APPLICATION OF BIOCLIMATIC PRINCIPLES TO REDUCE ENERGY CONSUMPTION IN THE DESIGN OF SENATE BUILDING FOR NASARAWA STATE UNIVERSITY, KEFFI.

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May, 2012

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NIGERIA

May, 2012

DECLARATION

I declare that the work in this thesis entitled **'APPLICATION OF BIOCLIMATIC PRINCIPLES TO REDUCE ENERGY CONSUMPTION IN THE DESIGN OF SENATE BUILDING FOR NASARAWA STATE UNIVERSITY, KEFFI**' has been carried out by me in the Department of Architecture Ahmadu Bello University, Zaria, under the supervision of Arc E. A. O. Eneh and Arc. Y.Y. Badaru

The information derived from the literature has duly been acknowledged in the text and a list of references provided.

Salihu Musa Aduwa	……	May, 2012
Name of student	Signature	Date

CERTIFICATION

This thesis entitled 'APPLICATION OF BIOCLIMATIC PRINCIPLES TO REDUCE ENERGY CONSUMPTION IN THE DESIGN OF SENATE BUILDING FOR NASARAWA STATE UNIVERSITY, KEFFI by Salihu Musa Aduwa meets the regulations governing the award of the degree of Master of Science in Architecture of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

Arc. E.O.A.Eneh Chairman, Supervisory Committee	Date
Arc. Y.Y.Badaru Member, Supervisory Committee	Date
Arc. Mas'ud. Abdulkarim Head of Department	Date
Prof. A. A. Joshua. Dean, Postgraduate School	Date

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DEDICATION

To God! To my parent! To my wife and to my children!

ABSTRACT

In the Traditional Architecture of any settlement, one can find a very strong relationship between the forms of architecture and the local climate. The form of shelter decides the bulk of its energy consumption. The climate becomes the dominant forces in finding the solution when there is scarcity of available resources. The modern buildings' unrealistic faith in artificial systems leads to designs which disregard the climate and produce buildings that are both physiologically and psychologically in hospitable as well as more energy consuming. Therefore, the need to design with climate for comfort has become necessary for modern architecture. The study is the application of bioclimatic principles to reduce energy consumption in the design of senate building for Nasarawa State University, Keffi. The aim is to design a senate building that will achieve bioclimatic comfort in hot humid climate region with reference to Keffi, Nasarawa state where the proposed project will be sited. This is done by researching into the general principles of bioclimatic design to adopt the requisite design strategies for the attainment of human comfort. The study was conducted and data's acquired through the review of literature and physical site survey. The data are examined using descriptive analysis by means of tables and charts. The study revealed that, temperature and solar radiation are the major elements that can have negative effects on the building. The discomfort level is higher during dry season and consumes more energy for ventilation and lighting. Lasting solution are drawn to reduce these energy consumption and evident constraints and some of the necessary measures required for achieving comfortable bioclimatic performance of the building (senate building), articulated as- proper siting and orientation of the building, use of energy efficient forms and shapes, shading devices, courtyard system, microclimate, materials and construction techniques. The study concludes with the view that if the above factors are properly applied , it would help in reducing the over dependent on mechanical and electrical means for achieving comfort in the building(senate building). Therefore, the evaluation of human comfort in relation to climate of the study area has been positively achieved.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Since independence, the Federal Government has been responsible for establishment and funding of Universities in Nigeria, with few exceptions where state governments established their own State universities some of which the Federal government took over as a result of the State inability to fund them adequately. Federal government thus acquired more of these universities than it can adequately cater for financially; hence the governments call for direct and full participation of the private sector in the development of Quality Higher Education in the country (NSUK Calendar, 2008).

As a result of the above call, and in line with the provision of Decree No. 9 of 1993 National University Commission and the Federal Government of Nigeria Guideline on University, Nasarawa State proposed and established owned, run and maintained a conventional university known as Nasarawa State University and located in Keffi, the Headquarter of Keffi Local Government Area (NSUK Calendar, 2008).

The University established in 2002, inherited some structures at its starting point but at this moment Has reached mature stage in terms of staff, students and the available programmes which required full administrative activities that demand for a new building to take care of that (the Senate Building). The Senate building is the seat of administration of the University and also housing the governing council activities.

Nasarawa State, located in the North Central part of Nigeria is characterized with hot – humid climate condition which experience variation in climatic elements due to daily weather changes (Iwena, 2008), thereby imbalance and discomfort in buildings, hence Bioclimatic consideration is necessary in carrying out a comprehensive climatic analysis of the existing area in terms of buildings, taking into consideration the architectural design, building form and material selected that will control the present unfavourable climatic condition.

Bioclimatic Architecture refers to the design of a building and space (interior, exterior – outdoor) base on local climate, aimed at providing thermal comfort making use of solar energy and environmental surrounding bioclimatic elements, (Olgyay 1963). Also, Bioclimatic design utilizes the local micro-climatic condition of the site to achieve thermal comfort in the building while minimizing the use of mechanical means and energy consumption, (Amitawa 2010). In line with the above, Bioclimatic principles have to be applied in the reduction of energy consumption in the proposed Nasarawa State University, Keffi.

1.2 STATEMENT OF PROBLEM

The growing population of the world is in geometric proportion (Albert 2009) and taken its toll, on the population of Nasarawa State and its environs. This is noticeable from increase in population of people within the community and high demand on the already existing educational facilities. The Nasarawa State University is the sole provider of academic excellence, hence lead to high demand on the tertiary education programmes and increase in the intake of students and also a proportional increase in staff strength leading to full administrative set up, hence a need to have a central administrative structure to replace the ineffective, inefficient existing structure which prompt the

demand for a new one (Senate Building) that will solve the problem of management and administration.

Nasarawa State is situated in the north central part of Nigeria characterized with hot – humid climate (Iwena, 2008). This zone experiences variation of climatic elements due to daily weather changes creates imbalance and discomfort to bioclimatic situation of the state and Keffi in particular, thereby affecting the thermal condition of the building interior and exterior. However, for a Senate building to be proposed, a comprehensive Bioclimatic principles and analysis have to be ascertained and considered, to come up with the building that will reduce the adverse effects of climate and maintain the thermal equilibrium between the human body and its environment by reducing energy consumption.

1.3 RESEARCH QUESTION

i. To what extend does application of Bioclimatic principles influence the thermal comfort of the building interior in hot-humid zone (Keffi – Nasarawa State)?

ii. Does climate of hot-humid zone influence the selection and application of materials used in building construction?

iii. Does natural elements influence the micro-climate of hot-humid zone (Keffi – Nasarawa State)?

1.4 AIM OF THE STUDY

The main aim of this study is to explore the bioclimatic design strategies and principles to reduce energy consumption in the proposed Senate building to create comfort.

1.5 OBJECTIVES OF THE STUDY

The above aim can only be achieve through the following set objectives, they are:

i. To identify the adverse impact of climatic elements in buildings (office) in hot-humid zone with emphasis on Nasarawa State and suggest materials to be used in construction that will suit local climate.
ii. To analyse various Bioclimatic Principles and their individual application to achieve comfort in hot-humid zone.
iii. To identify various climatic problems based on natural elements.
iv. To propose a befitting design of Senate Building that will reduce these climatic problems and enhance performance.

1.6 MOTIVATION

The research is motivated by the desire of the Nasarawa State University authority to replace the existing inherited structure of administration with the new one (Senate Building) and the intention of finding solutions to problems arising as a result of adverse climatic conditions in buildings which create discomfort in public or office structures, within the hot-humid zone.

1.7 JUSTIFICATION

The Nasarawa State University was established since 2002 and has reached its peak in terms of number of courses or programmes, increase in staff strength faced with high level of administration and management that make it necessary to propose a new administrative building (Senate Building), that will house all the administrative activities considering Bioclimatic situation.

The authority of Nasarawa State University, Keffi has proposed to construct a befitting modern Senate Building that will be thermally balanced and energy efficient.

1.8 DELIMINATION

The research provides and analysis of applying Bioclimatic principles on office buildings in relation to human comfort in hot-humid zone of Nigeria. The scope will be limited to the Bioclimatic condition of Nasarawa State within the hot-humid zone of Nigeria and the provision of proposed modern Senate Building design for Nasarawa State University, Keffi.

1.9 ARCHITECRURAL SIGNIFICANCE OF THE STUDY

This study is of significance to the architecture of hot-humid zone climate of Nigeria, which record prevailing north-east trade wind, temperature, humidity rate and solar radiation that create discomfort to the occupants of buildings for a significance part of the year. Recommending proper materials, design and construction methods that will solve these problems and preparing design guidelines that will alleviate these problems of Bioclimatic experience. Hence a greater contribution has been made to the architecture of this zone with particular reference to Nasarawa State.

CHAPTER TWO

LITERATURE REVIEW

2.1 APPLICATION OF BIOCLIMATIC PRINCIPLES T0 REDUCE ENERGY CONSUMPTION.

Many buildings today have a common characteristic of being high energy consumer(especially electrical). Energy was used, as it was then inexpensive and available to solve the problems of heat loss, solar – heat gain, lighting and cooling (Fang et al, 2004).

Few architects and the society in general were not particularly aware of the serious implications of resources consumption, while it is reasonable to question why society as a whole was short-sighted, it must not be forgotten that building of this era represented the general social concern of their time. In doing so, they have solved many of the social and technical problems of our age, and still continue to do so. Therefore, designers developed the ability to house group of people and activities in a way which we now take for granted.

Looking at building designed before energy become available and easily distributed, as well as building from cultures, where energy, as we use it was not available. Designers of these buildings overcome many of the problems faced by the manipulation of thermal mass, shading devices, orientation wind, and sun. These devices have often been instrumental in forming the architectural vocabulary of the building to which they were applied.

In view of the above, architects should evolve a means of manipulating energy control in order that they can provide and include the concept of applying bioclimatic principles in the reduction of energy consumption in the basic equation of designing their building.

2.1.2 THE BIOCLIMATIC APPROACH

Bioclimatic approach to architecture means design with climate (Almusa'ed,2004). It can also be said that the Bioclimatic techniques have been used as early as in Roman time (Girei, 2009). There are several barriers, like economic constrains, lack of commitment and knowledge which prevent architects from incorporating energy efficiency principles to a noticeable extent into their planning and design (Wittman 1997). However, the well proven and long developed bioclimatic approach has been applied to the low – energy design of small scale residential building (Olgyay, 1963). The major player for the systematization of bioclimatic design is Victor Olgyay. He deserved a comfort chart known as "Bioclimatic Chart" involving the physical factors in a format readily useable by architects.

The focus of the bioclimatic approach is the consciousness of the importance to conserve energy and environmental resources with sensitivity to ecological and regional concept. A bioclimatic approach to architecture implied designing for a long-term and sustainable use of natural resources (June, 1998) since a driving purpose of architecture is human comfort and well-being, climate design ought to be considered by the architect (Ogunsote, 1991).

Bioclimatic approach is an attempt to create comfortable conditions for people to carry out activities in building, by understanding the specific microclimate needed (Almusa'ed, 2004). The design process should result in design strategies using bioclimatic principles that incorporate natural ventilation, day lighting, passive heating and passive cooling (Sarkar, 2010). Bioclimatic Architecture refers to the design of buildings and spaces based on local climate, aimed at providing thermal and visual comfort (Fang et al, 2004). It is also the design to take advantage of the climate and the condition of surroundings with the purpose of obtaining thermal comfort (Kiang, B & Robson, D. (2006). Therefore Bioclimatic architecture is not a style but is an approach, nevertheless, whatever

their philosophy, all architects should approach every design bioclimatically because it is the very nature of architecture to relate humans to earth and the sky.

Bioclimatic approach to be considered in design process, the designer ''reflects –in-action on the construction of the problems, the strategies of action or the model of the phenomena, which have been implicit in the moves" (Schon, 1995). Therefore, reflectivity in design should work in harmony with the bioclimatic approach which seems to have important effects especially for the cost versus performance criteria. The benefits of using non-polluting energy forms, the balancing of artificial environments with nature, and the integration of local climate as a primary building factor, have all been given too little priority in design (Jones, 1998). If the essence of the energy conscious design is equaled to monetary savings then it is necessary to promote its merit in order to enhance its attractiveness. As the world become more alert to the limits of consumerism and the limitation of the resources in our planet, the bioclimatic approach for architecture is a sensible attitude for survival. Ultimately, it is the responsibility of the architect to ensure positive direct impacts on the occupants, the community the environment and the planet (Girei, 2009).

2.1.3 BIOCLIMATIC STRATEGIES

Bioclimatic strategies refer to strategies, which have positive effect on the micro climate around the building with emphasis on the appropriate optimization of plans, sections, use patterns and orientation. (Mohammed 2006). Another aspect of bioclimatic strategies relate to the form and envelope of the building (Almusa'ed, 2004). This refers to the relationship with service core positions as well as sun and wind – related devices. Another important component is the evaluation throughout the whole process of the building design. This situation assists architects in making environmentally responsive decisions to advance building design, to create improved environments

for the occupants. It is envisaged that to further advance the potential of bioclimatic designed buildings would mean an integration of the maximum number of bioclimatic strategies and principles in design process (Zaki, 2001).

2.1.4 CONDITION OF HUMAN COMFORT

The studies of comfort review the issues of human comfort by discussing it in terms of thermal and visual comfort. This is based on the theory on how comfort takes place and the premise behind comfort standards. It also deliberates on the nature of comfort in which questions are raised on how perceptions of thermal and visual conditions overlap. This is done by reexamining the studies on comfort expectation and how it is important for bridging the gap between thermal and visual comfort.

2.1.5 THERMAL COMFORT

Air conditioning gained widespread acceptance from the 1930s to the 1960s. Research in thermal comfort increasingly focused on establishing universality applicable stands that pertained to the designer of these systems (Kwok, 2000)

Thermal comfort is defined as the condition of mind that expresses satisfaction with thermal environment (Girei, 2006). Thermal control relate to the process by which the inflow and out flow of heat is regulated to achieve a comfortable indoor temperature (Falade, 1998). However, thermal comfort is a level of human well being in response to heat or simultaneous effect of air temperature, humidity radiation and air movement (Falade, 1998).

Thermal sensation relates to conscious feeling commonly graded into categories of cold to neutral to hot. The acceptable thermal environment is therefore an environment that is at least 80% of which the occupants would find thermally acceptable.

Thermal comfort research and the design guidelines generated often relied on climate chambers studies carried out in Europe and the United State of America prior to the 1990s (Oseland & Humphrey, 1993). From there explorations, Six key variables where identified as affecting the perception of thermal comfort (Fang et al, 2004).

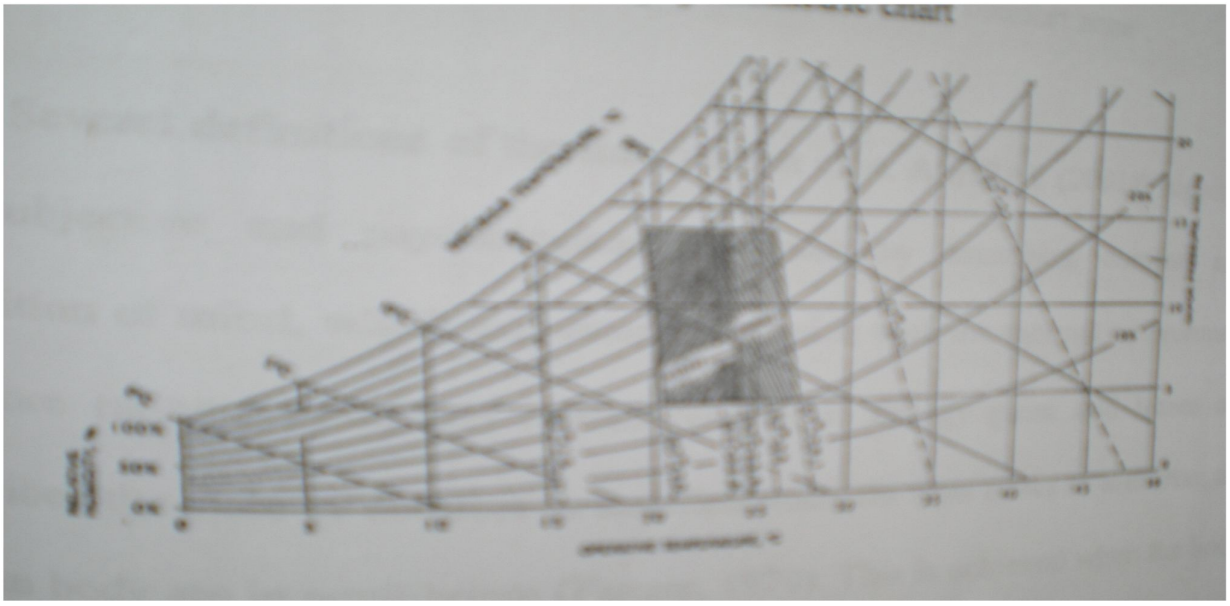


Figure 2.1 showing a typical psychometric chart

Source: Givoni (1981)

i. ENVIRONMENTAL:

Air temperature, radiation, relative humidity and air movement.

ii. OCCUPANT RELATED:

Clothing and metabolic rate. Man energy and health depends largely on the direct effects of his environment. It is observed that man's physical strength and mental activity are at their best within a given range of climate condition (Olgyay 1973). Environmental continents of light, sound, climate, space and animate act directly upon human body, which either absorbs them or tries to contract their effects. Man strives for the points at which minimum expenditure of energy is needed to adjust himself to his environment. The conditions under which he succeeds in doing so can be defined as the comfort zone" (Girei, 2009).

The objective and psychological dimension of thermal comfort was highlighted (ASHIRE, 2011). By describing comfort as a condition of mind, which express satisfaction with the thermal indoor environment. A more rational definition relates comfort to energy as satisfied when the heat flows to and from the human body are in equilibrium (Fang, 1970). This is achieved when the body data, that is skin temperature, sweat rate and or core temperature, are partly governed by the thermo-physiological regulations of a human being.

Achievement of human comfort is particularly in solar building. The manner in which solar energy is collected, stored and distributed can have a profound effect on the comfort of the occupants. In order to feel comfortable, man must maintain the temperature inside his body within narrow limit (Mohammed 2006). The metabolic process take place within the body which produces heat and the body loses the heat in order to maintain a stable internal temperature (Ango, 2010). Outside the

body, heat loss can be controlled by clothing, posture, choice of location and activities level which are individual voluntary control mechanism (Fang, 2004).

2.1.6 THERMAL COMFORT IN BUILDING

The internal temperature of the human body is constant. As the body has no means of storing heat, any heat generated by it has to be dissipated. An individual feeling of thermal comfort is optimal when the production of internal heat is equal to the thermal losses from the body (Fang et al, 2004)

The ambient environment has both a physical and emotional effect on man and is therefore of central importance in building design. One of the designer's main tasks is to create an environment inside and outside the building which is appropriate for all the human activities likely to take place there. The manner in which solar energy is collected, stored and distributed can have a profound effect on the comfort of the occupants.

The figure below shows the diagram of heat exchange between the body and its thermal environment and table of a typical metabolic heat generation for various activities

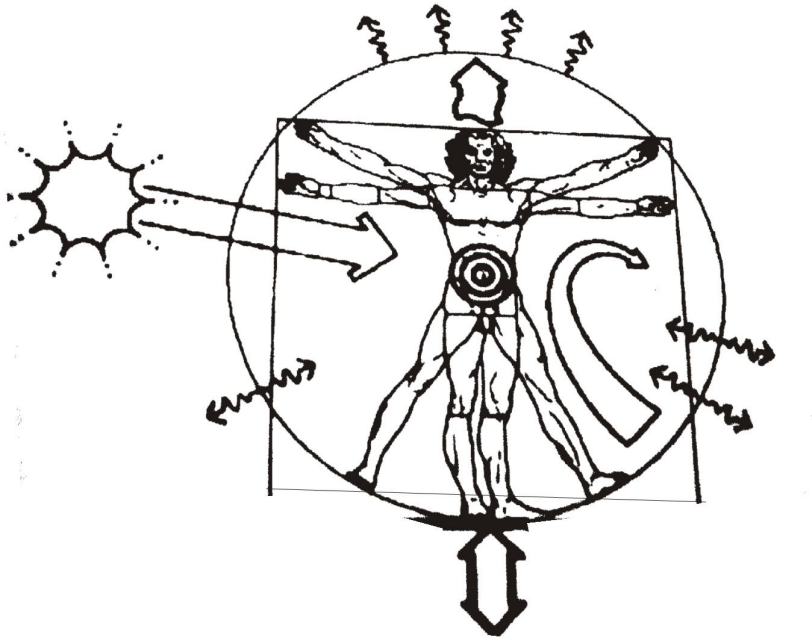


Figure 2.2 Heat exchange between the body and its thermal environment

Source: Neufert (2000)

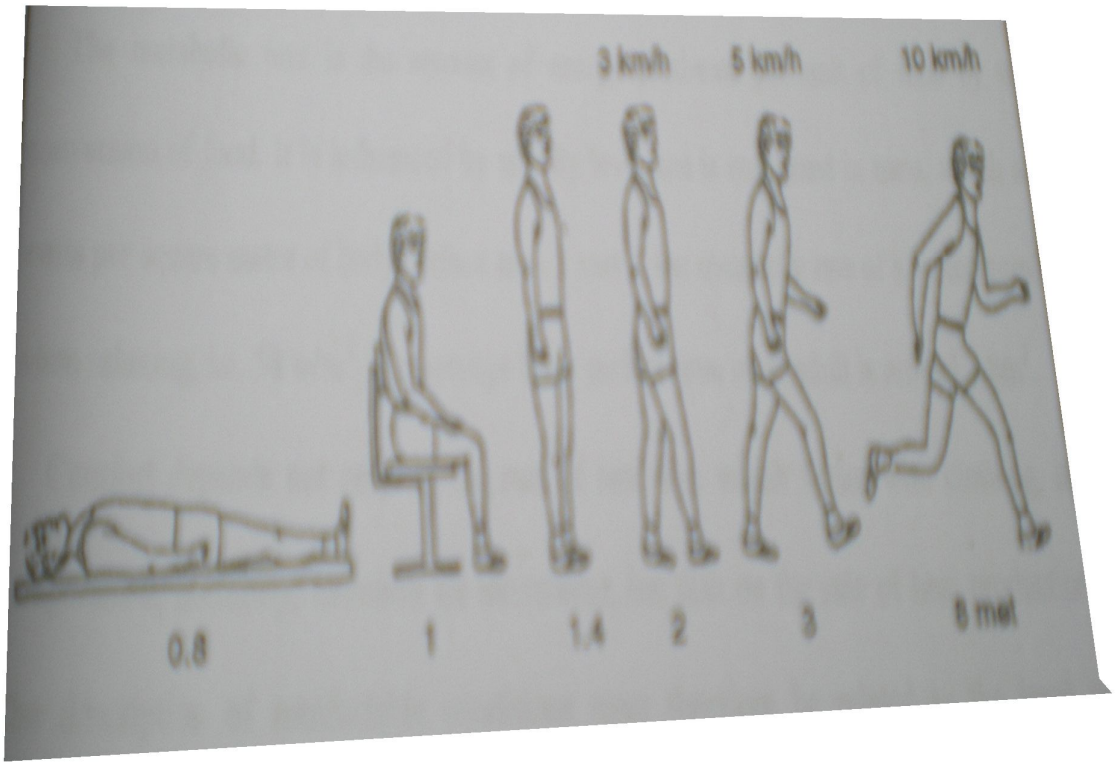


Figure 2.3 Metabolic rates of different activities

Source: John, 1993

The architect is primarily concerned with the control of the thermal environment by the physical design of buildings but the built environment forms only part of a total control system which extends from the body core to the neutral climate.

2.1.7 THERMAL COMFORT PARAMETERS

It is impossible to specify precise values for the seven comfort parameters which would give an environment suitable for everyone. The interactions between the parameters have, however, been

described by a number of thermal indices (such as the optimal operatives temperature, comfort zones, the predicted percentage of dissatisfied) which can be used to establish the conditions under which a percentage of occupants will be comfortable or dissatisfied (Girei, 2009). Comfort charts are also available to enable a quicker assessment of the comfort zones, for a predicted percentage of the population (typically 75%) to be made. These give values of certain comfort parameters as a function of the other comfort parameters. Bioclimatic charts also show the influence on thermal comfort zones of charging building related parameters (Olgyay, 1963).

The six parameters are the air temperature, the mean radiant temperature, air velocity, relative humidity, intensive clothing and the level of activities. The first four are factors of the thermal environment. Apart from these major factors, there are several others that have an effect on the sensation of comfort. These include age, sex, acclimatization, body shape and health (Ogunsote, 1991).

i. AIR TEMPERATURE:

The air temperature, that is the dry bulb temperature is a very important factor effecting thermal comfort when temperate are low, people feel cold and when they are high, people feel cold and when they are high, people feel hot. Comfort can approximately be achieved between 16^{o}C and 28^{o}C.

ii. MEAN RADIANT TEMPERATURE:

This refers to radiation to and from surfaces within an enclosure measured with the globe thermometer. The mean radiant temperature is calculated from the globe temperature using the air temperature and velocity. Comfort can be achieved if the globe temperature is between 16 and 28^{o}C

and if the difference between the mean radiant temperature and the dry bulb temperature is less than $5^{o}C$.

iii. AIR VELOCITY:

Air movement is very effective in increasing heat loss from the body at high temperature when sweating occurs. The air movement enhances the evaporation of sweat from the body thereby cooling down the body. Air velocity of up to 0.1 metre per second may lead to a feeling of stuffiness indoors. Air velocity 0.1 to 1.0 m/s are comfortable indoors when air movement is required but above this level courses discomfort. A thermometer is used to measure air movement due to low recounting. Und speeds of up to 2.0 m /s can achieve comfort especially if humidity is high and over 5.0 m /s is not comfortable.

iv. RELATIVE HUMIDITY:

When there is low humidity, the air is very dry and sweating is more effective in cooling down the body. However, when the humidity is high, the air is damp and clammy and sweating is no longer very effective in cooling down the body.

Thermal comfort can be achieved when the relative humidity is between 20 and 90%

v. INTRINSIC CLOTHING:

Clothing is measured in clo units. The thermal resistance of ordinary summer clothing is 0.5 clo while that of under winter wear is 1.0 clo; therefore the range of intrinsic clothing for thermal comfort is taken to be from 0.5 to 1.0c.

vi. ACTIVITIES LEVEL:

The activities represent the metabolic rate. The higher the activity, the more heat is or produced by the body. The metabolic rate is measure in w/m^2. (W-watt and m-metre)

The rate for a person sitting is about 58w/m2 and this is taken as the basic unit of activities known as the "met". These include sitting (1 met), sleeping (0.7 met), dancing (2.4 – 4.4 met) and heavy machine work (3.5 – 4.5 met). Therefore, comfort can be maintained with metabolic rates from about 0.7 – 2.5 met.

2.1.8 THERMAL INDICES:

The Thermal indices have been developed to describe the interactions between the six parameters above to evaluate the occupant's likely feeling of thermal comfort (Girei, 2009). It also relates to the scale that will combine the effects of all these factors and called comfort scale (Ogunsote, 1991). The indices are distributed by the following.

i. THE OPTIMAL OPERATIVE TEMPERATURE (OOT):

Is defined as the uniform temperature of a black radioactive enclosure in which the occupant exchanges the same quantity of heat through radiation and convection as he or she would in a non-uniform, real space. When the air velocity is 0.2 metre per second or less, the operative temperature can be taken to be the mean of the room temperature and the mean radiant temperature. The optimal value of the operative in the room is $27^{o}c$.

ii. COMFORT ZONES:

The human body involuntarily regulates its production of internal heat to the thermal conditions of the environment, eventually creating a situation where the metabolic generation of heat is offset by the heat losses so that the individual experiences only small variations in the feeling of thermal comfort and there by feels at ease.

i. THE PREDICTED MEAN VOTE (PMV):

Is a thermal sensation scale. The mean opinion of a large group of individuals expressing a vote on their thermal feeling under different thermal theoral circumstances has been used to provide an index to thermal comfort. A PMV value of zero provides the optimal thermal comfort condition. A positive PMV value means that is lower. The comfort zone is generally regarded as stretching from a slight feeling of cold (termed “fresh”, when the PMV is – I) to a slight feeling of warmth (termed “mild”, when the PMV is + I) (Girei, 2009).

ii. THE PREDICTED PERCENTAGE OF DISSATISFIED (PPD)

Is an indication of the percentage of people susceptible to feeling too warm or too cold in a given thermal environment. It can be deduced from the PMV, if, for instance, the PMV is in the range of -1 to +2, then the PPD index shows that 25% of the population will be dissatisfied. To reduce this figure to 10%, then the PMV has to be in the range of -0.5 to +0.5 (Girei, 2009).

