EXPLORING GREEN ARCHITECTURE PRINCIPLES IN THE DESIGN OF COLLEGE OF ENVIRONMENTAL STUDIES AT KWARA STATE UNIVERSITY, MALETE

BY

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DECLARATION

I hereby declare that all the work carried out in this project was done by me under the supervision of Dr. A. Ango and Arc. Badiru and to the best of my knowledge, has not been carried out anywhere for the award of masters degree. All sources of information have been duly acknowledged by means of references and the responsibility of any mistake is entirely mine.

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CERTIFICATION

The thesis titled "**EXPLORING GREEN ARCHITECTURE PRINCIPLE IN THE DESIGN OF COLLEGE OF ENVIRONMENTAL STUDIES AT KWARA STATE UNIVERSITY"** by Moshood Oladayo Olawumi meets the requirements governing the award of Masters of Architecture Degree in the Department of Architecture, Ahmadu Bello University, Zaria.

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DEDICATION

To God, to life and to Architecture.

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First and foremost, I would like to acknowledge specially, my supervisors for their noble support, assistance and guidance in the course of this thesis. May the Almighty Allah bless you all richly and increase you beyond your imagination. Also, to my highly esteemed lecturers in the Department of Architecture, for the knowledge and understanding they have imparted to me as well as the moral support and encouragement. May the Almighty Allah continue to bless you all richly and grant all your heart desires, amin.

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ABSTRACT

This research outlines the perception of a learning environment regarding the impact of implementing green practice. Educational infrastructure needs green and environmentally friendly school units to achieve maximum comfort which enhance learning process. The concept of a modern school determines the nature of school infrastructure. Implementing Green Architecture and using environmentally friendly materials reflect current trends in sustainable design. A green/sustainable building design is one that achieves high performance, over the full life cycle by minimizing natural resource consumption through more efficient utilization of non renewable natural resources, land, water, and construction materials, including utilization of renewable energy resources to achieve net zero energy consumption. This research work shall be carried out through physical examination of existing facilities of various schools of environmental studies, interviews with students of respective schools, and finally and examination of existing documentations on the topic. From these examinations, the most favorable conditions shall be proposed to accommodate the following building techniques: Using sustainable building materials such as recycled plastic, cement board siding, Design building with small footprints that take up less land, design exterior spaces with permeable materials to let water soaks in, and landscape with native plant which requires no chemical treatment of fertilizer.Build for clean air and lungs using less toxic materials such as particle board, wheat board etc.

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CHAPTER ONE

INTRODUCTION

1.1. BACKGROUND TO THE STUDY

In a constantly changing world, and in a society under almost daily transformation, education is increasingly called upon to play a decisive role. A country's educational infrastructure, which includes teaching, sports and cultural facilities, must create an appropriate environment for education and the transmission of knowledge, while respecting cultural factors and social sensitivities. Constructing modern, Green and environmentally friendly school units should be an objective of contemporary societies. The concept of a modern school determines the nature of school infrastructure. Implementing Green Architecture and using environmentally friendly materials reflect current trends in sustainable design and should satisfy the following objectives:

i. Conserving energy.
ii. Improving the school's microclimate.
iii. Producing energy from renewable sources, with the attendant environmental and economic benefits.
iv. Improving air quality in classrooms.
v. Minimising the use of toxic materials.

The need for energy conservation, environmental protection and improved living conditions for the users of school premises has led to implementing the principles of Green Architecture in school buildings (FEB Exchange, 2007).

The concept of Energy Efficiency has become a significant consideration in the construction industry due to its benefits in money saving, reduction of fuel poverty, and reduction in resource exploitation & environmental degradation. This

concept is derived from the conservation of resources which is considered a subset of the principle of green architecture.

Components of the principle of Green-architecture related to energy efficiency include energy conservation, passive energy use, use of material and designing with nature. Earon (2010) however expressed his concerns on the application of this principle and its components stating that "current green architecture does not underline the buildings spatial characteristics but stays on the surface". He views green architecture as a total package involving not only the aesthetics and symbolic representation of the vegetation of that region, but also functionality in its contribution to spatial experience. This simply means that Green-buildings should look green as seen in the application of vegetation; function green in relation to environmental impact; feel green which concerns the users comfort; and most importantly, be experienced as green through increased advantage to users over time (Ofri, 2010). The phrase 'Experienced as green' covers the concept of energy efficiency.

As Energy is considered one of the major components of a building composing of 45% of the total resources consumed (Environmental Protection Agency (EPA), 2000), the siting and designing of energy efficient buildings is deemed the industry's contribution to this concept and a practical approach in achieving the benefits. The stated value for the energy composition in buildings only specifies the general make-up. But, its quantitative amount varies from one building to another due to its function and size.

In the above literatures the authors focus mostly on the applicability of Green design principles but speak less on its direct effect to an academic environment. This research will focus on the relationship of each of the principle to a college environmental in

addition to providing a convenient learning atmosphere in a warm dry climate of Kwara state.

1.2 THE NEED TO BUILD GREEN

The world environmental problems are further compounded by building construction, use, demolition, as well as the manufacturing of building materials. By building green, we can help in preserving natural habitats, watersheds, and ecosystems, protect air and water quality, reduce greenhouse effects and solid waste, all while conserving natural resources, creating healthier indoor and outdoor environments and reducing negative impacts of built environment on human health.

Green buildings help improve public health through the utilization of non toxic material thus protecting users most especially children who are more susceptible to respiratory diseases.

It also contributes economically through its minimal use of energy thus reducing the buildings operational cost, and finally reducing maintenance and replacement costs due to greater durability of materials.

1.3 STATEMENT OF PROBLEM

In many countries, especially in the industrialized world, buildings account directly for over 50% of total energy consumption and even more when one includes what it costs to manufacture the materials required for construction (International Hotel and Restaurant Association, 2005).

Heating and cooling of buildings account today for high energy consumption because higher living standards lead to active climatization of buildings such as offices, schools, hotels and also residences (Adamson and Åberg 1993). In Nigeria, the problem is the unavailability of energy to sufficiently cater for institutional buildings such as faculty of Environmental design. Most of the existing institutions spend so much money to generate their own power on daily basis (Archibong, 2007) which are expensive and

emit gases that deteriorate the quality of the environment. The effect of the cost of private production of non-renewable energy is particularly significant in the Nigerian public buildings. In Nigeria as a whole, countless institutional buildings listed failure of the federal government to provide uninterrupted electricity (Archibong, 2007). This unfortunately, makes most institutions in Nigeria very expensive, as compared to what obtains in neighbouring countries. Therefore there is a need to find an alternate and efficient energy source.

This research is intended to check the extent to which green principles can be applied in the design of a college/faculty to ensure energy efficiency as a remedy to the environment. For practical purposes, the principles to be explored will be based on the ecological affordances on the proposed site.

1.4 RESEARCH QUESTION

The main research questions of this research are:

i. What are the green architecture principles?
ii. To what extent, exploration of Green principle has enhanced energy efficiency in our institutional facilities?
iii. How can this principle influence an academic environment through energy efficiency?

1.5 AIM AND OBJECTIVES OF STUDY

AIM:

To establish an Architectural form that can be used as a passive solution to enhance energy efficiency through exploration of Green-Architecture in the design of an institutional facility.

OBJECTIVES:

The aim mentioned above will be achieved through the following objectives;

i. To examine the need for an energy saving architecture, in the design of a college/ faculty design.
ii. To identify the principles of green architecture and find the green-solutions that will enhance the efficiency in energy conservation in a college/ faculty environment,
iii. To examine the relationships between Architectural forms and the principles of green architecture,
iv. To incorporate all the research findings in the design**.**

1.6 JUSTIFICATION

Inadequate exploration of green architecture principles in institutional facilities caused institutions in Nigeria to spend much to generate their own power on daily basis and emit gases that deteriorate the environment, the proper implementation of passive energy sources especially in a country with poor electricity gives an added advantage to the running process of the college, this implementation will also provide a conducive and eco friendly environment which is suitable for learning.

1.7 SIGNIFICANCE OF STUDY

Also, the research's dealing with the application of green-architecture will help to implement the policy on design of sustainable buildings for the purpose of preventing

further environmental degradation. The introduction of passive energy sources especially in a country with poor electrical and water supply gives an added advantage to the running process of the facility while creating an awareness of energy efficiency in all types of buildings. This will positively influence new institutional designs/projects because this green proposal will bring about a movement in architectural style and a review in the decision making of the building sector as regards to building production.

1.8 SCOPE AND DELIMITATION OF STUDY

The scope of the design will be concerned with Green design methods that aid in producing an energy conscious, environmentally friendly, functional and comfortable design for faculty of environmental design to accommodate administrative, social, learning activities. It will focus on facilities that aid Green design processes while incorporating new trends in modern faculty design. These spaces will include lecture theatre, administrative block, study area, offices and ancillary.

Despite the benefits of this research, there are several limitations in the process of undertaking this research project. These limitations include:

I. Inability of the researcher to inspect the existing locations of the foreign case studies which have incorporated the use of Green Architecture.

II. Time constraints to be able to cover the various principles of Green Architecture applied in public buildings in full detail.

III. Difficulties in obtaining authorization to examine closely institutional buildings chosen as case studies.

1.9 MOTIVATION

Buildings in general are known to be the major component in the urban environment that consumes about 40% of the total world energy and contributes to over 50% of

environmental degradation. If this consumption and pollution rate continues unchecked, the depleting environmental value, natural resources and energy resources are projected to be dangerously low in the future. There is therefore a need for architects to take responsibility in reversing/reducing these adverse effects their building have caused and prevent further damage to these resources. This may be achieved by implementing green philosophies for which one of its major objectives is conservation and is considered to be a suitable theme for institutional design since learning is best enhanced in a well set out natural/green landscaped environment which is a major component in the physical appearance of an environment which has applied green principles.

This research is therefore aimed at demonstrating how Green-architecture principles can be explored to enhance energy efficiency in a college/ faculty design.

1.10 RESEARCH METHODOLOGY

Investigation of all relevant data related to the research will be sourced from the following.

i. Literature review – this include materials like book, papers journals, write ups and magazines on related topics to this study of architecture. Some of the literatures were gotten from existing project related to parts of this research. In cases where the data collected are referenced to foreign development and research, this data will be stream lined to fit the locality of this research based on the availability of resources, design requirement of the project, nature and availability of energy sources, and the standard expected to be attained in the design proposal.

ii. Case study – study of similar buildings with similar disciplines as that of the study of architecture shall be analyzed to note their design approach to their various problems

taking note of their merits and demerits. Some of these studies are significant to just part of this research while other were based on foreign analysis.

iii. Existing documents on climatic data and environmental data in relation to the site location shall be studies to fine out the design implications and studies their relationships to the various Green design principles concerned.

iv. Personal observation – As a student of architecture, personal observation from personal experience cannot be ruled out as a point for inspiration and personal judgment.

The acquired data collected for the purpose of this study shall be analyzed by means of sharing them into two respective groups.

I. Quantitative Elements- these include materials like climatic data which shall be analyzed based on their actual values collected. The mode of representation shall be charts, diagrams and tables.

II. Qualitative Element- these are elements which shall be allocated variables which shall be weighted based on its attributes, with respect to its positive or negative influence. The weight scale shall be from the number 0 (zero) to the number five (5), 0 being the lowest threshold and 5 being the highest threshold.

CHAPTER TWO

LITERATURE REVIEW

2.1 GREEN ARCHITECTURE

Green Architecture is a term used to describe economical, energy-saving, environmentally-friendly, sustainable development. Green architecture seeks to

minimize the negative environmental impact of buildings by enhancing efficiency and moderation in the use of materials, energy, and development space (Jagadish. 2007**).**

Green architecture can also be defined as is an approach to buildings that minimizes harmful effects on human health and the environment. The green architect attempts to safeguard air, water and earth by choosing Eco-friendly building materials and construction (Craven, 2008).

'Green' applied to 'Architecture' is design of spaces and places in full consideration of the natural environment; it seeks to maximize efficiency and minimize impact while meeting the needs of its occupants. Green architecture is not a particular style of architecture but a thoughtful and holistic approach to design in which priorities and strategies must be developed for specific situations and locations.

According to Usama (2006), Green architecture- also called Eco-architecture, is not a fix concept and is under constant change, definition, and redefinition but includes '*green building'* and '*green construction'*, which concerns both natural environment protection and human comfort. *Green construction* practices reduce resource use and pollution while increasing the value derived from each resource used. It also protects healthy sites, restores or enhances marginal sites by working with natural processes, and contributes to regional habitat conservation. Within these parameters, *green construction* stimulates a stable and diverse local Economy, improves local quality of life, and improves human health (Thompson and Sorving, 2000).

The David and Licile Packard Foundation suggest that any building that has a significantly lower negative environmental impact than a traditional building qualifies as green (Stang and Hawthorne, 2005). The U.S. Green Building Council has defined *Green building* to mean "*structures that are designed, renovated, constructed, operated, and environmentally demolished in an environmentally and energy efficient manner with*

least impact upon our global and internal environment" (Burroughs and Hansen, 2004). *Green building* techniques minimize energy usage and destruction to the environment, as well as create safe, comfortable buildings for people (an example is the Eco-City Cleveland).

Plate I: Eco-city Cleveland
Source: http://www.greenarchitecture.com



Plate II: A view of Eco-city Cleveland
Source: http://www.greenarchitecture.com

Green building reflects the latent fusion of two powerful ideas from the late nineteenth century; preservation of the natural environment and protection of the public health (Guy and Moore, 2005). When the energy crisis was the overall theme of the 1970s, zero-energy buildings were the answer. When the problem was later formulated as a radical critique of our growth-oriented society, the answer coming from the grassroots was self-sufficient Eco-village and experimentation with ideology, technology and social organisation. When the authorities seriously started to act on the urban Ecology scene following their commitment, it was through subsidizing the different sectors.



Since the 1950's, various publications have presented issues and design approaches aimed at environmental integration.

Figure 2.1: The processes of green architecture (BEER)
Source: Usama, 2006

The reason why there seems to be a great number of definitions of green architecture is because this concept is widely embraced. But with this break down of the terms, a strong concept of Green-principles has been established. (Umar, 2010).

2.1.1 The Benefits of building Green Designs

There is a huge opportunity for the building and development industry to entice investors to invest in green developments and specifically, green office developments. The key benefits are grouped into economic, social, environmental, and institutional. Economically, the benefits to developers include product differentiation, exclusive market niche targets, streamlined design costs, reduced capital costs, reduced operating costs, increased market value, faster leasing, mortgage incentives, and new business opportunities. Socially, green developments contribute to indoor health and reduced

operating costs over the life of the building. Environmentally, they improve the use of resources and reduce the building footprint. Institutionally, they streamline the approval process, reduce liability risks, and provide partnerships and funded research opportunities (Magee, 2005).

Furthermore the benefits of building green can be simplified into three categories:

i. Environmental benefits which include the following: Enhance and protect ecosystems and biodiversity, Improve air and water quality, Reduce solid waste, conserve natural resources.

ii. Economic benefits which include the following: Reduce operating costs, Enhance asset value and profits, Improve employee productivity and satisfaction, Optimize life-cycle economic performance.

iii. Health and community benefits which include the following: Improve air, thermal and acoustic environments, Enhance occupant comfort and health, Minimize strain on local infrastructure, Contribute to overall quality of life.

2.1.2 Characteristics of Green Buildings

A green/sustainable building design is one that achieves high performance, over the full life cycle, in the following areas:

i. Minimizing natural resource consumption through more efficient utilization of non renewable natural resources, land, water, and construction materials, including utilization of renewable energy resources to achieve net zero energy consumption.

ii. Minimizing emissions that negatively impact our indoor environment and the atmosphere of our planet, especially those related to indoor air quality (IAQ), greenhouse gases, global warming, particulates, or acid rain.

iii. Minimizing discharge of solid waste and liquid effluents, including demolition and occupant waste, sewer, and storm water, and the associated infrastructure required to accommodate removal.

iv. Minimal negative impacts on site ecosystems.

v. Maximum quality of indoor environment, including air quality, thermal regime, illumination, acoustics/noise, and visual aspects to provide comfortable human physiological and psychological perceptions. (America Society of Heating, Refrigerating and Air-conditioning Engineers, ASHRAE, 2002).

2.2 PRINCIPLES OF GREEN ARCHITECTURE

Different sets of green architecture principles are generated from different points of view. Listed below is a brief description of each set of principles;

Set 1- Green Architecture Principles [Vale, 1991]

i. Conserving energy

ii. Working with climate

iii. Minimizing new resources

iv. Respect for users

v. Respect for site

Set 2- Green Architecture Principles [Barnett and Browning, 1995]

i. Make appropriate use of land

ii. Use water, energy, lumber, and other resources efficiently

iii. Enhance human health

iv. Strengthen local Economies and communities

v. Conserve plants, animals, endangered species, and natural habitats

vi. Protect agricultural, cultural, and archaeological resources

vii. Be nice to live in

viii. Be Economical to build and operate

Set 3- Green Architecture Principles [Environmental Building News, 2002]

i. Smaller is better. Optimize use of interior space through careful design so that the overall building size, resource use in constructing and operating process are kept at a minimum.

ii. Design an energy-efficient building. Use high levels of insulation, high-performance windows, and tight construction.

iii. Design buildings to use renewable energy. Passive solar heating, day lighting, and natural cooling can be incorporated cost-effectively into most buildings. Also consider solar water heating and photovoltaic.

iv. Optimize material use. Minimize waste by designing for standard ceiling heights and building dimensions. Simplify building geometry.

v. Design for water-efficient, low-maintenance landscaping. Conventional lawns have a high impact because of water use, pesticide use, and pollution generated by lawn mowers.

vi. Landscape with drought-resistant native plants and perennial ground covers.

vii. Make it easy for occupants to recycle waste. Make provisions for storage and processing of recyclables.

viii. Look into the feasibility of using grey water. Water from sinks, showers, and washing machines can be recycled for irrigation in some areas.

ix. Design for durability. To spread the environmental impacts of building over as long a period as possible, the structure must be durable. Durable aesthetics ("timeless architecture") are also important.

x. Design for future reuse and adaptability. Make the structure adaptable to other uses, and choose materials and components that can be reused or recycled.

xi. Avoid potential health hazards: radon, mould, and pesticides.

In summation, the above-mentioned principles describe green architecture as equally concerning both the natural environment and the human well-being. Natural environment includes conserving plants and animals and using land, water, energy and other resources efficiently. Human well-being includes enhancing human health indoor and outdoor; and general human comfort (Usama, 2006).

Irrespective of the format of the principle, its application will be based on the Ecological affordances of a site. This means the Ecological components or properties of a site will determine which principle can be applied to a design.

