DESIGN PROPOSAL
FOR

MODEL GREEN CITY, ABUJA

WITH EMPHASIS ON ENERGY EFFICIENCY

BY

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DECLARATION

I, SASETU JOHN I, of the department of architecture, postgraduate school, of the Federal University of Technology, Minna, hereby declare that this project thesis titled MODEL GREEN CITY, ABUJA, with emphasis on ENERGY EFFICIENCY is a product of my research work under the supervision Of ARC A. MOHAMMED, MNIA.

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CERTIFICATION

This is to certify that this research project is an original work undertaken by SASETU, JOHN I. (M.TECH/SET/1053/2003/2004) under the supervision of ARC A. MOHAMMED, MNIA, and has been prepared in accordance with regulations governing the preparation of projects for the award of Master of Technology Degree in the Department of Architecture, Federal University of Technology, Minna.

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DEDICATION

To the One; the source of all life.

God of gods. The Chief Architect.

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I acknowledge God, who has given me life and all the accessories of it, including the time, means and ability to do this project.

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ABSTRACT

The first part begins with an introduction to the study and statement of methodologies used for carrying out the research, including aims and objectives of this project. The research informed also the review of literature on energy efficiency, which results are given in the following chapter.

The third chapter gives results of the research carried out on energy and green buildings followed by a report of some case studies carried out on existing energy-efficient buildings to determine how they are faring. The next chapter relays some data collected on Abuja, where the project is to be located, while the following chapter gives results of appraisal carried out on the site in particular which is in Galadima in the phase II development area of the capital city. This was done to determine the suitability of the site for the proposed development.

Chapter seven gives a theoretical digest of the design proper, explaining all the measures and steps taken to achieve an energy-efficient design for each building. The following chapter gives a concise report on solar energy as a renewable source of energy and the photovoltaic system, which is the machine for harnessing solar energy, stating how it can be used and why it is a more reliable source of energy.

Finally, there is a statement of conclusion reached and a list of literatures referred to within the thesis and a bibliography of some literatures studied.

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CHAPTER ONE

1.1 INTRODUCTION

The earth is a ball of natural resources. They abound everywhere you turn, filling every sphere of man's existence. Man is using them as much as he can to better his own life, to make things easier and more comfortable for himself. Unfortunately, these resources are being used faster than they are being produced. In fact, some of these natural resources are actually irreplaceable. Nevertheless, man is using them up for his daily activities. One of the things man does with these resources is to build buildings. At any one time, at least a building is being raised up somewhere and that has been so for thousands of years now. And buildings are actually using up a handful of the earths resources. In fact it has been reported that buildings alone are responsible for 40% of the worlds' total energy use, 3-% of raw materials consumption and 16% of fresh water withdrawal (Worldwatch paper # 124, 2004). If buildings are responsible for almost half the world's use of energy, how much energy could be saved if this figure were significantly reduced? This same concern, coupled with the earlier mentioned fact that most of these energy resources are not at the moment replaceable, has lead many professionals to research into ways of making buildings have less impact on the world's resources. A number of successes have been recorded and even constructed. These buildings have been termed green buildings, sustainable buildings, high performance buildings or smart buildings.

More countries of the world are imbibing the culture of sustainable architecture and raising a few green buildings and many designers have designed such all around the globe. In fact, it is not only buildings that are being made "green" as there are now green cars, green appliances and many more energy smart facilities being researched and developed. In Nigeria on the other hand, little is being done to save our natural resources. However there are certain initiatives that are tending towards this field but none wholly. This project is therefore a step into this little-known-in-Nigeria world of sustainable architecture in a bid to produce a model for future green buildings and introduce the country to energy-saving initiatives via architecture.

Residences are agreeably the most impacting on human life and performance, as far as buildings are concerned, since an average man spends his most valuable time in his own home. A man's residence shapes the way he thinks and how much he gets out of life since ideally, it is usually the place to recline. With this in mind, more residential buildings need to be made sustainable than any other types of building.

1.2 AIMS OF THIS STUDY

1. The underlying aim is to introduce the country of Nigeria to the field of sustainable architecture.
2. This is also an attempt to provide an architectural solution to the problem of poor energy and resource management in the area of

building and construction technology through relevant design and material specification.

3. To provide a model for future endeavors into green architecture, so as to accurately study the profitability and viability if such green buildings to increase public interest and gain government confidence.

4. To reduce the negative impact of building architecture on our environment by reducing dependence on use of non-renewable sources of energy and also to reduce the use of toxic-waste-generating energy sources.

5. To suggest ways of effectively managing the use of fresh water by buildings through efficient use and reuse and remote sourcing.

1.3 RESEARCH METHODOLOGY

Research is necessary when doing a study. There are various methodologies that can be used. They include: (i) Historical research method, which is used mainly by researchers in the social sciences and the arts; (ii) Analytical method which is used by statistics analysts to analyse data that has been collected; (iii) Experimental method which is relevant for scientists to carry out experiments, and (iv) Descriptive survey method, which is used mainly by researchers in the Construction Technology field where Architects belong.

This study required detailed research because of its peculiar nature. It is still quite a virgin field especially in Nigeria. Because of this, much research was conducted using mainly the Historical and Descriptive survey methods.

Initially, the historical method was used for obtaining information from sources as the Internet, which served as the basis and the motivation upon which the whole study is based and books were also consulted to establish an adequate bank of information. Furthermore, various relevant literal sources were consulted from hard copies of resources available in this field. Then the descriptive survey method was employed, where similar projects were visited to physically appraise the structures and carry out interviews with occupants of these buildings to ascertain the advantages that are presented by these buildings over conventional buildings and the disadvantages they also present. This was necessary to gain insight into the viability of such a project under the circumstances that exist.

1.4 SCOPE AND LIMITATION

This study is meant to be like a model or a demonstration project; so it will be correct say it concerns the whole nation. But since it is a demonstration project including the fact that such a project is usually initially capital intensive, it is being done on a small scale including 30 housing units, a multipurpose hall, a restaurant, shops and a cyber café. There is also a central water system and waste management unit.

1.5 IMPORTANCE OF STUDY

As earlier mentioned, much of the energy sources in use today are non-renewable sources and a good number of these also produce pollutants and are even expensive. The world is having another look at cheaper energy from renewable sources as solar and wind to reduce the impact of buildings on the environment. This spells out in no deem terms the importance of this study to our existence and the integrity of the building construction industry. If the building construction industry should retain a place in the future, it has to convince the now-aware populace that it has a more sure way of curbing the exploitation of man's one heritage (the environment) as a result of its activities.

1.6 GLOSSARY OF TERMS

1. Aero generator – Also called a windmill, it is a power-generating machine moved by the wind that strike the blades on the machine.
2. CFCs - Properly chlorofluorocarbons. There are the three chief elements that are responsible for the depletion of the ozone layer.
3. Climate – A regular pattern of weather conditions of a particular area over a long period of time.
4. Conduction – The passage of heat through a body by contract.
5. Conductivity – The ability of a body to conduct heat.
6. Convection – The movement of heat in space when warm air is replaced by cool air because cool air is denser (heavier).
7. Density – The quality of having more mass per unit area, which determines weight.
8. Emissivity – At a given wavelength, the maximum amount of radiation that can be emitted will be that form a black body.

9. Energy – Various sources of potential that are available that can be converted into power by various means.

10. Energy Efficiency – The ability of an appliance or a facility to save energy when in use.

11. Environment – everything whether tangible or intangible, around a particular person or thing.

12. Flat Plate Collectors – Flat rigid material that collect and store the sun's energy to be converted to power.

13. Flexible Collectors – Flexible material that collects and stores the sun's energy before being converted to electrical power.

14. Fossil Fuels – Fuels that are gotten from mineral sources that have been formed in the earth crust over a long period of time (e.g. crude oil, coal).

15. Greenhouse effect – An effect that occurs when short-wavelength heat gets transmitted into a system but reflected long-wavelength heat refuses to re-transmit through the same surface. As a result there is heat buildup.

16. Insulation – When a body prevents the passage of heat wave through it.

17. Micro-irrigation – Irrigation that is done excluding sprinklers and high-pressure sprayers.

18. Ozone – A layer of thick space around the earth composed of variant molecules of oxygen that protect the earth surface from dangerous ultraviolet solar radiation.

19. Photovoltaic – An array of cells made from semiconductors that collector solar energy and stores it for conversion to electrical power.

20. Pollution – When the environment looses its purity and integrity due to the action of man.
21. Radiation – When a body sends out heat in the form of rays, usually most liable with darker bodies.
22. Reflection - When a surface throws back heat waves that meet it by reason of its texture or colour.
23. Reflectivity – The ability of surfaces to reflect heat, usually most liable with smoother surfaces and lighter colours.
24. Renewable Energy – Energy from a replaceable source or from an inexhaustible source (e.g. sun's energy).
25. Solar Energy – Energy from a replaceable source or from an inexhaustible source (e.g. sun's energy).
26. Solar Power – Power that is generated from solar energy.
27. Specific Heat – The amount of heat usually gained by a body per unit mass of the body at a given temperature.
28. Stack effect – The effect that occurs when less dense warm air rises to make way for denser cool air.
29. Stuffiness – The extreme opposite end of the scale as opposed to freshness
30. Thermal comfort – The comfort of an occupant in relation to heat.
31. Ventilation – To allow fresh air to enter and move freely through a space.
32. Wind Power – Power that is generated when wind energy is converted to power by means of an aero generator.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 SHELTER

Wandering across the land in search of game or fruit, early man had no time to make himself permanent shelter. Man's shelter habits have always been connected with his food-finding habits. The wandering early man spent 'bedtime' just anywhere dusk weighed on him, anywhere safe. Safety, now that is another issue that has necessitated and determined the form of shelter. Safety from what? Basically, the long list must have included wild animals, evil spirits; enemy-human beings, inclement weather. Weather and climate have also determined the form of shelter that man has built. The kind of climate that different peoples found themselves dictated to them how to build their homes.

2.1.1 The metamorphosis of shelter

It must have all started with a few leaves or an animal skin arranged over an over-hanging branch, or a night in the safety of a cave where there was one around. The cave served for shelter for quite a long time since it was resistant to practically all adds, matter of factly, men live in caves even today. But outside the cave, man began to feel the need to organize his shelter more properly and so the birth of buildings. There have been so many separate origins, development and myriad branchings but the pioneering materials can be summarized into stone, earth, fabric wood, reeds, thatch and even bones, all organized to make the must simple of houses.

Some of these forms developed into bigger and better structures, but some remained practically the same till date with only a little change. But from those single room shacks, man began to expand to cover certain activities until he felt the need to build separately for different activities. Fear of war and armed raids quickly transformed shacks into fortresses in some regions. Fortresses where built as strongholds against enemies basically by those that could afford it or had fierce attitudes enough to command manpower. Civilization however, thinned these fortresses down to simple buildings requiring less and less protection, with protection being secured in weaponry rather than solid structures.

The discovery of fantastic sources of energy and the development of technology opened up doorways of opportunity for better structures and it has only gotten better since. Nowadays, we have structures towering more than 100 storeys high, actually 'scraping' the sky. It must be noted here that some of the sources of inspiration for better structures were religion and other beliefs. This has left its mark on our world of today. From shack to skyscraper; one thing has been the main driver- better shelter.

2.1.2. Across the cultures

The most common forms of shelter developed by different cultures have been determined by a number of factors, including: way of life, culture and tradition, climate and available materials. It is interesting to know that some of these have remained virtually unchanged through the ages.

1. People that found themselves surrounded by water, as in the River Rhine areas built their houses on water. This were composed of a wooden, high-gabled structures raised on stilts with walkways that were equally so raised, linking separate structures and carrying occupants straight into canoes. Of course these structures have modern descendants today.

2. In Asia's warm, tropical rain forests, houses were also raised on stilts, although this time around, they were built on land. These structures were also high gabled and of timber but covered in thatch. This form of building was necessitated by the rainy, warm, tropical climate the locals found themselves in. The region was liable to flooding often due to the troublesome monsoon winds that regularly swept across the land. The raised houses helped the occupants stay out of harm's way.

3. Nomadic lifestyle among the Native Americans gave them the well-known wigwams or tepees. These were merely poles arranged together to form a rigid frame with animal skins (this was latter replaced by fabric) thrown over them. These structures could be easily dismantled and reassembled elsewhere, usually with a new set of poles.

4. The Eskimos in Greenland have similar houses built like wigwams in the summer. But the summer huts had whale rib bones instead of

timber as framework with the same animal-skin covering. The windows were made of seal intestines. But the most popular Eskimo dwelling is the igloo. These winter shelters were built of blocks of snow with interiors lined with animal skin.

5. In the Middle East or virtually all regions surrounding the Sahara and the Arabian deserts, buildings were built of mud and were flat roofed. These houses, usually built around an oasis, were built because of the desert climate. In the daytime, temperatures are almost boiling point and in the night, temperatures fell significantly. Because of these differences in day and night temperatures, mud walls, built thick, were the only options to keep the interiors comfortable to a good extent. The flat roofs were a result of little rain. These flat roofs could be used as functional spaces for different activities. This form of structures actually is very much around today.

It is interesting to know that most of these cultures unconsciously developed their buildings to be energy efficient, driven involuntarily by all the factors mentioned.

2.2 BUILDINGS IN NIGERIA.

To really talk about shelter in Nigeria, we must first take into consideration her own traditionally developed means of shelter. We must peep back and see what these traditional buildings looked like and then see how they have been influenced by various factors. In doing this we will arrive at 4 major categories, namely the northern traditional buildings, the western traditional buildings, the middle belt traditional buildings and the eastern traditional buildings.

In the North, notably in ancient Zaria, buildings were (and most are still) flat-roof, built of mud and organized into complex compounds. In Zaria, must of the more public buildings were four-concerned while the main living spaces were circular in plan. The flat roof is encouraged by the dry, low-rain climate and the compound organization was a result of close family ties between significantly large families.

In the middle belt, the compound system is more simplified and most, if not all, buildings were circular in plan. The roof of this round huts is pitched and is thatch covered.

In the West, almost all buildings were either rectangular or square-shaped in plan. In the West, there is more rainfall per annum. Because of this, huts bore high-pitched roofs and were covered in galvanized iron (zinc). But before then, Raffia was the best option for roof covering.

In the East, conditions are quite similar to what is obtainable in the West, because of this houses were quite similar in both regions, except for a greater dedication to decorative details in the East, and the fact that raffia was mostly used even after the West had gone zinc.

One thing is common to all the individual historical architectural practices of the various sub-regions; the use of earth as building material. Earth was convenient and economically viable to use despite the varying climatic conditions, which actually were responsible for the various forms.

CHAPTER THREE

3.0 ENERGY EFFICIENCY

3.1 THE ENERGY ISSUE

Energy has various definitions according to what field it is being referred to in. the Oxford Advanced Learners Dictionary (1998) defines it as "the ability to put effort and enthusiasm into an activity" and also "a persons physical and mental powers available for work", both of which actually drive home the same issue: availability of something for doing something. However, the last definition given by the dictionary states that energy is "fuel and other sources of power used for operating machinery" within which is contained the category of energy that pertains to this study even though it is rather shallow. (Marcus and Morris, 1980), referring to buildings only, have considered energy as that potential required to control and maintain the internal environment of buildings. And so, putting all these pieces together, and referring specifically to the construction industry, it can be suggested that the energy under study is that potential offered by nature that can be harnessed and used for the construction and running or operation and the maintenance of buildings in a way that will satisfy occupants.

It has been reported that buildings, alone, are responsible for 40% of the worlds total energy use (world watch, 2004). This percentage clearly spells out the role buildings are playing in energy consumption. This also means that if this percentage was reduced significantly, the impact on world consumption of energy will be easily noticeable. Using up so much of available energy by buildings has impacted and is still impacting the environment. Considering also that most of the sources of energy are non-renewable and most produce harmful wastes during processing and during use of them. Fossil fuels are the commonest examples of non-renewable sources of energy there is also nuclear energy (mineral source). Fossil fuels include: oil, gas and coal. These sources of energy cannot be replaced readily and so are bound to finish someday, and with the rate of use, that might be sooner than we think.

It is also a fact that fossil fuels and nuclear fuels produce harmful waste products. Fossil fuels release a lot of harmful, toxic gases into the air including the ozone-depleting Chlouro-Flouro-Carbons. These gases pollute the environment and come back to affect the building and its occupant. Nuclear energy also produces waste. In fact, different countries often go about looking for places to dump nuclear waste. How long shall this continue to happen? How energy is used in a building is the next issue to be considered.

There are three major areas that pertain to occupant health and comfort that are usually addressed in the design of a building; they are lighting, ventilation and thermal comfort.

3.2 THE THERMAL ENVIRONMENT

In the temperate climate, designers think of how to bring in heat into the building and keep it in, while in the tropics, where solar radiation is more intense, designers think of how to send out the heat and keep it out or not to allow it come in at all. The thermal environment is much affected by lighting (both natural lighting and artificial lighting) and by ventilation (also both natural and artificial). In employing natural lighting, especially in the tropics, sometimes too much direct sunlight entering the building causes thermal energy (heat) build-up within a building apart from the fact that glare is produced. Similarly, when there is minimal exchange of stuffy air in a building with fresh air, there is usually a heat build up resulting in thermal discomfort. There has been extensive study of man's response to the thermal environment. And some have attempted to establish standards based on long periods of observation, and results have been recorded. One such table of results is shown below. Although it can be said that a standard is hard to establish since different human beings have varying responses to the thermal environment due to many factors.

SET (°c)	Temperature Sensation	Discomfort
Higher		Limited Tolerance
40	Very Hot	Very uncomfortable
37	Hot	Uncomfortable
35		
33	Warm	Slightly uncomfortable
30		
37	Slightly warm	
25		
23	Neutral	Comfortable
20	Slightly cool	
17	Cool	Slightly comfortable
15		
13	Cold	
10	Very cold	Uncomfortable

Table 3.1 Human Thermal Responses to The Standard effective Temperature

3.2.1 Thermal Energy

Thermal energy is transferred from one location to another by three ways; conduction, convection and radiation. This energy moves from one mass to another whenever the temperatures of the two differ. The direction of the energy movement is from the higher temperature zone to the lower temperature zone. The speed, or rate, at which the energy transfer occurs, is usually a function of the amount of temperature difference. (Meyer, 1983).

3.2.2 Conduction

conducted thermal energy is transported between parts of a mass, owing to the transfer of kinetic energy between particles at the atomic level, typically through a solid such as a metal. Materials, which are good conductors of electricity, are typically good conductors of heat:

Figures 3.1 gives clarity to what happens in conduction.

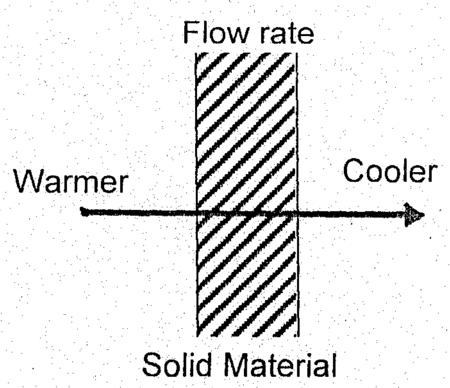


Figure 3.1 Heat Flow through Solid Material

Conductivity is measured by R-values and U values and is expressed in terms of rate of heat flow per unit of temperature over a given cross-sectional area.

$$U = \frac{I}{R} = \frac{I}{Rs_1 + R_1 + R_2 \text{---------} + R_a + R_{so}} = (W/M^2\ {}^oC)$$

Where R_{s1} = Internal surface resistance

R_{so} = Outside surface resistance

R_a = Air space resistance

R_1, R_2 etc = resistance of components $= \frac{L}{K}$

Where K = thermal conductivity = (w/m ^0C)

L = thickness of component layer

The thermal conductivity (K value) is often related to density of materials. Less dense materials such as fiberglass have low conductivity, while denser materials such as steel or glass have high conductivities.

	Structure	U value
1.	Solid brick wall unplastered	2.3
2.	Solid brick wall plastered	2.1
3.	150mm concrete	3.5
4.	150mm concrete with 50mm woodwool and plastered	1.1
5.	150mm concrete with 19mm Asphalt	3.4
6.	150mm aerated concrete with 19mm asphalt	0.88
7.	Internal 150mm concrete floor with 50mm screed	2.4
8.	Single glazing on timber frames	4.3
9.	Single glazing on metal frames	5.6
10.	Double glazing on timber frames	2.5
11.	Double glazing on metal frames	3.5

Table 3.2 U values for common building structures
Source: Neufert (1999).

In a room where materials of high conductivity are used, much energy will be wasted in trying to keep the heat out of the building.

3.2.3 Convection

Convection is the movement of heat through fluids. Heat transfer by convection typically occurs in a room or building when air masses over a solid surface of a different temperature or when warmer air moves to a position here colder air exists. Forced convection occurs if the movement is caused by a mechanical means such as a fan. Natural convection on the other hand is what occurs if movement of air is caused by density difference due to a temperature difference as in stack effect. (Meyer, 1983).

The choice and location of openings and their sizes ultimately affects the convectional heat flow within a building. Consequently, wrong choices will result in much energy being employed to keep the building cool.

3.2.4 Radiation

Heat transfer can also take place between two bodies even when there is no solid or fluid between them. This process is called radiation. In this case thermal energy is transmitted through space by electromagnetic waves. Radiation is distinguished from convection and conduction in that it does not depend on the presence of an intermediate material as a carrier.

Heat transfer by radiation depends on the surface condition of both the emitting material and the receiving material. The concepts, which help to describe the radiation-related properties of such surfaces, are emissivity, absorptivity, reflectivity and transmittivity. Surface condition refers to the texture and colour of the material.

Emissivity is the ability of a material and its surface to radiate or emit energy. At a given wavelength, the maximum amount of radiation that can be emitted will be that from a black body. That means that the emissivity of a black body = 1.0. A non-black body will have an emissivity less than 1.0 (Marcus, et, al, 1980).

Absorptivity is the ability of a material and its surface to absorb heat. In opaque materials, whatever energy is not absorbed is reflected so that the two concepts represent mutually exclusive phenomena. In terms of reflectivity, the more dense and smooth a surface, the more reflective it is. In terms of colour, darker colours are more absorptive than lighter colours. For example, a material painted with flat black paint will absorb 90 percent of the solar radiation.

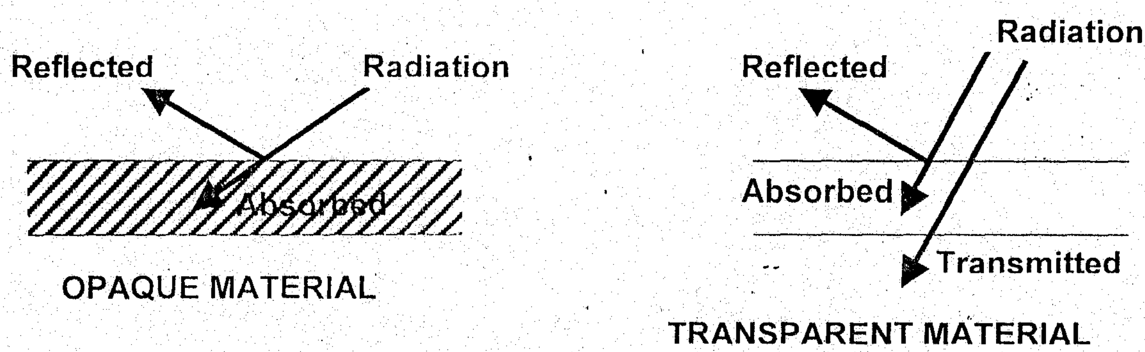


Figure 3.3 Reflection, Absorption, And Transmission In Opaque And Transparent Materials

It follows that the choice of material affects the rate of radiation into a building and out of it and consequently the amount of energy required to control such energy (thermal energy).

3.3 LUMINOUS ENERGY (LIGHTING)

The other factor that designers consider aside from the thermal conditions is light.

Light is measured by a *lumen*, which is defined as the light emitted by a sing\le candle. The intensity of that light is a function of the distance from the light source. The intensity of light one foot away from a candle on a surface one-foot square is called a *footcandle*. In other words:

$$1 \text{ fc} = 1 \text{ lm/ft}^2$$

Light energy striking an opaque surface is partly absorbed and partly reflected. Light striking a transparent surface is partly absorbed, partly transmitted, and partly reflected. Light that enters a building space becomes heat as soon as it is absorbed by surfaces within the space.

Sunlight, or solar radiation, is about one-half visible energy, or light, and one half invisible energy. The invisible portion is made up of shorter wavelengths called ultraviolet and longer wavelengths called infrared. When both visible and invisible solar radiation is absorbed by a material, it becomes heat.

Natural light for a building comes directly and indirectly from the sun. Direct solar illumination is not obstructed in its path from the sun to a building. Its angle of arrival on a building's surface varies constantly. Intensity of direct sunlight can be greater than 9000 footcandles.

