KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
KUMASI

COLLEGE OF ARCHITECTURE AND PLANNING

DEPARTMENT OF ARCHITECTURE

TOPIC:

COMPUTER ASSEMBLY PLANT – TEMA

A THESIS REPORT SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE
FACULTY OF ARCHITECTURE AND BUILDING TECHNOLOGY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF

POST GRADUATE DIPLOMA (PGDip) IN ARCHITECTURE DEGREE

BY

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SEPTEMBER, 2009

DECLARATION

I declare that I have personally, under supervision, undertaken the design thesis herein.

Signature .... Date 23rd September, 2009

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I declare that I have supervised the student undertaking the design thesis and confirm that the student has my permission to submit it.

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DEDICATION

This thesis design is dedicated to the gracious God for his love, mercy and grace which has been sufficient for me through these past years.

It is also dedicated to my parents and siblings who have brought me this far with their love and support in every way.

It is also dedicated to all my lecturers who gave their all in giving me the best of education.

ACKNOWLEDGEMENTS

It would have been impossible for me to write this book without the favour, grace and mercy of the most high God.

I would also like to express my profound appreciation to Mr. Daniel Duah for his supervision throughout the design. I appreciate his constructive criticism, suggestions and the encouragement he offered me throughout my course of study.

I am extending my sincere appreciation to my parents, for their love, prayers, financial support and faith in me to be able to come this far.

Finally, to all who have contributed in one way or the other, before and during the compilation of this Thesis.

ABSTRACT

The world is now global village virtually sustained by Information And Communication Technology which has computers as the backbone.ICT has boosted the economies of many countries in the world and developing countries like Ghana even though with a low computer literacy rate is gradually embracing ICT which is evident in many government policies and the influx of many private IT institutions in the country. This ICT revolution is however becoming gradually unsustainable due to the lack of access to good computers by many Ghanaians. This is due to the cost and also the overdependence on used foreign computers which break up easily. The overdependence of foreign importation is also leaving the Ghanaian economy struggling.

The documentation and design of a computer assembly plant to assemble computers locally and also train people and create jobs is the main objective of this thesis. This assembly plant would assemble computers locally for the Ghanaian market and also for exports and help reduce the cost of computer to the average Ghanaian. A serial assembly process is envisaged for this computer assembly plant. The Serial process is a medium by which the entire process is broken into individual steps, and completed by different assemblers in a specific sequence. The plant would not only consist of a factory but also a training school to help train people for the ICT industry.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 PREAMBLE

It is an undisputable fact that the world is a global village greatly influenced by Information Technology which has computers at its backbone. The use of computers and Information Technology has transformed many economies in the world, through its applications in many aspects of a country's economy, be it commerce, medicine, agriculture, education, banking and even defence. The world economy now can be said to be dominated by computers and IT and Ghana cannot be left behind.

Ghana also faces challenges in her socio-economic development attributed to many factors. This includes the lack of modernisation of the economy through I.T which has computers as its backbone. Also the fact that Ghana cannot augment its imports with its exports leads to a strain on the economy. A relatively low computer literacy rate due to the lack of access to computers also impacts negatively on the economy.

The Government of Ghana has accepted the crucial role computers and I.T play in the economy and has initiated moves to equip every school going child with computers and highly encouraging foreign investors to invest directly into the country in the field of I.T. This thesis seeks to design a computer assembly plant which will be located in Tema. This facility will assemble computer components or parts into usable computers for the West African market and Ghana. This would help solve the Governments quest to make Ghanaians computer literates and thus computerise the economy with all its benefits and also help balance the import export defect of the economy.

1.2 PROBLEM STATEMENT AND JUSTIFICATION

Computerization of Ghana and Ghanaians is now high on the government's agenda since the Ghana Government has realised the crucial role computers and I.T plays in a country's economy. Even though computers were scarce in Ghana some years ago, its use has now become part of everyday life in all fields of endeavour.

