ENHANCING THERMAL COMFORT IN BUILDINGS THROUGH DESIGN AND CONSTRUCTION METHODS IN THE CLIMATE CHANGE CENTRE, F.U.T. MINNA

BY

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CERTIFICATION

This thesis report, Design Proposal for the CLIMATE CHANGE CENTRE< Federal University of Technology by Akano S.A. meets the regulation governing the award of the degree of Master of Technology (M.TECH.) in Architecture of the Federal University of Technology, Minna.
It is approved for its contribution to Knowledge and literary presentation.

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DEDICATION

To God's glory, I dedicate this project to my Dad, Mr. Joel Kolawole Akano. His small boy has eventually become a man.

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The Lord has done it again! Blessed be the name of the Lord who fulfilled His promise concerning me-two degrees in quick succession.

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ABSTRACT

Energy from the Sun drives the Earth's weather and climate, and heats the earth's surface; in turn, the Earth radiates energy back into space. Atmospheric greenhouse gases (water vapour, Carbon dioxide, and other gases) trap some of outgoing energy, i.e. trapping heats somewhat like glass panels of a greenhouse.

Without this natural "greenhouse" effect, temperatures would be much lower than they are now, and life as known today would not be possible. Instead, thanks to greenhouse gases, the earth's average temperature is a share hospitable 60°F. However, problems may arise when the atmospheric concentration of greenhouse gases increases.

Increasing concentration of greenhouses gases are likely to accelerate the rate of Climate Change. Scientists expect that the average global surface temperature could rise 1.6-6.3°F by 2100, with significant regional variation. Evaporation will increase as the Climate warms, which will increase average global precipitation. Soil moisture is likely to decline in many regions, and intense rainstorms are likely to be become more frequent. Sea level is likely to rise two feet along the coasts.

It was against the backdrop of the imminent problems associated with greenhouse gases, that many international scientific programmes concerned with ecological issues were initiated. In Nigeria, the Climate Change Centre was established in the Federal University of Technology as a result of an agreement between the Federal Environmental protection Agency and the University.

The design proposal for the Centre, therefore, goes a long way in suggesting a provision for the infrastuctural facilities.

CHAPTER 1

1.0 INTRODUTION

On the 7th of March 1995, the Federal Environmental Protection Agency (FEPA) entered into an agreement with the Federal University of Technology, (F.U.T), Minna, on issues that border on the implementation of the climate change convention. One of the major decisions reached was the proposal for the establishment of a Centre within the University to take care of climate related activities.

The Centre that subsequently emerged from that pact was named "the Climate Change Centre" and is set up as a research and academic entity within the university premises. As a result of the function of the Centre, which includes capacity building and Institutional strengthening, a befitting infrastructural edifice needs to be erected to facilitate the functionality of the Centre.

A design proposal is hereby, presented to be considered to serve as the Centre within the University. Though the Centre is the only one of its kind in the country, the issue of environmental awareness (which culminated in the emergence of the climate change convention) is not a new phenomenon. For several centuries, scientists have been aware of anthropogenic effects on the natural world. In Europe, the popularization of environmental science or natural history as it was then called, first caught the public imagination with the work of early explorer-naturalists in the late eighteenth and nineteenth centuries. They discovered the extent of biological diversity, the striking variations between communities of plants and animals throughout the world, and the particular ecological niches of many rare species. Their detailed observations facilitated the laying of foundations for present-day environmental science. These explorer-naturalists developed revolutionary concepts such as natural selection and adaptation to the environment.

After an initial flurry of research activities, progress on understanding environmental issues was curtailed during the first and second world wars, and it was not until the late 1950s that the scientific community began to study ecological systems. These studies were aided by new technologies and a more rigorous, quantitative approach to gathering data on issues such as climate. Also, there were rapid advances in the field of photography, for example with the development of machines such as scanning electron microscope. Improved, machine-based method of accurate chemical analysis replaced the laborious wet-chemistry techniques that used to take days to weeks, rather than minutes to hours. The introduction of computers offered quick statistical analysis of data.

Civilization is now so advanced that we are able to study in considerable detail our planet and universe. Scientists can now examine the earth at all scales, from the subatomic using high-energy physics, to cosmic scales using the most sophisticated telescopes and spacecraft. Images of earth from space are now commonplace. Sophisticated global climate modelling and predictions about future climate change are becoming commonplace.

1.0.1 STUDYING EARTH

Through studies and observations scientists have become increasingly aware of the relationships and interactions between the Earth and the solar system, or the universe, the inorganic and organic world. No matter how detailed the studies, there are always new principles and phenomena to be discovered. Some relationships are so complex that scientists can hardly understand them, yet others seem very simple. The laws of physics and chemistry allow the description of many natural phenomena. Physicists concern themselves with the ultimate origin of matter and time, and they endeavour to quantify this

TABLE 1 *Composition of the atmosphere.*

Constituent	*Chemical formula*	*Abundance by volume**
Nitrogen	N_2	78.08%
Oxygen	O_2	20.95%
Argon	Ar	0.93%
Water vapour	H_2O	variable (%–ppmv)
Carbon dioxide	CO_2	340 ppmv
Neon	Ne	18 ppmv
Helium	He	5 ppmv
Krypton	Kr	1 ppmv
Xenon	Xe	0.08 ppmv
Methane	CH_4	2 ppmv
Hydrogen	H_2	0.5 ppmv
Nitrous oxide	N_2O	0.3 ppmv
Carbon monoxide	CO	0.05–0.2 ppmv
Ozone	O_3	variable (0.02–10 ppmv)
Ammonia	NH_3	4 ppbv
Nitrogen dioxide	NO_2	1 ppbv
Sulphur dioxide	SO_2	1 ppbv
Hydrogen sulphide	H_2S	0.05 ppbv

*ppmv = parts per million by volume; ppbv = parts per billion by volume
Source: After Henderson-Sellers and Robinson (1986).

absolutely fundamental problem of science. Yet, the complexity of the living, organic world still defies such elegant mathematics.

In other to understand the world better, the various intellectual attempts at understanding the natural world need to be simplified. No single person, however, intelligent, could hope to comprehend the range and depth of all knowledge, let alone interpret it. So society has developed with different areas of knowledge, such as mathematics, philosophy, music, history, medicine and literature, each with its own so-called experts or practitioners. Many of these subjects are extremely specialized, but nevertheless they are not independent of each other.

These specialties include subjects that form the focus of this project, such as geography, geology, meteorology, hydrology, oceanography, geodesy, pedology and zoology, all viewed as much as possible from the perspective of an architect.

1.0.2 EARTH IN SPACE

The earth is one of nine planets that orbit the Sun. These heavenly bodies, together with their moons and a belt of fragmented planets –the asteroids-, constitute the solar system. The solar system containing planet earth is just one of about 10^{11} (100,000,000,000) which form our galaxy, the milky way. This in turn, is one of 10^{11} galaxies in the universe, all with similar numbers of planets and stars to our own galaxy. Our planet, therefore, is estimated as just one of at least 10^{22} planets traveling in space, held in their orbits by the gravitational forces that exist between the planets and stars.

Cosmic distances are phenomenally large, for example, the distance from the Earth to the sun is 150 million Km. These distances are measured in light years, which is the distance light travels 300,000Km. It takes around eight minutes for light to reach the Earth from the sun, while it would take 100,000 years for light to travel across the diameter of our galaxy. Humankind is traveling in a spacecraft planet as it revolves around the sun at speeds of about 107,000Km per hour. The sun travels around the galaxy at about 300 Km per second, which itself is traveling at enormous speed outwards from the centre of the universe which is still expanding after its creation in the Big Bang. The creation of the universe probably occurred some 10,000 million to 20,000 million years ago. This contrasts with the date of 4004 BC for God's creation of the world as proposed by Irish archbishop of Armagh, Usher,(Hawkins 1988).

Humankind is currently living through the growing pains of the Space Age, which really began in the 1960s. On 12th April 1961, Yuri Gagarin's historic space flight aboard his Vostok capsule began the era of extra-terrestrial human travel. The dream of countless earlier generation was fulfilled in this Soviet mission. The race to land a man on the moon was on. The USA with strong presidential backing, especially from J.F Kennedy, and massive public investment, were the first to land astronauts on the moon in the Apollo II mission in 1969.

On 12th April 1981, exactly 20 years to the day after Yuri Gagarin's flight, the space shuttle 'Columbia' was launched by the USA. But tragedy was to strike the space shuttle programme, when in 1986, just 73 seconds after lift-off, the space shuttle 'Challenger' exploded. The accident caused people to ask about the cost of space travel, not only in terms of astronaut's life but also in relation to broader human costs versus benefits.

1.0.3 THE OUTER LAYERS OF THE EARTH

Earth scientists divide the outer layers of the earth into four main spheres or realms, which are the: lithosphere, comprising the outer layers of the solid

Earth, as rocks, sediments and soils; atmosphere, the layers of gases that extend from the Earth's surface up to about 100Km to the outer boundary of our planet; hydrosphere, the layer of water that covers our planet, from a maximum depth of more than 11Km in the oceans to shallower and less extensive bodies of water such as lakes and rivers; biosphere, a term first made famous by the Swiss geologist, Suess, for the thinnest layer, comprising organic matter, which is generally only up to a few metres thick covering much of the land surface (this layer, at its thickest, reaching several tens of metres in rainforests, also extends into the atmosphere as creature fly and plant spores are blown by the wind, and deep into lakes, seas, and oceans into the deep sea trenches). Human beings are part of the biosphere, and exist by interacting with the other three "spheres".

Even though the world can be split into these four sections, they are closely interrelated: all are part of the ecosphere. Ecology is the study of the ecosphere, what many people loosely refer to as the study of the environment. It is being examined as well in order to fully appreciate factors that lead to climate change that are discussed in the next two chapters of this project.

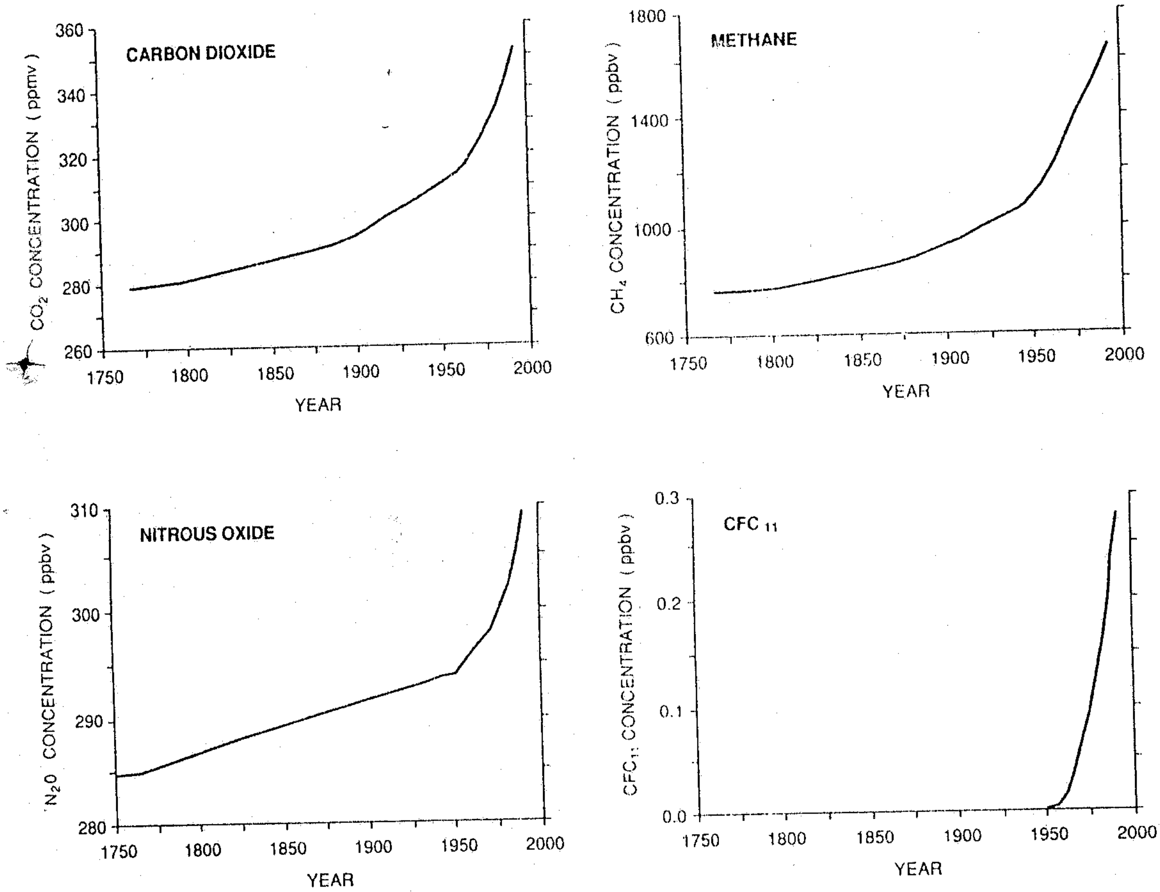


TABLE 2. *Changes since the middle of the eighteenth century in the atmospheric concentration of carbon dioxide, methane, nitrous oxide, and the commonly occurring CFC, CFC-11. Over the past few decades there has been a very large increase in the atmospheric concentrations of CFCs, which were absent before the 1930s. After IPCC (1990).*

1.0.4 LIFE ON EARTH

The sun's rays provide energy to drive the ocean currents and atmospheric processes (the weather), helping to distribute gases, water, and the heat around the Earth. The Earth's rocks furnish the vital nutrients and water essential for life, and its surface provides the substrates for life. Humans, the most complex and sophisticated of all organisms, live on Earth as an integral part of it; people are short-stay passengers, and are affected by its internal surface and atmospheric processes. More importantly, human activity may be profoundly altering the Earth's atmospheric systems and climate. Although, each person only rides a short way with Earth, the pollution left behind can have a long-term influence.

On cosmic scales, planet Earth seems insignificant but it may be unique. It is the only planet that scientists are aware of which is capable of supporting human life. Various chemical and physical arguments suggest that our Earth is about 4.6 billion years old. Life on Earth is incredibly diverse. It has been estimated there are as many as 1.4 million formally described species of animals and planets on Earth (Wilson 1989). There are many more that await detailed study and the conferment of formal species names. Conservative

TABLE 3 *Estimates of future global sea level rise (cm).*

	Thermal expansion	*Alpine*	*Greenland*	*Antarctica*	*Best estimate*	*Range*[f]	*To (year)*
Gornitz (1982)	20	20 (combined)			40		2050
Revelle (1983)	30	12	13		71[b]		2080
Hoffman *et al.* (1983)	28–115	28–230 (combined)				56–345	2100
						26–39	2025
PRB (1985)	[c]	10–30	10–30	−10–100		10–160	2100
Hoffman *et al.* (1986)	28–83	12–37	6–27	12–220		58–367	2100
						10–21	2025
Robin (1986)[d]	30–60[d]	20±10[d]	to +10[d]	to −10[d]	80[i]	25–1,659	2080
Thomas (1986)	28–83	14–35	9–45	13–80	100	60–230	2100
Villach (1987)							
Jaeger (1988)[d]					30	−2–51	2025
Raper *et al.* (1990)	4–18	2–19	1–4	−2–3	21[g]	5–44[g]	2030
Oerlemans (1989)					20	0–40	2025
Van der Veen (1988)[h]	8–16	10–25	0–10	−5–0		28–66	2085

[a]From the 1980s
[b]Total includes additional 17 cm for trend extrapolation
[c]Not considered
[d]For global warming of 3.5°C
[f]Extreme ranges, not always directly comparable
[g]Internally consistent synthesis of components
[h]For a global warming of 2–4°C
[i]Estimated from global sea level and temperature change 1880–1980 and global warming of 3.5±2.0°C for 1980–2080
Source: IPCC (1990), references cited therein.

TABLE 4 *Estimated sources and sinks of carbon monoxide (Tg per annum).*

	WMO (1985)	*Seiler & Conrad (1987)*	*Khalil & Rasmussen (1990)*	*Crutzen & Zimmerman (1991)*
Primary sources				
Fossil fuel	440	640±200	400–1,000	500
Biomass burning	640	1,000±600	335–1,400	600
Plants	–	75±25	50–200	–
Oceans	20	100±90	20–80	–
Secondary sources				
NMHC oxidation	660	900±500	300–1,400	600
Methane oxidation	600	600±300	400–1,000	630
Sinks				
OH reaction	900±700	2,000±600	2,200	2,050
Soil uptake	256	390±140	250	280
Stratospheric Oxidation	–	110±30	100	–

NMHC = non-methane hydrocarbons
Source: IPCC (1992), references cited therein.

estimates put the actual number of species on Earth closer to 4 million. The Earth provides the life support system for this diverse and abundant array of organisms. The atmosphere filters out potentially lethal radiation from the sun, yet at the same time allows some of the radiation to penetrate through and provide the energy for planets to construct tissues of carbohydrates from carbon dioxide (CO_2) and water (H_2O) in the process of photosynthesis. These planets, in turn, are a food for the animal kingdom. In addition, the atmosphere provides the carbon dioxide, oxygen (O_2), and much of water vapour needed for the basic functions of animal life.

1.0.5 TIME AND RATES OF CHANGE

The rate at which processes take place must also be considered. This is one of the hardest factors to appreciate because our concept of time is influenced by the experience of a single human lifetime, for most a mere 70 or so years. Time in terms of Earth history is measured in thousands, tens of thousands, millions or even billions of years.

Geologists believe the age of the Earth is about 4,600 million years. The first bipedal hominid (Australopithecus afarensis) evolved about 3.75 million years before present (BP) while true modern humans (Homo sapiens sapiens) have only been in existence for about 200,000 years. For this reason, geologists divide time into a number of geological periods; defined where possible by global events. The present period, for example, is called the Quaternary with a beginning defined by evidence to suggest that its marks the start of the last major, abrupt, global cooling at about 2 million years ago.