2.1.9 BIOCLIMATIC CHART

Bioclimatic charts have been prepared by (Ginovi, 1990). That makes it possible to determine the effect on thermal comfort of charging building related parameters such as thermal inertia and ventilation rate. They show that by charging these parameters, the comfort zone can be extended a considerable amount even when the external climate conditions are unfavourable. Thus showing that, by applying the concepts of climate sensitive architecture the effects of climatic variation on the interior environment can be minimized to the extent that they become negligible.

2.1.10 BIOCLIMATIC DESIGN PRINCIPLES

The bioclimatic design approach in architecture utilizes the local micro-climate conditions of the site to achieve thermal comfort in the building while the use of mechanical means and energy consumption (Sarkar, 2010). The study is to explore the bioclimatic design strategies above to achieve energy efficiency in building design creating comfortable indoor living condition. The Bioclimatic chart explains above together with the climatic analysis for analyzing climate parameters are used together with the principles below to achieve comfort (Amjad, 2011). Into account of local climate and the following principles:

Heat protection of the building in winter as well as in summer, using appropriate techniques which are applied to the external envelope of the building, especially by adequate insulation and air tightness of the building and its opening.

Bioclimatic design takes Use of solar energy for heating building in the winter season and for day lighting all year round. This is achieved by the appropriate orientation of buildings, especially their openings (preferably towards the south), by the layout of interior spaces according to their heating

requirements, and by passive solar systems which collect solar radiation and act as “Natural heating as well as lighting systems.

i. Protection of the building from the summer sun, primarily by shading but also by the appropriate treatment of the building envelope (that is use of reflective colours and surfaces).
ii. Removal of the heat which accumulates in summer in building to the surrounding environment and by natural means (passive cooling systems and techniques), such as natural ventilation, mostly during night time.
iii. Improvement – Adjustment of environmental conditions in the interiors of buildings so that their inhabitants find them comfortable and pleasant (that is increasing the air movement inside spaces, heat storage, or cool storage in walls).
iv. Insuring Insulation combined with solar control for day lighting of buildings, in order to provide sufficient and evenly disturbed light in interior spaces.
v. Improving of the microclimate around buildings, through the bioclimatic design of exterior spaces in general, of the built environment, adhering to all of the above principles.

2.1.1 PASSIVE SOLAR SYSTEMS:

Passive solar systems are the integration parts – elements of the building which function without mechanical parts or additional energy supply and are used for heating as well as cooling naturally. The passive solar systems are divided into three categories: (Amjad, 2011). They are Passive solar heating system, passive (natural) cooling and systems and techniques for natural lighting.

The bioclimatic design of a building requires the simultaneous and coordinated operation of all the systems so that thermal and visual benefit can be combined throughout the year in terms of natural cooling and lighting.

i NATURAL COOLING:

Strictly defined, the term “passive cooling” applies only to those processes of heat dissipation that will occur naturally, that is without the mediation of mechanical components or energy inputs (Girei, 2009). The definition encompasses situations where the coupling of spaces and building elements to ambient heat sink (air, sky, earth and water) by means of natural modes of heat transfer leads to an appreciable cooling effect indoors. However, before taking measures to dissipate unwanted heat, it is prudent to consider how the unwanted heat can be minimized in the first place. In this context, natural cooling may be considered in a wider sense than to hold on the above definition, including preventive measures for cooling loads as well as the possibility of mechanically assisted (hybrid) heat transfer to enhance the natural process of passive cooling.

A useful design strategy for overheating is to first control the amount of heat from solar radiation and heat air reaching the building, then to minimize the effect of unwanted solar heat within the building skin or at opening, next to reduce internal or casual heat gains from appliances and occupants and finally, where necessary, to use environmental heat sinks to absorb any remaining unwanted heat. In practice, a combination of these cooling techniques is almost invariably in operation.

Fixed or adjustable shading devices or shading provided by vegetation and special glazing may be used to reduce the amount of solar radiation reaching the building.

External heat gain due to solar radiation can be minimized by insulation, reduced window sizes, thermal inertia in the building envelop, reflective materials and compact building layout.

i. Infiltration gains can be reduced by cooling the incoming air and by reducing its infiltration to a minimum necessary for comfort and health.

ii. Ventilation using cooled fresh air driven through the building by naturally occurring differences in wind or air pressure can help to reduce internal temperature.

Several methods of natural cooling, including increase in air speeds to maximize perceived level of cooling, ground and evaporation cooling to reduce the temperature of ventilation air and night – time cooling of the building by radiating heat loss to the sky and enhanced ventilation can help to maintain comfortable indoor conditions.

ii. DAY LIGHTING:

The optimal use of natural day light, especially in building used mainly by day, can by replacing artificial light, make a significant contribution to energy efficiency, visual comfort and the well – being of occupants. Such a strategy should take account of the potential for heat gain and conservation, energy savings by replacing artificial light and the more subjective benefits of natural light and external views enjoyed by the occupants (Amjad, 2011).

System has a range of elements, most of which must be incorporated into the building at an early stage in its design. Good day lighting can be achieve by consideration of the following in relation to the incidence of daylight of the building.

i. The orientation, space organization, function and geometry of the spaces to be lit
ii. The location, form and dimensions of the opening through which daylight will pass.
iii. The location and surface properties of internal partitions which will reflect the daylight and play a part in its distribution.
iv. The location, form and dimensions of movable or permanent devices which provide protection from light and glare.
v. The optical and thermal characteristics of the glazing materials excessive.

]

Good daylight design will not only reduce energy cost and consumption related to artificial lighting but will also diminish the need for mechanical devices to cool rooms overheated by low efficiency electric lighting appliance (Neufert, 2000).

Achievement of comfortable building conditions in a space depends on the amount, distribution and quality of the light. Enough luminance indicated by a sufficiently high daylight factor, should be provided to allow relevant objects to be seen easily, without fatigue (Girei, 2009).

The light distribution in the space should be such that excessive differences in relative illumination which could give the impression of inadequate lighting are avoided. Sufficient contrast should however, be retained for the relief of each object to be brought out. Window openings and artificial light sources should be placed in such a way that glare is minimized (Neufert, 2000). Therefore, particular care should be taken over the quality of the light to be provided. Both the spectral composition and light should be appropriate for the task to be performed (Nicholls, 1994).

Illuminance: Although the human eye is extremely adaptable, it can nevertheless only perform visual functions within a small range of illuminance levels. Illuminance relate to the bright colourful lights used to decorate or define the building interior for a special purpose (Hornby, 2000). For a particular task, the range is affected by the visual performance required, the light distribution in room and the luminance of the walls and other surfaces (Neufert, 2000). Recommended optional illuminance values for the work place for different types of task are given in the building energy code published by the UK Chartered Institute of Building Services Engineers (C.I.B.S.F).

iii. CONTRAST:

Contrast is the difference between the visual appearance of an object and that of its immediate background. It can be expressed in terms of luminance, iluminance or reflectance between surfaces. The amount and the distribution of the light in a room is very dependent on the reflectivity of the walls and other surfaces. Surface finishes should therefore, be chosen with regard to their reflectance (the ratio of overall reflected radiant energy to incident energy). In general, to achieve good luminance distribution, light colours, should be used for large surfaces (Clark 2001).

iv. **GLARE**:

Glare is caused by the introduction of intense light sources into the visual field (Girei, 2009). It is also caused by direct and indirect reflection from surfaces and by unfavourable luminance contrast (Neufert, 2000). It can be mildly distracting or visually for the occupant whatever its level it always produces a feeling of discomfort and fatigue. Direct glare occurs when a light source with a high luminance enters directly into one's field of view. It can be experienced with interior lighting or when the sun or clear sky is seen through window's surface. Indirect glare occurs when the luminance of wall is too high. Reflected glare is caused by specula reflection from polished interior surfaces. Glare can be controlled by careful design and choosing light sources and background of suitable luminance (Neufert, 200).

v. **LIGHT CONTROL**:

Penetration of solar radiation into buildings contribute much to the quality of the lighting there, so long as the sun's rays do not reach the occupant's eyes directly or by specula reflection. The penetration of natural light can be controlled by reducing the incident flow, the amount of direct or diffuse sunlight is important to comfort because it reduces glare. It can be achieved either by incorporation of permanent or moveable exterior devices into the building design or to reduce the view of the sky or by using moveable interior screens to reduce the luminance of the window

interior surfaces. Glare can be controlled by careful design and choosing light sources and background of suitable luminance (Neufert, 200).

vi. **HEALTH EFFECTS**:

Besides being needed for visual perception, light also regulates metabolic processes in the human body, and affects the immune system and psychological and emotional states. Daylight is involved in setting the "biological clues" and its associated rhythms. A lack of light (particularly in winter at high Latitude) can lead to seasonal affective disorder (SAD) with symptoms of lethargy and depression. This effect could be enhanced in the occupants of deep-plan buildings where artificial light levels are insufficient to trigger physiological responses.

Daylight also provides clues for spatial and time orientation which, when removed, leads to psychological discomfort and loss of productivity. Humans evolved in an environment of purely natural daylight and it seen likely that it has other, hither to unknown effects on the human mind and body.

2.1.11 BIOCLIMATIC REGIONAL EVALUATION (HOT-DRY CLIMATE)

The application of bioclimatic principles in the reduction of energy consumption focus on human comfort as it relates to the climate of man's immediate environment. This research will focus on the hot dry climate (Nasarawa State) as the region to which the research will lay it emphasis.

A hot-dry climate is defined as a region that receive more than 500mm of annual precipitation and either has 3,000 or more hours of 67 degree 7 temperature or 1,500 or more hour 73 day 7 temperature during the warmest six months of the year (Building Science Corporation 1999) In this type of climate, the main function of the building is to moderate the daytime heating effects of the

external air (Givoni, 1969). In order words, it is important to design buildings whose structure and interior are best able to keep warm air out. Living in a hot climate can quickly become uncomfortable for its inhabitants with extreme heat that is built up by mid-day. That is why it is important for the building's structure to have effective ventilation and an internal temperature below the outdoor level (Givoni, 1969). The ventilation keeps air moving through the environment and therefore keeps the inhabitants cooler.

SUMMARY

Design with bioclimatic principles to achieve comfort in buildings are accomplished not by mechanical equipment, but mostly by the design of the building itself. The design decisions that affect heating, cooling and ventilation as environmental controls have, for the most part, a strong effect on the form and aesthetics of buildings. Thus, through design, architects have opportunities to simultaneously satisfy their need for aesthetic expression and to efficiently achieve bioclimatic comfort in buildings. Only through bioclimatic design principles can a building be heated, cooled and lit in an environmentally responsible way. Therefore, the importance of bioclimatic design principles or approaches is to achieve human comfort and the sustainability of the environment.

2.2 ENERGY CONSUMPTION IN BUILDING

2.2.1 INTRODUCTION

Essentially, economic consideration led architects and building developers to seek alternatives to the conventionable fossil fuel sources of energy. Today, equal emphasis is placed on the ecological necessity for change, By means of energy conscious design and construction, the energy

requirements of living accommodation can be reduced by around 50% in comparison to older buildings (Neufert, 2000).

Energy is defined as the ability of matter or radiation to work because of its mass, movement, electric charges and so on (Hornby, 2000). Therefore, a very generic term within the bioclimatic Architecture can be fitted averagely to reduce the impact of the power (energy) consumption in the buildings (self – sufficient). It makes reference to the techniques to obtain a certain independence of the building with respect to the centralized networks of provisions (electrical, gas, water and even foods), taking advantage of the resources the immediate surroundings (water of wells, streams or rain, photovoltaic energy of the sun or the wind, panels or orchards). Bioclimatic architecture collaborates with the self-sufficiency in which it talks about the energy provision (Amitava, 2010). Energy is also defined by Encyclopedia Britannia as the ability to do work. One of form through a process called "transformation of energy". For example, radian energy from the sun can be converted into heat absorbed into a body or it can be converted directly into electrical energy through the use of solar cells.

The use of energy in buildings becomes an issue in Nigeria because of the cost of its supply (electrical energy) and scarcity and for wind or tidal energy. It becomes a point of concern as a result of destruction caused to roofs of buildings. For solar heat, there is an excess of this form of energy, hence it becomes of concern to architects on how to control its menace and reduce its penetration in a building which causes great discomfort (Hamzah, 1998).

2.2.2 SOURCES OF ENERGY

Basically, there are two sources of energy supply that occur naturally, these are:

i. Renewable Sources

ii. Non – Renewable Sources

RENEWABLE SOURCES:

These are sources that occur naturally and which replenish themselves naturally in a relatively short time, and will therefore be readily available for use, example, hydro – electric power, ocean thermal, solar energy, tidal energy, wind energy and wood fuel sources.

i. NON – RENEWABLE SOURCES:

These sources are of two processes, that is, they originate from two different processes, by photosynthesis and fossilation of plants and animal life and the process of formation of the earth itself. The first process gave rise to source in form of the following: coal, oil (petroleum), and natural gas. The second gave rise to the following sources in form of fuel for nuclear energy, that is, uranium. Some nations have developed a technology to use nuclear stations to generate electricity, using uranium as raw material (Amitava 2011).

2.2.3 TYPES OF ENERGY AND THEIR EFFECT ON BUILDING

There are many forms of energies, and their sources as discussed above. However, the types to be discussed will be restricted to those that effect buildings directly or indirectly, within, or without the building envelope. These are:

i. Electrical Energy

ii. Heat/Solar Energy

iii. Human Energy

iv. Tidal/Wind Energy

v. Mechanical Energy

vi. Sound Energy

A. **ELECTRICAL ENERGY:**

This is the most utilized form of energy within a building envelope.

ARTIFICIAL LIGHTING SYSTEM DESIGN (PARAMETERS)

This is a complex process and required the services of an electrical engineer to specify. However, it is good to introduce some of the basic considerations in the design.

(a). **THE BUILDING PROBLEM:**

This relates to the function and structure of the area to be lit. This problem relates to specific task to be lighted.

(b). **METHOD OF ARTIFICIAL LIGHTING:**

There are four to be chosen from they are General lighting, Angle Lighting, localized lighting and local lighting.

(c) **ILLUMINATION VALUE REQUIRED:**

This relate to amount of the illumination for a task depends on the following: size of the detail to be seen, contrast between the object of version and its background, reflective factor and motion of the object.

(d) **TYPES OF FITTINGS:**

Factors that influence the choice of fittings includes; the light distribution, the brightness of fittings, luminous efficiency and mechanical characteristics of the fitting.

(e) **TYPES OF LAMPS:**

The choice of lamps depends on the special composition of light, source brightness, source area and economic factors.

(f) **NUMBER AND PLACING OF FITTINGS:**

This is determined by the available mounting height and the illumination required. The shape of the room determines the arrangement of fitting

(g) **LIGHTING STANDARD:**

The day light factor required to provide adequate illumination depends on how much light is available from the sky. This in turn depends on the thickness of cloud cover. Design sky is a level of illumination and changes from place.

Electrical energy is used for many purposes within a building example. Lighting, air conditioning (ventilation) and heating,(Clark, 2001).

In an office building, however, the highest consumption of electric energy is in form of lighting and enhancing ventilation (air conditioners and fans).

1. LIGHTING IN BUILDING

One of the most visible sources of energy waste in a building is the traditional design lighting system. Excess lighting results in energy waste for both lighting itself and in warm weather for the cooling needed to offset the heat created by the light.

In low-rise buildings without elevator, lighting can consume 60% of the supplied electric power. In hot weather, lighting system account for one fourth to two – thirds of the cooling load in typical office building (Fang et al, 2004). Day lighting does not reduce the amount of artificial lighting that must be installed in a building, since it must be designed for the worst, that is, night condition. It does however, reduce the total consumption of the lighting energy for certain areas which receive sufficient natural lighting to allow the lights to be turned off for part of the occupied hours.

In the event, area near windows should have a system of switches that allow the artificial lighting to be turned on and off, or dimmed, according to the amount of day lighting available at a given time. With respect to artificial lighting, there are three approaches to control electrical energy. They are;

i. Reduce lighting level where practical
ii. Upgrade the efficiency of lighting fortunes
iii. Turn off lights where possible.

One of the most important contributions an architect can make is to design space that is light efficient. (Bawa, 2002) and this can be achieved through

i. Room surfaces of light colour with high reflectance
ii. The wall colour should have a light reflective valve greater than 60%.

iii. Ceilings should be white

iv. The furnishing should be of light colour with melt furnishing

v. Open (office) planning permits the greatest light flow over a given area.

Switches also affect energy consumption in the lighting system. The amount of energy that switches can save depend on how and what lights the switches control, and whether the switches are organized and located so that people can use them easily.

ii. **VENTILATION (AIR CONDITION)**

In an office building, ventilation is second to lighting in electrical energy consumption. Air condition involves the enhancement of ventilation through the use of mechanical gadgets (Nuefert, 2000).

Air conditioning design is not only a question of building physics and physiological principles, but also relates to analysis of the usage of the space. Cooling loads vary from area to area on a typical floor, depending on the space function and the time of the day (Enviz & Jeremy, 2008).

To save energy and capital cost, we must aim for minimum plant capacity. This is achieved: if the air flow is reversed from the conventional ceiling to floor or from floor to ceiling, resulting in a possible reduction in capacity. The average building temperature is allowed to rise during the day, energy losses in distribution system are reduced to minimum.

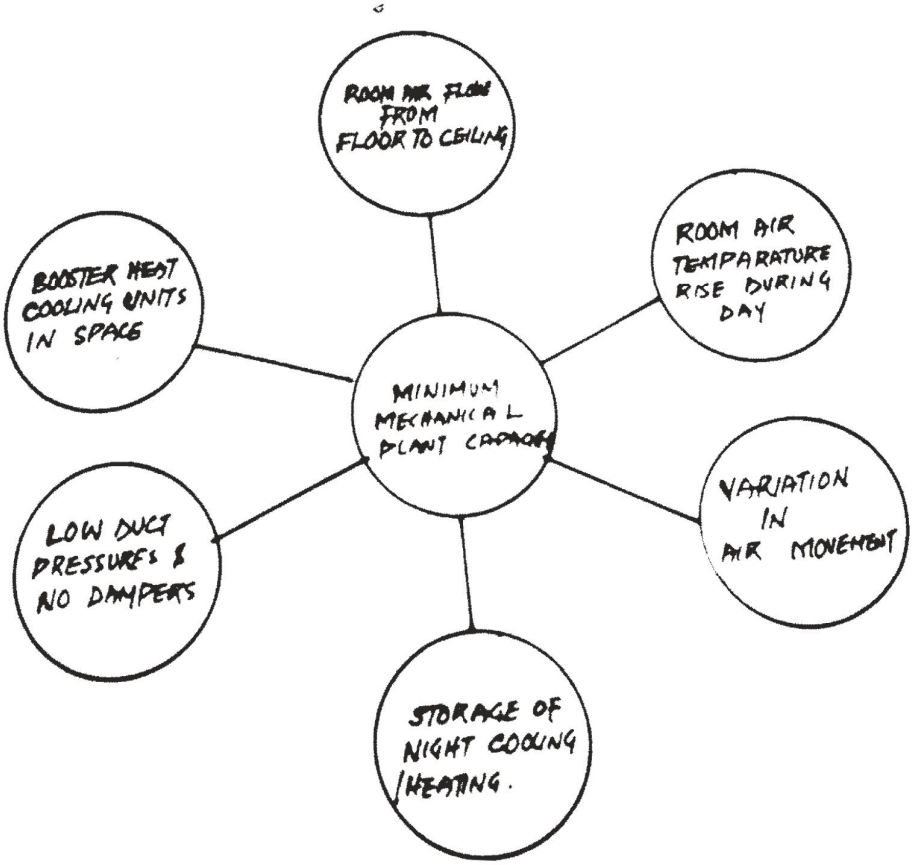


Figure 2.4: Minimization of mechanical plant capacity

Source: Hamzah, 1998

B. **WIND ENERGY**

Wind energy in form of rainstorm and trade winds are significant for building occupant comfort. However, when they exceed the optimum required, they become dangerous for the building especially the roof and external finishes of the building.

1. **WIND EFFECT ON BUILDING:**

Wind creates pressure on the wind-ward side of a building and suction on the leeward side. This creates air movement within the building in the direction of the wind. This wind is deflected over the roof and around the side of the building creating suction. For wind acting at an angle to a rectangular building, pressure is experienced in a two wind-ward side while suction is experienced on the other two. Suction and pillars on an L shape building follow the same principles (Ogunsote, 1994).

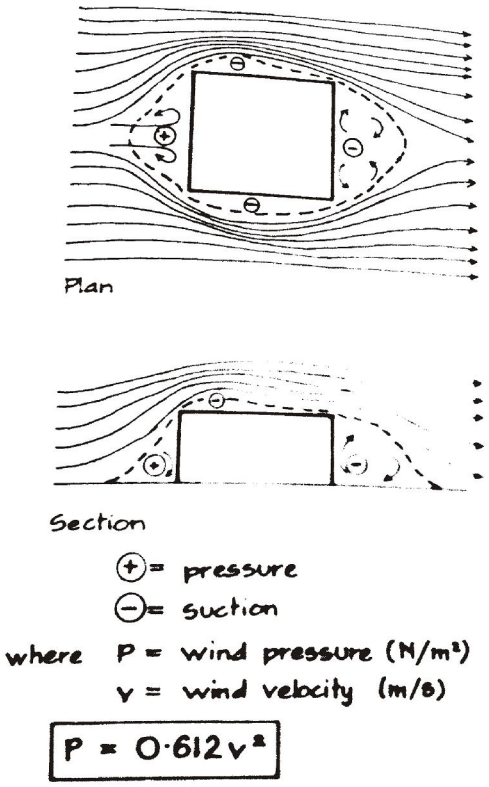


Figure.2.5 Wind Pressure on Building

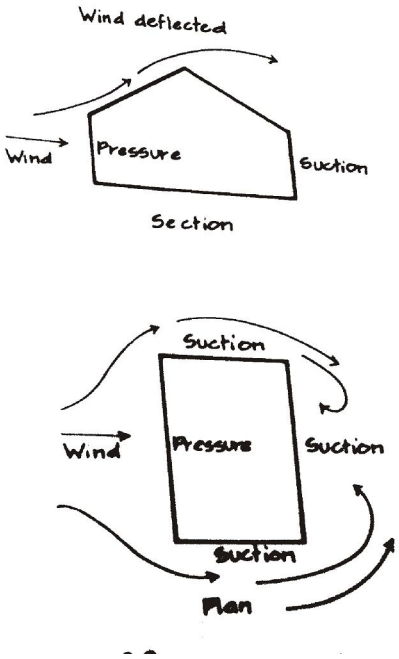


Figure. 2.6 Wind pressure And suction on building

Source: Ogunsote, 1994

Buildings that are positioned perpendicular to the wind direction receive their exposed side, the full sweel of the velocities. Therefore, the determination of wind loads for roof design should reflect maximum values to avoid blowing off of the roofs.

The proximity and light of neigbouring building also affect the wind flow patterns. For two buildings arranged across the direction of the wind flow, the wind is channeled between them, creating stronger suction than for free standing buildings. When buildings are arranged in the direction of wind flow and the second building is taller, a wind pressure may be experienced on upper building in the presence of open spaces. See figures below:

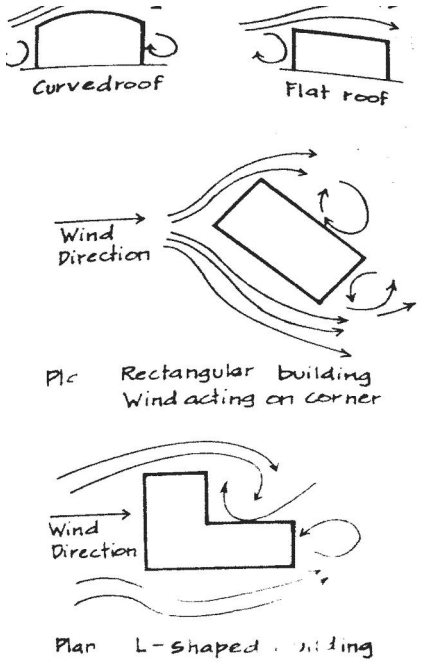


Figure 2.7 Wind flow round buildings

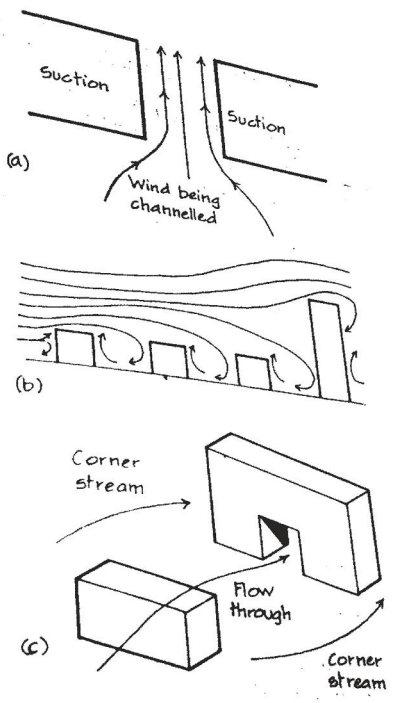


Figure 2.8 Effect of neighbouring Buildings on wind flow

(a) Channeling of wind (b) Interaction of low and high rise

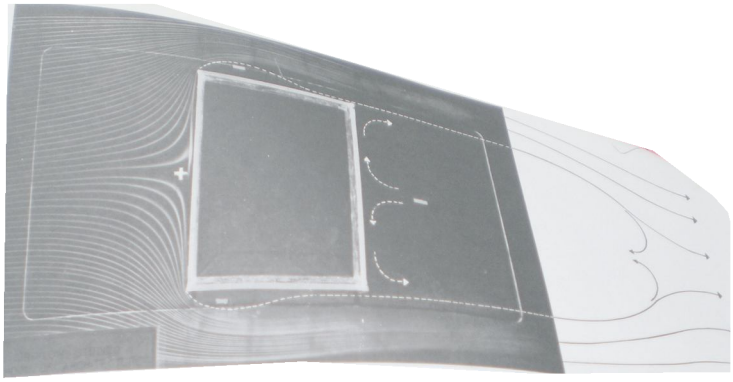
building (c) wind flow round buildings

Source: Ogunsote, 1994

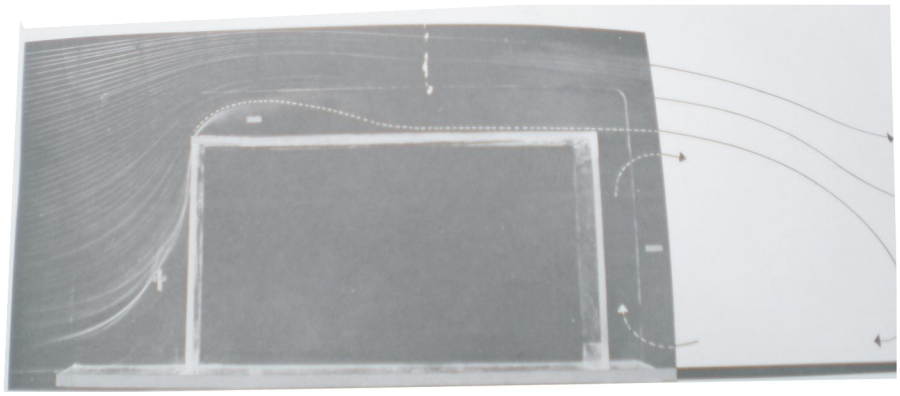
Buildings planned in row arrangement cause a wind shadow over subsequent units that reinforced the wind to channel through free spaces and pass by the later units. Staggered arrangement takes advantage of direct flow to subsequent structure but cause damage to the roof.

ii. STACK EFFECT

The stack effect refers to the movement of air as a result of differences in air pressure of two bodies of air at different temperatures. Thus when there is a significant difference in the temperature of air within and outside a building possessing appropriate air inlets and outlets, air movement results. (Ogunsote, 1991) example, if the temperature outside the building is lower than that inside, then cold air will enter through the lower inlet and warm air will rise and exit through the upper outlet.



a. Pattern of air flow surrounding a building



b. Pattern of the air movement at the section of building

Figure 2.9 Ventilation by Stack effect

Source: Olgyay, 1963.