2.3 GENERATED GREEN ARCHITECTURE PRINCIPLES

From previous green architecture principles and rating systems, 14 green architecture principles are generated. Each principle includes some theoretical green architecture design strategies. These fifteen principles were generated as the main green architecture principles from the previous categories demonstrated by existing green architecture rating systems and checklists. Regarding the elements of the natural environment (energy, water, materials, atmosphere, land fauna and flora), the green architecture principles make a balance among the elements of the natural environment and human well-being. These categories are listed as follows:

i. **Sustainable Site Planning:** The sustainable sites performance category encourages site selection, planning, landscaping and design strategies that use land more effectively and minimize construction and operational impacts.

ii. **Water Efficiency:** The water efficiency category encourages strategies that reduce the amount of potable water used for landscape irrigation and building operations. It also emphasizes strategies that reduce municipal infrastructure for the supply of potable water and removal of sanitary waste by reducing water use.

iii. **Storm Water:** The built environment disturbs storm water runoff from land, causing a range of negative environmental effects including degradation of waterways, loss of aquatic life, flooding, and loss of groundwater recharge.

iv. **Energy Efficiency:** The energy and atmosphere category emphasizes reducing the depletion of non-renewable energy resources and related environmental impacts, particularly emissions of local, regional and global air pollutants. Renewable energy sources with low environmental impacts are encouraged. Also, reducing building energy consumption, using renewable energy, and eliminating ozone depletion are promoted as well. The application level of the component can be experienced by harnessing solar radiation and wind to enhance daylight architecture, solar energy source, and passive means of ventilation. This forms the core focus of this research.

v. **Pollution:** Addressing pollution levels in the design means ensuring that no ozone depleting substances are present and low CO_2 emitting substances are used in the construction of the building.

vi. **Materials Conservation:** Material conservation hopes to encourage the design strategies that reduce and reuse material resources and reduce construction waste. Moreover, it encourages the selection of building materials, which are environmentally

preferable. It is also to minimize construction waste, re-use existing building facade, and use recycled and salvaged materials.

vii. **Resources Conservation:** Resources include building materials, water and natural resources, have to be protected by reuse, reduction and recycling**.**

viii. **Improving Indoor Air Quality:** Poor indoor air quality affects occupant health. Generally, it influences feelings of well-being. Since the interior space is where the most people spend the majority of their time, it is important that it offer a healthy environment

ix. **Occupant Satisfaction:** A building that fails to provide satisfaction to its inhabitants has ultimately failed its basic task of providing acceptable shelter.

x. **Innovation:** Innovation substantially exceeds the different rating systems performance credit such as energy performance or water efficiency. It involves strategies or measures that are not covered by different rating systems such as acoustic performance, education of occupants, community development or lifecycle analysis of material choices.

xi. **Waste:** Waste is generated throughout the life of a building. Some waste examples are brick, metals, wood, cardboard and others that are generated during building demolition, renovation, and construction. Land filling construction and demolition waste, if not recycled, is a loss of material resource.

xii. **Toxic Materials:** Toxic materials may have to be used during the building process; however, it is important to minimize their impact through appropriate procedures for their storage, use, and final disposal.

xiii. **Transportation:** The way in which buildings are designed can affect the amount of automobile traffic generated by the new development. The associated negative environmental impacts include air pollution, gasoline consumption, and traffic

congestion. Buildings that are designed with pedestrian and transit access consideration and which minimize the number of parking spaces may reduce the amount of traffic.

xiv. **Environmentally Friendly Homeowner:** An environmentally friendly homeowner is pledged to limit his use of toxic chemicals and dangerous herbicides, pesticides and fertilizers. This includes limiting his/her level of yard watering, practicing new and improved methods of lawn care such as using a mulching mower, or "grass cycling," a process of which means leaving his grass clippings on the lawn after cutting to help naturally fertilize your garden**.**(Usama, 2006)

They are all important, and they provide the tools for approaching most design challenges associated with green/Ecological architecture. For the purpose of this research and the proposed design, energy efficiency can be ensured by properly applying principles **I, V, VII** and **VIII**.

2.4 FACULTY OF ENVIRONMENTAL DESIGN

A faculty is a division of university: a department or group of departments dealing with a particular subject in a university or college (Encarta dictionary, 2009).Therefore, faculty of environmental design refers to a division of a university which deals with the study and management of the built environment. Nowadays in Nigeria, faculty of environmental design offers B.sc or B.Tech in at least 5-areas of studies namely Architecture, Building Technology, Urban and Regional planning, Land surveying and geo-informatics, Quantity surveying and Estate management. These courses are offered in several universities in Nigeria for example Ahmadu Bello, University Zaria, University of Lagos, University of Nigeria, Federal University of Technology, Minna and so on.

2.4.1 Components of Faculty of Environmental Design

Faculty of Environmental in most of the universities in the world especially in Nigeria consist of the following departments namely:

i. Department of Architecture.
ii. Department of Building Technology.
iii. Department of Land Surveying and Geo-Informatics
iv. Department of Quantity Surveying.
v. Department of Urban and Regional Planning.
vi. Department of Estate Management and Valuation (Federal university of Technology, Minna site, 2011).

2.4.2 Nuc guideline for space requirement of faculty of environmental studies

s/no	Space	No Req.	No of Users	Total Area (m^2)
1.	Dean	1	1	36
2.	Secretary	1	1	24
3.	Deputy dean	1	1	36

4.	Faculty officer	1	1	24
5.	Faculty. office	1	4	36
6.	Conference room	1	30	72
7.	Publishing Office	1	2	36
8.	Storage space	1	-	12

Table 2.1: Deanery space requirement
Source: Nigeria University Commission

s/no	Space	No of office Req.	No of Users	Area (m^2)	Total Area (m^2)
1.	Office	4	4	24	96
3.	Lecturer-I office	9	18	24	216
4.	Lecturer-II office	10	10	30	300
5.	Snr. Tech. staff	3	6	24	72
6.	Jnr. Tech. staff	1	4	24	24
7.	Workshop/lab	2	80	300	600
8.	Classroom	6	240	48	288

9.	Library	1	120	150	150
10.	Design studio (Under grad.)	4	160	240	960
11.	Design studio (post grad.)	2	90	180	360
12.	Lecture theatre	2	10000	1500	3000

Table 2.2: Academic Spaces Per Department
Source::Nigeria University Commission

s/no	Space	No of Req.	No of Users	Total Area (m^2)
1.	Head of dept.	1	1	30
2.	Secretary	1	1	18
3.	Head, under-grad.	1	1	24
4.	Head, post-grad.	1	1	24
5.	Exam officer	1	1	24
6.	Gen. office	1	4	24
7.	Board room	1	15	60
8.	Storage space	1	1	18

Table 2.3: Administrative Spaces Per Department
Source: Nigeria University Commission

2.5 FACTORS THAT ENHANCE LEARNING

Dipali (2010), states these factors below as environmental factors that affect learning

i. **Heredity:**

Children of bright parents tend to be bright and the children of very inferior parents are often inferior. Though, heredity follows the principle of regression that says that traits when passing form parents to children tend to move towards the average. The genius son of a genius father is as very rare thing. Again, there is a tendency among the off-spring to be higher in the traits in which their parents are low and lower in which their parents are high. They move towards the average that is they regress. The reason for not showing consistency in the attainment is due to the complex nature of heredity, as heredity of a child is not solely determined by his immediate parents but from all his forefathers and ancestors (Dipali, 2010).

ii. **Environment:**

Our environment is our habitation in the fullest sense. Not only our physical surrounding but also the people around us, social customs and traditions, culture, education and training all constitute our environment. A number of studies conducted show that environment has remarkable influence on the learning of the individuals (Dipali, 2010).

iii. **Freedom and Self-discipline:**

Until recently, school discipline was regarded narrowly as merely a means of restraining pupils from creating disorder. So that learning activities may be carried effectively. Restrain commonly took the form of stern teacher imposed authority involving the extensive use pf punishments. It was based on the assumption that the child is a bundle of evil qualities and that he should be corrected and moulded into shape by the iron rod of authority. Thus no child could escape beating (Dipali, 2010).

iv. **Recognition of Teachers' Authority:**

One should not accrue that the teacher has lost its importance in the modern time. Rather, modern school situations demand a more carefully selected and well prepared teacher than was necessary for the traditional schools. Infact education on an atmosphere of freedom demands on teacher than does education guided by the old ideas of authority imposed. It demands a new atmosphere in the school and a new attitude in the teacher. It also demands new methods which advocate free activity of body, mind and soul of the pupils. The teacher instead of being a slave driver forcing the unwilling pupils to learn becomes a guide, makes himself one of the group, brings to the help of the group his larger experiences and thus helps the group in the search for truth, encourages them in every way to think, feel and work for themselves (Dipali, 2010).

v. **Nature Neglect:**

A teacher should have a complete knowledge of the biological laws. He should know how the whole organism works. He should realize that the whole child comes to school and not only his mind. The mind and the body are an entity. They cannot exist without each other. A Latin proverb says that " Mens Sano in Carpore Sano" means "A sound mind in a sound body". Mind lived in the body as in a clay cottage but it would be more true to say that the mind grows in the body as a plant grows in its soil. Poorer the soil, the more arrested the growth; richer the soil better the growth (Dipali, 2010).

vi. **Physical Environment of School:**

In general, the school environments present an educative atmosphere. The modern school site, building and equipments are adequate, safe, sanitary comfortable and attractive. It is only in the best environmental setting that the most effective learning takes place. The improvement of the environment no doubt, lies in the hands of school authorities rather than teachers. Yet, the requisitions, request and suggestions by the teacher can correct the environment to a considerable extent. The teacher can suggest

about lighting arrangements in the class, as due to defective lighting and ventilation arrangements the crowded classrooms lead to overheated conditions which reduce working capacity and encourage the spread of respiratory infections. Further, it will amount to restlessness, inattention and unsatisfactory work. It is a well know fact that individuals work much better in a room with an attractive atmosphere (Dipali, 2010).

vii. **Gap between School and Community**

The traditional schools are directed from social life and social activities. It has confined itself to book learning which has no utility for the child in his later life. But, the modern school represents the society in miniature. It has an intimate and organic relationship with the society. It incorporates such experiences which are intimately connected with actual living and enable the individual to lead a successful life in society (Dipali, 2010).

viii. **Wholesome Experiences:**

Real education is the acquirement of experiences which will help the pupil to adjust himself to his environments. Modern school, therefore, is an experience giving institution where pupils learn things through purposeful experiences. The old conception of the pupils mind of clean state, upon which the teacher is to write are gone. Now the school is an institution where learning takes place through experience (Dipali, 2010).

2.6 GREEN ARCHITECTURAL DESIGN PRINCIPLES THAT REDUCE ENERGY CONSUMPTION

From the literatures discussed above, Green design principles were categorized by Umar, (2010) into:

i. **Sustainable Site Planning:** The sustainable sites performance category encourages site selection, planning, landscaping and design strategies that use land more effectively

and minimize construction and operational impacts. Some effective site planning may minimize storm water run-off, encourage car-pooling and bicycling, increase urban density and green space and avoid major alterations to sensitive topography, vegetation, and wildlife habitat.

ii. **Energy Efficiency:** The energy and atmosphere category emphasizes reducing the depletion of non-renewable energy resources and related environmental impacts, particularly emissions of local, regional and global air pollutants. Renewable energy sources with low environmental impacts are encouraged. Also, reducing building energy consumption, using renewable energy, and eliminating ozone depletion are promoted as well. The application level of the component can be experienced by harnessing solar radiation and wind to enhance daylight architecture, solar energy source, and passive means of ventilation. This forms the core focus of this research.

iii. **Materials Conservation:** Material conservation hopes to encourage the design strategies that reduce and reuse material resources and reduce construction waste. Moreover, it encourages the selection of building materials, which are environmentally preferable. It is also to minimize construction waste, re-use existing building facade, and use recycled and salvaged materials. Conservation also can take place by using renewable construction materials, design, and construct buildings that are more durable.

iv. **Resources Conservation:** Resources include building materials, water and natural resources, have to be protected by reuse, reduction and recycling.

2.7 EXTRACTION OF GREEN ARCHITECTURE THAT ENHANCE LEARNING PECULIAR TO FACULTIES OF ENVIRONMENTAL DESIGN.

Green Architecture strategies such as “roof garden” which can be used as a garden by the student, sit out for group discussions, relaxation during breaks from lectures, tests and art works.

These green also serve the following purpose:

i. Reduces environmental impacts

ii. The reduce green house effect

iii. The improve the microclimate of their immediate surroundings especially during the hot season

iv. They also reduce temperature to about 2-3^{o}C (Anne, et. Al, 2008).

2.8 EMBODIED ENERGY AND LIFE-CYCLE ASSESSMENT ON GREEN BUILDING

Building materials used in the construction and operation of buildings have energy embodied in them due to the manufacturing, transportation, and installation processes of converting raw materials to final products. The material selection process should also consider the environmental impact of demolition and disposal after the service life of the products. Life-cycle assessment (LCA) databases and tools are used to calculate and compare the embodied energy of common building materials and products. Designers should give preference to resource-efficient materials and reduce waste by recycling and reusing whenever possible.

2.9 THE RELATIONSHIP BETWEEN ENERGY AND THE ENVIRONMENT

First in foremost, energy is defined as a power supply or source for electrical and mechanical purposes. This existing energy supply to buildings contributes to environmental degradation. The best solution will be to reduce the consumption level of this energy by the use of alternative sources which must be renewable and of a natural form (to promote energy conservation as the source cannot be exhausted and does not pollute the environment). The main natural/environmental elements which can

be harnessed to generate an alternative energy source include air, water and sun through the use of wind turbines, hydro electricity and solar panel respectively.

I. **Existing energy source**

The present energy source is hydro electricity through the use of ***dams*** and nuclear energy through the use of ***nuclear power plants*** especially in more developed countries. This energy is distributed to various buildings through the central power grid consisting of a series of high and low tension cables, transformers and distribution boxes to the appliance.

II. **Energy consumption**

There are 3 main ways through which buildings consume energy.

i. ***Operating energy***: the energy necessary for maintaining required levels of comfort and operating conditions in the building (such as lightning, ventilation, etc.).

ii. ***Induced energy***: energy consumed indirectly through construction. For example, commuter traffic or supply of goods.

iii. ***Production energy***: (embedded/embodied energy) in the energy invested in the building material through the process of production, assembly, maintenance, alteration and demolition, and of recycling components or materials *(Roy, 2008)*

The common devices in any building that consume energy include all electrical appliances. Some examples are; Lightning, Ventilation devices (vents), heating and cooling, sockets/ power outlet, etc. the sophistication of the electrical appliances in a building depends on the scale of the operation carried out in the building as well as the size of the building itself. This implies that electricity may also be required for mechanical purposes such as water pump especially in facilities where such provisions have been made. Also cooling, heating, and ventilation system consume a large amount

of energy pending on the scale of its service and since the proposed facility can be categorised as having a large scale operational system there is bound to be a lot of energy consumed.

Energy consumption is beyond just electricity used in the building for its operation but also branches into het area of material used for the construction of that building. Now the whole purpose of this study is to create an environmental friendly and energy conscious architecture to help reduce energy consumption and in the long run reduce environmental degradation. So, clearly no building can claim to be a Green-building if it is constructed from materials that had a major environmental impact elsewhere and add to energy consumption even during its processing stage. For these reasons, the concept of *embodied energy* is central to good environmental design. The *embodied energy* of a building material is the energy that has been required to extract, process, and manufacture it and then to transport it to the building site. The embodied energy in the structure of a new building is considerable, exceeding the total energy required to heat that building for the next twenty years (Umar, 2010).

In terms of the energy of manufacture, the highest embodied energy is found in metals (steel requires 57,000kWh to produce one cubic metre), and highly processed industrial products (hardboard and MDF require 2,000 kWh to produce 1m3). The middle ranges of materials are simpler to make but require lot energy in their manufacture (bricks and concrete blocks need 700kWh/m3). The lowest embodied energy is in materials that require only simple processing (building timber needs 180kWh/m3) or those made from salvaged materials or local natural materials, which require virtually no energy (Umar, 2010).

III. **The issue of embodied energy divides new Green-buildings into two distinct families.**

i. One kind of Green-building aims to obtain the lowest possible energy consumption with the most efficiently available technology, such as high performance insulation and solar panels. Such buildings have a high embodied energy which they hope to justify with large savings in their energy consumption, or even to generate and export a surplus of energy.

ii. The other kind of Green-building aims to achieve the lowest possible embodied energy by using salvaged materials or simple local materials (straw bales, rush matting, mud bricks). Such buildings will usually perform less well in terms of annual energy consumption, and are less durable, but often have a lower overall environmental impact over the course of their lifespan.

The Proposed *faculty of environmental design* falls under the first category since its future projection points towards larger energy consumption and requires high durability for its expected long life span than any other conventional building. This is because of the intended scale of the operation of the facility. Notwithstanding, the material to be employed will try to reduce any negative environmental impact.

Embodied energy is usually a good guide to wider environmental impacts, especially for toxic waste and atmospheric pollution. There are two main exceptions to this:

Cement and Concrete, which has a mid range embodied energy, but a disproportionately high impact on climate change. When limestone is burnt to make lime it releases an equal weight in carbon dioxide. Taken as a whole, the cement industry produces 5% of the world's human carbon dioxide emissions.

Timber has a low embodied energy, but can have a very high environmental impact if taken from old growth forests.

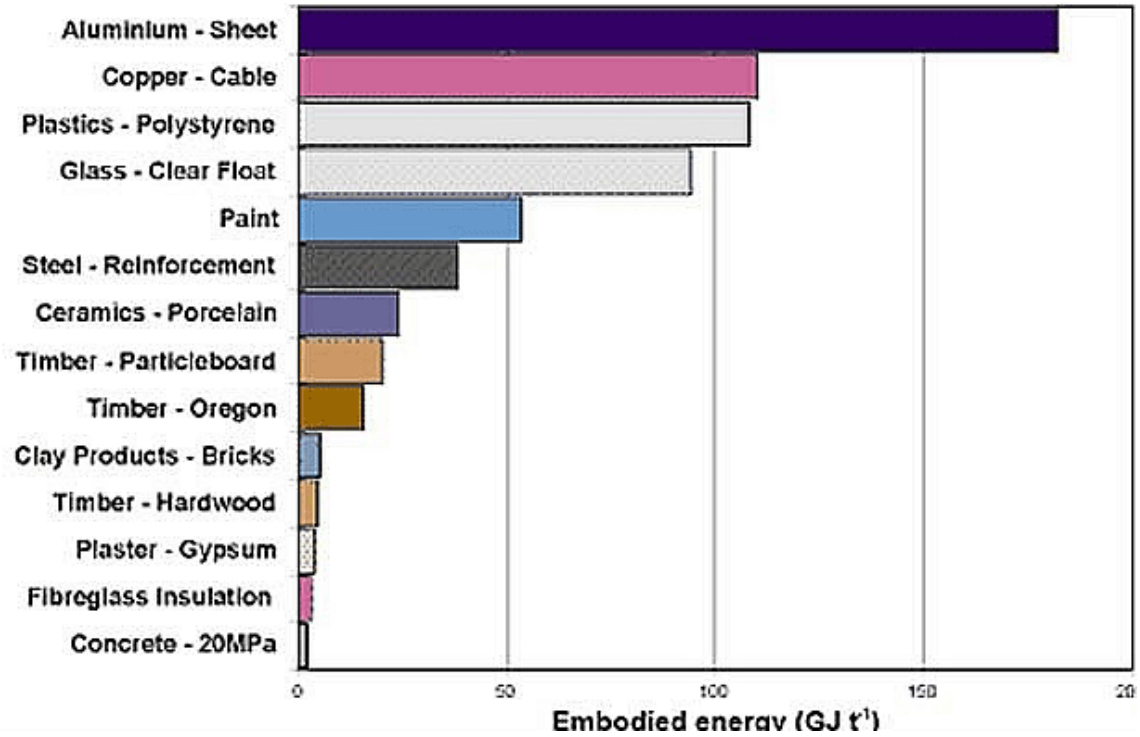


Figure 2.2: Embodied energy of materials
source: http://www.paradiseprofit.wordpress.com.

From the chart, aluminium has the highest embodied energy while materials with low embodied energy include timber, bricks/clay product, plaster (gypsum), and fibreglass insulation. Concrete a midrange embodied energy (measured as 20MPa).