In recent years, the mathematics of chaos theory has been applied to earth's natural systems. Many scientists believe that systems, such as weather patterns, are in a state of chaos. Chaos dictable nature of physics of motion, for example, means that in any new circumstances, however closely it appears to mirror the original set of circumstances, it will always produce a unique outcome. The weather systems were first modelled quantitatively by the meteorologist Edward Lorenz, using simple computers. Using a weather model, he found that he always obtained different results from almost identical inputs. From mathematically plotting the output from his model he produced a curve, which defied mathematical definition. The showed that no event could be predicted and that the smallest change of inputs could produce very different results. This very unpredictability however means that chaos is in a sense predictable; that is, you know in advance that predictions are impossible. The shape of the graph produced by the experimental result of

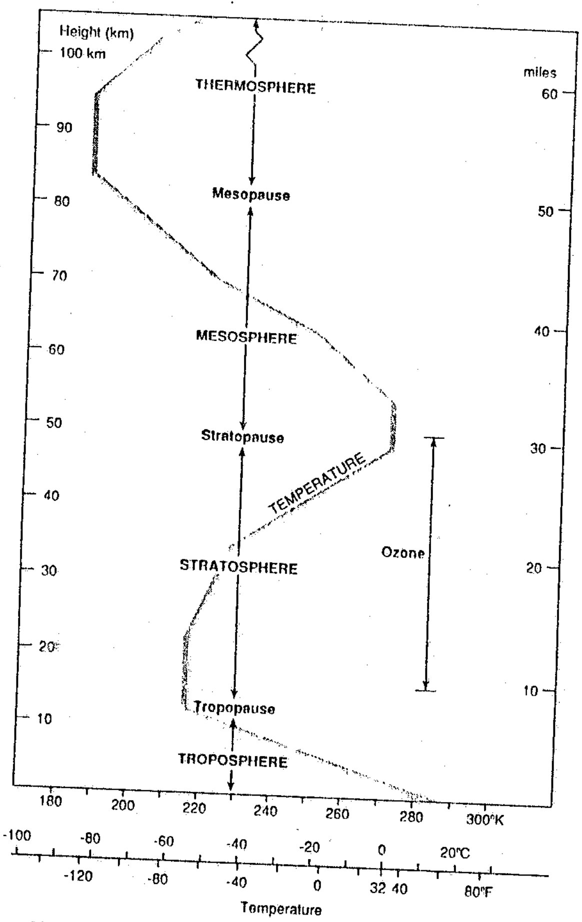


FIG 1.1 *Thermal structure of the atmosphere to a height of approximately 110 km (68 miles).*

Lorenz looked similar to a butterfly and so his principle became known as the butterfly effect. Analogies were drawn with natural processes. Using this principle, for example, the consequences could be such that if a butterfly flapped its wings in Beijing, it would cause turbulence in the atmosphere, which could ultimately lead to the hurricane in Florida. Such small occurrences could have profound, large, and even catastrophic effects. Many scientists are now beginning to explore the interrelationships within natural systems using the mathematical principle of chaos theory. Any turbulent system, such as the motion of air masses or ocean currents in which turbulent eddies form and decay, lends itself well to chaos theory.

All these natural processes and responses need to be understood if the consequences of human actions are going to be appreciated. It is imperative, therefore, that there is a good understanding of just how the Earth works, the intimate interrelationships between the inorganic and organic elements of the planet, the mutual relationships between organisms and their environments, and the reciprocal relationship between human beings and the Earth. Not only is this interesting and satisfying to natural instinctive curiosity, but also if the human species is going to survive, then it is vital that the life support machine planet Earth is maintained and functions at the optimum efficiency. The

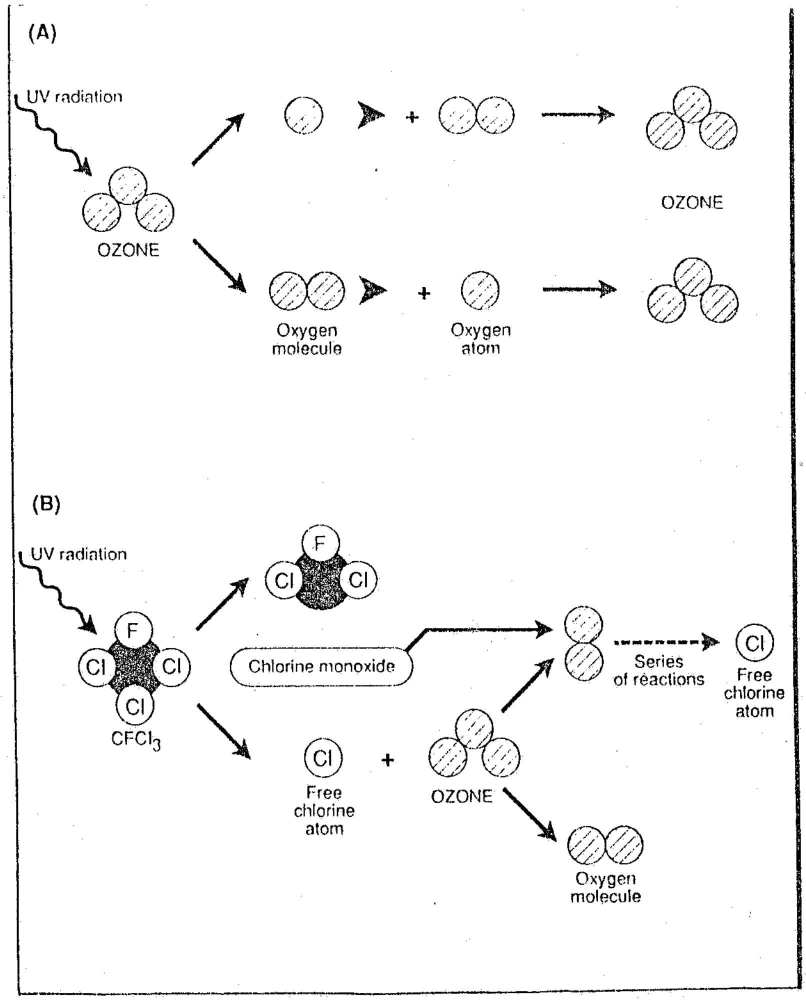


FIGURE 1.2 *(A) The naturally occurring chemical processes leading to the formation and decomposition of ozone in the atmosphere in the presence of ultraviolet radiation. (B) The decomposition of ozone initiated by chlorine atoms released during the breakdown of a commonly occurring, anthropogenically generated CFC believed to be harmful to the atmosphere ($CFCl_3$). Not all the two-atom (diatomic) molecules of oxygen combine to form ozone, and the free chlorine atoms that are liberated are potentially capable of initiating further reactions that lead to the breakdown of ozone.*

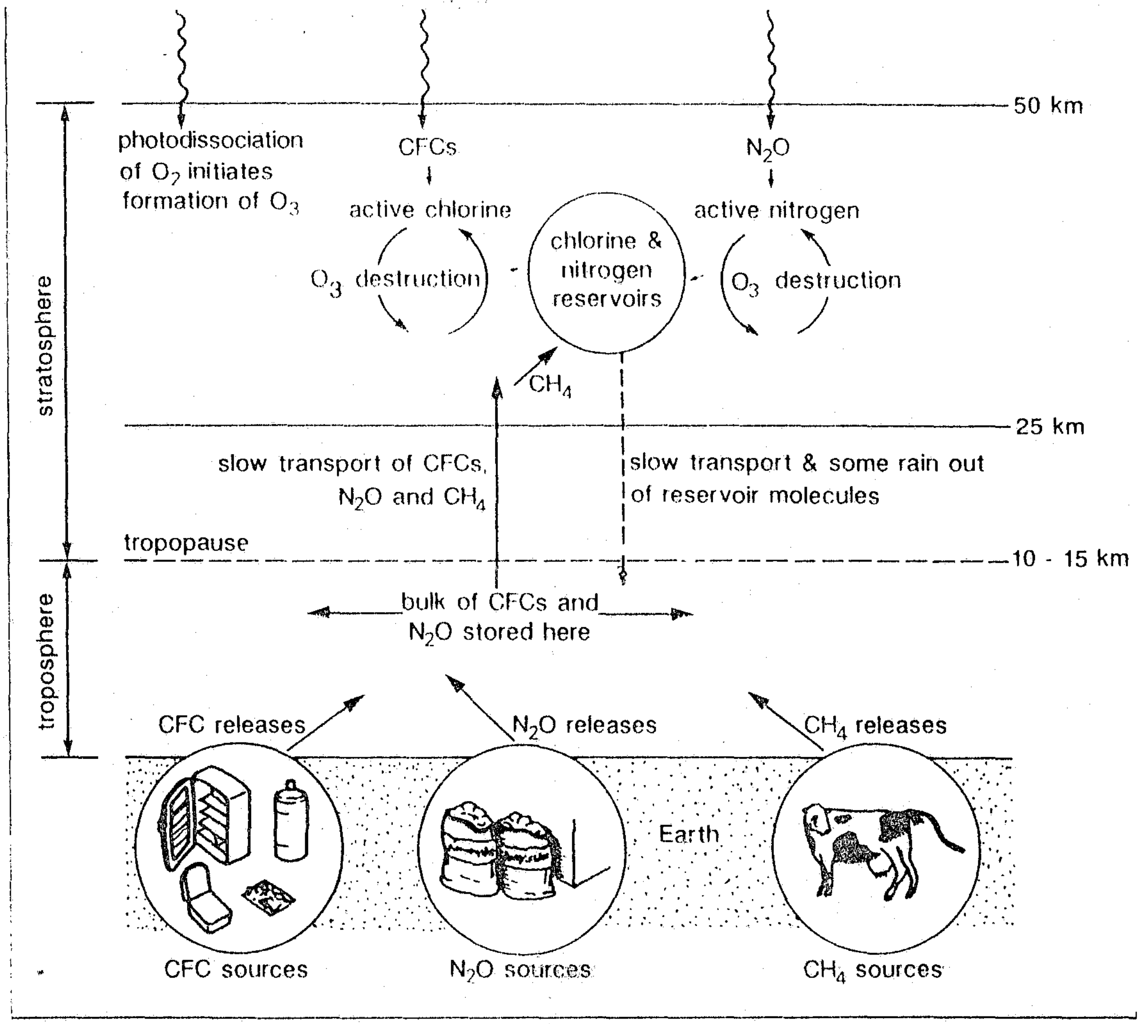


FIG. 1.1 *Schematic diagram to show the principal sources of atmospheric ozone, and the main reactions that cause ozone depletion in the stratosphere. After Smith and Warr (1991).*

climate change centre is a place that is well equipped to maintain our beautiful planet Earth.

1.1 AIM OF THE PROJECT

The project, a proposal for the Climate Change Centre, is aimed at generating credible data and to train manpower for planning purposes in Environmental Management and on the issues of freshwater resources and the implementation of the climate change convection.

1.2 OBJECTIVES OF THE PROJECT

This project will enable the university:

a) Serve as the climate change Centre for freshwater resources management and the implementation of the climate change convention;

b) Assist the Ministry of Environment and the Federal Environmental Protection Agency (FEPA) in training and research in the areas of:

i) Climate data bank;

ii) Climate change in Nigeria with particular reference to water resource development and prospecting;

iii) Design and implementation of environmental monitoring of hydro-climate elements for special locations such as dams, reservoirs for power generations etc.;

iv) Early warning systems and amelioration strategies for adverse effect of water development projects;

v) Conservation of ecological system of water bodies;

vi) Other identifiable projects that are of relevance to the objectives of the FEPA mandate.

1.3 RESEARCH METHODOLOGY

The research methodology employed for this project is categorized into three:

i) Data Analysis

ii) Visits

iii) Literature Review

i) Secondary data were obtained and sources credited, as there are many sources where climatic issues are discussed.

ii) Visits were made to related areas of interest to the climatic change topic. As a result of the non-existence of such a place in the country, the case studies of related fields were made (as indicated in the later chapter) and an appraisal is drawn to examine their potentials and lacks.

iii) The climate change subject, though a relatively new area of study, is an interesting one; therefore, there abound relevant journals and materials in libraries on the area and related topics. As such, they served as ready sources for bringing out facts and figures for the research and literature review.

1.4 IMPORTANCE OF STUDY

The Earth contains a lot of prospects, which the human race has been exploiting since time immemorial. A study into the generation of climatic data will enable the researcher to answer pertinent questions to the effective management of the Earth. Such questions include: can human activities and population growth be sustained without extreme environmental damage? How will human activities change global climate? What lessons can be learnt from studying past climates and then applied to help predict future climate change?

1.5 DEFINITION OF TERMS

The following words may have diverse meanings from everyday English usage as they occur in the text. Hence, the meanings as used in the thesis have been defined.

1) **Anthropogenic** – human influenced processes or forms

2) **Big Bang** – explosion that marked the creation of the universe, which probably occurred about 15,000 – 20,000 million years ago.

3) **Bipedal Hominids** – two-legged creature of the family Hominidae (primates) of which only one species exists today 'Homo sapiens sapiens'

4) **Butterfly effect** – highly variable knock-on effect (positive feedback) or output produced by a system as a result of subtle change in the initial inputs.

5) **Combustion-dust loading** – increased quantities of dust in the atmosphere produced as the by-product of burning fossil fuels.

6) **Ecosphere** – all-encompassing realm which includes the atmosphere, hydrosphere, lithosphere and biosphere.

7) **General Circulation Models (GCMs)** – simulation of atmospheric circulation involving a system of equations used to describe atmospheric, and ocean-water motion, the heat exchanges and fluxes within this system, and the consequences.

8)**Geodesy** – the study of shape and size of the Earth by survey and mathematical means.

9) **Hydrology** – the study of the movement of water (vapour, liquid, and solid) on, in and above the Earth's surface.

10) **Ice age** – period in Earth's history when ice-sheets are extensive and sea-ice and permafrost are widespread in mid and high altitudes.

11) **Ignimbrite** – welded to non-welded pyroclastic rock, and comprising mainly pumice and ash

12) **Interstadial** – warm period during a glacial stage

13) **Light year** – distance light travels in one year

14) **Meteorite** – extra-terrestrial material that may fall to Earth if it travels across the Earth's orbits.

15) **Meteorology** – the study of the dynamics and composition of the atmosphere.

16) **North Atlantic Deep Water (NADW)** – cold dense Deep Ocean current that travels southwards in the North Atlantic.

17) **Palaeoclimatology** – the study of past climates, their rates of change and dynamic.

18) **Palaeo-oceanography** –science of past oceans, their configurations, chemistry and dynamics.

19) **Radiometric** – prefix to age or the technique used to date a substance in years, by determining the relative proportions of radioactive isotopes and their decay products within that substance.

20) **Solar Flux** – flow of radiation from the Sun to the Earth.

21) **Tephra** – general term used for all pyroclastic deposits produced by explosive volcanism.

CHAPTER TWO

LITERATURE REVIEW.

2.0 INTRODUCTION TO CLIMATE CHANGE AND PAST CLIMATES.

The earth's climate has not always been as it is today. There have been times in the geological past when the global climate was warmer or considerately colder than at present. The geographic and temporal distribution of organisms, preserved as fossils, and the particular chemical signatures and sediments types available for study, show that the earth's climate has fluctuated over geological time. As an example, 4.3 – 3.5 million years ago (Ma) parts of eastern Antarctica were a lot warmer. (K.T Pickering, 1995) During the tertiary period of Earth history, from about 64 Ma but prior to 1.64 Ma, boreal forests were growing in the Canadian high Arctic as far north as 78^0 N (K.T Pickering, 1995), now preserved as fossil forests. Although it is now known that there have been substantially different climates in the past, the exact causes of such variations remain unclear.

Besides intellectual curiosity that drives human kind in search of knowledge about past climates on Earth, about how climate change may come about and the rates at which such changes could occur, it is possible to begin to make sensible predictions and models about negative and positive feedback processes in controlling global climate change. Put more simply, the geological record provides an unprecedented insight into the circumstances in which the green house effect occurs, and the opportunity to assess the potential impact of human activities in controlling climate change.

Climates, both past and present, are studied by many people: meteorologists trying to improve weather predictions and construct climatic conditions that prevailed during the early development of human life around the globe, and Earth scientists endeavouring to unravel the history of our planet and the dynamics of Earth surface processes. Public interest in global warming, acid rain, the potential effects of nuclear winter, and how other forms of chemical pollution in the atmosphere or oceans affect climates have all contributed to a resurgence of interest in past climates, primarily as a key predicting future climatic change.

Earth scientists have suddenly found themselves at the Centre of media attention. Large sums of money are now available for research into past climates. Computer based climatic models, commonly referred to as general circulation models (GCMs), are in vogue. The past four years have witnessed a concerted effort to understand causal factors which contribute to global climate change.

Scientists studying past climates over hundreds of thousands of years used to consider themselves involved in tertiary or Quaternary studies, but suddenly newer labels are in fashion which emphasize the oceanic or climatic aspects of their work, such as palaeoclimatology or palae-oceanography. A quiet revolution in the Earth's sciences has crept up at on all of us and, arguably, there is a real need for a whole new area of study to be recognized formally and budgeted for, at least at the level of higher education. Palaeoclimatology as a scientific subject is truly interdisciplinary, regularly and necessarily involving many different Earth scientists, chemists, biologists, physicists, astronomers and mathematicians. It is, perhaps more than any other current scientific pursuit, the youngest science looking for universal recognition.

Earth scientists have now established that global climatic changes occur on scales up to hundreds of millions of years, but they have not yet developed well – constrained cause – and – effect models for global changes in climate. One of the main ways to understand past climates and the nature of climate change over the past hundreds thousands years is through study of ice cores, therefore increasing attention is being focused on the climatic signatures preserved in such cores.

In terms of climate change, humanity is currently in a particularly interesting period of geological time, the quaternary often referred to as the present Ice Age. During the period, which extends back for over 1.64 million years (Harland etal 1989), the Earth's climate has cooled down and undergone a series of rapid fluctuations between warm and cold phases. It is important to understand the nature of these changes if Earth scientists are to resolve the effect of human activities and natural variation in the climatic system. Particular attention therefore, is given to the nature and study of the Quaternary in this chapter. Whatever the exact cause, or causes, of the past sudden shifts in Earth's climate, the one thing that earth scientists are certain of is the catastrophic consequences for life on Earth at such times. Clearly, just as current political thought and, hopefully action, is built upon the lessons that history teaches, so humankind should attempt to gain a better understanding of Earth's history in order to appreciate the potential that exists, either natural or human made for destroying various animal and plant life on this planet. Human activities may be exerting a forcing effect on world climate.

2.1 CAUSES OF GLOBAL CLIMATE CHANGE.

In order to consider past and present climate, it is important to have at least a rudimentary understanding of the principal components of any system (figure

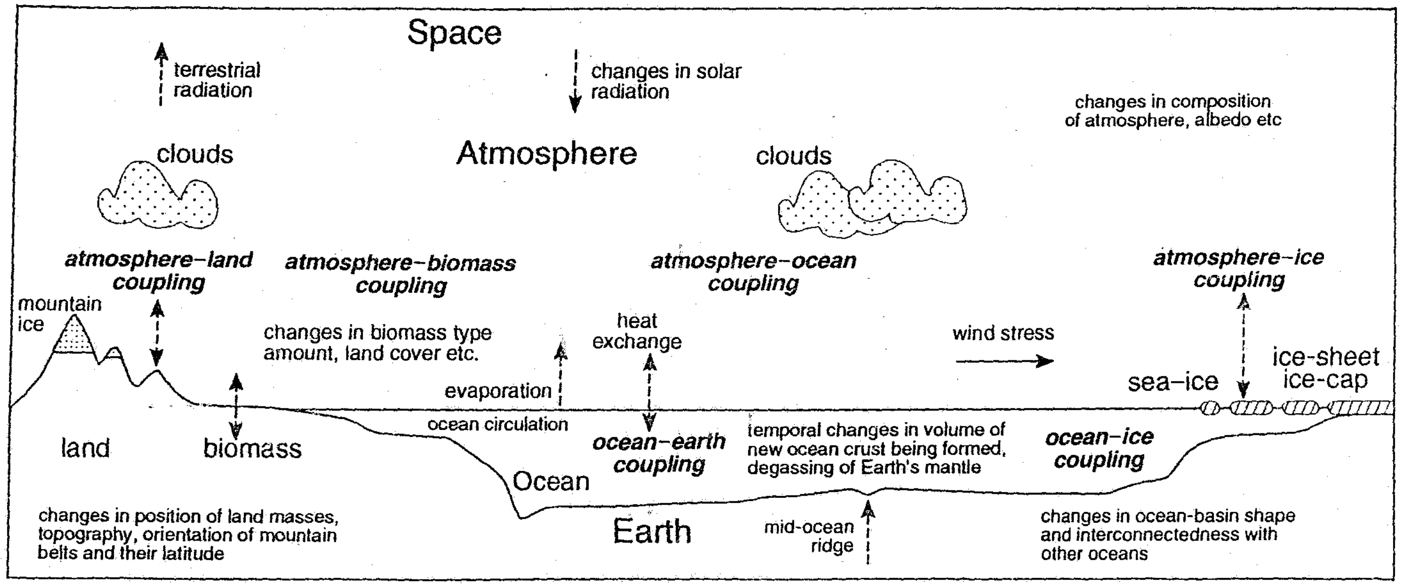


FIG. 1.0 *Principal components of a climate system.*

2.1), the structure of the Earth's atmosphere (figure 2.2), and the ocean conveyor belt (figure 2.4), which distributes heat around the Earth's surface. Up to about 100Km above sea level, the Earth's atmosphere comprises an essentially uniform mixture of gases bur with substantially varying proportions of water vapour, concentrated mainly in the troposphere.