The rate of ventilation achieved is directly proportional to the area of inlet and the square root of the difference in temperature between inside and outside air, and the difference in height between the inlet and outlet. The ratio determines the correct factor. Ventilation rate increases in the ratio of the area of the outlet to that of the inlet.

Stack effect usually produces some air movement even for small differences in temperature and height. In warm humid conditions, such as in Lagos, stack effect cannot be relied upon to provide adequate cooling by air movement, even with large window. This is due to the low difference in temperatures between the inside and the outside. In hot dry climates, stack effect can provide structural cooling at night time. The cooling produced by stack effect can be increased by better design – of – openings. Inlets should be on the windward side of buildings with outlets on the leeward side. The difference in height between inlet and outlets should be maximized. Window s should be large, with bigger outlets.

iii. WIND ENERGY MEASURES

Large air masses cannot be altered in their motion which is dictated by differences in air pressure. However, velocities near the living or ground level can be controlled to certain extend; through the use of the following:

a. **VEGETATION**:

The friction drag of vegetation and resistance and obstruction created by trees can cause diversion in the air flow which may be utilized beneficially, beside their aesthetic and shape, giving properties, the value of tree breaks lie in their ability to reduce wind velocities. This mechanical effect brings perceptible changes in the temperature and humidity of the air.

A wind break divert the air current upward and while they soon turn back and again sweep the ground, an area of relative calm is created near the ground. The most protected part of this area is close to the wind break on the leeward side it becomes exposed as the distance increases until a point is reached where the air have again full velocity. There is a smaller calm area, on the windward side especially if the wind break is quite dense.

b. **LANDSCAPING:**

The immediate surrounding near a building has an effect on wind velocities. Landscaping frees the building to a certain extent from rigid orientation requirements. The landscape design elements including plant materials, trees, and shrubs, walls and fences create low pressure that divert high wind velocities to a low speed. Care should however, be taken that the arrangement and orientation do not eliminate the desirable cooling breeze during over heated periods as orientation

for ventilation might not be suitable for wind control and planting should be designed to direct and accelerate beneficial air movement into the building.

c. USE OF PARAPET WALL (AS ROOF);

The use of a parapet wall is also another means of protecting a building especially the roof. This is achieved by wind diversion, thus reducing loads on roof by wind pressure, where the roof is exposed to wind without any obstruction around the building; walls prevent the roof from being exposed to wind but increase load to the building.

C. SOUND ENERGY

Sound energy can be defined as longitudinal waves originating from a source and conveyed through a medium (Ogunsote, 1991). The source can be a vibrating action on the air. The medium may be either a fluid or a solid. Sound is characterized by its velocity, frequency, wave-length and amplitude. The amplitude indicates the intensity of the sound. The power of sound is measured in watts (w) while the intensity is in watt per square metre (w/m^2).This may be transmitted, absorbed or reflected.

i. TYPES OF SOUND

There are three basic types, categorized based on their forms of transmission:

a. Structure Borne Sound

b. This is caused through the vibration of molecule of the barrier which may then remit the sound.

c. Impact Sound: this is generated through the use of mechanical means.

d. Air Borne Sound: this form of sound is the types emitted through the air.

ii. **SOUND / NOISE CONTROL INDOORS AND OUTDOORS**

The object of noise is the reduction of unwanted sound to tolerable levels. The first step is to determine what constitutes unwanted noise. The normal practices are to refer to standards that give acceptable noise levels for different situations and buildings. The source of the noise should then be determined.

The major sources of noise are: road traffic, railways, aircraft, industry, office machines, people, and home motorized appliances. These sources of noise can be broadly divided into two categorized, external noises and internal noises.

a. **CONTROL OF EXTERNAL NOISES**

External sources of noise can be controlled by

i. Screening (using wall, hedges or other barriers)

ii. Planning (Site planning and building locations)

iii. Building design (zoning of functions)

iv. Insulation (insulating material and surfaces

b. **CONTROL OF INTERNAL NOISE:**

Internal sources of noise can be controlled by:

i. Reduction at source (flexible mountings to prevent vibrations)

ii. Use of absorbent screens and surface

iii. Insulation (sound gaps)

iv. Building design (zoning of internal functions)

D. **SOLAR ENERGY**

The sun is the main sources of energy on earth. The energy comes in form of electromagnetic radiation. The heat flow rate is measured in watts (w) that is joules per second (j/s). The speed of light (c) is the product of its frequency (v) and its wavelength (Lambda), and it is a constant (Hamzah, 1998).

However, it is not all the solar radiation coming from the source reaches the outer surface of the earth, for instance assuming the solar radiation reaching the outer surface of the earth as 100%, then 20% is reflected from the clouds, 25% is absorbed in the atmosphere and 5% is reflected from the ground, only 5% of the total radiation is thus absorbed by the earth's surface with 23% of this being in the form of diffuse radiation and the remaining 27% as direct solar radiation, this form of radiation is called in-coming radiation and it is finally absorbed by the bare soil, hydrosphere, to raise water temperature, and use by marine vegetation.

The earth loses the heat absorbed through long-wave radiation 40%, evaporation, 40% and convention.

i. SOLAR ENERGY AND ITS EFFECT IN BUILDING

As explained above, the only source of solar energy is sun. The overall shape of building affects the amount of solar energy it will consume. In general, a configuration that resist unwanted heat gain or losses result in an energy conserving body. To minimized heat losses result in an energy conserving

body. To reduce heat transmission for a given enclosed volume, a building should be constructed with minimum exposed surface area. A spherical or round building has fewer surfaces hence less heat gain or loss than any other shape for an equal amount of total floor area. A square building has fewer surfaces than rectangular one of equal are per floor, and so undergoes less thermal transmission loss or heat gain. The penetration of solar radiation into a building envelope especially in the tropics causes a lot of inconvenience and discomfort for the occupant (Neufert, 2000).

ii. **SOLAR RADIATION CONTROL MEASURE IN AND AROUND BUILDING**

Solar control measures generally taken to reduce the intensity of the insulation with in the building envelope are:

i. Elements of site control
ii. Design principle (Architectural)

a. **ELEMENT OF SITE CONTROL**:

The purpose of site control is to modify the adverse effect of the solar intensity at a distance before they impact on the building. They include:

i. shade trees: this is used as from of landscaping to absorb, this is so because plant absorb sun light and get lower temperature, because of evaporated cooling which occurs during the

transpiration of plants. The net heat gain from the sun is rapidly dissipated by the enormous surface area of the leave.

ii. Ground surface (paved and planted): this involves the use of light coloured ground surfaces to reflect sunlight on to the building, dark coloured surfaces to absorbed sunlight and raise temperatures and planted surface to both absorb sunlight and lower outside temperature.

iii. Orientation to the sun: the general strategy for the placement calls for the largest window area on the side where the sun exposure minimizes combined heating and cooling needs.

The percentage of the incident solar energy that a window transmits for any given day depends on the angle at which rays of sunlight intercept the window, and for how many hours the window receive the light.

c. **ARCHITECTURAL DESIGN PRINCIPLE**

Solar energy can be control through design principle using the following:

i. Sizes of penetration

ii. Use of solar energy efficient materials and finishes

iii. Use of sun shading devices

iv. Use of verandahs

E. MECHANICAL ENERGY

The use of mechanical energy in building is in form of machineries that may require the use of electricity to operate or through manual means. Some of these machines and equipment are used to achieve active control of energy in the building, they include:

i. Air conditioners to enhance ventilation
ii. Electric fan
iii. Mechanical heaters.

There are also equipment that are used for mechanical transportation systems in the building, they are

i. Lift
ii. Escalator

The above equipment emits heat energy during their operations.

MECHANICAL ENERGY CONTROL MEASURES IN BUILDING:

The energy control measures that can be used include

i. Active means (minimal plant capacity, easy installation, operation and maintenance of plant)

ii. Design (provision of adequate service core, spaces appropriate location of services cores)

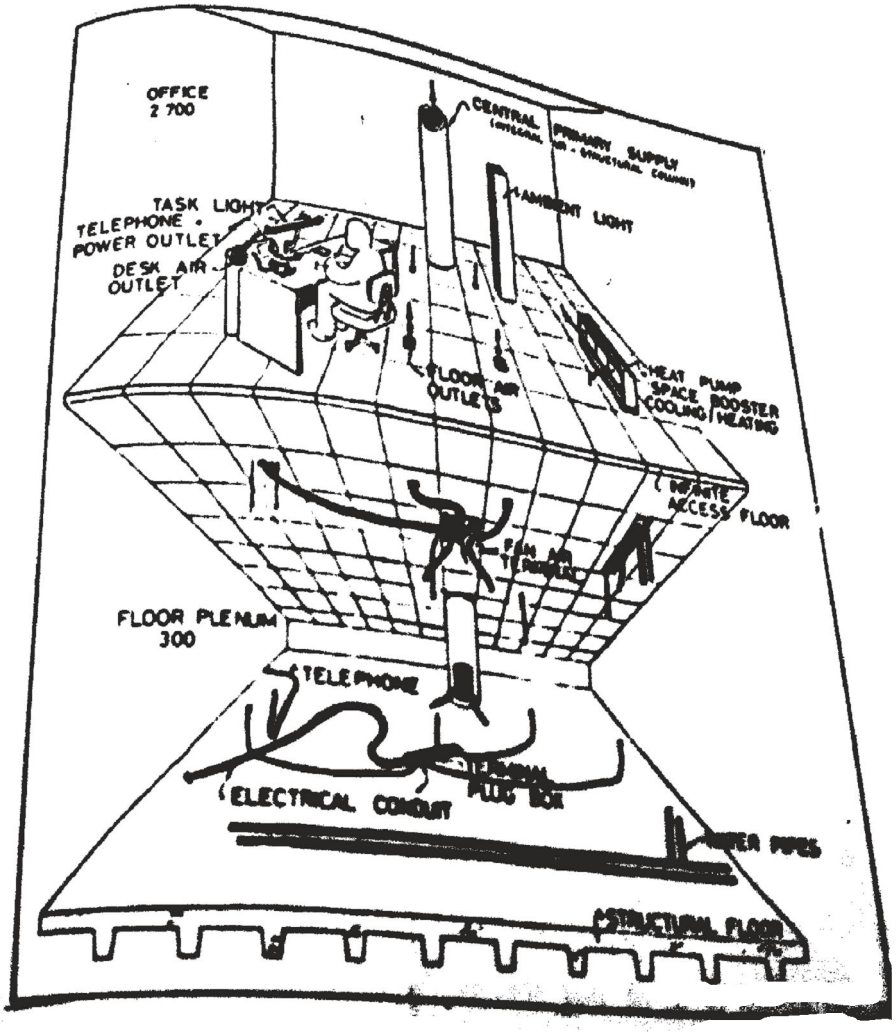


Figure 2.10: Electrical and Mechanical installation increases the energy Consumption in building.

Source: Amitava, 2010

2.3 UNIVERSITY EDUCATION IN NIGERIA

2.3.1 INTRODUCTION:

The demand for a University education in Nigeria started long before independence. In the 1930s from the African Intellectuals and fore front nationalist. The first institution of higher learning was established around 1934 in Nigeria i.e. the Yaba College of Technology which was later upgraded to University College Ibadan and attain fully autonomous as a result of it initial relationship with University of London (NSUK Calendar, 2008). The establishment of the University trigged another series of calls, for creating of more Universities immediately after independence (1962). A paramount commission was then created called National Universities Commission to coordinate and ensure a balance developments and growth of the university education in Nigeria.

More Universities were also established around 1970, across the country, they are Bayero University, Kano, University of Calabar, University of Ilorin, University of Maiduguri and Usman Dan Fodio University, Sokoto in 1975. These universities came much later after the establishment of the first generation Nigerian Universities such as University of Nigeria Nsukka (1960), University of Lagos (1962), Ahmadu Bello University, Zaria (1962) and the University of Ife (1962).

The oil boom of 1970s, led to Federal government decision to create seven more universities of technology and spread them evenly in the country, these universities include Federal University of Technology, Bauchi, Makurdi and Owerri (1980), Yola and Akure (1981), Abeokuta and Minna (1983).

State governments with a very large number of students and who can afford to established their own State universities with the sole aim of catering for their own candidates. These states include,

River State University of Technology, Imo State University, then Bendel, Ondo, Ogun, Lagos and Cross River State University.

A Military training institution was converted to a full fledge degree awarding University, in the late 1980s. This is solely responsible for the training of junior officers that graduate with a rank of a degree equivalent i.e. the Second lieutenant (2^{nd} liet).

2.3.2 ADMINISTRATIVE STRUCTURE OF NIGERIAN UNIVERSITIES

Generally, the federal and state universities have the same administrative structure. The following officers are involved in the administration of a university (NSUK Calendar, 2008).

i. The visitor
ii. The chancellor
iii. the Pro-chancellor
iv. The vice-chancellor
v. The Deputy Vice-chancellor (Academic and Administration)
vi. The registrar
vii. The Bursar
viii. The Librarian

Source: NSUK Calendar, 2008

The first three officers perform ceremonial duties to a university, while the others are directly involved in the day to day administration of a university.

The following are duties and responsibilities of the above officers

i. VISITOR:

The visitor to the federal universities is the president, Head of state or Head of government of the federation, while that of state university is the state governors, administrator or the chief executive of the state. They confirm the appointment of the chancellor, pro-chancellor and vice chancellor after due consultations.

ii. THE CHANCELLOR:

Traditional rulers (mostly first class) are normally appointed as chancellor of the university, they are to preside over ceremonial occasion e.g. Convocation, Orientation and so on and normally appointed by the visitor of the university

iii. PRO-CHANCELLOR:

The main function is that he serve as the chairman of the university council, which is the highest ruling body of the university, usually appointed by the visitor and usually an eminent personality.

iv. THE VICE CHANCELLOR:

He is in charge of the general administration of the university. Her is responsible to the senate of university, presides over senate meeting and usually appointed by the visitor after due consultation with the council and the senate.

v. DEPUTY VICE-CHANCELLORS:

a. DVC ACADEMIC:

To assist the vice chancellor on academic matters and can act for and on behalf of the vice-chancellor on academic matters of the Institution appointed by the council

b. DVC ADMINISTRATION:

To assist the vice-chancellor in the general administration of the university, he can act for and on behalf of the vice chancellor on academic matters, appointed the council.

vi. THE REGISTRAR:

Assist the vice chancellor in the daily happening of the university e.g. appointment, registration, recruitment etc. He is the secretary of the senate and council appointed by the council.

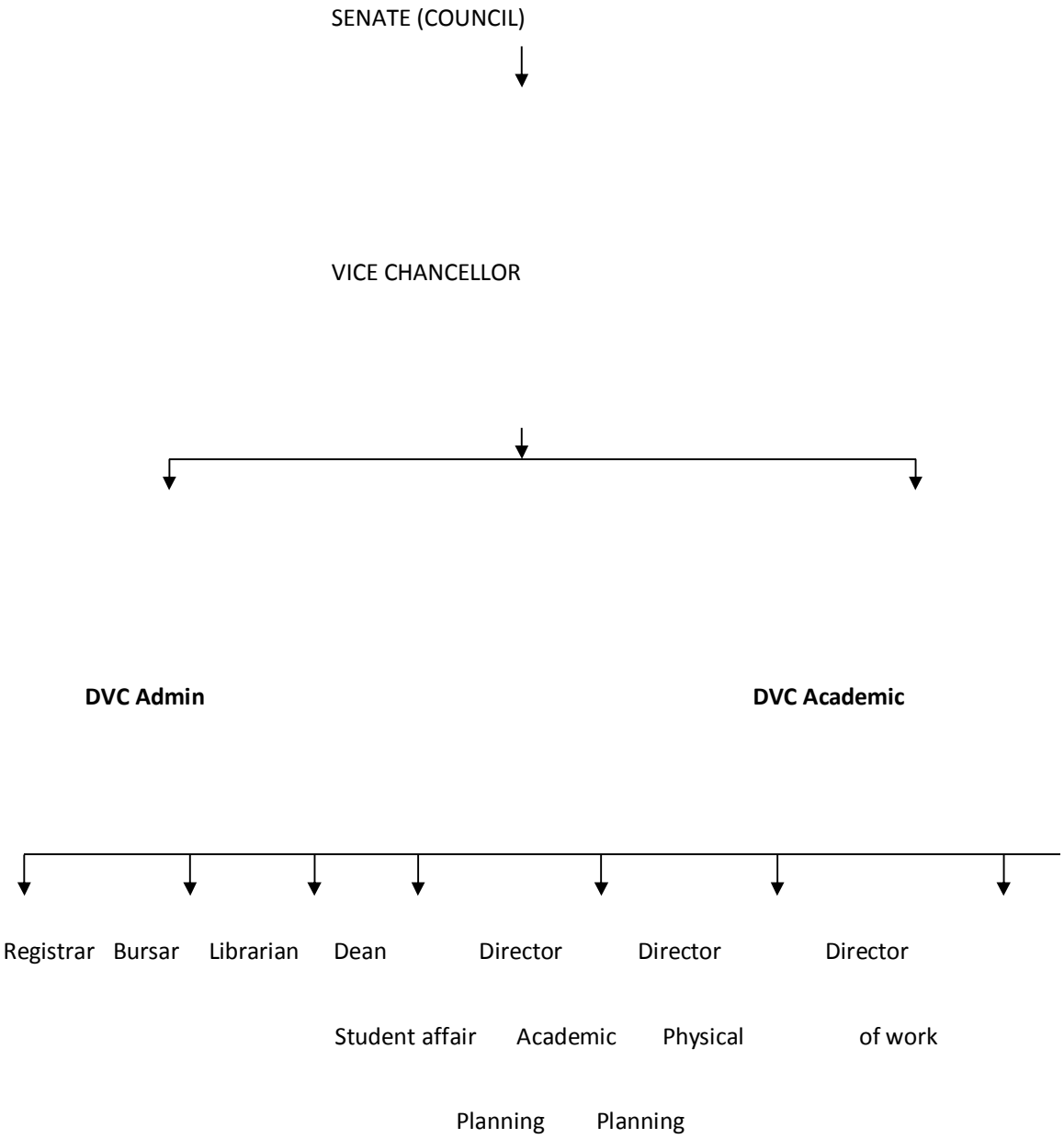
vii. THE BURSAR:

Responsible for financial matters of the University. Report to vice-chancellor for financial status and appointed by the council of the university.

viii. THE LIBRARIAN:

Responsible to the vice chancellor on library matters and appointed by the university council

2.3.3 NIGERIAN SYSTEM UNIVERSITY ORGANOGRAM



Source: NSUK Calendar, 2008

2.3.4 ADMINISTRATIVE BODIES OF NIGERIAN UNIVERSITIES

The to simplify the general administrative of the university, there are responsible for decision taking an different matter; these bodies are:

a. The council

b. The Senate

c. Facility Board

a. THE COUNCIL:

This is the highest ruling body of a university system. It comprise of eminent personalities representing the general public interest and also notable official of government agencies and ministries selected across the country or state depending on the university. They are policy makers, and of the major committee i.e. committee on finance and the general committee,

b. THE SENATE:

The senate is second to the University council; it is generally concerned with academic matters. The senate is responsible to the council on the above matter. The senate comprise of many boards comprising of students welfare board, apartments and promotions board etc. they charge with the responsibility of taking decision on policy affecting organization and control of academic activities, coordinating and recommendation to various facilities and department as well approving appointments and promotions of worker especially the

academic staff. PF the member of senate include vice chancellor, the entire professors, and head of departments, the librarian and other academic and non-academic staff drawn from the university.

c. FACULTY BOARD:

The faculty board is charge with the responsibilities of organizing and controlling academic programmes of the faculty subject to senate approval which include decision on examination and screening of students. Faculty board is responsible to the university senate. The dean of the faculty is the chairman of the faculty board. Other members include the vice-chancellor, the deputy vice-chancellor, and all heads of department under the faculty.

2.3.5 CLASSIFICATION OF NIGERIAN UNIVERSITIES

Nigeria Universities are classified according to the area of specialization and emphasis of courses and disciplines. This covers state, private and federal Universities.

a. CONVENTIONAL UNIVERSITIES:

These are universities that offer arts, science and technology in its curriculum. There is no particular emphasis of one of the above or another except perhaps the recently 60:40 science: arts ratio of student's enrolments examples of such Universities are; ABU Zaria, BUK Kano, University of Ibadan and Calabar and Nasarawa State University when fully operating.

b. FEDERAL / STATE UNIVERSITIES OF TECHNOLOGY:

These are universities whose curricular has more emphasis on the Technological development, the emphasis is on practical Technological application of Knowledge through the use of machines etc. they are established with sole aim of enhancing the nations technology. They are namely federal university of Technology Bauchi, Yola, Minna, Owerri and Akure.

c. FEDERAL UNIVERSITIES OF AGRICULTURE:

To enhance food production and research in that area, the government decided to convert two Universities to universities of agriculture e.g. federal university of Agric Markurdi, and the Benue State University of Agriculture, Markurdi.

d. MILITARY UNIVERSITIES:

Nigeria Defense Academic (NDA) which is a military training institute has been converted to a full fledge degree awarding University in the 1980.

2.3.6: PLANNING CONCEPTS IN NIGERIAN UNIVERSITIES

Studies on planning concepts adopted in Nigeria universities has been shown that these are four major concept with emphasis on four key constituents of a university systems, they are, the central administrative (senate building), academic core (teaching/research areas), accommodation (staff and students) and recreational areas (sport).

a. **CLOSE CONCEPT:**

In this concept, schools or facilities are located at different place within the town of the universities location e.g. ABU Zaria with campus at Congo, Shika and Samaru all in Zaria.

b. **LOOSE TIE CONCEPT:**

In this concept, each of the constituent is independent of one another, but located in one place. It allows for expansion of each unit, the central administration is normally placed at the centre in between the academic core and accommodation of staff and students.

c. **RING CONCEPT:**

In this, the entire constituents are arranged in a ring form, i.e. formed around one another. The central administration is normally placed at the centre and surrounding by academic core, which in turn is surrounded by housing areas for students and staff. Interaction is enhanced among members of the University community.

d. **SEGREGATED TYPE OF CONCEPT:**

This concept promotes strong relationship between the campus planning elements, on spatial relationship. In this case, the central administration and the academic core are fused or located together while the student and staff accommodate facilities placed at opposite sides.

2.3.7 CAMPUS SYSTEMS OPERATING BY NIGERIAN UNIVERSITIES

Generally, four systems are being operated by our universities, though all universities could have one or even combine the system at the same time. They are as follow:

a. CITY HEART CAMPUS SYSTEM:

This campus system has its campus located right inside the city e.g. Bayero University, Kano

b. MULTI CAMPUS SYSTEM:

Ahmadu Bello University is an example of this campus system it tends to have sub-campus which are in one way or another connected each campus however, is sufficient in terms of amenities they are normally compact. The advantage of this system is that it reduces the concentration of the activities at a place, hence reduce congestion

c. URBAN CAMPUS SYSTEM:

In this University campus is located close to the city centre. In fact, presence of the campus can influence the growth of the city itself Basic amenities are shared between the university community and the city one of such university for example is the Ladoke Akintola Universi

2.3.8 THE ADMINSTRATIVE (SENATE) BUILDING IN NIGERIA UNIVERSITIES

Administrative (Senate) building of any university is primary to provide office accommodation to the administrative staff of the university as well to provide for a suitable area or place for meetings of the University councils.

This name senate Building / House derives its name as a result of the provision of the senate chamber meant to be used for the meetings and deliberations of the councils, and the academic body of the university in the senate. Senate is the sole academic body of any University, it therefore, responsible for taking decision about matters concerning the academics of the university.

The university council also meets and deliberate in this chamber, it decision involves the general administration of the university, it could be seen hence that the senate is solely an administrative building of a university.

a. **LOCATION:**

The location of a university senate is of utmost importance the location of this building has consistently been centralized with a university as could be seen in case studies can be out in the subsequent chapter.

The central location of this building is recommended because of the following:

i. ACCESSIBILITY:

This building is supposed to be easily accessible to all segments of the university. That is, the academic core, the accommodation area etc. this will also ensure easy proximity from the main entrance for visitors.

ii. ITS POSITION OF SEAT OF POWER:

This building accommodates the office of the highest officers of the university hence it serves as the highest policy formulating of the university.

iii. Serves as a part of call for solution of one problem or another from other department of the university.

iv. Senate building also is the main facilitator of the growth of a university; hence its central position is like a centre of a circle to which all lines radiates from.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 INTRODUCTION

Different individual have offered definitions of research at different times. According to Asika (1996), "research is any organized enquiry that is aimed at providing information for solving a problem". It is also defined by Akuzilo (1990) as "step by step procedure for concluding a research project in such a way that, designed system has been implemented" while Osuala (1985), see research as "the process of arriving at dependable solution to problems through in planned and systematic collection analysis and interpretation of information or data" therefore, research relate to careful study of a subject, especially in order to discover new facts or information about it. (Hornby, 2000).

3.2 SAMPLING METHOD

A sample is a portion of the total amount of information that can be conceivably be gathered. It is also a small amount of a substance taken from a large amount and tested in order to obtain information about the substance (Hornby, 2000) "A collection of observations from apparent population or Universe" (Mare Crown, 1979). Conclusion can be drawn from the sample gathered and they must represent the whole population in the area concerned if they are to be valid therefore, sampling is the process of taking a sample.

3.3 METHODS OF DATA COLLECTION.

The data collected and used in this research can be classified into two primary and secondary data.

3.3.1 PRIMARY DATA

This data was expressly collected to determine how the bioclimatic principle can reduce energy consumption in the design of Nasarawa State University administrate building (Senate). The advantage of the primary data is that, the exact information is obtained in a shorter time.

The instrument used in collecting this data consists of questionnaires which were designed and administered to some staff of Nasarawa State University (Keffi, Pyanko and Lafia) physical observation, photographs and survey of some selected buildings and inspection. A personal interview was also conducted with some staff of the study area.

3.3.2 SECONDARY DATA

The secondary data used in this research consist of text books, journals, pamphlets, newspapers, seminars/workshop papers, maps, calendar and relevant note books. Most of the information obtained here constitutes the literatures review (Chapter two) of this research work.

3.4. METHOD OF DATA ANALYSIS

The raw data gathered though the questionnaire administered and personal interview with some staff is analyzed with the use of descriptive analytical tools. Such tools are tables and chart those tools are most appropriate to portray some of the data obtained in this study. These tools are used to interpret some research findings and conclusions later drawn.

CHAPTER FOUR

4.0 CASE STUDIES AND PHYSICAL CHARACTERISTIC OF STUDY AREA

4.1 INTRODUCTION

To achieve a functional and effective and adequate administrative offices (senate building) complex for Nasarawa State University, Keffi, a similar existing structure (senate buildings) needed to be studied with a view to ascertaining and assessing functional lapses so as to produce and propose a more effective and functional complex that will reduce these lapses.

The case studies were aimed out on this existing senate buildings in Nigeria and the international case studies.