In lieu of this, many computerization projects of many sectors of the country's economy has been stepped up with the provision of computers to many ministries and departments of government and the education sector is not left out with the governments plan to equip every school going child with computers and equipping educational institutions with computers. Furthermore the government is establishing ICT centres in the country to train people in the field of ICT to help the economy and these centres would have computers as their nerve centres. However, these computers are imported at very astronomical prices, putting a strain on the economy and beyond the reach of average Ghanaians. Most of these computers are usually not new and later become redundant and are dumped later leading to serious environmental pollutions. The backbone of this problems is because there is virtually no facility to assemble the computers locally which would cut down drastically on its cost making it affordable and exporting the assembled computers to the rest of West Africa helping to boost the economy. Even though some private companies assemble computers in Ghana, this is on a very small scale and quiet insignificant.

A computer assembly plant is therefore urgently needed in the country if the government's agenda to computerise and modernise the economy is to be achieved and the Ghanaian economy stands to benefit from it if the export potentials are achieved.

1.3 OBJECTIVES

The objectives of this project are to design a computer assembly plant in order to achieve the following targets:

- To assemble computers locally for the Ghanaian market and export.
- To provide affordable computers to help augment the governments quest to modernise the economy and improve the socio-economic conditions of Ghanaians.
- To help create jobs and transfer of technology.
- To help train people for the ICT industry.

1.4 SCOPE

- The various technicalities associated with the provision of affordable computers and ICT.
- An extensive brief and design for a computer assembly plant at Tema. The facility would include the following: an assembly factory, training school, administration block and welfare unit.

1.5 TARGET GROUP

The target group of this facility are the West African sub-region and Government institutions and Ghanaians.

1.6 CLIENTS

The main client for the project is Dell Computers with support from the ministry of Education and the Ministry of science and Technology on behalf of the Ghana Government.

1.7 SOURCES OF FINANCE

The project would be financed by Dell inc with support from the government of Ghana through the ministry of communication, trade and industry and ministry of education

1.8 CLIENTS BRIEF

- Production factory
- Workshop
- Training school
- Administration
- Showroom
- Canteen
- Car park
- Storerooms

1.9 LOCATION

The Computer Assembly Plant will be located in the exports processing zone in Tema in the Greater-Accra region of Ghana.

1.10 METHODOLOGY

The methodology to be employed can be identified as;

Survey and Data collection - this will involve the collection of all relevant data, that is general reading and subject matter, discussions, visual surveys and pictures taking, collection of statistical data and measured drawings,

Analysis and synthesis - this includes the probing of data collected with respect to the site, activities/operations, technical and statistical dimensions and the co-ordination of the analyzed data.

1.11 LIMITATIONS

Most of the computer assembly facilities are owned by private business organizations. For this reason, the author was not allowed to access several technical spaces in these facilities. Also, internet information on computer assembly building layouts was either scanty or virtually unavailable.

However, effective analysis and synthesis of this seemingly scanty information has resulted in the compilation of this complete report.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

The term modern world associated with high technology is basically as a result of the use of computers. The computer is defined by the Chambers 21st Century Dictionary as "as an electronic device which processes data at great speed according to a program stored within the device". Computer program in this case is "a set of coded instructions for the performance of a task or a series of operations, written in any of various programming languages" Different types and sizes are used throughout society in the storage and handling of data, from secret governmental files through banking transactions to private household accounts. Computers are now essential tools in the modern world supporting almost every aspect of life. They are used in almost all fields of endeavour be it health, education, banking, security and even religion.

2.2 HISTORY OF COMPUTING

The first adding machine a precursor of the digital computer was devised in 1642 by the French Scientist, Mathematician, and Philosopher, Blaise Pascal. This device called the Abacus employed a series of ten tooled wheels, each tooth representing a digit from 0 to 9. The wheels were connected so that numbers could be added to each other by advancing the wheels by a correct number of teeth.