The sun has a direct and important influence on the atmosphere – ocean system: indeed they are literally solar – powered. Short – term changes in global climate, on a scale from tens of thousands to hundreds of thousands of years, appear to be a result of slight changes in the distribution and amount of solar radiation, or solar flux reaching the surface of the earth. Such changes in solar flux result from variations in the orientation and proximity of the Earth to the sun. These factors can be thought of as external controls on climate.

Broecker and Denton (1990) advocate a mutual interaction between global climate and ocean current circulation. They suggest that warming in the northern hemisphere prompts biological activity, and the consequent production or release of carbon dioxide from oceans to the atmosphere. In turn this changes the ocean circulation, together with the way in which heat energy is transferred through the oceans. Such changes in the thermal structure of the oceans induce the formation

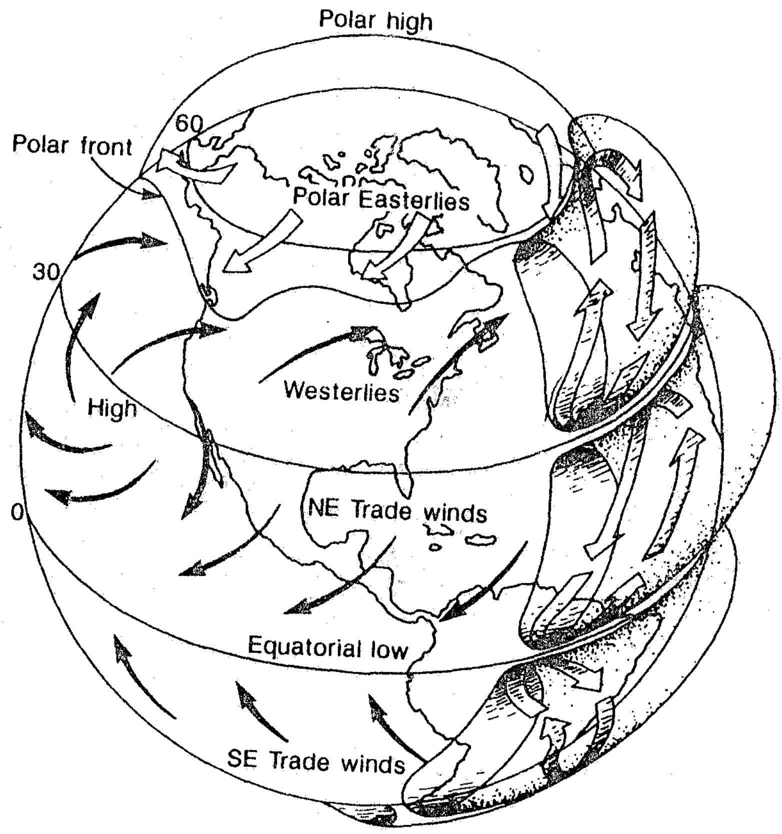


FIG 2.3 *Idealized global atmospheric circulation.*

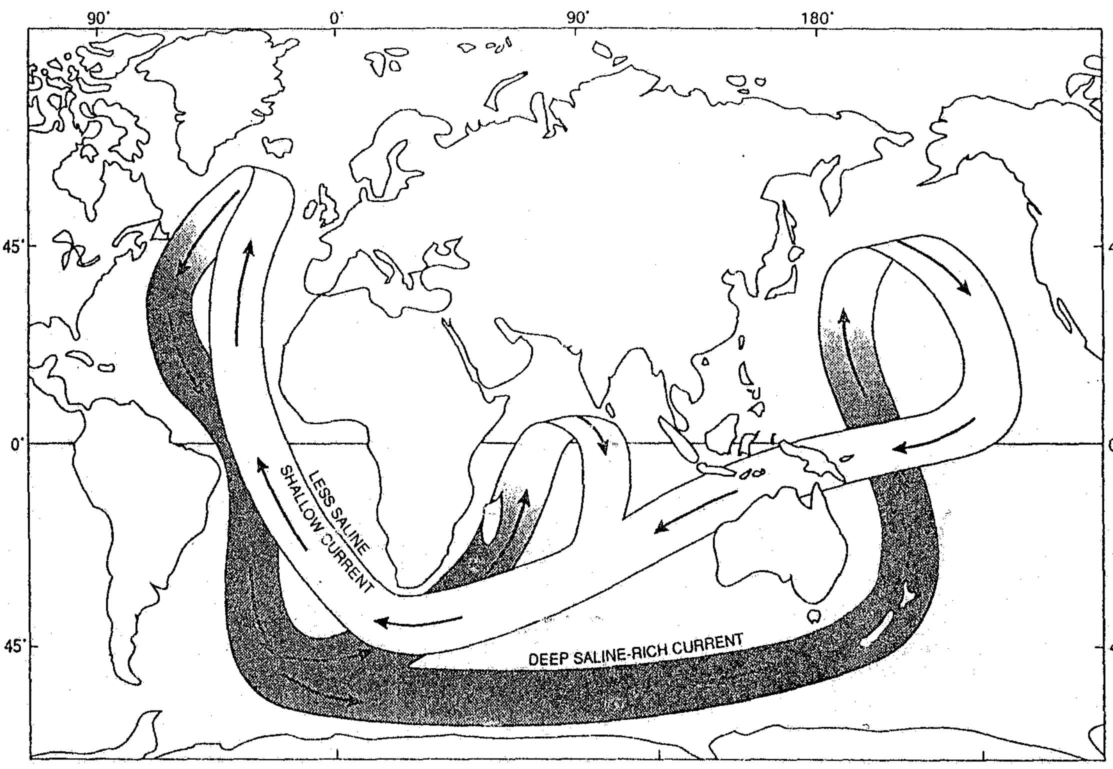


FIG. 2. 4 *The thermohaline (heat-salt) conveyor belt in the oceans. Dark bands show flow of deep, cold, and salty water; light bands show return surface flow. The deep currents begin in the North Atlantic, in the East Greenland Sea, then move southwards from the Atlantic into the Pacific Ocean. The upper, warmer current may begin in the tropical seas around Indonesia, and includes the strong flow out of the Gulf of Mexico.*

of the North Atlantic Deep Water (NADW), a deep ocean current that is currently active but did not flow as strongly during glacial times. The formation of the NADW involves the upwelling of north –flowing waters of high salinity from depths of about 500m, and as these cold waters rise to the surface they replace the warmer surface waters that flow southwards, aided by the strong winter winds. As the surface water travels northwards, it loses heat energy and cools, which together with its high salinity leads to an increase in water density, and it therefore begins to sink to abyssal depths and then flow south, across the equator, towards Antarctica and into the Pacific Ocean. This Atlantic conveyor, as it has become known, releases vast amounts of heat energy during this process, approximately equivalent to one third of the direct input of solar energy to the surface of the North Atlantic. The volume of flowing water is immense, roughly equivalent to 20 times the combined flow of all the world's rivers. Scientists now believe that towards the end of a glacial period when the NADW begins to form, it fashions a different pattern of global oceanic circulation, and redistributes the heat energy in a manner different from that of the present day. Such changes in oceanic circulation and heat exchange between the oceans and atmosphere may have had a profound effect on global climate and help drive the rapid climatic changes.

Besides Milankovitch cyclicity – the way in which the orbital parameters of the Earth moving around the sun influence global climate change – it has also been suggested that climatic fluctuations on a time scale up to thousands of years may result from variations in solar activity, generally measured as a function of sun – spot activity. Records of sun – spot activity since about 1700 show a cyclicity of roughly 11 and 100 years. By dating samples of wood using the radioactive isotope of carbon, ^{14}C (produced in the atmosphere by the interaction of cosmic rays and atoms of the nitrogen isotope ^{14}N), a 9000-year record of solar activity has become available to us. During periods of increased solar activity more particles are emitted from the sun as a solar wind, which effectively holds back, more of the rays and therefore, less ^{14}C is produced in the Earth's atmosphere. Data gathered during the last 200 years show that variations in sun – spot activity closely correlate with the ^{14}C record. Correlating sun – spot cycles with historical data has led to uncertainties and conflicting views about the cause of short – term fluctuations in global climate. Tropical temperature records for the period 1930 – 50, for example, show a positive correlation with sun – spot activity, but a negative correlation between 1875 and 1920. It has been suggested that there could have been a correlation for this latter time interval, but that is masked by variations in stratospheric ozone concentrations. Ozone appears to be more abundant about two years before sun – spot minima resulting in stratospheric warming which, in turn, weakens the subtropical anticlines and westerlies. Cool and dry weather then follow slightly out of phase with the sun – spot cycle. Measurements of atmospheric turbidity, for most practical purposes considered as an indication of atmospheric dustiness or dirtiness, have shown enormous increases (30 – 50 percent) since the beginning of this century. Bryson (1968), estimates that these increases may lead to a 3.5 – 6.5 ^{0}C lowering of the Earth's surface temperature. During the 1960's, it was from evidence such as this that the Earth may return to glacial conditions within the near future was fostered. Ironically, any cooling this might initiate will probably be greenhouse gases, today, however, there is more concern about global warming than cooling.

2.2 LARGE IGNEOUS PROVINCES AND CLIMATE CHANGE

Over time intervals in tens of millions of years, global climate is strongly influenced by the amount of new oceanic crust being produced at oceanic spreading centers (such as the Mid – Atlantic Ridge or the East Pacific Rise, linear, mainly submarine, mountain chains, and associated central depressions or graben formed by the extrusion of new and warm basaltic magmas and lavas), and also from so called mantle plumes. Mantle plumes rise diapirically through the Earth's mantle, and are caused by the detachment of mantle melts or magmas from depths in the Earth of between 670 – 650 Km and possibly even from sources as deep as the core – mantle boundary in the Earth to produce so – called 'super – plumes'. At the Earth's surface, the expression of such mantle plumes is the eruption of large volumes of basaltic igneous rocks to produce the large igneous provinces with diameters of up to about 1400 Km. Mantle plumes are about 200^0C hotter than the surrounding mantle through which they rise, and therefore commonly associated large scale uplift or doming of the Earth's crust.

An example of igneous province is the Ontong – Java plateau in the western Central Pacific Ocean where an estimated 12 – 15 Km^3 of igneous rock were erupted annually (Coffin & Eldohm 1993). Given that the estimated global network of mid – ocean ridges has produced 16 – 26 Km^3 of new oceanic crust at rates comparable to, or greater than, that of seafloor spreading. It has been estimated that a single flood basalt event which generates 1000 Km^3 of lava, typical of the 16 million years ago Columbia River igneous province in the western USA, is associated with the emission of 16 x 10^{12} (trillion) Kg co_2, 3 x 10^{12} (trillion) Kg of sulphur, and 30 x 10^9 (billion) Kg of halogens (e.g F,Cl,Br) (Coffin & Eldohm in 1993). Since large volumes of gases such as Co_2 and So_2 are emitted from the Earth's mantle, any dramatic increase in the rate of generation of oceanic crust and associated mantle degassing over short time intervals will have a profound forcing effect on global climate. An example of this effect occurred during the cretaceous periods of Earth's history, where igneous activity peaked around 120 million years ago, with very large – volume volcanic activity centered in the Pacific Ocean basin. This cretaceous igneous activity appears to have been associated with a greenhouse period of Earth's history, when global mean annual temperatures were much warmer than today (in order of 10°C warmer), global sea level was higher (by more than 100m), and organic – rich black mud accumulated in many parts of the worlds oceans in oxygen – poor waters – created by the decreased rate of ocean – current circulation in the warmer climate and therefore, its reduced ability to dissolve oxygen and ventilate the world's oceans.

Many of the large igneous provinces appear to be associated with large - scale or mass extinction events in Earth history. For example, the biggest extinction event known throughout Earth history occurred 248 million years ago when about 95 percent of all marine species were wiped out in a mass extinction event, which coincided with eruption of the voluminous Siberian Traps, a major igneous province. While a large meteorite impact may have been the principal cause, the eruption of the Deccan traps, about 65 million years ago, may have contributed to the major extinction event that witnessed the demise of the dinosaurs (Kevin Pickering, 1994).

2.3 MODELLING OF GLOBAL CLIMATE AND CLIMATE CHANGE.

In attempts to understand better, the nature of global climate change scientists are developing computer models to predict future changes in climate. Climate models are used by many research groups to evaluate the effects of the various positive and negative feedbacks that can influence climate change. In effect, such models are less sophisticated versions of the weather forecasting models, which appear on the world television networks. The various computer based general circulation models represent the atmosphere as a finite number of stations both in geographic locations around the world, and three dimensionally as vertically stacked points in the atmosphere. In many GCMs, the oceans tend to be represented as stations with a defined sea – surface temperature, although more sophisticated models are beginning to divide the ocean into vertical slices, a three – dimensional grid of points is fed into a computer program, whose physical states are mathematically linked to neighbouring points. The computer programme then runs, and the numerical relationships are allowed to evolve in discrete temporal steps until predetermined conditions are satisfied – for example, a certain time period has evolved. Because the more sophisticated computer programs require very large amounts of memory and relatively lengthy running times, super-computers are well suited to GCMs.

An important aspect of GCMs is that they are only models, and the output can only be as good as the data which are input – they are approximations to what may actually happen. For example, the atmosphere and oceans are continuous fluids, but they are represented as finite points in the model. In most GCMs, grid points typically involve horizontal separations of 500 Km and with time steps of say 30 minutes. Cloud cover and cloud types, for example, are parameterized so that their evolution is described by substantial approximations to the physical and chemical processes affecting them, ideally in a manner that preserves the important spatially averaged properties of the variable. Ocean circulation and the way in which heat is transferred within the ocean – atmosphere system is a current area of research, and therefore not included in most GCMs. To improve GCMs, much more research is required such as sensitivity analysis of GCMs to many poorly understood variables, for example cloud types and cloud forming processes, and heat transfer in the oceans.

As GCMs are developing, mainly for predicting future potential climate, Earth scientists are beginning to make use of such models to try and understand past climates. Currently, there are three main GCMs: the Canadian climate Centre model, the US Geophysical Fluids Dynamics Laboratory model and the UK

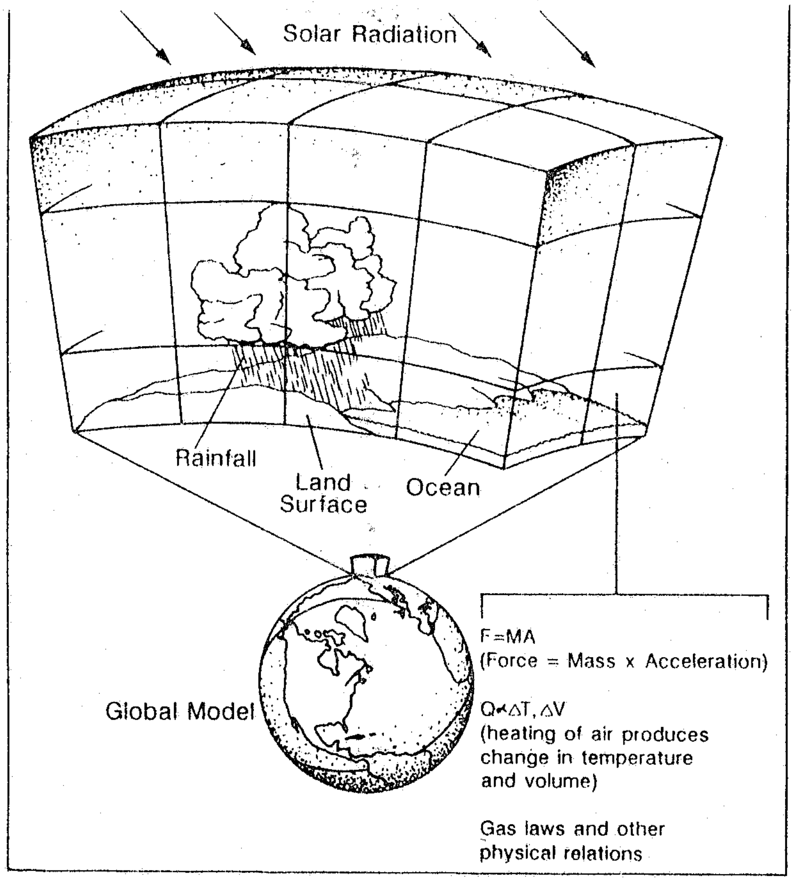


FIG 2.2 *Schematic diagram of global climate system, to illustrate the way in which the Earth's atmosphere–ocean system, and land surface area, is divided into thousands of boxes with sides typically extending several hundred kilometres in latitude and longitude, and with heights of a few kilometres in altitude. In a general circulation model (GCM), the computer treats each box as a single element as it calculates the evolving global climate. The GCM imposes seasonal and latitudinal changes of incoming solar radiation, the height and shape of the continents, and other external conditions which affect the behaviour of the atmosphere. In GCMs, for example, the equations may be solved in hourly increments over at least 20 years of simulated time to generate an output which is statistically 'accurate'. Such large and time-consuming calculations require the use of super-computers. After Ruddiman and Kutzbach (1991).*

Meteorological Office Model. Several assumptions may be given to the various GCMs with resultant effect of variations in their weightings.

2.4 CONTINENTAL POSITIONS, MOUNTAIN – BUILDING EVENTS AND GLOBAL CLIMATE CHANGE

The very long – term changes in global climate, over hundreds of years of millions of years; appear to be strongly controlled by the position of the continents. As the plates, which make up the outer surface of the Earth relentlessly move around, at speeds typically measured in millimeters to centimeters per year, so the size and positions of continents or land area changes. The theory which explains the movement of these plates is known as 'plate tectonics'. Plate tectonics is the theory, which explains the nature of the Earth's surface in terms of continental and oceanic plates. Currently, there are eight major and several minor lithospheric plates, which move relative to each other because of connection cells in the Earth's mantle.