The three senate building studied in Nigeria includes:

i. Ahmadu Bello University Senate building –Zaria

ii. Nasarawa State University senate building, Keffi

iii. Ladoke Akintola University senate building-Ogbomoso

iv. Mahaweli ministry building, Colombo. Sri Lanka. (The international case study)

The criteria for each case study are discussed base on location, site organization (planning concept) building orientation, facilities, and Architectural expression and energy consideration.

a. LOCATION

The choice of a site is of very important for any senate building proposal which primary interest is to serve as the central and the core area of the university system and administration usually located where all functional department actually radiate from. The senate building is considered the heart of the university.

b. SITE ORGANIZATION (PLANNING CONCEPT)

The relative orderly, special arrangement, organization of buildings and other infrastructure in line with the dictates of the site is what make a piece of architecture great and pleasant through vivid and profound understanding or awareness of man needs with nature, the site and the climate (micro climate).

c. BUILDING ORIENTATION

The building orientation determines the amount of radiation it receives owing to the facts of the buildings position or cardinal placement in relation to the solar chart. The orientation with respect to air/wind pattern and the solar incident affect the general amount of natural ventilation, heating and cooling, thus influencing the energy consumption and internal comfort.

d. FACILITIES

Senate building is the core area of university, therefore, the main specific facilities includes:

i. Vice chancellor area,

ii. Senate chamber

iii. Student affair department and

iv. Finance department.

e. ARCHITECTURAL EXPRESSION

The structure, construction methods and material used should be base on bioclimatic Principles. The services and the overall aesthetics appeal of the senate building have a lasting impression on the university activities.

f. ENERGY CONSIDERATION

The discussion will be restricted to those energies as explained in the earlier chapters, which have direct effects on the building. They are;

i. Solar energy

ii. Wind energy

iii. Sound energy

iv. Electrical/mechanical energies

These energies are carefully examined to see how they affect the building and proper possible means of reducing its consumption in the building using the biochemical principles, to create comfort in both internal and external aspect of the building.

4.2 AHMADU BOLLO UNIVERSITY ZARIA SENATE OF BUILDING

The senate building was built in early 1980s by the then civilian administration principally to accommodate the administrative staff of the institution. It is located at the samara main campus. It

is an eight floor building with the first two floors as open plaza and six storey tower with the senate chamber in-between the podium & tower.

4.2.1 LOCATION

The senate is located in the mid of the academic cone of the university, that is, bounded by SGRS library on the south, the convocation square on the north, the assembly Hall to the west and the old administrate block on the east .the location is said to be strategic because of its direct access to the main gate, that is the access from the main gate is easy.

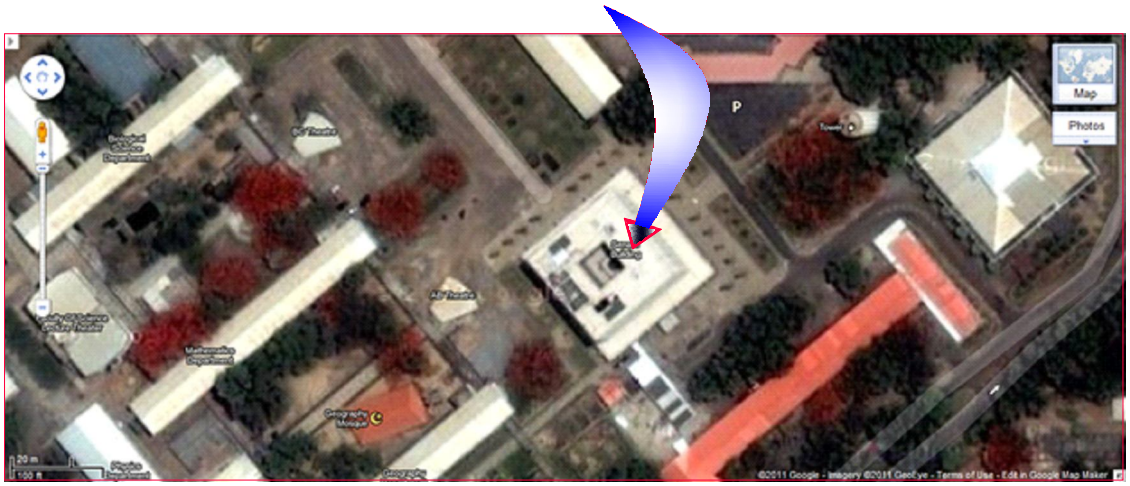


Figure 4.1: Google Map showing Senate building of ABU Zaria

Source: Google Map

4.2.2 DESIGN APPRAISAL

i. The design has clearly identified itself as seat of authority (power) for the university because of its elegance size and domination over all the buildings surrounding it.

ii. The design is well befitting for a university of Ahmadu Bello Status.

iii. The building has succeeded in providing adequate accommodation to the administrate staff of the university.

iv. Each of the function spaces/offices was clearly defined and easily accessible.

v. The structure considered human traffic within the building became of the provision of horizontal and vertical transportation systems and location of functions most frequented by the people around the ground floor.

vi. Adequate commiserates were provided with all floor, where two sets of toilet was provided for each floor.

vii. Good quality construction and durable materials.

viii. The concept is very simple intern to design and construction.

4.2.3 DESIGN CRITICISM

i. Undefined parking spaces, scattered parking area provided was grossly inadequate.

ii. The stair cases provided for vertical transportation (escape) are hiding and the areas for the stair are very dark.

iii. Some functions are beings interrupted by free standing Columns hence affect the arrangement of the Rooms.

iv. The location of commiserates (Toilet) are not easily accessible particularly at the ground floor were they are located behind lifts.

4.2.4 BIOCLIMATIC PRINCIPLES.

1. Use of shading device (solar)

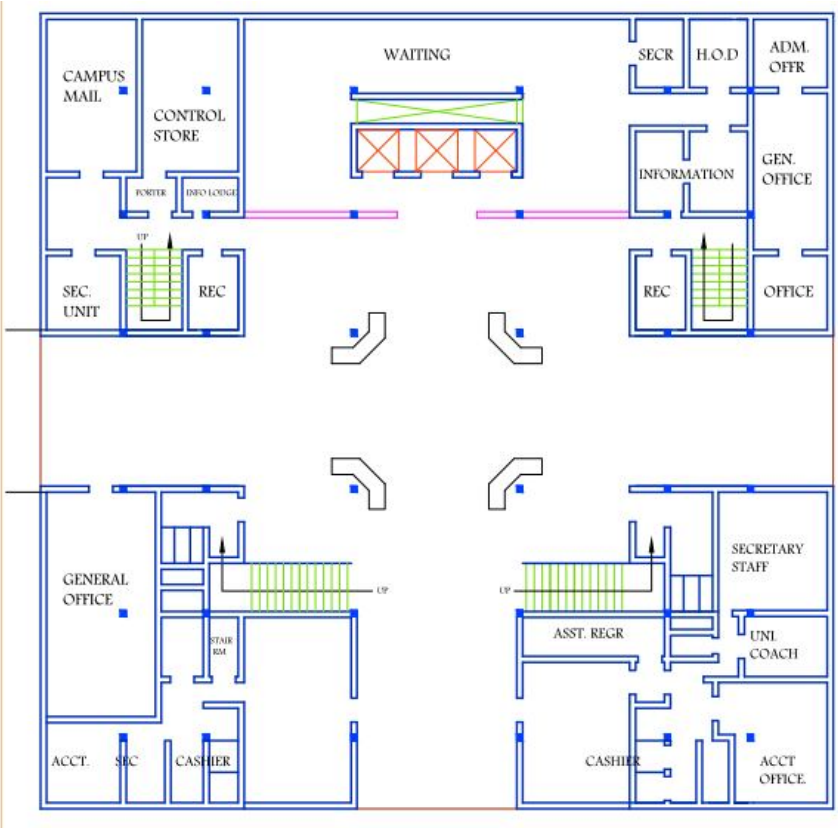
2. Landscaping (wind and sound energy)

3. Provision of opening for ventilation.

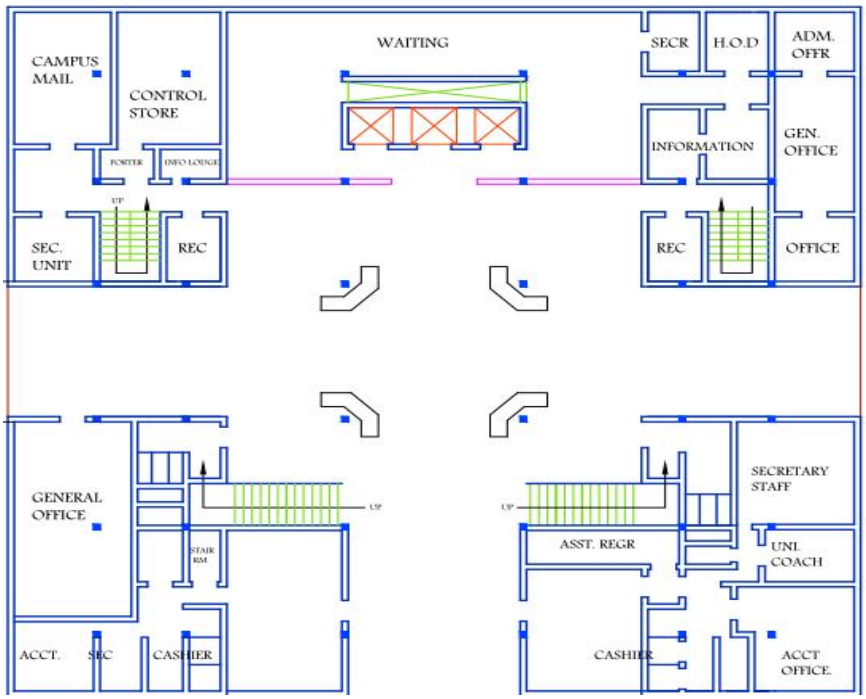
4. Use of court yard system.



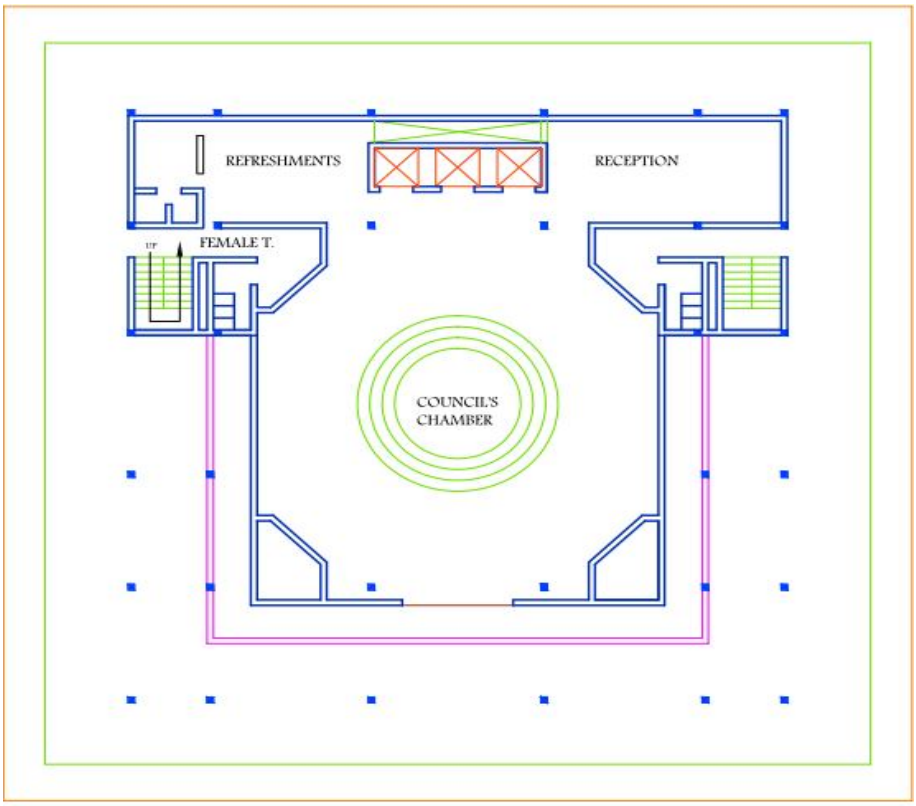
Plate 4.1: Picture showing ABU Tower



(A) Ground Floor Plan

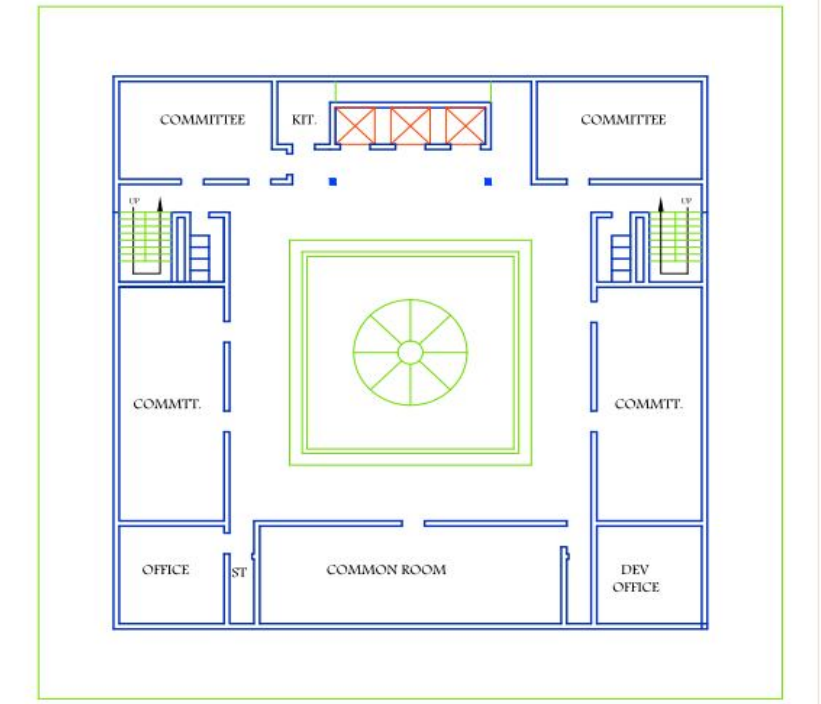


(B) First Floor Plan



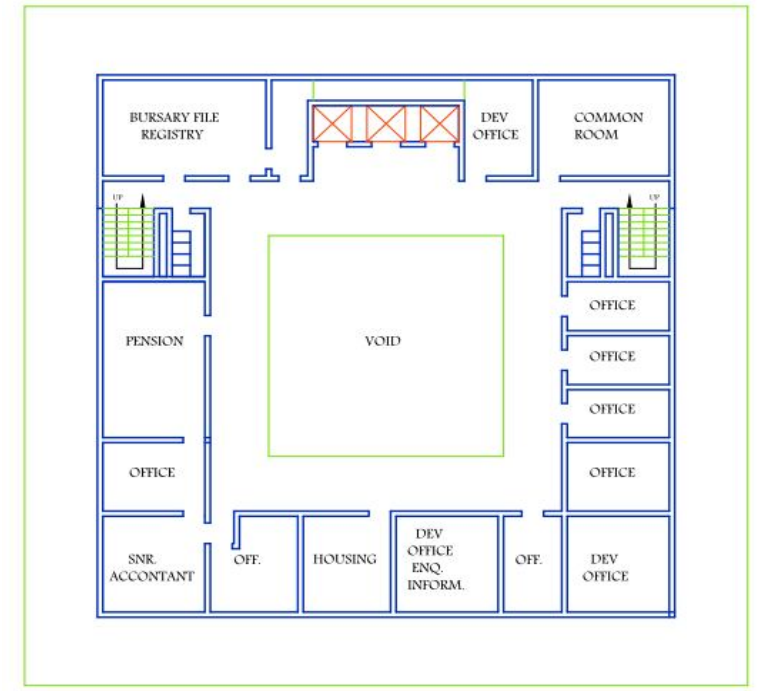
2ND FLOOR PLAN

(C) Second Floor Plan



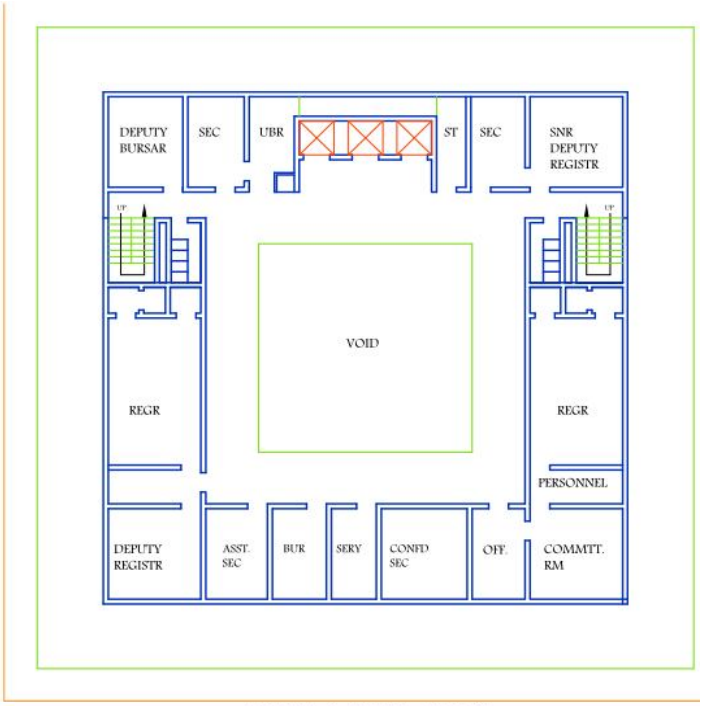
3RD FLOOR PLAN

(D) Third Floor Plan



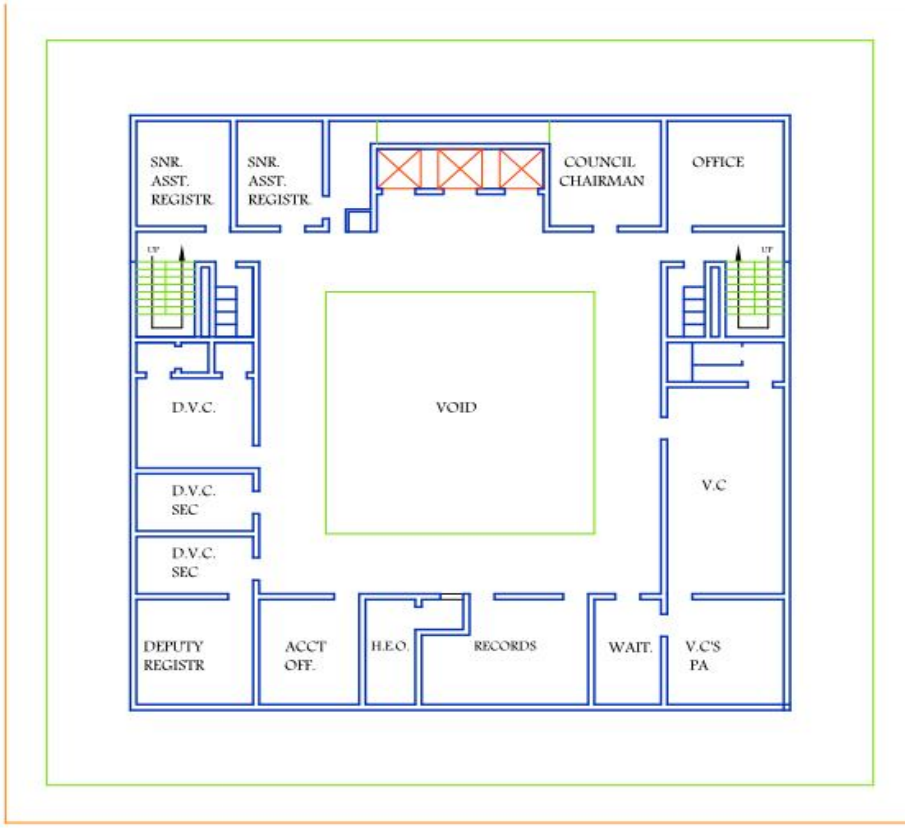
4TH, 5TH AND 6TH FLOOR PLANS

(E) Fourth Fifth and Sixth Floor Plan



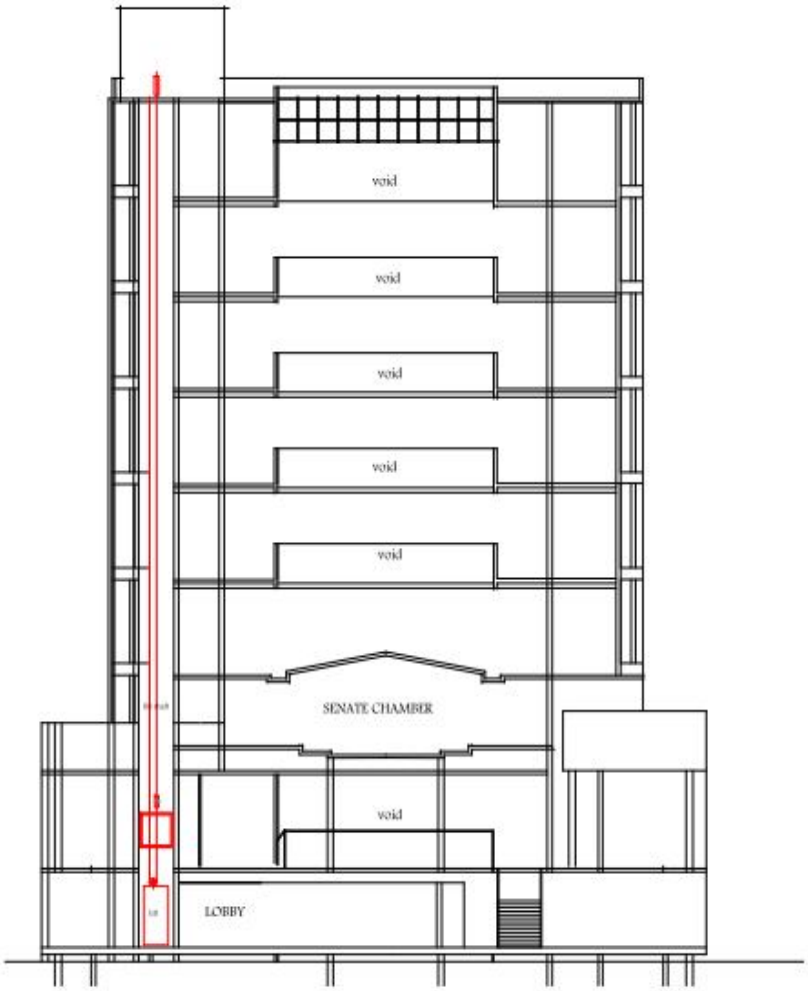
7TH FLOOR PLAN

(F) Seventh Floor Plan



8TH FLOOR PLAN

(G) Eighth Floor Plan



SECTIONAL VIEW OF THE SENATE, SHOWING LIFT SHAFT DETAIL

(H) Section

Plate 4.2: Picture showing Floor Plans of Senate building of ABU Zaria



(A) Approach View



(B) Lateral View



(C) Parking Area



(D) Side View

Plate 4.3: Pictures of ABU senate building views

4.3 NASARAWA STATE UNIVERSITY SENATE BUILDING, KEFFI.

The senate building was built in the early 2005 principally to accommodate the administrate staff of the institution at it starting stage consisting of a few numbers of the offices.

The complex was later extended or expanded in 2009 as the institution standard improved, to accommodate more staff. The senate building is located in Keffi, the main campus. It is one storey floor arrangement with two internal courtyards with the chamber place at the first floor

4.3.1 LOCATION

The senate building is located at the entrance of the institution after the main gate. The senate is located in such away that is the first place of visit as an administrative area bounded with other facilities, to the north is the main gate and the parking area, to the east is the Students and staff area, to the south is the department and to the west is the activities area (convocation square).

The location could be said to be strategic because of its direct access to the main gate. That is, access from the gate is very easy.



Figure 4.2: Google Map Showing Nasarawa State University, Keffi

4.3.2 DESIGN APPRAISAL

1. The design is simple rectangular form with courtyard made of only one storey.
2. The construction method and materials used are very simple, using the normal materials of sand Crete blocks, glass and normal construction techniques.
3. The use of landscape element interms of spot planting around the courtyard.

4.3.3 DESIGN CRITICISM

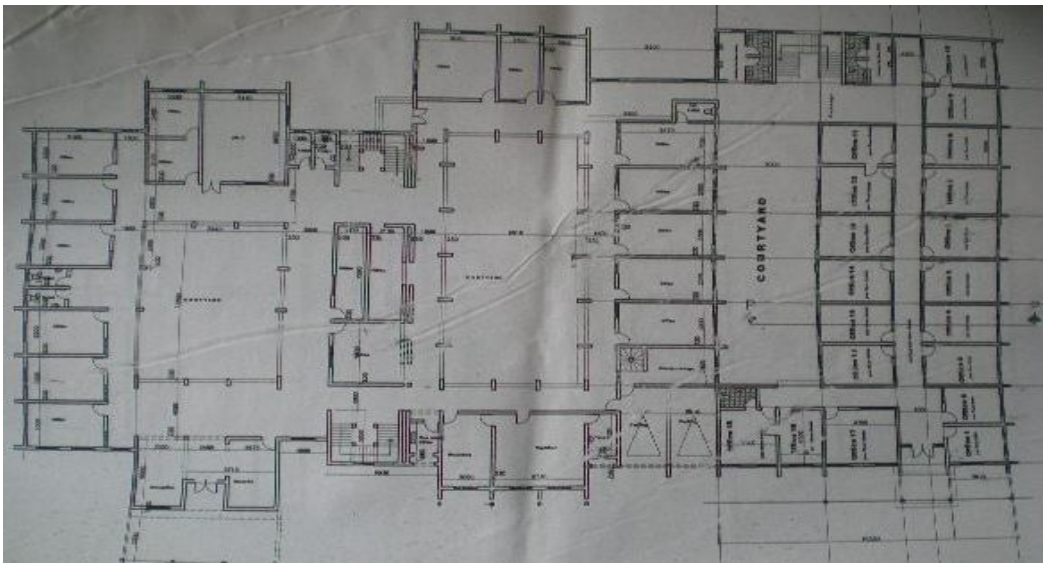
The criticism of this senate building includes:

1. No active parking spaces for students' and staffs.
2. Inadequate office accommodation.
3. The building does not portray its position as a seat of power for the university.
4. No adequate landscaping to influence the microclimate.
5. No effective use of shading devices, especially around the eastern and western directions.

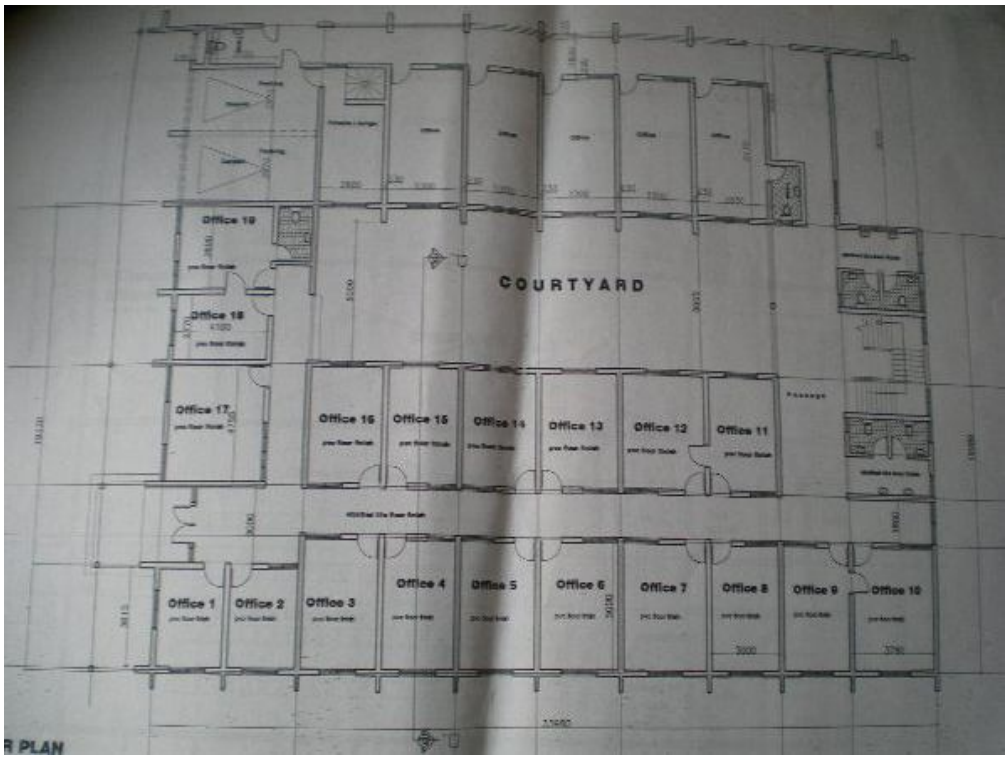
4.3.4 BIOCLIMATIC PRINCIPLES

1. The building shape that is rectangular shape that ensures good distribution of sound.
2. Building orientation with longer side facing the north.
3. Use of opening to insurance lighting and ventilation.
4. Landscaping element though inadequate.