Also in the 19the Century, the British Mathematician and inventor Charles Babbage worked out the principles of the modern digital computer. He conceived a number of machines, such as the Difference Engine, that were designed to handle complicated mathematical problems.

Many historians consider Babbage and his associate the true pioneers of the modern digital computer. One of Babbage's designs, the Analytical Engine, had many features of a modern computer- "a store" for saving data, a "mill" for arithmetic operations and a printer that made a permanent record. Babbage however failed to put this idea into practice, though it may well have been technically possible at that date.

Modern computing can probably be traced back to the 'Harvard Mk I' and Colossus (both of 1943). Colossus was an electronic computer built in Britain at the end 1943 and designed to crack the German coding system - Lorenz cipher. The

'Harvard Mk I' was a more general purpose electro-mechanical programmable computer built at Harvard University with backing from IBM. These computers were among the first of the 'first generation' computers.

First generation computers were normally based around wired circuits containing vacuum valves and used punched cards as the main (non-volatile) storage medium. Another general purpose computer of this era was 'ENIAC' (Electronic Numerical Integrator and Computer) which was completed in 1946. It was typical of first generation computers, it weighed 30 tonnes, contained 18,000 electronic valves and consumed around 25KW of electrical power. It was, however, capable of an amazing 100,000 calculations a second.

The next major step in the history of computing was the invention of the transistor in 1947. This replaced the inefficient valves with a much smaller and more reliable component. Transistorized computers are normally referred to as 'Second Generation' and dominated the late 1950s and early 1960s. Despite using transistors and printed circuits these computers were still bulky and strictly the domain of Universities and governments.

Name	First operational	Numeral system	Computing mechanism	Programming	Turing complete
Zuse Z3 (Germany)	May 1941	Binary	Electro-mechanical	Program-controlled by punched film stock	Yes (1998)
Atanasoff–Berry Computer (US)	1942	Binary	Electronic	Not programmable single purpose	No
Colossus Mark 1 (UK)	February 1944	Binary	Electronic	Program-controlled by patch cables and switches	No
Harvard Mark I – IBM ASCC (US)	May 1944	Decimal	Electro-mechanical	Program-controlled by 24-channel punched paper tape (but no conditional branch)	No
Colossus Mark 2 (UK)	June 1944	Binary	Electronic	Program-controlled by patch cables and switches	No
ENIAC (US)	July 1946	Decimal	Electronic	Program-controlled by patch cables and switches	Yes
Manchester Small-Scale Experimental Machine (UK)	June 1948	Binary	Electronic	Stored-program in Williams cathode ray tube memory	Yes
Modified ENIAC (US)	September 1948	Decimal	Electronic	Program-controlled by patch cables and switches plus a primitive read-only stored programming	Yes

				mechanism using the Function Tables as program ROM	
EDSAC (UK)	May 1949	Binary	Electronic	Stored-program in mercury delay line memory	Yes
Manchester Mark 1 (UK)	October 1949	Binary	Electronic	Stored-program in Williams cathode ray tube memory and magnetic drum memory	Yes
CSIRAC (Australia)	November 1949	Binary	Electronic	Stored-program in mercury delay line memory	Yes

Table2.0 Defining characteristics of some early digital computers of the 1940s

The explosion in the use of computers began with 'Third Generation' computers. These relied on Jack St. Claire Kilby's invention - the integrated circuit or microchip. The first integrated circuit was produced in September 1958 but computers using them didn't begin to appear until 1963. While large 'mainframes' such as the I.B.M. 360 increased storage and processing capabilities further, the integrated circuit allowed the development of Minicomputers that began to bring computing into many smaller businesses. Large scale integration of circuits led to the development of very small processing units, an early example of this is the processor used for analyzing flight data in the US Navy's F14A `TomCat' fighter jet. This processor was developed by Steve Geller, Ray Holt and a team from Air Research and American Microsystems.