Figure 2.3: comparison of embodied energy between steel, wood, and concrete
Source: http://www.mgerwing.wordpress.com

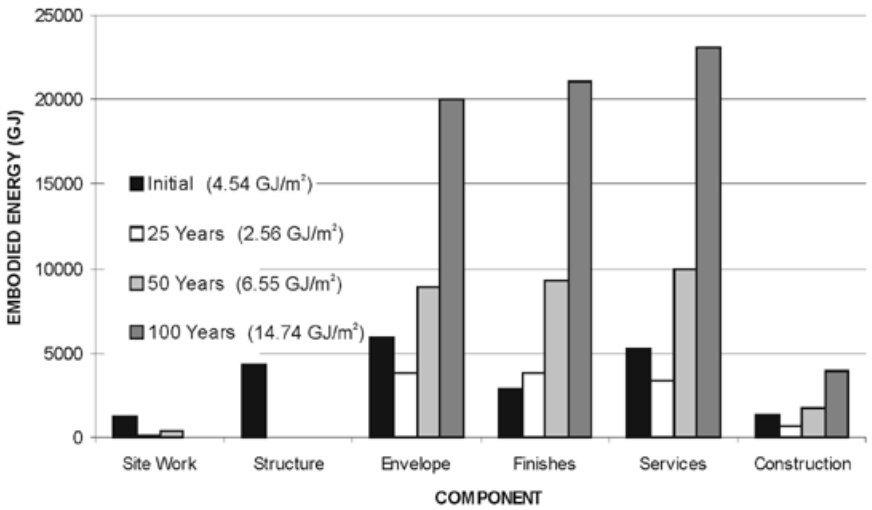


Figure 2.4: embodied energy of building component based on time - source: http://www.tecEco.com

MATERIALS	*ENERGY CONTENT (KWH/KG)*	*RATING*
Soil/earth	0.01	Very low
Brick	0.86	Medium
Concrete/sand Crete (1:3:6)	0.28	Low
Aluminium	27	Very high
Timber (local)	0.2	Low
Timber (imported)	1.4	Low
Glass	9.2	Medium
Plastic	45	Very high

Table 2.1: *energy content and rating of building material*

***source**: Sinha, 1997*

The chart above show that site work usually uses material with lower embodied energy compared to services and it is expresses though out the lifespan of the building.

2.10 **GREEN-ARCHITECTURE AS A PASSIVE ENERGY SOLUTION**

Passive elements of Ecology include sun, water, wind and green/vegetation each of which has an effect when applied into a design (Umar, 2010). For example the sun can be used as a source of lightning during the day time and could be harness to supply electricity to mechanical devices and artificial lightning at night. The wind could be used as a means of natural ventilation and cooling while vegetation can be used to provide shade and reduce the air temperature of the environment. Water also has this temperature reducing quality when properly applied in a Green-design. The sun is the most prominent element on any site and since the application of Green principles are to be applied in the design of a proposed faculty design Nigeria, design guidelines based on the use of these Green elements will be making reference to the climatic and vegetation characteristic of the region.

Nigeria is located in the tropical regions of the world is characterised by high solar radiation. To therefore create an alternative source of power using Green architecture principles, it is best to employ this sun and other natural resources because it will never become scarce.

2.11 **ARCHITECTURAL RELEVANCE IN PASSIVE ENERGY SOLUTIONS**

The physical characteristics of a building play a significant role in incorporating the Green elements in to the design. The form of the building can optimize the penetration of daylight needed in the interior and also to direct air flow in and around the building/facility. There are design guidelines that should be followed so that the building can properly integrate the Green-elements and make the building a solution to excessive energy consumption through passive techniques.

Guide Line 1: Working With the Sun

The contribution of the sun to a building's internal heat is called the *solar gain*. To achieve this solar design combines four (4) strategies: *orientation, thermal mass, thermal zoning and glazing* (Umar, 2010);

I. ***Orientation-*** is crucial for determining the amount of sun a building receives. Solar gain surfaces should face the sun to maximise irradiation. All other surfaces should be shaded. Also, properly shaded structures should be wind oriented. A well functioning Green-building will have as much of its glazing as possible in vertical windows facing between South East to South West, and as few windows as possible facing North East through to North West with an orientation of the longer sides of the building lying on the North and South axis.

II. **The Thermal mass** of a building is a measure of its capacity to store and regulate internal heat. Buildings with a high thermal mass take a long time to heat up but also take a long time to cool down. As a result they have a very steady internal temperature. Buildings with a low thermal mass are very responsive to changes in internal temperature as they heat up very quickly but they also cool down quickly. They are often subject to wide variables in internal temperature. This is more suitable for the proposed building as a low thermal mass characteristic is essential.

The best materials for storing heat are those that are very dense, heat up slowly, and then give out that heat gradually. Brick, concrete and stone have a high thermal capacity and are the main contributors to the thermal mass of a building. Water has a very high thermal capacity, so it is well suited to central heating systems. Air has a very

low thermal capacity- it warms up fast but cannot stay warm for long. Only when the walls and floors in a building have warmed up will the air stay warm.

Green-buildings are usually designed to have a high thermal mass for several reasons:

i. To hold over daytime solar gain for night time heating.

ii. To keep the building cool during the day in summer.

iii. Increase the efficiency of a central heating boiler.

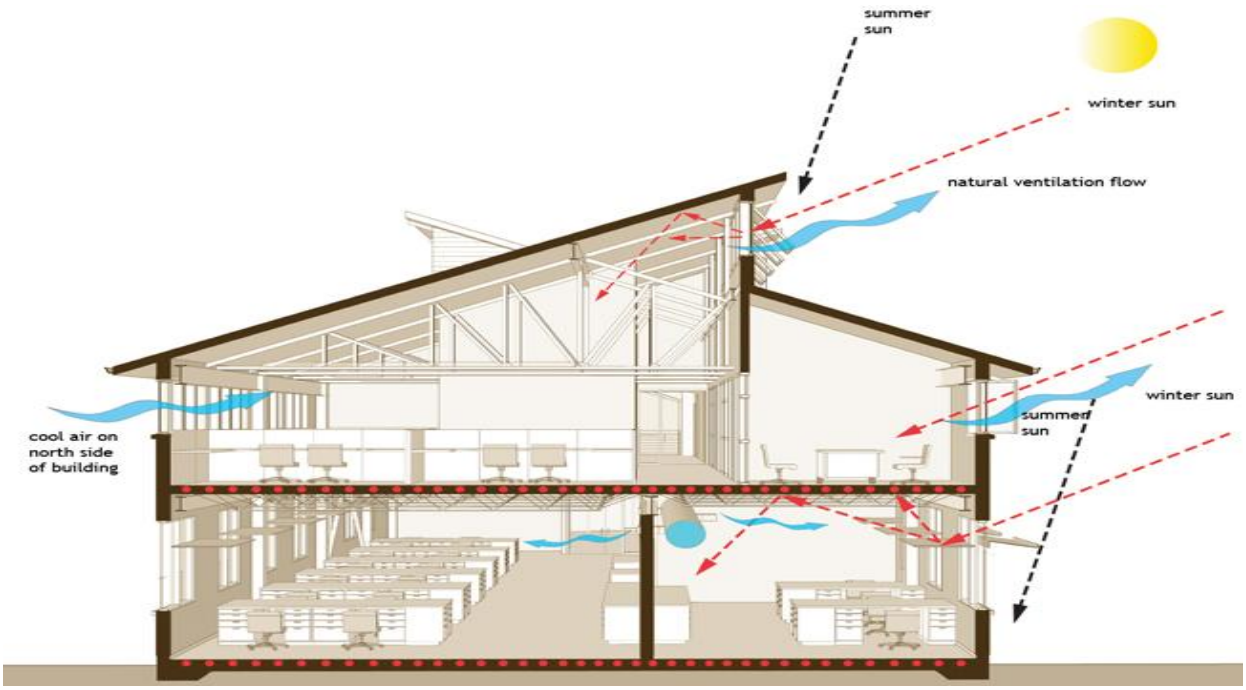


Figure 2.5: solar massing process
Source: architecture.uwaterloo.com.

III. **Thermal Zoning:** Different temperatures are required for different spaces. An efficient Green-building recognises these differences and creates different thermal zones for the different spaces. Also, orientation determines the temperatures of different spaces. Naturally, spaces in the east to west axis tend heat up more than spaces in the north and south. Office spaces, computer rooms and waiting areas should definitely be kept away from hot zones as most of the time will be spent in these areas, especially in the office spaces. Toilets where natural lighting and good ventilation is desirable should also be kept away from hot or warm zones.

IV. **Controlled Glazing** is the vital component of environmental design. Glass allows 90% or more of the energy in the sun's rays to pass through and then traps the resulting heat. Glass can let in indirect daylight so we can avoid using electric lights (enhancing day lightning) whilst keeping out draughts. However, there are problems with glass too. It is a very poor insulator - a sheet of glass has about the same insulating power as a sheet of hardboard. Double glazing is twice as good (or half as bad) because the small air gap between the sheets of glass is a good insulator. Even so, double glazing still only has the insulating power of a single layer of bricks. As long as the sun is shining through the glass, it is receiving more energy from the sun than it is losing through heat loss. In the case of the tropical climate which Nigeria happens to fall under, the openable area of the glass should be maximised to let in as much fresh air as possible. The trick here is to provide sufficient sunlight and air, but use low emission glass which will keep the heat out of the building (Umar, 2010).

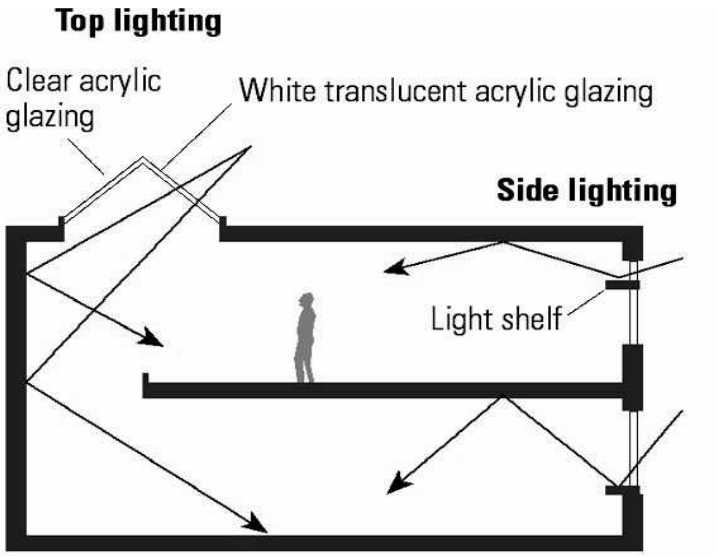


Figure 2.6: day lightning strategies
Source: energy design resources, 1999.

The energy design resources (1999) stated that the level of integration of daylight into the design can have a profound influence on the architectural form of the building. To

achieve proper daylight within the faculty buildings or any building, six design principles will need to be applied;

i. Treating the building as a luminaire:
ii. Separating the vision and daylight glazing.
iii. Positioning the day lighting apertures to create mood and visual focus.
iv. Addressing the requirements of the visual task.
v. Integrating the daylight system with the architecture.



Plate III: the Solar Energy Research Facility (interior of a luminaire building) - **source**: energy design resources laboratory, (1999)



Plate IV: The Solar Energy Research Facility (an exterior view of luminarie building) **Source**: energy design resources laboratory, (1999).

Guide line 2: working with the wind (Passive ventilation and cooling)

Passive ventilation is defined as Ventilation obtained without the use of mechanical devices and external energy. Natural ventilation is the process of supplying and removing air through an indoor space by natural means, meaning without the use of a fan or other mechanical system. It uses outdoor air flow caused by pressure and temperature differences between the building and its surrounding to provide ventilation and space cooling. Ventilation is closely related to natural cooling and if the renewing air that penetrates the building passes through cold places such as cisterns, the effectiveness as a cooling system increases.

There are many systems depending on the physical principle applied. Passive ventilation and cooling can be achieved through three (3) main techniques;

1. ***P***

ressure Driven Ventilation: also called cross ventilation. The options for appropriate location and sizing of the openings are varied.

i. In cases where ***opening are relatively large on the face exposed to the wind and a smaller one on the opposite face***, both in central position, air enters more easily but with moderate interior velocity. A stripe with relatively good ventilation is formed, while laterals have poor ventilation.

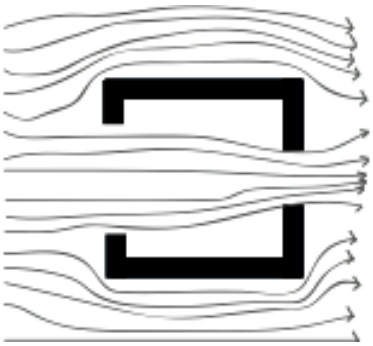


Figure 2.7 pressure induced ventilation
Source: Lascano, 2011

ii. For ***smaller frontal opening***, the simple change produces two important effects: the ventilated stripe shows air velocity quite elevated, while laterals show greater air movement due to turbulence. In other words, ventilation is better than in the previous case.

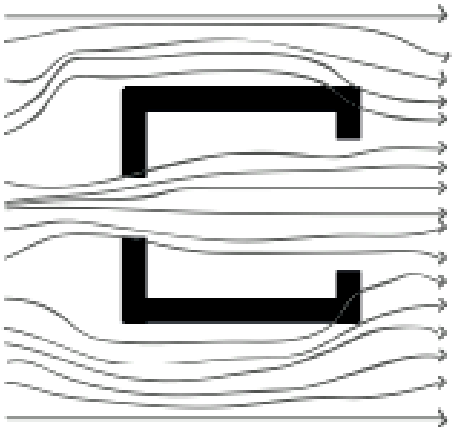


Figure 2.8 pressure induced ventilation
Source: Lascano, 2011

iii. But in ***regular sized opening on both facades,*** there is a relatively intense airflow that is larger in the central area. Laterals present less efficient ventilation due to reduced turbulence.

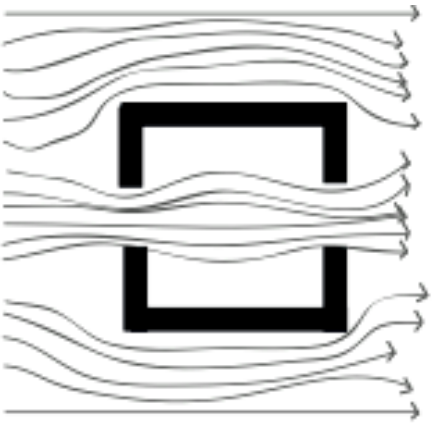


Figure 2.9 pressure induced ventilation
Source: Lascano, 2011

This shows that the concept of "cross ventilation" is more efficient when its possibilities are taken to the limit, that is to say, when airflows can pass through the space as widely as possible. To sum up, the efficiency of cross-ventilation/pressure induced ventilation as a passive cooling resource depends mainly on the following factors:

i. Openings oriented strategically to take advantage of high and low pressures generated by the prevailing winds of the site.
ii. The adequate modulation of the size of openings to create flows with optimal velocity.
iii. The relative position of openings, so that airflows can reach a more extensive part of the interior space.

2. ***Wind Driven Ventilation: (***application of wind tower systems***)*** Wind driven ventilation or roof mounted ventilation design in buildings provides ventilation to occupants using the least amount of resources. Drawbacks include the use of equipment that is high in embodied energy and the consumption of energy during operation. By utilizing the design of the building, Wind Driven Ventilation



takes advantage of the natural passage of air without the need for high energy consuming equipment.

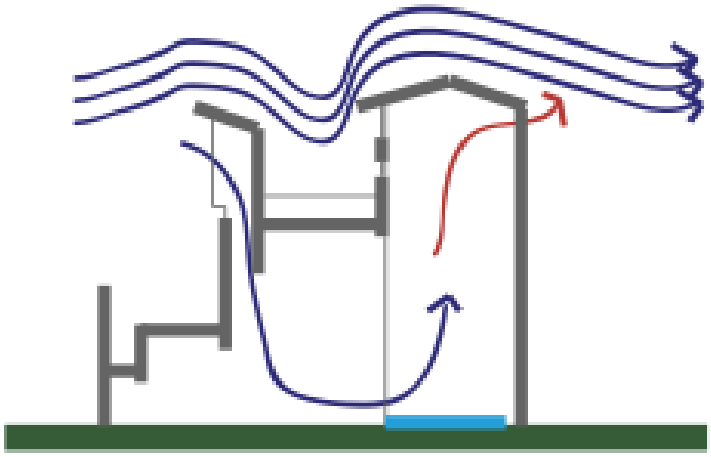


Figure 2.10 wind induced ventilation (wind catcher)
Source: Lascano, 2011

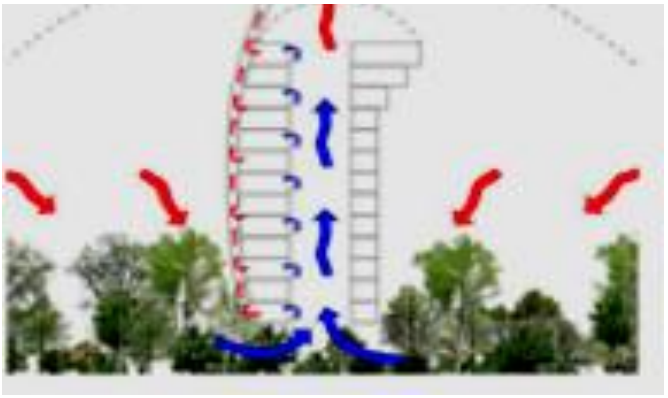


Figure 2.11 vertical ventilation (high rise)
Source: Lascano, 2011

The efficiency of collecting towers depends on many factors;

i. The winds available: When there are regular winds with relatively constant direction, the collecting towers show their greatest potential.
ii. Height: When height is greater there is more wind pressure and therefore, ventilation rates increase.
iii. The size of the upper opening: If the opening is bigger, more air will be collected and go inside.

iv. The position regarding the served spaces: It is important that they are located in a way that allows the airflow pass through the living space, as you can see in the model.

3. ***Stack Driven Ventilation:*** (application of solar chimney in warm and sunny climate) Buoyancy ventilation can be induced by temperature (known as stack ventilation) or by humidity (known as cool tower). Most commonly used is the stack driven ventilation. For stack ventilation to work properly there must be a temperature difference. However, stack driven ventilation is limited to a lower magnitude than wind driven ventilation. It is also very dependent on the inside and outside temperature differences. When air warms, it expands, becomes less dense than the surrounding air, and rises. This process is called convection and is the main process by which heat moves around a space and the building (Lascaro, 2011).

