

Vijaykumar, K.C.K., Srinivasan, P.S.S. &Dhandapani, S. (2007). A Performance of Hollow Clay Tile (HCT) Laid Reinforced Cement Concrete (RCC) Roof for Tropical Summer Climates. Energy and Buildings, 39 (8): 886-892.

White, Jerry. "Shopping Centers."In *Encyclopedia of 20th-Century Architecture*, ed. R. Stephen Sennott, 1204-1206. New York : Fitzroy Dearborn, 2004.

Wen.H ,Madelaine, S.C, Ruth ,A. S, Mark, L. C,(2007). *Building Energy Efficiency* Why Green Buildings Are Key to Asia's Future

Watson, D. & Labs, K.(1983). Climatic Building Design: Energy-Efficient Building Principles and Practice. New York: McGraw-Hill.

Wong, N.H. & Li, S. (2007). A Study of the Effectiveness of Passive Climate Control in Naturally Ventilated Residential Buildings in Singapore. Building and Environment, 42 (3): 1395-1405.

Watson, D. & Labs, K. (1983). Climatic Building Design: Energy-Efficient Building Principles and Practice. New York: McGraw-Hill.

Xiaoyu. S, (2010).Public Procurement of Energy Efficiency Services: Barriers and Models

Yin, R.K .(1994). Case Study Research: Design and methods. Second Edition. Thousand Oaks, California: Sage.