On November 15, 1971, Intel released the world's first commercial microprocessor, the 4004. Fourth generation computers developed, using a microprocessor to locate much of the computer's processing abilities on a single (small) chip. Coupled with one of Intel's inventions - the RAM chip (Kilobits of memory on a single chip) - the microprocessor allowed fourth generation computers to be even smaller and faster than ever before. The 4004 was only capable of 60,000 instructions per second, but later processors (such as the 8086 that all of Intel's processors for the IBM PC and compatibles is based) brought ever increasing speed and power to the computers. Supercomputers of the era were immensely powerful, like the Cray-1 which could calculate 150 million floating point operations per second. The microprocessor allowed the development of microcomputers, personal computers that were small and cheap enough to be available to ordinary people. The first such personal computer was the MITS Altair 8800, released at the end of 1974, but it was followed by computers such as the Apple I & II, Commodore PET and eventually the original IBM PC in 1981.

Although processing power and storage capacities have increased beyond all recognition since the 1970s, the underlying technology of LSI (large scale integration) or VLSI (very large scale integration) microchips has remained basically the same, so it is widely regarded that most of today's computers still belong to the fourth generation

2.3 TYPES OF COMPUTERS

Two main types of computers are in use today, analogue and digital. Analogue Computers exploit the mathematical similarity between physical interrelationships in certain problems, and employ electronic or hydraulic circuits to stimulate the physical problem.

Digital computers solve problems by performing calculations and by dealing with each other digit after digit.Installations that posses elements of both digital and analogue computers are called hybrid computers. They are usually used for problems in which large numbers of complex equations known as time integrals are to be computed. Data in analogue form can also be fed into a digital computer by means of an analogue-to digital converter.

Analogue Computers

The simplest analogue calculating device is the sliding rule, which employs specially calibrated scales to facilitate multiplication, division and other functions. The analogue computer is a more sophisticated electronic or hydraulic device that is designed to handle input in terms of for example, voltage levels or hydraulic pressures, rather than numerical data. In a typical electronic analogue computer, the inputs are converted into voltages that may be added or multiplied using specially designed circuit elements. The answers are subsequently generated for display or for conversion to another desired form.

Digital Computers

Digital computers function is basically based on one operation; the ability to determine whether a switch or "gate" is open in any of its microscopic circuits; or of high voltage or low voltage, or in the case of numbers 0 or 1. The speed, at which the computer performs this simplest act, however is what makes it a marvel.

2.4 RANGE OF COMPUTER ABILITY

Computers exist in a wide range of sizes and power. The smallest are embedded within the circuitry of appliances, such as televisions and wristwatches. These computers are typically pre programmed for a specific task, such as tuning to a particular television frequency, delivering doses of medicine, or keeping accurate time. They generally are "hard-wired" that is, their programs are represented as circuits that cannot be reprogrammed.

Programmable computers vary enormously in their computational power, speed, memory, and physical size. Some small computers can be held in one hand and are called personal digital assistants (PDAs). They are used as notepads, scheduling systems, and address books; if equipped with a cellular phone, they can connect to worldwide computer networks to exchange information regardless of location. Hand-held game devices are also examples of small computers.

Portable laptop and notebook computers and desktop PCs are typically used in businesses and at home to communicate on computer networks, for word processing, to track finances, and for entertainment. They have large amounts of internal memory to store hundreds of programs and documents. They are equipped with a keyboard; a mouse, trackball, or other pointing device; and a video display monitor or liquid crystal display (LCD) to display information. Laptop and notebook computers usually have hardware and software similar to PCs, but they are more compact and have flat, lightweight LCDs instead of television-like video display monitors. Most sources consider the terms "laptop" and "notebook" synonymous.

Workstations are similar to personal computers but have greater memory and more extensive mathematical abilities, and they are connected to other workstations or personal computers to exchange data. They are typically found in scientific, industrial, and business environments especially financial ones, such as stock exchanges—that require complex and fast computations.