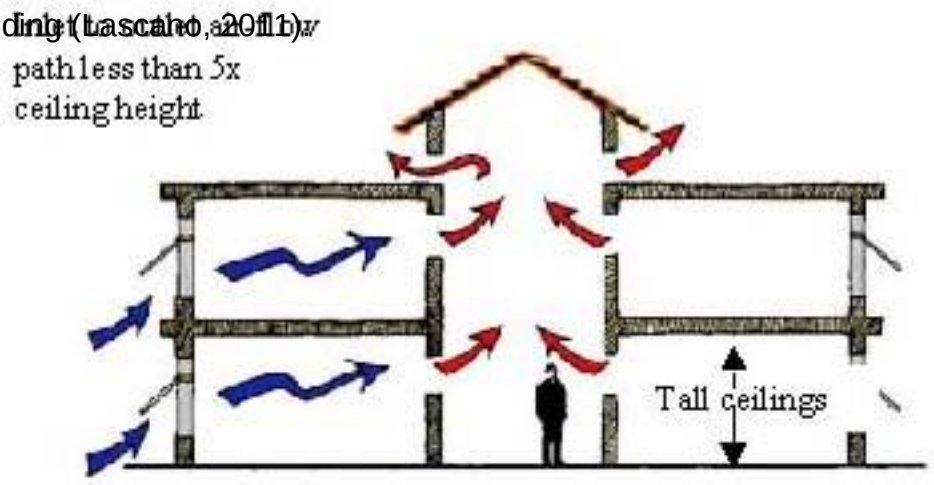


Figure 2.12: Schematic diagram of stack effect. (Cool air replaces hot air which has risen and is taken out by higher place outlets)
Source: http://www.googleimages.com,2009

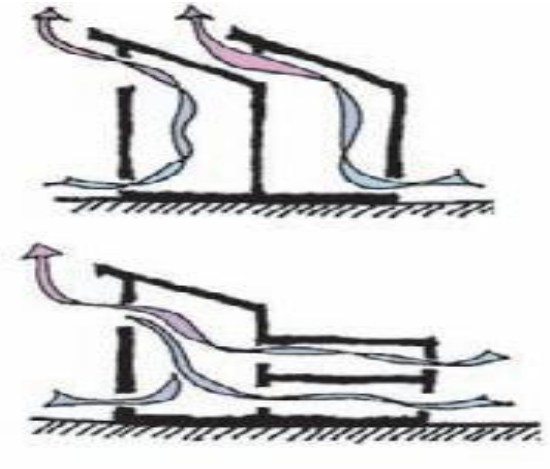


Figure 2.13: Various Stacks Ventilation Configurations
Source: Kate, 2004

Guide line 3: working with water

Water can be used to regulate temperature within a building and around it. It usually works hand in hand with ventilation and is considered to be the major Green-element needed in cooling especially in tropical regions.

Passive cooling through the application of pressure driven ventilation can be achieved when a water body is present near the building. As warm air is cooled by the water body on the wind ward side of the building, the cool air is force into the building like in the second case. The wind direction (arrows) and wind velocity (lines of similar velocity and area of diffused colours) are indicated in the plate below. The blue indicates the lowest values of wind velocity and red the highest values.

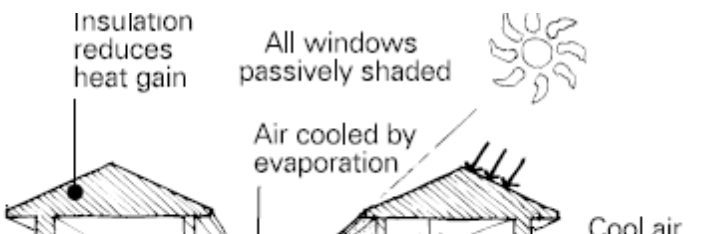


Figure 2.14: pressure induced cooling
Source: Chris, 2002

The use of water in building interiors can also apply the same principles, landscaping elements like fountains and spring (basically water in motion) is the fastest way to cool the surrounding air temperature during the day. Since water has a high solar gain and hold the heat gained throughout the day, it can also warm up the surrounding air at night. Rainwater collection techniques would be used to ensure water conservation in the building but is a water body is present on site; Green -design will incorporate it into the building.

Guide line 4: working with vegetation

Vegetation plays a major role on the symbolic representation of a green building. It also acts as an indicator of the region where the building was constructed since most green life are specific to a particular region or geographical area. The type of plant also help to improve health conditions of the occupant of a building by improving the air quality (through photosynthesis) when the plant uses the carbon dioxide and replaces it with oxygen it produces and cooling through evapo-transpiration when evaporation occur from stems of plant. It can also be used to reduce direct solar radiation thereby

improving day lightning and all other principles applied when designing with the sun. The most obvious effect of vegetation in building design is the aesthetics it produces when it is used in, on or around the building.



Plate V exterior view of Nan yang Technological University

Source: Feldman, 2009



Plate VI: The EDITT tower by Ken Yeang (Vegetation integrated into the building's interior)

Source: http://www.inhabitat.com, 2011.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter aims to present the theoretical assumptions underpinning this research, as well as to introduce the research strategy and the empirical techniques applied. The theoretical assumptions underlying this research come from the qualitative tradition, which deals in interpretation of contemporary situations (Linda and David 2001). The research strategy adopted was to conduct multiple case studies in different regions similar to the intended design or the principle to be applied. The main data collection techniques used in this research study will be semi-structured interviews, group discussion, participant observation, documentation analysis and questionnaires

3.2 CASE STUDY SELECTION CRITERIA

The selection criteria for the case studies in this research are based on the current thinking on space norms and standards for physical facilities.

This study is relevant to the faculty strategic planning priorities which include a commitment to investigate and improve the physical and learning environment of institutional buildings. The information collected will provide practical details relevant to the designer's work.

Each case study will be analyzed based on two aspects:

I. A general documentation of the faculty of Environmental Design buildings. (The researcher has kept detailed notes of features of each of the faculty buildings and also took photographs).

II. An assessment on the application of Green Architecture principles in faculty of Environmental designs.

3.3 AREA OF STUDY

The libraries which have been selected for this study include:

i. Faculty of Environmental Science, Ladoke Akintola University of Technology Ogbomoso.

ii. Faculty of Environmental Technology, Abubakar Tafawa Balewa University Bauchi.

iii. Faculty of Environmental Technology, FUTMinna.

3.4 SAMPLE AND SAMPLING TECHNIQUE

The random sampling technique was used during the research so as to have an accurate and straight-forward result.

3.5 DATA COLLECTION

The main data collection techniques used in this research was case studies, visual survey, oral interview.

3.5.1 Instruments for data collection

The instruments used for collection of data for the research were: Photographs, Tables, Internet, Sketches and Notes.

3.5.2 Procedure for data collection

The information of this research proposal was obtained from the following procedure for data collection.

i. **Visual survey:** This was done by looking and identifying what has been achieved by existing faculty building where Green Architecture has been applied.

ii. **Case studies:** this involved the visitation to notable faculty of Environmental Design within Nigeria universities for personal observation of facilities, services rendered, problems, functional flow of activities within the institutions at large.

iii. **Oral interview**: Interview of academic and non-academic staff under case study to acquire information on several aspects of the building: its history, construction, administration and other relevant information. These interviews are required to get detailed and precise information on the functionality of the building.

iv. **Internet**: this involved browsing the related website of the research topic under study.

3.6 DATA ANALYSIS AND PRESENTATION

Data collected for the research were analyzed and represented in different forms which include:

i. **Photographs**: Pictures of the existing faculty buildings were taken and documented showing the facilities and how Green design elements were applied.

ii. Tables: Data collected on this research were documented and presented on the case study assessment tables.

iii. **Figures:** Data collected on the case studies were documented in form of drawings.

iv. **Descriptive Analysis:** This is use to show how elements and features of Green design principles have been applied to achieved a suitable learning environments. This can be viewed under the case study summary and conclusion sheets.

3.7 VARIABLES OF STUDY

The parameters for the variables which satisfy the research questions and are to be used to assess the case studies are;

i. Architectural Expression: this refers to the design form and concept applied in the design and its significance in energy conservation.

ii. Building's relationship to the site: this refers to the site planning, Green features conserved, and how the building interacts with its surrounding to harness natural resources in terms of energy conservation.

iii. Building materials: the type of material used in the buildings construction and its contribution to energy conservation.

iv. Existing energy source: the present source of energy used in the running operation of the facility to be studied. If the facility is self sustaining in energy usage, it will be regarded strong otherwise it will be regarded as weak.

v. ***Green-architectural features:*** from the Green-architectural guide line established in the literature review, this variable will point out which of the elements of Green-architecture had been applied in the cases and how energy conservative the elements are.

vi. ***Scope of the facilities provided:*** this is basically referring to the spaces and equipments (that make up the whole facility) provided to ensure the facility functions fully as intended and to establish how much energy it consumes based on this provision.

CHAPTER FOUR

FINDINGS AND DISCUSSIONS

4.1 INTRODUCTION

The findings from the case studies carried out have been discussed under the following sub-headings: Background, site planning and landscaping, structure and materials, assessment of the exploration of green principles in the Architectural design of the faculty complex.

The case studies were selected based on the site location and three geo political zone that has some similarities and differences in the climatic condition and are: North-Central, North-East and South-West.

4.2 Case Study One: Federal University of Technology, Minna, Niger State.

4.2.1 Background

The federal university of technology, Minna is a federal government owned university. It was established on 1st February, 1983. The objective for its establishment is to give effect to the Nations drive for much –needed self-reliance in sciences, Engineering and especially technology. It is a specialized university of technology.

At inception, the university acquired on a permanent basis, the facilities of the former government teachers' college Bosso which now serves as the Bosso campus of the university. The university acquired 10,600 hectares of land along the Minna Kataeregi-Bida Road for the main campus of the university, to cater for the kind of necessary expansion envisaged.



Plate VII: Approach view to faculty complex
Source: Author, 2014

4.2.2 Site Planning and Landscaping

The faculty is located within the heart of the Campus at Gidan Kwano, the site consist of both vehicular and pedestrian access with large open spaces. The land is relatively flat, the few existing buildings are the School of Agriculture, School of Engineering and Computer complex. The layout is simple with the main entrance to the faculty from the parking lots (see plate 4.2).



Plate VIII: Parking lots
Source: Author, 2014

Both the central court yard and the outdoor spaces of the faculty complex is partially landscaped with plants and the surface is treated with concrete paving. Good drainage system within the court yard to channel out runoff water from the building.



Plate IX: Central Court
Source: Author, 2014

4.2.3 Structure and Materials

The main building materials used were sandcrete blocks, reinforced concrete, glass and aluminium. Burnt bricks and rammed earth was also used on the facade of the complex. The plan is made up of simple regular grid of supporting columns spaced by about 7.6m to 7.2m. The plan form takes on a single



banking system with corridor running the entire length of the "E" shaped form facing the enclosing courtyard.

Plate X: Facade of the complex
Source: Author, 2014

4.2.4 Assessment of the exploration of green principle elements

VARIABLES OF STUDY		WEIGHT FACTOR	REMARKS
Use of Materials	A sustainable material (burnt bricks) was used extensively on the facade of the building.	4	Very good
Use of Court-Yard	Court-yard was considered in the design but not well landscaped, hence the aim was actualized but the intension was partially achieved.	2	Fair
Use of	Shading fins were not incorporated in the design and	-	Poor

Shading Device	there was no provision of planting trees at both the Eastern and the Western sides of the complex to shade the building against solar glare.		
Green Balconies	No provision for green balconies in the design.	-	Poor
Outdoor Landscape	The design of the complex incorporated both soft and hard landscape features, but was not well achieved and the ones in placed are not properly maintained.	2	Fair
Use of sustainable power source	No provision	-	Poor
Green Roof	No provision of green roof in the design	-	Poor

Table 4.1: Case Study 1 Assessment Table
Source: Author, 2014

Weight Factor: Excellent = 5, Very Good = 4, Good = 3, Fair = 2, and

Poor = 1.

4.2.5 **CONCLUSION**

It was observed that the design of the faculty complex fulfill some sustainability principles, however it can be inferred that the designer had sustainability in mind during the design process but was partially fulfilled, thereby making the complex not energy efficient.

Therefore, for the complex to be energy efficient and also to create a conducive learning environment, a large amount of money will be required to power and sustain the complex which is quite expensive and not economical.

4.2.6 Interview Result

i. The complex indoor spaces are always un conducive (i.e. ventilation problem) anytime there is no power supply.

ii. The court yard sit-out is abandoned due to poor landscaping.

iii. The indoor spaces is affected by solar radiation during the sun rise and sun set hour of the day due to absence of shading device.

4.3 Case Study Two: Abubakar Tafawa Balewa University Bauchi, Bauchi State.

4.3.1 Background

Abubakar Tafawa Balewa University (ATBU) is a federal university of Technology located in Bauchi. The University is named after the first Prime Minister of the federal republic of Nigeria. It was established in 1980. The objective for its establishment is to give effect to the Nations drive for much–needed self-reliance in sciences, Engineering and especially technology. It is also a specialized university of technology.

At inception, the university inherited the site of the former Bauchi College of Arts and Science (BACAS) at Yelwa. It has undergone a tremendous transformation at the Yelwa

campus and the University is now developing the permanent site (Gubi Campus). The Yelwa campus of the university acquired 7,000 hectares of land along Yelwa Tudun Road and the Gubi campus acquired 4,500 hectares of land off Bauchi-Ningi Road was later acquired for the Institution where Physical development is in progress. Work had steadily progressed for the physical development of the main campus which in phase consists of the school of Engineering, Science, Environmental Technology, Agriculture, Management Technology and school of Technological Education, university library, student hostel, the staff resident, the computer centre as well.



Plate XI: Approach view of the faculty complex
Source: Author, 2014

4.3.2 Site Planning and Landscaping

The faculty is located at one extreme of the campus at Yelwa Tudun, the site consist of both vehicular and pedestrian access with large open spaces. The land is relatively flat, the few existing buildings are lecture theatre, School of Sciences, School of Engineering and Workshops. The layout is simple with the main entrance to the faculty from the parking lots (see plate 4.6).



Plate XII: A side view of the faculty complex
Source: Author, 2014

There is no element of landscape in the parking lots, both the central court yard and the outdoor spaces of the faculty complex is partially landscaped with plants and the surface is not treated with concrete paving.

Good drainage system within the court yard to channel out runoff water from the building.



Plate XIII: Central Court Yard
Source: **Author**, 2014

4.3.3 **Structure and Materials**

The building materials used were sandcrete blocks, reinforced concrete, glass and aluminium. Burnt bricks and rammed earth was not used in any part of the building.



Plate XIV: Side View of the Building
Source: Author, 2014

On the side elevation, the building was supported with slanted columns at specific intervals with balconies at each floors for relaxation and student group discussion.

4.3.4 Assessment of the exploration of green principle elements

VARIABLES OF STUDY		WEIGHT FACTOR	REMARKS
Use of Materials	No sustainable material (burnt bricks, timber finish, etc.) was used.	-	Poor
Use of Court-Yard	Court-yard was considered in the design but lacks both hard and soft landscape elements.	2	Fair
Use of Shading Device	Shading device was not incorporated in the design but fins were provided but not pronounced	2	Fair

	to actually shade the building against solar glare.		
Green Balconies	The design incorporates balconies on both the East and West elevations of the building but attempt of making the balconies green was not achieved.	2	Fair
Outdoor Landscape	The design shows that outdoor landscape was incorporated but was not clearly defined.	2	Fair
Use of sustainable power source	No provision	-	Poor
Green Roof	No provision of green roof in the design	-	Poor

Table 4.2: Case Study 2 Assessment Table
Source: Author, 2014
Weight Factor: Excellent = 5, Very Good = 4, Good = 3, Fair = 2, and Poor = 1.

4.3.5 CONCLUSION

The design of the faculty complex incorporated some sustainability principles but almost all the principles incorporated was not actually achieved thereby making the building not energy efficient.

4.3.6 Interview Result

i. The complex indoor spaces are always unconducive (i.e. ventilation) anytime there is no power supply.

ii. The court yard sit out is abandoned due to poor landscaping.

iii. There is adequate lighting in the both the lecture rooms and studios.

iv. The indoor spaces is affected by solar radiation during the sun rise and sun set hour of the day due to absence of shading device.

4.4 Case Study Three: University of Lagos Akoka, Lagos state.

4.4.1 Background

The university of Lagos is a federal government owned university popularly known as UNILAG. It was established in April, 1962. The objective for its establishment is to give effect to the Nations drive for much–needed self-reliance in Art, Social Sciences, Environmental Science, Pharmacy, Law, Engineering, Sciences, Business Administration, Education.

The university was made up of two campuses- the main campus at Akoka, Yaba and the college of Medicine at Idi-Araba . It has undergone a tremendous face-lift and wears a beautiful outlook befitting a modern university. The university acquired 802 acres (3.25sq km) of land along the lagoon for the main campus of the university.



Plate XV: Approach view of the Department of Architecture
Source: Author, 2014

4.4.2 Site Planning and Landscaping

The faculty is located at one extreme of the campus at Akoka Yaba, the site consist of both vehicular and pedestrian access with large open spaces. The land is relatively flat, the few existing buildings are Faculty of Art, lecture theatre, Faculty of Sciences, Faculty of Engineering. The layout is simple with the main entrance to the faculty in close proximity to the parking lots.



Plate XVI: A side view of the faculty building

Source: Author, 2014

There are elements of landscape in the parking lots, both the court yard and the outdoor spaces of the faculty buildings are well landscaped with plants and the surface is also treated with concrete paving, the court yard also serve as a buffer.



Plate XVII: Outdoor Landscape
Source: Author, 2014

4.4.3 Structure and Materials

The building materials used were sandcrete blocks, reinforced concrete, glass and aluminium.



Plate XVIII: Side View of one of the Faculty Buildings
Source: Author, 2014

On the side elevation, the building was supported with slender columns at specific intervals with walkways linking the buildings.

4.4.4 Assessment of the exploration of green principle elements

VARIABLES OF STUDY		WEIGHT FACTOR	REMARKS
Use of Materials	No use of sustainable material (burnt bricks, timber finish etc.) on the faculty buildings.	-	Poor
Use of Court-Yard	Court-yard was considered in the design and is well landscaped with both soft and hard landscape element.	4	Very good
Use of Shading Device	Shading fins was incorporated in the design and was pronounced enough to shade the building from solar glare.	4	Very good
Green Balconies	No provision for green balconies in the design.	-	Poor
Outdoor Landscape	The outdoor was well landscaped with plants compared to the other case study, both hard and soft landscape element was incorporated and well maintained, both the pedestrian and vehicular access was well distinguished.	4	Very good

Use of sustainable power source	No provision	-	Poor
Green Roof	No provision of green roof in the design	-	Poor

Table 4.3: Case Study 3 Assessment Table
Source: Author, 2014
Weight Factor: Excellent = 5, Very Good = 4, Good = 3, Fair = 2, and Poor = 1.

4.4.5 CONCLUSION

The design of the faculty buildings incorporated sustainability principles to some extent and all the principles incorporated was actually achieved which makes the faculty to be better than the other case studies in terms of the design and implementation of the sustainable principles.

4.5 GENERAL SUMMARY

It was observed during the fieldwork that the three case studies had some element of green principle in their design but was not properly implemented. In the case of UNILAG, the principles used were better actualized than the latter.

4.6 RECOMMENDATION

For green principles to be fully implemented in such academic buildings, such complex design should incorporate the followings elements:

i. Use of material (i.e. burnt bricks, timber finish etc.)

ii. Use of court yard.

iii. Use of shading device.

iv. Green Balconies.

v. Use of sustainable power source.

vi. Well outdoor landscaping.

vii. Green roof.

If the above listed elements can be properly and practically implemented in such building, then such building will be energy efficient.

CHAPTER FIVE

SITE

5.1 SITE LOCATION

The site for the proposed college of environmental studies and is located in Kwara state university, Malete campus Ilorin. Kwara state is centrally located, lying above the hot humid lowlands of Niger trough but below the hot dry parts of the savannah to the north. Ilorin is located in the park savannah region of Nigeria between latitudes 8°31N" north of the equator and longitudes 5°00" east of the Greenwich meridian. The total area of covered is 34,467.5 square kilometers. It is bounded by Niger state, Kogi state, Ekiti state and Osun state respectively.



Fig 5.1 Kwara state in Nigeria map
Source: Google.com

5.2 SITE CHARACTERISTICS

5.2.1 Physiography

The area is characterized by gentle terrain. A visual scale is created by the green vegetation around the site and the campus.