At times in Earth's history, there have been super – continents when many continental plates were locked together. At other ties, the distribution of continents has been more like it is today, with many large continents separated by oceans. The size and distribution of these continents for example centred over polar or equatorial latitudes, profoundly affects global climate, as does the rate at which ocean basins floored by oceanic crust are created – on a time scale measured in tens of millions of years. At times when there was fast production of new oceanic crust at mid ocean – ocean ridges, greater amounts of heat energy were released from within the Earth together with more greenhouse gases. The result of this enhanced heat exchange between the solid Earth and hydrosphere – atmosphere/biosphere is that it could have caused past greenhouse periods in the Earth's history. These factors can be thought of as internal controls that are entirely a consequence of processes within the Earth's heat engine.

Some scientists believe that mountain building episodes can give rise to ice ages. Ruddiman and Kutzbach (1991), and more recently Raymo and Ruddiman (1992), for example have proposed that the uplift of Tibet, the Himalayas, and the American south – west caused large areas of land in low latitudes to reach a height that altered global atmospheric circulation patterns, which helped induce global atmospheric cooling. In addition, they argue that increased uplift exposed more rock, which then underwent accelerated rates of chemical and physical weathering. During many weathering reactions, CO_2 is extracted from the atmosphere to react with the decomposing minerals and form bicarbonates. These bicarbonate compounds are soluble in water and were carried in solution finally to be deposited as sediments in the oceans. Also the uplift increased river gradients causing the rivers to erode ore deeply and carry sediment. To the seat at greater rates, and the uplift could be have increased storminess along the mountain front leading to more rainfall, faster – flowing rates in rivers. In essence, there is a net removal of CO_2 from the atmosphere during the chemical reactions associated with the breakdown of rock forming minerals, a process that can therefore reduce any potential greenhouse warming, and hence encourage a global cooling. Such tectonic processes of mountain – building, or orogeny could provide a negative feedback to the atmosphere system.

2.5 TECHNIQUES FOR STUDYING PAST CLIMATES

Palaeoclimatologists looking back in time on a scale of hundreds of years have historical records as well as an enormous range of sophisticated scientific techniques to probe past climates. Many techniques are available, and their applicability depends upon the age of the sediments and fossils, and each is associated with varying degrees of confidence or error bars.

2.5.1 FOSSILS

The remains of dead organisms (fossils) are extremely important in understanding ancient environment and past climates. Large colonies of reef corals, for example, suggest low – latitude / equatorial, warm, clear waters as of the Bahamas or Great Barrier Reef today. Fossils are also virtually important in helping to date ancient sediments accurately, something that is essential in any discussion on what the Earth's climate was like at various times in the geological past.

The analysis of pollen as an aid in the interpretation of palaeoenvironmental change is one of the most widespread methods adopted by palaeoclimatologists. Pollen grains extracted from ancient organic deposits such as peat provide information regarding changes in vegetation through time. Pollen grains are easily preserved because they are protected by a coat called 'sporopollenin'.Pollen grains are identified under optical and scanning electron microscope and plotted graphically on pollen diagrams. This allows determination of the changes in vegetation down through a section of a sedimentary deposit that is through geological time. Over the last 20 years, fossil insects have provided an exciting new means of studying environmental change throughout the Quaternary. These include bugs, flies, bees, dragonflies, and beetles. The Coleoptera provide the best value because they have very robust itinous exoskeletons that tend to survive with their original chemical signature. hey are well preserved in a wide variety of deposits, and they can often be

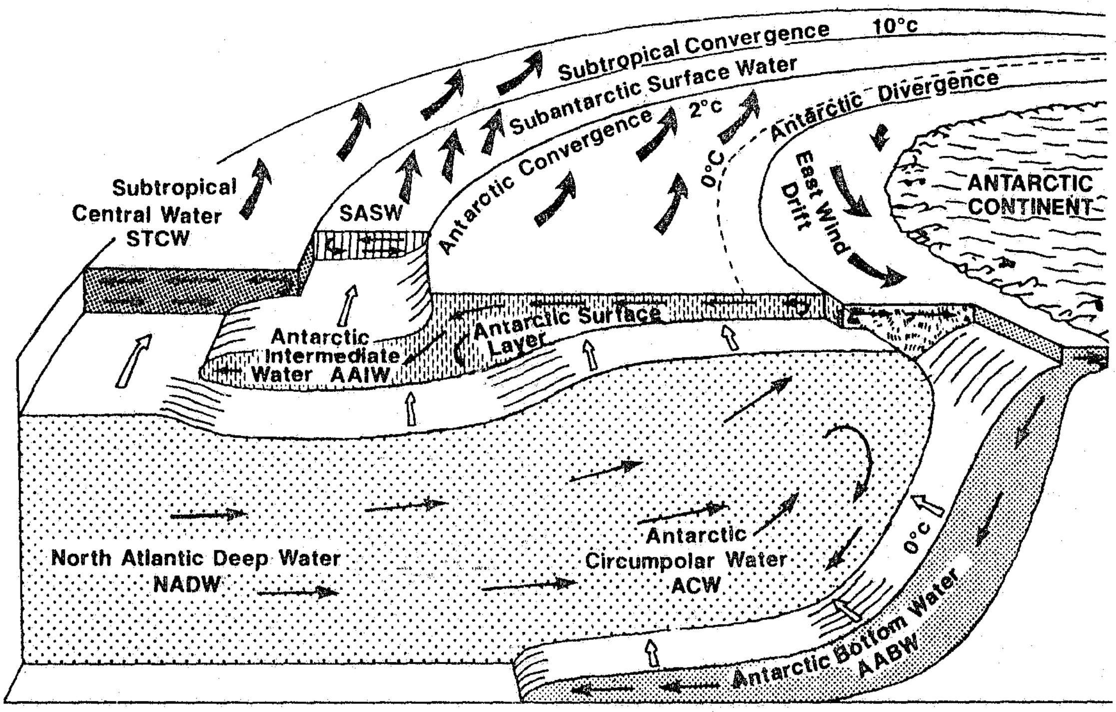


FIG. 2.5 *Schematic illustration to show the principal water masses in the Southern Ocean in proximity to Antarctica. The water masses have different temperatures and densities, and move as discrete currents. There is upwelling of cold, nutrient-rich water where the surface currents diverge, whereas 'downwelling' takes place where currents converge. The Antarctic Bottom Water (AABW) flows into the Atlantic Ocean. After Williams* et al. *(1993).*

identified from isolated fragments of the body including head, thorax, wing covers, and genitalia.

Unlike pollen, fossil beetles are commonly preserved at or in very close proximity to where they lived. They are the most studied and collected group of insects, colonizing almost every terrestrial freshwater and intertidal environment, where humidity, temperature, vegetation, water conditions and substrate satisfy a rather limited range. They are therefore, good indicators of palaeoclimate and particularly palaeotemperature. It has been shown that in northwest Europe subtle variations in temperature over the last 50,000 years, because of the stadials and interstadials, can be picked out by the dominance and presence of various beetle species, Coope, (1986).

Most studies of past climates have focused on rock types that contain abundant fossils. There has been a tendency to neglect the ancient dry regions simply because they yield less data.

2.5.2 CHEMICAL METHODS.

The chemistry including isotope studies, of sediments and fossils as a tool for trying to understand past climates, and estimating palaeotemperatures, oceanographic, and atmospheric conditions, is coming of age. Many chemical techniques are now available, and their use and interpretation is the subject of considerable current research.

The calcareous skeletons of planktonic 'foraminifera' are commonly chosen for isotope analysis because these organisms live in surface waters and therefore, they provide one of the best measures of surface water temperature: in turn, sea surface temperatures can be linked to global temperatures. Determination of past ocean temperatures, using isotopes, also involves estimate of the volume of water stored in ice sheets and the oceans, and the change in volume per millionth part in isotopic composition of a shell which is precipitating out of sea water, and in isotopic equilibrium with the sea water. Oxygen isotopes curves predominantly present fluctuations in the global ice and ocean volumes. Work on 'benthic foraminifera' may be more truly representative of oceanic volume changes, so that such temperature – dependent variations in oxygen isotopes can be disregarded (Dansgaard, 1984).

Detailed studies of ^{18}O values in marine microfossils over the past 350,000 years, in the Quaternary period, have revealed fluctuations in climate over scales of tens to hundreds of thousands of years (Chappell and Shackleton 1986). Figure 2.

Illustrates the variations in the sea surface temperature calculated from ^{18}O values measured from a core collected from the Caribbean. The last Ice Age can be seen as higher ^{18}O values from just over 110,000 to 20,000 years ago. This isotopes signal thus provides a record of glacial and interglacial stage. By convention, odd numbered stages represent interglacial and even glacials. The records show that there have been more cycles so far identified from other lines of evidence in the contents. It also shows that glacial stages are about five times longer than interglacial that is stadials and interstadials respectively. For the last 15,000 years there have been dramatic climatic changes on a scale from a few hundred to a few thousand years, spanning the deglaciation from the last glacial phase into the present interglacial.

2.5.3. THREE RINGS AND RECENT CHANGES IN CLIMATE.

Studies of three rings can be used to infer past climates. An example of this approach is the work undertaken by Earth scientists examining west European oaks and their three characteristics. Temperature, barometric pressure and precipitation data are available from the study area.

The width of three rings is related to the rate of growth, which in turn tells us about the overall climatic conditions in any particular year. By studying many trees across a wide area, it is possible it see if there are years in which a significant proportion of trees show similar changes in growth – ring width. Using this techniques on west European oaks, it has been shown that the years in which there was greater growth of tree rings tended to be associated with enhanced cyclonic activity over middle latitudes of western Europe, accompanied by an increase in precipitation. Temperature variations appear not to have played a significant role in the growth of tree rings. Changes in growth rates of tree rings can be related to past climate by studying the chemical; isotopes of the cellulose in the tree rings, it is possible to interpret the past composition of the atmosphere and the hydrosphere. As a reliable and absolute time scale is developed, so this techniques is becoming a very powerful means for understanding the changes in global climate brought about by the last major glaciation (Pleistocene) to our present warmer (Holocene) period.

2.5.3 EXTENT OF GLACIERS, ICE CAPS, LANDFORMS AND SEDIMENTS.

Particularly important to the study of palaeoenvironmental change is the reconstruction of the former extent of ice bodies such as valley glaciers and ice sheets. During glaciations when the Earth's climate was much colder, precipitation was dominated by snowfall. Over the years, the compacted and buried snow can become thick enough to change its structure and form glacier ice. As a result, valley glaciers and ice sheets formed, increased in size and flowed across the continents. These glaciers eroded the landscape and deposited glacial debris to form a rich variety of landforms. In response to the changing global climate, there have been many advances and retreats of glaciers, some of which may be globally synchronous, but others appear to have been more localized.

In some areas, ice sheets were very extensive. During the last major glaciation, ice covered most of northern Europe, extending south to the north German Plain from the Fennoscandian ice sheet, and south to the English Midlands for British ice sheet. It was from evidence such as this for the former extent of continental ice during past glaciations, particularly on the continents of South America, Africa, Australia, and India that led Alfred Wegner, in 1915, to propose that the continents had drifted amid the surface of the Earth. Wegner used such information to reconstruct the super continent of 'Gondwanaland'. These ideas were embodied in his theory of continental drift, which provided many of the early ideas that were interpreted into present theory of platetectonics.

Mapping and geochronological dating of glacial landforms provides information on the former extent and temporal variation relating to past climate. Research has shown that several periods of ice advance can be identified for most high – and mid – latitude regions of the world. Many of these occurred at the same time, suggesting global changes in climate. Of particular interest are the fluctuations during the past few centuries, especially during the seventeenth century, which was a cold period known as the Little Ice Age. Christmas cards that use these paintings from this time show a great deal of snow and ice.

From this and other types of data discussed earlier, it is possible to reconstruct, with a relatively high degree of accuracy, estimates of temperature changes over the past several hundred thousand years, from which it is possible to begin to understand the nature of changes in global climate.

2.5.4 SEA LEVEL CHANGE.

During times when there were substantial ice caps on Earth, sea level changes appear to occur at frequencies of $10^4 - 10^5$ years, and with amplitudes from 10 to more than 100m, resulting from expansion and contraction of continental ice sheets, apparently at Milankovitch frequencies (Kevin Pickering, 1994). A puzzle however, has been to explain such fluctuations in global (eustatic) sea level even at times during Earth history when there appears to have been no significant continental ice.

Raised beeches and coral reefs provide important information regarding sea level changes throughout the Quaternary, and reflect the amount of water stored as glaciers during glaciation, and the volume of water released into the oceans when ice sheets melted. If the entire Greenland ice sheet (within estimated 2.82×10^6 Km^3 of ice) melted, global sea level would rise by about 6m. If the entire Antarctic ice cap melted, global sea level would rise by approximately 60m. Additionally, raised shores may allow reconstructions of former ice thickness. This is because the growth of ice and glaciers depresses the Earth's crust due to their extra weight. When the ice melts, the Earth's crust responds to the releases stress by rebounding upwards, in a process known as glacio – isostatic rebound. It transpires that the amount of lift is directly proportional to the thickness of ice. The uplift history, however, is complex because as the ice sheets melt sea level also rises. To determine the absolute amount of uplift, curves for global sea level changes have been constructed using shorelines and coral reefs in geologically stable areas that were not glaciated (Jelgersma 1966, Fairbanks 1989).

Two lines of evidence may suggest the growth of polar ice sheets, that is, satellite altimeter measurements over Greenland, and positive correlations between net snow accumulation and increased air temperature. Satellite altimetry measurements are limited in duration, and can be compromised by a number of factors, including the changing distance from moisture sources. Jacobs (1992) concluded that it is too early to say whether the Antarctica ice is shrinking or growing.

2.6 QUATERNARY CLIMATES.

As far back as 1909, the Alpine glaciations and interglacial periods were interpreted as alternating warm and cold stages by the German geographers Albrecht Penck and Eduard Bruckner. In 1842, the French mathematician Adlemar invoked changes in the orbit of the Earth around the sun as being the main reason for such climatic change, while in 1864, the Scottish geologist James Croll hypothesized that changes in the Earth's orbital eccentricity could be the cause of the Ice Ages, a theme he elaborated upon in his book 'Climate and Time', published in 1875. Without a very precise means of dating the Climatic changes and linking them to orbital parameters, these ideas lay dormant. It was until well into the twentieth century, between 1920 and 1940, that these astronomical interpretations for Climatic changes on Earth found support and widespread acceptance throughout the scientific community.

2.6.1 A BRIEF HISTORY OF THE QUATERNARY.

The Quaternary is defined by Earth scientist as the relatively recent period of geological time spanning the last 1.64 million years of Earth history. Flora and faunal evidence suggests that there was an abrupt change from warm to cold Climatic conditions anywhere between 2.6 million years ago and 1.64 million years ago, depending upon which data are used. In 1985, at Vricia in Calabria, Italy the International Commission on stratigraphy formally defined the base of the Quaternary period as where a clay stone horizon containing the first appearance of 'thermophobic foraminifera' directly overlies a 'sapropel'. The identification of ice rafted debris in cores from sea, however, has placed the onset of glaciation as far back as 3.5 million years ago, together with other lines of evidence, although dating of diatom – bearing glaciomarine strata in east Antarctica suggests that there was an extensive deglaciation of Antarctica at approximately million years ago.

The last glaciation was a period of extreme cold on Earth when the polar ice caps were more extensive than today, much of the continents were covered by continental glaciers and ice caps, and sea level was much lower than at present. Different names were given to that glaciation period throughout the world, for example the Devensian in Britain, the Wilconsin in North America, and the

Weichselian in mainland Europe. The table below show the correlations of synonymous names for various Plastocene phases in the northern hemisphere.

CO_2 and CH_4 (carbondioxide and methane) concentrations in the atmosphere have also changed considerably during past glacials and interglacials. During interglacials, there is an approximately 25 percent more CO_2 and 100 percent more CH_4. These changes in concentrations of atmospheric gases have important implications for understanding the global carbon cycle. It suggests, for example, that organic productivity was greatest during glacial periods thereby providing a sink for carbon, for example in the oceans. Such changes in CO_2 and CH_4 concentrations from glacial to interglacial periods appear to have taken place suddenly, that is within a few hundred years (Jonzel etal. 1987). The precise causes of these changes in atmosphere concentrations, and the threshold conditions that precipitated a switch from glacial to interglacial period, remain poorly understood.

2.6.2 HUMAN EVOLUTION IN THE QUATERNARY PERIOD.

A study of the Quaternary period is important in understanding human evolution and colonization, including the human impact on the natural environment. It was a little time prior to the onset of the Ice Age that the first bipedal hominids evolved (3.75 million years BP). These were known as 'Australopithecus afarensis'. The most famous fossil found was unearthed by Louis Leakey in Ethiopia in the mid – 1070s and became known as 'Lucy'. It is believed that the genus 'Homo' evolved from ' afarensis' about 2million years ago. The first species was Homohabilis but within another 500,000 years 'Homo erectus' evolved. 'H. Erectus' probably organized themselves into groups for hunting and gathering food as well as making tools and utilizing fire. Many scientists believe that 'H. erectus' was the ancestor of modern humans (Homo sapiens sapiens) and evolved about 200,000 years ago. Neanderthals (Homo sapiens neanderthalensis) are also believed to have evolved from ('H. erectus', but became extinct about 30,000 years B.P (before present).

By 50,000 years BP, Homo sapiens sapiens has spread to Australia. They arrived in the Americas between 14,000 and 12,000 years BP and by the start of the Holocene had colonized every continent, except Antarctica. The migration was undoubtedly influenced by climatic change, often aided by the extensive coastal regions that were created as a result of the fall in the sea level caused by ater beign locked up in the ice sheets during the last glacial.

Towards the close of the last glacial, about 15,000 years BP, hunter – gatherer communities began to develop, and these groups began to clear land for farming and settlements. They were the first humans to initiate the process of deforestation. This practice of farming organized settlements and land clearing began in many regions, particularly in the Near East, Central Asia and South America. In the Near East, by 10,000 years BP, the domestication of plants and animals was well established. By about 9,000 years BP Jericho, one of the earliest permanent settlements, was established, associated with cultivating cereals, wheat and barley. The domestication of animals became more sophisticated.

Such changes led to the modification of the landscape, vegetation, soil, and watercourses, as modern humans cleared more forest for farming and the establishment of permanent settlements. The need for tools also had a profound effect on the environment, as more trees were required for charcoal to aid in smelting of metal ores. In the Near East, by 7,000 years BP, copper was being smelted, which then gave way to arsenic bronze by 5000 years BP, and eventually iron about 4,000 years BP.