APPENDIX

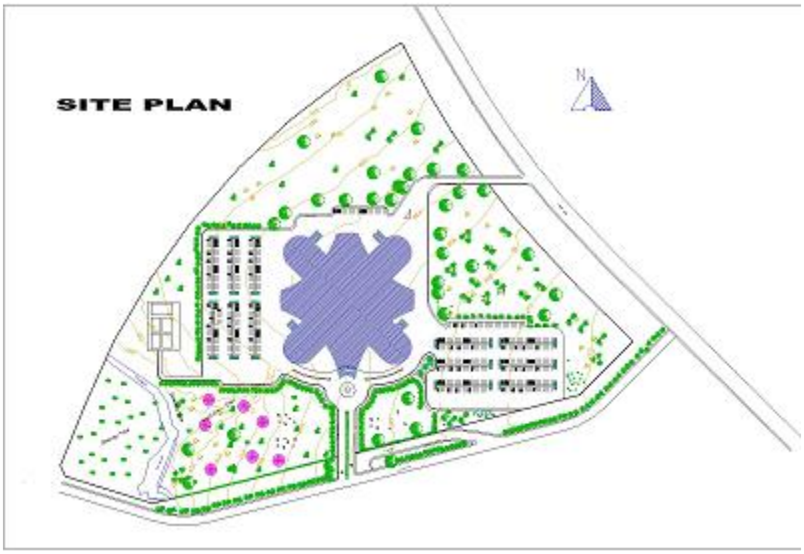


Figure 1. Site plan

Figure 2. Plan on site

GROUND FLOOR PLAN

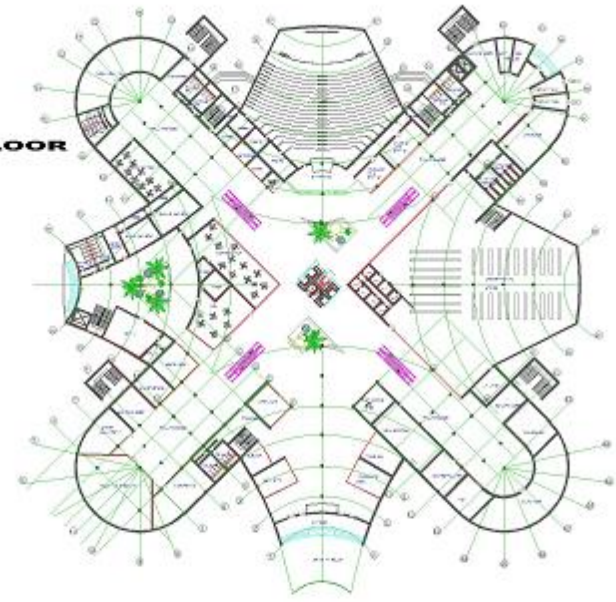


Figure 3. Ground floor plan

FIRST FLOOR PLAN

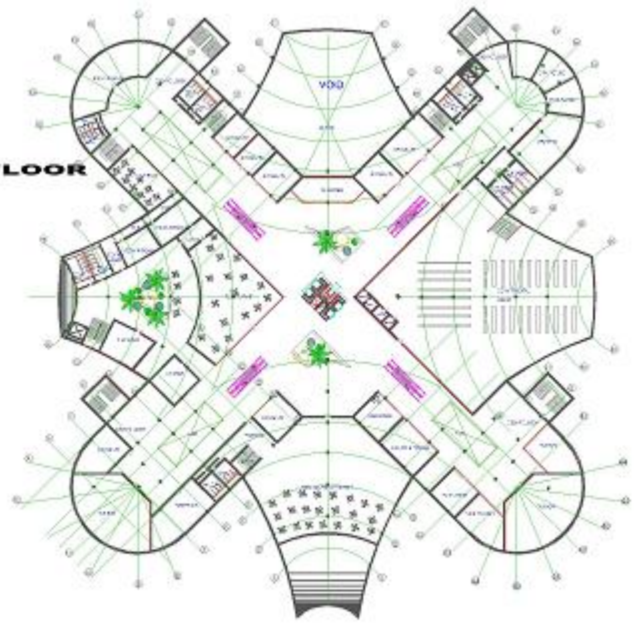


Figure 4. First floor plan

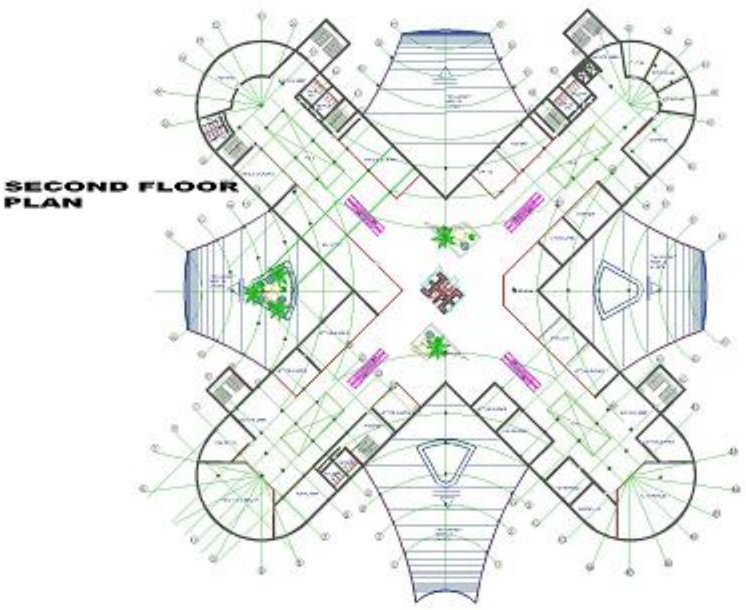