5.2.2 Soils

The soils underlying are derived from granite. Their suitability for development land uses varies with depth, occurrence or iron pan, texture, erodability, run-off potential and drainage. Severe constraints for foundations, streets and underground utilities occur when soils are shallow, strong, locally high in swelling clays or iron pan or poorly drained.

5.2.3 Vegetation

The vegetation is characterized by bush land - shrub land mosaic dominated by acacia species and high trees. There are occasional patches of forest or heavily wooded areas. The tree stratum is less dense than that of the savannah woodland, but more substantial than that of the shrub savannah.

5.2.4 Topography

The site has an even and gentle slope with natural drainage features around it. The soil is relatively stable as other erected structures around the site have shown no significant deformation due to instability of the soil. This provides a large buildable land area for construction.

5.2.5 Climate

The climate of Ilorin is the humid tropical climate and it is characterized as the wet and dry season. In the daytime temperatures generally reach highs of around 34°C - 29°C, at night the temperature drops to 24°C -20°C.

a) Humidity: High humidity levels are attained during the rainy season. Humidity values generally drop during the dry season, from November – March.

b) Rainfall: Rainfall begins in April and rapidly tapers off after October. The rainy season lasts for an average of 185 days.

c) Wind: Two major air masses dominate Ilorin: the Tropical Maritime air mass and the Tropical Continental Air mass. The tropical maritime air mass is formed over the Atlantic ocean of the south of the country and is therefore warm and moist. It blows from south-west to north-east the tropical continental is developed over the Sahara desert and thus is warm and dry and blows from north-east to south-west. The tropical continental air mass comes with the dry season while the tropical maritime air mass, the wet season.

d) Sun and Cloud cover: There is a general increase in the total hours of sunshine further north of the Atlantic coast. The sunshine ranges from a minimum of 1300 hours in the Niger delta to over 3200 hours in the extreme north-east of the country.

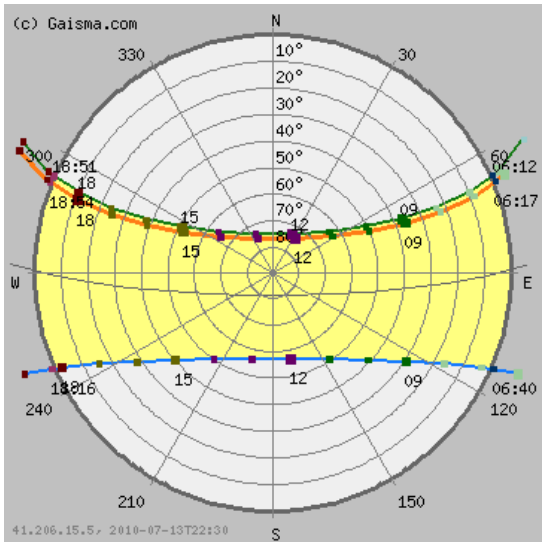


Fig 5.2: Sun Path Diagram, Ilorin
Source: (http://www.gaisma.com

TABLE 5.2 CLIMATIC DATA FOR ILORIN (1994-2003-2008)

Latitude: +8.03 (8°03'31"N)

Longitude: +5.00 (5°0'2"E)

Time zone: UTC+1 hours

Local time: 23:30:32

Country: Nigeria

Continent: Africa

Sub-region: Western Africa

Distance: ~120 km (from your IP)

Altitude: ~520 m

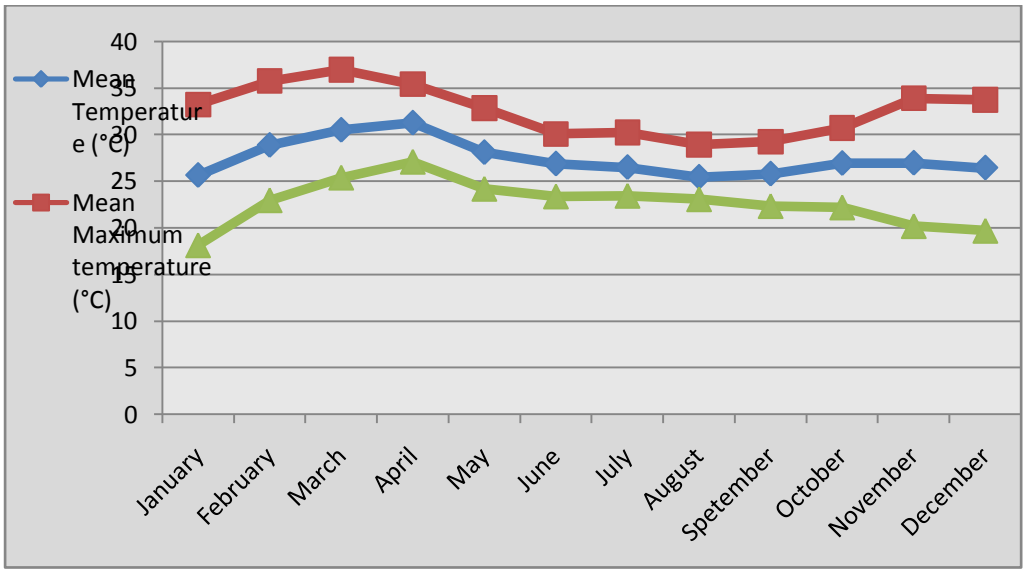


Fig. 5.3: Temperature Chart, Ilorin
Source: (http://www .gaisma.com)

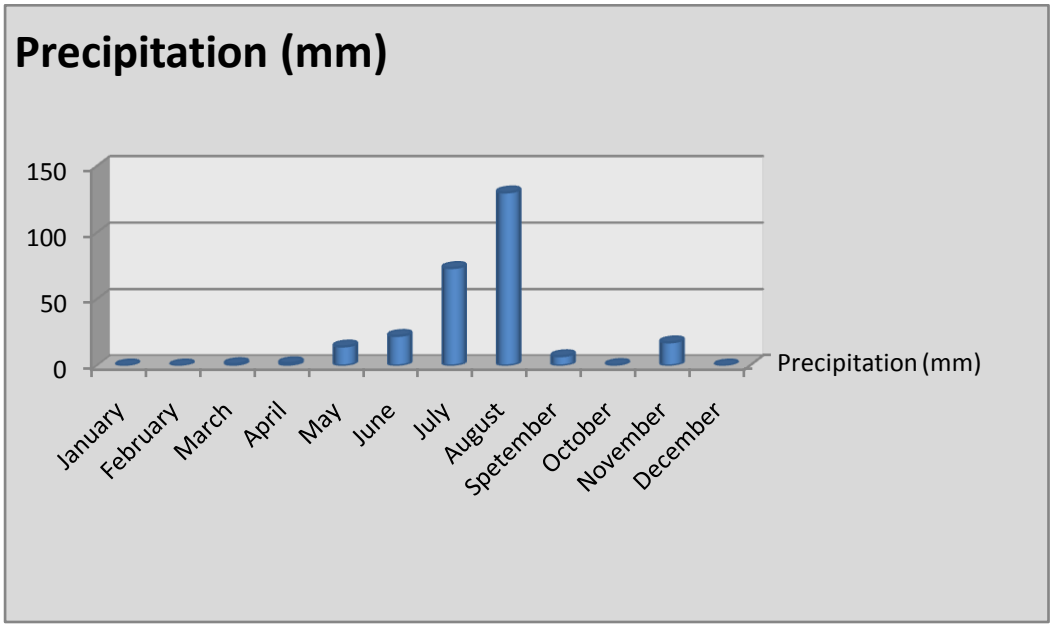


Fig. 5.4: Precipitation Chart, Ilorin
Source:(http://www.gaisma.com)

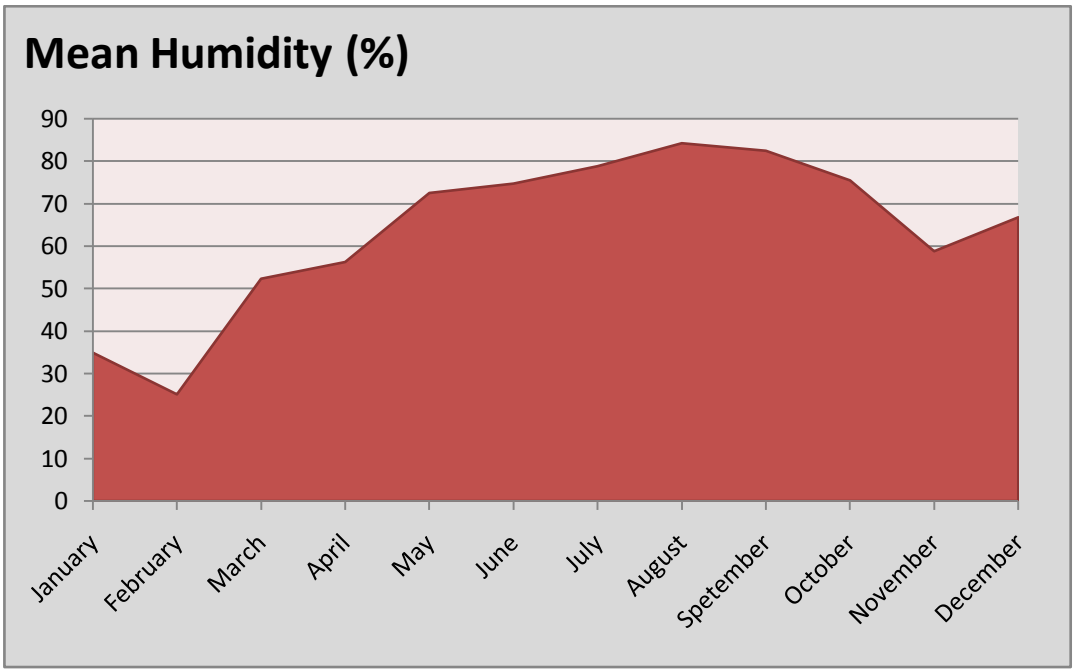


Fig. 5.5: Mean Humidity chart, Ilorin
Source: (http://www gaisma.com)

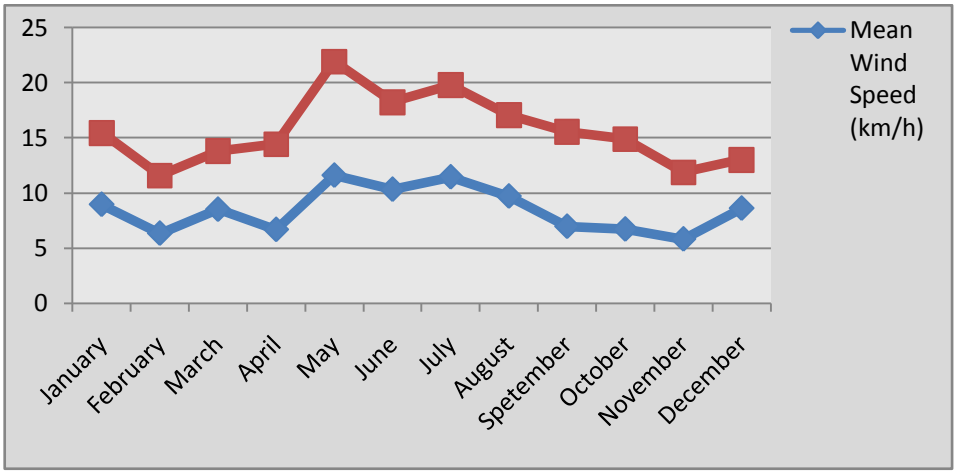


Fig. 5.6: Wind speed, Ilorin
Source: (http://www gaisma.com)

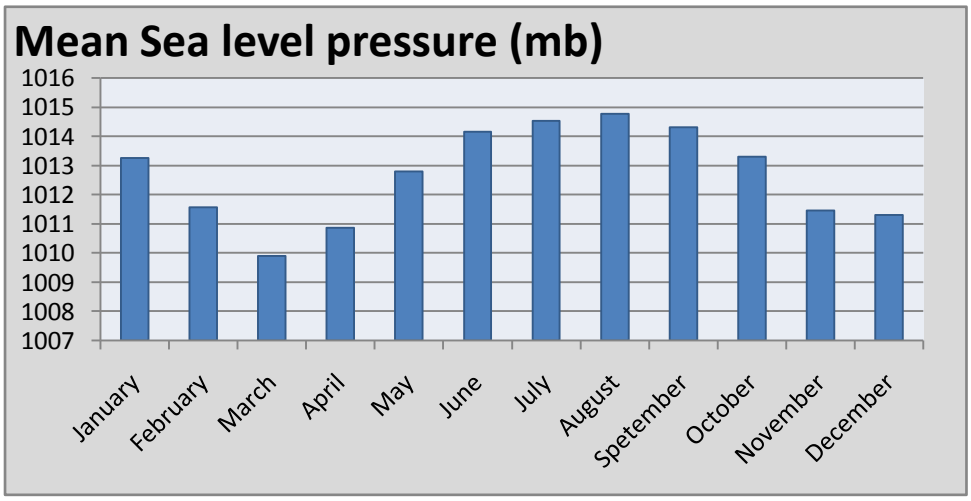


Fig. 5.7a: Mean Sea Level Pressure, Ilorin
Source: (http://www gaisma.com)

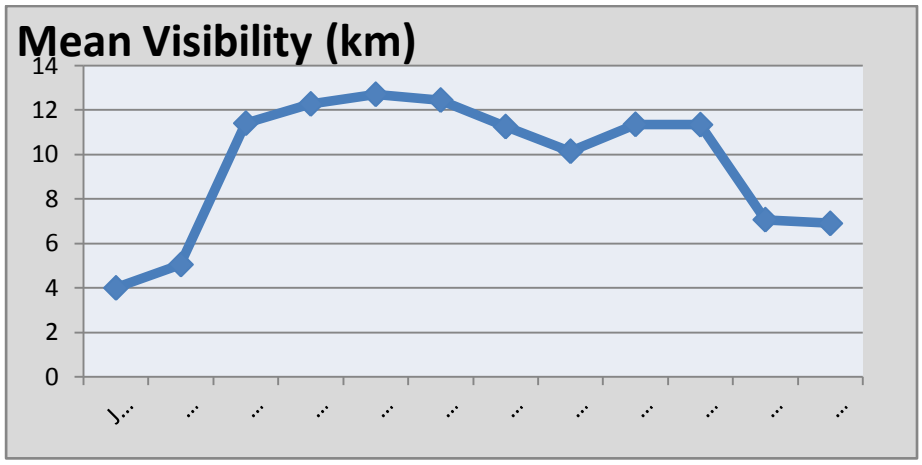


Fig. 5.7b: Mean Visibility, Ilorin
Source: (http://www gaisma.com

5.3 SITE SELECTION CRITERIA

Choosing a viable site in the campus was a bit challenging due to rapid decision from the school authority. Two sites have been selected. The first is located outside the academic core. The second site is located within the academic core. The following under listed criteria shall be used to weigh the suitability of each of the site and thus the most appropriate site shall be selected. They are:

a) Location/Accessibility

b) Proximity to Student Hostels

c) Presence of organic features

d) Size of site, Possibility for expansion, suitability and availability

e) Land use compliance

CRITERIA	SITE 1 (outside academic core)	SITE 2 (within academic core)	REMARKS
Location/Accessibility	4	4	Located along the campus main road
Proximity to Student Hostel	3	5	Site within the academic core is more accessible to students and staff
Presence of organic features	3	5	Site within the academic core has more organic features
Size of site, Possibility for expansion, suitability and availability	4	4	Site is more spacious
Land use compliance	3	5	Site within the academic core is more compliant

Total	**17**	**23**	

Table 5.1: Site selection criteria table
Source: Author, 2014
Weighing scale: Excellent 5, Very good 4, Strong3,Weak 2, Very Weak 1.



Plate XIX: Site topography, Campus
(**Source**: Author's fieldwork)



Plate XX: Existing Road to the site, Campus
(**Source:** Author's fieldwork)



Plate XXI: Site Vegetation, Campus
(**Source:** Author's fieldwork)



Plate XXII: Site Landscape, Campus

Source: Author's fieldwork, 2014

5.4 SITE ANALYSIS

5.4.1 Access: The site is readily accessible since the campus major road pass in front of the site. At the moment, both vehicular and pedestrian access is possible as shown in the site access picture above.

5.4.2 Vegetation: Densely distributed vegetation with existing trees spread on site with a grass cover. Site to be well landscaped and trees retained to reduce solar radiation and avoid soil erosion.

5.4.3 Utilities: Existing electricity, sewage, water and telecommunications network available on site.

5.4.4 Topography: Low lying strip of land with 0.5% gradient sloping towards the south-west end of the site. Earthwork to be carried out

5.4.5 Air Movement:

a) North East Trade Winds: Bringing dry humid desert winds sweeping south west across the site Trees and shrubs to be used as shield and air filter.

b) South West Trade Winds: Blowing north east across the site with rain and humid air from the Atlantic Ocean. Wind pressure to be created through small external openings and large internal openings.

c) Orientation of Buildings: Longer side of the building should face north-east direction to reduce discomfort.

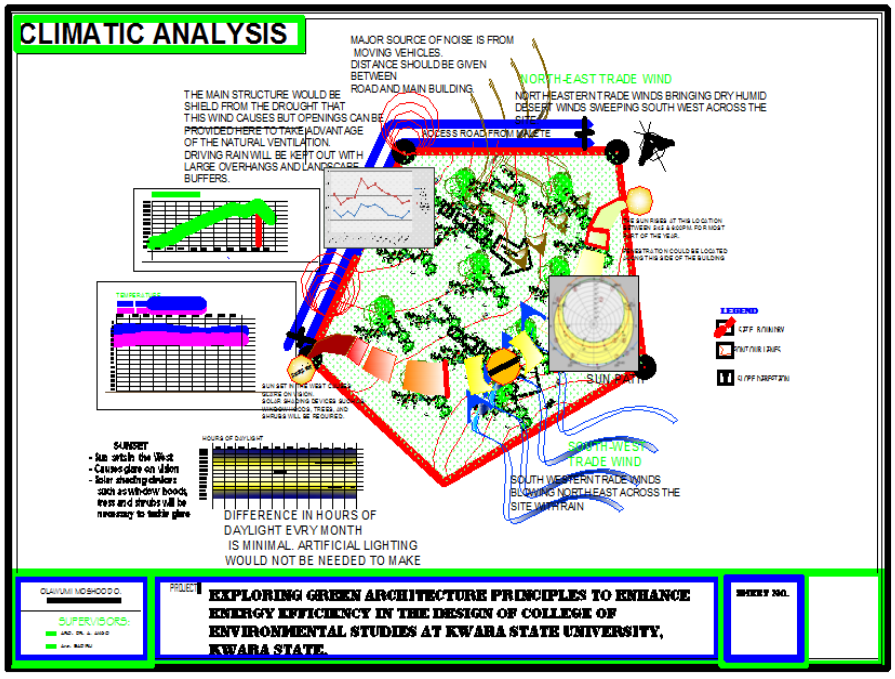


Figure 5.8 Site analysis (climatic data)
Source: Author, 2014

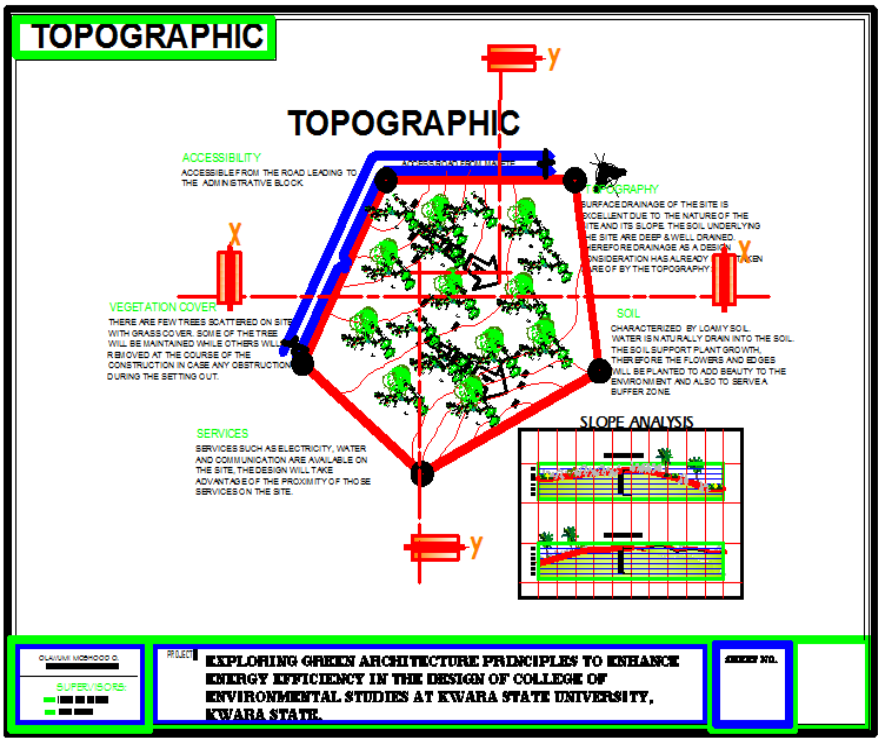


Figure 5.9 Site analysis (slope analysis)
Source: Author, 2014

CHAPTER SIX
DESIGN BRIEF

6.1 PURPOSE OF DESIGN

The proposed College of environmental studies shall be viewed as a thesis proposal for the design of a college complex building which will house facilities to cater for the Architecture, Urban and regional Planning, Building and Quantity survey.