Indirect natural light is sunlight that has been reflected off particles and surfaces before it reaches a building. There are two basic categories of indirect sunlight: skylight and ground-reflected light. Skylight is sunlight that has been reflected off particles in the atmosphere. Ground-reflected light is sunlight reflected off the surfaces of objects resting on the ground plane, including buildings, trees, lakes, pavements, and many others. Indirect sunlight rarely gets above intensities of 1000 footcandles.

Light, as does any form of radiation, behaves according to the inverse-square law. This law states that the illumination intensity, usually measured in footcandles, or lumens per square foot, varies inversely with the square of the distance between the source and the surface being measured.

Table 3.3 gives some the visual efficiencies of different sources of light.

It then follows that the amount of light allowed into a building's interior as natural light determines the energy that will be needed to supplement with artificial lighting. But as natural light is admitted, if it is allowed to caused heat build up, it will also affect the amount of energy needed to remove the heat from the building. Careful design and choice of material is important to this effect.

	Light source	U value
1.	Flame	0.2
2	100-watt bulb	.18
3	40-watt fluorescent	59
4	Daylight	90-120

Table 3.3. Visual efficiency of various light sources. Source: Ecole Polytechnique

3.4 VENTILATION

Fresh air is also related to the thermal environment and undisputedly a major factor in comfort of occupants. The availability of fresh air is important for three purposes: first, to supply an adequate level of oxygen for breathing; second, adequately to dilute odour arising from bodies, smoking, cooking or industrial processes to make them acceptable or unnoticeable; and third, to dilute air that has been polluted with bacteria sufficiently to make infection a negligible hazard. Much window and louvre design, ventilation and air conditioning and fan design are aimed at achieving these objectives without causing draughts.

The planning of ventilation channels and the level of air-conditioning that is chosen will have several significant effects;

1. It will cause heat loss or heat gain, according to the direction and magnitude of the inside and outside temperature difference.

2. It will require inlets and outlets, and proper mixing in the occupied spaces, without causing excessive movement giving rise to draughts, disturbance of papers and other unwanted local effects. (Marcus at al, 1983).

The achievement of the required ventilation rate is a question of careful design of openings, adjustable for variety of wind and temperature conditions, so that two basic processes of air exchange can be used:-

1. Pressure differentials due to wind.
2. Stack effects, due to the lower density of warm air, causing it to rise and hence encouraging the entry of low-level, cooler air. Since the temperature inside a building is likely to be different from that outside, this implies that the internal and external air will have different densities. Where there are openings at different levels this variation air density can produce a flow of air.

Ventilation is necessary; natural ventilation must be ensured to minimize the amount of energy used to artificially ventilate any building space.

All the three factors that have been discussed, namely: thermal energy, luminous energy and ventilation, are all interrelated and together affect greatly, the way buildings are designed. When all three are carefully considered to ensure that they are naturally provided without ill effects, energy will be saved. As a result of this awareness, designers have been dabbling into energy conscious designs. This awareness is growing by the day and there seems to be a revolution coming on.

3.5 THE GREEN REVOLUTION

This revolution is yet to occur but is on the track, but there has been a general shift towards energy conscious designs or green buildings. This shift to green design is due to the fact that designers are becoming aware that buildings do have a great impact on the environment in not only the consumption of energy, but also with the use of materials and the issuance of waste, and the fact that building materials, design, construction, techniques, building operation and maintenance all have environmental impact that can be minimized.

In plain terms, energy is scarce or fast becoming so. Buildings consume a lot of this scarce energy and that consumption should be reduced. As a matter of fact, it is not only the building industry that is shifting to green design but even other industries also. For example, car manufactures are now designing 'green cars' which use no fossil fuel but run on electricity through solar and battery power, and produce mainly water as waste. Similarly there are various green products being produced by various industries. It is indeed the first steps towards a green revolution. But where is the place of Nigeria in this green revolution?

Some designers in Nigeria are only beginning to venture into green design, although there have been certain projects that have been completed with aspects of energy saving initiatives but there are hardly whole green buildings in Nigeria right now from the best of knowledge.

3.6 COMPONENTS OF A GREEN BUILDING

A green building is one that is healthy and comfortable for its occupants and is economical to operate. It conserves resources (including energy, water, raw materials and land) and minimizes the generation of toxic wastes in its design, construction, landscaping, and operation. In a nutshell, there are certain components that must be represented before a building can qualify to be called 'green'.

3.6.1. Energy Efficiency and Renewable Energy Sources

A green building should use renewable energy sources. Renewable energy sources exclude fossil fuels and mineral nuclear energy, which have become the most widely used energy sources. Hydro energy can also be considered as renewable, but this can only be economical on large scales. The most reliable sources of renewable energy include solar energy and wind energy, which are also usually economical on small scales, even for single building units. According to the U.S. Department of Energy, (2004), "if only 10 percent of homes in the U.S. used solar water-heating system, we would avoid 8.4 million metric tons of carbon emissions each year". Careful study and countless demonstration projects have shown that it is actually cheaper in the long run to use solar or wind over than other sources of energy although it can be capital intensive depending on the circumstances.

Furthermore, when this energy is generated, it must be used in an efficient manner to minimize excessive usage and waste. This can be achieved first, by design, i.e. by ensuring natural ventilation, natural lighting and choosing the right construction materials, secondly, by specifying components and operation equipment which are energy efficient (which are actually available now in the market) and thirdly, by maintaining the right attitude in operation of the building.

3.6.2. Materials Efficiency

It has been reported that buildings are responsible for 30% of the world's total raw material consumption (World watch, 2004). It becomes imperative to select sustainable construction materials and products by evaluating several characteristics such as recycled and reused content, zero or low off gassing of harmful air emissions, zero or low toxicity, sustainable harvested materials, high recyclability, durability, longevity, and local production. Such products promote resource conservation and efficiency.

It will also mean using dimensional planning and other building efficiency strategies. These strategies reduce the amount of building materials needed and cut construction costs. For example, rooms are designed using local brick or block dimension to minimize the wastage of bricks or blocks.

Demolition materials and recycle construction are used e.g. as base courses for parking lots keeping materials out of landfills where they would have been dumped as waste and saving cost also. This also requires incorporating a waste management programme that prevents waste generation.

3.6.3. Water Efficiency

Green buildings can be designed with dual plumbing to use recycled water for toilet flushing or a gray water system that recovers rainwater or other non-portable water for such uses as site irrigation. In addition, water-conserving fixtures like low-flush toilets and low-flow shower heads are used to minimize waste. This also means using micro-irrigation to supply water to landscape plants (this a excludes sprinklers and high pressure sprayers).

3.6.4. Indoor Air quality

To ensure indoor air quality,(since occupant health and safety is a major concern of green buildings), construction materials with zero or low toxic emissions are chosen. Materials that are more natural than artificial are desirable. In addition, all spaces including bathrooms and toilets are properly ventilated and the building and its surroundings are properly drained.

3.6.5. Environmental Impact

World watch, in a paper numbered 124 (2004), has reported that buildings consume or are responsible for 35% of the world's carbon dioxide emissions (the chief gas blamed for ozone depletion), 16% of fresh water withdrawal, 40% of municipal solid waste destined for local landfills or dumpsites. These statistics show very significant figures. Green building designers have to think of possible ways (and there are) that buildings can interact more positively with the environment by paying special attention to preserving the site's integrity and natural characteristics, landscaping appropriately and selecting materials that have lower embodied energy and those that are produced locally. Landscapers should use plants with low water and pesticide needs and consider using recycled-content paving materials.

3.6.6. Operation and Maintenance

The goals of green buildings also include low maintenance and operation costs. To ensure that green building work as intended, commissioning should include processes as testing and adjusting mechanical, electrical, and plumbing systems to ensure that all equipment meet design criteria. This also includes instructing staff or occupants on the operation and maintenance or equipment.

3.6. 7. Accessible Siting

Green buildings should be, as far as practicable, sited within reach of public infrastructure to facilitate easy access to infrastructure like transportation, medical facilities, shopping areas and recreational facilities.

While having all these in mind, care must be taken to take note of different climatic and cultural factors for different regions, which , as has been shown, is a major determinant of building forms and styles.

3.7 DIFFERENCE BETWEEN A GREEN BUILDING AND A GREENHOUSE

Much has been said already about a green building which basically is a high performance, sustainable, energy efficient building made up of various components as have already been discussed.

A green house, on the other land, is simply a space enclosed in glass where the 'green house effect' is taken advantage of for various purposes like plant nursery, heat supply ands so on. A greenhouse effect occurs when high-frequency ultraviolet solar radiation (basically light). Passes through the glass, but when it is radiated back by internal components as low frequency ultraviolet radiation, much of it those not pass through the glass anymore, as a result, the energy becomes trapped and can be used for specific purposes. As a matter of fact, greenhouses have been used in green buildings in the past as a form of trapping the sun's energy for heating rooms in cold climates, for example designer William Meyer used greenhouses to supply heat for octagonal row houses he built in 1981 (Meyer, 1983).

CHAPTER FOUR

4.0 CASE STUDIES

4.1 CASE STUDY 1

THE PLANT NUSERY OFFICE, NICON HOTEL, ABUJA

Introduction

The building under study is an office building belonging to the plant nursery of the Nicon Hitton Hotel. The hotel itself is owned by Nicon (National Insurance Company of Nigeria) but it is run by Hitton Hotels, a foreign-based hotel management expert. The hotel was opened in 1980 The plant nursery is run by the hotel to cater for her own needs and also for commercial supplies. The building is made up of four (4) offices for the manager and other staff. The building is located in the services wing of the hotel where only staff are allowed to gain access. This is also the area where the laundry service unit is located, as well as other service units. But the building itself is a separate, peculiar looking building. It is built near the plant nursery itself with only about 8m separating them.

DESIGN AND PLANNING

The building is on a rectangular plan with recesses on all the four sides with a total area of about $70m^2$ (seventy square metres). It is located in a depression with a natural embankment towards the left side of the building. This has served as a natural noise screen far the office the building is aligned with plant nursery opposite the service unit of the hotel.

The building is planned with a green concept, but more in sympathy with the plant world than any other environmental representations. The building itself appears to be a plant with a stunningly natural look to it, and it is surrounded by dozens of potted plants The house is designed to "let the environment in" because there is practically no ceiling, as a result, all the interiors an exposed to the environment. Furthermore, it somewhat blends into the greenery of its immediate environment. There are no air-conditioners in the interiors. Some parts of the exterior, particularly the parts exposed to entry views, are covered with climbing plant. As a result, at first sight, the walls appear to be built of green plants and covered with thatch.

MATERIALS AND FINSIHES

The walls of the building are built with sandcrete blocks. About 100mm of earth is used to cover the walls all round the exterior surfaces giving it on earth look. About one-third of the wall area is covered with a climbing plant. The interior surfaces of the walls are plastered and painted. The windows are fixed with glass louvers with wrought iron burglary-proofing. The roof structure is of hardwood timber covered with galvanized iron sheets, which are in turn covered with thatch. The floor is reinforced concrete. The whole building is surrounded by potted plants.

MERITS

1. The use of natural, unmodified earth on the exterior surfaces almost eliminates the need for artificial air-conditioners.
2. The used of plants on the wall also contributes to the insulative quality of the wall and also gives a certain freshness to the atmosphere around the building.
3. The green initiative is achieved by the natural materials that have been used on the building in contribution to its location behind the trees as viewed from the approach.
4. Adequate landscaping has been around the building in comforming with the purpose of the building and for achieving the 'natural' outlook.

5. There is high security around the building as there is a presence of security personnel at the entrance.
6. The structure is under careful and regular maintenance to preserve the uniqueness of the building.

DEMERITS

1. The building is not sealed off from intrusion. The eaves are open into the interior. This also means creeping animals can easily access the interior and disease could easily be translated also.
2. The building requires constant and careful maintenance if the building is to stay in good condition.
3. The buildings landscaping features are those that will require much water for sustenance.

DEDUCTIONS

1. The building is a good example of low natural materials could be used to save energy and the earth's resources. Since earth is known to be a bad conductor of heat not to talk of planted surfaces. Thatch is also a good heat insulator.
2. It is observed that there is an advantage to retaining natural landscaping which could be only enhanced for the best result. This retains the landscape and saves water resources.
3. A good building needs to be sealed against intrusion and to protect the occupant disease infiltration.

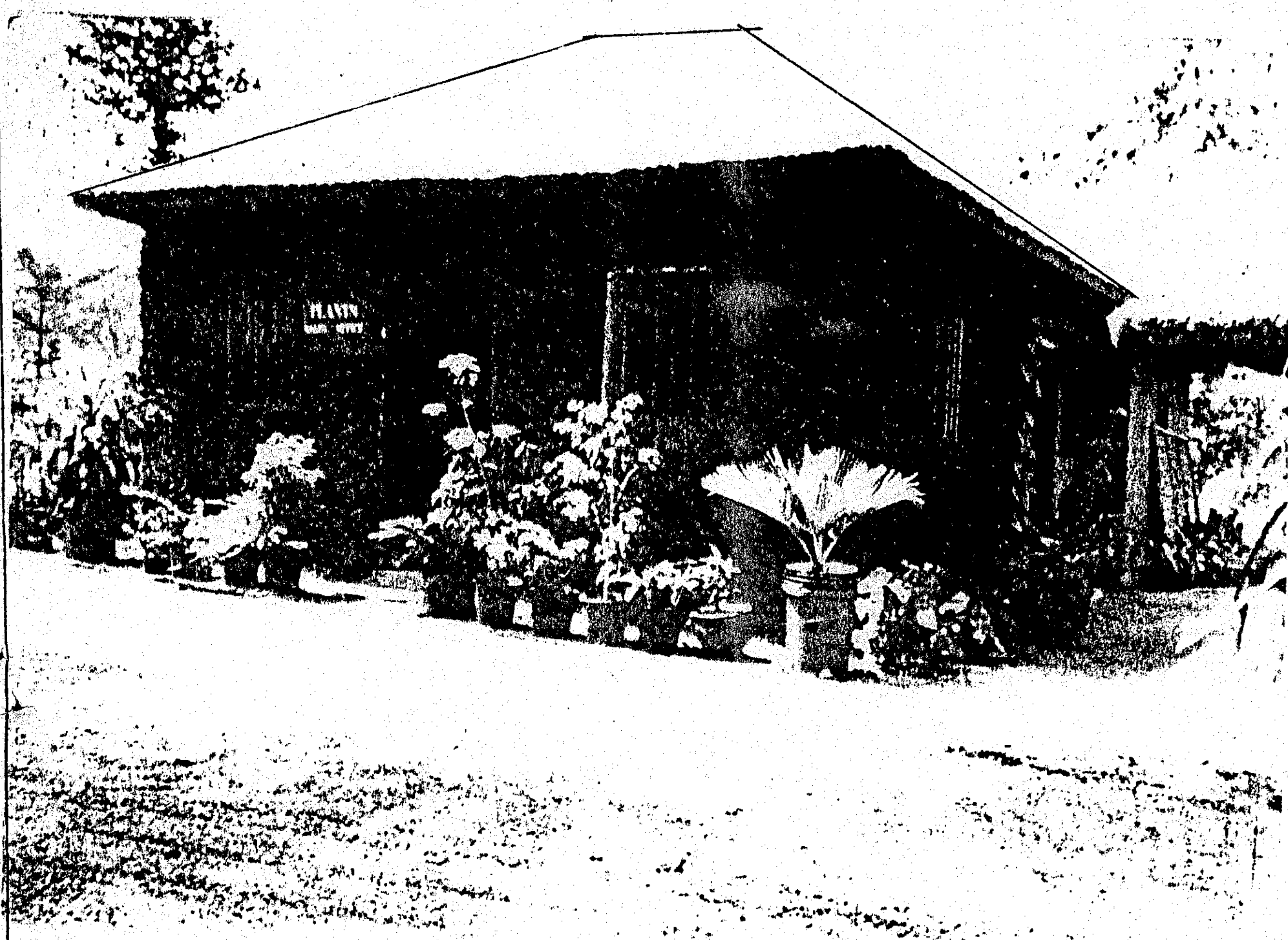
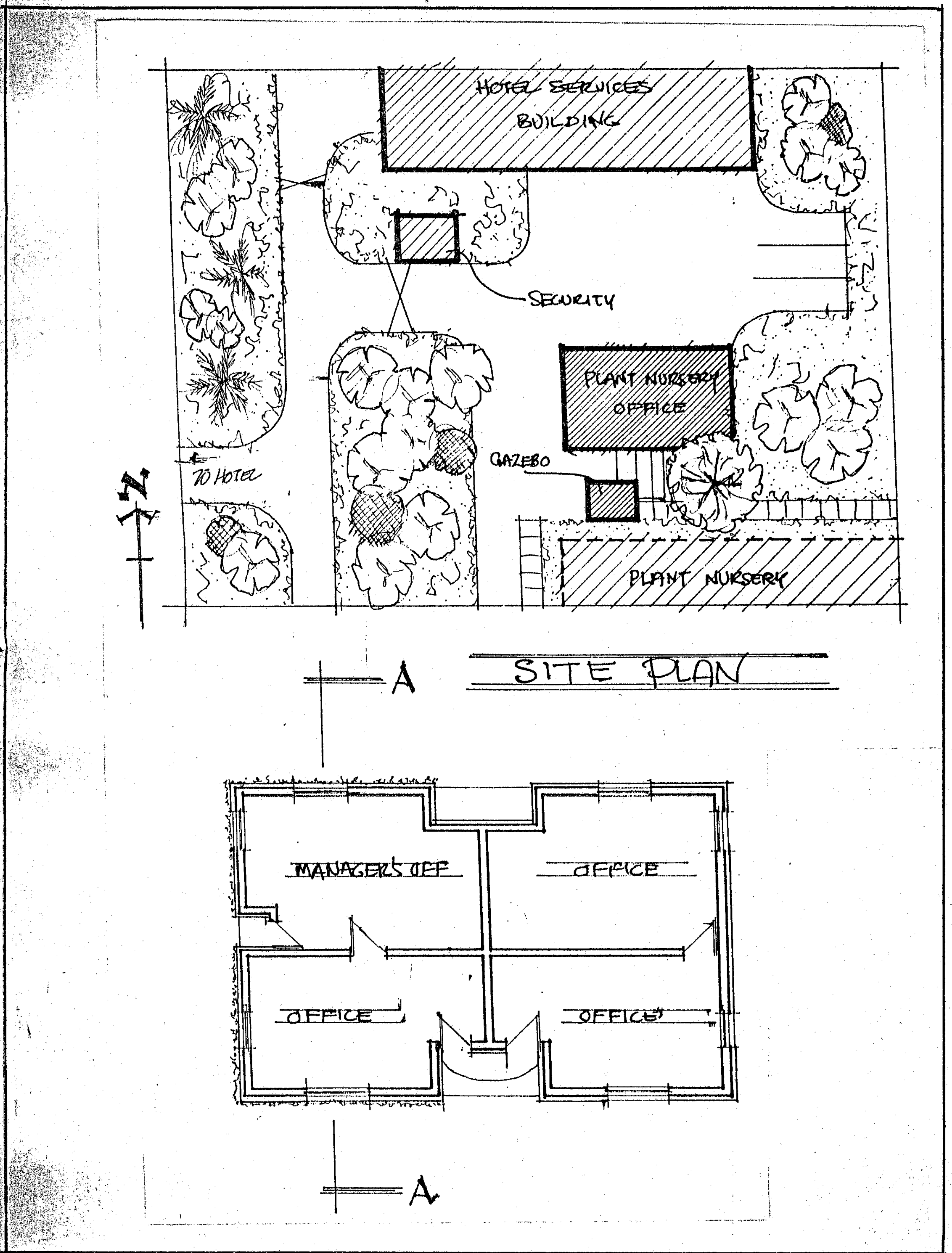


Plate 4.1. View of plant Nursery Office, Nicon Hilton, Abuja.



APPENDIX 1. CASE STUDY 1

4.2 CASE STUDY 2

CETECH BRICK HOUSE AVENUE, JOS PLATEAU.

CETECH means Center for Earth Construction Technology. It is established under the National Museum and Monuments in Jos. The center has been researching into ways to developing natural earth into a suitable and safe building material. The research has reached advanced stage and an earth brick has been developed. This brick has been used to build several demonstration projects including residences, French centre and others. One of those residences is a brick house built for the director of the centre, built since July 1991; it was built to prove the possibilities available with the use earth bricks as a building material. The building is located along St. Piran's avenue on the museum property towards the south-east end it is located in a natural landscape with a handful or trees. There is a stream to the east of the building and a lake towards the northwest. The director of the center presently lives in the building with his family.

DESIGN AND PLANNING

The building is on a rectangular plan with a long corridor that carries an occupant from the living room or dining room into the rest of the house, which are four bedrooms, two toilets, a bathroom, including also a kitchen. It is a simple design with a long rectangle, with an arrangement almost like an office (front to front). The building has four curved areas, not at the four corners but at three; the other being at one bedroom. the roof plan is a simple gable with falls on the long sides. The entrance is oriented towards the south, where the access road is (St. Piran's avenue), no additional landscaping was done to the surrounding natural landscape, although much of the trees were cleared around the building.

MATERIALS AND FINISHES

The foundation system is built of concrete and sandcrete blocks topped with a concrete slab. The rest of the walls, from the floor up, is built of earth bricks, including the columns at the entrance porch. The lintels are of reinforced concrete finished with light gray emulsion paint over cement plaster. The windows are glass, side-hung casement in steel frames. The roof structure is of hardwood timber with asbestos ceiling. The roofs are asbestos cement. The exterior walls are left with the natural earth look but some portions are painted with gloss paint, painted directly on the brick plastering.

MERITS

1. The use of earth bricks has contributed to the control that has been established over the thermal infiltration into the building
2. During cold season also, the brick assists in keeping heat within the interiors.
3. All the rooms are spacious because of the simple design.
4. The building is easily accessible to public infrastructure because of its good location. This is one of the criteria for cost-effective buildings like this to prevent multiplicity.
5. According to requirement of the green initiatives, much of the landscape has been left natural, although much of the trees in the approach were cleared during construction.
6. The asbestos cement roofing sheets also helps to control and reduce the passage of heat into the exterior in the hot season and out of it in the cold season.

DEMERITS

1. The way the building has been oriented with the longer side towards the East and West exposes much of the wall area to direct solar radiation and this could make a difference in heat gain.
2. There is no storage facility within the building
3. The long corridor is not a desirable design solution.
4. Two of the bedrooms are not cross-ventilated.
5. No further landscaping was done on the site, which gives the cleared portion an empty look.
6. The natural landscape is not being maintained regularly.

DEDUCTIONS

1. The use of earth is advantageous in controlling the flow of heat into the interior and vice-versa according to the season.
2. Accessibility is a vital part of cost saving imitative whether it has to do with proximity to access roads or other infrastructure already available. This is determined by selection of good site.
3. Natural landscape should be supplemented with artificial landscaping for the best results and should be well maintained.
4. The brick house, along with all the other projects verifies the viability of earth bricks as a building material.

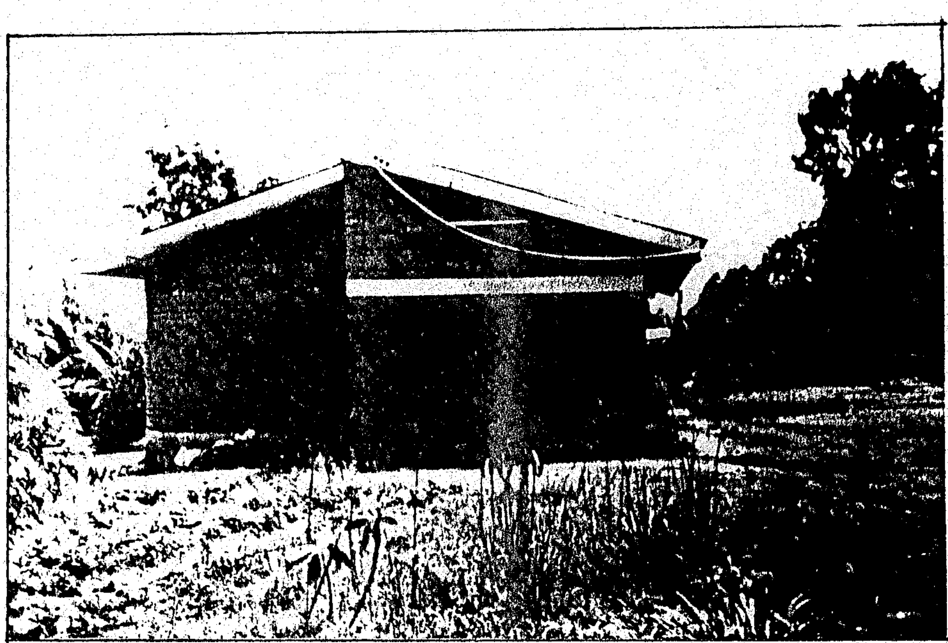


Plate 4.2. Front View of Cectech Brick House, Jos.