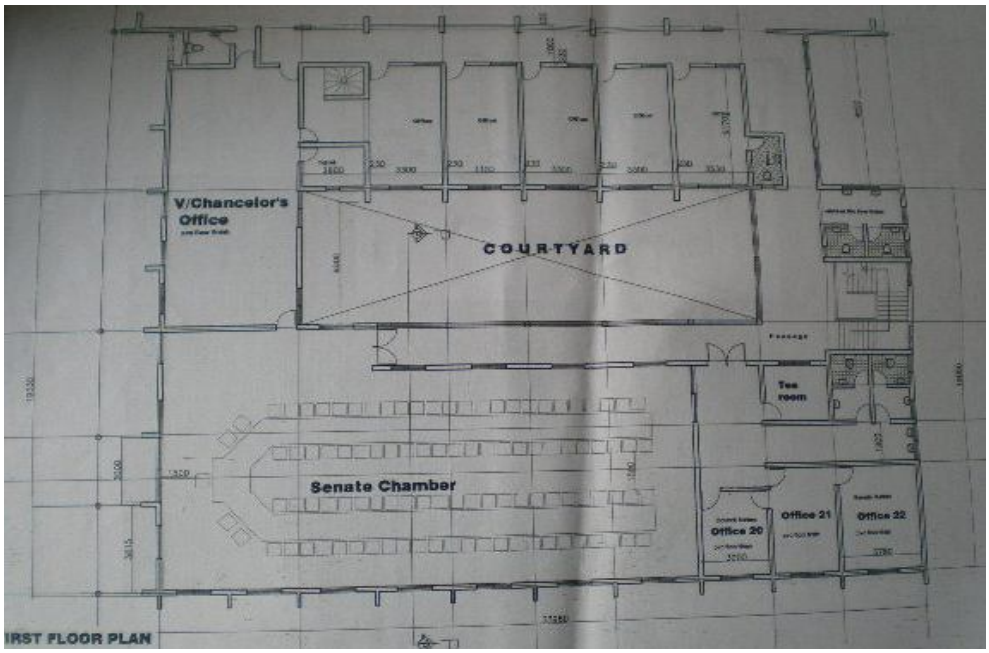
5. Introduction of internal courtyard to influence ventilation.



(A) Ground Floor Plan



(B) Floor Plan of Extension



(C) First Floor Plan Showing the Senate Chamber

Plate 4.4: Pictures of Nasarawa state senate building floor plans



(A) Approach View



(B) Parking Space



(A) Approach



(B) Front View



(C) Picture showing the courtyard



(D) Side View

Plate 4.5: Pictures of Nasarawa state senate building views

4.4 LADOKE AKINTOLA UNIVERSITY SENATE BUILDING, OGBOMOSO, OYO STATE

The completely circular building was completed and commissioned by May, 2006 to complement the rapid development and growth of the school. The centre of administration and a four (4) storey structure that excellently portrays modern architectural style, conceptual form as a generic form from a funnel of knowledge that represent the immense contribution of the institution towards academic excellence.

4.4.1 LOCATION;

This senate building is located in the mid of the academic core areas of the university, which is bounded by faculty of engineering and technology on the south with department of urban and regional planning/student affairs to the north. The student union building on the west and the school of pre-degree and science block on the east. The location is said to be strategic because of its direct access from the second gate at close proximity.

4.4.2 DESIGN APPRAISAL;

i. The structure has magnificently shows of architectural master piece of an elegant power and authority abode.

ii. The design is a purposed made, thereby providing a functional special arrangement.

iii. The shape and the size of the building defined the structure as the centre of administration and determine the bioclimatic consideration of form.

4.4.3 DESIGN CRITICISM;

i. To many accesses into the building that make the building too porous.

ii. In adequate courtyard to enable effective lighting and ventilation.

iii. No define escape route and poses traffic problem in the case of emergency

iv. In adequate fenestration for the provision of thermal comfort indoor environment.

v. Insufficient landscaping elements to influence the micro-climate.

4.4.4 BIOCLIMATIC PRINCIPLE;

i. The use 0f circular shape

ii. The use of vertical and horizontal shading devices

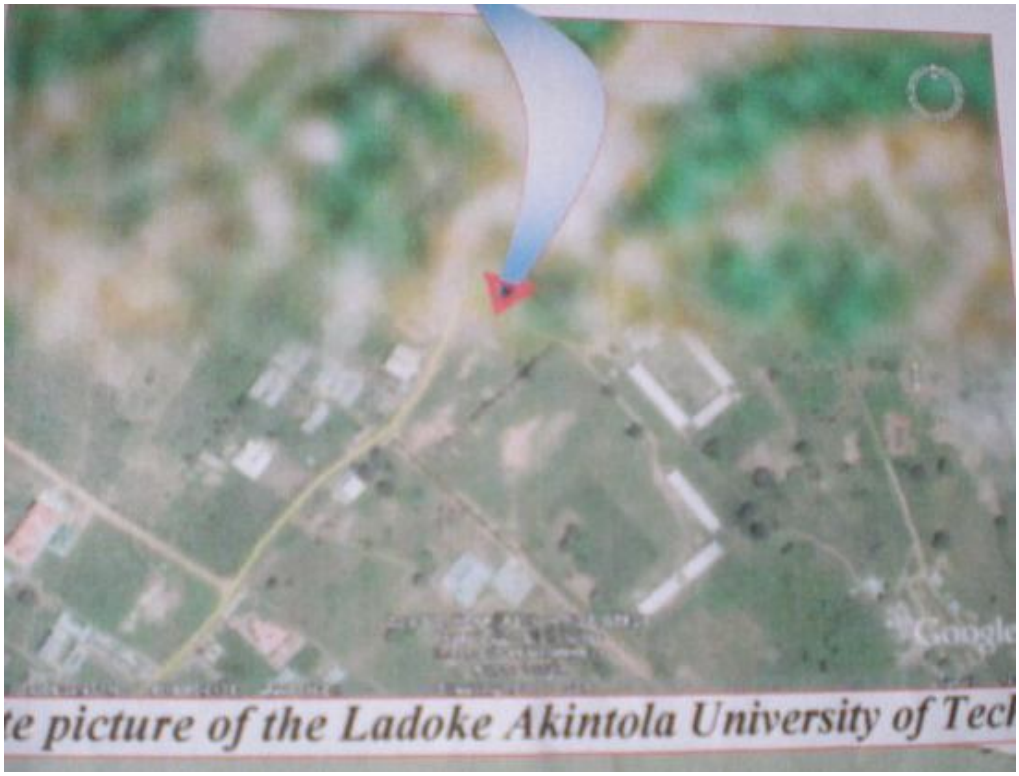
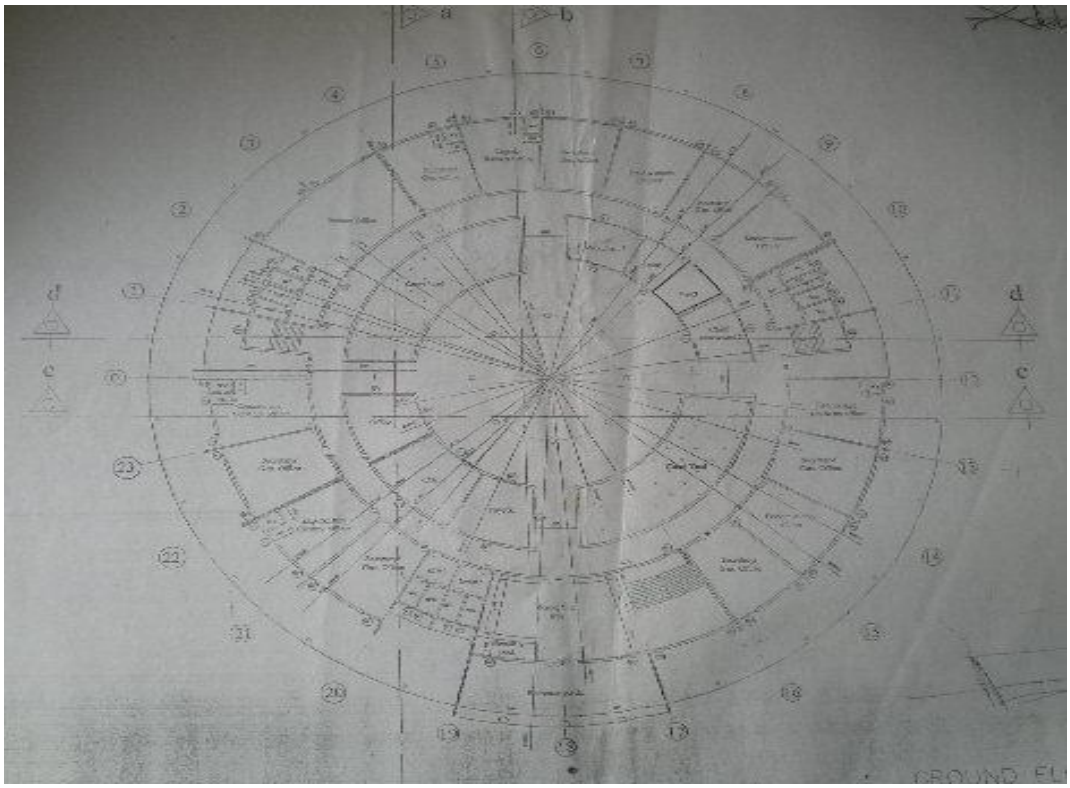
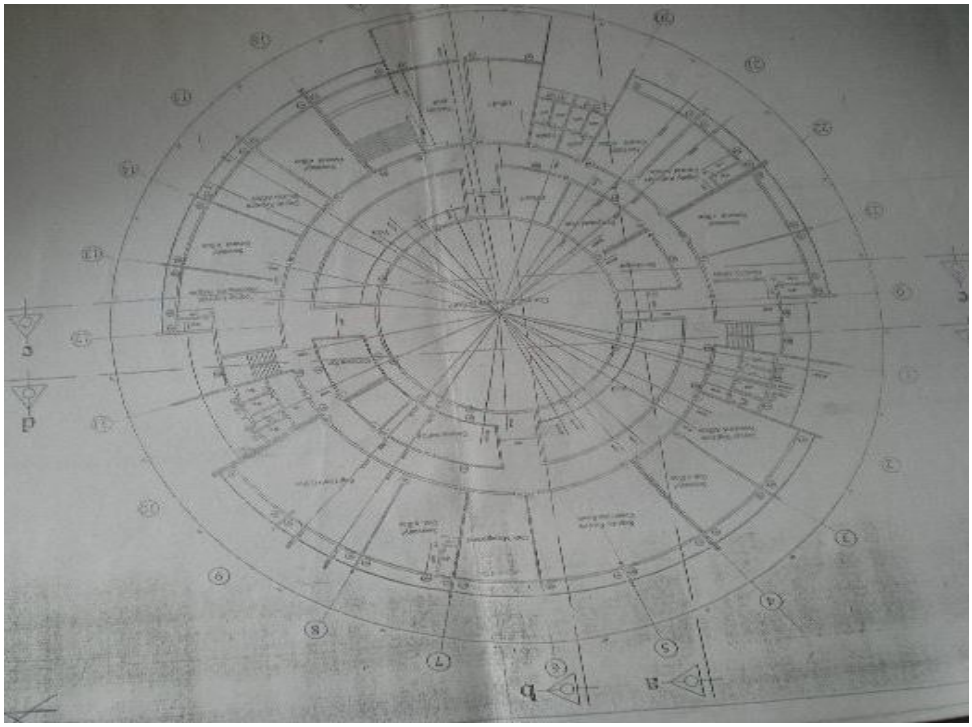


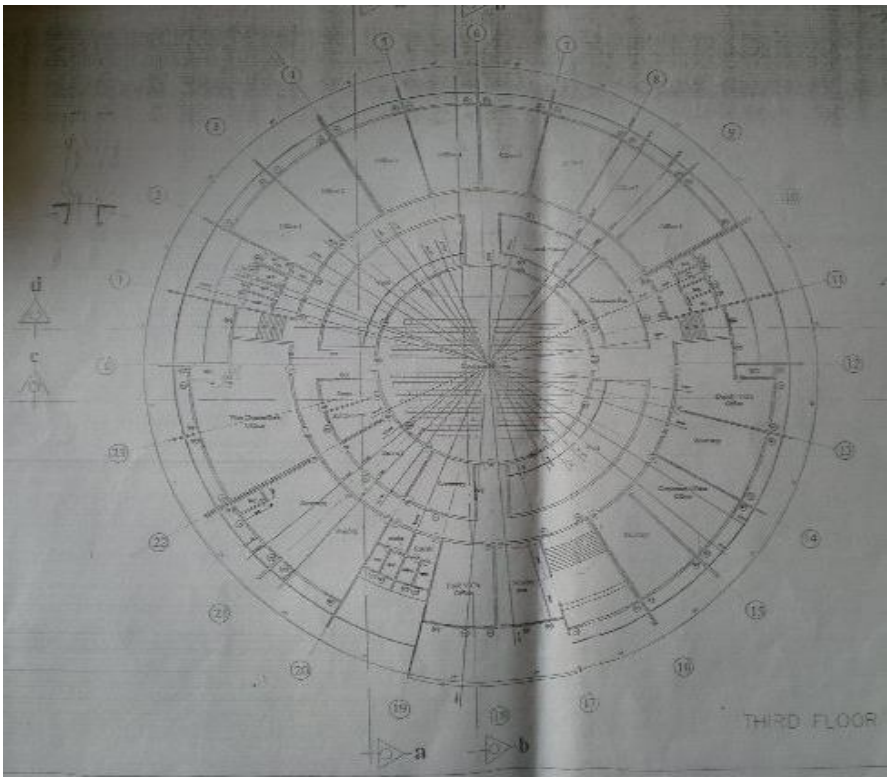
Figure 4.3 Google Map Showing LAUTECH Senate Building



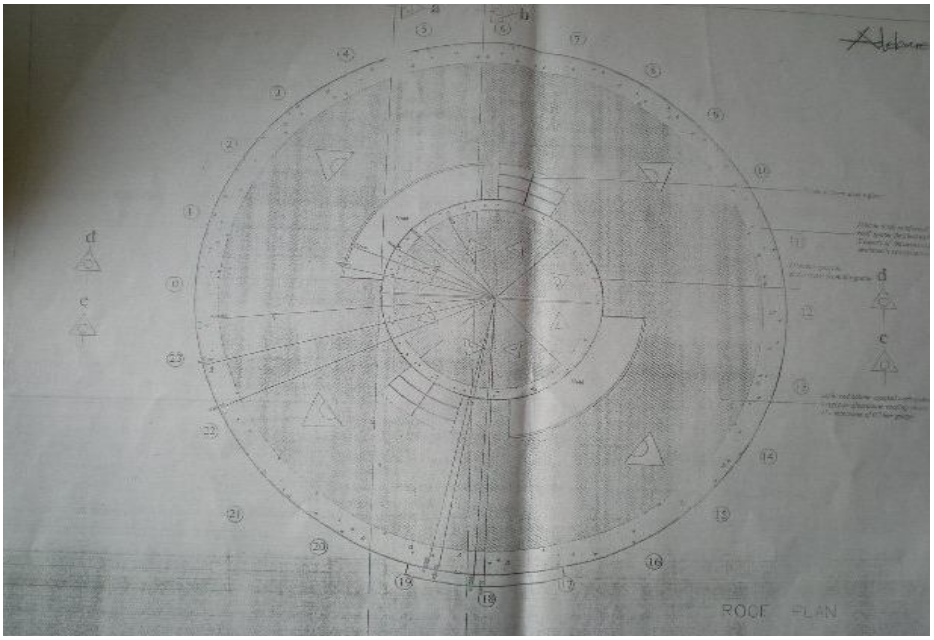
(A) Ground Floor Plan



(B) First Floor Plan



(B) Second Floor Plan



(C) Roof Plan

Plate 4.6: Picture of LAUTECH senate building floor plans



(A) Approach View



(B) Picture Showing The Courtyard



(C) Picture Showing The Courtyard

Plate 4.7: pictures of LAUTECH senate building views

4.4.5 MAHAWELI MINISTRY BUILDING, COLOMBO, SRI LANKA

A Bioclimatic office building design for natural lighting and ventilation that is of twelve (12) storey. The twelve storey state mortgage bank building that is now known as Mahaweli ministry building in Colombo, Sri Lanka. This building was designed by the late Asian architect called Geoffrey Bawa in 1972, which incorporated many environmental responsive design principles long before the buzz words of bioclimatic and sustainable architecture become common place. The building houses the mortgage bank on the ground floor and the offices at the upper floors. The two (2) topmost floors are shielded by a floating canopy and serve as an office and entertainment suite for the ministry. The roof was designed to serve or is used as Helicopter landing pad for the ministry.

4.5.1 LOCATION;

The building is sited within the highly commercialized district between Barley road and the southern tip of the Beira Lake and overlooks Colombo's Hyde Park in Sri Lanka.

4.5.2 DESIGN APPRAISAL;

i. The design is a purposed made bioclimatic building that uses or emphases on bioclimatic principles.

ii. The roof designed and used as Helicopter landing pad for the ministry is a good architectural master piece.

iii. Office spaces were designed as open plan with a minimum numbers of columns with windows (openings) stretching from column to column to bring natural light and ventilation.

iv. Stair cases, lifts and toilets are located at the perimeter wall.

4.5.3 BIOCLIMATIC PRINCIPLE;

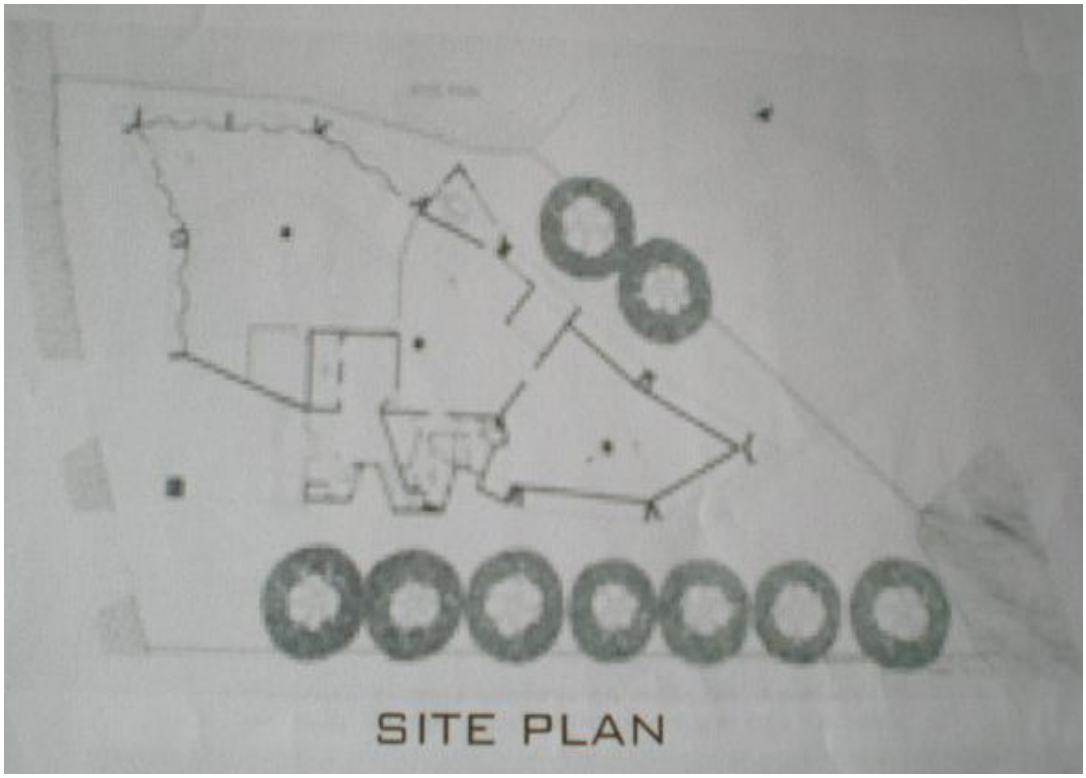
i. Building shape and orientation; the site is awkward and of irregular shape that gave the type of plan that will respond aerodynamically to the prevailing wind while reducing solar gain.

ii. Natural ventilation and day light; the design allow for cross section that allowed for adequate air movement at different body levels by the provision of larger openings.

4.5.4 DESIGN CRITISICM;

i. Effect of noise and dust that prevent the occupants from opening their windows for natural ventilation.

ii. Sky glare and paper flying about.



(A) Site Plan

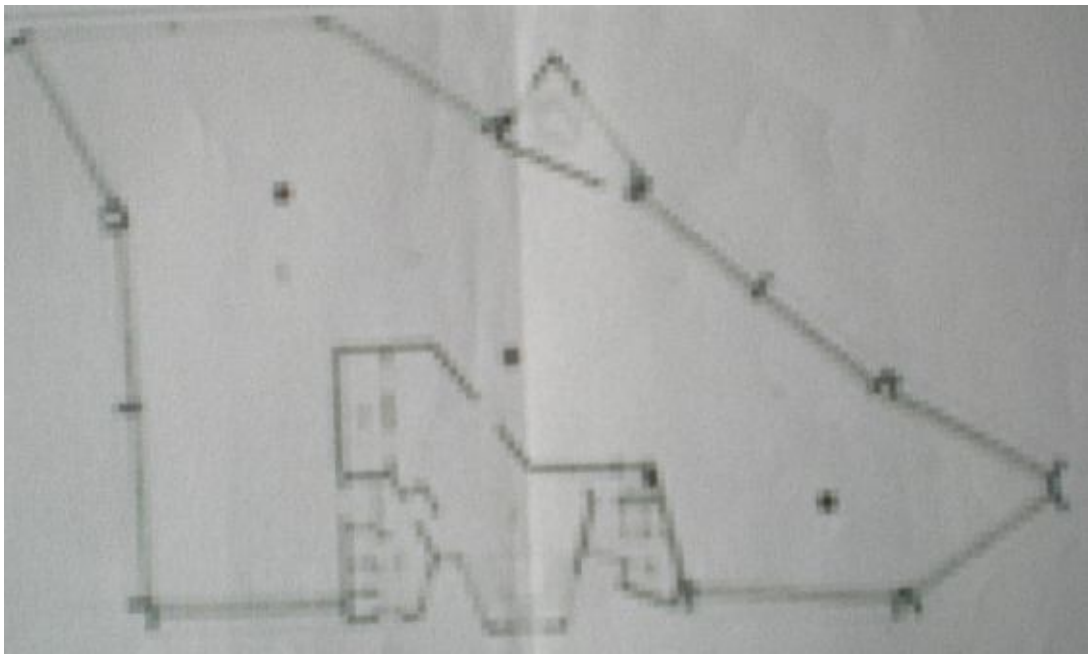


Plate 4.8: Picture of Floor Plan of Mahaweli ministry building, Colombo

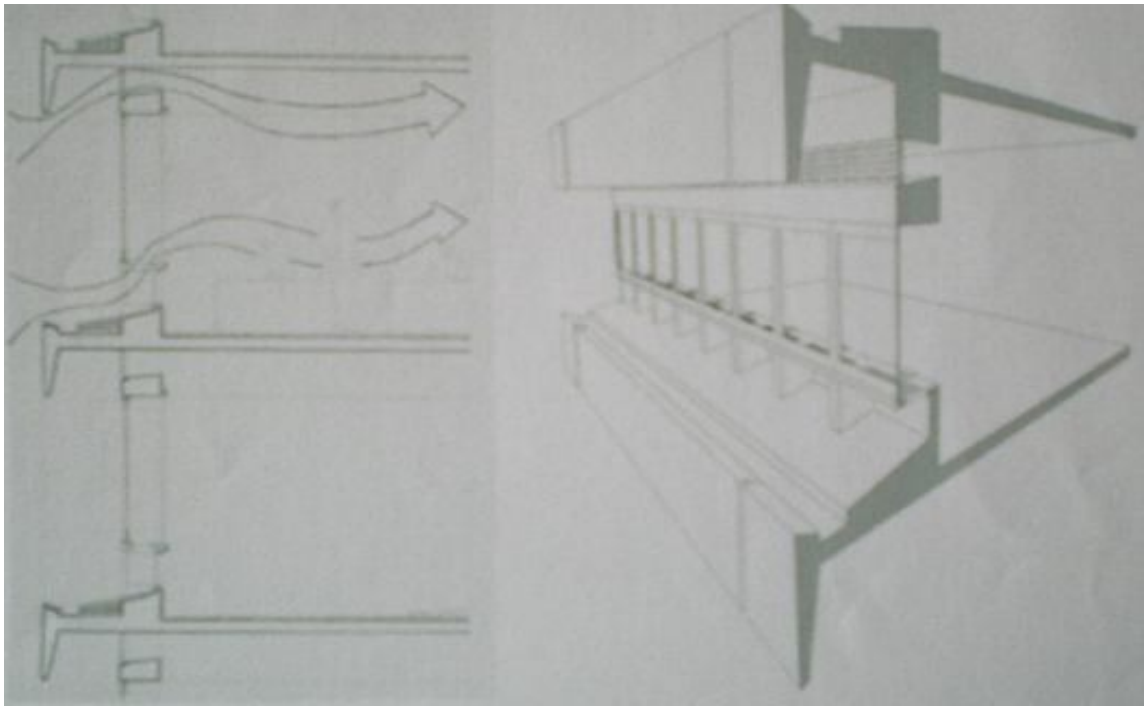


Plate 4.9: Sectional View, Mahaweli ministry building, Colombo



Approach View



Plate 4.10: Site Views of Mahaweli ministry building. Colombo

4.6 GENERAL SUMMARY OF FINDINGS FROM CASE STUDIES

Variables **Bioclimatic principles**	**ABU Zaria**	**NSU Keffi**	**LAUTECH Ogbomosho**	**MMB Colombo**	**Remark**
Site Orientation	50%	60%	50%	65%	Bioclimatic principles where applied to some extended in all the case studies carried out.
Building forms and Shapes	100%	100%	100%	40%	
Provision and position of openings	63%	40%	35%	80%	
Provision of shading devices (Vertical and Horizontal)	80%	40%	55%	80%	

Micro – climate	30%	35%	50%	52%	

Table 4.1: showing summary of findings from case studies.

Source: author's research

4.7 DEDUCTIONS FROM THE CASE STUDIES

Based on careful study and analysis of all the case studies the following was ascertained, they are:

i. The emphasis on building orientation to control and modified wind and solar radiation.

ii. The building form and shape also determined the thermal condition of the building.

iii. Adequate provision and positioning of opening play a vital role in ventilation and lighting.

iv. Effective use of shading devices both vertical and horizontal.

v. Micro climate determine the comfort condition of the building.

CHAPTER FIVE

5.0 PHYSICAL CHARACTERISTIC OF STUDY AREA.

The project is to be sited at Nasarawa state University, Keffi campus. Keffi, the Headquarter of Keffi Local Government Area. And one of the thirteen local government area of Nasarawa State.

5.1 SITE LOCATION

The site chosen for the location of this project is the main campus of Nasarawa State University, Keffi it is located on Longitude +7.88=>$7^0$52,48" E and Latitude of +8.84=> $8^0$50,24" N with a time zone of UTC +1hour (NASA,2002) the site is located in area demarcated for senate building by the blaming department of the institution.



Figure 5.1: Map of Nigeria showing the location of Nasarawa State.

Source: Zakari, 2010



Figure 5.2: Map of Nigeria and Nasarawa State.