The important point through this deviation into human history is that through the Quaternary there is evidence for studying the human impact on the natural environment. The human impact has to be considered when studying climatic and palaeoenvironmental change during this time period. At present, there is great debate regarding the extinction of many species of animals, as well as major changes in natural vegetation that occurred near the end, and after, the last glacial stage. The fossil record for the last interglacial shows a decline in diversity of species. In Europe, during the last interglacial, abundant elephants, rhinos, bison, and giant deer were present. In Australia, a more diverse marsupial fauna existed, including giant wombats, giant kangaroos, a diprotodont (a marsupial somewhat like a hippopotamus), and in New Zealand there were giantbirds. In Australia the marsupials were greatly reduced by 30,000 years BP, while in North America three quarters of the geacra disappeared by about 11,000 years BP. The most recently colonized regions of the world, such as Madagascar and New Zealand, saw the extinction of large flightless birds like the rocs and moa, respectively.

A detailed study of the Quaternary period of Earth history allows us to assess the possible relationship between the growth of human society and the extinctions of various species together with any environmental changes, towards the end of the last glacial stage. It may be that the extinctions and changes in the natural environment occurred entirely independently of human activities, because of natural processes that exerted a more profound influence, for example, the changes in the ocean – atmosphere system brought about by the end of the last glaciation.

2.7 METEORITE IMPACTS ON EARTH AND GLOBAL CLIMATE CHANGE.

Another example of abrupt global climate change occurred about 65 million years ago when a great meteorite impacted on the Earth's surface. This is particularly interesting because it provides Earth scientists with information on how external, cosmic processes may lead to major climatic change, and the extinction of faunas and floras.

Approximately 65 million years ago a phenomenal catastrophe hit the Earth, the consequences of which were fatal for many organisms. An estimated 70 percent of flora and fauna on Earth became extinct. Such is the significance for the evolution of life on Earth that Earth scientists define the time era after 65 million years ago as the Tertiary, and the immediately preceding time interval as the end of the cretaceous period hence the K – T boundary event. The 'K' is from the German spelling 'Kretaceous'.

The most widely known event at the K – T boundary was the extinction of the dinosaurs. The demise allowed the humble mammals to inherit the role of dominance from the dinosaurs paved way for human beings. There have been many theories to explain the extinction of the dinosaurs, but here only the most plausible event is presented, an explanation subscribed to by most Earth scientists, which is the impact of massive meteorite.

2.8 DEDUCTIONS

From the various sub-topics discussed above we can find out that:

i) The Earth's climate has changed throughout geological time and is still undergoing change. Palaeoclimatology is the study of past climate. There have been at least six major cold periods, or Ice Ages, throughout geological time.

ii) The natural causes of global climate change result from:

   a. Internal earth process such as plate tectonic processes, which lead to redistribution of land masses and altitude which, in turn, influence global atmospheric, hydrologic and biologic systems, together with volcanic activity which may cause changes in atmospheric aerosols and gases;

   b. Processes external to the Earth, such as Milankovitch cyclicity resulting from variations in the Earth's orbital parameters around the sun, and solar variations in the amount of solar insulation to the Earth's surface;

c. Catastrophic events such as large meteorite impacts, which may cause large – scale extinction events and thereby open up ecological niches for existing or new species to inhabit and evolve within.

iii) An understanding of past global and regional climate change, the causes, processes, and effects, is important to humankind in order to distinguish natural from human – induced climate change.

CHAPTER THREE

"ENHANCING THERMAL COMFORT IN BUILDINGS THROUGH DESIGN AND CNSTRUCTION METHODS"

One of the climate types identified by Miller (1961) is the type found in Nigeria and other parts of Africa along the equator. He called it equatorial climate and it is also called warm-wet climate.

In this region temperatures are high at an average of about 27°C, mostly range of 1-3°C and diurnal range of 8°C. Maximum temperatures are usually about 30°C with possibility of about 38°C.

Humidity and rainfall are high during most of the year, and the daily incidence of rain is very regular in each particular location usually occurring in the afternoon. As it is called warm-wet region, the vapour content of the atmosphere is very high with water vapour pressure of 25mm Hg and a relative humidity occasionally as high as 90%. The intensity of direct and diffused solar radiation varies widely with the cloud conditions, and reflected radiation from the ground is usually low as vegetation is dense and the soil dark.

3.1 HUMAN AND THERMAL REQUIRMENTS

As the seasonal climatic variation are very slight, the physiological thermal requirements, and hence the building characteristic necessary to fulfill them, are similar for the whole year.

He predominance of high humidity (due to large month of rainfall than dry season) necessitates a correspondingly high air velocity to increase the efficiency of sweat evaporation, and to avoid as far as possible discomfort due to moisture on skin and clothes, Continuous ventilation is therefore the primary comfort requirement and affects all aspects of building design, such as orientation, size and location of windows, layout of the surrounding etc

In warm-wet areas torrential rains alternate frequently with intense solar radiation, while humidity remains high and thus provision must be made for protection from rain and sun without impairing ventilation conditions.

Even with the maximum ventilation there are limits to the conditions under which comfort can be achieved in a warm-wet climate.

3.2 PRICIPLES OF BUILDING DESIGN

The requirements to be satisfied by the design and construction of a building in a warm-wet climate include provision of continuous and efficient ventilation; protection from the sun, rain and insects; prevention of internal temperature elevation during the day and minimization during the evening and night.

To adequately cross-ventilate the occupied areas of a house, either all the rooms should be provided with doors, windows etc on both windward and leeward sides.

Open planning and wide, free spaces between buildings help to achieve good ventilation. Orientation also should be aimed at providing the best possible ventilation and therefore the direction of the prevailing winds, as at angles of up to 50° on either side of the wind direction of the storm should also be taken into consideration in order to minimize their impact.

In rooms were the habitable zone is very narrowly defined as in bedrooms for instance, it is possible to achieve maximum concentration of the wind by providing smaller inlets than outlets and thus concentrating the incoming airflow.

But in rooms were the occupied zone may extend over most of their area, as in the case of living rooms, it is preferable to have inlets and outlet of similar size.

Large openings, doors and windows, are of advantage in a warm-wet climate provided that they are effectively protected from penetration of solar radiation and driving rain. The advantage of large openings is not only due to the better ventilation conditions that they provide, but also because they enable the achievement of low temperatures during the night.

When a given room does not have direct cross-ventilation but the airflow has to pass through another room on its way outwards, it is essential that the openings between the two rooms be at least of the same are as the external inlet and outlet openings. The partition opening should be so placed and detailed as to direct the airflow towards the occupied zone.

The most effective height of the windows from the human comfort aspect is about 0.5- 1.5 metres above the floor (the occupied zone). In bedrooms it is particularly important to bring the window sill as close as possible to the height of the beds, thus ensuring adequate air flow around the occupants sleeping area at those times when the outdoor wind speed is very low. When upper windows have to be used for any reason, it is preferable to use horizontally pivoted windows with upper hinges which, when open would direct the air flow down wards.

Large sliding walls, which may be kept open most of the time, but closed during storms, may provide good control of the conflicting requirements for maximum ventilation alternating with wind and rain protection during storms. Adjustable or retractable louvres and other shading devices may be equally satisfactory or if they are able to withstand the force of the wind.

Fly-screens area essential in most warm-wet regions, but they may reduce appreciably the airflow. To minimize their blocking effect it is preferable to install them at some distance from the wall, rather than directly on the windows. When there is a balcony adjacent to the room it is possible to ensure insect protection with less interference of ventilation by erecting a fly screen around the balcony, thus enabling the entry of air through a wind free area.

The large area of openings required in a warm-wet climate necessitates adequate shading; otherwise indoor temperatures may rise appreciably above the outdoor level. Shade is required not only against direct solar radiation, but also against diffused radiation from the sky, which in tropical regions may reach very high intensities.

In many instances, solar protection may be combined with rain protection, not only with respect to the windows but also for the whole are of the walls, by extending the roof beyond the floor area. This is more necessary in warm-wet regions as tropical rains are very heavy and wind-borne, where the almost horizontal wind-driven rain penetrates through joints and cracks in the walls and fenestration. Unprotected walls may become saturated, and the rapid succession of wetting and drying spreads up deterioration of their component materials, especially.

Another problem connected with tropical rain concerns the necessity for providing means of disposal of the run-off water and prevention of soil erosion around the buildings. Planning according to the control line helps greatly in reducing the erosion hazard.

The shading devices should not reduce air velocity within the occupied zone. When horizontal adjustable louvres are used they should be constructed so as to enable their opening at an angle of approximately 120°, so that when required they direct the airflow downwards towards the occupied zone. In multi-storeyed buildings, window overhang shades tend to reflect an appreciable amount of solar radiation on to the walls and into the windows of the upper storeys. Inclined slats, in the other hand, running parallel to the wall between horizontal beams projecting from the walls, can provide fully effective shading while at the same time reflecting the sun's rays outwards and enabling free air movement over the external surface of the walls. Such slats can be made of pre cast concrete, asbestos-cement wood etc. Moreover, they allow better illumination than do solid overhangs, but provide less protection from the driving rains.

3.3 CHOICE OF MATERIALS

Because of the permanent ventilation requirements and the small outdoor diurnal temperature range characterizing the warm-wet climate, it is not feasible to utilize the heat capacity and resistance of the walls as a means of reducing the daytime temperatures to those below the outdoor level. Therefore the main criteria in choice of materials are prevention of daytime indoor temperature rise to above outdoor level, and minimization of such elevations during the evening and night hours. Other factors concern the weathering qualities of the materials in a damp and humid environment, and the likelihood of biological attack by insects (e.g. termites) and of fungoid growth. The heat capacity of the building should be as low as possible in order to prevent accumulation of heat during the daytime, which would elevate the indoor temperature during the night when the external wind speed is usually at its lowest.

Thermal resistance of the external walls is advantageous within certain limits in minimizing the heat flow from the external surfaces warmed by the sun .It is possible by this means to maintain the temperature of the inside surfaces of the external walls very close to the indoor air temperature because of the intensive ventilation. Modern insulating materials, which combine very low weight and heat capacity together with high thermal resistance, may provide the best indoor climatic conditions. It is essential, however, that such materials be protected from biological attack and fire hazard. Although light, reflective external colours would reduce solar heat gain in warm-wet climates, as in any other hot climate, it is much more difficult to maintain these colours because of the high humidity and fungal growth. The thermal resistance should therefore be sufficient to minimize inward heat flow despite the absorbed solar radiation.

When, for structural reasons, heavyweight materials must be used, it is possible to minimize the effect of the heat capacity by covering them with an insulating layer, thereby maintaining the surface temperature very close to the surrounding air temperature. Thus, for instance, when concrete floors are used in multistoried buildings, the corresponding ceilings may be covered by a layer of insulating material so that their temperature at night would closely follow the air temperature.

Lightweight roofs, covered with tiles or sheets of asbestos-cement or aluminum, are preferable in a warm-wet climate owing to their low heat capacity. But such roofs, which are externally usually dark in colour, or at any rate, not whitewashed, are heated by solar radiation and may cause heat stress during the daytime. Therefore thermal insulation either at the ceiling level or beneath the upper roof layer is to be recommended. An effective means of insulation is by placing aluminum foil beneath the roof in order to reduce the radiant heat flow from roof to ceiling. This may be supplemented by an insulating layer above or beneath the ceiling, and by ventilation of the attic space.

Double roofs consisting of two layers with a ventilated air space are desirable not only because of their solar-protecting quality, but also by virtue of the protection they offer from the rain. Care must be exercised, however, in ensuring their resistance to the lifting power of stormy winds.

Ventilation of the attic space within the addition of insulation is inadequate, as the main heat flow from roof to ceiling is by radiation.

When concrete roofs of light heat capacity are constructed it is preferable to provide an insulating layer below the ceiling, thus reducing heat flow during the day and enabling rapid lowering of the ceiling temperature during the night.

CHAPTER FOUR

4.0 CASE STUDIES.

INTRODUCTION.

Case studies are carried out to appraise buildings, which have a bearing with the structure being proposed. However, in the case of the Climate Change Centre, there is no existing Centre other than the one found in F.U.T Minna. Therefore, the case studies carried out were those of infrastructures that are generally climate – related.

4.1 CASE STUDY 1

DEPARTMENT OF METEOROLOGICAL SERVICES

Federal Ministry of Aviation, Oshodi – Lagos.

LOCATION: Oshodi, lagos.

CLIENT: Federal Ministry of Aviation

INTRODUCTION:

The Nigerian Meteorological service is a department of the Federal Ministry of Aviation established in 1938 under the then British – West African Meteorological services.

4.1.1 FACILITIES

The department has the following facilities

- Central forecasting office
- Networking unit
- Climatological unit
- Regional training school
- Ozone measuring station
- Conference Centre
- Mechanical workshop/ + Fuel depot

4.1.2 APPRAISAL

The department is at its original site but due to space constraint, the department is operating below capacity. Although there is some landscaping, it could be improved.

4.2 CASE STUDY 2

NAME: NATIONAL CENTRE FOR REMOTE SENSING.

LOCATION: Bukuru Road, Jos Plateau State.

CLIENT: National Agency for Science and Engineering Infrastructure (NASENI)

INTRODUCTION:

The Centre was created in 1995 under the auspices of the National Agency for Science and Engineering Infrastructure to provide the Nation's need for remote sensing and space application.

4.2.1 FACILITIES:

The Centre has departments namely:-

- Production/ cartography department
- Application department and
- Administration / Finance department

The Centre is headed by an assistant director with a staff strength of 25.

4.2.2 APPRAISAL:

The Centre is currently being housed at its temporary site along Jos – Bukuru road. The building is a renovated building donated by the Plateau State

Government. The Centre is under accommodation hence they are not functioning in full capacity due to the fact that movement of their equipment are not installed. It also has acoustic problem and lacks proper landscape.

4.3 CASE STUDY 3.

NAME: REGIONAL CENTRE FOR TRAINING IN AEROSPACE SURVEY.

LOCATION: Obafemi Awolowo University, ILE IFE, OSUN STATE.

CLIENT: UNITED NATIONS ECONOMIC COMMISSION FOR AFRICA (UNECA)

INTRODUCTION:

The Regional Centre for Training in Aerospace Survey (RECTAS) located in the premises of the Obafemi Awolowo University, OAU, Ile Ife was opened on 1922.

The Centre is bi – lingual with English and French as official languages. It is a joint project between the participating countries and UNECA.

4.3.1 OBJECTIVES:

The objectives of the Centre are:

i) To provide theoretical and practical training in the field of meteorology including in particular weather forecasting, photogrammetry, remote sensing, geographic information system (GIS), atmospheric research and airborne atmosphere analysis.

ii) To provide advisory and consultancy services upon request on meteorology and atmospheric analysis including their instrument maintenance to government (including their agencies) or the numbers of the Economic Commission for Africa.

4.3.2 TRAINING COURSES:

The courses at the Centre are taught in English and French. The Centre presently offers full time courses in photogrammetry, meteorology, at technician, technologist and post – graduate levels. It also conducts on special request customized operator course in meteorology to suit the individual training of member states.

4.4 CASE STUDY 4

NAME: SWEDISH METEOROLOGICAL CORPORATION (SMC)

LOCATION: KIRUNA

CLIENT: Ministry of Industries.

INTRODUCTION:

The Swedish Meteorological Corporation, SMC, is a state owned company, under the ministry of industry responsible for the implementation of Sweden's Space and Atmosphere research programmes since 1972.

SMC is internationally oriented and has extensive experience in the field of space technology and meteorology. The activities cover the entire range of space related work and meteorology, from feasibility studies, weather forecasting to operational application of advance technology.

SMC is established in two locations: the headquarters situated in Stockholm, whereas the main operative units are in Kiruna in the northern part of Sweden.

4.4.1 FACILITIES:

- The Esrange
- Earth observation services
- Telecom services department
- Strategic development department

The Earth observation services include the Esrange Satellite Receiving station. This division deals with Satellite data reception, processing and archiving, weather forecasting and monitoring, marketing of satellite data products.

CHAPTER FIVE

DATA COLLECTION

5.0 CLIMATE CONDITIONS

For the Climate Change Centre, which is being proposed to be sited in Minna to be a model Centre, its design has to take maximum advantage of the climatic condition of the town.

The climatic condition of Minna town will be discussed under the following headings:

i) Temperature

ii) Humidity

iii) Sunshine rainfall

5.1.1 TEMPERATURE:

The mean monthly temperature is highest in March at 30.5^0C (87^0F) and lowest in August at 25^0C (77^0F). The town experiences very hot and uncomfortable weather between late February and early April. The temperature falls during the rainy season due to cloud cover.

The Climate Change Centre as a model intends to eliminate the use of artificial ventilation because of the danger that is imminent in the use of ozone depleting substances found in air-conditioning compressors. Therefore, adequate landscaping, roofing have been used to overcome the problem of excessive heating in the Centre.

5.1.2 HUMIDITY.

The relative humidity of a region influences the comfort level of such a region. It varies with different seasons of the year. It is highest in the rainy season and lowest in the dry season. The lowest relative humidity of about 13.4% is experienced between the month of December and the highest of about 85.3 in August.

5.1.3 SUNSHINE

Sunshine in Minna is quite prominent, especially between the months of November and April. This is a major contributor to the hotness of Minna town. The sun usually rises between 6:45 am and 7:15 am and sets around 6:15 pm. According to Mabogunje (1977) Minna is exposed to 2,500 sunshine hours annually. With the approach of the rainy season, cloudiness increases in the sky and sunny hours of the day are drastically reduced.

5.1.4 RAINFALL.

Minna town has mean annual rainfall of 1334 mm taken over a period of years. The highest mean of about 300 mm is recorded in September. The rainy season starts around April and last till about the ending of October.

During the rainy season, the tropical maritime air mass, formed over the Atlantic, blows from the south to the north stretching across Minna. It is attributed to start the rains. The rains are preceded quite often by heavy wind and sand storm.

The implication of the rains and the storms architecturally means having a safe and durable structure or building that can overcome the effects of the rains. Windbreakers and parapets were used to protect the structures from the storms. Selected trees were planted as well to reduce the effects of the wind.

TABLE 5.1

MONTH	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
RAINFALL (mm)	0.4	6.4	13.8	51.4	125.5	166.3	242.3	274.6	298.7	230.3	7.4	1.3

5.2 GEOLOGY AND TOPOGRAPHY.

Minna is underlain by basement complex rock of which gneiss and magnetite predominate. The igneous rocks are mainly granite while the metamorphic sediments include quartzite and schist. The igneous rock (granite) is prevalent in the northeast of the town. This has constrained any effective development in this direction. The metamorphic sediments found mainly in the season along the courses of the rivers. The factors of geology are necessary for the foundation design and the landscaping elements.

5.3 SOCIO-CULTURAL LIFE

5.3.1 HISTORICAL BACKGROUND.

Minna is basically a Gwari town and got its name from a ritual performed yearly by the Gwari founders of the town to observe the beginning of a new year. The word 'Mina' in Gwari means to spread fire. It came into existence because the Gwaris used to put out every point of fire in the area, even in all the kitchens of the town, on the last of every year.

About three days to the last day of the year, the chief of the town, his chief priest, and some members of the traditional council would travel to Lafiagi, a village about 60 kilometers away to bring fire.