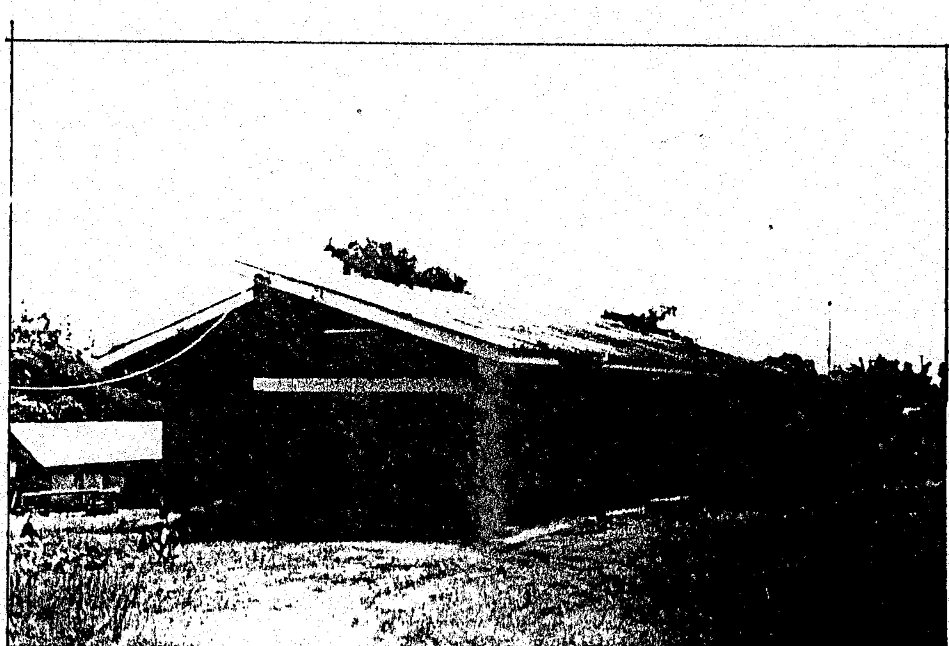
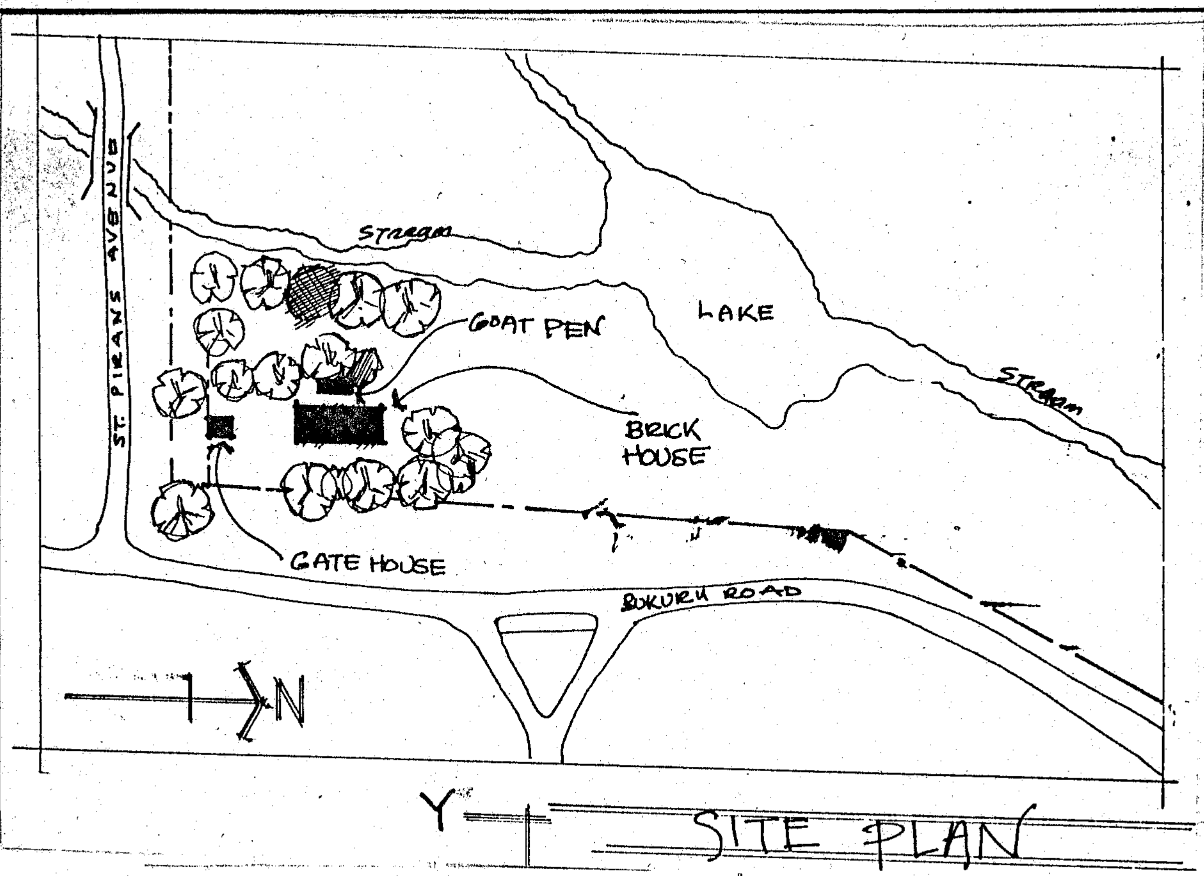
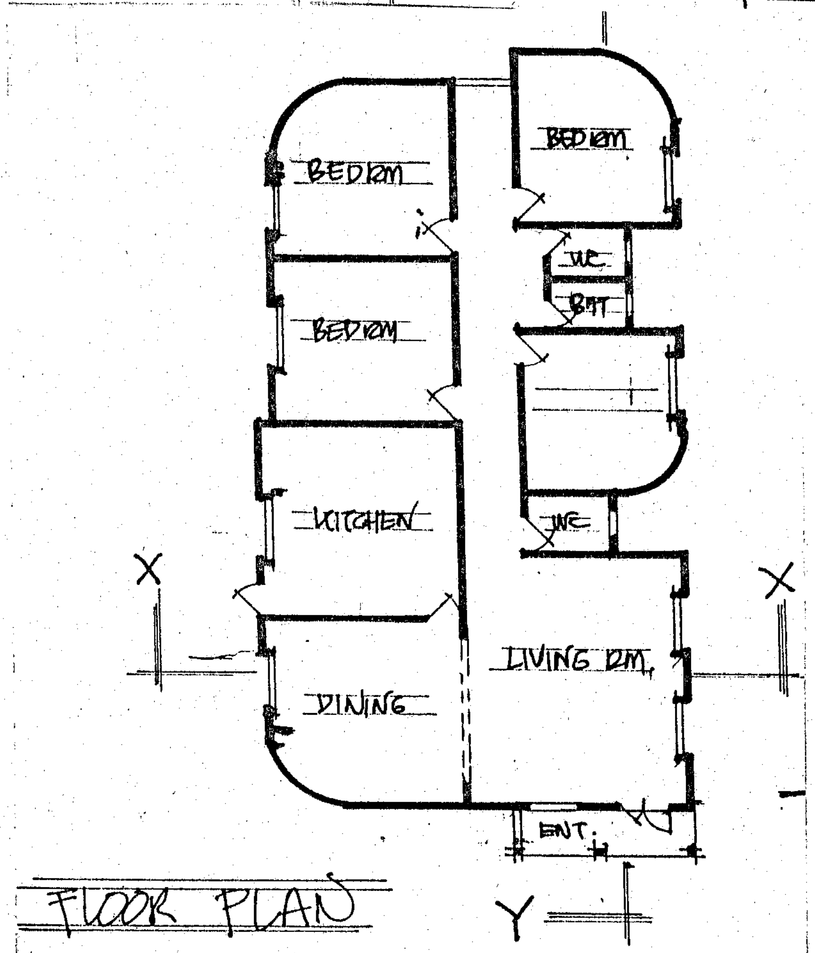


Plate 4.3. Perpective of Cectech Brick House, Jos.





APPENDIX 2. CASE STUDY 2

4.3 CASE STUDY 3

EXXON HOUSE, WASHINGTON TOWNSHIP, NEW JERSEY, U.S.

INTRODUCTION

Exxon, in 1979, commissioned architect William T. Meyer to design energy conscious houses for her. Several of those buildings were designed. The architect's goal was to achieve buildings that could save energy through both passive and active means. One of those buildings (the particular one under study) was commissioned in 1981. The building is located in Washington Township, a town under the state of New Jersey in the U.S. This meant high velocity winds from the North East because of the state's location at the shore on the North-Eastern part of the United States near New York.

DESIGN AND PLANNING

The building is a duplex of 3 bedrooms with a living room, a family living room, a dining room, a kitchen, a toilet and bath with a dressing area and a garage for one car. The house is on a rectangular plan with the longer sides facing East and West. The entrance to the house is on one of the longer sides facing west. The garage is on the northern end of the house, which is the only part of the house, that does not go up to another floor. That part is roofed with a learn-to roof. The rest of the building is roofed with a simple asymmetrical pitch gable. The North side has a long, gently sloping roof, which the architect explains that it functions to deflect high velocity North prevailing winds to reduce the wind load on the building. On the Southern side is a short, steep slope of the roof fitted with an array of solar cells used to capture the sun's energy for winter heating needs. The walls on the south side are recessed behind balconies and overhangs. This, the architect explains, functions to admit the short angle winter sun and keep out the long angle summer sun, thus maximizing the potential of the sun's energy. The East and West walls have more openings because only indirect, weak sunrays reach these sides. This will help in admitting in more light.

MERITS

1. The building is properly oriented with long sides toward East and West as is the practice in the temperate region where summer heat gain is to be minimized.
2. The roof has been designed to reduce the impact of inclement weather on the building.
3. The design is simple and economical since there are no wasted spaces.
4. The location of openings, their sizes and types have all been done to maximize energy economy.
5. The used of solar energy as a renewable source of energy.

DEMERITS

1. Not enough trees planted to help buffer the effect of the winter prevailing winds and further reduce load on building.
2. The house is rather exposed as there are on surrounding trees or shrubs

DEDUCTIONS

1. Good design practices can help reduce the impact of inclement weather on the building and also take advantage of good weather conditions in an energy saving initiative.
2. Alternative, renewable power sources can be used to help reduce the impact of buildings on the environment.
3. Usage of soft landscaping, especially trees, can significantly affect the way buildings interact with the environment.

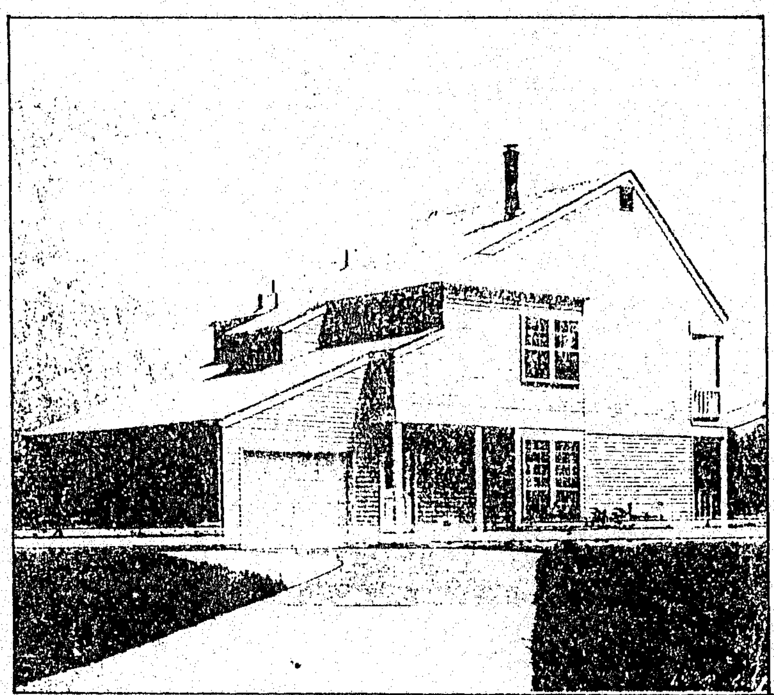
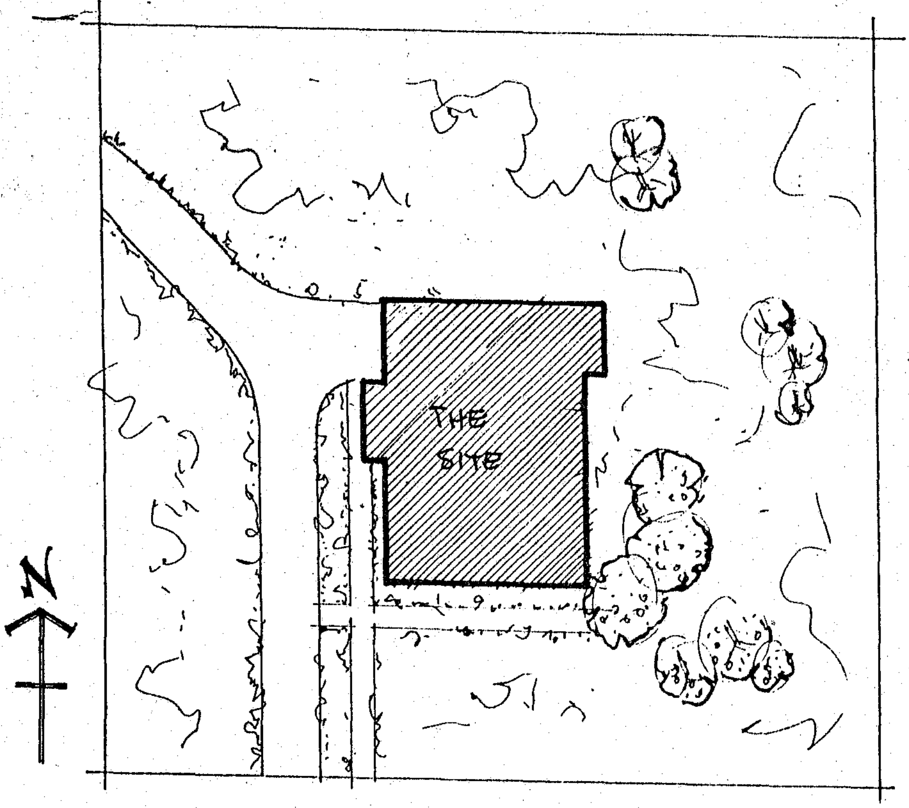
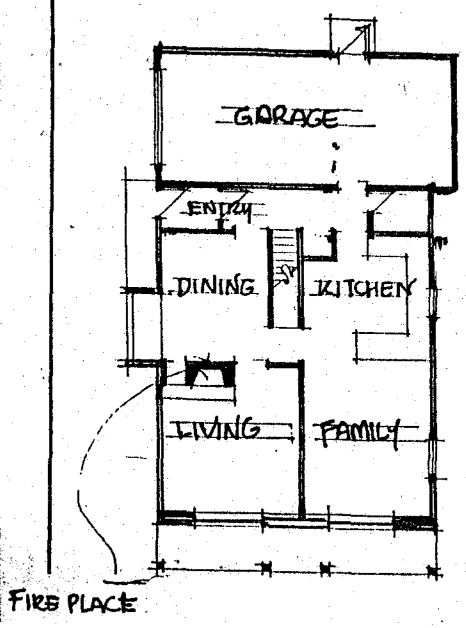
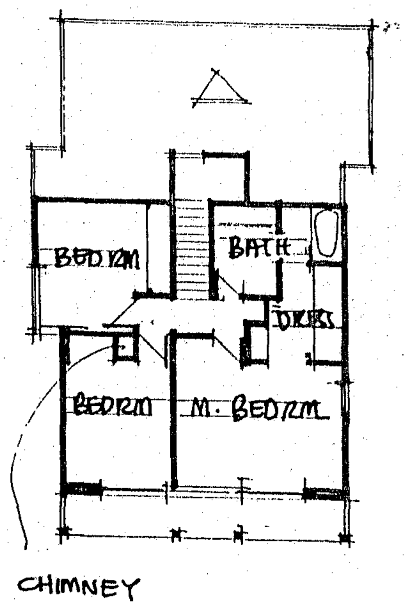


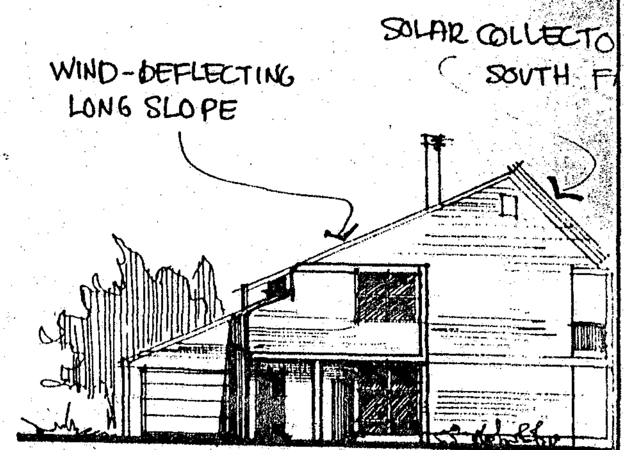
Plate 4.4. Exxon House, New Jersey, U.S.



SITE PLAN







FRONT ELEVATION

GROUND FLOOR

FIRST FLOOR

APPENDIX 3. CASE STUDY 3

CHAPTER FIVE

5.1 DATA COLLECTION. ABUJA CITY

5.1.1 INTRODUCTION

The city of Abuja came into existence because of a need for a new, centrally located Federal Capital City to replace Lagos city which was not conveniently located, was uniethnically populated among other factors that made it unsuitable for an ideal capital city. The Federal Capital Development Authority (FCDA) was established in 1975 to develop this new Capital.

The site was thus selected and defined in the 1976 decree with a total area of about 8000 square kilometers surrounded by Niger, Kaduna, Kwara, and Plateau (now Nasarawa) state. The site would " attract diverse ethnic settlement" the city lies just above the hot and humid low lands of the Niger-Benue trough but below the drier part of the country to the north.

AIMS consultants planned the city. It was conceptualized with an axis towards Aso Rock that serves as a focal point where the central area will 'fall' towards with the districts arranged around it. Though much has been altered since 1975, the basic concept is still intact.

5.1.2 CLIMATIC CONDITION.

The climate of Abuja city is much like any region where similar climates produce savanna situations. But the climate was greatly affected by the Jos Plateau, which extends well into the middle of Abuja and the Niger-Benue trough, which is toward the south of the city. The climate is a warm condition throughout most of the year though there are usually hot peaks and equally cold peaks. The rainfall is moderate.

According to the Daily Trust (Feb. 6,2003), the city of Abuja is now experiencing a major transformation in climate due to global warming caused by the action of pollutants on the ozone layer. There are developing times of very hot and uncomfortable periods and abnormally cold periods, which is evidence of quick radiation to and from the surface of the earth respectively. This quick radiation happens because of the thinning of the ozone layer over the city.

1. TEMPERATURE

Abuja experiences its highest temperature in the dry season especially February/March. Here, differences between the highest and the lowest temperatures have been recorded up to 17^{0}C. During the dry season, temperatures fall considerably in the night between 2am to 5 am.

The wet season, specifically between July and September is milder in temperature differences. The difference between the peaks is considerably lower-mostly lower than 10^{0}C.

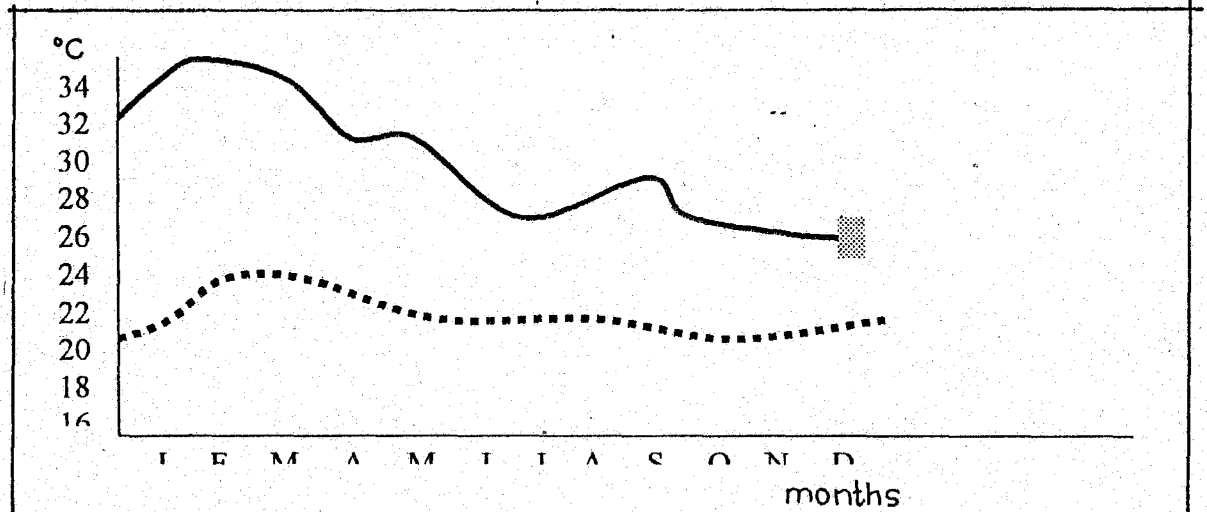


Fig 5.1 Maximum and Minimum monthly temperatures for Abuja.

2. HUMIDITY

Humidity is lowest during the dry season due to a blast of dry wind from the Sahara which sweeps in from the northeast. At this time, relative humidity falls to as low as 20% in the city. It soon begins to rise when the humid, prevailing southwest trade winds begins to blow from the Atlantic Ocean bringing on the rains. At this time relative humidity is as high as 95% in the morning creating a heat trap.

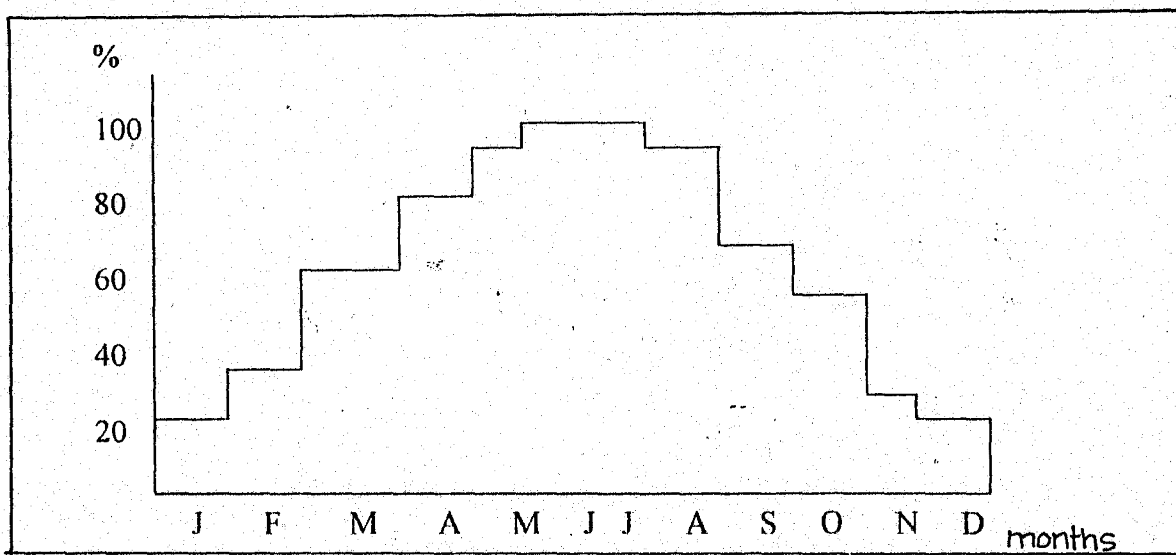


Fig. 5.2 Mean Monthly Relative Humidity for Abuja.

3. RAINFALL

Rain begins to fall in April and fades out in October, a total of about 180 days. The mean monthly distribution shows a tendency for concentration in 4 months. Infact 60% of annual rainfall is between July and October, heaviest showers may last for up to 1 1/2 hours followed by light drizzles for a much more longer time. Towards the end of the wet season, the trend becomes light showers for half or more of a day, sometimes even throughout the day.