Source: Zakari, 2010

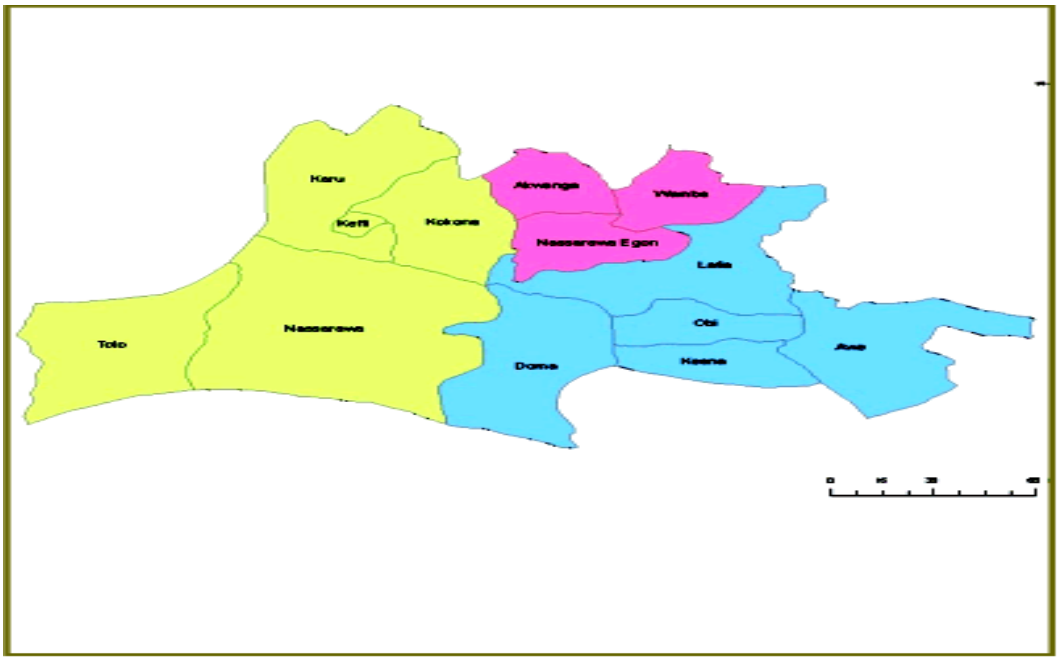


Figure 5.3: Map of Nasarawa State showing Keffi L.G.A

Source: Zakari, 2010



Figure 5.4: Map of Keffi L.G.A showing the location of Nasaraswa State University

Source: Zakari, 2010



Figure 5.5: Google Map showing the proposed site

Source: Google Map

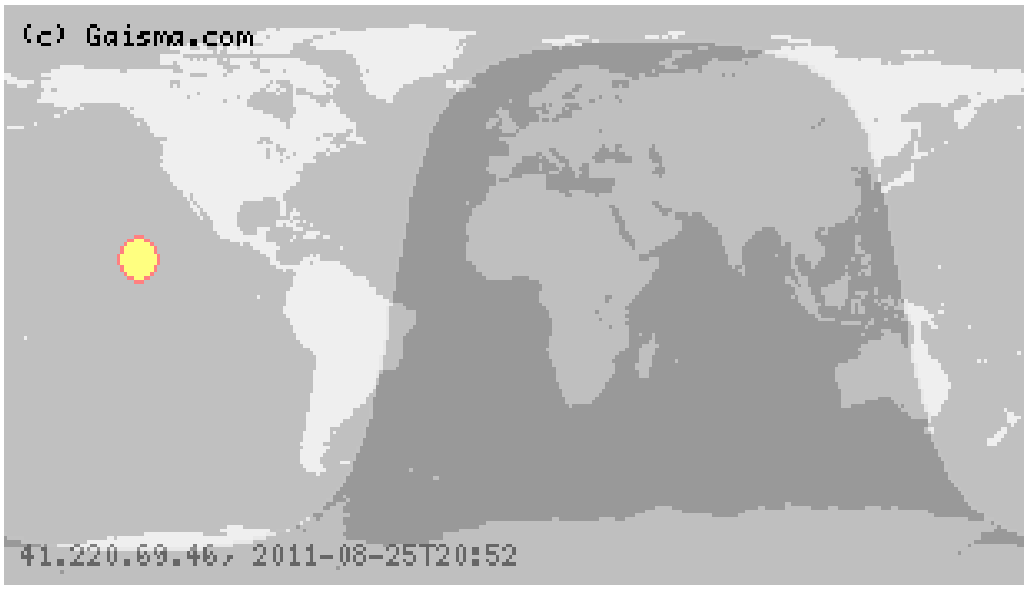


Figure 5.6: Location of Keffi Town

Source: GAISMA

5.2 SITE SELECTION

The site of the proposed senate building was established by the planning authority of the institution that is Nasarawa State University base on their panning concept.

The site was selected based on the following criteria:

a. ACCESSIBILITY

The site is easily accessible because of the proximity to the major road (Keffi-Akwanga road) that run through the front of the university and from which the major entrance to the university is located. The road to the site is tarred making it easy to vehicular access.

b. AVAILABILITY OF LAND:

Senate building being the centre of administration and the heart of the university, there is need fro a very large plot of land to allow for flexibility, expansion, landscaping and sufficient parking facilities. These are major consideration in senate building design. The selected site is large enough to allow for the actualization of the project.

c. TOPOGRAPHY AND LANDSCAPE FEATURES

The site has good topographical features such as contours, which influence the site damage system. The site is of clay-loamy which make it stable to ensure minicost on foundation. The site consists of scanty landscaping such as planted trees and some landscaping features of relatively flat lands with little grasses.

5.3 CLIMATIC DATA

The climate of Keffi, Nasarawa State is characterize to be hot humid climate that influence the variation in good weather condition of the area inform of rainfall, temperature, and variation, humidity rate and show climate factors.

Keffi experiences two (2) main seasons. The wet season start from April to September and the dry season start from October to March. Each of this season, is characterized by a specific type of prevailing wind. The wet season brings with south-west trade wind originating from the equatorial belt and blowing from the high pressure zone which occur over the Atlantic during this period. The dry season is accompanied by the harmattan, a dust laden wind blowing from the east.

5.3.1 RAINFALL

Nasarawa State University, Keffi which is the proposed site is located in Keffi town of Nasarawa state. It is within the middle area of Nigeria. It has two (2) main seasons which are the wet and the dry seasons. The wet season is from the month of April to the month of October and the dry season start from the month of November to the month of March.

Keffi recorded the highest amount of rainfall within the months of July and September with the precipitation value ranging between 209mm and 229mm.The lowest amount of rainfall usually occurred between the November and February and can be as low as between 0.0mm to 3mm

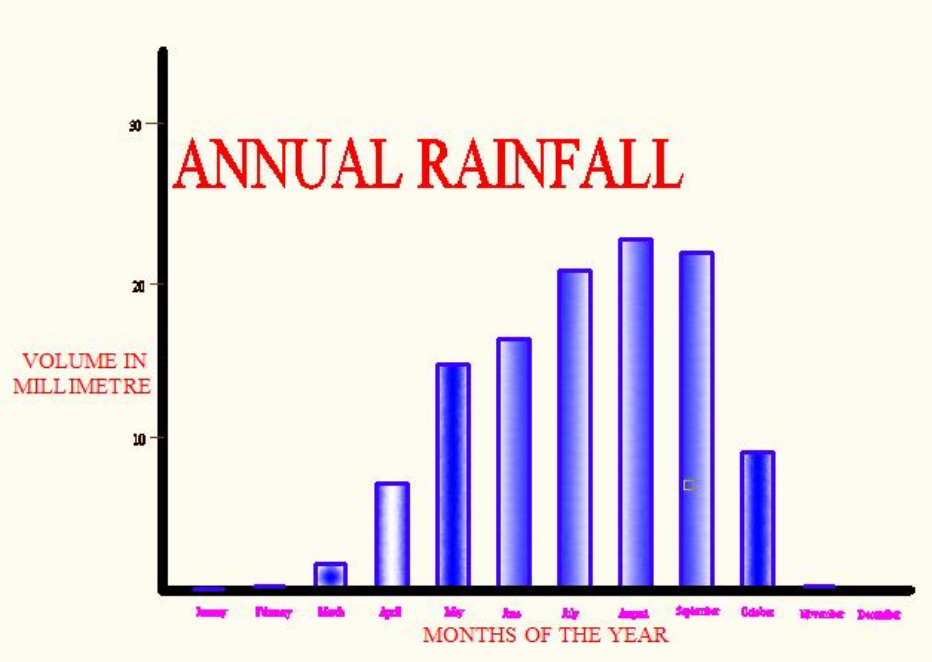


FIGURE 5.7: Chat showing annual rainfall

Source: Author

5.3.2 TEMPERATURE

The maximum monthly mean temperature is 30.54oc while 22.69oc is the minimum monthly mean temperature. The hottest period of the year is between middle December and middle of May with the maximum and minimum temperature of 30.54oc and 26.53oc respectively.

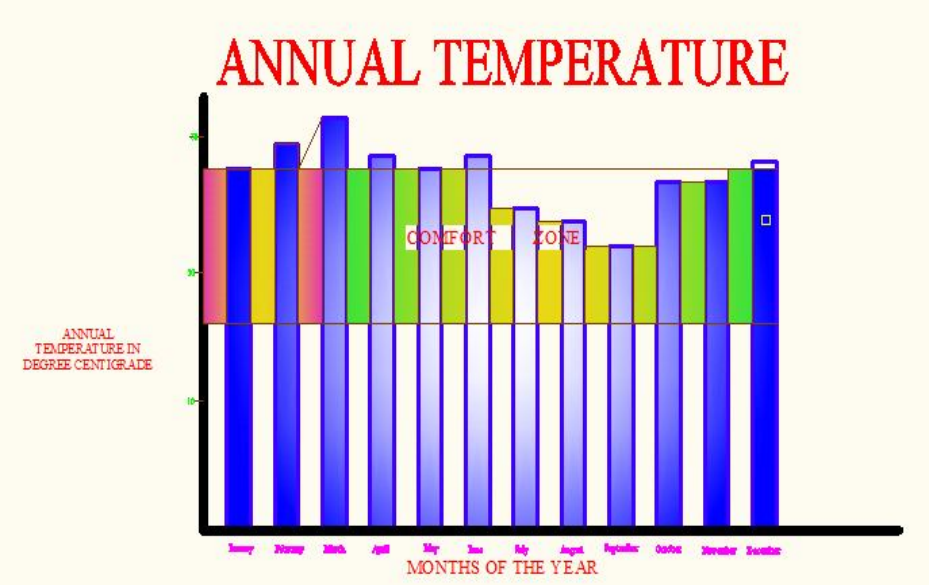


Figure 5.8: Chat showing temperature

Source: Author

5.3.3 WIND

The two most prevailing winds experienced are the North-East trade wind that brings harmattan, a dust laden wind blowing from the desert between the month of November and February and the South-west trade wind that is humid in nature and brings the cool breeze air from the Atlantic Ocean between the months of March and October . The breeze brings about the rainfall.

The wind speed within Keffi area ranges between2.97m/s to 3.86m/s (m=meter and s=second) with the maximum speed occurring at the month of March and the minimum speed occurring in the month of October.

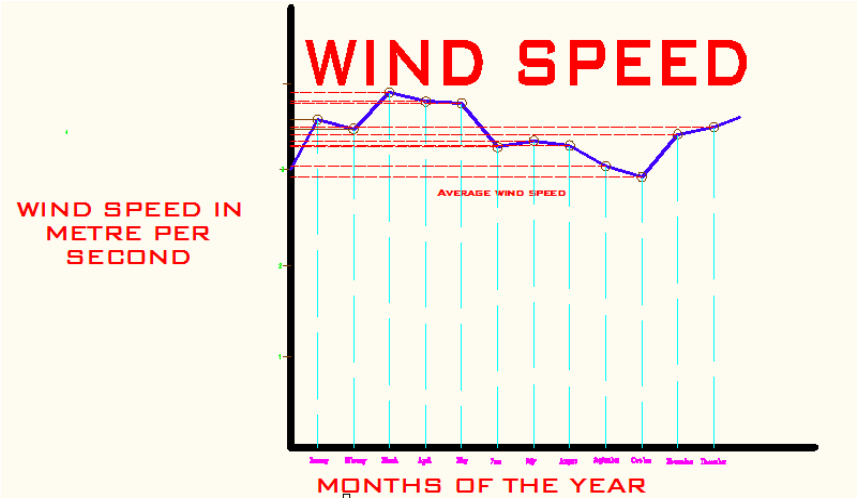


Figure 5.9: Graph showing wind speed.

Source: Author

5.3.4 RELATIVE HUMIDITY;

Due to the present of rivers and lakes around Keffi town, it records a very high humidity especially during rainy or wet season with about 81 percent in the morning (April to August). The lowest average humidity is experienced during the dry season (December to March) influenced by harmattan wind that reduces it to the average percentage of 31 and the seasonal variation of 65 percent.

5.3.5 SUNSHINE AND RADIATION;

Keffi, a tropical city experiences a lot of sunshine. The hours of bright sunshine are greater during the months of November to April. The average daily sunshine period of six to seven hours is observed and the lowest sunshine is in the months of July and October. Radiation brings about glare effect which should be guided against in design. To this, effective orientation of building and possible shading devices should be provided to check glare problem.

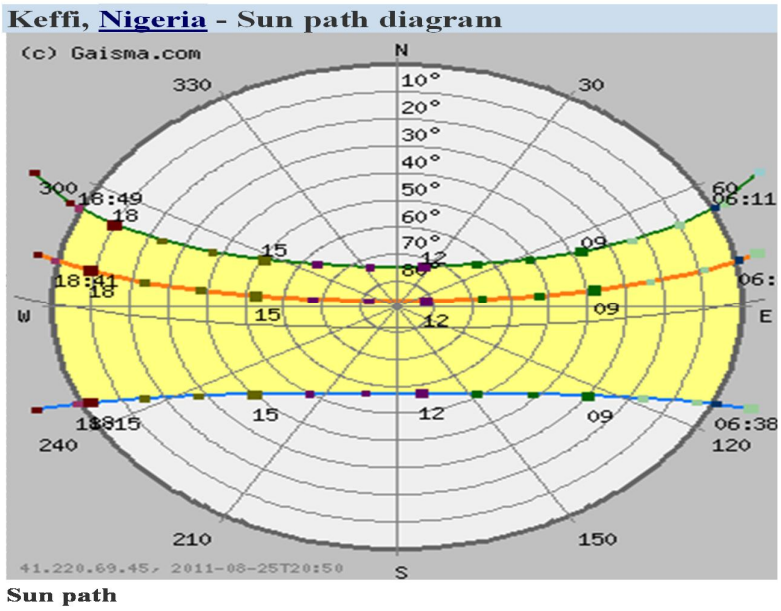


Figure 4.10: Sun path diagram of the site

Source: GAISMA

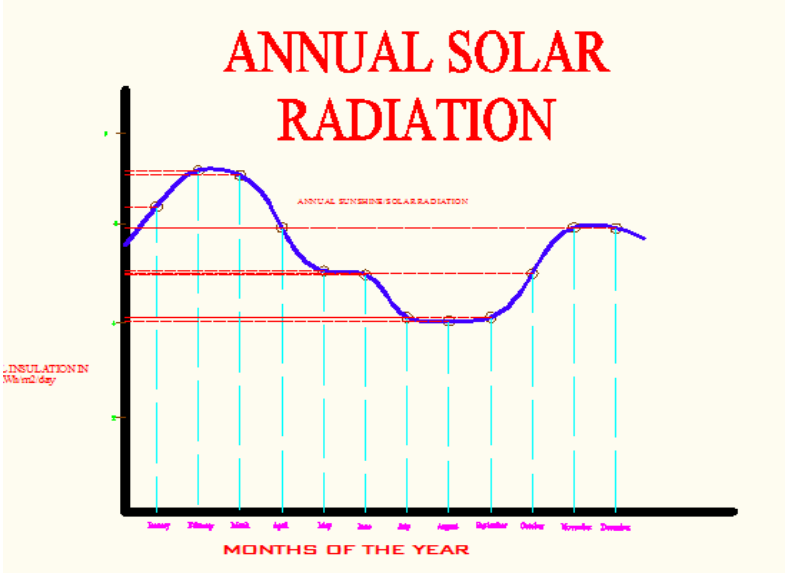


Figure 5.11: Graph showing solar radiation

Source: Author

5.3.6 GEOLOGY;

Keffi and its surrounding area are underlain by igneous and metamorphic rocks belonging to the basement complex. The complex is mainly of granite, mica, marble and meta-segments. The area features a gentle terrain with scanty landscape with geological alluvium of loamy clay nature.



Plate 5.1: Showing the soil formation of the proposed site

Source: Author

5.3.7 VEGETATION;

The site consists mostly of grasses with sparsely spread clusters of trees mostly of perennial foliage.

The site requires more vegetation to enhance microclimate of the area to influence comfort.



Plate 5.2: Showing the grasses and trees in the proposed site

Source: Author

CHAPTER SIX

6.0 DESIGN PROPOSAL AND REPORT

6.1 BIOCLIMATIC DESIGN PROPOSAL

This chapter deals with the description of architectural response to the design of a senate Building (Administrative building) in general and the application of the bioclimatic principles to structure. The senate building was design primarily to tackle the challenges of design by solving the planning demands of spaces and circulation as well as utilizing the bioclimatic principles to reduce energy consumption in the building and also creating bioclimatic comfort strategies to improve the indoor environmental qualities for the general comfort of the building and the occupants.

6.2. BIOCLIMATIC DESIGN ELEMENT

The Bioclimatic design principle used in the building has the following objectives:

i. Reduction and control of solar radiation.

ii. The provision of natural ventilation for natural cooling of the indoor environment and the building enveloped.

These objectives were achieved through the following:

i. Minimizing the surface area of exposed facade

ii. Avoidance of excessive heat gain and

iii. The use of the roofs as active skin

Base on the above mentioned factors. Bioclimatic principles were applied in the design of the proposed Senate Building to reduce energy consumption, to create comfort in the building.

6.3 BIOCLIMATIC PRINCIPLES APPLIED TO DESIGN

6.3.1 BIOCLIMATIC ORIENTATION AND FORM

The shape of the building was defined by the site micro-climate, which is the geography of the immediate environment of consideration. The shape of the building determined adopted to utilize the aerodynamics for improved wind speed around the building for ventilation purpose.

The building orientation is along the north-south axis to reduce the area of exposed facades, to direct solar radiation from the sum. The building used the end-core strategy for the positioning of the functional spaces, by placing auxiliary space of lifts, stairs, and so on, on the easily accessible location.

The design seeks to balance the various requirements of Senate Building taking into account, the reduction of energy consumption using the bioclimatic principle to achieve comfort in both outdoor and indoor function.

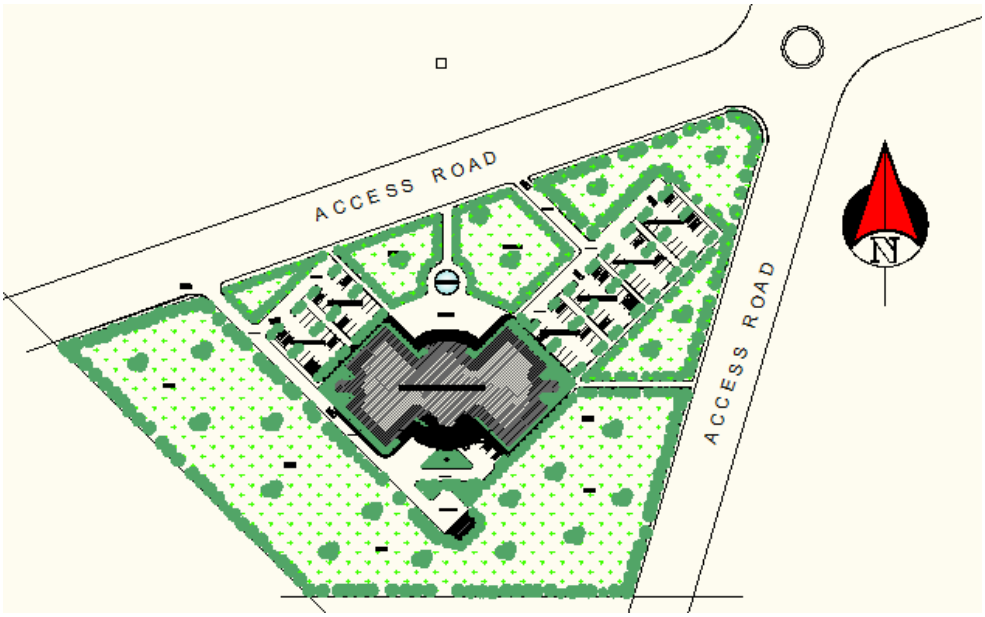


Figure 6.10: Site plan of the proposed senate building showing the building orientation

SITE PLAN

In order to fulfill all principles of Bioclimate, the building site plan to start with, was preplanned in orientation to maximize the reception of North Lighting and the use of large foliage plant and cover crops are aimed at achieving the bioclimatic principles. also the use of green

6.3.2 CLIMATIC ANALYSIS

The environmental approach of the design proposal is directly linked to the selection of bioclimatic design principles that were derived from the climatic analysis of the proposed area.

The climate of Keffi is characterized by wet and dry seasons, consequently, during the heating period, the contribution of solar radiation to the passive heating of the interior spaces. The radiation of conventional energy consumption for heating is very important.

During the hot, that is the dry season, the climate is characterized as hot and dry and the selected bioclimatic strategies are primarily efficient for shading and providing natural ventilation, as well as exploitation of the building's high thermal mass.

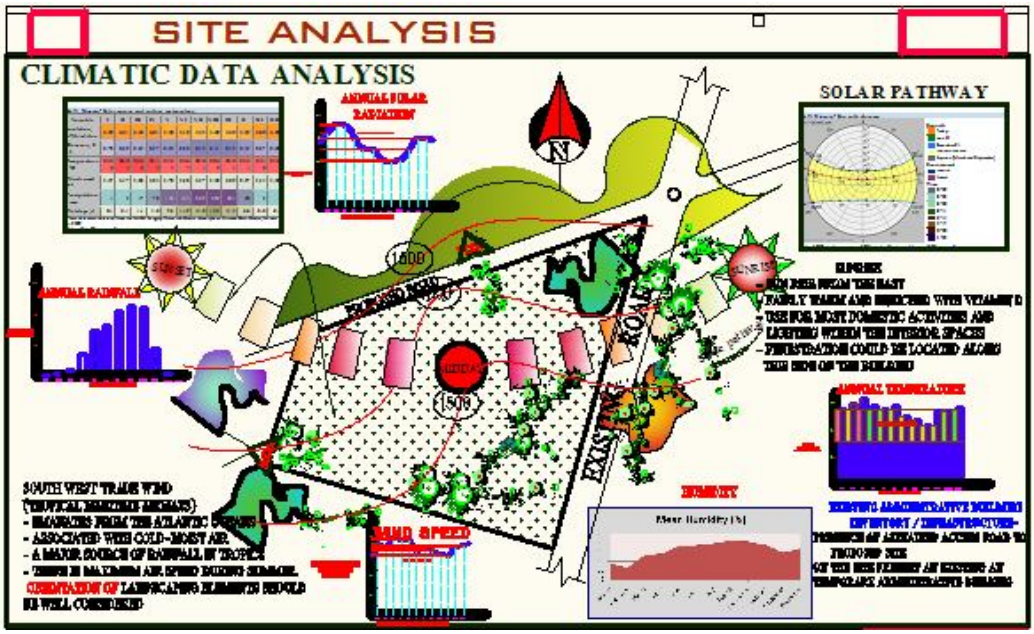


Figure 6.11: : Site analysis of the proposed senate building showing climatic data

The design explore the microclimatic data obtained about the Lafia (Nasarawa) regional climate. Hanessing the wind direction to venetilate throught effective positioning of fenestrations and the use of architectural design techniqes example the use of window staking helps to bring thermally conducive enverionment in the senate building design.

6.3.3 ENVIRONMENTAL FAÇADE/DOUBLE SKIN

In attempt to improve internal indoor environment, the design used this principle of environmental façade on the north and south façade to reduce the amount of solar energy as well as heat gained through the building envelope to create comfort.

The building envelope of environmental façade is designed to have two layers of insulation with growth (landscape element) around the building exterior and a Teflon Coated Fabric Parchments placed at some areas on the north and south facades of the building. The Teflon coated Fabrics greatly reduced the solar insulation (solar energy) into building without negating or affecting the ventilation due to double skin placement design.

The innovation principles of the building elements as used in the façade design include but not limited to the following:

i. Teflon Coated Fabrics, which reduce U-shape

ii. Vertical Landscape

iii. Air space between the Verticals Landscape and Teflon Coated Fabric facade cooling.

6.3.4 WALL INSULATION

Thermal Insulation was the feature that was considered in the design of curtain walls used in the building. This was done primarily to prevent heat conduction to the indoor environment through the walls (heat/energy reduction using wall insulation).

As a measure, the wall is a composite element comprising of the polystyrene core braced with iron mesh to receive sprayed concrete finishing on both the interior and the exterior.

6.3.5 INTEGRATION OF RENEWABLE ENERGY

Application of bioclimatic principles in the design of proposed Senate Building is expected to improve the general comfort within the building, through acclimatizing the building and also to reduce energy consumption of the building, to reduce gain within the building.

During the cooling period, the shading of the glazed surfaces of the building mainly depends on their orientation. East facing surfaces are shaded by external, vertical, reflective louvers, which block solar radiation, whereas the south facing elements are shaded from the direct solar radiation by proper structure and geometry. The south facing façade of the central courtyard is also shaded by external horizontal balconies.

The enhanced natural ventilation of the building is primarily achieved with its placement at an angle to the prevailing wind. The central courtyards space plays an important role in the overall ventilation of the building during the dry season (hot period), as the opening of the sky lights promotes stack ventilation (Bernoulli Effect). The same principles are applied for the offices in the upper storey.

6.3.6 SIZES AND POSITION OF OPENINGS

There is also the possibility of cross ventilation which will be promoted with operable ventilation openings placed on the partitions and external walls of the offices to the courtyard and the external environment. During the night time, when environmental temperature is lower, the ventilation rates increases that assures the adequate cooling of the building's thermal mass, that is concrete slab and building shell.

6.3.7 MICRO-CLIMATIC MODIFICATION

The surrounding open space will be appropriately design in order to promote both the wet and the dry season's micro-climatic conditions. The existing trees are preserved and the proposed vegetation involving local or indigenous plants, which will be able to withstand

local dry season conditions, that is increase temperature and lack of water.

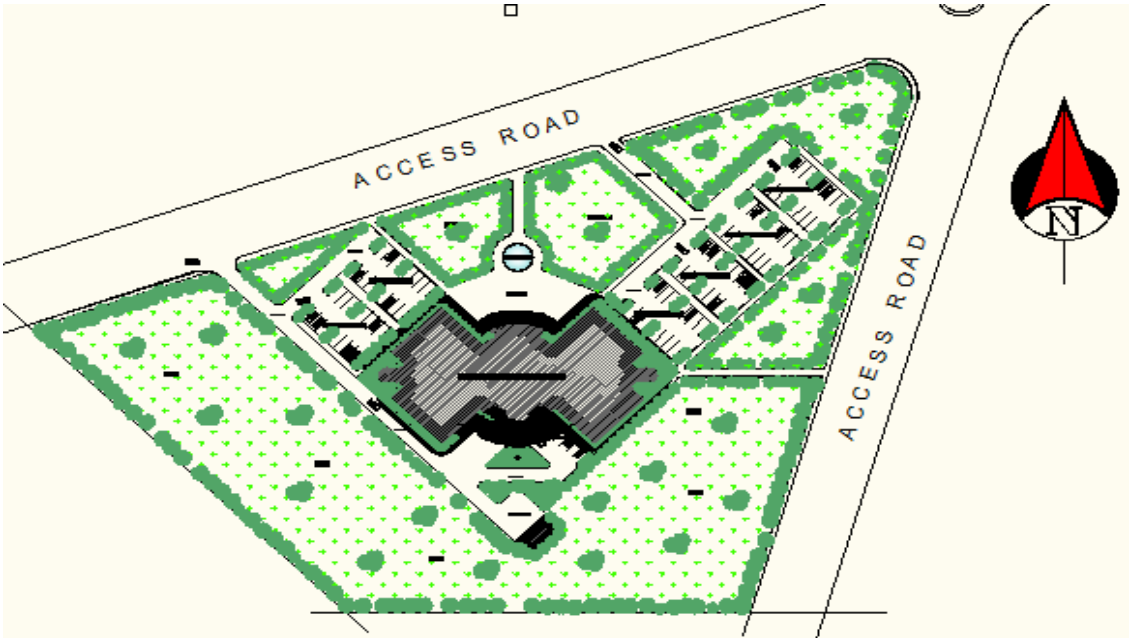


Figure 6.12: Site plan of the proposed senate building showing the building orientation

The site plan was done in order to integrate the building to the surrounding and existing school facilities, walkways linking all department and students activity to the building. The building impact accessment to others surrounding building are carefully considered in the planning the site.