The proposed building shall be a single unit of integrated complex functions, which is hoped to be a manifestation of the various factors to enhance better atmosphere for learning and student productivity in our ever evolving world.

A curriculum which will not only play a vital role in providing conducive environment for students, but as well as keeping up to the minimum comfort required to aid the learning process for schools of environmental studies.

The objective of the facility will be to provide a well conducive space to house the various departments within the college and yet increase productivity by enhancing social interaction within and around the college.

6.2 DESIGN BRIEF

The college of environmental complex shall be aimed at housing four departments which are seen as the bedrock of the college and are required to cater for the challenges the country of Nigeria is faced with. They are as follows

- Department of Architectural Design
- Department of Urban and regional planning
- Department of Building
- Department of Quantity survey

The college complex will provide and cater for both academic and administrative functions for both staff and students along with supporting ancillary facilities. The academic spaces shall include design studios, classrooms, library as well as research or test laboratories. The administrative spaces shall include office facilities to cater for departmental offices as well as the office of the dean. The ancillary spaces shall include parking spaces, computer rooms and business centres. Other communal spaces like common rooms, cafeteria, and lounges shall be provided accordingly.

6.3 POPULATION OF THE COLLEGE

The population of the college will be composed of both staff and students. The number ratio will follow the minimum stipulated ratio stated by the Nigerian university commission for schools of environmental studies. However, an additional percentage shall be added to the size of the student facilities to cater for unforeseen circumstances experienced in the educational aspect like fluctuating number of students admitted or taking a particular course and backlog of graduating students (spill over students).

6.3.1 STUDENT POPULATION

The proposed facility shall cater for a two-tier educational program; a four year non professional bachelor's degree in science (B.Sc) and a five year professional bachelor' s degree in science (B.Sc), followed by a two year professional master's degree in science (M.Sc).

S/N	Department	100L	200L	300L	400L	500L	M.Sc I	M.Sc II	TOTAL
1.	Architecture	50-60	50-60	50-60	50-60		40-60	40-60	280- 320
2.	U. R. P.	50-60	50-60	50-60	50-60	50-60	40-60	40-60	330- 370
3.	Building	50-60	50-60	50-60	50-60	50-60	40-60	40-60	330- 370
4.	Quantity Survey	50-60	50-60	50-60	50-60	50-60	40-60	40-60	330- 370
	TOTAL	**200-240**	**200-240**	**200-240**	**200-240**	**150-180**	**160-240**	**160-240**	**1270-1430**

Table 6.1 Projected Student Populations

A current trend has shown the admission of a greater number of post graduate students to under graduate students. This shall be catered for by providing larger facilities for the second ties students of each department.

The total departmental population shall be projected between 280 to 320 in architecture and 330 to 370 in the other departments each, while the total faculty population is projected between 1270 to 1430 students, facilities, however, shall be provided to cater for the upper projections.

6.3.2 STAFF POPULATION

The minimum bench mark stated by the Nigerian university commission for architectural education states that the staff student ratio should be 1:15.

S/NO	DEPARTMENT	RATIO	STUDENT POPULATION	STAFF POPULATION
1.	Architecture	1:15	280 - 320	18 - 21
2.	U. R. P.	1:15	330 - 370	22 - 25
3.	Building	1:15	330 - 370	22 - 25
4.	Quantity Survey	1:15	330 - 370	22- 25
	TOTAL		**1270-1430**	**84 - 96**

Table 6.2 Projected Academic Staff Population

The total projected staff population to be catered for per department shall be between 22-25 persons, making a total faculty staff population to be 84 -96 persons.

Provision will also be made separately for non academic staff and offices held by academic staff other than their lecturing positions like the head of department and the office of the dean.

6.4 GENERAL SPATIAL REQUIREMENTS OF THE COLLEGE

These shall be grouped into the academic, administrative spaces and ancillary spaces.

6.4.1 ACADEMIC SPACES

- Staff offices
- Classrooms
- Lecture theatres
- Workshops and laboratories
- Library/data rooms
- Design studio
- Meeting spaces/ Seminar rooms
- Lounges
- Presentation/ exhibition areas

a. STAFF OFFICES- these will provide for both academic and administrated functions, and for both staff and students. The spaces should also cater for interaction between staff and students at an informal and formal basis.

b. CLASSROOMS- these will be provided to cater for students engaged in lectures on their course of study. This should hold as much as 60-80 students comfortably for lectures with ample space to prevent discomfort from congestion. Waiting areas should be provided in close proximity to them. There will be a generous provision for natural lighting and ventilation.

c. LECTURE THEATRES- this will cater for not less than 200 students and should have good, unobstructed visibility and positive acoustic properties. Generous Provision should also be made for lobby spaces to serve as waiting areas.

d. WORKSHOPS AND LABORATORIES- these will be provided to cater for large number of users, both staff and students, because they are areas to expect large turnout of participants. They should be located at easily accessible points and properly zoned and buffered to prevent noise disturbance to other parts of the site. Storage space as well as attendant offices should be provided as well.

e. LIBRARY/DATA ROOMS- provision will be made for the entire College. These should also cater for a large number of users, both staff and students. Provision should also be made for storage spaces and attendants as well.

f. DESIGN STUDIO- is one of the focal point of this study. It will house the design activity. It should be done to encourage communication, competition and cooperation among its users. One shall be provided for each respective level of study for the undergraduate section to aid the acquisition of generalized knowledge. Natural lighting and ventilation should be achieved to increase comfort of usage. Consideration should be made for networking and printing rooms as well as storage spaces.

g. MEETING/SEMINAR ROOMS- one will be provided per department and will combine all functions for meetings and seminar paper presentations for reasons of space economy. It will be large enough to cater for a population consisting of all members of staff of each department.

h. LOUNGES- these will be provided for adequate lighting and to encourage social and informal interaction between both staff and students of the entire faculty. It will be planned to attract individuals from all wings of the building complex to meet and exchange ideas and knowledge.

6.4.2 ADMINISTRATIVE SPACES

- College offices
- Departmental offices
- Student offices

a. COLLEGE OFFICES- this will house the office of the dean and general faculty office space as well as their meeting rooms.

b. DEPARTMENTAL OFFICES- this will cater for the office of the head of departments as well as other heads of various sub units and are to exist separately for all respective departments. Provision will also be made for conference and seminar rooms.

c. STUDENT OFFICES- this will serve for offices held by students and will be provided for each department.

6.4.3 ANCILLARY facilities

- Parking spaces
- Business centres
- Cyber café
- Cafeteria
- Exhibition and display
- Stationary/book store
- Sit outs, terraces and lounges

6.5 SCHEDULE OF ACCOMODATION

s/no	Space	No Req.	No of Users	Area/ User	Space Area	Total Area

				(m^2)	(m^2)	(m^2)
1.	Dean	1	1	36	36	36
2.	Secretary	1	1	24	24	24
3.	Deputy dean	1	1	36	36	36
4.	Secretary	1	1	24	24	24
5.	Faculty off.	1	1	24	24	24
6.	Gen. office	1	6	9	54	54
7.	Meeting room	1	30	1.5	45	45
8.	Waiting area	1	30	1.5	45	45
9.	Storage space	2	-	-		
10.	Exhibition	1	-	-		

Table 6.3: Faculty Office/ Office Of The Dean
Source: Author, 2014

s/no	Space	No Req	No of Users	Area/ User (m^2)	Space Area (m^2)	Total Area (m^2)
1.	Office	6	1	24	24	144

2.	Office	6	1	24	24	96
3.	Lecturer-I office	6	1	18	18	72
4.	Lecturer-II office	6	1	18	18	72
5.	Snr. Tech. staff	4	1	24	24	48
6.	Jnr. Tech. staff	4	1	18	18	36
7.	Workshop/lab	2	80	4	320	640
8.	Classroom	3	80	1	80	240
9.	Library	1	120	2	240	240
10.	Design studio (Under grad.)	4	40	6	240	960
11.	Design studio (post grad.)	4	150	6	900	3600
12.	Lecture theatre	1	240	1	240	240

Table 6.4: Academic Spaces Per Department
Source: Author, 2014

s/no	Space	No Req.	No of Users	Area/ User (m^2)	Space Area (m^2)	Total Area (m^2)
1.	Head of dept.	1	1	36	36	36
2.	Secretary	1	1	24	24	24
3.	Head, under-grad.	1	1	24	24	24

4.	Head, post-grad.	1	1	24	24	24
5.	Secretary	1	1	24	24	24
6.	Exam officer	1	1	24	24	24
7.	Gen. office	1	10	9	90	90
8.	Meeting room	1	30	1.5	45	45
9.	Storage space	1	-	-	40	40

Table 6.5: Administrative Spaces Per Department
Source: Author, 2014

6.6 DESIGN PARAMETERS

After case studies were carried out, major parameters that were used in their designs were studied and the important ones incorporated in the proposed project. The parameters would now serve as the basis for the success of my own design. They are as follows-

6.6.1 DESIGN PARAMETERS

This has low embodied energy, less impact on the environment, cost and maintenance effective, may be recycled etc.

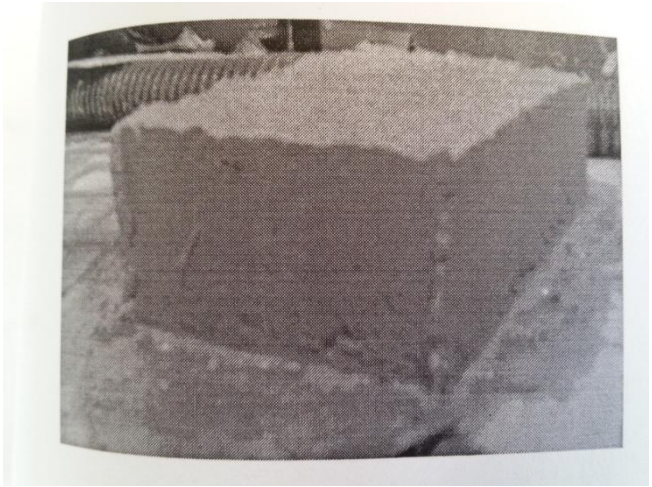


Plate XXIII: A recycled paper block (Paper Crete)

Source: http://www.meta4r.com

6.6.2 SOLAR / PHOTOVOLTAIC PANELS (PV)

The use of the material is dependent on orientation, solar intensity, size and function of the building (which will determine the surface area of panels needed to supply the required energy), and building form.

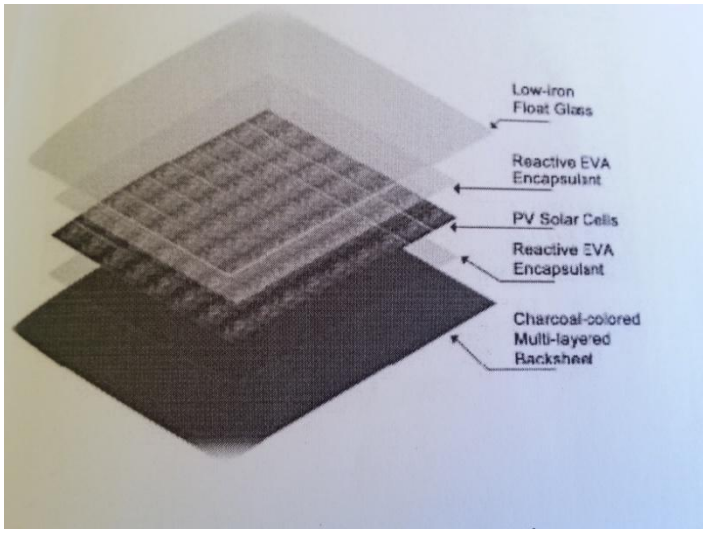


Plate XXIV: BIPV Panel Cross Section

Source: Kogi, 2007.

There are several ways in which PV was integrated into the buildings design:

i. Roofing

ii. Facade

iii. Shade screens.

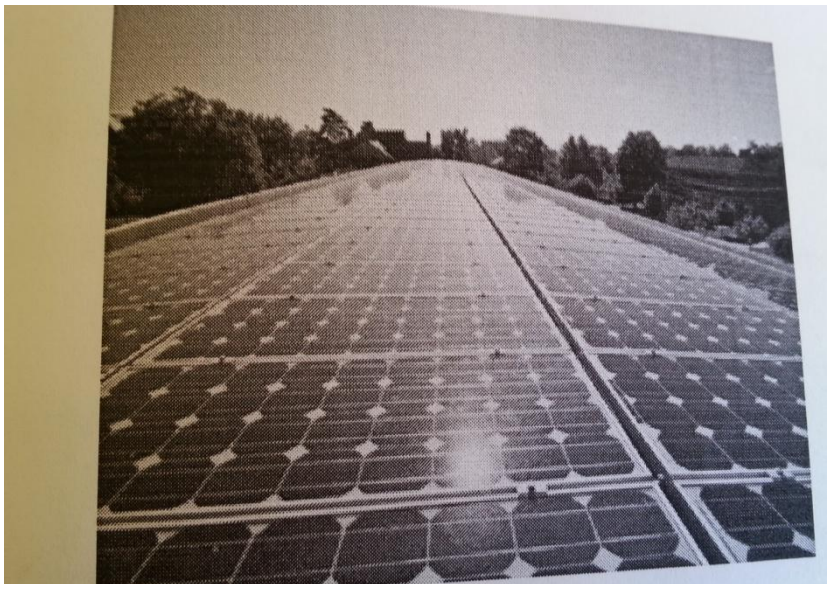


Plate XXV: PV Panel on a building's roof

Source: http://wwwgreenhabitatdesign.com, 2011

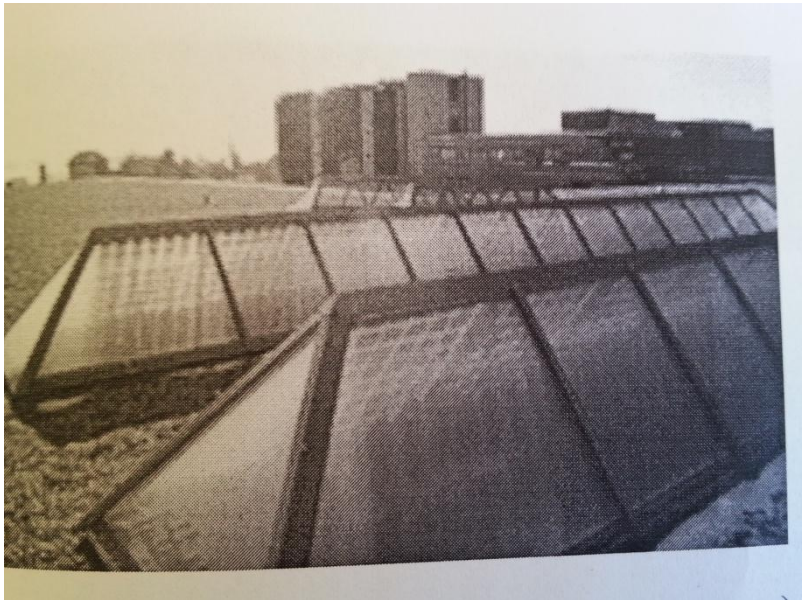


Plate XXVI: PV integrated into a skylight (Germany)

Source: Kogi, 2007



Plate XXVII: PV shade screen (Left: Finland, Right: Switzerland)

Source: Kogi, 2007

6.6.3 PASSIVE VENTILATION AND COOLING

This will depend on the existing environmental features (e.g. presence of water bodies, vegetation etc.), building form and climatic data relating to humidity, wind velocity and air temperature.

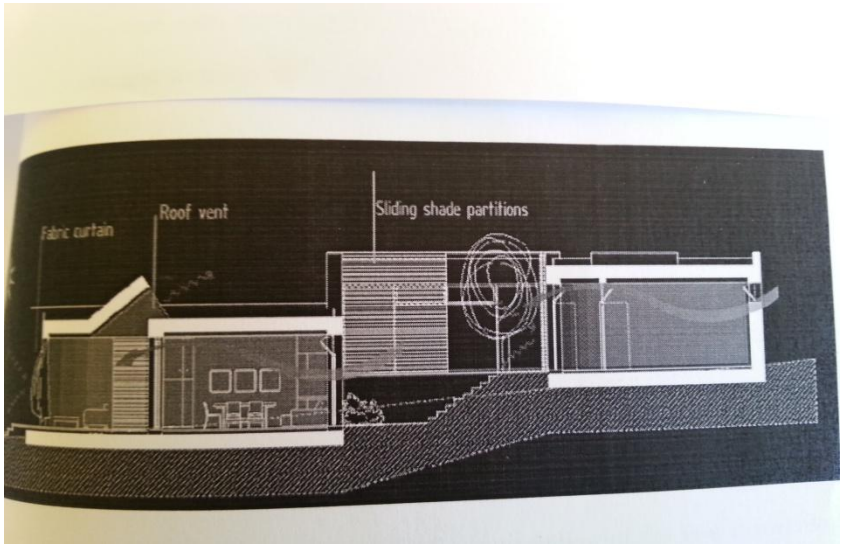


Plate XXVIII: Passive Ventilation

Source: http://www.ecohmes.gr

6.6.4 DAY LIGHTING

This will be achieved through the use of appropriate architectural forms, glazing, orientation, sun position and some climatic data.



Plate XXIX: Application of day light in a building interior

Source: http://www.structuremag.org

6.7 CONCEPT DEVELOPMENT

Different case studies were carried out checking the building forms and how they were able to respond to incorporating green architecture principles. These served as the basis for my own concept development.

6.7.1 PLAN CONCEPT

The plan concept evolved from the composition of the four department which constitute the college of environmental studies. This is to take maximum advantage of the central court-yard and the building orientation.