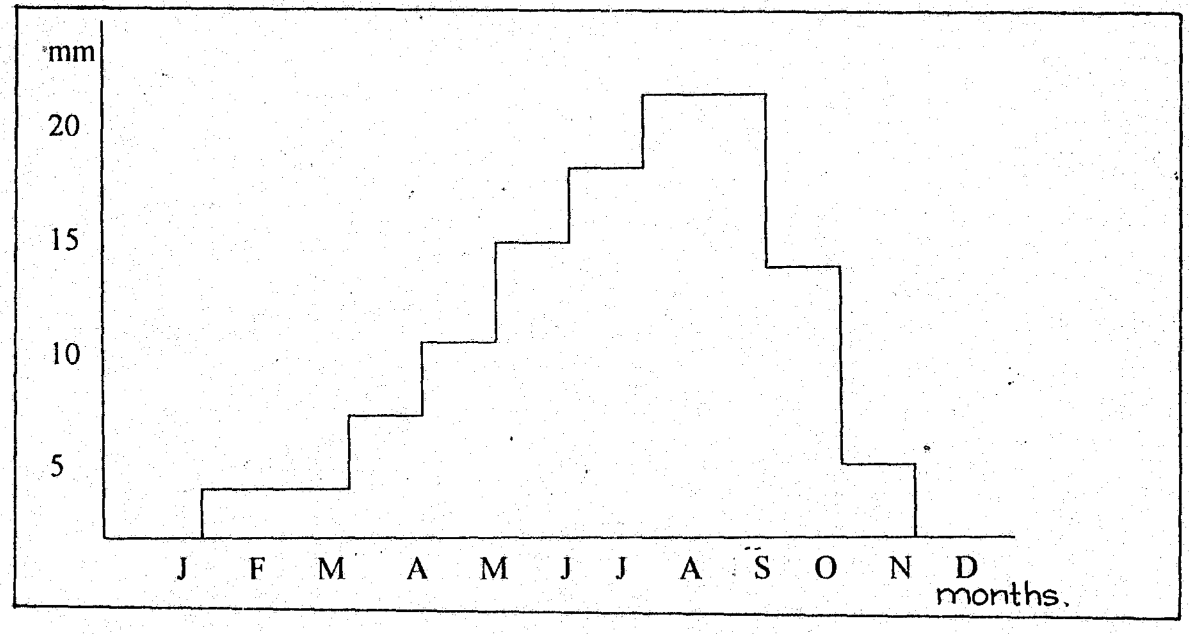


Fig. 5.3. Mean Monthly Rainfall for abuja.

4. SUNSHINE

Abuja is exposed to 2500 hours of sunshine annually (Mabogunje, 1977). The dry season experiences most of this is due to thin cloud cover of high altitude cirrus clouds, which encourages rapid radiation. The amount of sunshine decreases in the wet season due to low radiation caused by adverse cloud cover of the rain-laden nimbus and cumulus variety. The amount of ultraviolet radiation has also been increased due to the depletion of the ozone layer.

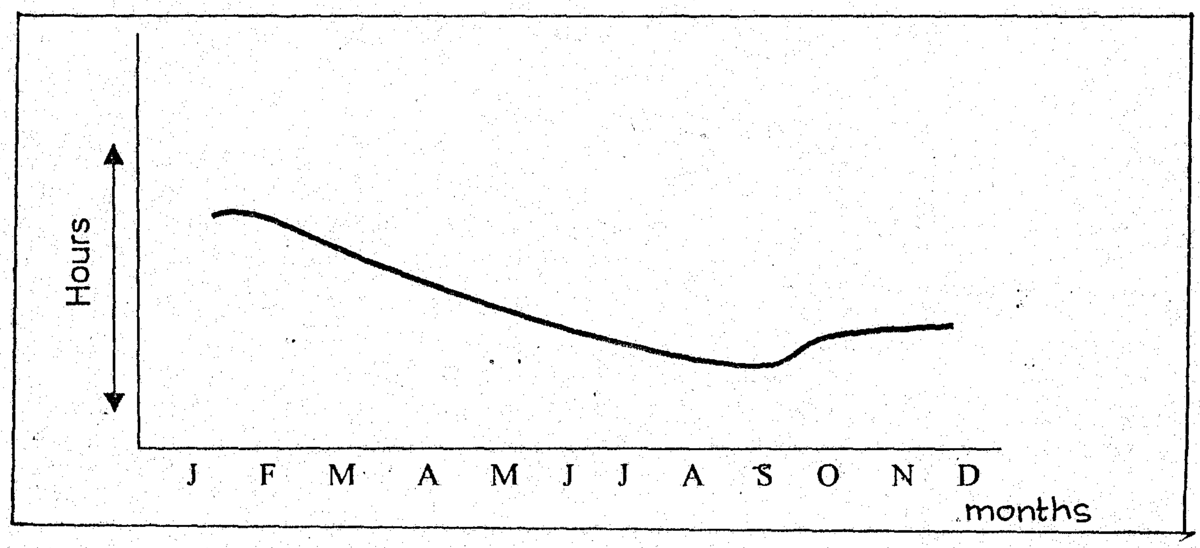


Fig. 5.4 Hours of sunshine per month for Abuja.

5.1.3 GEOLOGY AND TOPOGRAPHY

The territory has just north of the wide alluvial plains formed by the confluence of the two National Rivers. Large sparsely inhabited areas lie between Kaduna and the territory and extensive farmlands between it and Nasarawa State over the ridge to the East of Okwa valley and more farmlands between the Territory and Minna. The city is crusted with metamorphic rocks such as biotite, muscoute, schist, and magnematite underlying most of Abuja. Igneous rocks such as granite, ryoite and porphyritic deposits have been found in great masses. There are also sedimentary settlements in streams beds located throughout the city. Sand gravel beds, clay deposits and laterite are also found.

Clay has been largely used by locals in pottery. Granite is being mined in large quantities for construction purposes.

The city is tilted in its plane, rising from about 100m above sea level from the Southwest edge to about 700m at its Northeast edge. Several ridges of low mountains or high hills lie between the Shiroro dam site and the Federal Capital. A high ridge of hills lies between the Okwa valley and the Federal City. Also, the Jema'a platform, a continuation of the Jos plateau extends well into the middle of the territory. The hills change to flat – topped, laterrite-capped mesas overlooking the Niger-Benue lowlands.

Four major rivers flow southward into the Niger-Benue trough either though or adjacent to the territory. The Gurara River flows through the western edge, its watershed drains most of the territory into the Niger. To the west and the north of the territory lies the largest of the four- the Kaduna River (where a new dam is being constructed at the point where it joins with the River Dinya approximately 100Km north of the city's boundary). The Jatau river lies between the Kaduna River and the city. And the fourth is the Okwa River, east of the city.

5.1.4 SOCIO-CULTURAL LIFE

The initial inhabitants of the Federal Capital are chiefly the Gbagyis. But the city itself could now be said to be a 'no-man's-land' because it is now peopled by virtually all the ethnic groups to be found in the Nation. This multi-ethnic occupancy was part of the original goal for creation of the Capital Territory. Right now, most of the original occupants have been resettled in satellite towns and the surrounding area councils. The culture of these people is heavily represented throughout the city. But the predominant cultural exhibition is a derived, unified, urbanized form. The social order in the city is observed to be deeply classed. The high classes are high indeed and the low are low indeed.

5.1.5 ECONOMY AND COMMERCE

The city is equipped with an efficient central business district which is truly the nerve center of the Territory's economic activities. Automatically, the state of the National Economy means the state of city's economy because of the simple fact that it is the seat of national decision making. It therefore gets the worst or best of any variation in the state of the economy. This privilege is shared by Lagos, Ibadan and Port Harcourt and some parts of east but especially Lagos which is reputed as the largest city in the country.

Recently in July 2003, there was an economic crisis that occurred because of a longer-than-usual national labour strike that dealt a blow to the

Nation's already shaky economy. As it is to be expected, the FCT took the brunt of it. It is therefore assumed that the economic situation of the city is not at its best at the moment. There are, for example, high prices on goods and services due to the hike in oil price (the better controller of the Nation's economy)

Accommodation situation is very difficult in the city, forcing workers and business persons to seek shelter elsewhere in neighboring towns. The commercial activities in the capital are shared by both the government and the private sector, but the private sector seems to have the upper hand. Chief among the ventures in the city are Hotels and accommodation, Banking, construction and Communications.

5.1.6 DEMOGRAPHIC DATA:

According to the Daily Trust (Feb. 6,2003), the initial estimated optimum population of the Federal Capital was 3.1 million people. But right now, the population of Abuja has soared to approximately 10 million persons. This increase is due to massive immigration from all parts of the country, people that have been driven from their places by communal clashes or just people in search of 'greener pastures' including people that came for business purposes and other various reasons.

According to recent statistics, the largest age group is between 20 and 24 with 16% of the total population. In this age group, males are more with 66.06% as against females' 33.94%. The lowest age group in number is between 70 and 74 years of age with only 0.15% of total population. The details are given in the table below.

Table 5.1 Some demographic data of Abuja.

Age group	Females (%)	Males (%)	% Of Total
0-4	50	50	14.14
5-9	52.56	47.44	11.73
10-14	51.43	48.57	10.53
15-19	40.98	59.02	10.13
29-24	33.94	66.06	16.39
25-29	37.21	60.79	12.93
30-34	40.38	59.62	7.82
35-39	37.84	62.16	5.56
40-44	40.74	59.26	4.06
45-49	41.18	58.83	2.56
50-54	46.15	58.85	1.95
55-59	50	50	0.90
60-64	50	50	0.45
65-69	50	50	0.23
70-74	50	50	0.15
75-Above	66.67	33.33	0.23

5.1.7. TRANSPORTATION AND TRAFFIC FLOW

The transportation that serves the capital mostly is road transport. Buses, government, labour and private owned, ply the roads conveying people in, around and out of the city. Cars flow around the city constantly. Trucks and trailers are also constant road pliers delivering and moving around goods. The city has yet to have a workable railway transport system. Air transport is well developed with an appreciable modern international airport that serves both domestic and international flights. A lot of international and private airlines operate in the city.

The city's central area is streeted in a grid pattern making traffic control flow easily. There is one major entrance into the city from the airport called the inner southern expressway and the inner northern expressway take road users out of the city. Crossing these are several transit ways forming arcs around the central area. The use of linear spine feeder systems makes possible a series of entrances and exit that make traffic flow effective and easy.

However, difficulties have arisen due to in-adherence to the master plan and the worst is several traffic jams along the busiest streets. But government has already taken steps to arrest such problems by dualizing highways and building flyovers where, according to plan, they should have been. There has been some relief in this area.

5.1.8. EXISTING LAND USE AND FUTURE TRENDS

According to master plan, the central business district is the central area. It is also the government-reserved area with government buildings, ministries, embassies and High Commissions, and also the three arms Zone. Arranged around the central area are the districts with various uses from residential to commercial and community.

The Capital is planned to be developed in phases. Development started with the central area, phase I, with Garki, Wuse, Maitama and Asokoro districts. The districts bear the residential neighbours in well planned communities inter-spaced with government facilities. The next phase of development continues with central area phase II and districts like Wuye, Kukwaba, Utako Mabushi, Durumi, Katampe and Gudu.

There are strict laws on development control, and even though some of these laws have been partly violated, there is still hope of a dynamic city that matches up to most capitals in the world.

5.2 DEDUCTIONS

1. The terrain of Abuja, which is mainly a flat land with only a small percentage of undevelopable areas, is a potential for good development.
2. The climate is favourable for the time being, for almost all classes of people.
3. The city has great economic and commercial potential and since development will go on for decades to come, the potential is yet of great importance to the nation.
4. The city is well planned, comparable to other great Capitals of the world with a good traffic system and a systematic development process. And this will be a landmark if not tampered with.
5. The city is a good location for the estate and planning laws and development control laws will ensure meaningful development.

6. Steps have to be taken to reduce the amount of Choro-flouro-carbons reaching the ozone to help reduce global warming.

CHAPTER SIX

6.0 SITE ANALYSIS

Choice of site for this sort of development is a very important factor due to the peculiar nature of the buildings. Because the buildings are to be of high performance, a site that will assist in this task is ideal. Although the buildings can be located anywhere (in which case they will be designed to fit the peculiar situation of the site), a good choice could be made which will ultimately affect the performance of the building. In making the choice of this site therefore, certain criteria were considered as mentioned below.

6.1 CRITERIA FOR SITE SELECTION

1. First of all, the site was chosen in conformity with the master plan of the Federal Capital Territory. The area chosen is cut out in the master plan as area for future residential development, since the development is to be a residential estate. It was termed "Future" because, the area falls within the phase II plan of the development of the capital city.
2. The site is sufficiently large for the purpose to which it is to be put, on the basis of the number of residential units chosen, including the supporting facilities with enough space for an open, recreational park.
3. The site is located close to basic infrastructure since it is opposite another fully developed residential estate. This is so to prevent multiplicity of infrastructure in accordance with guidelines for green architecture.
4. The site has a good road access. A major, dual carriageway, namely the Murtala Mohammed expressway, passes by front of the site. Other services are also readily available like electricity lines and water.

5. The site was also chosen for its topography and vegetation the site is rich with trees and shrubs, which will be maintained as natural landscaping features. The site also has an even drainage towards the road, which will present little difficulty in locating drainage facilities.
6. The site was situated in Abuja due to the fact that the development is to National interest, since ultimately, the benefits will be for the whole populace.

6.2 LOCATION OF SITE

The site is located along the Murtala Mohammed expressway (Northern) in Galadima of Kado district. Directly opposite is the Adkan-Constructed Abuja Model city which is part of the Gwarinpa Estate. Adjacent to the site is the other major residential estate called Cittec Villas. There are other patches of residential and commercial developments beside the site, on both sides. Behind the site, on the northern end, is a range of hills, which form a buffer for the prevailing winds in the dry season, namely the North East winds.

6.3 SITE INVENTORY

1. Topography

The site slopes gently towards the South, which is towards the Murtala Mohammed Expressway (Northern).

This sloping is almost even except for a sharp drop beside the road that was created during road construction. A range of hills lines the rear of the site on the northern end. This range puts the site in a partial lee against the Northeast trade winds in the dry season.

2. Vegetation

The site has rich, agriculturally significant soil, which is able to support a richer savanna situation. The site is therefore having a sizable amount of trees all over, up to the hills on the rear end. There is also an equal amount of shrubs and younger trees. All parts that are not covered with trees or shrubs are covered with grass. Presently, some farming is going on some parts of the site. Most of the trees will be retained as landscaping features in an attempt to preserve the integrity of the site and minimize the consumption of water.

3. Soil

The pale brown colour of the soil indicates rich loamy topsoil. The general profile of the soil, however, indicates a soil of good bearing capacity. The soil is not waterlogged, but it is well drained. The exposed surface of the steep bank created by the road construction reveals a redder, hard-bearing soil.

4. Drainage Pattern

The site drains towards the road on the Southern side of the site. This sort of drainage will be of advantage, because storm water can be easily managed and collected for purification and redistribution.

5. Prevailing Winds

The prevailing winds blowing across the site during the two major annual seasons are the Northeast Trade winds and the Southwest Trade winds. The Latter blows from the Atlantic Ocean where it picks up vapour. As a result, it is usually laden with vapour and is responsible for bringing on the wet season over the site. It is cool and comfortable and should be best savored for ventilation.

The North-East Trade Winds, on the other hand, blows from the Sahara desert. It is usually dry and dust-laden and uncomfortable. It brings the dry season or the harmattan.

However, its effect is affected by the range of hills on the North, which puts the site in a Lee. Furthermore, the trees that line the foot of the hills in ward, will serve as a filter for the winds.

6. Noise

Most of the noise that reaches the site is from passing vehicles on the highway, namely, the Murtala Mohammed expressway. Vehicles ply the expressway almost throughout the day, but peak moments are between 7am and 11am and between 4pm and 8pm in the evening. Since there are little trees blocking out the highway, most of the noise hits the site. Therefore a cluster of trees will be required between the highway and the site to screen off the noise. This forms the only major source of noise.

7. Temperature

Temperatures on the site are generally warm. The highest temperature is in the dry season. The difference between the highest and lowest is about 19^0c. The lowest temperature is also in the dry season. The difference in the wet season is 7^0 lower (10^0c) than that in the dry season.

8. Rainfall and Humidity

Rain begins to fall in April and fades out around October. 60% of this is between the months of July and October. The beginning half of the rainy season is heavy showers. It gets lighter as the season comes to an end.

Humidity is lowest during the dry season about 20%. It rises to 95% (especially in the mornings) in the wet season.

9. Sunshine

There is more sunshine in the dry season due to the cloud cover. And this solar radiation is increasing in the intensity due to global warming. The intensity decreases in the wet season because of cloud cover. However, the amount of sunshine even in the wet season will be sufficient enough to be harnessed as solar energy for power generation.

6.4 ACCESS AND CIRCULATION

The road system in Abuja allows for a free, almost circular movement around the city. This minimizes traffic jams. There are few major expressways with axes from Aso Rock. One of them passes the northern end of the site, which forms the frontage of the site. This road is the Murtala Mohammed Expressway (Northern). It is the major access to the site, link by the Shehu Musa Yar'adua way and other smaller streets.

6.5 UTILITIES

1. Power

Electric power is available from overhead lines passing the sit, it will only require the establishment of a distributor transformer station to make the power available.

2. Water

Portable water is available from water lines near the site from the water board. Water supply through these lines is almost constant. However, storm water will be collected during the wet season for purification and redistribution for non-portable uses like plant watering and other household uses.

3. Waste Disposal

Waste is disposed of by the authorities when they are packed into government-provided, green waste bins. Sometimes, however, the authorities concerned do not empty these promptly and this results in overflowing refuse, which can litter streets and drainages.

4. Communication Lines

Landline telephone lines are available near the site. Mobile telephone services are also available on the site.

6.6 SCENERY AND MAN-MADE FEATURES

As one stands at the centre of the site, the panorama towards the South is a long line of residences and taller buildings beyond. The panorama towards the north is a range of hills patched with clusters of trees. Panoramas to east and west reveal more trees blocking the view with small buildings peeping through the trees. The other man-made features prominent on the site are the power cables passing the site spread on strong poles and the cliff that was created during the road construction.

6.7 ENVIRONMENTAL PROBLEMS

As a general effect on the Federal Capital City and most parts of the country, there is increasing effects of warming caused by the depletion of the ozone layer. The ozone layer is being worn away by chlorofluorocarbons (CFCs). Automobiles are the chief dischargers of these CFCs. And according to the Daily Trust (Feb 6, 2003), this effect is already being felt in the city.

The next environmental problem is waste, man-made waste which is not usually disposed off on time and tends to hip up with time.

6.8 DEDUCTIONS

1. The site is suitable for locating the estate for all the factors that have been enumerated.
2. The site will need to be screened off from vehicular traffic noise most probably by a line of trees.
3. The prevailing winds crossing the sight will have to be taken advantage of for natural ventilation to the buildings on the site.
4. The trees on the site will be preserved so as to protect the integrity of the site as such the trees on site present an advantage.
5. More efforts need to be put into waste disposal. In this case, a central waste management unit is desirable.

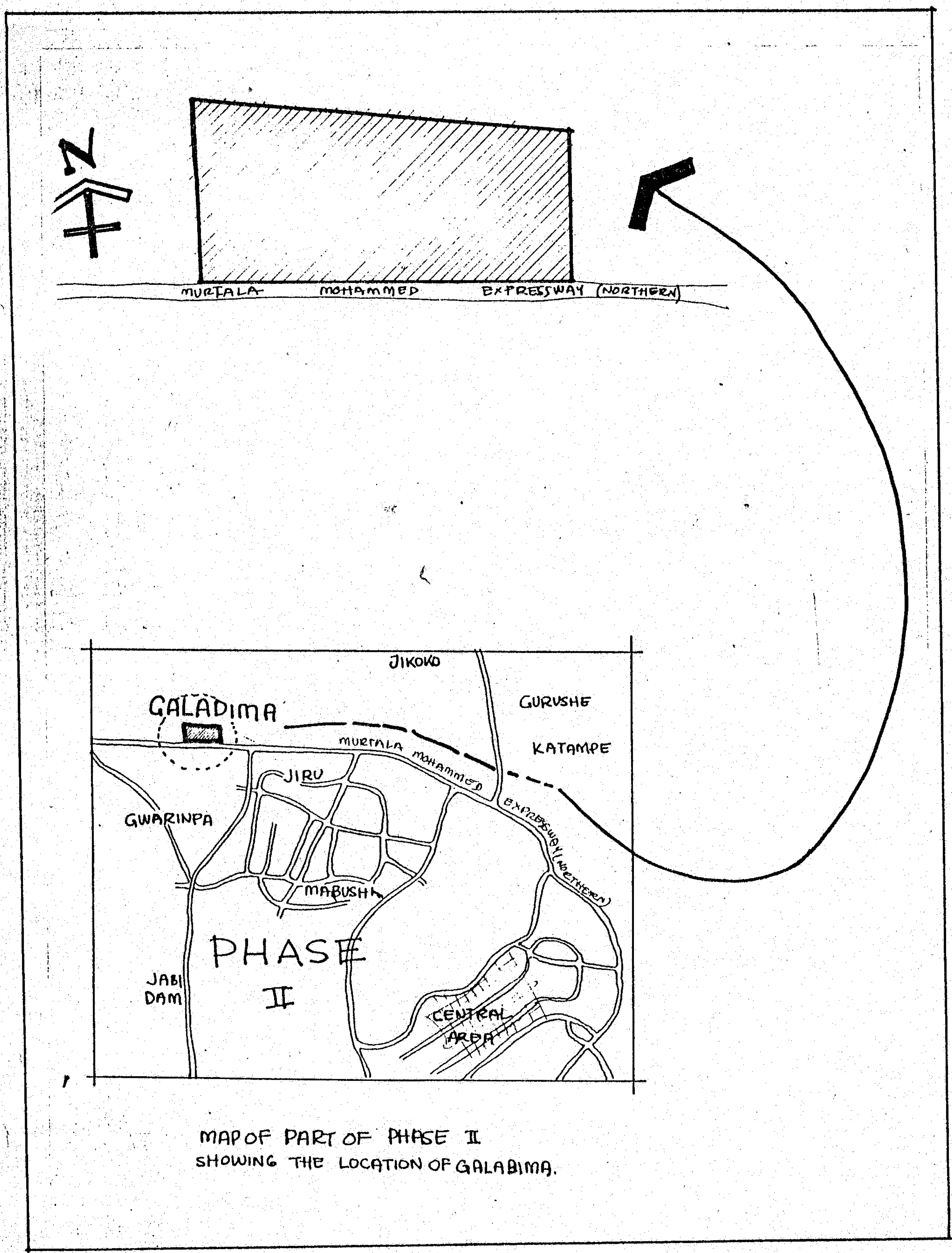


Fig. 6. The site within Abuja, Phase II.

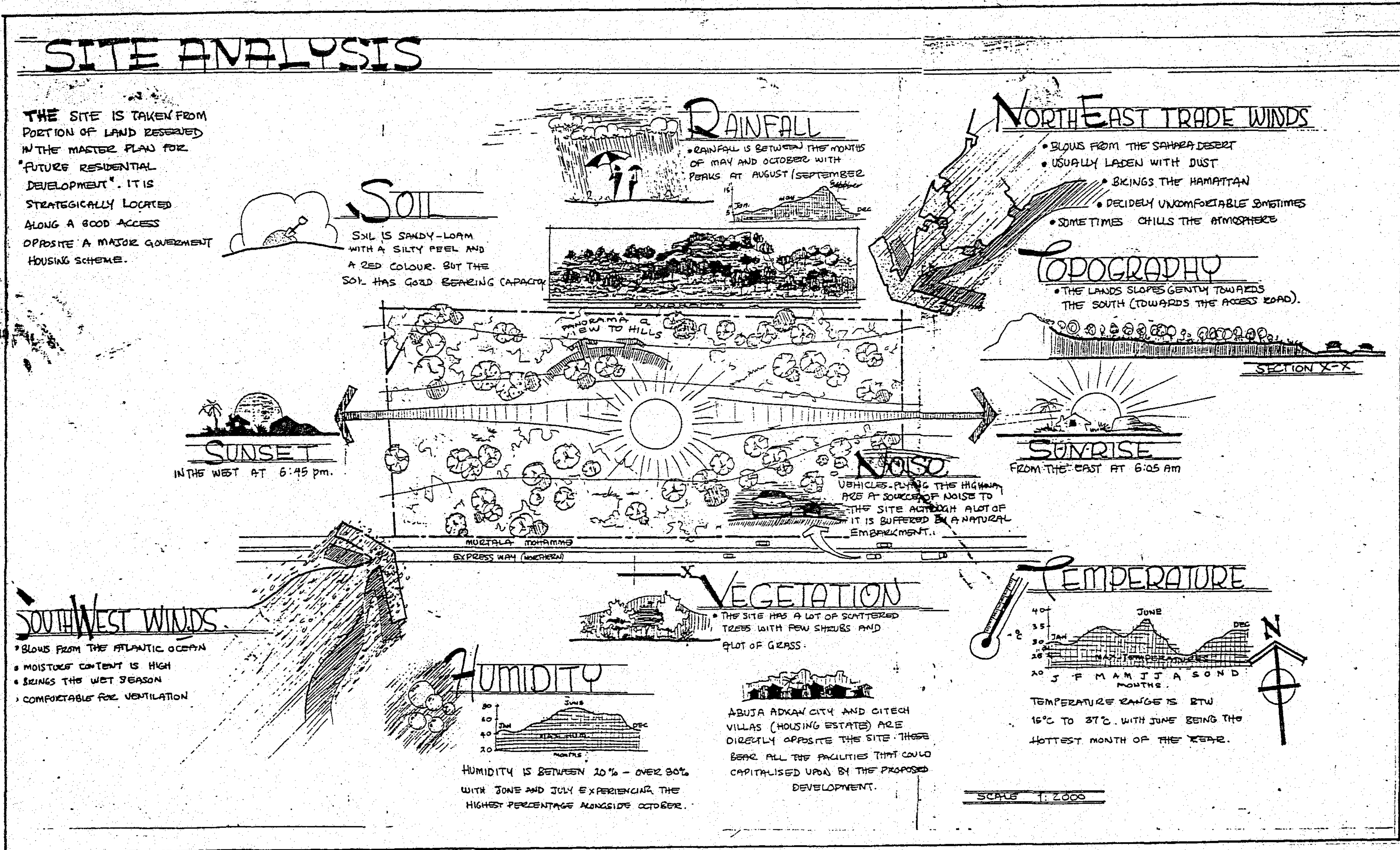


fig. 6.3. Analysis of the Site.