Figure 5. Second floor plan

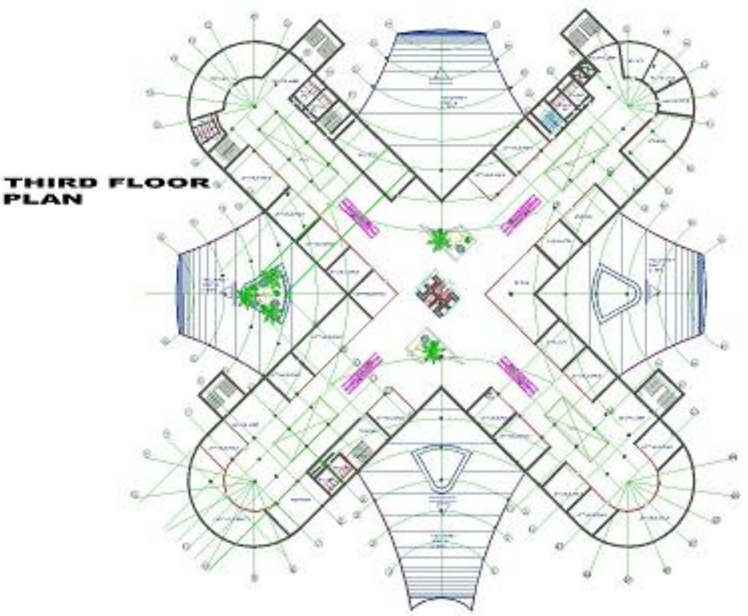


Figure 6. Third floor plan

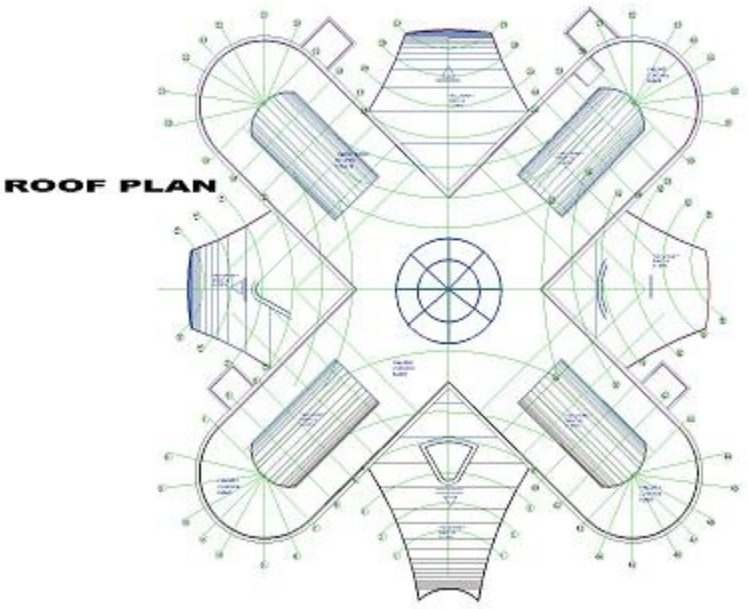


Figure 7. Roof plan

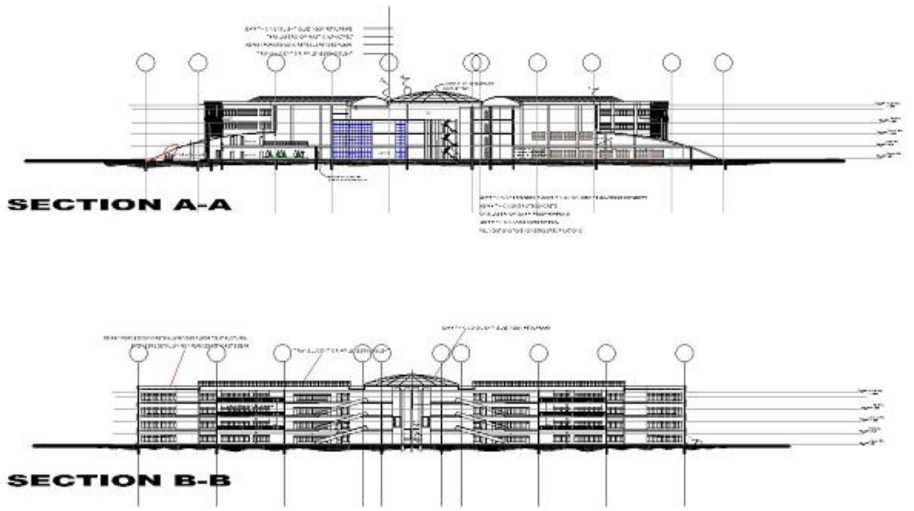
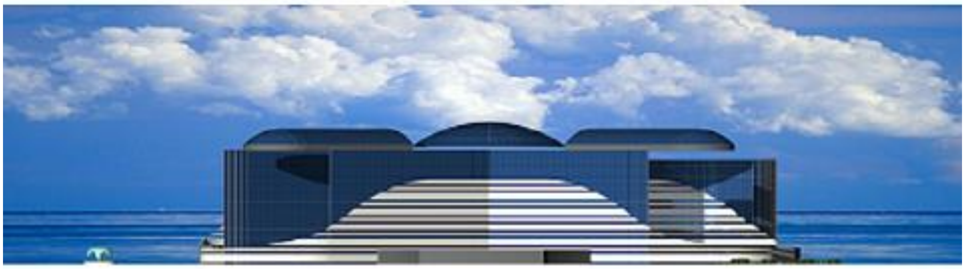


Figure 8.Sections

EAST ELEVATION



SOUTH ELEVATION

Figure 9. Elevations