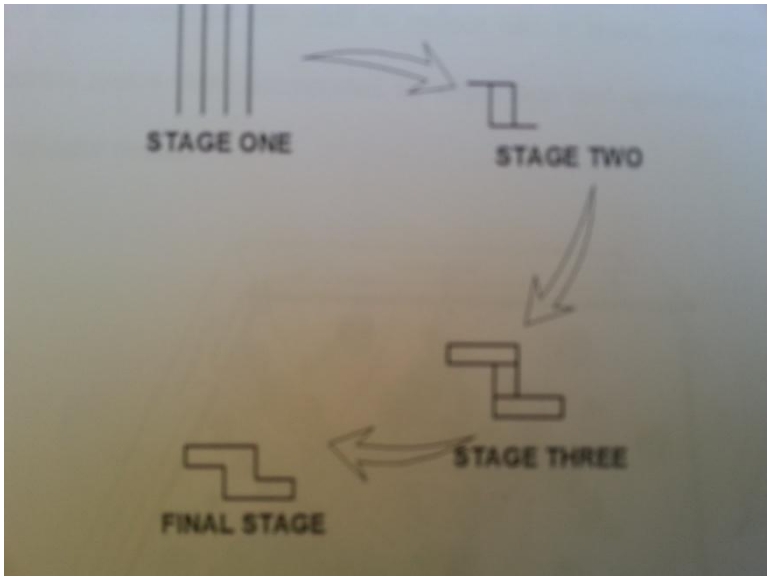


Figure 6.1 Plan concept
Source: Author, 2014

6.7.2 SITE PLANNING

The active interaction of the building base to the street level is an important aspect in formulating the program and its spatial organization. The spatial arrangement used was aimed at increasing social interaction between occupants of various spaces and increased spatial continuity as much as possible. This was achieved by the use of horizontal spreading space organization creating adjacent location of respective spaces. This has the effect of increasing the foot print of the building and reducing its height to four main floor levels. I was able to achieve this through controlled movement patterns via space allocation of functions with respect to one another.

The site is going to be pedestrian friendly with superfluous walkways and a reduction in the amount of parking for vehicles. The site has two entrances: the main entrance and the delivery entrance to the workshop. The vehicular parking bay is only meant for the staff to reduce and a broad pedestrian route. The pedestrian routes were demarcated by vegetation and sometimes bollards from the vehicular routes.

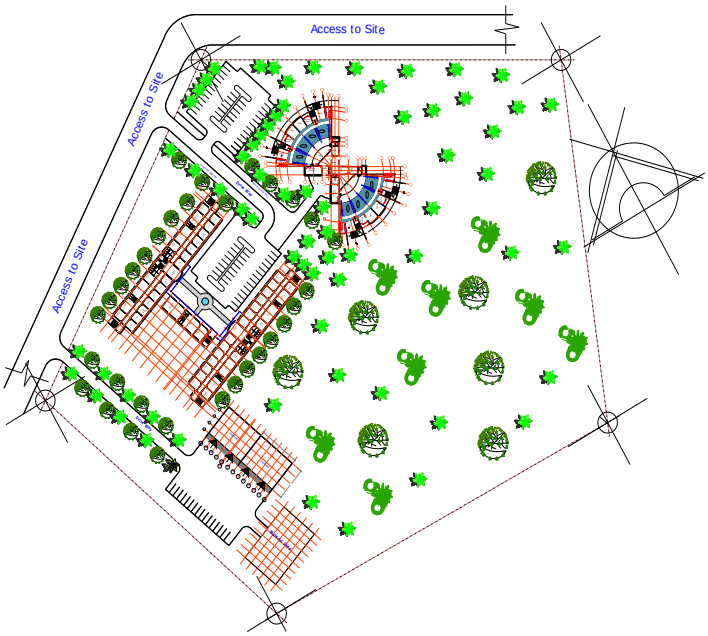


Figure 6.2 Site Plan
Source: Author, 2014

6.8 DESIGN FEATURES

6.8.1 DESIGN STRATEGIES

The environmental complex has a central court-yard which serves as a source of light and ventilation which admit day light and fresh air into the building. Larger part of the office zone has controlled ventilation through perimeter stack.

Internal heat gains draw air up into each floor. Fresh air then passes through low-level openings which bring the temperature up to the desired level. The floor-to-ceiling dimension of 3.45m assists the natural buoyancy-driven displacement strategy by ensuring warm, stale air remains above head height. Air flows relatively freely beneath the exposed concrete soffits through open castellated beams.

6.8.2 PASSIVE COOLING TECHNIQUES

The following techniques were applied in the course of the design to minimize the overdependence on active cooling system, in other words, enhancing passive cooling of the building.

i. **Site and Context**

The incorporation of vertical landscaping on the building and the use of roof garden helps in increasing the air quality and also the shading of the building from the sun. Also the design took advantage of the slope of the site, taking cognisance of the wind direction. The soft landscape elements are wholly native to the site too.

ii. **Building Orientation**

The orientation of the building took advantage of the natural forces of sun and wind. The longer facades of the building is positioned in the north-south direction and the shorter facades mostly made of toilets, auxiliary and services are placed on the east-west direction. This is to reduce the cooling demand of the building.

The wind was also harnessed for natural ventilation by the provision of openings on the north-east and south-west axis of the building. They were placed in these position so as to take advantage of the prevailing south-western and north-eastern winds for natural ventilation.

iii. **Shading**

The design of effective shading devices depends on the solar orientation of the building facades. For example, simple fixed overhangs were used at the north and the south facing windows, because of their effectiveness in the dry season when sun angles are high. However, the same horizontal device is ineffective at blocking the morning sun from the east and the low afternoon sun from entering west-facing windows during peak heat gain periods. So solar panel are used as shading devices at such facades.

iv. **Roof, ceiling and attic insulation**

- Photovoltaic panel were used on the roof of the building.

- Application of aluminium foils insulation under tile to reduce radiant heat gained by the roofing from being radiated to the ceiling.
- Ventilating the loft area above the ceiling and below the roof tiles.

  Measurements taken in this loft area have been found to go as high as 45 ^{o}C for outside air temperature of 35^{o}C for non-insulated roofs.

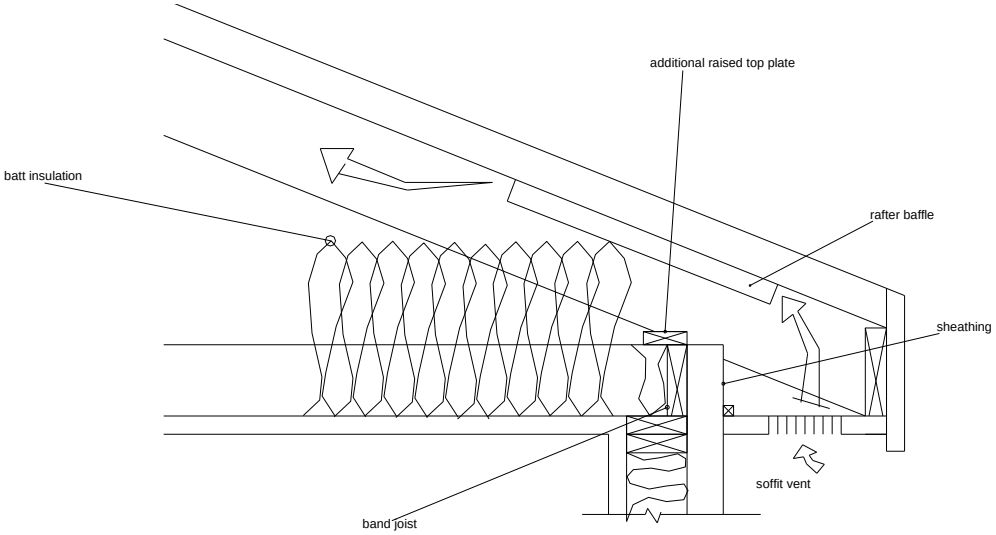


Figure 6.3: Roof section showing attic insulation
Source: Author, 2014

CHAPTER SEVEN
SUMMARY, CONCLUSION AND RECOMMENDATION

7.1 SUMMARY OF FINDINGS

The studies carried out in the course of this research shows generally that, institutional buildings in Nigeria are expensive to maintain at a conducive temperature; it require considerable cooling almost throughout the year except for some few months of the year when the weather is very cold. The effect on buildings in Nigeria is that they tend to recycle air with expensive air conditioning systems inside the building, in an attempt to maintain a comfortable internal environment. This situation makes it imperative to consider the use of environmentally sensitive strategies in the provision of an energy efficient environment for the different zones.

Based on findings, green architecture principles are not widely explored in the design of institutional buildings in Nigeria. This can be seen in the case study summary sheet in chapter 4, where it shows that only few variables are applied. However some of the international precedents have shown immense application of green architecture principles and the viable ones in the Nigerian context were adopted so as to achieve an energy efficient design.

The intent of the thesis was to examine the green architecture principles, its level of applicability in architecture with particular reference to institutional development. This situation makes it imperative to consider the use of environmentally sensitive technologies in the provision of a conducive environment.

The conclusion drawn from these findings are perhaps with an intuitive application of some of the mentioned green architecture principles in institutional building designs in Nigeria, that the college of environmental studies will become more energy efficient since it will enhance a well conducive academic environment.

7.2 CONCLUSION

In this research, several green architecture principles were reviewed and discussed with reference to their design implications and architectural interventions. The continuing increase of energy consumption suggests a more profound examination of the urban environment and the impact on buildings as well as to an extended exploration of green architecture principles. Appropriate research should aim at better understanding micro-climates around buildings, and to understand and describe comfort requirements under transient conditions during the heat period.

Studies have shown that the application of green architecture principles in buildings may reduce their energy consumption up to 50% - 60%. Generally, concern for energy consumption is only marginal in the majority of architectural design practices, even in

the developed countries. Energy efficient building design should be the first aim of any building designer, because in most cases, it is a relatively low-cost exercise that will lead to savings in the capital and running costs of the building.

7.3 ARCHITECTURAL CONTRIBUTION

The architectural contributions of this study using the basis of previous findings are:

i. The study demonstrated that, green architecture principle can reduce to greater extent (40% - 50%) the use of mechanical cooling devices in academic buildings.

ii. The study has shown that roof gradient reduces energy use, provides habitat for wildlife, increase life span of roof on site and also enhance learning process.

iii. Grid - tied photo voltaic solar array reduces dependency / spending on municipal energy.

7.4 RECOMMENDATION

This thesis can be used as starting point towards more detailed research in the development of energy efficient buildings. Further investigation into renewable technologies such as Eco and Techno - centric sustainable design principles, the comfort levels in different ventilation strategies, the impact of building materials and the opportunity to use recycled building materials into different types of buildings, without affecting the performance of the building could be pursued.

As technologies improve from day to another, there is always room for improvement, the investigation could be further extended to investigate the impact of:

i. The need for a long term commitment from the Government to promote energy efficiency in buildings.

ii. Better end - use analysis needs to be undertaken in order to know what progress is being made on improving energy efficiency of buildings.

iii. Certification needs to be implemented in parallel with effective information campaigns to explain to the wider public.

iv. The energy certification programmes should be designed to help construct and maintain end - use data base to help in the policy analysis.

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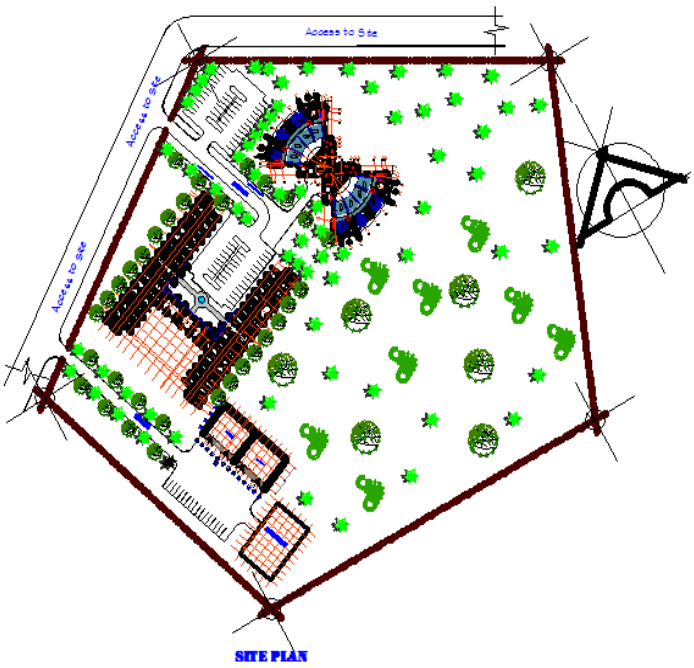
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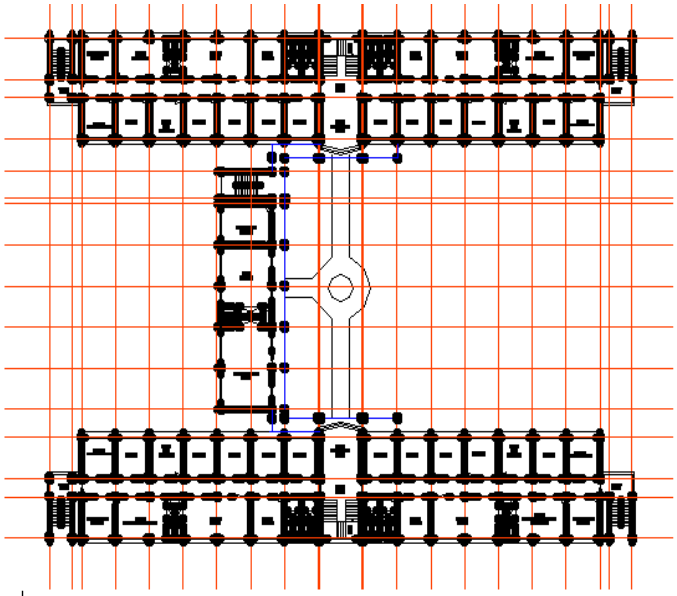
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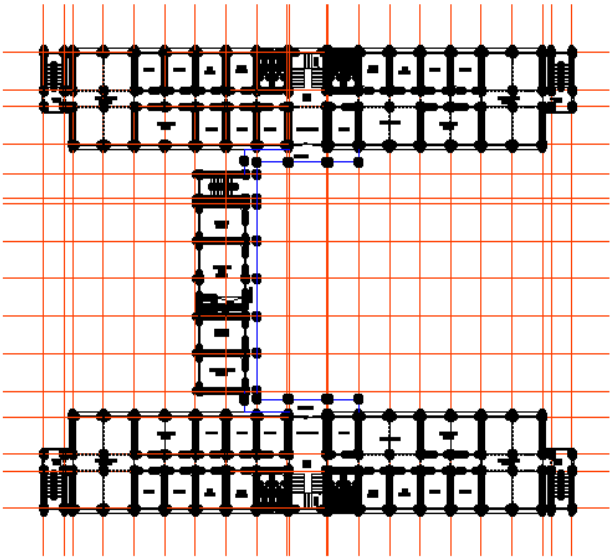
APPENDIX