CHAPTER SEVEN

7.0 THE DESIGN

7.1.1 Concept

The sun is the ultimate source of all energy since it gives force to the daily activities of nature, which spins and prepares the energy sources. The illustration shows the major elements arranged the sum as the centre of activity. This analogy is used for planning of the site. The site is zoned in a radial pattern with the city centre (Multipurpose auditorium, restaurant, shops and café) as the central focus with all other units radiating out from it, beginning with the high density housing to the low density houses at the furthest end of the radius. The city centre is chosen as the focus because of its purpose of bringing the inhabitants of the houses inwards to a meeting point.

7.1.2 Descriptions

The design of each unit is made on a function-to-form basis with a particular focus on energy-efficiency features as are applied. For each unit, the spaces are free flowing, to enable circulation of air through the spaces without much difficulty. For the site plan however, the design is based on the analogy presented in 7.1.1 above. The service area of the site is placed on the left containing the estate office, waste management and waste disposal services, and this is clearly separated from but related to the rest of the site. This is balanced out by locating all the five-bedroom duplexes on the right. The rest are equally placed on both sides of the city centre. At the central core, the first point of contact is the general parking then the multipurpose hall with the shops and cafe, then the restaurant. Behind these is the recreational area with a view to the hills.

7.2 MATERIALS AND CONSTRUCTION

The materials used and the construction techniques chosen are based on energy-efficiency requirements, thus, certain factors were considered before employing them.

7.2.1 Substructure

The foundation will be reinforced concrete and the foundation walls will be of concrete-filled sandcrete blocks. The walls will be topped with concrete floor. In any case, the design and construction of the foundations for each unit will be based on the structural engineer's details. However, each unit is stepped according to the slope of the piece of the site that it is located upon. This means that little of the natural ground will be remodelled; as much as possible, the land will be left natural. Damp proof courses will be applied to all parts of the foundation to ensure that the bricks are protected from ground water as much as possible.

7.2.2 Superstructure

The walls of all the units will be constructed of stabilized earth bricks. The technology of the earth bricks is obtained from the centre for Earth Construction Technology (CECTech), in Jos, Plateau State. This centre has been involved in research concerning the successful use of earth as a building material. Unlike red clay bricks, these bricks are almost natural with a very small percentage of hardeners added; therefore, they are relatively cheaper and easy to use and yet strong and stable.

For the single-storey units, the superstructure will be of concrete, lightweight frame construction with the earth bricks being used as non-loading-bearing, infilling walls. All lintels that are 1200mm and lower will be made of bricks which details are given in the drawings. All arches will also be of bricks. The walls will be 140mm thick, according to the size of the brick. The whole design is done to minimize the use of concrete as much as possible.

The choice of earth bricks here is made based on the known fact that earth is highly resistant to heat transfer. This will ensure that minimum heat transfer occurs either from interior to exterior or vice-versa, according to temperature differences between the two.

All windows will be aluminium framed sliding windows with clear glazing. The high-level vents will have two-leaf louvres. All exterior doors, on the other hand, will be of steel panel, while the interior doors will be wooden flush doors.

All concrete parts will be plastered and painted with white or cream emulsion while the interiors will be painted with brown emulsion. The floors are finished with PVC tiles.

The roof structure will be constructed of hardwood timber coated with anti-insect and fire resistant chemicals. The roofing sheet will be of long span aluminium. Between the purlins, a layer of heat insulation will be placed under the roofing sheets. The roofing of each unit is done with the major structure being a simple gable. On each side of the gable, an array of photovoltaic cells will be laid for power generation.

The ceiling will be of celotex, painted white, with wood skirting at the junction of ceiling and wall.

7.3 SPACE REQUIREMENTS

The space allocation was done with direct regard for standards and also to ensure free flowing spaces to allow for the movement of convectional currents, especially between living rooms and dining rooms. However, much of it is affected by the size of brick. The following spaces have been allocated to the functions concerned.

7.3.1 HOUSING

5-bedroom duplex (ground floor)

Living room	$40.8m^2$
Dinning room	$17.2m^2$
Kitchen	$14.9m^2$
Guest room	$18m^2$
Bedroom	$18m^2$
Store	$7.7m^2$
Bath / Dressing	$9m^2$
Guest Bath	$5.1m^2$
Visitors' Toilet	$3.3m^2$
Stair well	$9.6m^2$

5-bedroom duplex (first floor)

Family room	$40.8m^2$
Master bedroom	$26.4m^2$
Bedroom 1	$22m^2$
Bedroom 2	$16m^2$
Battery room	$3.6m^2$
Master bath	$7.9m^2$

Bath	4.6m^2
Toilet	3.3m^2
Stairwell	9.6m^2

3-bedroom bungalow

Living room	41.4m^2
Dinning room	21.2m^2
Master bedroom	25m^2
Bedroom	18m^2
Kitchen	16.7m^2
Store	5.5m^2
Master bath	7.4m^2
Guest bath	6m^2
Bath	m^2
Visitors' toilet	3.1m^2
Battery room	3.6m^2

2-bedroom semi-detached

Living room	36m^2 x 4
Dining area	9.8m^2 x 4
Bedroom 1	.18.8m^2 x 4
Bedroom 2	18.8m^2 x 4
Kitchen	9.6m^2 x 4
Store	2.6m^2 x 4
Bath 1	7.1m^2 x 4
Bath 2	5.1m^2 x 4
Visitors' toilet	3.2m^2 x 4

Battery	$3.25m^2$ x 2
Stairwell	$12m^2$ x 2

7.3.2 CITY CENTRE

Auditorium (500 capacity)

Hall	$65.6m^2$
Backstage	$22m^2$
Male changing	$9.2m^2$
Female changing	$9.2m^2$
Shower and toilet	$7.8m^2$ x 2
Storage	$18.2m^2$ x 2
Battery room	$26.4m^2$ x 2
Shops	$12m^2$ x 3
Cyber cafe	$26m^2$ x 2
Office	$12m^2$

Restaurant

Dining hall	$100m^2$
Cooking	$33m^2$
Storage	$15m^2$
Changing	$9.1m^2$
Toilet x 5	$14.4m^2$
Manager's Office	$10m^2$
Secretary	$9m^2$

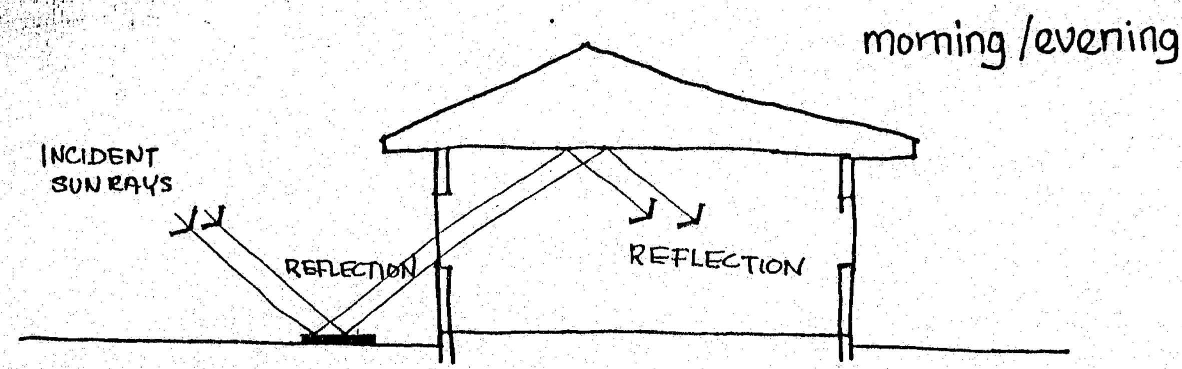
7.4 ELECTRICITY AND LIGHTING

The main source of power supply to each building is through solar energy. Photovoltaic (PV) arrays are laid on rooftops which trap the sum's energy to be stored and converted for use in powering all electrical appliances and fixtures. The choice of solar energy is due to the fact that it is a renewable source of energy. All parts of the world are looking more and more to solar energy as a reliable source of energy. However, NEPA power will be tapped, to be used only as a support system for automatic changeover in times of need.

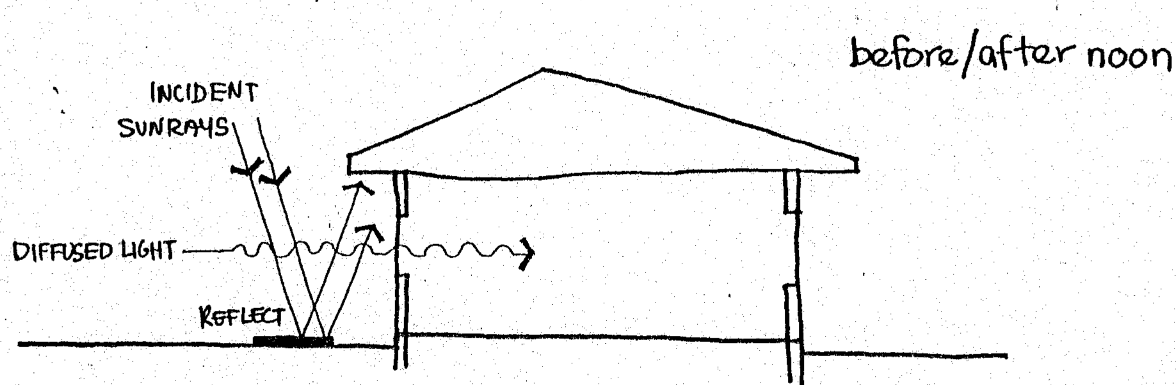
Artificial lighting fixtures are specified to be energy-efficient fixture, which are available in the market, to minimize the amount of wattage that will be consumed by each building. Furthermore, task lighting will be used for all spaces were it will be required like dining rooms and study rooms or libraries. This is to ensure that light is used only as needed.

7.5 HEATING, COOLING AND VENTILATION

Natural ventilation is a major consideration in this proposal. A natural ventilation system has been developed to minimize the use of artificial ventilation systems, thereby saving energy. this specific ventilation system is based on two principles of nature: The stack effect of air and the fact that air in compressed form and in forced motion tends to cool down. The system involves a high level opening with deep screens on the exterior. As air passes through this screens, it is cooled down a little and louvers in the opening direct the air to the top where, if cooler than interior air, it descends to replace warmer air, generating convectional currents and aiding ventilation. Furthermore, the screens are oriented with only 15^0 a difference with the Northeast-Southwest axis to capture prevailing winds. Further air conditioning is done to large spaces like living rooms in times of need.



REFLECTIVE GROUND SURFACES REFLECT LOW ANGLE MORNING AND EVENING SUNLIGHT INTO THE INTERIOR WITHOUT HEAT BUILD-UP

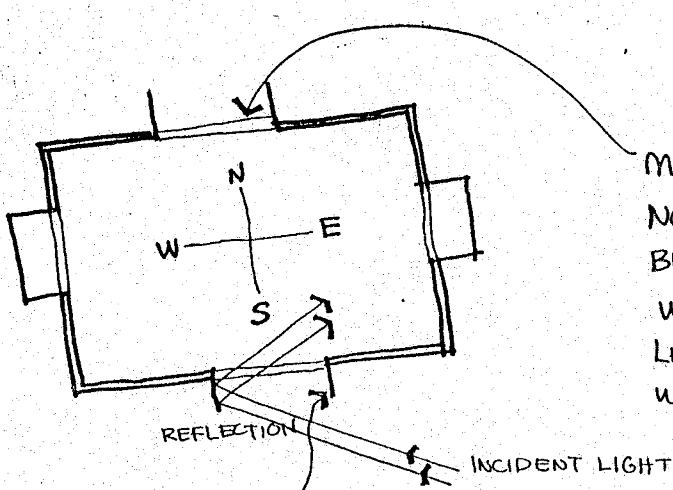


HIGH ANGLE SUNRAYS WHICH ARE HOT ARE NOT REFLECTED INTO THE INTERIOR THERE BY REDUCING HEAT BUILD-UP.

MORE DIFFUSED LIGHT THAN DIRECT LIGHT ENTER THE BUILDING'S INTERIOR.

fig 7.1. Luminous Implications.

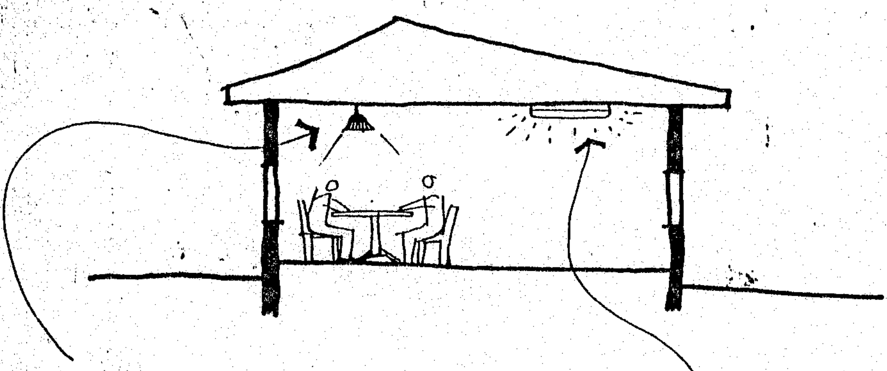
ORIENTATION



MORE GLAZING HAS BEEN USED ON NORTH AND SOUTH SIDES OF THE BUILDING TO ADMITT MORE LIGHT WITHOUT CAUSING HEAT BUILD-UP. LESS DIRECT SUNLIGHT ON EAST AND WEST SURFACES.

INNER SURFACES OF SHADING DEVICES ARE PAINTED WHITE TO MAXIMIZE REFLECTION OF LOW ANGLE SUNLIGHT INTO THE BUILDING'S INTERIOR.

ARTIFICIAL LIGHTING



TASK LIGHTING IS USED IN SPACES SUCH AS DINING ROOMS WHERE THEY ARE MOST NEEDED TO MINIMIZE THE NEED FOR LAVISH LIGHT IN NIGHT TIME.

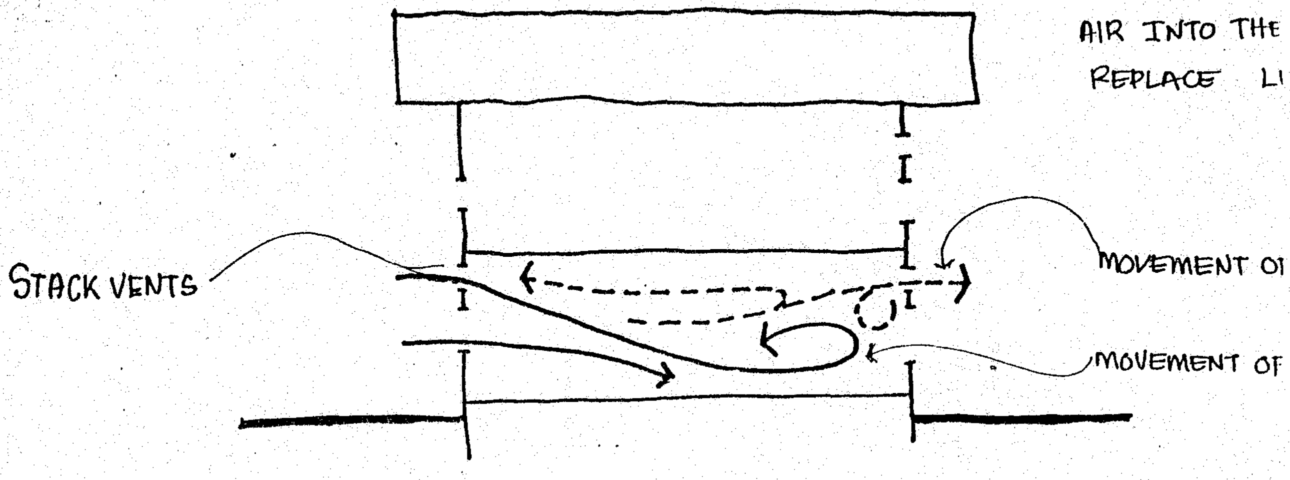
LOW-ENERGY LIGHTING FIXTURES ARE SPECIFIED TO MINIMIZE ENERGY CONSUMPTION AND STILL ACHIEVE LIGHTING NEEDS.

fig. 7.2. Luminous Implications II.

VENTILATION

"STACK"

HIGH LEVEL O
BEEN CREATE
STACK EFFECT
AIR INTO THE
REPLACE LI

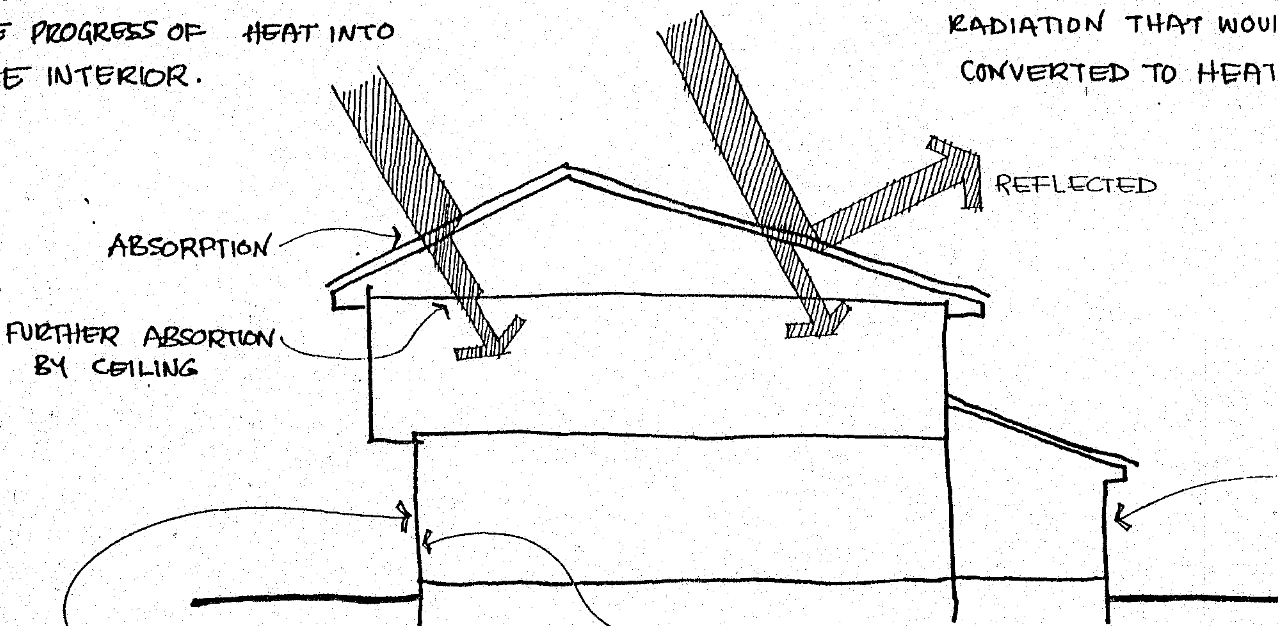


THERMAL INSULATION

INSULATIVE MATERIAL PLACED UNDER ROOFING SHEET TO RESIST THE PROGRESS OF HEAT INTO THE INTERIOR.

ROOF COLOU

REFLECTIVE 'NAKED'
HAS CHOSEN TO REFLE
RADIATION THAT WOU
CONVERTED TO HEAT



WALL TEXTURE

SMOOTH TEXTURE EXTERIOR SURFACES REFLECT MORE SOLAR RADIATION MINIMIZING HEAT TRANSFER INTO THE INTERIOR.

WALL COLOUR

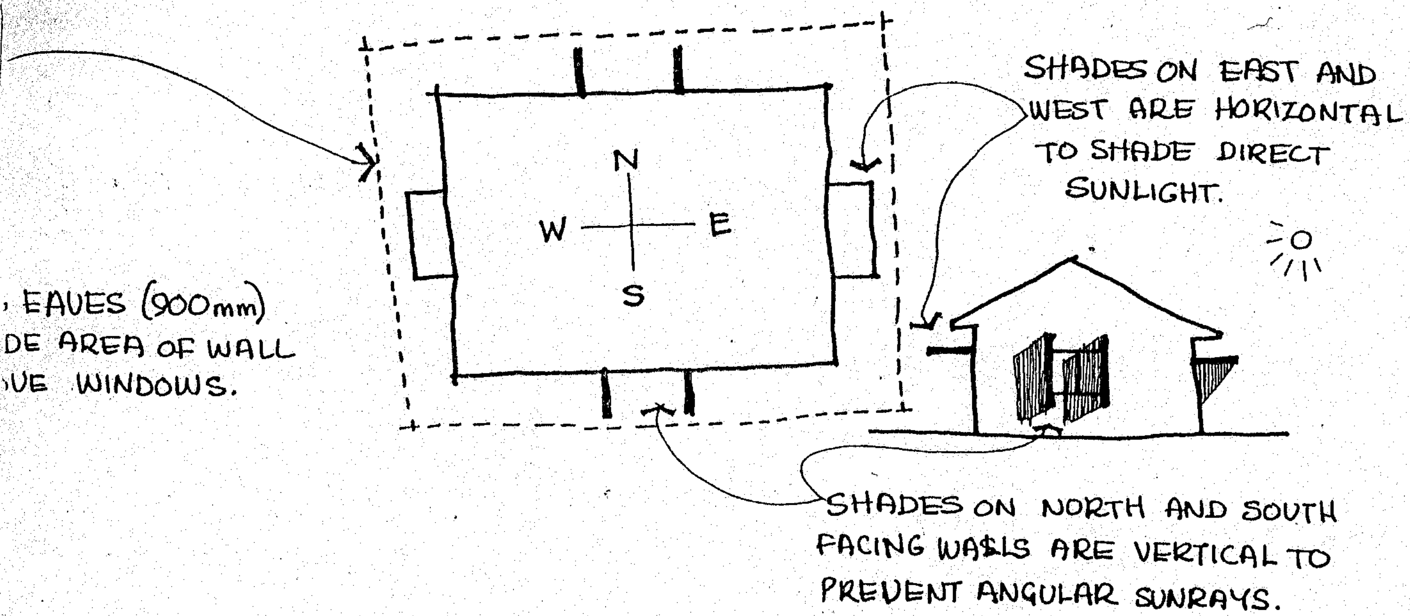
BRICK COLOURS ON EXTERIOR SURFACES ALSO ENCOURAGE REFLECTION OF SOLAR RADIATION DISCOURAGING TRANSMISSION

WALL M

EARTH HAS
UNIVERSALY
INSULATIVE
LOWER EM

fig. 7.3. Thermal Implications.