The journey was calculated so that, their return with the fire fell on the last day of the old year. On the night of the new year, the people of the town would gather to lay plenty of firewood together and later light it up with the new year, everybody would then take his fire out of the public fire to go and light it again in his house to mark the start of the new year. The ceremony eventually became synonymous with the town and consequently gave the town its name.

The early settlers of the town lived on top of the range of hills, which are located in the northeastern parts of the town. Evidence of early settlements on the hill top remains in form of dilapidated foundations, broken pots, and many baobab trees that characterized ancient town in the north and are found on the hilltops.

5.3.2 SOCIO-POLITICAL SETTING:

Minna town underwent for metamorphosis before it became the modern city it is now.

The first was in 1905 when the construction work of rail line got to the area. As there was no local labour at that time, the contraction workers were Gwaris, Nupes and Hausas. The various people were accommodated in different camps to ensure access and prevent desertion. The camps later became permanent settlements and eventually formed some of the present wards of the town. Before the camps became settlements, the chief of the town was asked by the railway authorities to provide an arbiter who would settle the feud between the labourers. The late chief of Bosso, Mallam Abubakar Zarumai became the choice with Muazu Paiko as his secretary. He transferred from the hilltop to settle near the camps as the administrator while his father Mallam Godeyize who was then on the throne as the chief of Bosso remained on the hill.

In 1908, the second facelift of the town took place when an Alkali (Judge) was provided for the camps. A permanent house for the Alkali was built and within the compound there was provision for a prison. Later the first contingent of police was introduced.

The third metamorphorsis was in 1910 when the gwari inhabitants decided to move from the hilltop to settle down on the areas of the present Paida, one of the wards of Minna and the abode of the founder of the town.

As the railway workers' camp started developing into permanent settlements and gradually and gradually overshadowed the influence of the indigenes, the Minna town council was established in 1934 comprising of members, distinguished representatives of the various settled tribes. This, however, was short-lived and Gwari federation Native Authority was soon formed. By November 1950, a chief of the whole of the new Minna area, comprising all settlers was enthroned. He was Alhaji Ahmadu Bahago (I).

The fourth change in status of the town came in 1976 February when it was made the capital of the then newly created Niger state. Since then the town of Minna has been witnessing a tremendous transformation to a befitting state capital.

5.4 ECONOMY AND COMMERCE.

Minna being the Niger state capital has in place reliable infrastructure ranging from good roads, rail, airport, digital telecommunication line, electricity, and pipe borne water. Minna has a good access from the north through Mokwa-Jebba road.

The state government has recorded tremendous achievements especially in the establishment of medium and large-scale industrial ventures.

5.5 DEMOGRAPHIC DATA:

Minna like very other city in Nigeria is growing in population at a fast rate due to natural development factors.

Demographic surveys, carried out by the United Nations and National population Commission, 1986, have shown that there has been increase in the Niger state and the country birth rate and a decline in the mortality rate estimates based on 1963 population census.

The 1992 census figures show that Niger state has a population of 1,194,508. An annual rate of 5 % for local government headquarters and 2.5% for other towns and villages. The population density as at 1963 was estimated at 16 persons per square kilometer. However, with the recent growth in population, this figure was nearly doubled in 1995 with an average density of 31 persons per square kilometer.

The 1995 figures show that Niger state population has increased to 2,289,225 while is about 92% increase against the 1963 figures.

5.6 TRANSPORTATION AND TRAFFICATION.

Within the city of Minna, the Mobil area is the Central Business district (CBD). From Mobil roundabout, direct vehicles can be boarded to most parts of Minna and even surrounding towns like Paiko and Maikunkele.

The transport pattern is usually straight from Maikunkele area through Bosso road, Mobil, and Tunga to Chanchaga area. There is a western bye-pass almost parallel to Bosso but it is not used extensively because the main Bosso road is not fully congested. This bye-pass gives a smoother access to the Minna airport via the Bosso estate.

5.7.0 EXISTING LAND USE AND FUTURE TRENDS:

A major land use policy in Minna, Niger State is controlled land intensification use, to ensure allocation of space for essential services such as community services, transportation, recreation and commercial facilities.

The site located within the permanent site of the University along Minna – Bida road is presently thinly populated. However, the movement of the University to the permanent site is expected to give a new lease of life to that area.

CHAPTER SIX

6.0 SITE ANALYSIS

For any design project to be successful, adequate consideration has to be given to the area where the project will be sited. This clearly spells out what factors are of benefit to the Architect, what factors are of disadvantage and then what factors should be put into consideration before allocation of cost, spaces and zoning.

6.1 SITE SELECTION CRITERIA

This is wholly determined by the location of the university in the permanent site. There abound plenty of land for infractructural development and experimental or research purposes.

Also the following factors were put into consideration to arrive at the chosen area:

(a) Proposed access road on the university master plan;

(b) Proposed network of water, sewage, electrification, landscape and a moderately flat relief (at 1metre rise for about 10 metres distance.

6.2 LOCATION OF SITE

The chosen site is within the permanent site of the Federal University of Technology Minna Campus, off Minna-Bida Road. The plot is within the main campus core plan between student's union building and the school of Engineering complex.

6.3 SITE CHARACTERISTICS

The entire site access roads are tarred he access is about 12 kilometres from Minna town along the Minna-Bida road. The road branches on the right to enter the university junction.

On the site is sparse growth of trees such as mango, shed butter, acacia, baobab and enveloped in a thick bush of grasses.

Around the site are structures of the student's union office and the Engineering complex all at various stages of construction presently.

The relief of the site is quite mild at about 1:10 as illustrated on the location layout.

6.4 ACCESSES AND CIRCULATION

As stated above, the site is accessible by road along Minna-Bide road. Also for the fact that Minna has facilities for both Railway and air transport, visitors or guests can find their way from the railway station through KpaKunga and from Maikunkele airport through the Dutsenkura bye pass.

6.5 UTILITIES

On site presently a number of service installations are being put in place. Electricity poles are being installed and generators have being provided. Also borehole have been sink to provide potable water for the site.

6.6 SCENERY AND MAN-MADE FEATURES

Within the University campus presently are building structures at different stages of construction and the vegetation. This makes a large expanse virgin land available for exploitation into beautiful landscape.

6.7 ENVIROMENTTAL APPRAISAL

Environmental appraisal of the site can be made under two headings:

(i) Physical appraisal

(ii) Social appraisal

(i) Physical Appraisal

This includes all that can be seen and can be felt on the site. Like it has been discussed earlier the site is placed between structures at various stages of construction. Also the Federal Environmental Protection Agency, (FEPA), found it appropriate to site such a project within the University that can provide the necessary physical infrastructure. Hence the site is going to just be alright for the project.

(ii) SOCIAL APPRAISAL

The involves the human factors inhabiting the area. As a research Centre within the University, social appraisal examines whether there are infrastructures accessible to the site such as adequate staffing to enhance the optimum performance of the site.

CHAPTER 7

DESIGN CONCEPT AND CONSTRUCTION

7.0 CONCEPT AND DESIGN

Within the proposed Centre are five units namely: administrative block, training and research department, auditorium, accommodation and the canteen. However, the administrative block is regarded as the Centre as the concept was chosen from the letter 'c' which starts the three words that make up the name 'climate change Centre'

7.1 MATERIALS AND CONTRUCTION

7.1.0 MATERIALS

Diverse materials are employed in the design of the Centre. The materials include concrete, reinforced concrete, glass, steel, timber, ceramic tiles, aluminum sheets, blocks etc.

7.1.1 CONCRETE

Concrete is a mixture of a paste of blinded agent and an aggregate. The paste is formed by a chemical reaction between water and the binder. Compressive strength in addition to being the most important quality of concrete is indicative of its other properties. Tensile strength, elasticity, durability and impermeability are all directly related to compressive strength.

Proportioning of Concrete

The paste or cementing medium is the fundamental basis of strength development of concrete. The interest strength of the paste is a function of the ratio of its two components expressed in gallons of water per bag of cement (known as the water/ cement ratio. The different types of compressive strength of concrete are seen in two main types of cement.

(i) Portland cement

(ii) High-early-strength cement

In a concrete mixture, the maximum amount of aggregate should be used to produce an economical mix with low shrinkage. The amount of aggregate used depends on the effect of the consistency of the mix. The limiting amount then is the maximum amounts that can be used and still attain full compaction of the concrete. Consistency is determined by slump test, which measures the volume of mass concrete that will settle after the slump core been removed from the concrete.

Curing

The purpose of curing is to influence the rate of chemical reaction between cement and water. Curing is an important consideration in structural concrete, particularly in pre cast and pre stressed works that require high-early-strength development. Availability of water and control of temperature are the main requirements for curing. Pounding, sprinkling and saturating the aggregate prior to its use are three of the methods used to ensure adequate moisture for continued hydration. Minimum temperatures for the air surrounding normal concrete are $70^{0}F$ for the first days. If the amount of line available to develop the necessary strength is limited, the temperature should be increased. In one method, saturated steam employing temperatures in the range of 140 to $150^{o}F$ is used. Insulation, which retains the heat librated from the reaction between cement and water will also contribute to rapid strength development.

7.1.2 CONCRETE BLOCK

These are extensively used for both load bearing and non-load bearing walls. Light weight aggregate concrete blocks have good insulating properties against heat transfer and are much used for the inner skin of cavity walls either with a brick outer skin or concrete block outer skin.

The disadvantage of concrete block as wall unit is that they outer moisture movement which may cause cracking of applied finishes such as plaster. To minimize cracking due to shrinkage by loss of water vertical movement joints were provided along block walls. These joints are continuous vertical joints filled with plastic.

7.1.3 MORTAR

Mortar is a artificial stone-like material consisting of a hardened mixture of carefully selected and proportioned binders, fine aggregate (sand) and water. In contrast to concrete, mortar has no aggregate. Some special purpose mortars may contain fine aggregates other than sand, mineral aggregates and many other admixtures.

According to their purpose, mortar makers may be classed into masonry mortar, used for masonry walls and built up of bricks, nibble, concrete blocks and clay tiles, finishing mortar used for plastering, decorative coating and ornamental casting; and special purpose mortar such as water proofing mortar etc.

Basically two kinds of mortars are recommended.

(i) The masonry mortar for all masonry works; and

(ii) Finishing mortar to plaster over the walls where concrete blocks are used expect foundation walls.

7.1.4 GLASS

Glass is a thermoplastic material that can be shaped at temperatures about 2800°F (1261°C) In its molten state; the various chemicals tend to crystallize out of the solution. When crystallization takes place, the glass is said to be 'frozen'. To avoid this obstruction, glass is carried through the crystallization temperature as quickly as possible so that it will form an amorphous solid characterized by hardness, brittlesness, transparency, and chemical neatness.

These are different types of glasses. Some of these are sheet glass, plate glass, tempered glass, wire glass, laminated glass, and heat absorbing glass etc. Out of these, the following are recommended.

(i) Sheet glass;

(ii) Plate glass;

(iii) Tempered glass.

(i) Sheet glass

Sheet glass is the most common type for glazing purposes. This is transparent, relatively thin (2 to 6mm) flat glass having glossy plane and smooth surface, visible when viewed at an angle or under reflected light. Transmits light rays of the visible portion of the spectrum (the light transmission being within 85 to 90%) and blocks practically ultraviolet rays. The density, strength and thermal conductivity of sheet glass is predominantly used for glazing purposes (window interviews, doors, skylights etc). Sheet over 3mm thick are also employed in manufacturing multiple glass for glazing exterior doors, shops, windows and showcases.

(ii) Plate Glass

Plate glass is thicker than window glass (over 6.5mm in thickness) and is available in large sheets (up to 4.5 x 3.5m). It is usually of better quality than window glass and shows no distortion of vision when viewing objects through it at any angle. It may be both polished or unpolished. Plate glass is usually flat, bent shapes being made to order. Polished plate glass has very high compressive strength (up to 1200Mpa). Its bending impact strength can be improved by tempering and exchange and other methods. The light transmission of plate glass amounts to 87%. Polished glass is obtained by mechanical grinding and polishing are by floating the molten glass on the surface of molten tin contained in a tank. Plate glass is used for glazing shop windows, showcases, and partition. Because of its application in public building and thermal properties it is recommended for the administrative block

(iii) Tempered Glass

Tempered glass features high mechanical strength heat resistance. It is manufactured by heating thick sheets (over 5mm thick) to a temperature of 700^{o} to 900^{o}c and then rapidly and uniformly cooling them with a steam of air or with a liquid (by immersion, spraying or hosing). Glass products to be tempered are fully shaped in advance, because tempered glass cannot be ground, drilled or otherwise worked. The bending and impact strength of tempered glass is approximately 5 to 6 times, and its heat resistance is 2 times, as greet as these for ordinary annealed glass.

Tempered glass is employed for glazing show windows and showcase. Also it is an excellent choice for public building forestuction, flush, partitions, and other structures, which must stand up well to impact loads.

7.1.5 STEEL

Steel used in the building industry can be classified according to their quality, manner of manufacture treatment and purpose. The quality of steel is largely affected by the percentage of harmful impurities (such as sulphur) that it contains. Such impurities impair the are chemical strength of steel and cause brittleness. The most widely used grade; the carbon steel, although allay steel materials also find quite a number of applications.

Structural steels are generally worked by hot rolling, cold drawing, pressing, forging and some combination method. The range of rolled-steel sections is extremely wide. It includes various shapes (for example joint, beams, channels, angles box selections and nails) sheets, plates and tubing, all generally made of low carbon steel. These are usually the cheapest products since the rolling is continuous.

7.1.6 ALUMINIUM

In the 1960s, an advanced manufacturing process was integrated into practice, which made it possible to combine the continuous casting of the metal with rolling. The aluminum alloy brand manufactured by this technique are flat, corrugated, and channeled aluminum alloy sheets. Their faces could be covered with polymer film to give then a pleasing appearance.

7.1.7 TIMBER

Timber is classified into hardwoods and softwoods, but these are botanical grading, which may not in actual sense relate to the texture of the timber section

Hardwoods: Are from broad-leafed trees, most of which are deciduous, although only certain oaks and the majority of tropical trees are evergreen. Hardwood contain resins and oils which interfere with the hardening of paints.

The cheaper hardwoods are approximate in cost with the more costly softwoods. Cost also varies with species, quality, availability and dimensions.

Softwood: Not all softwoods are soft. Some are very hard, strong and durable while certain softwoods have greater moisture content than any softwood.

CHAPTER EIGHT

DESIGN SERVICES

8.0 DESIGN SERVICES

In simple terms, design may be referred to as such facilities other than the building block, which will enhance safety, comfort and usability of the building structure.

A careful design and specification is required in order to achieve efficiency in building utilization. Global technological advancement has clearly defined and enhanced specialization as regards building services. However, as an architect, a good knowledge of materials and means will enhance the functionality of the building structure.

8.1 ELECTRICITY AND LIGHTING

The proposed site of the project has work going on as regards the electricity services from NEPA. However, there are also standby generators being installed as a temporary measure.

One to the size of facilities being proposed for the Centre a three-phase supply is recommended.

Internal lighting includes surface mainted appliances, recessed lighting and chandeliers. The auditorium has focus lighting installed and controlled from the electrical services unit at the backstage.

Some specific lightings for the administrative block include;

(a) Halogen floor lighting for security and spot lighting of the globe sculpture

(b) Alkaline flood lighting to highlight and beautify the landscape

(c) Post top luminaries for the landscaped areas with short lamp ports

Power circuit shall consist of:

(a) 13amp socket switch outlet as final sub circuit at all design locations.

(b) 15 amp switch socket outlets for electric power supply to the studio, laboratories and kitchenettes.

8.2 HEATING, COOLING AND VENTILATION

As observed from the site analysis in chapter 6, the location of the Centre I Minna, which is in the savanna region. The characteristics of such type of climate is marked wet (rainy) season and extremely hot dry season. This therefore, means that how to generate heat may not be a problem but how to minimize or reduce the heat. The issue of thermal insulation has been dealt with in chapter 3.

Most of the coolants in artificial ventilators contain ozone depleting substances, hence their applications minimized to the auditorium only where design may not be easily used to achieve natural ventilation. The other units have adequate natural ventilation and the only mechanical means recommended is the fun. Another reason why artificial ventilation is desirable in the auditorium is because opening of windows lead to distortion of sound.

8.3 WATER SUPPLY

Water supply is expected to be in adequate supply to the site from the town's mains by the time the site is moved into. However, it is recommended that borehole be provided to augment shortage from the township mains.

A borehole is sunk by driving or drilling steel lining tubes down to a water-bearing permeable stratum. Water enters the perforated or slotted shoe of the tubes and is raised by a force pump. It can be done both manually and with the use of electricity.

Connections to the existing mains are to be made by the plumber with the use of galvanized iron service pipe. The service pipe is run underground and into the building. For convenience it is recommended to run the service pipe into the building through the drainpipe channel to facilitate maintenance and replacement if need be.

8.4 DRAINAGE AND SEWAGE DISPOSAL

Rainwater mining off pitched roofs is to be collected by eares or valley gutters and off flat roofs by gutters and discharged by rainwater pipes to drains.

For surface water drainages, paved areas are to be laid to gradients (actual slope of the site) towards gutter or channels that collect surface water and discharge through drains to soak ways. As a general guide, a paved area of 200 to 250m^2 at a gradient of 1 in 50 can be drained to on gully.

8.5 RESFUSE DISPOSAL

As it is the present practice, the works department of the University is in charge of disposing refuse within the Campus, They are expected to carry out the function within the regular cleaning and temporary disposal, plastic refuse bin are recommended due to the advantage they have over steel dust bines.

Plastic refuse bins are about half the weight of a standard steel bin of the same capacity and if made of high density polyethylene or polypropylene are rigid, durable, easy to clean and may have a useful life of several years if reasonably handled. Also they do not deteriorate by oxidization as steel bins, without flutes or corrugations, a reinforcing rim, lofting handles and a loose lid. Usual capacities are 0.071 and 0.092m^3

8.6 ACOUSTICS

In the Centre acoustic design and in the school. The object of acoustic design is to be able to absorb sound energy, rather than to allow it to be reflected and to reverberate within the working area.

Prevention of External Noise Perpetration

The main ways by which external airborne noise enters a dwelling is via windows, doors, gasping walls and through the roof. In general, even the most inadequate solid brick airborne noise and can be ignored.

(i) Windows

To make windows reasonable sound resistant special acoustic double glazing has to be used. This must comply with the following specifications.

(a) All joints must be completely air tight and sealed with foamed polyurethane.

(b) The space between panes must be at least 100mm and preferably up to 200mm wide.