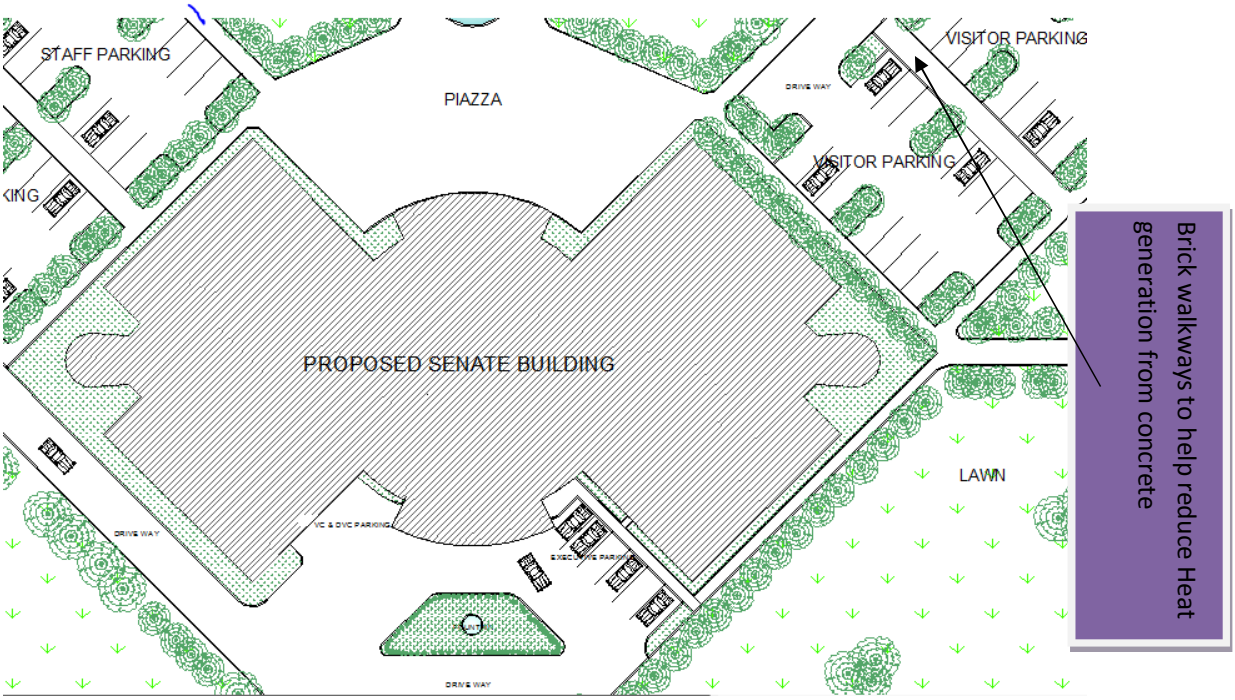


Figure 6.13: Site plan of the proposed senate building showing the building orientation

The design provides varieties of vehicular and pedestrian links to enhance circulation, landscape protected or guided by the use of burnt bricks interlocking walkways that helps to minimizes heat transmittance into the building, bricks were known to be poor heat conductor. The use of private drive way separating the public and the administrative parking spaces to ensure security and plantings to alter micro climate

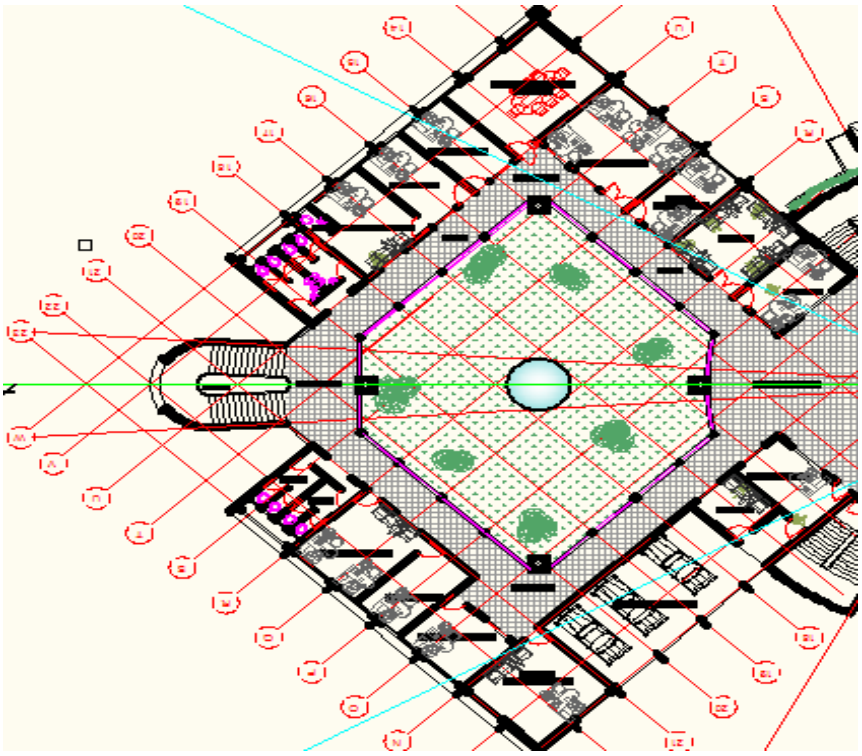


Figure 6.14: Ground Floor plan of the proposed senate building showing the location and size of windows

The design explore the use of non structural fins so as to ensure excessive solar obstruction and severe as excessive wind breaker, helping to maintain interior conducive environment and resultant thermal conducive environment, additional open and wide centrally located courtyard to enhance the overall building ventilation. Ground floor consist of the non essential administrative spaces such as security, reception, account, sport office, general office, alumina relations and development unit etc well linked to each other through the use of lobby around and within the courtyard. It is also serves as the podium, on which the tower stands.

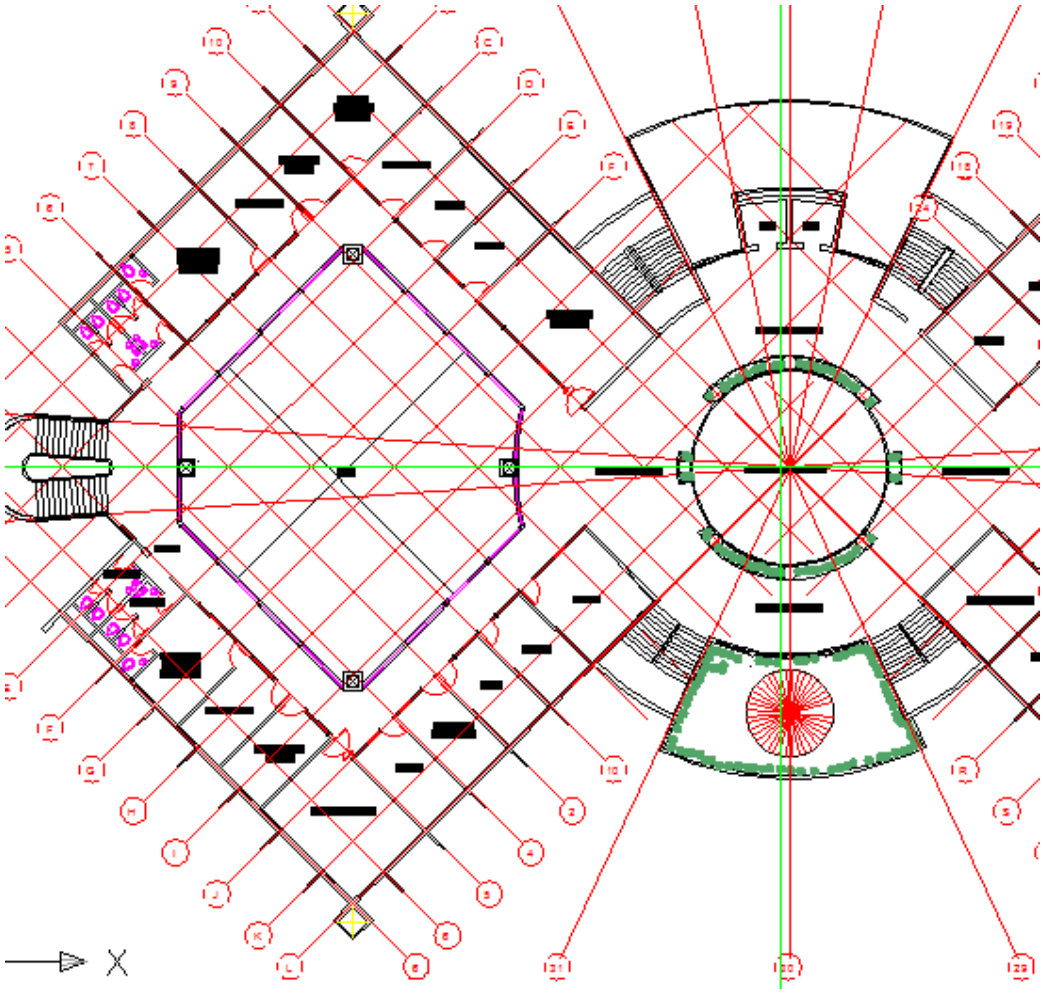


Figure 6.15: First Floor plan of the proposed senate building showing the location and size of windows

First floor plan of the podium floor and creating roof space for green garden that helps to mentaining interior environment temprature by improved air quality of the office spaces, also serving receation at lesiure hours for staff of the university administrative building.

The first floor plan carries the all professional offices such as quantity surveyor, enginers architects etc. Also the DVC office, staff welfare office, exam office, general offices and some alotted offices. All easily accessible for students visitor and staff

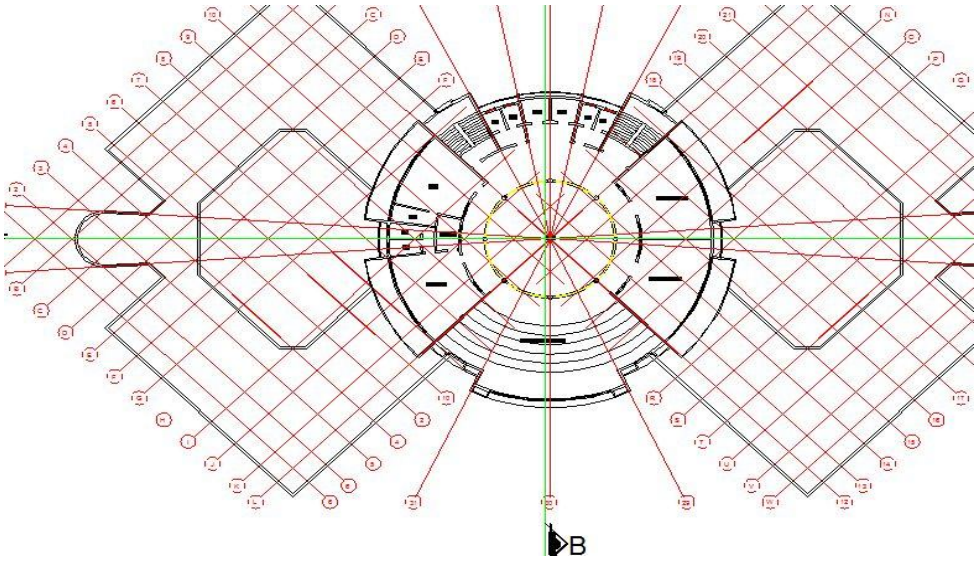


Figure 6.16: Four Floor plan of the proposed senate building.

The fourth floor council chamber, committee rooms, public relation office, lunges and so on. At this level to privacy has been observed to curtail movement of user to the ground level.

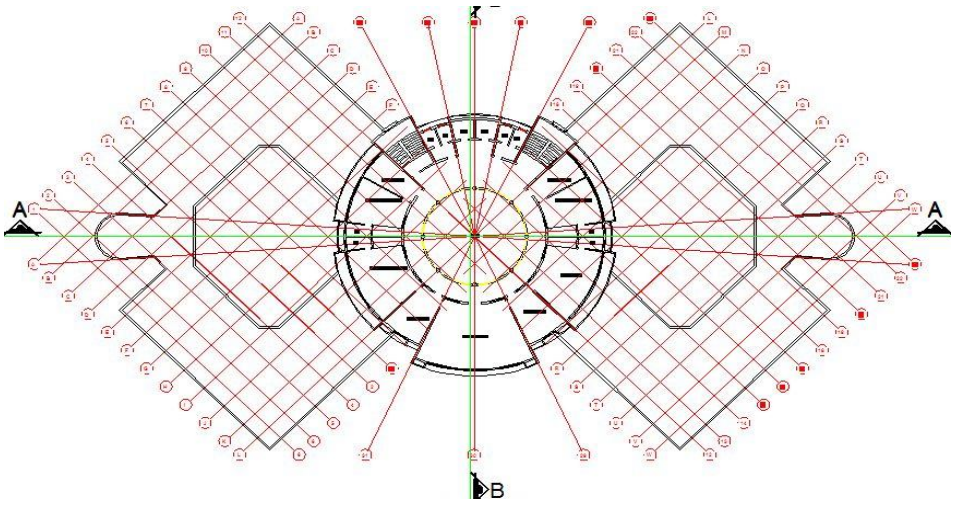


Figure 6.17: Fifth Floor plan of the proposed senate building.

The tower structure reducing the total building surface area and the use of open terraces to enhance ventilation through large and sizable fenestrations. The design at fifth floor contains registrar, executive office, deputy registrar, conference room.

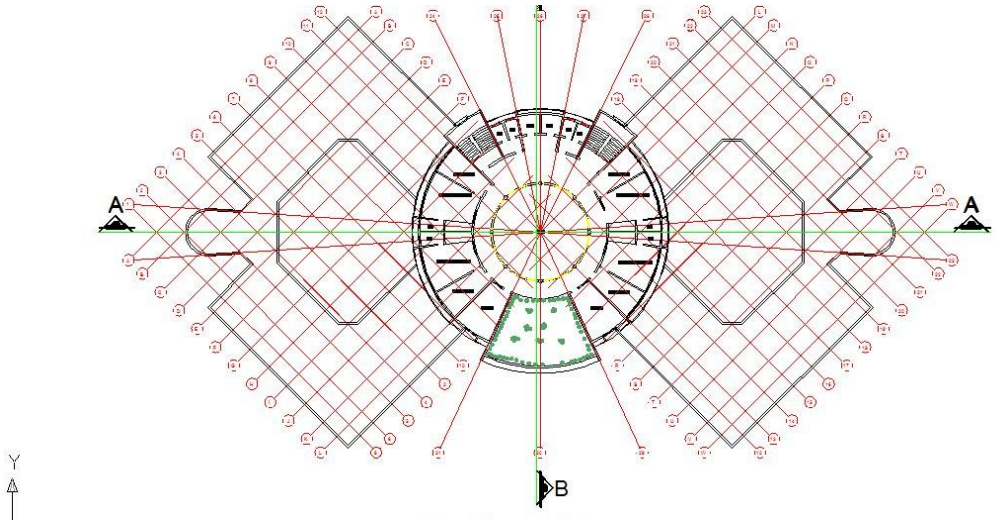


Figure 6.18: Sixth Floor plan of the proposed senate building.

The floor contains the executive offices located far up in the tower that stood over the pavilion.

Showing some level of the privacy at the floor level.

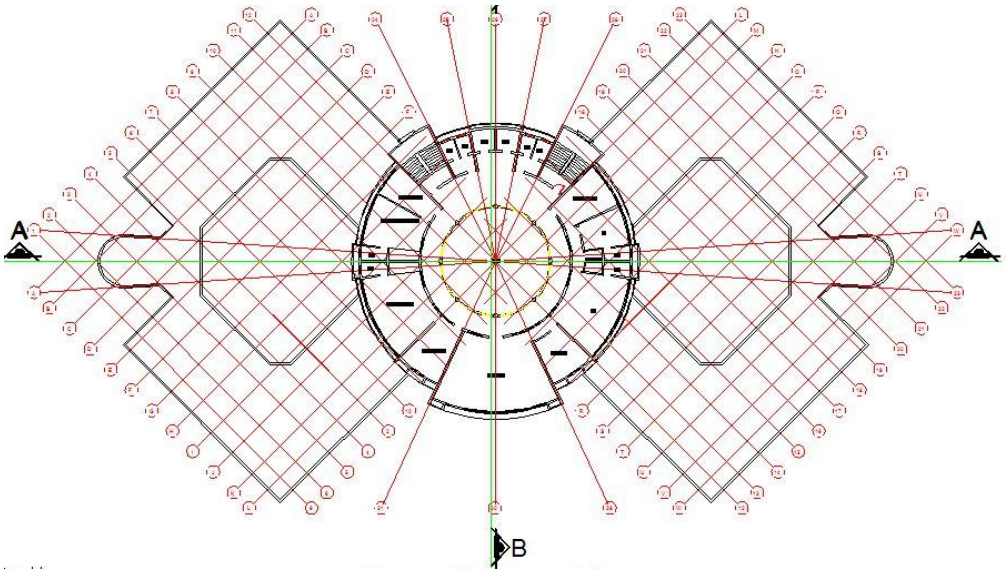


Figure 6.19: Seventh Floor plan of the proposed senate building.

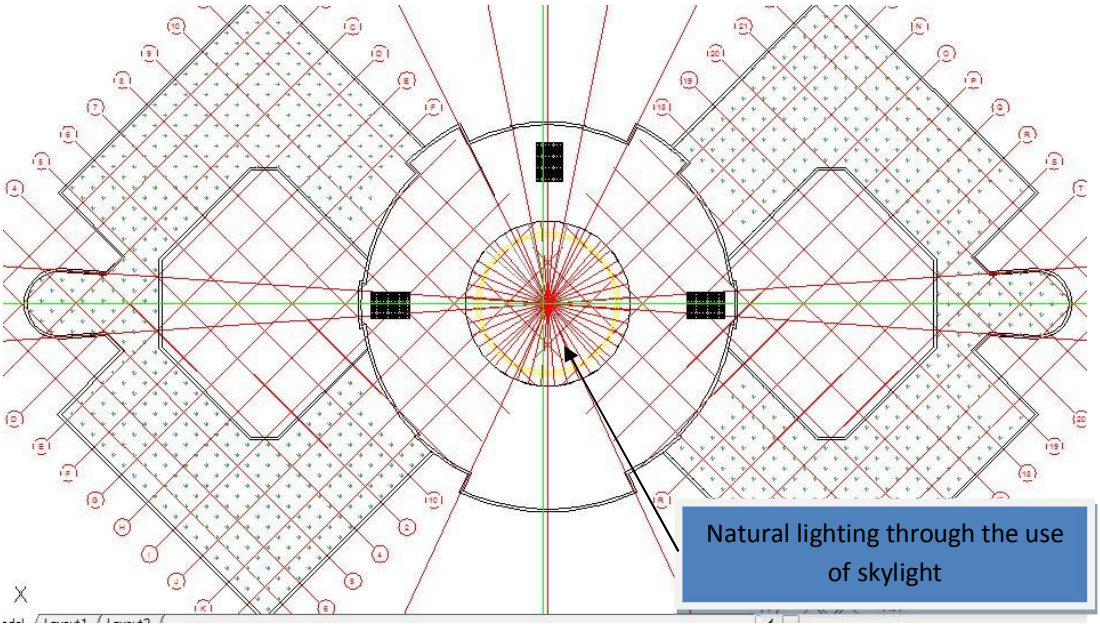


Figure 6.20: Roof Floor plan of the proposed senate building.

6.3.8 SHADING DEVICES

The design adopted balconies and corridors as its shading device system, to exclude direct sunlight from entering the building. The use of independent fins, recess and projection are also used to control and reduce the amount of solar energy into the building. It is also used to break direct effect of wind energy by redirecting as well as reducing same into the building. The design also takes into consideration the use of both vertical and horizontal shading devices.

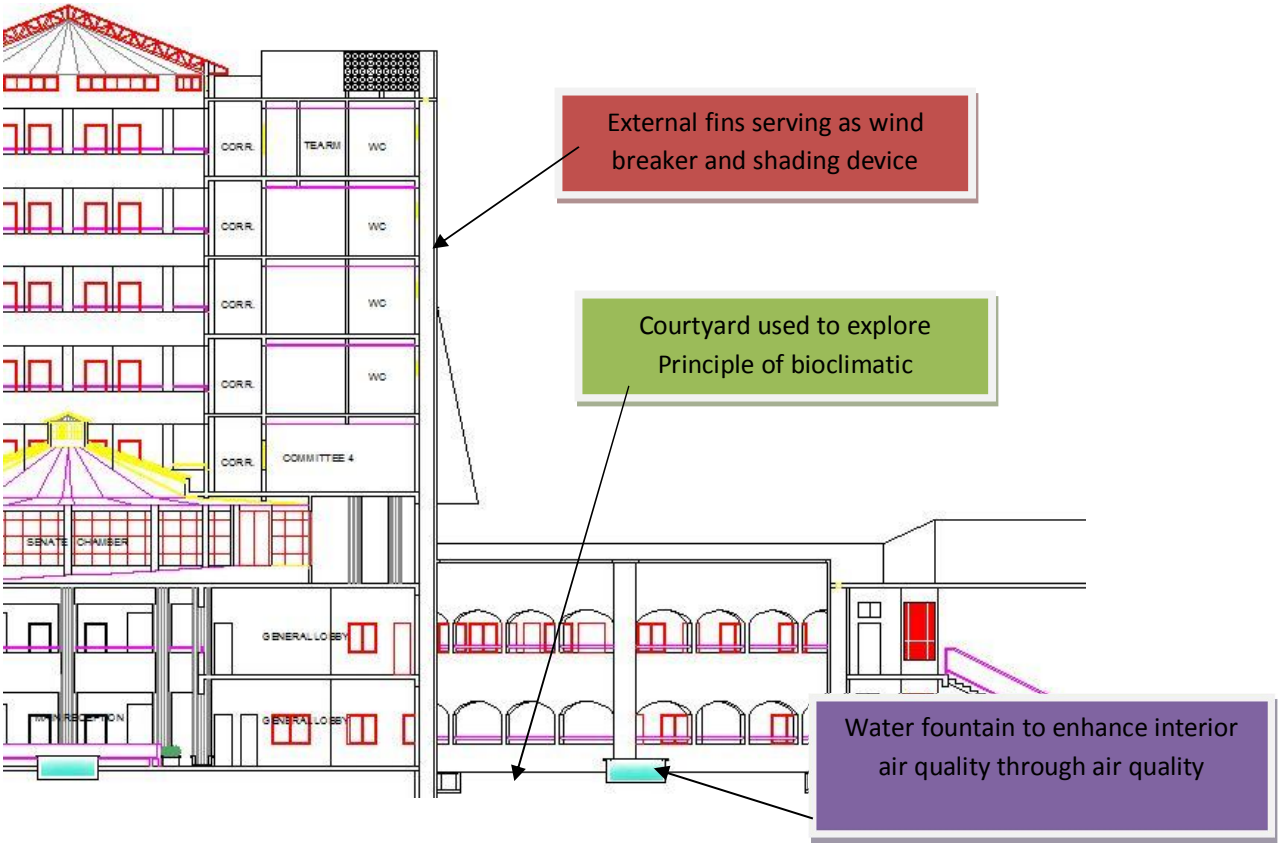


Figure 6.21: Section of the proposed senate building.

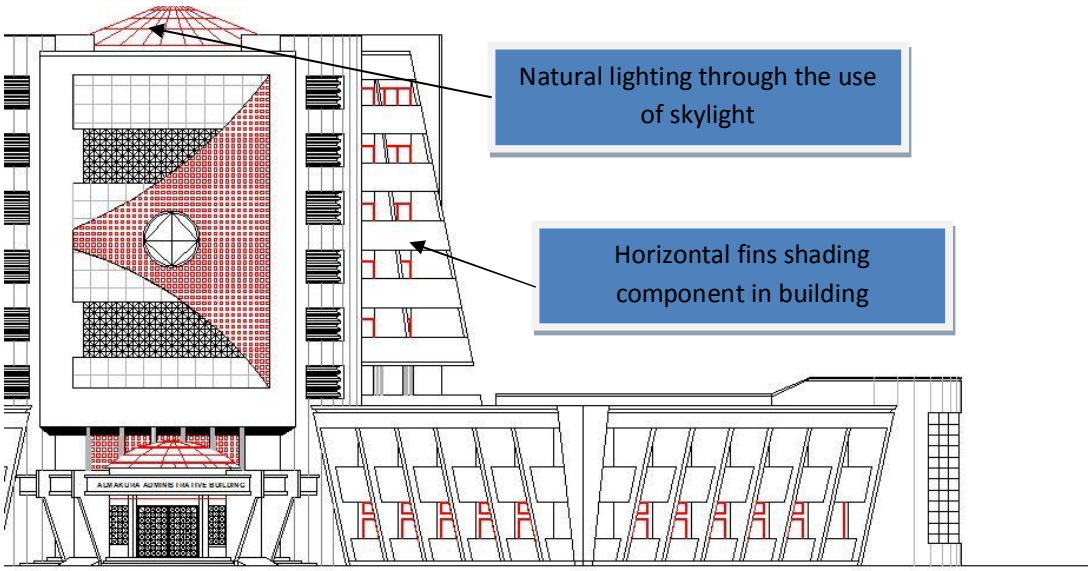


Figure 6.22: North side proposed senate building showing the shading devices.

Brick surface finishes to enhance cooling of the interior space

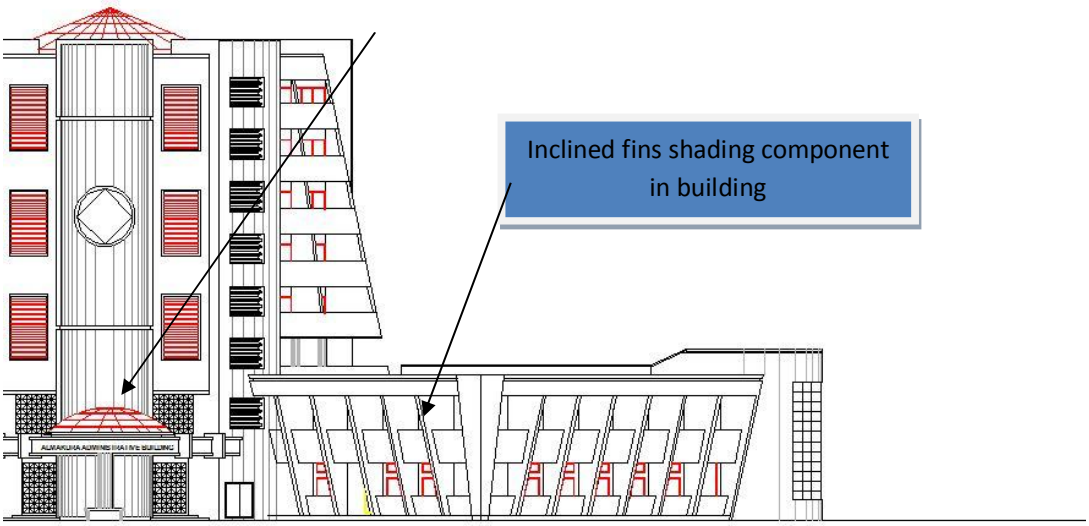


Figure 6.23: South side proposed senate building showing the shading devices.