SUN SHADING



ORIENTATION

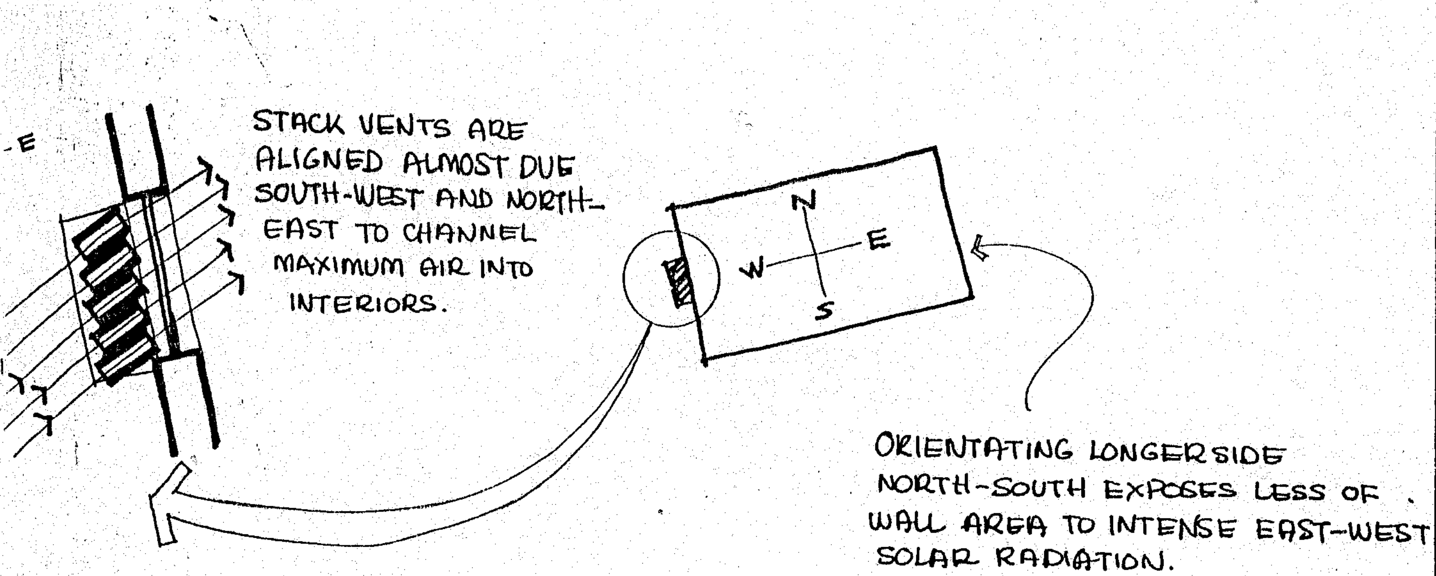


Fig. 7.4. Thermal Implications II.

7.6 WATER SUPPLY

Water supply is from the Abuja Water Board. However, certain measures will be put in place to minimize the excess use of water, since a lot of energy goes into preparation and distribution of portable water. One of those measures includes the collection and storage of storm water to be purified and redistributed in the dry season for non-portable uses like plant watering. The other measure includes the specification of low water-consuming sanitary appliances, which are available in the market. These measures will ensure that portable water from water board is used with utmost economics.

7.7. DRAINAGE AND SEWAGE DISPOSAL

The site slopes towards the front of the site in an almost even pattern. This presents little challenges for drainage. Consequently, a central sewage system will be employed in managing all the sewage originating from the various units to be on the site and as mentioned earlier, a central storm water collection and redistribution plan is intended and this is located on the left hand side of the site behind the estate management office.

7.8. REFUSE DISPOSAL

On the site, a waste management office is intended. This will serve as a unit where solid waste is sorted and all recyclable and reusable materials are removed and stored or prepared for reuse. During construction, this unit will be responsible for sorting out cut-off building materials to determine which wastes can be put to other uses. For example, tiles that have been cut out from interior floor filing could be used for paving car parks and so on. The waste disposal area is located at the north-western end of the site where all waste material that have hot been picked for reuse or recycling will be taken care of either by incineration or otherwise. All biodegradable waste is made into compost for use as manure. In this way the amount of real waste is significantly reduced.

7.9 ACOUSTICS

For all the residential units, no particular acoustical measures are taken, except for the fact that the walls serve as noise isolators to protect the occupants of the building from excessive exterior noise from whatever source.

For the multipurpose hall, the walls in the interior will be lined with sound-absorbing materials to prevent unwanted echoes from spoiling the quality of sound produced within the hall. Similarly, the floor of both the multipurpose auditorium and the restaurant will be padded to prevent the reflection of loud sound off them.

7.10 FIRE SAFETY

Fire preventive materials will be used in all the buildings. The roof-structure timber will be coated with flame-retardants. Also, since the surface of the brick to be used will be left in its natural form in most parts of the interior, there is little danger of fire spreading along the walls.

Furthermore, fire protection devices are to be installed in all buildings, including g sprinklers and cylinder extinguishes.

7.11 SECURITY

As a general precaution on the site, security posts will be provided for all entrances and an office will be provided at the management office for security personnel. Steel panel doors will be used on all exterior door openings while burglary proofing will be applied on all fenestrations. The entrances to the site are limited to two, both of which have security posts. The perimeter of the site will be protected with fencing and barbed wire.

7.12 COMMUNITY

In contributing to community needs, all public facilities on the site like, the multipurpose centre and recreational parks will be open to controlled public use, so that the immediate community can benefit the community will also be able to benefit. The community will also be able benefit from the waste management programme. Reciprocally, the community will support the estate with essential facilities, which should not be duplicated.

7.13 MAINTENANCE

Maintenance is indeed of peculiar interest in this project to justify each building's sustainability; each building must perform to optimum standard. Maintenance must be ensured to enable each building reach its designed lifecycle. First of all, construction must be of high quality, no matter the cost, to minimize the amount of monies that will be spent thereafter to maintain the building. Furthermore, the estate management office will be engaged in a planned maintenance programme and this will also include orientating occupants from time to time on how to get the best performance out of their buildings, especially owing to the peculiar nature of the buildings.

7.14 SOLAR CONTROL

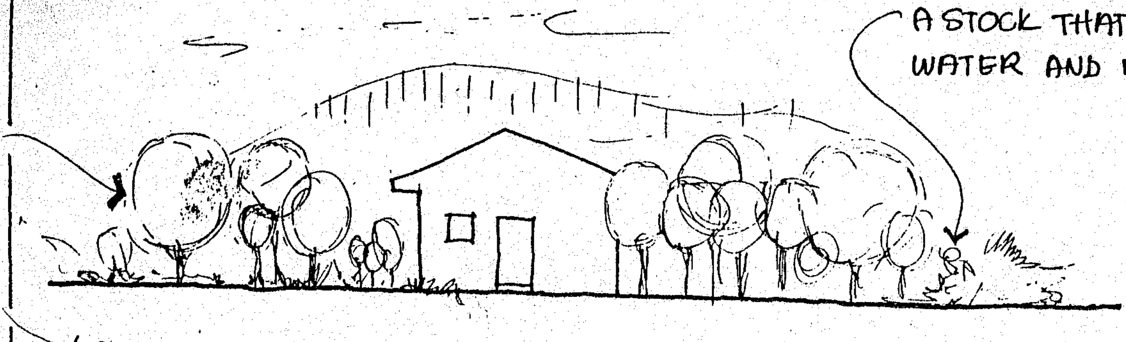
It can be mentioned again before hand, that solar energy is used to power each building. To prevent solar glare to occupants of each building however, the wider openings are specified only on south and north facing walls and the east and west facing fenestrations are adequately shaded. The widest of openings are recessed behind, verandas and balconies. No solar control glazing is done on the residential units except for the city centre. This is to maximize the influx of low angle evening and morning sunlight to ensure as much natural lighting as possible.

7.15 LANDSCAPING

Much of the landscape will be left natural, to be enhanced only. This is done to prevent the use of plants that require much watering and man-hours in care as well as to protect the integrity of the site's natural landscape. The paving will be done of bright coloured interlocking tiles and at a distance from the building to prevent excessive water splashing on the walls and to effect light reflection into the interior but only for low angle sunlight. In all, the landscape will be enhanced with additional plants that will be chosen from low water-consuming varieties while the whole landscape will be carefully maintained with dry-season watering and all-year-round manuring.

LANDSCAPING

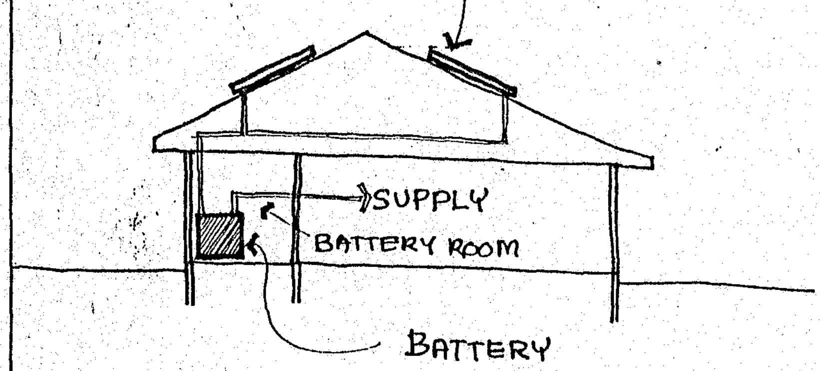
PLANTS TO BE USED FOR HERE WILL BE SELECTED FROM A STOCK THAT REQUIRES LESS WATER AND MAINTENANCE.

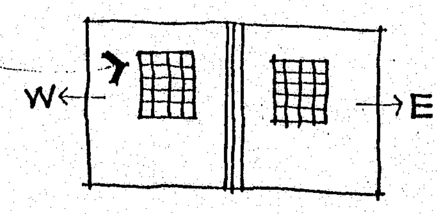


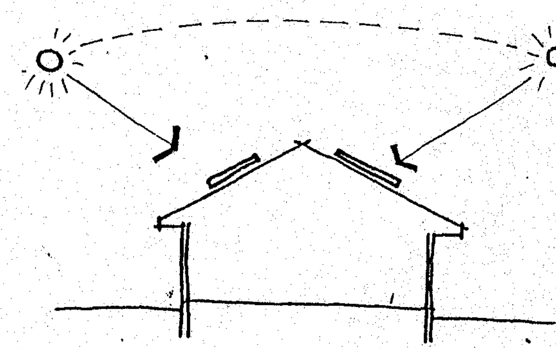
MUCH OF THE LANDSCAPE IS LEFT NATURAL, SUPPLEMENTING WITH OTHER INTEGRATED FEATURES. THIS ENSURES THAT THE BUILDING IS BUILT TO FIT INTO THE ENVIRONMENT RATHER THAN CREATING CLEARANCE FOR FRESH LANDSCAPE WHICH IS EXPENSIVE.

POWER

PHOTOVOLTAIC CELLS



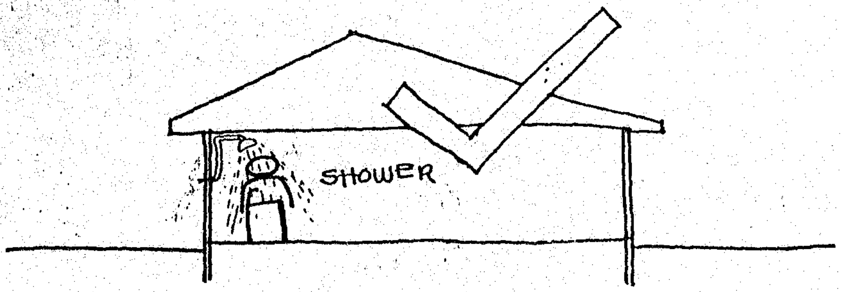




MAJOR SOURCE OF ENERGY IS SOLAR ENERGY WHICH IS A RENEWABLE SOURCE OF ENERGY. THIS WILL ONLY BE SUPPLEMENTED WITH POWER FROM THE PUBLIC GRID.

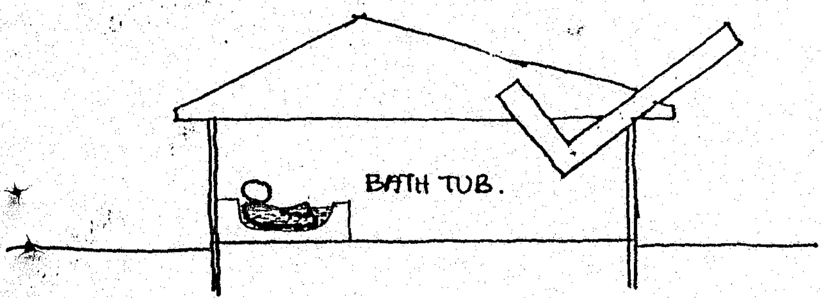
Fig. 7.5. More features.

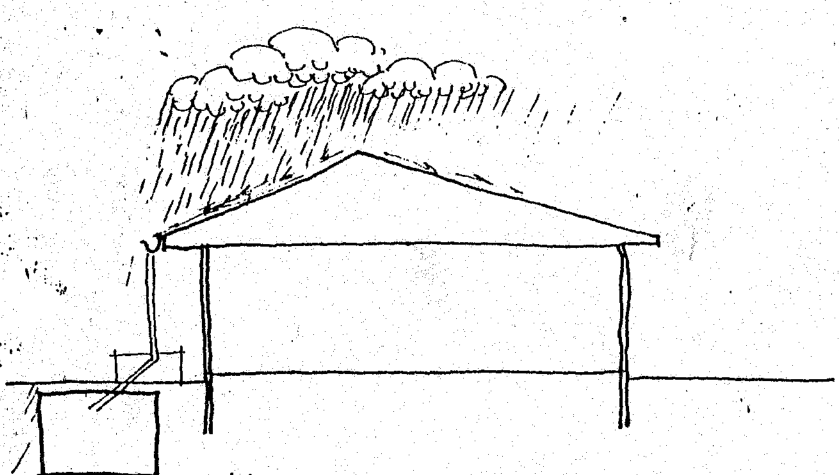
WATER EFFICIENCY



LOW-WATER-CONSUMPTION FIXTURES ARE SPECIFIED TO PREVENT WASTAGE OF WATER IN USE.

- LOW FLOW TOILET BOWLS
- WATER EFFICIENT THUBS
- SHOWERS ARE CHOSEN FROM RANGES WHICH ARE CHARACTERISTICALLY WATER-EFFICIENT.
- RECOVERED RAINWATER IS USED FOR TOILET FLUSHING.





- STORM WATER IS COLLECTED AT CENTRALISED WATER STORAGE AND REDISTRIBUTION CENTRE DURING THE WET SEASON FOR USE IN THE DRY SEASON.

WATER IS COLLECTED INTO STORAGE TANKS IN THE RAINY SEASON WHICH WILL LATER BE PUMPED FOR USES SUCH AS WATERING LANDSCAPE PLANTS AND OTHER NON-PORTABLE USES SUCH AS TOILET FLUSHING.

fig. 7.6. More features II.

CHAPTER EIGHT

8.0 SOLAR ENERGY

8.1 INTRODUCTION

Solar energy is the energy obtained from the sun. The sun emits a tremendous amount of energy; part of this can be trapped and converted to heat or electricity. Solar energy is a renewable source of energy. The world is looking away from fossil-fuel dependent sources of energy to completely renewable sources to save the earth's resources.

Hot climatic regions are particularly rich in solar energy. There, the amount of energy per square metre of horizontal surface ranges between 1300 and 1900 kilowatt. In Asia, the energy collected from the sun rays incident upon an area about 70km square equals that obtained from burning the total of the USSR (now Russia and other countries) Oil production in 1986 (about 615 Million tones). (STOLL, 1987).

In August 1981, reports STOLL (1987) a UN conference was held in Nairobi on novel and alternative power sources. In December 1983, an international conference on solar energy took place in Kuwait. In 1s982, the African Regional Centre for solar Energy was established in Addis Ababa whose major objective was to develop and integrate into practice, solar power plants in Africa. Similar moves have been made in several countries worldwide, some earlier, some later. Africa does have an abundant solar energy supply.

8.2 PHOTOVOLTAICS

The equipment for capturing and converting solar energy are called photovoltaics, photovoltaic (PV) systems convert light energy into electricity. The term photo is a stem from the Greek word *phos*, which means, "light". The word

"*Volt*" comes from a pioneer in the study of electricity" Alessandro Volta. Photovoltaic, then, could literally mean "Light Electricity.

Photovoltaic (PV) or solar cells as they are often referred to, are semiconductor devices that convert sunlight into direct current (DC) electricity. Groups of PV cells are electrically configured into modules and arrays, which can be used to charge batteries, operate motors, and to power any number of electrical loads. With the appropriate power conversion equipment, PV systems can produce alternating current (AC) compatible with any conventional appliances, and operates in parallel with and interconnected to the utility grid (www.fsec.ucf.edu).

8.2.1 HISTORY OF PHOTOVOLTAICS

The first conventional photovoltaic cells were produced in the late 1950s, and throughout the 1960s were principally used to provide electrical power for earth-orbiting satellites. In the 1970s, improvements in manufacturing performance and quality of PV modules helped to reduce costs and opened up a number of opportunities for powering remote terrestrial applications, including battery charging for navigational aids, signals, telecommunications equipment and other critical, low power needs (ibidem)

In the 1980s, photovoltaics become a popular source for consumer electronic devices, including calculators,sss watches, radios, lanterns and other small battery charging applications. Following the energy crises of the 1970s, significant efforts also began to develop PV power system for residential and commercial uses both for stand-alone, remote power as well as for utility-connected applications. During the same period, international applications for PV systems to power rural health clinics, refrigerator, water pumping, telecommunications, and off-grid households increased dramatically, and remain a major portion of the present world market for PV products. Today, the industry's production of PV modules is growing at approximately 24 percent annually, and major programs in the U.S., Japan and Europe are rapidly accelerating the implementation of PV systems on buildings and interconnection to utility networks (ibidem).

Photovoltaic History Timeline

1839	–	PV effect first observed by Henri Becquerel
1870	-	Selenium PV produced with 1.2% efficiency
1954	-	PV cell produced with 14% efficiency
1958	-	Vanguard space satellites use PV array to power radio. Commercial space applications of PV begin.
1970's	-	Energy crisis periods stirs interest in terrestrial applications of PV.
1980's and 1990's		Explosion of PV for telecom use
Late 1990's	-	Emergence of grid – connected applications as highest growth PV sector.

8.2.2 HOW PHOTOVOLTAICS WORK

A typical silicon PV cell is composed of a thin wafer consisting of an ultra-thin layer of phosphorus-doped (N -type) silicon on top of a thicker layer of boron-doped (P-type) silicon. An electrical field is created near the top surface of the cell where these two materials are in contact, called the P-N junction. When sunlight strikes the surface of PV cell, this electrical field provides momentum and direction to light-stimulated electrons, resulting in a flow of current when the solar ceil is connected to an electrical load conditions. The current (and power) output of a PV cell depends on its efficiency and size (surface area), and is proportional the intensity of sunlight striking the surface of the cell. For example, under peak sunlight conditions a typical commercial PV cell with a surface area of 160 cm ^2 will produce about 2 watts peak power. If the sunlight intensity were 40 percent of peak, this cell would produce about 0.8 watts.

8.2.3 PV CELLS, MODULES, & ARRAYS

Photovoltaic cells are connected electrically in series and /or parallel circuits to produce higher voltages, currents and power levels. Photovoltaic modules consist of PV cell circuits seated in an environmentally protective laminate, and are the fundamental building blocks of PV systems. Photovoltaic panels one or more PV module assembled as a pre-wired, fixed –installable unit. A Photovoltaic carry array is the complete power-generating unit, consisting of any number of PV modules and panels.

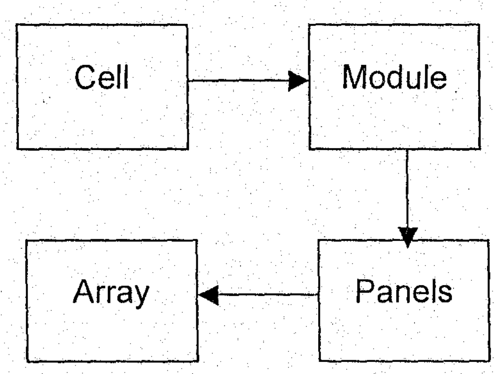


Fig 8.1 Photovoltaic Cells, Modules, Panels and Arrays

Today 's photovoltaic modules are extremely safe and reliable products, with minimal failure rates and projected service lifetimes of 20 to 30 years. Most major manufactures offer warranties of twenty or more years for maintaining a high percentage of initial rated power output. product listing (UL), qualification testing and warranty information in the module manufacturer's specifications.

8.2.4 THE WORKING OF A PV SYSTEM

Simply put, PV systems are like any other electrical power generating systems, just the equipment used is different than that used for conventional electromechanically generating systems. However, the principles of operations and interfacing with other electrical systems remain the same, and are guided by a well-established body of electrical codes and standards.

Although a PV array produces power when exposed to sunlight a number of other components are required to properly conduct, control, convert, distribute, and store the energy produced by the array.

Depending on the functional and operational requirements of the system, the specific components required, and may include major components such as a DC-A power inverter, battery bank, system and battery controller, auxiliary energy sources and sometimes the specified electrical load (appliances). In addition, an assortment of balance of system (BQS) hardware, including wiring, overcurrent, surge protection and disconnect devices, and other power processing equipment. Figure 8.2 show a basic diagram of photovoltaic system and the relationship of individual components.

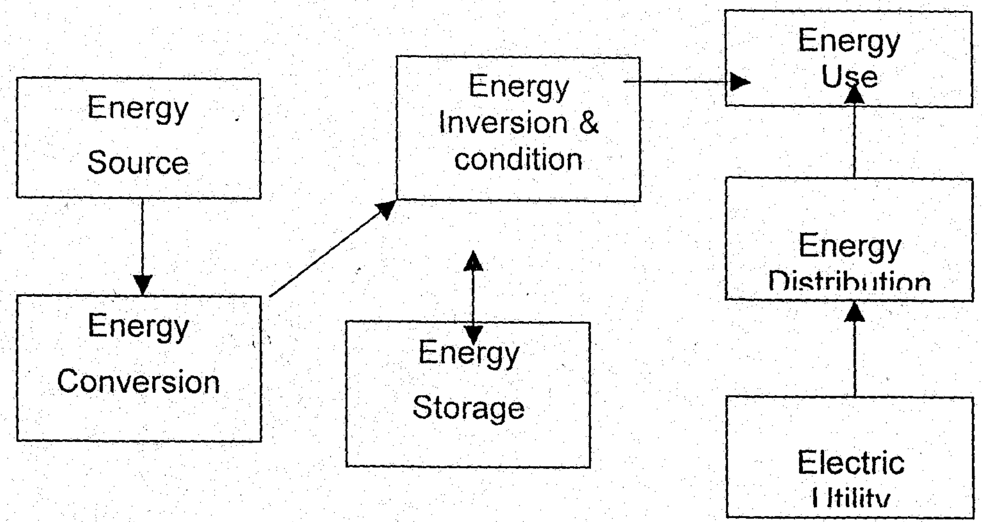


Fig 8.2 Major photovoltaic system components

Batteries are often used in PV systems for the purpose of storing energy produced by the PV array during the day, and to supply it to electricity loads as needed (during the night and period of cloudy weather). Other reasons batteries are used in PV systems are to operate the PV array near its maximum power point, to power electrical load at stable voltage, and to supply surge currents to electrical loads and inverts. In most cases, a battery charge controller is used in these systems to protect the battery from overcharge.

8..2.5 TYPES OF PV SYSTEMS

Photovoltaic power systems are generally classified according to their functional and operational requirements, their component can figurations, and how the equipment is connected to other power sources and electrical loads. The two principle classifications are grid-connected or utility-interactive systems and stand-alone systems. Photovoltaic systems can be designed to provide DC and or / AC power service, can operate interconnected with or independent of the utility grid, and can be connected with other energy sources and energy storage systems.