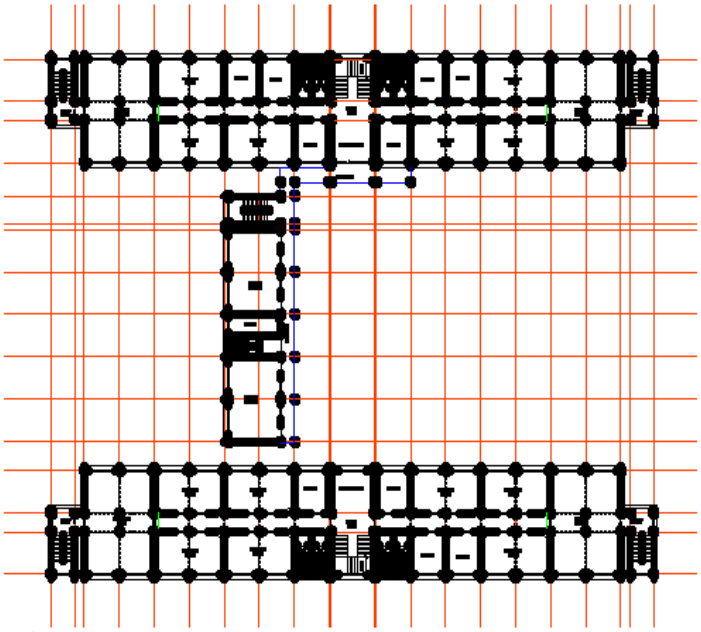
SITE PLAN



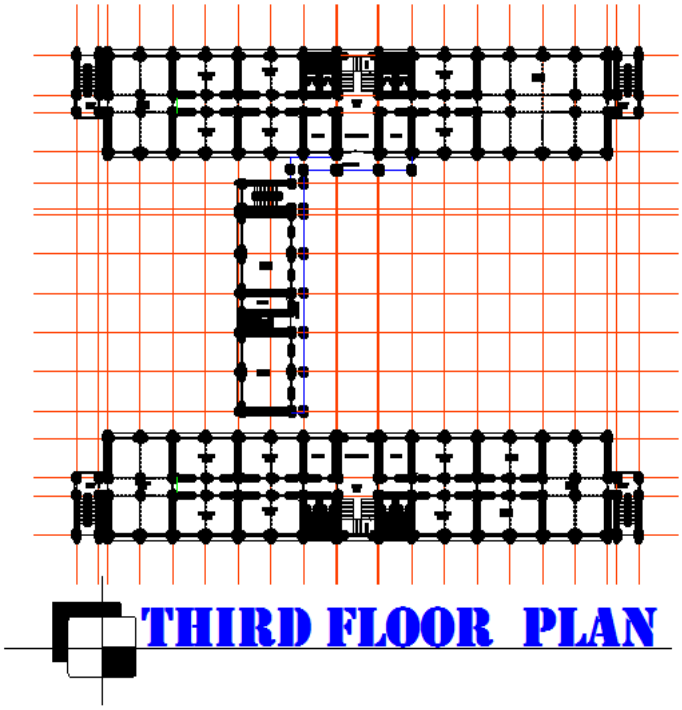
GROUND FLOOR PLAN

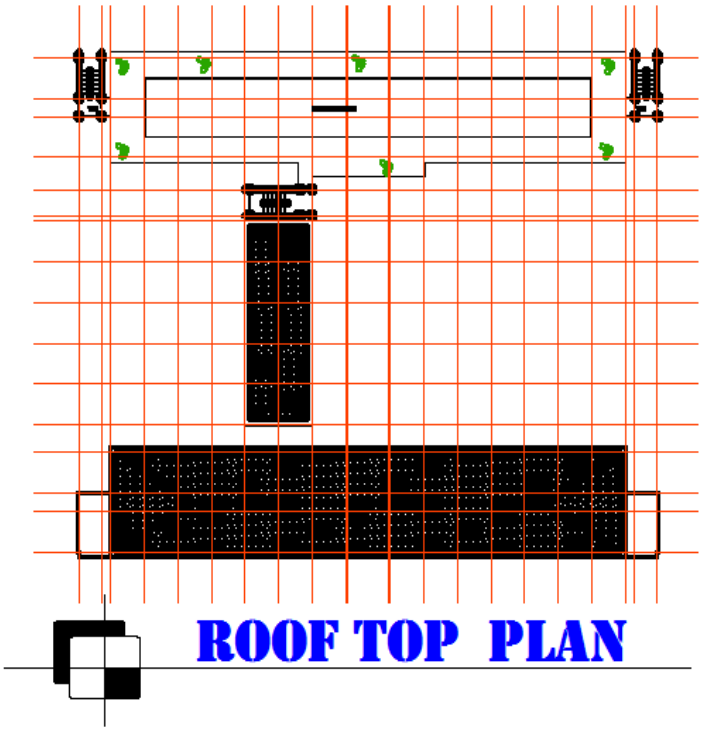


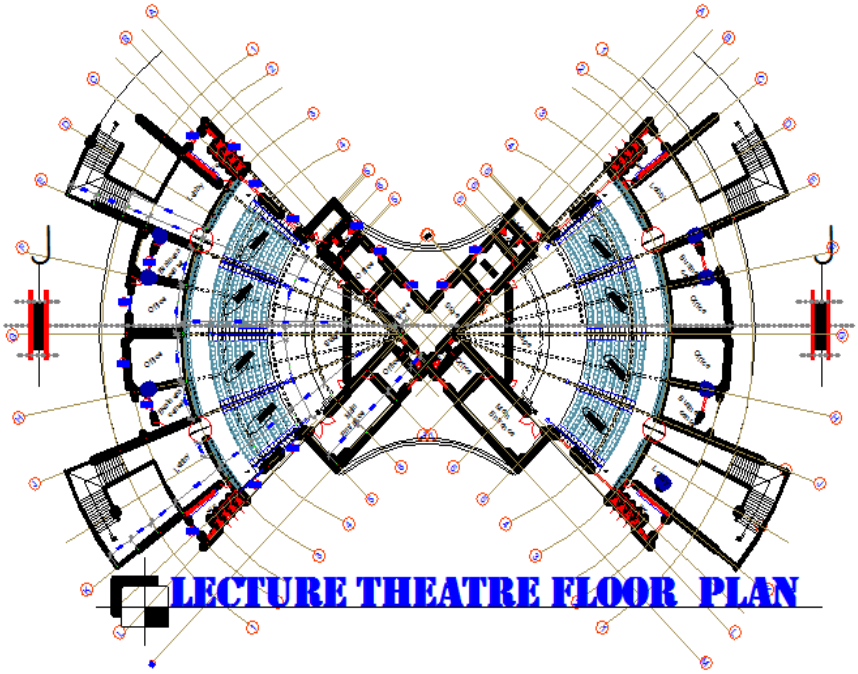
FIRST FLOOR PLAN

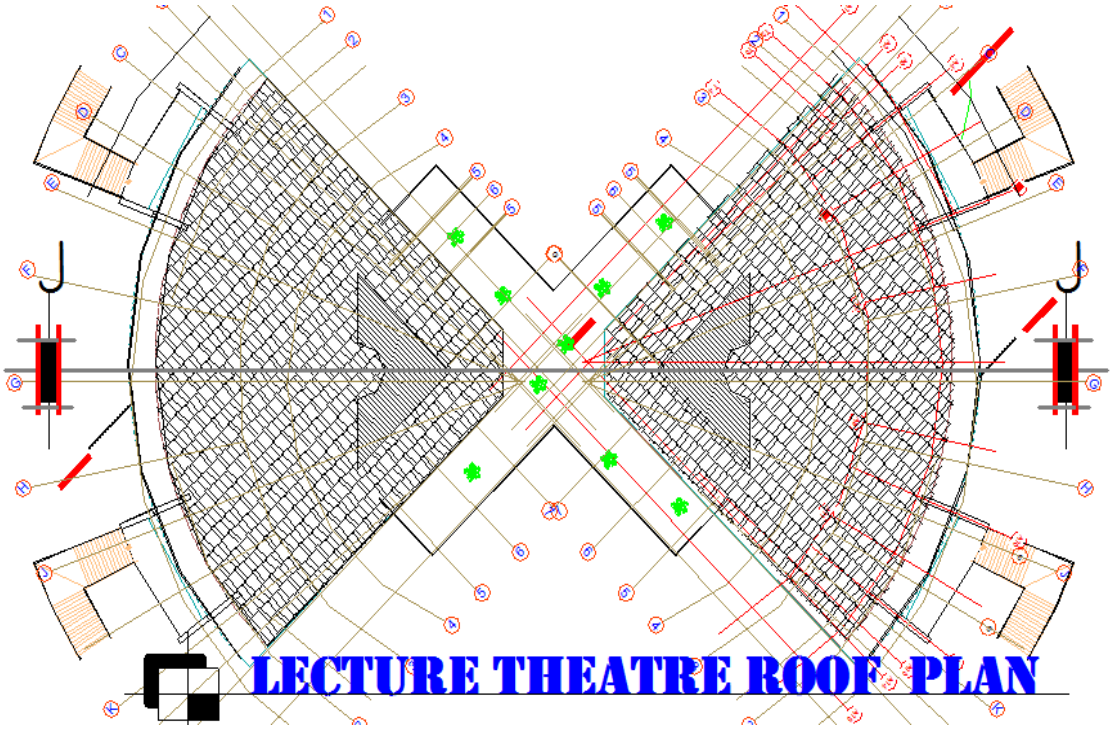


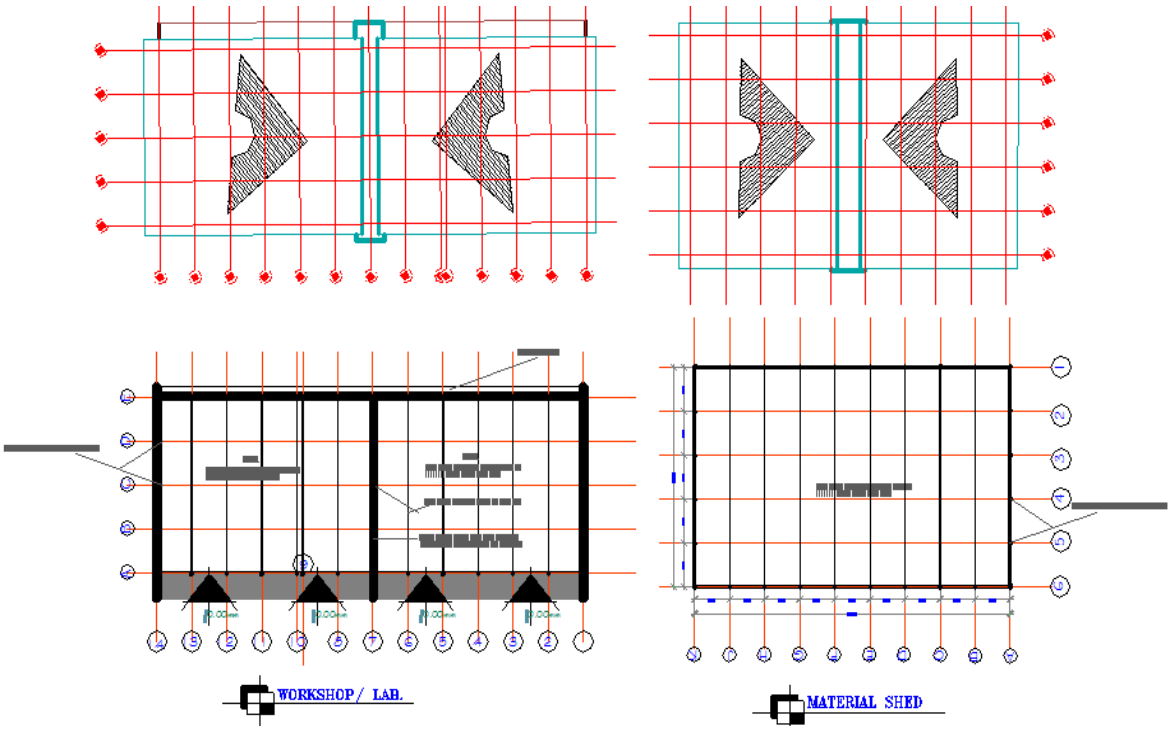
SECOND FLOOR PLAN

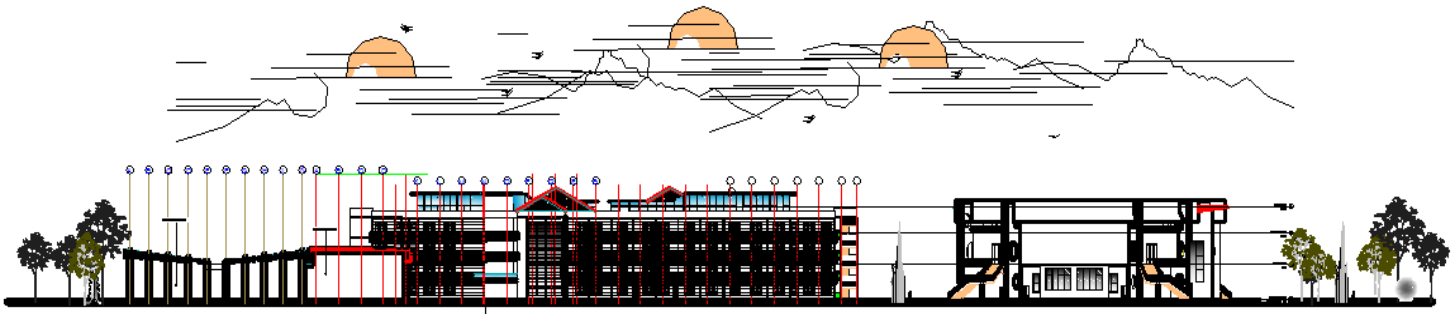

THIRD FLOOR PLAN

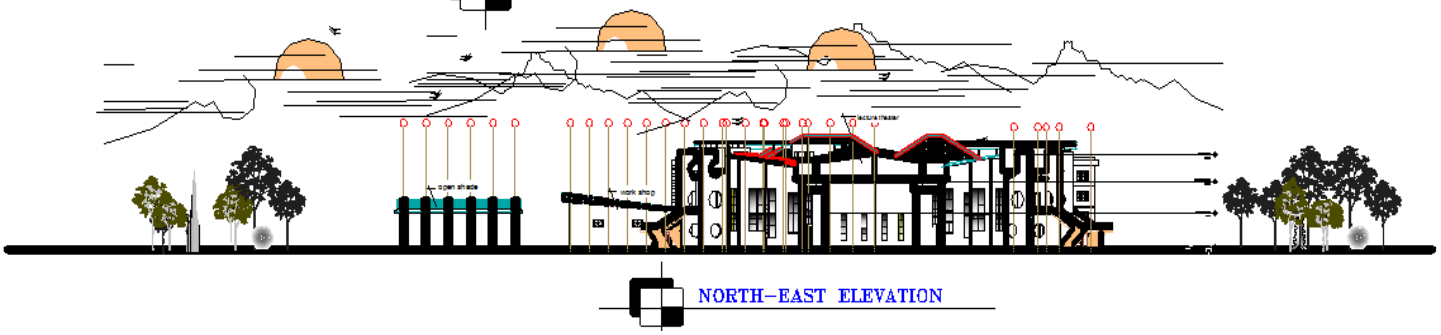

ROOF TOP PLAN

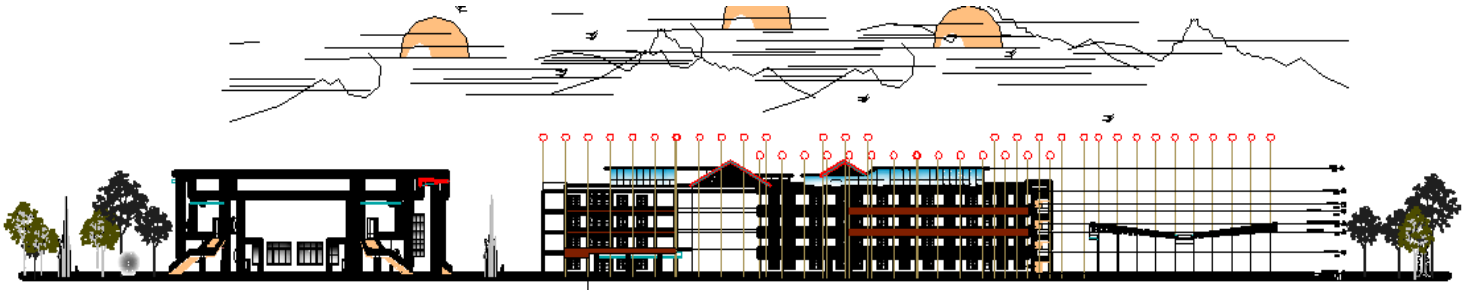

LECTURE THEATRE FLOOR PLAN


LECTURE THEATRE ROOF PLAN

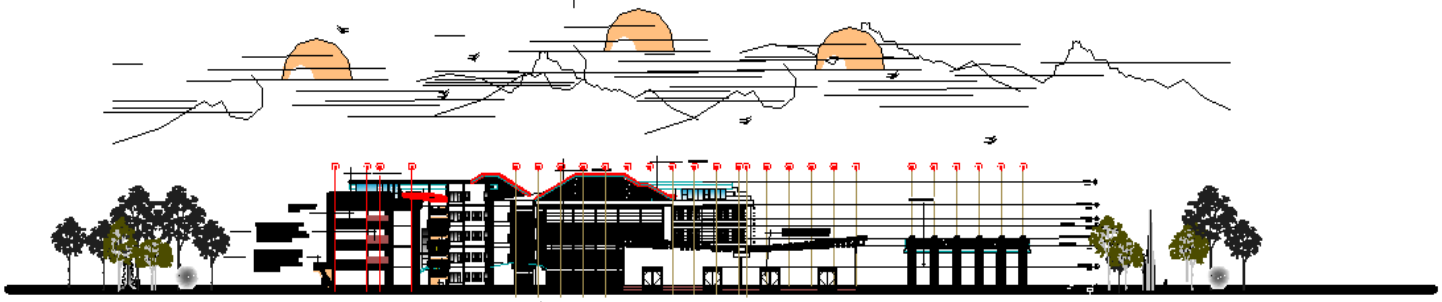

WORKSHOP / LAB.
MATERIAL SHED


SOUTH-EAST ELEVATION

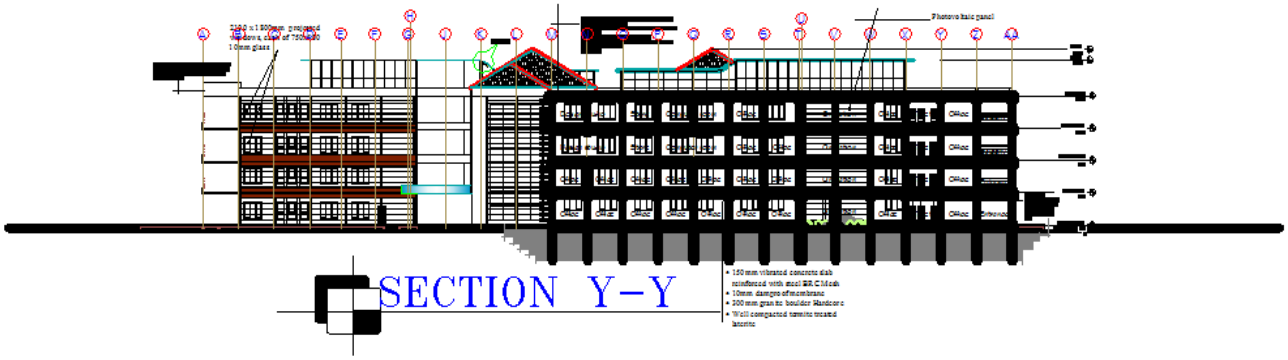

NORTH-EAST ELEVATION



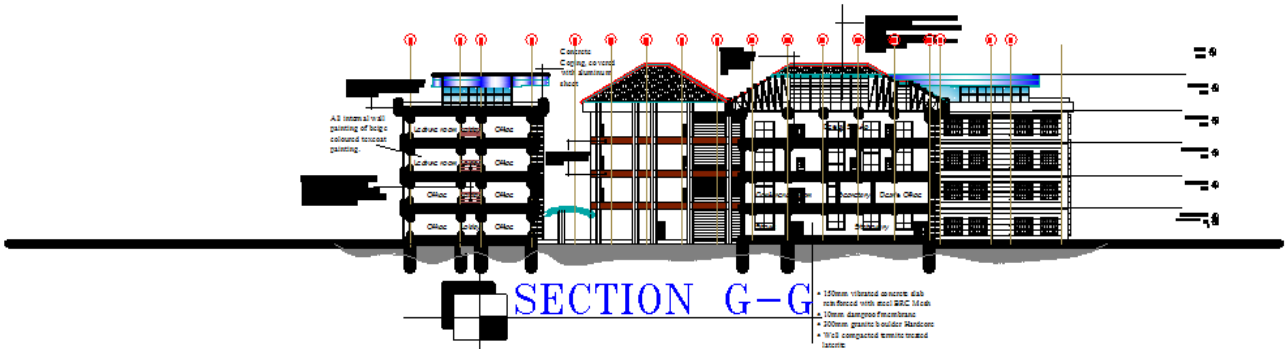
NORTH-WEST ELEVATION



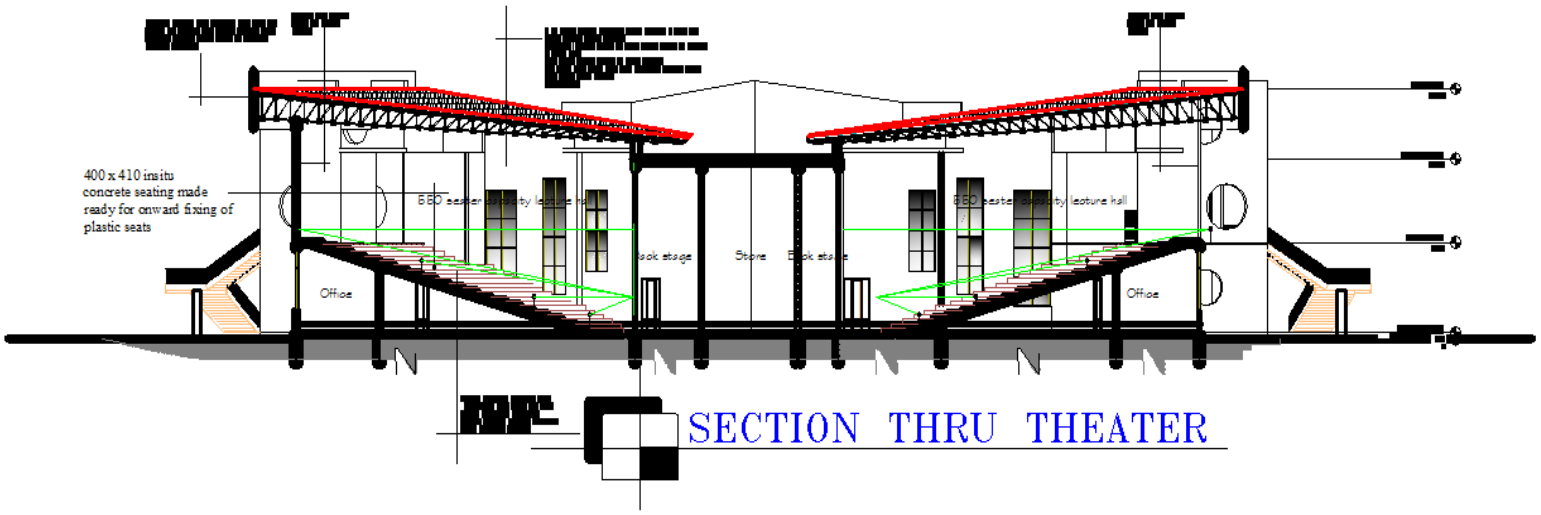
SOUTH-WEST ELEVATION



SECTION Y-Y



SECTION G-G



SECTION THRU THEATER