6.3.9 MATERIALS AND BUILDING TECHNIQUES

The bioclimatic approach to the proposed design of senate building also includes the selection of effective building materials and techniques.

6.4 SITE SELECTION

The senate building site was arrived through a careful site selection influenced by the choice of the school (university) authority to site the building in the given area based on the established map influenced by the following factors:

i. Availability of land and accessibility

ii. Natural landscape features

iii. Topography

iv. Proximity to other university facilities such as research area, staff/students area library and other services.

In view of the aforementioned, that the research conceived the design of the senate building for Nasarawa State University, Keffi which will consist of the staff accommodation that comprises of student/staff area, student affairs department, office of principal officers such as Vice Chancellor, Deputy Vice Chancellor, Bursar and the main senate chamber and other meting areas.

6.5 PLANNING CONCEPT (CRITERIA)

The Planning Concept recommended for the university is the Ring Concept approach or system based on the research's thorough study of the Various Concepts as earlier enumerated in chapter Two.

Ring Concept has been considered basically for the following reasons;

i. The first and the foremost is that, this concept considers Senate Buildings (administrative Buildings) as its main points of emphasis where all other departments actually radiates from. The Senate Building served as the heart of the university where authorities are maintained.

ii. In the Ring Concept the senate is placed at the centre, followed by the academic core, that is, Academic department and facilities, followed by student's hostels and staff quarters and other activities, all going round the senate building in ring form

iii. In Ring Concept Approach, interaction is enhanced within other members of the university community, to greatly reduce the individual distance to the core.

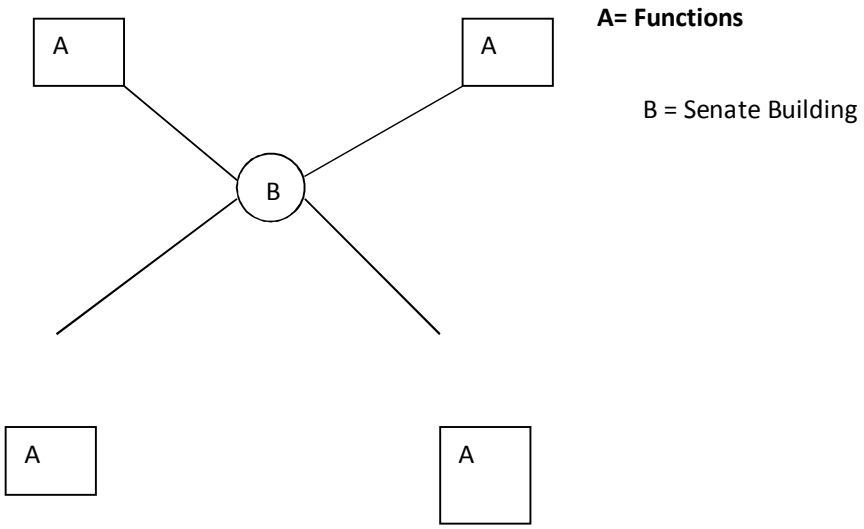


Figure 6.24: Senate building and other functionaries within the university

Source: Author

6.6 SITE CONCEPT (ZONING)

The Site Zoning concept takes into consideration the need for a reduced ecological foot print with the main building taking a composite form and outdoor facilities that has little destruction of the site's ecosystem where sprayed out. The asphalt roads within the site determine the accessibility to the site and limited to the building gate to main entrance leading to the parking lots, having foot paths connecting the different functions or school facilities.

The site area of the senate building was zoned based on the following:

i. Accessibility

ii. Noise control

iii. Functionality (privacy)

6.6.1 ACCESSIBILITY

In the zoning based on the accessibility, the offices that are to be more patronized or frequented are to be more accessible, while those offices for the senior executives are less accessible to people. This helps in regulating the human traffic and therefore determines the location of these offices in terms of location and floor arrangements.

6.6.2 NOISE CONTROL

Offices like Accounts, Students and Staff Registration, Documentation and Accommodation areas are noisy hence need to be located on the ground and the first floors to prevent its closeness to the Principal Officers offices which is quite and requires privacy.

6.6.3 BASED ON FUNCTIONALITY (PRIVACY)

This refers to the strategies and logical location of offices, service core and other functions in the complex or building to achieve harmony and comfort in the usage of the building.

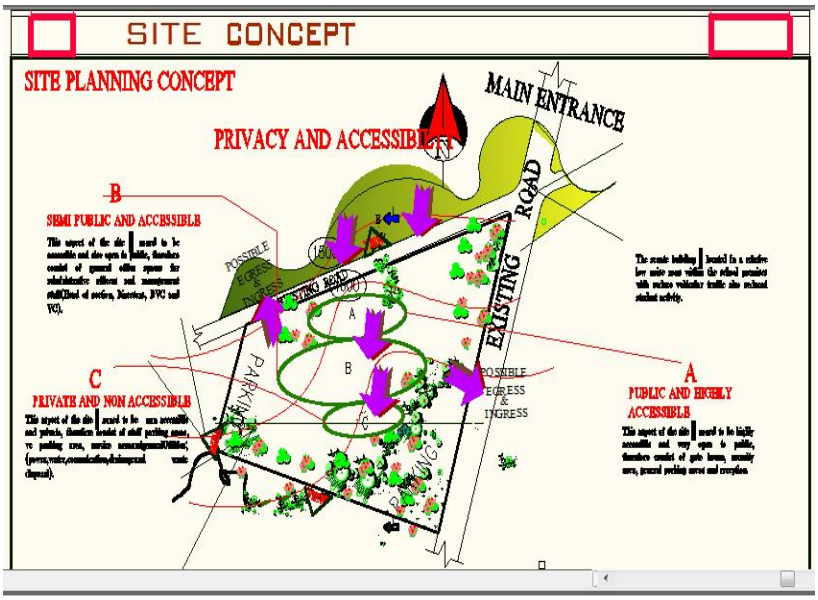


Plate 6.25: site concept showing the site zoning

6.7 DESIGN BRIEF

As earlier mentioned, the design scope shall be based on four (4) major areas, such as follows:

i. Office of the Vice Chancellor

ii. Office of the Registrar (which includes the registry).

iii. Finance Officers Office (Bursary)

iv. The Senate Chambers

6.7.1 OFFICE OF THE VICE CHANCELLOR

The office of the Vice Chancellor shall comprise of the following:

I. Office of the Vice Chancellor

II. Office of the Secretary

III. General Offices for other staff. Example, special assistant and the administrative staff.

IV. Office of the Deputy Vice Chancellor Administration and Confidential Secretary.

V. Office of the Deputy Vice Chancellor Academics and confidential Secretary

6.7.2 OFFICE OF THE REGISTRAR

I. The Registrar and Assistant Registrar's Office

II. Secretary's Office

III. Committee's Room

IV. Dean, student's Affairs/ Secretary.

V. Establishment

VI. Admission section (Academic Office)

6.7.3 OFFICE OF THE FINANCE OFFICERS (BURSARY)

I. Finance Officers Office

II. Secretary

III. Committee's Room

IV. Student Accounts section

V. Staff Accounts Section (Payroll, etc)

6.7.4 SENATE CHAMBERS

I. Senate Chamber fro Meeting

II. Refresh Area

III. Committee's Room

The above are the special arrangements considered in the design proposal. However, more explanation as per size can be seen in the schedule of accommodation below.

6.8 SCHEDULE OF ACCOMMODATION

6.8.1 OFFICE OF THE VICE CHANCELLOR

	FUNCTIONS	AREA (M^2)
I.	Office of the Vice Chancellor	54
II.	Secretary	18
III.	General Office	24
IV.	Deputy Vice Chancellor	36
V.	Secretary to Vice Chancellor	12

6.8.2 STUDENT'S AFFAIRS

I.	Den of students	16	
II.	Secretary's Office		10
III.	Committee's Room		12
IV.	Sport Office		12
V.	Academic Secretary		20
VI.	Secretary' Office		12
VII.	Computer Room		24

6.8.3 EXAMINATION OFFICE

I.	University examination Officer	16	
II.	Secretary's Office		10
III.	General exams Office		24
IV.	Student's Record		24

6.8.4 ESTABLISHMENT DIVISION

I.	Senior Assistant Registrar	24
II.	Secretary's Office	12
III.	Housing and Passage	24

IV.	Officer in Charge		12
V.	General Office	24	
VI.	Staff Office		16
VII.	Secretary's Office		10
VIII.	Intermediate & Junior staff Matters		24

6.8.5 SECRET REGISTRY

I.	Senior Assistant Registrar	16
II.	General Registry	24
III.	Computer Room	24

6.8.6 ADMISSION OFFICE

I.	Admission Office		12
II.	Secretary's Office		10
III.	General Office	12	
IV.	Asst. Admission Officer		
V.	Accommodation Offer	12	

6.8.7 OFFICE OF THE FINANCE OFFICER

I.	Finance Officer	24
II.	Senior Accountant	12
III.	Student's Account	24
IV.	Computer Room	24

6.8.8 STAFF ACCOUNT

I.	Payroll Office	12
II.	General and Advances Office	24
III.	Accountant	12
IV.	Computer Room	24

6.8.9 SENATE CHAMBER

I.	Meeting Chambers	120
II.	Refreshment Area	40
III.	committee Room	40
IV.	Kitchenette	24
V.	Conveniences	12

6.9. DESIGN CONCEPT

The design of the Senate Building for Nasarawa State University, Keffi uses the Bioclimatic Design Principles, which utilizes the understanding of Local climatic features and application of passive principles or strategies in order to achieve energy reduction in consumption and a better comfort condition within the Senate Building and its outdoor environments.

The bioclimatic Design concept used in the design of the Senate Building used the earlier discussed bioclimatic principles to attain the standards concerning thermal comfort relevant to the design of administrative or office building, included in the ASHRAE Standard. (American Society of Heating, Refrigerating and Air Condition Energy).

To achieve an effective energy reduction in building, studies were carried out on the various plan shapes, in relation to different types of energy in the building environment. It was ascertained that various shapes have different energy absorption factors, example, a circular shape absorbs less of solar energy than a square which in turn absorbs less than a triangular shape.

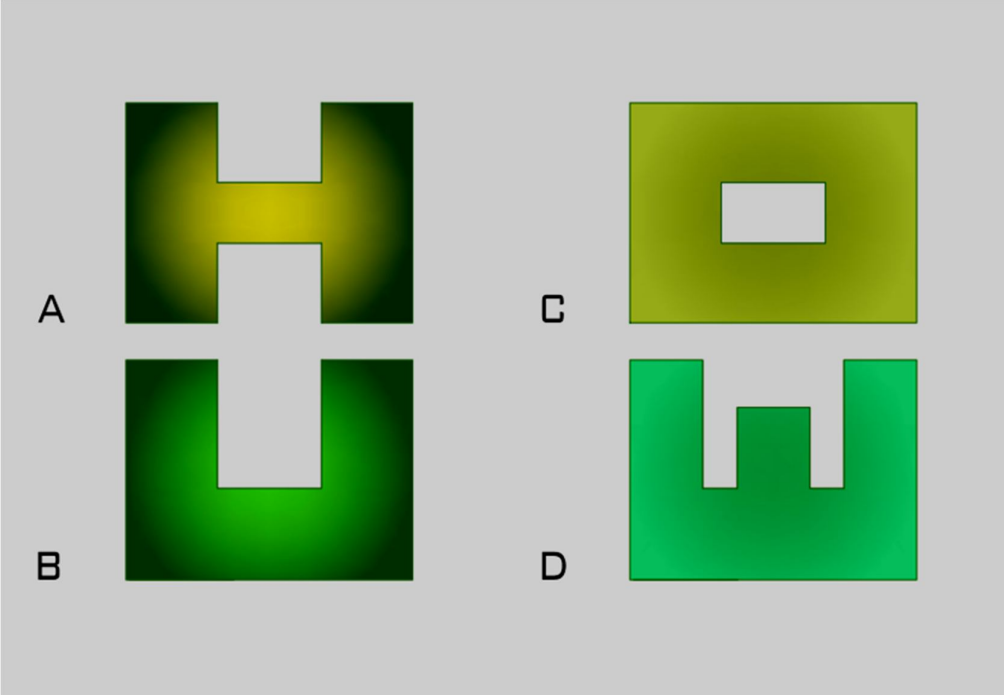


Figure 6.26 Energy efficient Plan Shapes

Source: Hamza, 1998

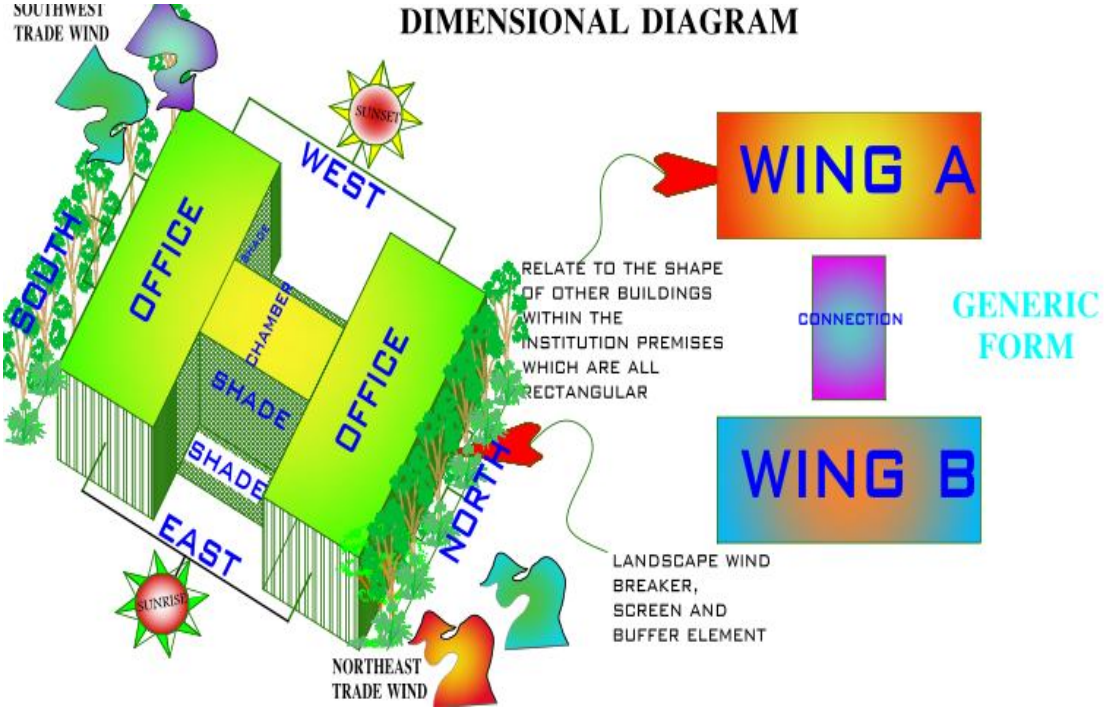
Regarding energy reduction, there are basically four plan types that are more energy effective and efficient than the other. The plan shapes are energy effective and efficient because of the following reasons.

i. The plans encourages shallow planning

ii. It is easier to achieve cross ventilation in the offices

iii. It is also easier for day light penetration into offices.

The H-Concept has been chosen among the plan shapes because of its advantages as explained above.



'H' Concept (proposed) Concept Analysis

Plate 6.27: Proposed concept

6.10 ELEVATIONAL CONCEPT

Concept is define as a "process of obtaining an explicable vocabulary of architectural forms and spatial relationships that is a true refection of the goals and objective of the client as sought to be represented by the building" (UJI, 2002). Therefore the elevational concept will be base on form fellow function.

6.11 DESIGN REPORT

6.11.1 SITE PLAN

The access to the site is through the major road, Keffi- Akwanga road which has been analysed to be the strongest part from which the senate building can be usually appreciated. The site will be access via the minor road linking other function. This is directed to parking areas through which are further link to the complex via a pedestrian movement.

PARKING AREAS

There are four (4) main defined parking areas design to take care of the senate building, they are;

- **i.** The public/visitor parking area located toward the north.
- **ii.** The staff parking area located toward south.
- **iii.** The vice chancellor/executive parking area located toward east, at the rear side.
- **iv.** The service parking area for service area located at the rear and toward eastern pert.

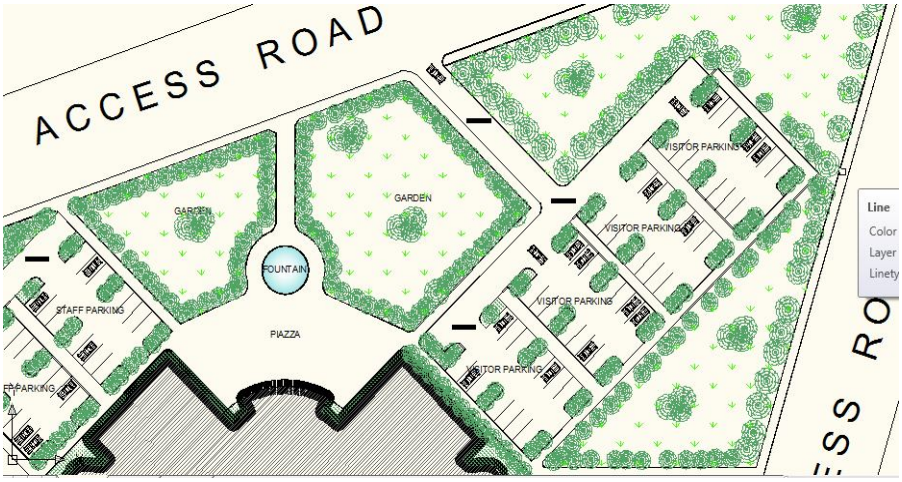


Plate 6.28: Site plan of the proposed senate building showing the parking area

The parking areas will be pave with purposed made clay interlock tiles to enhance absorption of solar radiation and allow soaking surface water. The parking areas are also landscape with ever green trees (umbrella trees) to provide shade to vehicles and the drivers. It also consists of pedestrian walkways leading to the building.

6.11.2 BUILDING DESIGN

The proposed design consists of two office blocks and a senate chamber in between the two blocks forming a later '' **H** '' concept.

Block A and Block C; The blocks consists of offices that are more frequented by students, therefore, consists of offices for general staff and administrative officers of standing departments, such as head of department and other principal officers. The blocks are one storey building connected together by central reception coordinated through courtyards system to enhance ventilation.

Block B; This block consists of reception, senate chamber, committee rooms and executive offices and made of seven storey with reception at the ground floor, senate chamber at the first floor. The block forms the tower with verandah and atrium with adequate provision for stack effect.

6.11.3 BUILDING MATERIALS AND CONSTRUCTION TECHNIQUES

a. WALL CONSTRUCTION

Clay bricks will be used for wall construction because of its weather resistance characteristic, durability and less in weight. Reinforced concrete pillars, fins and beams serves as structural members and the suspended floors are all of reinforced concrete,

b. ROOF

The roof is made of reinforced concrete slab with garden on the two blocks (A and C) to modify the micro-climate. The block C is to be roof with green solar cooling membrane on steel roof skeleton or members.

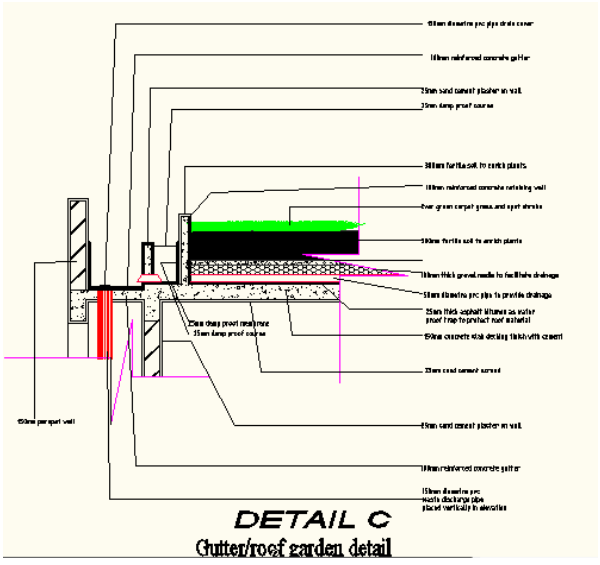


Plate 6.29: Roof detail of the proposed senate building showing the roof garden

c. OPENINGS

Windows panels are made of reflective glasses which reflect incidence solar radiation of almost 50%.

Doors panels are made of steel flush doors finish with weather resistance elements.

d. **COURTYARD SYSTEM**

The courtyard will well landscaped with ground cover(carpet grass) and spot planting of trees to enhance cross ventilation and the general surrounding and reduces the amount of pavement.

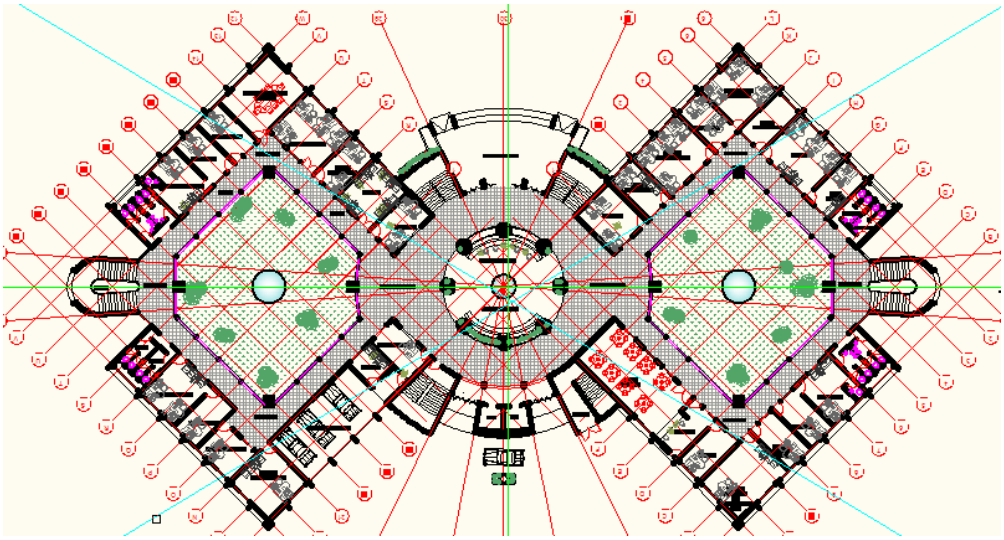


Plate 6.30: Ground floor plan of the proposed senate building showing the courtyard systems

6.11.4 DESIGN PHYLOSOPHY

The sub-topic for this project is reducing energy consumption in the design of senate building. These energy forms as explained are those that have effect on building. They include;

i. Solar energy

ii. Wind energy

iii. Sound energy

iv. Electrical energy and

v. Mechanical energy

6.11.4.1 Solar energy

This is the most problematic form of energy in building because of the heat it transmits through conduction, convection and radiation. Therefore, the design philosophy centres on how to control and reduce this form of energy.

i - SHADING DEVICES

The control and reducing of this form of energy is achieved through the use of shading devices by application of vertical and horizontal structural elements, thus casting shadow and providing shade and also absorbed and radiate part of the radiation.

ii- MATERIALS AND CONSTRUCTION

Clay bricks are used for wall construction, which is thermal resistance, hence control the interior part of the building. The clay tiles are also used for pavement which prevent the reflection of solar radiation are reduce it effect on the surrounding. Glasses as solar absorbent, the glass recommended is reflective glazing which reflects at least 50% of the solar radiation.

iii- LANDSCAPE ELEMENT

The ground cover plays the role of absorbing the incident solar radiation and prevents it from reflecting or radiating to the building and its surrounding. The trees also help to serve as buffers between the sun and the building envelop, hence reduce the solar action on the building.

iv. FORM AND ORIENTATION

The building is on the north-south axis for the longer side and the shorter side facing the east-west axis, thus will ensure reduced direct solar radiation since windows are placed along the longer axis.

The use of sun- shading device as design concept (philosophy) was done by Frank Llyord Wright in his design of price tower, Beltsville's O.K.

6.11.4.2 Wind energy

Wind energy control measured employed include;

i- Orientation to the wind direction where the building is placed at the angle of 45% to direction of both axis

ii- The use of trees as buffers for the wind, greatly help to reduce the speed before it reaches the building. This was possible by creating a turbulence of the wind, therefore, absorb the energy by frictional drag. These trees also filter the dusty wind from north-east trade wind.

iii- The sun-shading devices used also allow free circulation of air because of the gap between the element and the building external wall.

iv- Parapet wall used help to prevent and reduce direct wind action, therefore, prevent roof blown off.

6.11.4.3 ELECTRICAL ENERGY

Electrical energy is used in the office building basically for three purposes;

i- Lighting

ii- Ventilation

iii- Operating machinery

i- LIGHTING

Lighting in this case and in this design, day lighting has been encourage through the provision of adequate openings and positioning in all offices and verandah. Also with the provision of courtyard also help to influence the day lighting in the whole building.

ii- VENTILATION

Ventilation in this design is enhanced with the use of adequate provision of openings, sizes and their locations in the building. The courtyard system also enhances effective cross ventilation, therefore, making the whole environment very conducive

6.11.4.4. SOUND ENERGY

Sound energy occurs as result of accessibility interms of vehicular and pedestrian movement in and around the building causing unwanted sound called noise. Noise was taking care in this design by segregating noisy and quite areas, by zoning the site interms of noise. Block A and C are students activity area which produces higher level of noise, therefore separated with the executive and principal offices, that is block C.

6.11.4.5. Mechanical energy

In this building, there is very minimum use of machinery, except for the computer rooms that requires air conditioner to enhance it efficiency and for lift operating system.

CHAPTER SEVEN

7.0 CONCLUSION AND RECOMMENDATION

7.1 CONCLUSION

The research study set out to design for reduced energy consuming senate building for Nasarawa state through the application of bioclimatic principles. Quantitative analysis that encompasses data collection of climate of the study area was done and related literatures reviewed and analysed using the psychometric and bioclimatic charts. It is concluded that, Keffi climate is hot and humid and therefore, requires the use of bioclimatic principles that could reduce direct solar radiation into the building, improve on wind speed through effective ventilation and influence other forms of energy.

The research was concluded by proposing a befitting design for the senate building which adopted some basic bioclimatic design principles of building form and shape, building orientation, use of shading devices, provision of internal courtyard, Provision of green roof, adequate sizes of openings and their locations, and the use of clay bricks and tiles for major construction.

Findings in bioclimatic design, shows that the effective use of these mentioned principles provides a bioclimatic comfort building as adopted in the design of Nasarawa state senate building are effective in achieving human comfort in the building.

7.2 CONTRIBUTION TO KNOWLEDGE.

The research focuses on application of bioclimatic principles to reduce energy consumption in the design of senate building. From the research, it can be deduced that:

i. The use of green roof and soft landscape enhanced general cooling and reduced ambient heat.

ii. The use of clay bricks and interlock for wall construction and pavement reduced direct heat and enhanced thermal comfort within the building.

iii. Effective used of forms and good orientation help to modify the micro climate.

iv. The use of acoustic ceiling board reduced sound energy transmission.

7.3 RECOMMENDATION

Public building in general and senate building in particular can help to inform and educate the public on issue of environment protection and energy efficiency. For this reason, their design and construction is of upmost importance.

The presented thesis for design proposal for senate building tried to fulfill, in the best possible way, the aforementioned needs and demands. The thesis shows that it is possible to combine the principles of bioclimatic and environmentally friendly architecture with the need for contemporary architectural design. For this reason to happen, designers have to take into consideration issue of climate, landscape and materials from the first stage of the design process. The thesis and the proposal have to be continuously reviewed and validated in terms of thermal and visual comfort.

However, further research on this topic should introduce a number of other variables that could include determination of the performance of those building designed for bioclimatic comfort through reduction in energy consumption by adopting the use of computer aided simulation and other post occupancy evaluation techniques. Additional research could be done to examine the relationship between design for bioclimatic comfort, energy efficient building and building energy cost and other themes identified in the research and investigate these within the content of the relevant available literatures.

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