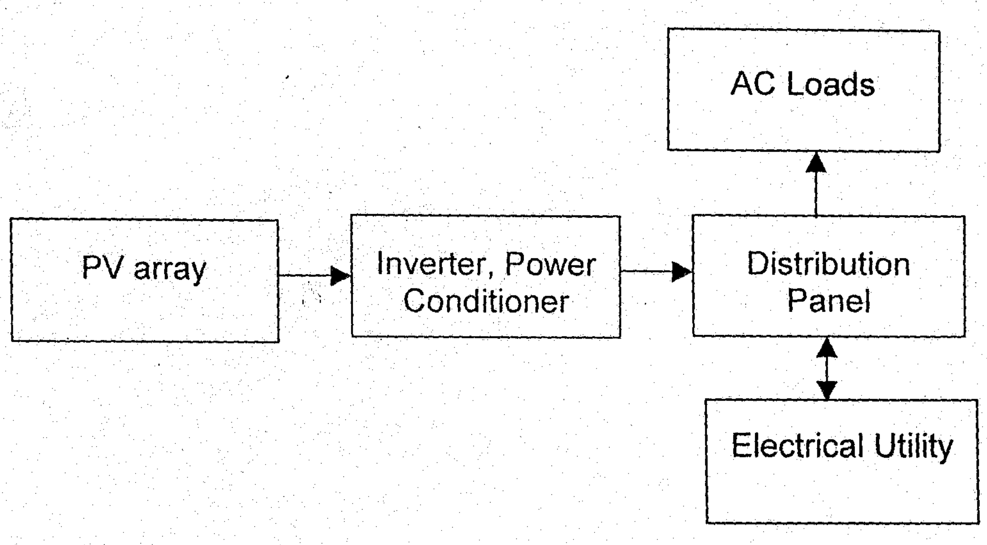


Figure 8.3. A Grid – Connected PV System

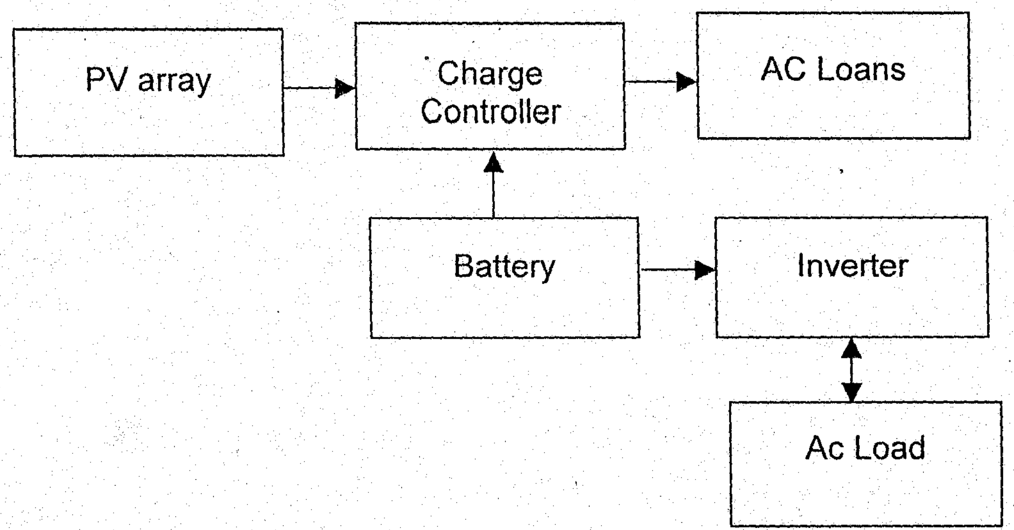


Figure 8.4. A Stand – Alone PV System

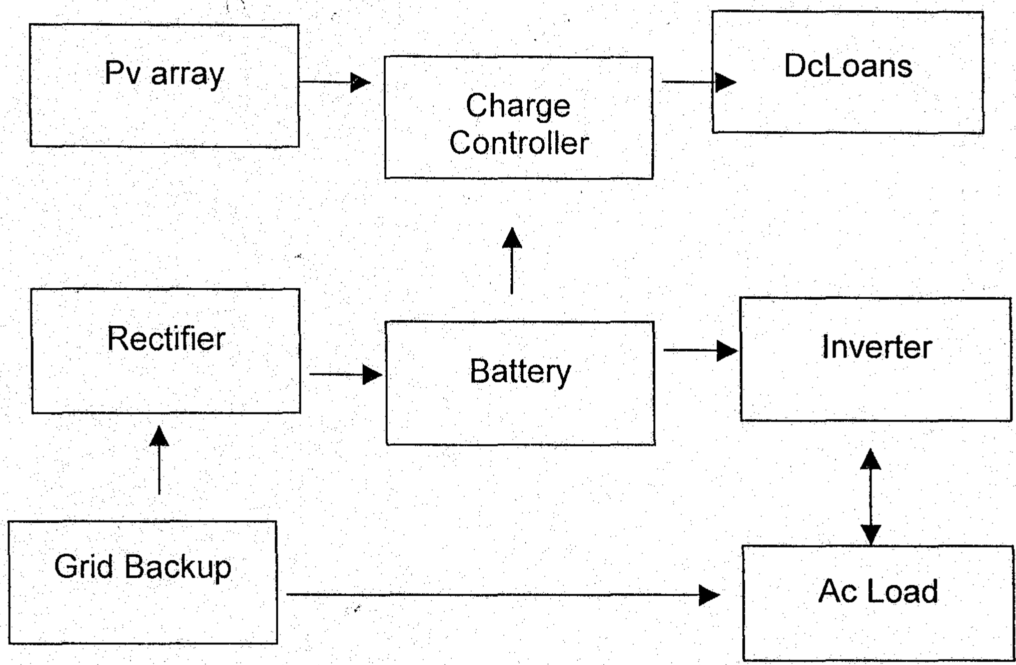


Figure 8.5 a PV hybrid System

8.2.6 THE MAKING OF PV CELLS

The process of fabricating conventional single – and polycrystalline silicon PV cells begins very pure semiconductor – grade polysilicon – a materials processed form quartz and used extensively throughout the electronics industry. The polysilicon is then heated to melting temperature, and trace amounts of boron are added to the melt to create a P-type semiconductor material. Next, an ingot, or block of silicon is formed, commonly using one of two methods: by growing a pure crystalline silicon ingot from a seed crystal drawn from the molten polysilicon of by casting the molten polysilicon in a block, creating a polycrystalline silicon material. Individual wafers are cleaned, they are placed in a phosphorous diffusion furnace, creating a thin N-type semiconductor later around the entire after surface of the cell, and electrical contacts on the top (negative) surhe back (positive) surface of each cell, resorting the P=type properties of the back surface by displacing the diffused phosphorus layer. Each cell is then electrically tested, sorted based on current output, and electricity connected to other cells to form cells circuits for assembly in PV modules.

8.3 BENEFITS OF SOLAR POWER

8.3.1 Reliable And Low Maintenance

With no moving parts, solar generations systems reliably power some of the world's must mission-critical applications, from space satellites to microwave stations in remote and harsh environments.

8.3.2 Modular and Scalable

Solar electric generation is highly scalable and can be deployed in many configurations from hand-held devices to large grid connected systems in urban centres anywhere in the world.

8.3.3 Zero Emissions

Solar power produces no emissions and no noise. As a result, they can be easily sited in densely populated urban areas.

8.3.4 Renewable

Solar electric power is a 100% renewable energy source. Solar electric power systems provide the advantage of other distributed generation system without fuel or regular maintenance requirements.

8.3.5 No Fuel or Infrastructure

Solar electric power is not dependent on the existence, development or maintenance of a fuel delivery infrastructure, nor is it dependent on the cost of fossil fuel. Thus, it offers electricity users an important hedge against future fuel price volatility.

CONCLUSION

The energy of the earth is worth saving, considering its importance in our daily activities. If the building consumes so much energy and other resources, then its impact on the environment cannot be overlooked. Because of this fact, the building industry needs to step into place and go with the good tide. More energy-saving buildings are needed on the scene.

Nigeria is blessed with an abundant supply of solar energy. This potential needs to be harnessed for use to reduce Nigeria's dependence on fossil fuels. Nigeria needs to build buildings that are not so much affected by fossil fuel driven economies as we have them today, and solar energy can contribute to that effect.

Finally, the building industry must contribute its quota to saving the earth's resources by engaging in green architecture and thereby increasing the public's confidence in it.

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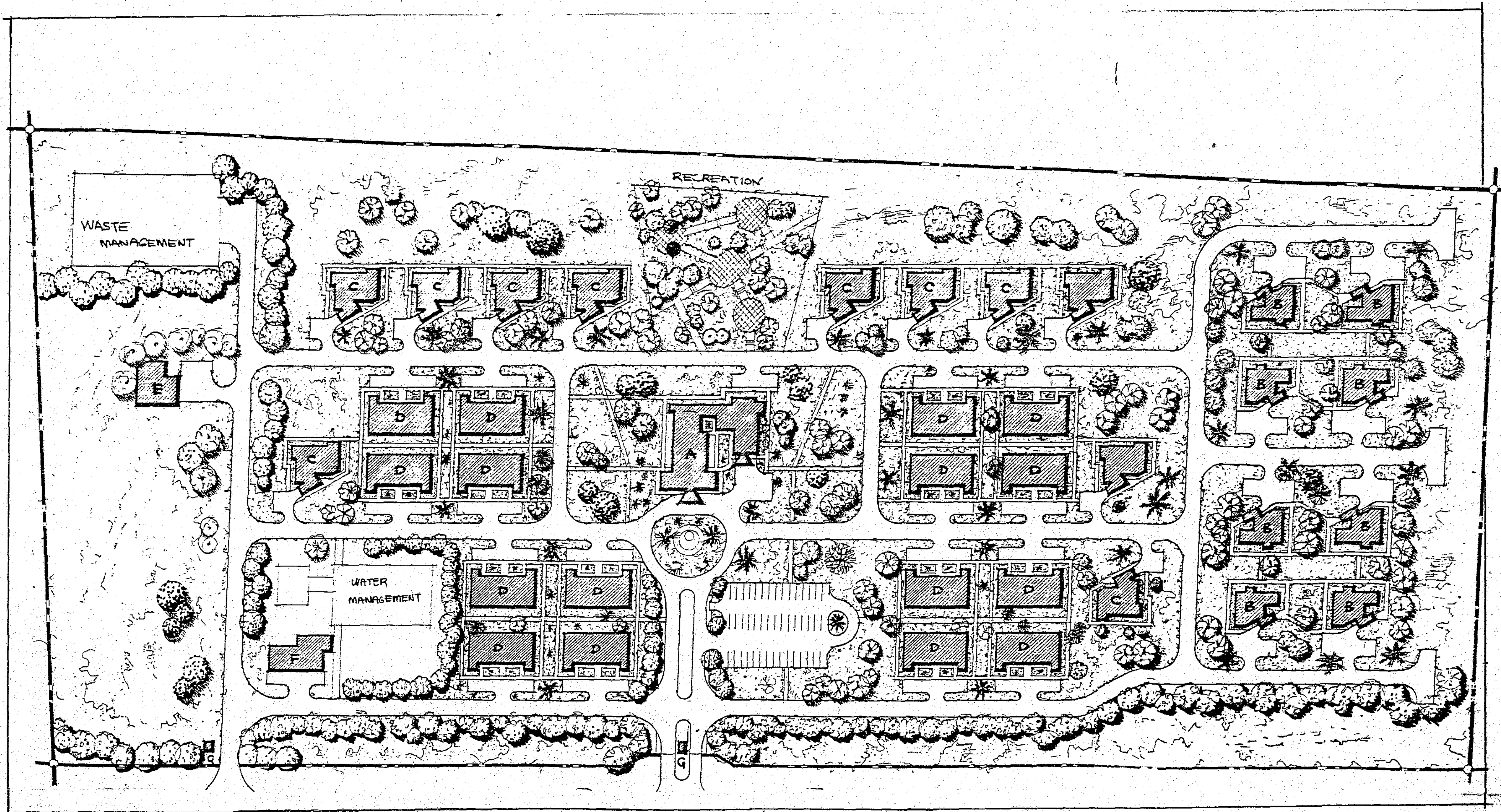
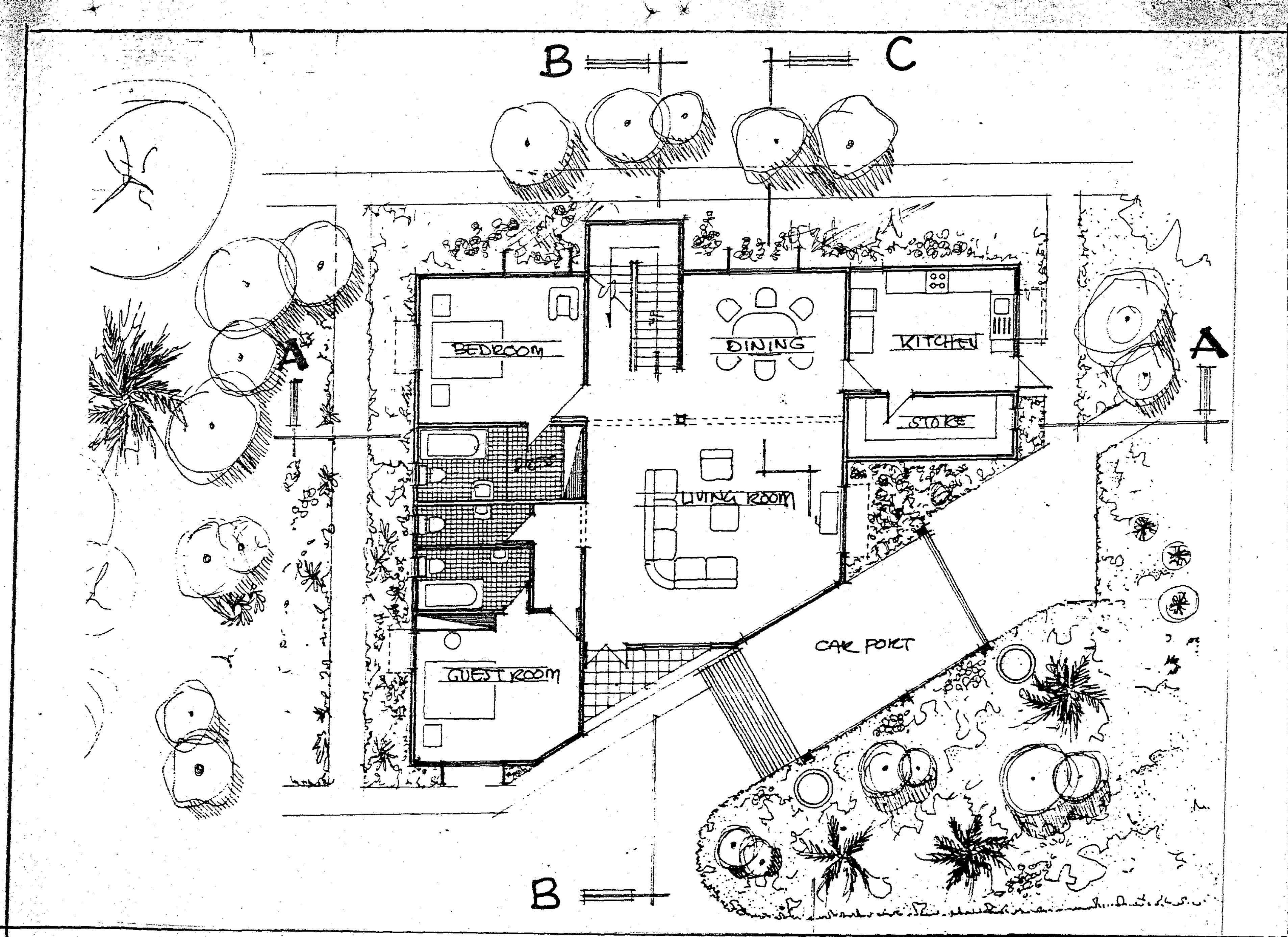
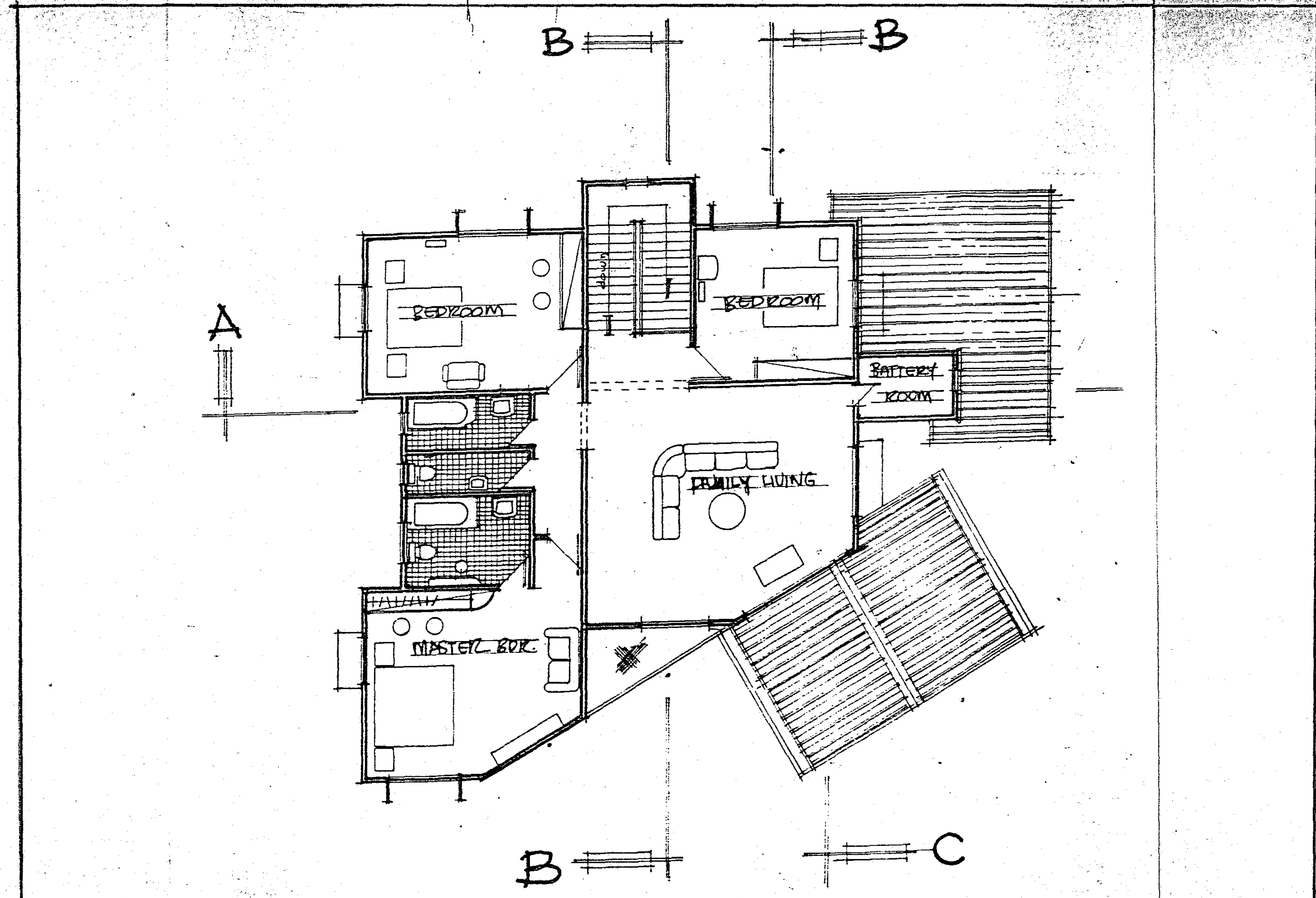


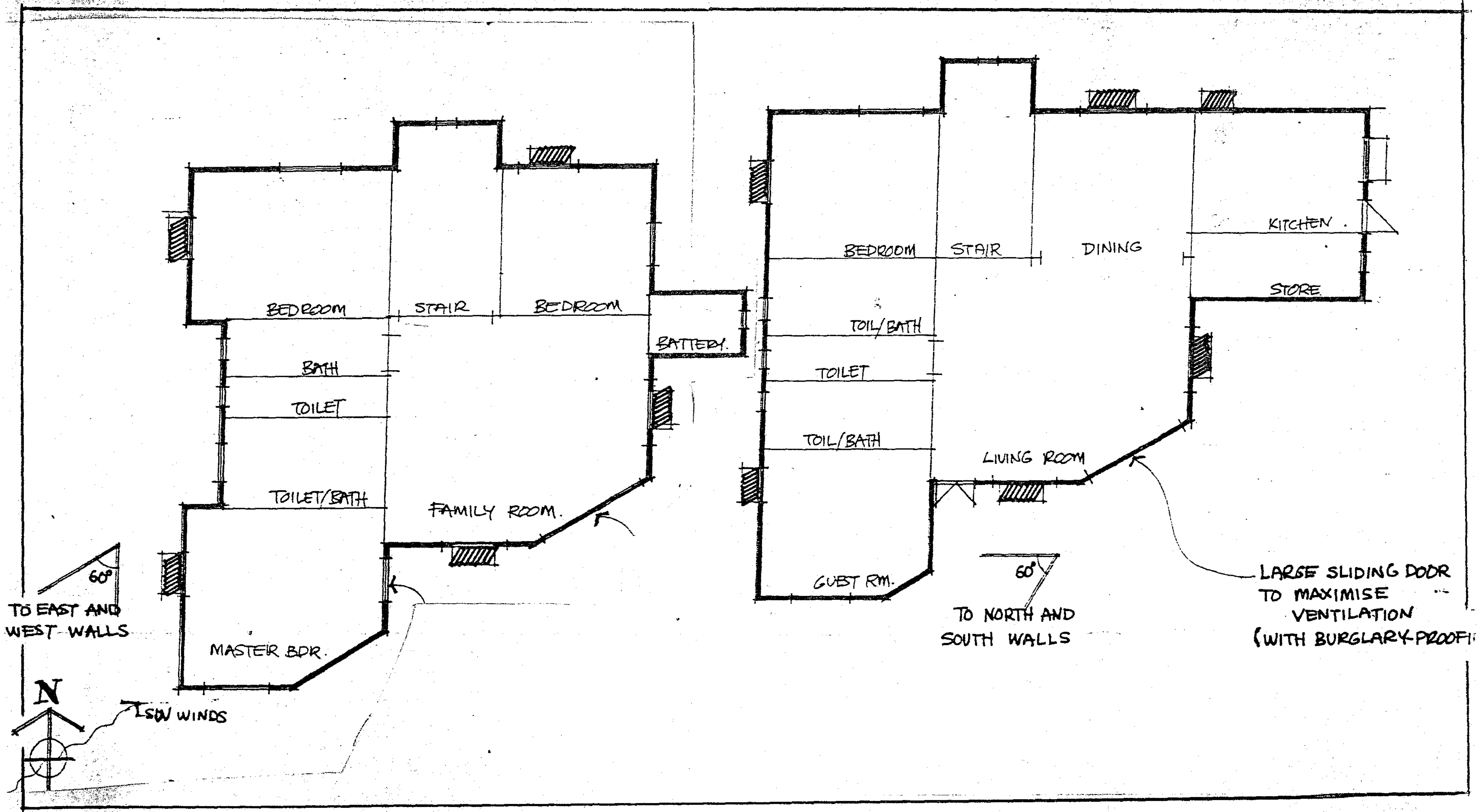
APPENDIX I. SITE PLAN OF ESTATE



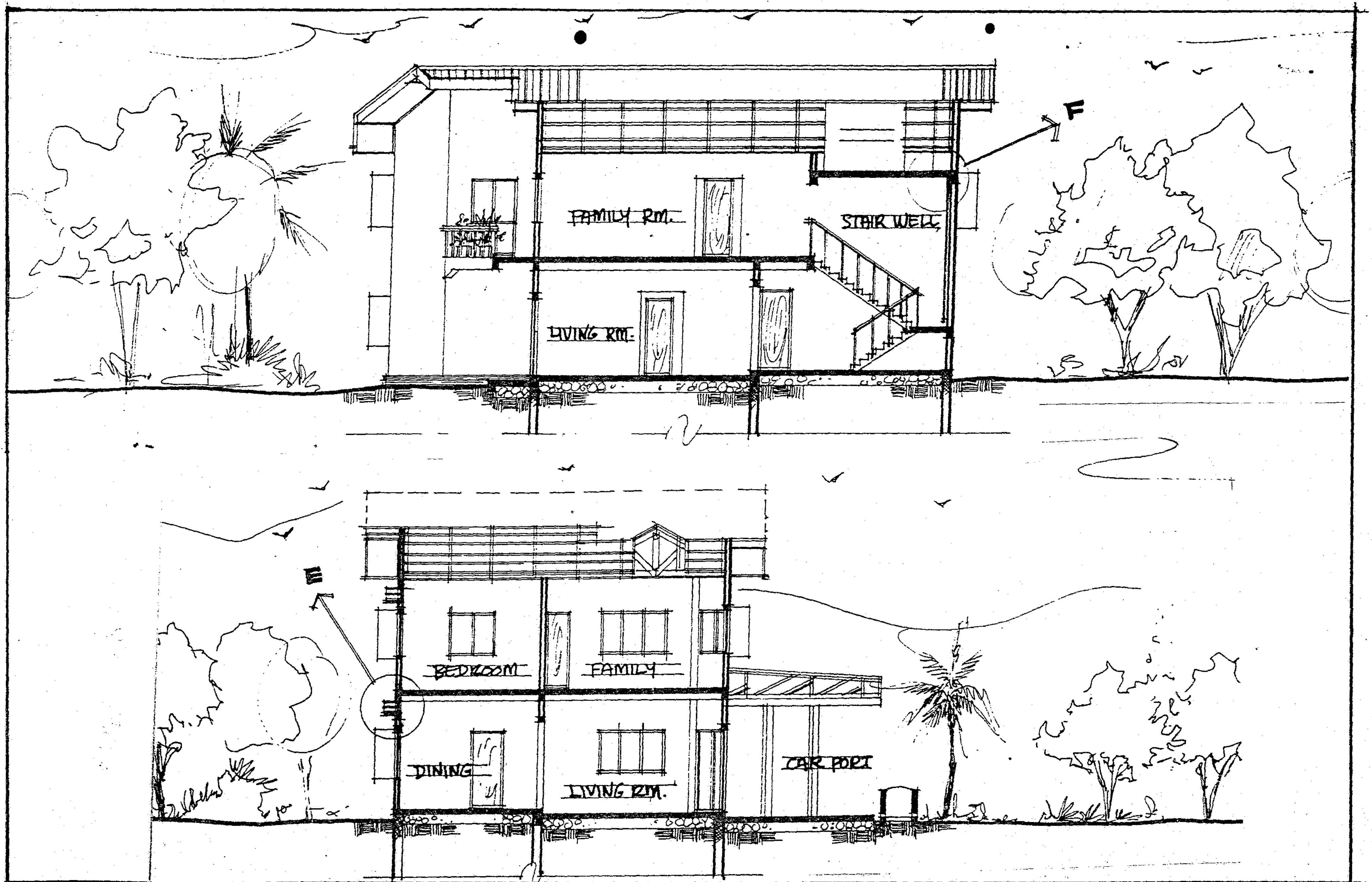
APPENDIX 4. GROUND FLOOR PLAN, 5-BED UNIT.