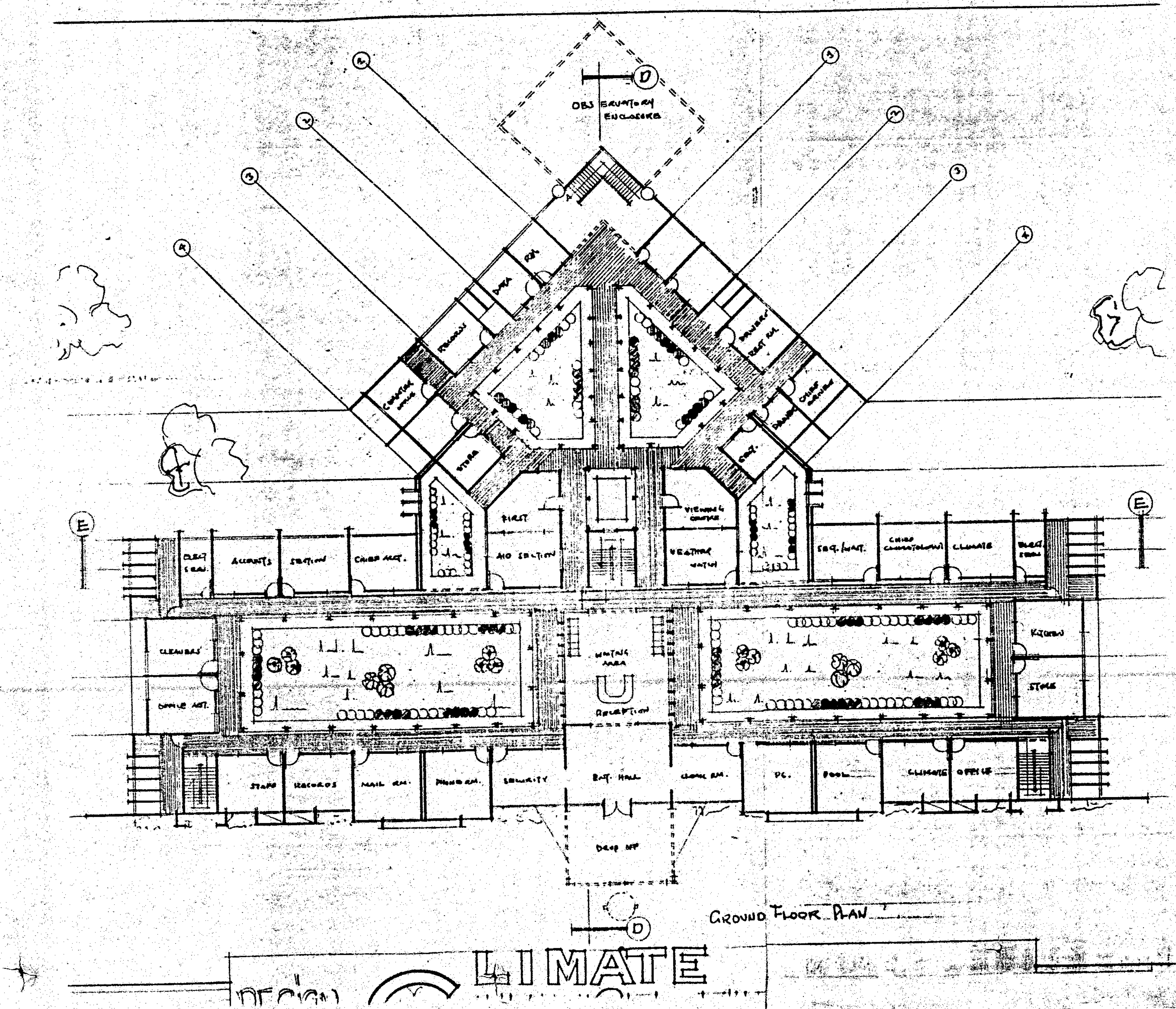
(c) The head sill and reveals of the windows should be lined with soft sound adsorbent materials such as framed rubber.

(ii) Doors

Very lightweight doors constitute an acoustic path through which noise may enter a dwelling. It is better to use heavy doors and the balconies are to be lined with acoustic materials along the walls.

(iii) The Roof

Lightweight roofs are sometimes penetrated by the intense sound of aircraft, especially when they fly about low or near an airport. This noise is overcome by the use of insulation layers on the top of the ceiling with an adequate air gap between this insulation layer and the roof above.


OBSERVATORY ENCLOSURE
DATA RM.
RECORDS
COMPUTER OFFICE
STORE
DRAWERS REST RM.
CHIEF OBSERVER
CONF.
FIRST AID SECTION
VIEWING CENTRE
WEATHER WATCH
ELECT. ROOM
ACCOUNTS SECTION
CHIEF ACCT.
SEC./WAT.
CHIEF COMMISSIONER
CLIMATE
CLEANERS
OFFICE ACCT.
WAITING AREA
RECEPTION
KITCHEN
STORE
STAFF
RECORDS
MAIL RM.
PHONE RM.
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PC.
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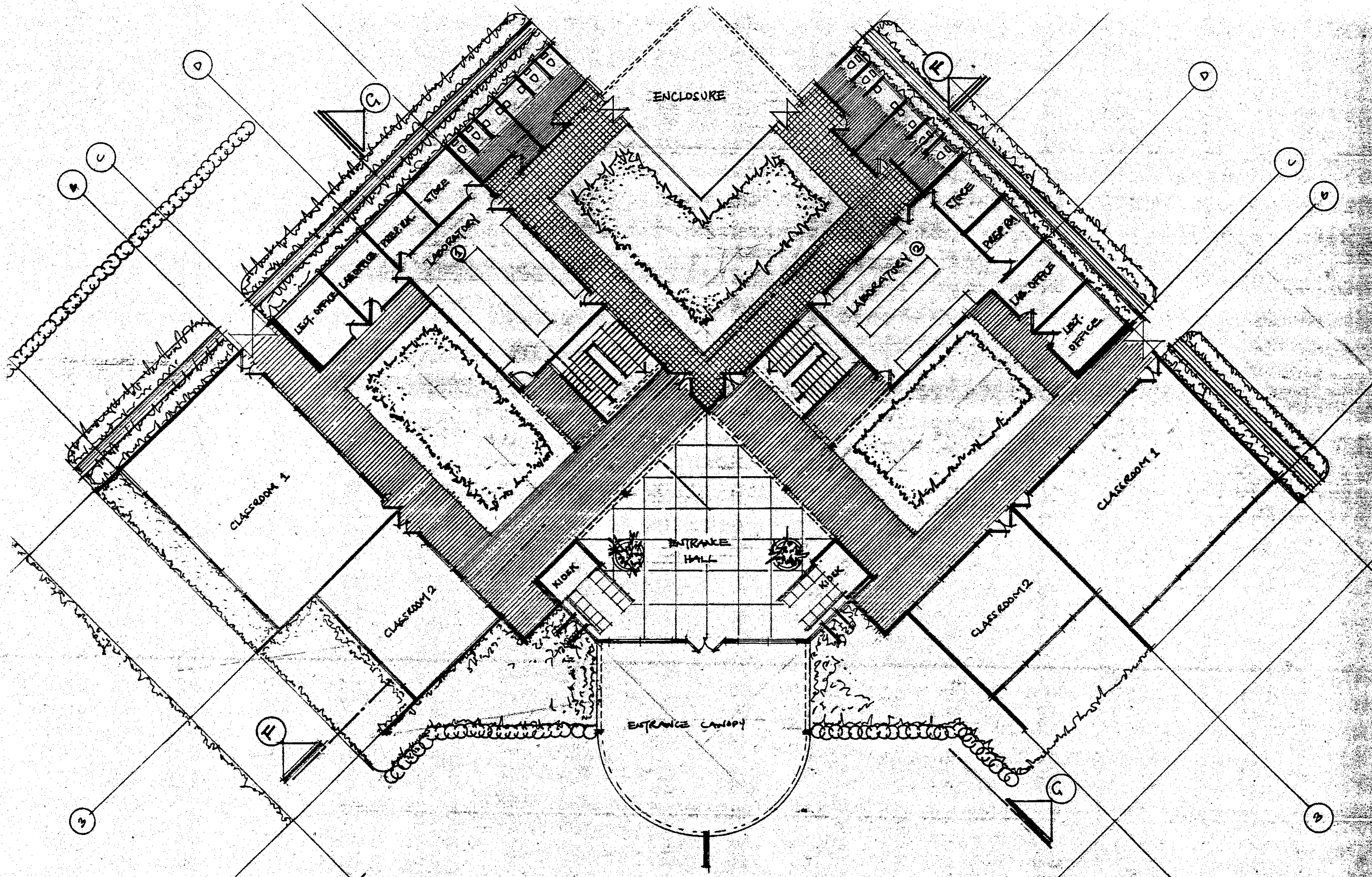
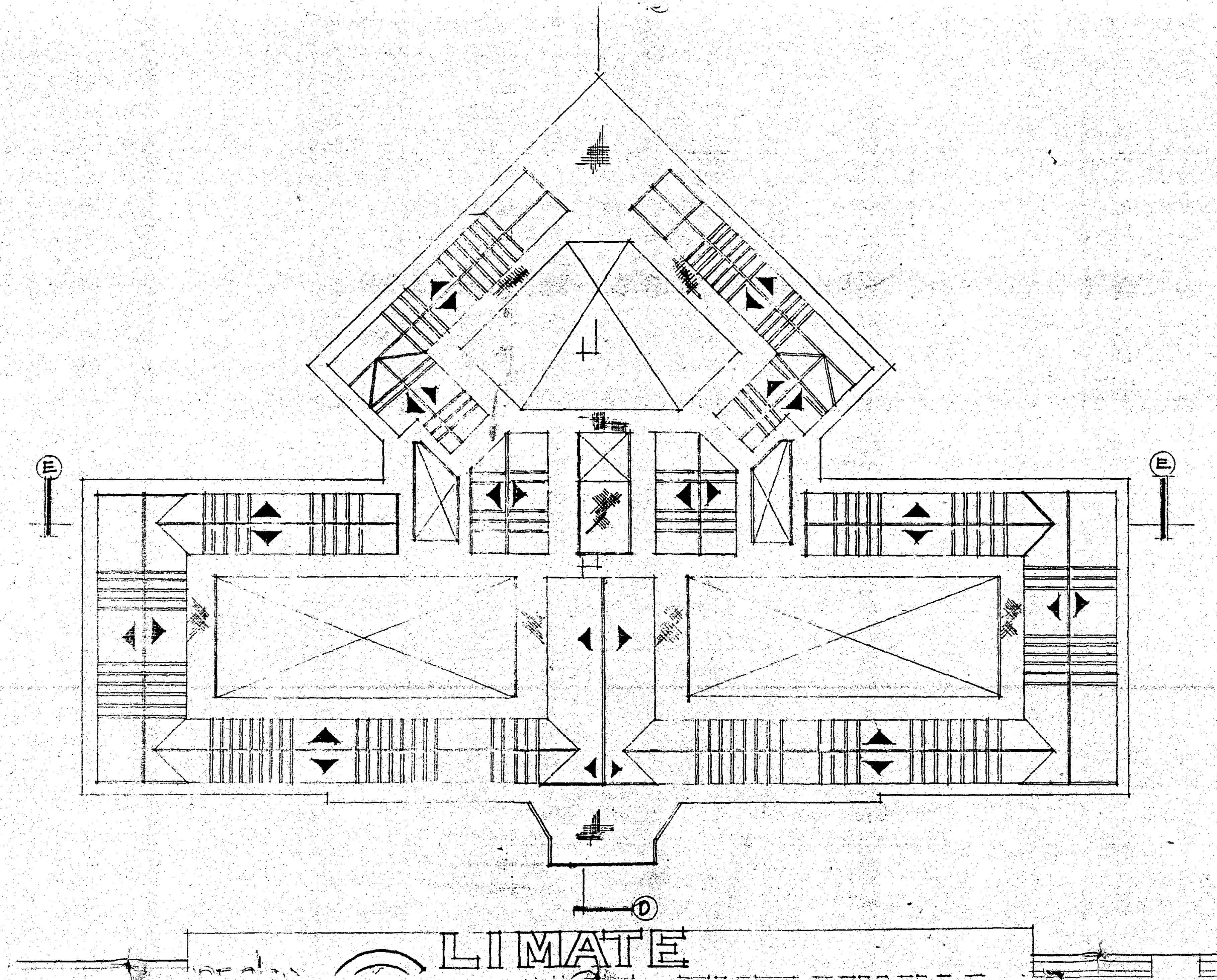
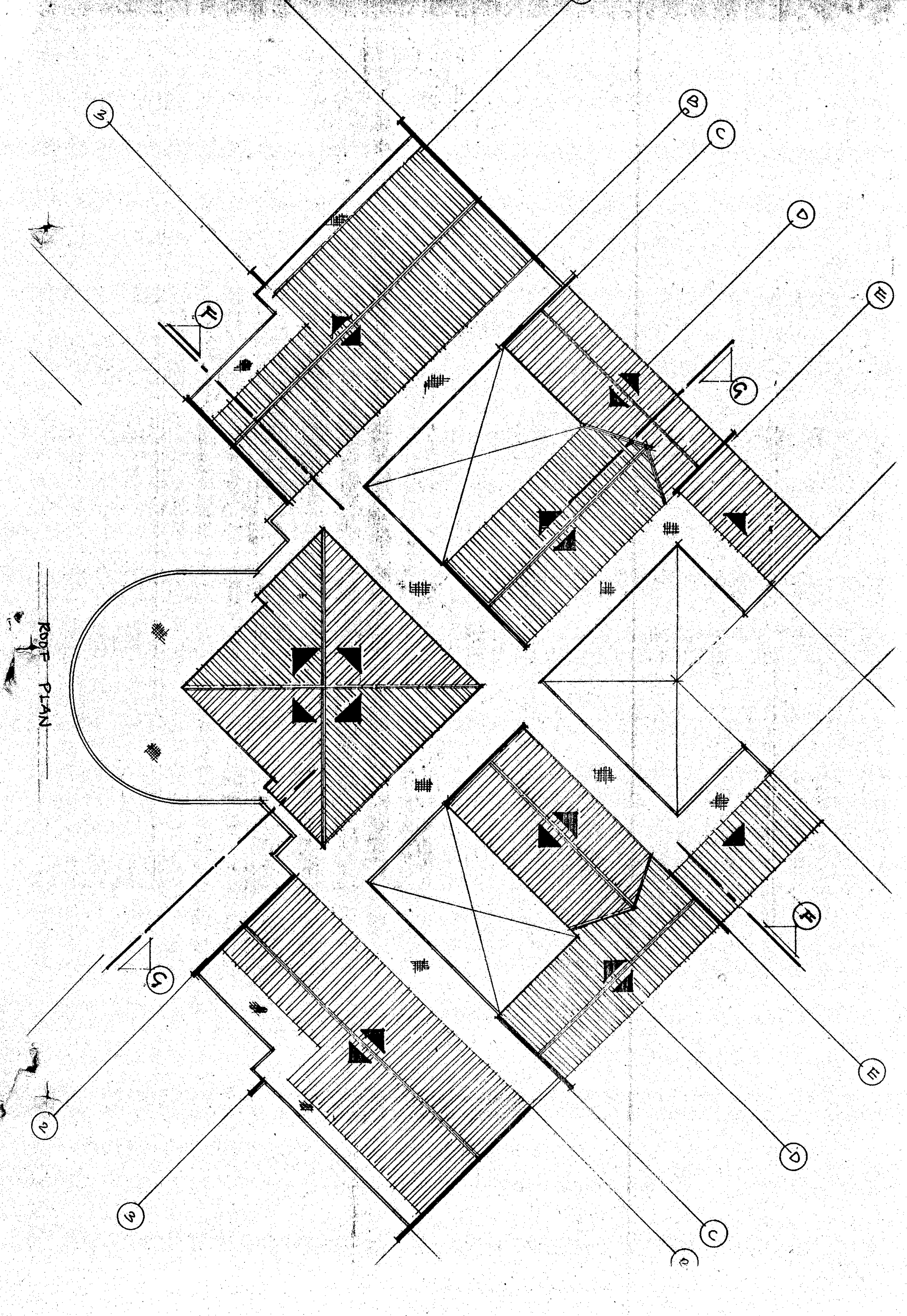
GROUND FLOOR PLAN
CLIMATE
DESIGN