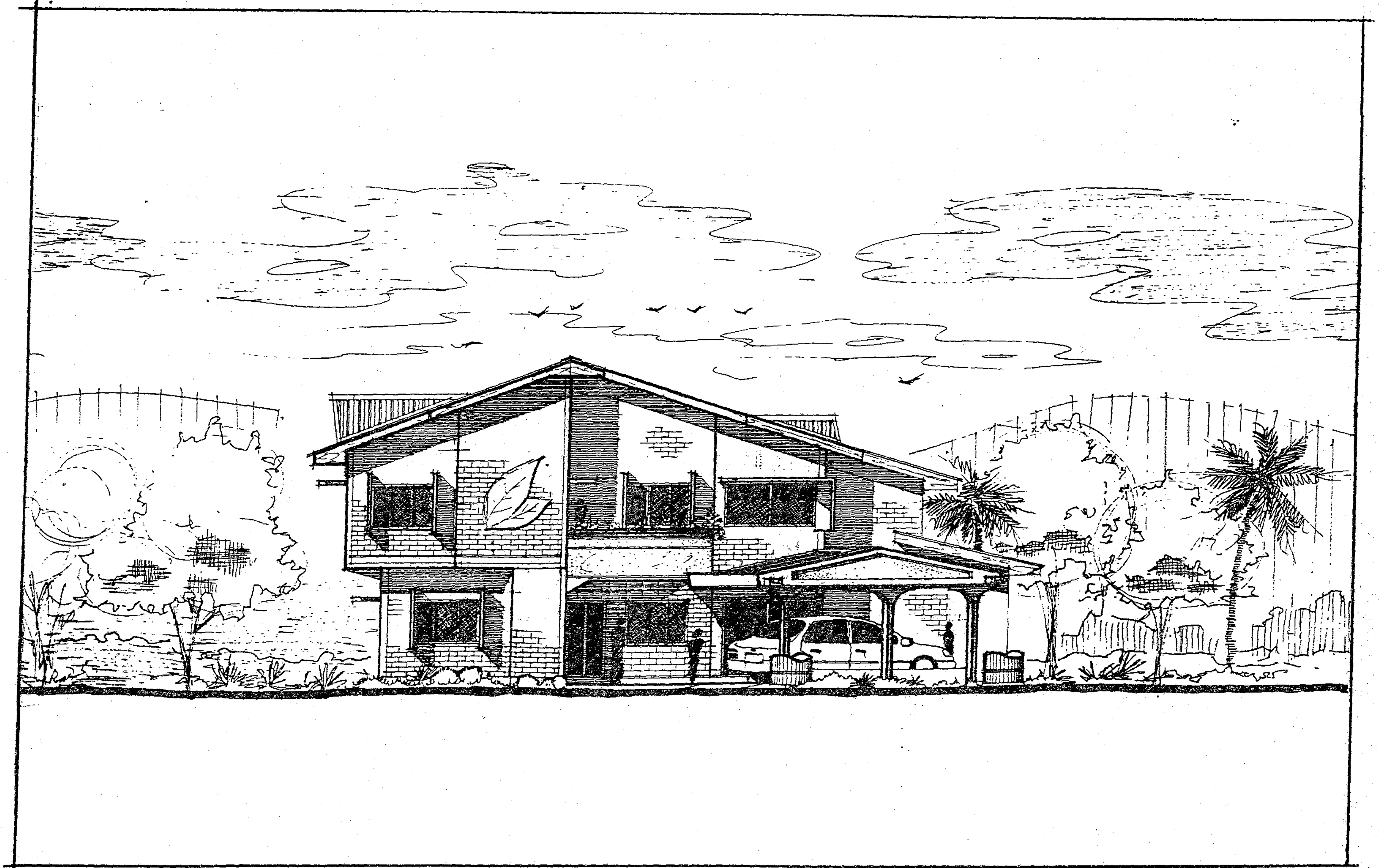
APPENDIX 5. FIRST FLOOR PLAN OF 5-BED UNIT



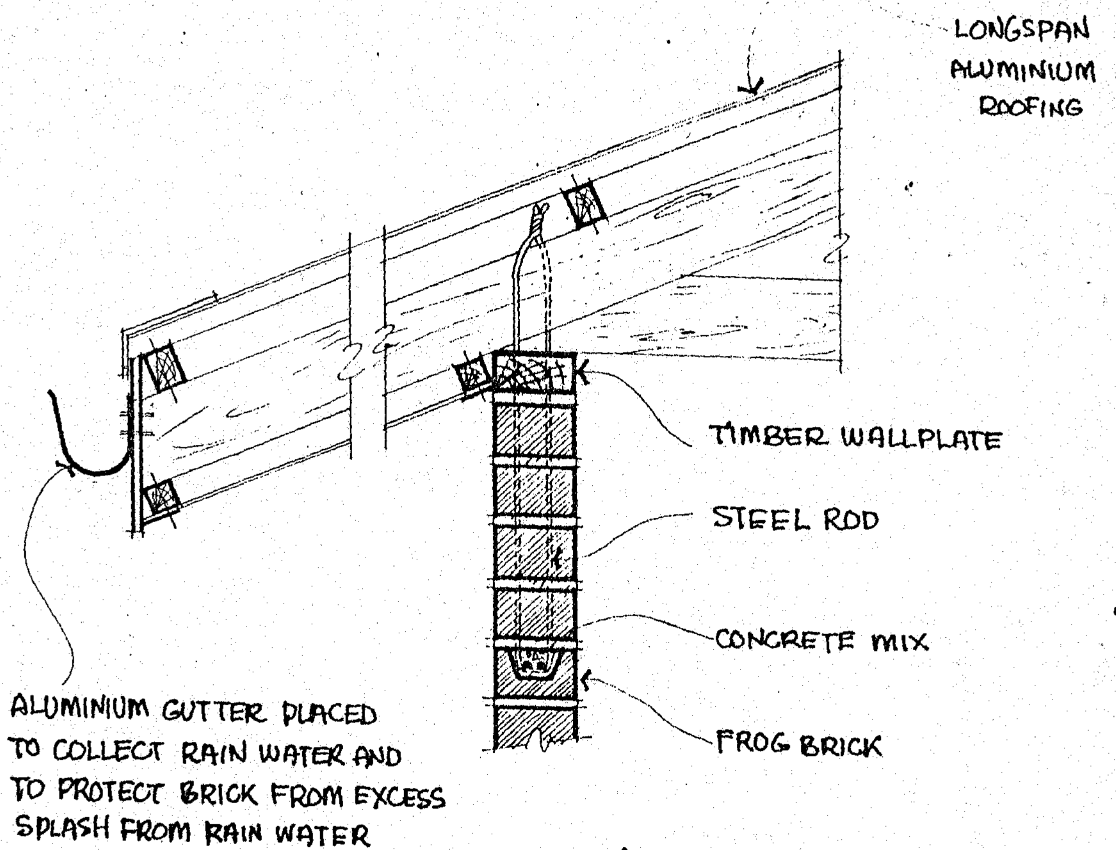
APPENDIX 6. STACK VENTILATION PLAN



APPENDIX 7. SECTIONS OF 5-BED UNIT



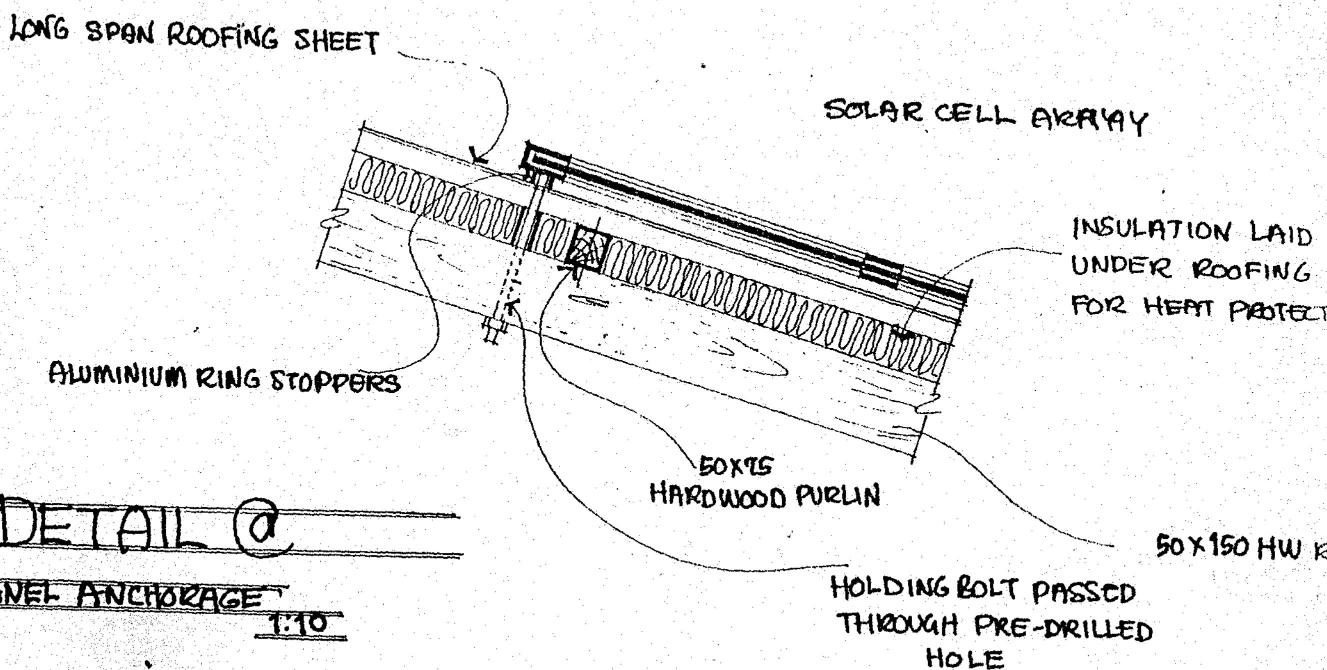
APPENDIX 8. FRONT VIEW OF 5-BED UNIT.



DETAIL @

(ROOF ANCHORAGE)

1:10

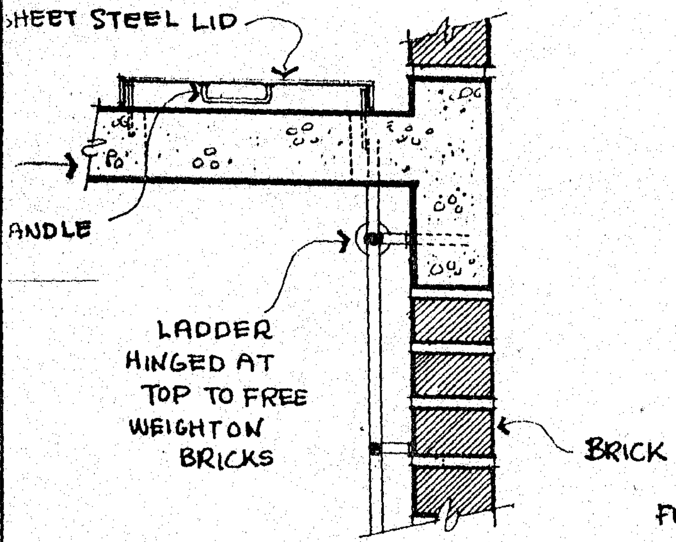


DETAIL @

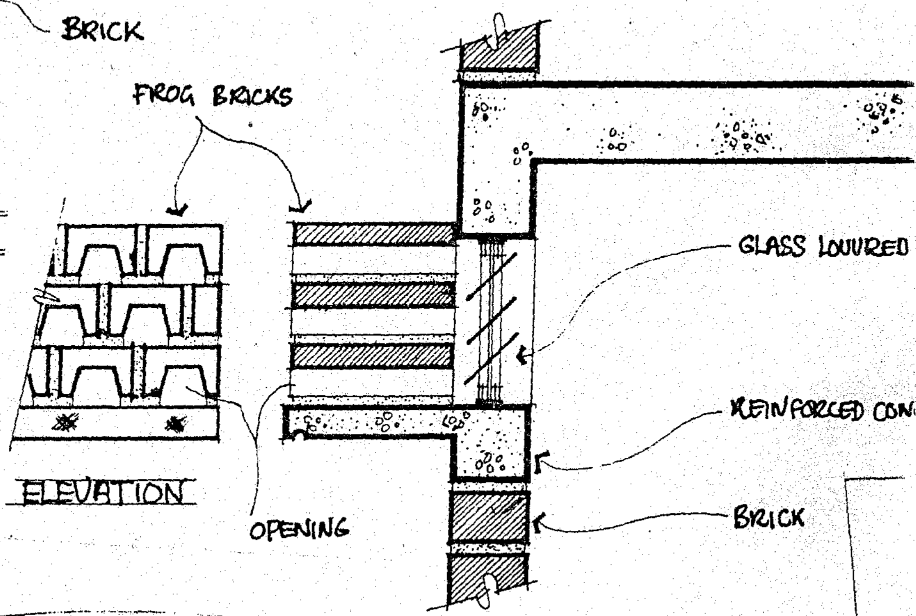
PANEL ANCHORAGE

1:10

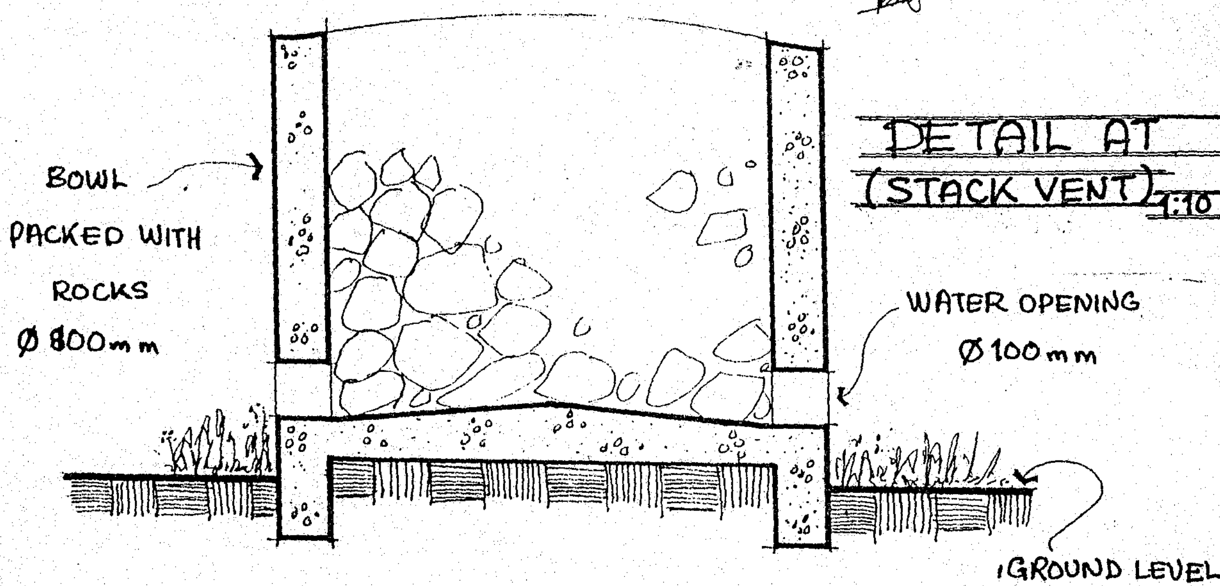
APPENDIX 9. DETAILS



DETAIL @ CAT LADDER 1:10

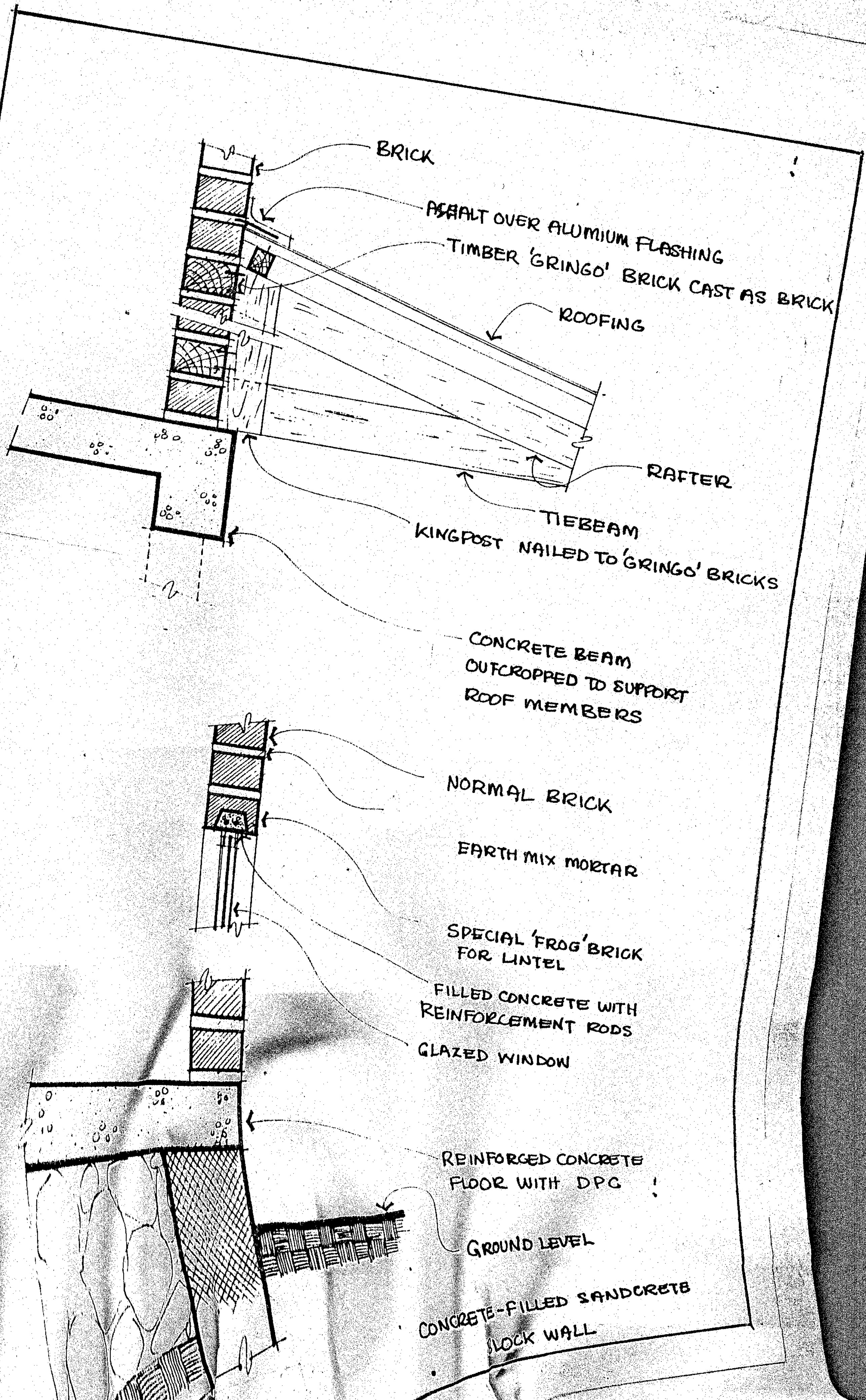


DETAIL AT (STACK VENT) 1:10

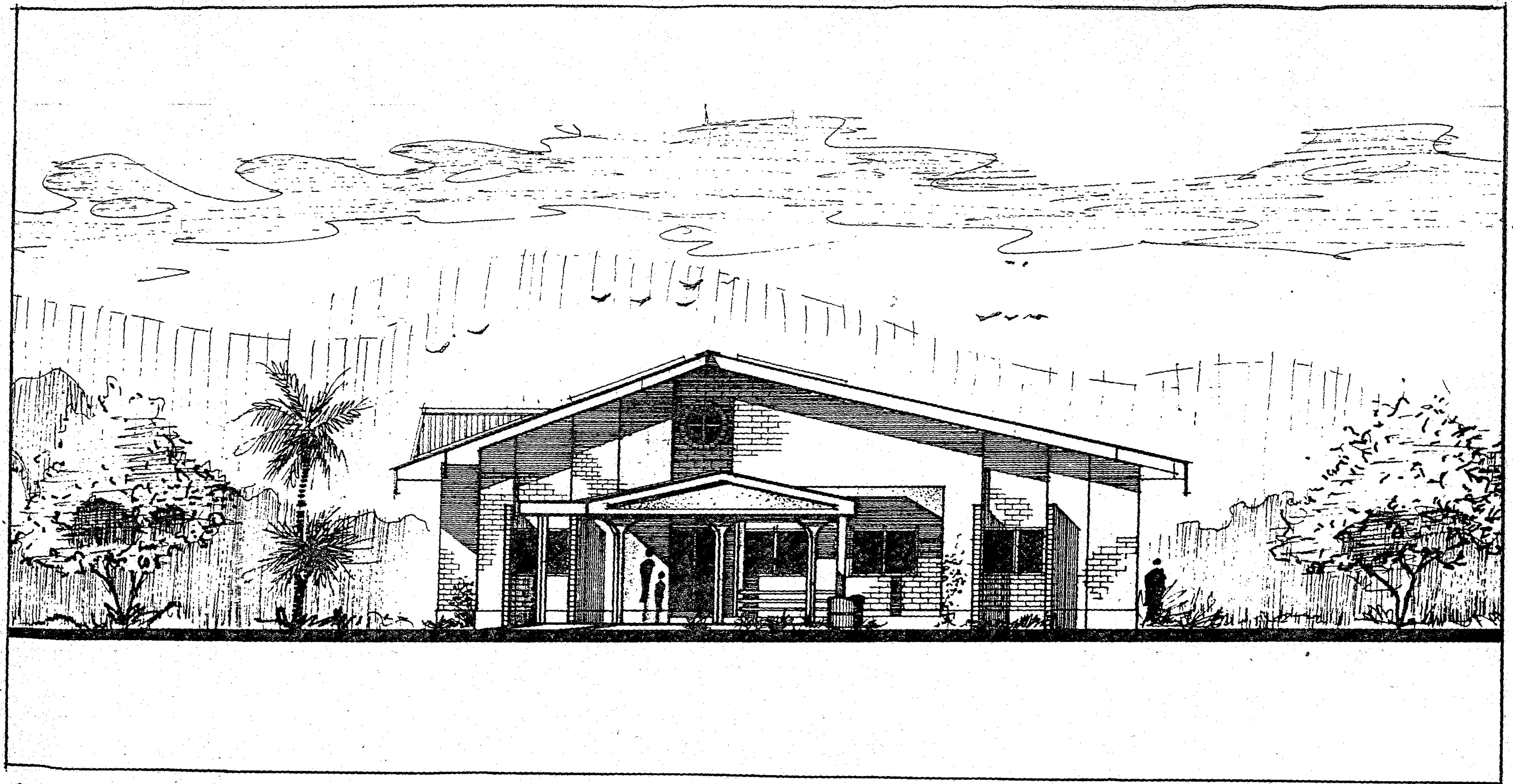


DETAIL AT ('NO-SPLASH' BOWL) 1:10

APPENDIX 10 DETAILS



BRICK
ASPHALT OVER ALUMIUM FLASHING
TIMBER 'GRINGO' BRICK CAST AS BRICK
ROOFING
RAFTER
TIEBEAM
KINGPOST NAILED TO 'GRINGO' BRICKS
CONCRETE BEAM OUTCROPPED TO SUPPORT ROOF MEMBERS
NORMAL BRICK
EARTH MIX MORTAR
SPECIAL 'FROG' BRICK FOR LINTEL
FILLED CONCRETE WITH REINFORCEMENT RODS
GLAZED WINDOW
REINFORCED CONCRETE FLOOR WITH DPC
GROUND LEVEL
CONCRETE-FILLED SANDCRETE BLOCK WALL



APPENDIX 12. FRONT VIEW OF 3-BED UNIT.