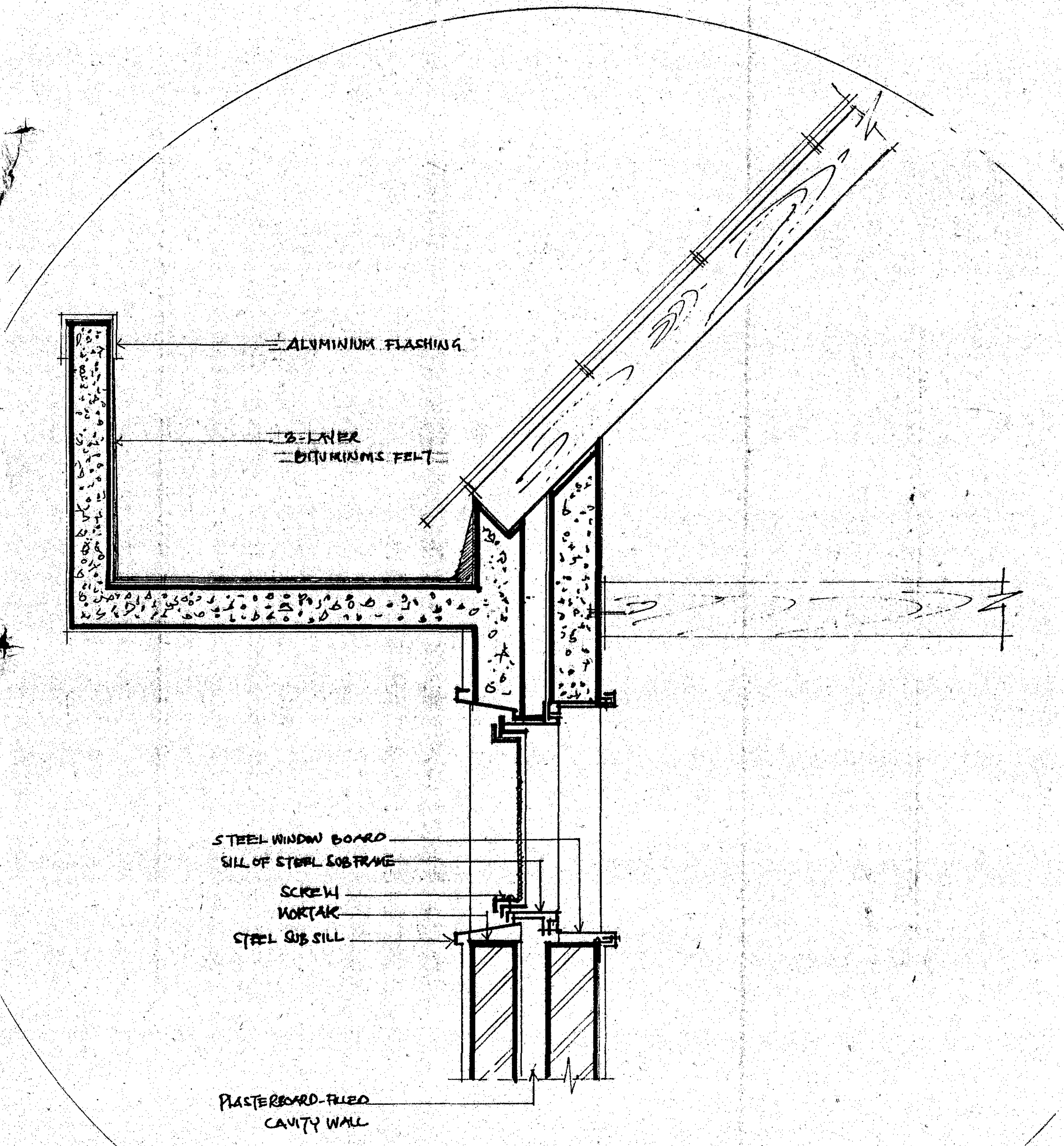


GROUND FLOOR PLAN


LIMATE



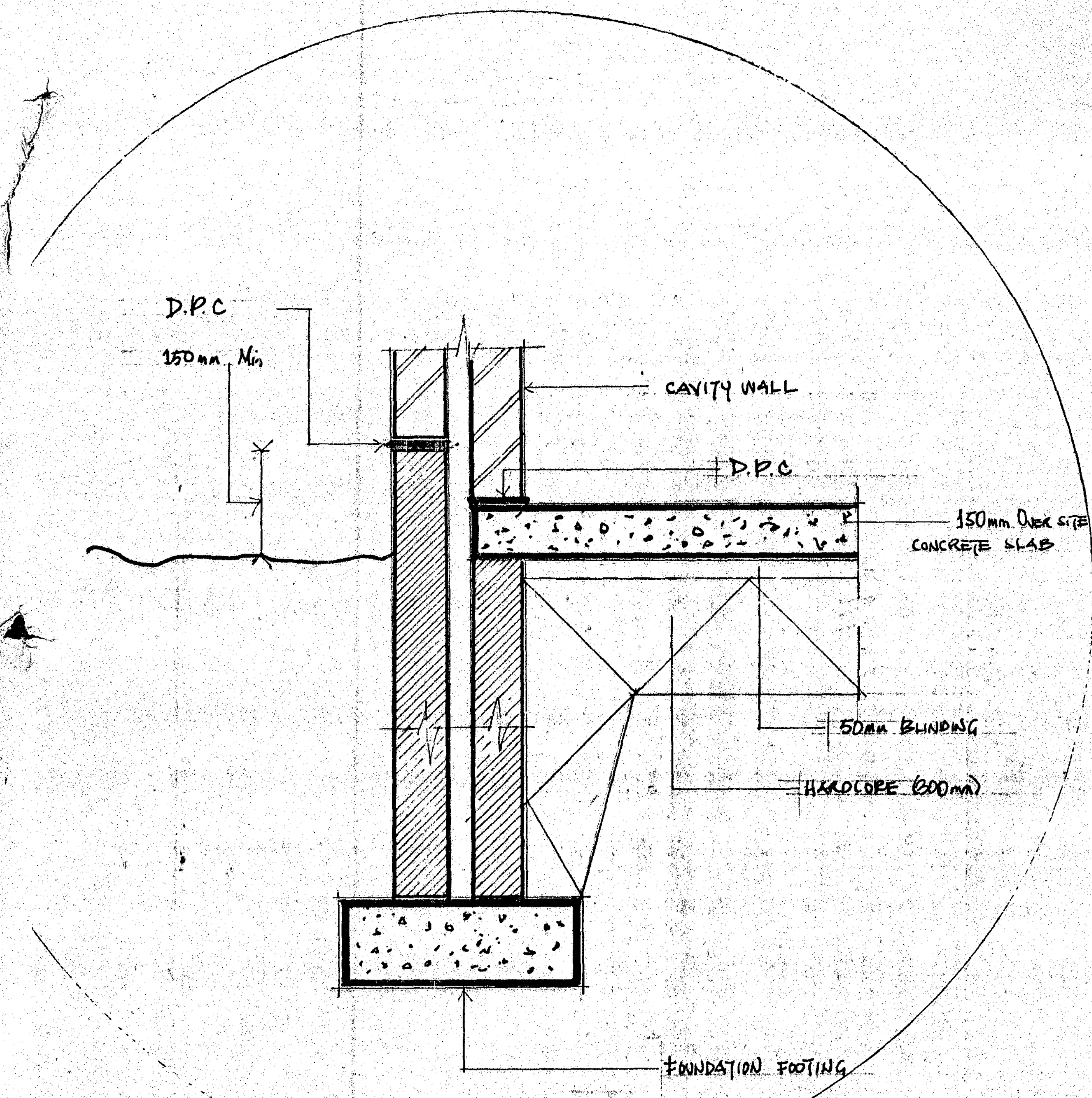
ROOF PLAN



DETAIL 01

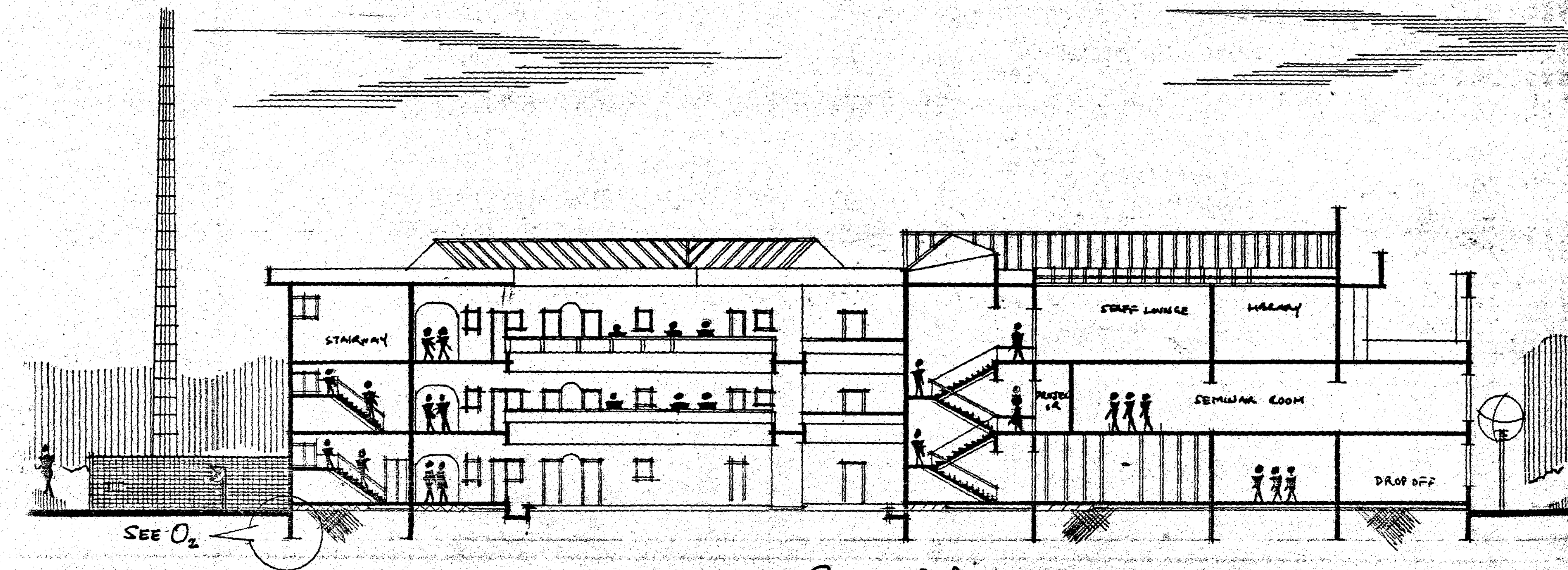
CAVITY OPENING TREATMENT

LIMAT

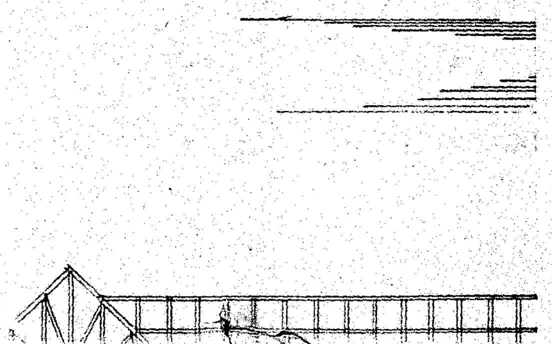


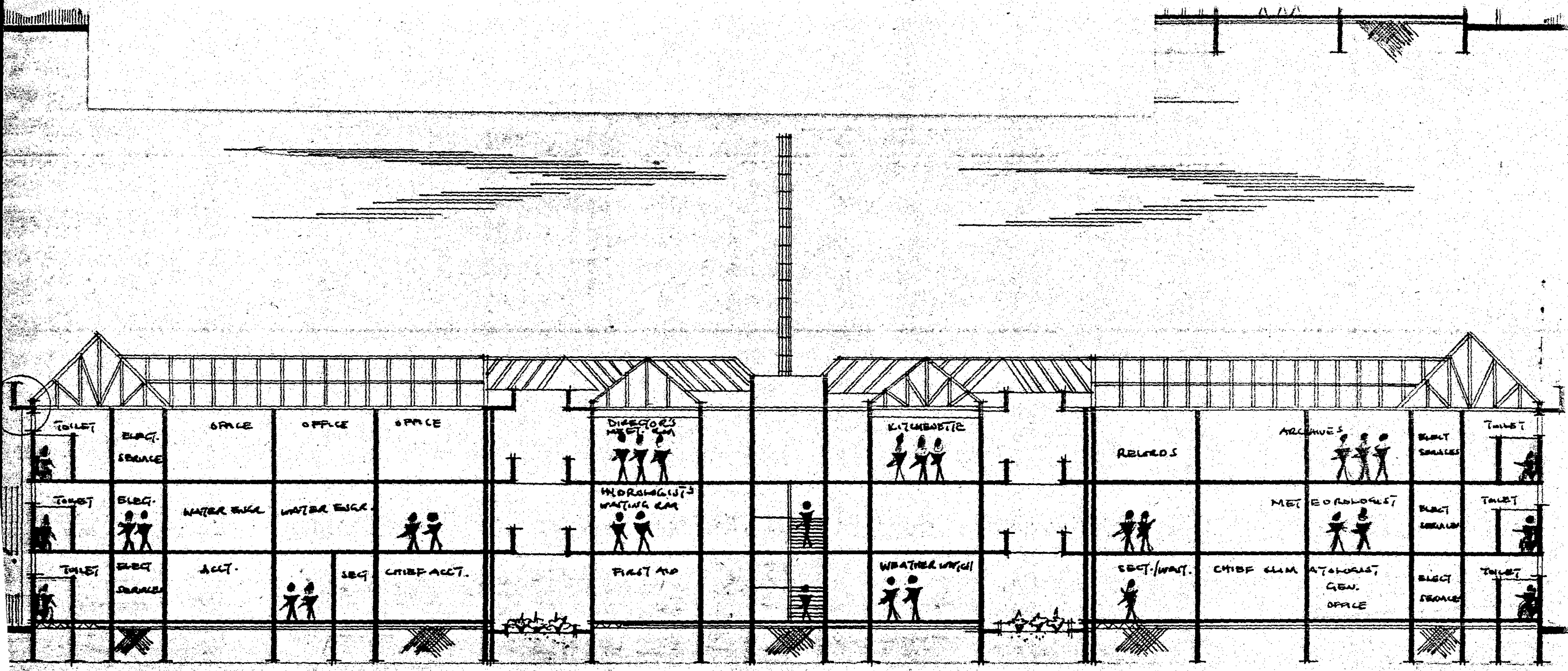
DETAIL 02
CAVITY FOUNDATION

MINNA



SECTION D-D

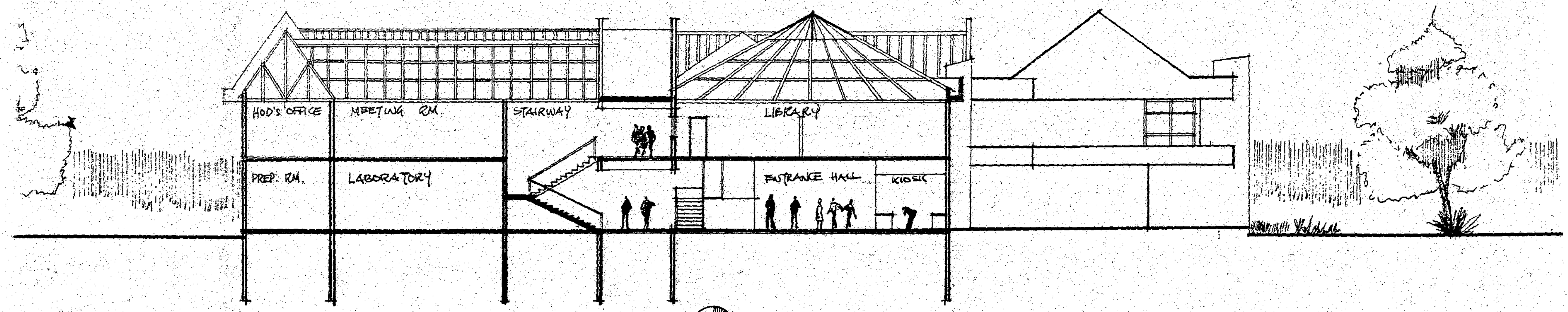




SECTION E-E

DESIGN PROPOSAL

CLIMATE CHANGE CENTRE FUT MINNA



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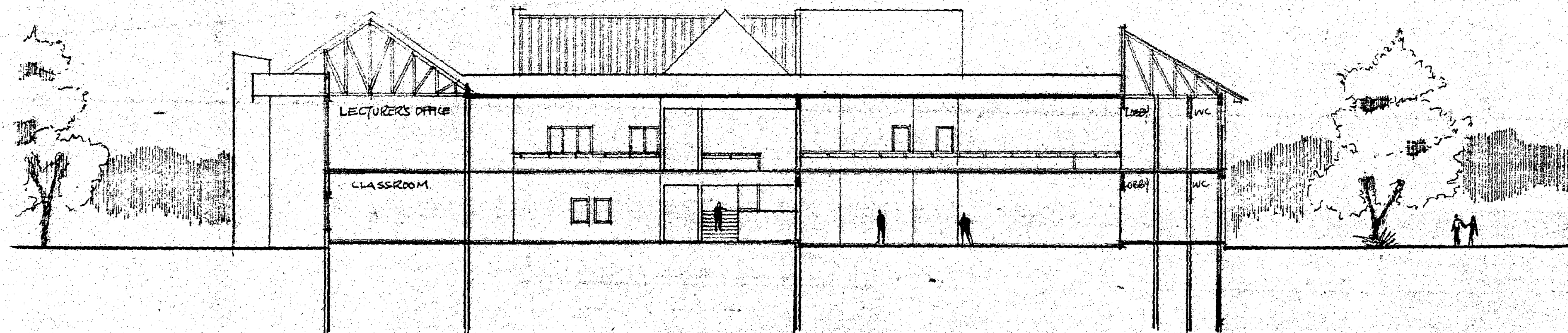
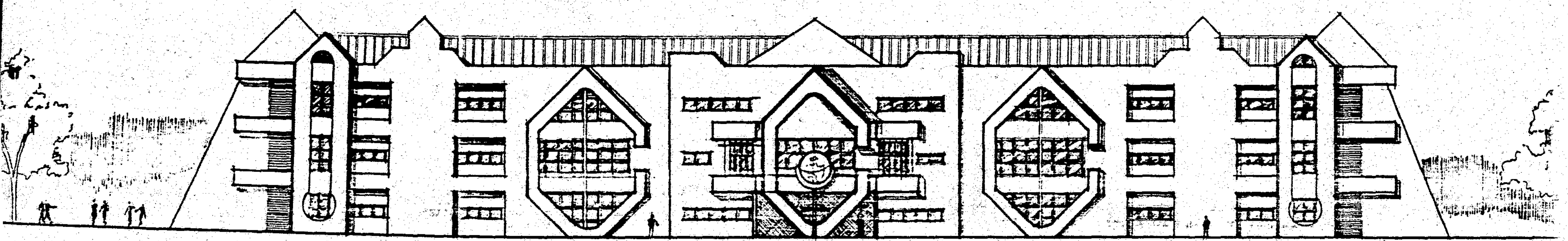
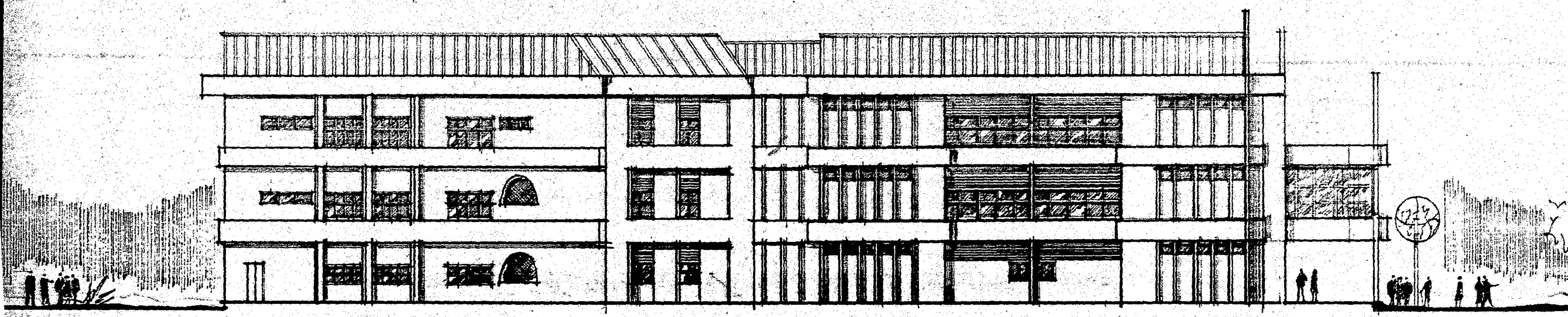


SECTION F-F



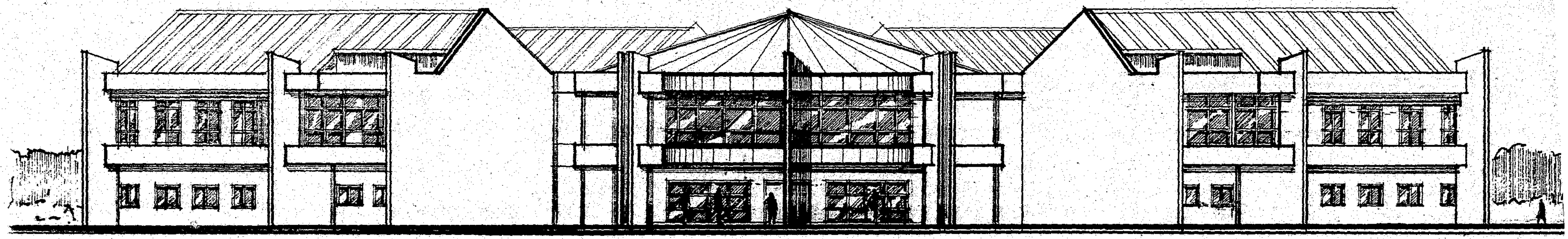
FRONT ELEVATION



LEFT SIDE ELEVATION

DESIGN PROPOSAL

CLIMATE CHANGE FUT MINNA CENTRE



APPROACH ELEVATION

LEFT SIDE ELEVATION