Supercomputers: The highly calculation-intensive tasks can be effectively performed by means of supercomputers. Quantum physics, mechanics, weather forecasting, molecular theory are best studied by means of supercomputers. Their ability of parallel processing and their well-designed memory hierarchy give the supercomputers, large transaction processing powers.

Microcomputers: A computer with a microprocessor and its central processing unit is known as a microcomputer. They do not occupy space as much as mainframes. When supplemented with a keyboard and a mouse, microcomputers can be called as personal computers. A monitor, a keyboard and other similar input output devices, computer memory in the form of RAM and a power supply unit come packaged in a microcomputer. These computers can fit on desks or tables and serve as the best choices for single-user tasks.

Mainframe computers have more memory, speed, and capabilities than workstations and are usually shared by multiple users through a series of interconnected computers. They control businesses and industrial facilities and are used for scientific research. The most powerful mainframe computers, called supercomputers, process complex and time-consuming calculations, such as those used to create weather predictions. Large businesses, scientific institutions, and the military use them. Some supercomputers have many sets of CPUs. These computers break a task into small pieces, and each CPU processes a portion of the task to increase overall speed and efficiency. Such computers are called parallel processors. As computers have increased in sophistication, the boundaries between the various types have become less rigid. The performance of various tasks and types of computing have also moved from one type of computer to another. For example, networked PCs can work together on a given task in a version of parallel processing known as distributed computing.

Minicomputers: In terms of size and processing capacity, minicomputers lie in between mainframes and microcomputers. Minicomputers are also called mid-range systems or workstations. The term began to be popularly used in the 1960s to refer to relatively smaller third generation computers. They took up the space that would be needed for a refrigerator or two and used transistor and core memory technologies. The 12-bit PDP-8 minicomputer of the Digital Equipment Corporation was the first successful minicomputer.

Wearable Computers: A record-setting step in the evolution of computers was the creation of wearable computers. These computers can be worn on the body and are often used in the study of behaviour modelling and human health. Military and health professionals have incorporated wearable computers into their daily routine, as a part of such studies. When the users' hands and sensory organs are engaged in other activities, wearable computers are of great help in tracking human actions. Wearable computers are consistently in operation as they do not have to be turned on and off and are constantly interacting with the user.

2.5 LIMITATIONS OF COMPUTERS

Computers have their limitations in one way or the other. One example is quiet theoretical; there are undecidable propositions whose truth cannot be determined within a given set of rules, such as the logical structure of a computer. Because no universal algorithmic method can exist to identify such propositions. A computer asked to obtain the truth of such a proposition will continue indefinitely; a condition known as the "halting problem."

Other limitations reflect current technology, for example a computer might have a difficult task of recognizing spatial patterns, such as easily distinguishing among human faces, because it must process the information sequentially, rather than grasping details overall at a glance, but this feat is easily achieved by the skilled human mind. Another problematic area for computers involves natural language interaction. Because so much common knowledge and contextual information is assured in ordinary human communication, researchers have yet to solve the problem of providing relevant information to general-purpose natural language programmes.

2.6 COMPUTER HARDWARE

Computer hardware consists of the components that can be physically handled. The function of these components is typically divided into three main categories: input, output, and storage. Components in these categories connect to microprocessors, specifically, the computer's central processing unit (CPU), the electronic circuitry that provides the computational ability and control of the computer, via wires or circuitry called a bus.

Computer hardware can be categorized into two: Input hardware and Output hardware.

Input Hardware:

Input hardware consists of external devices—that is, components outside of the computer's CPU—that provide information and instructions to the computer. Examples are mouse, keyboard, touch pens, joystick, scanner microphone and a network interface card.

Output Hardware:

Output hardware consists of internal and external devices that transfer information from the computer's CPU to the computer user. Graphics adapters, which are either an add-on card (called a video card) or connected directly to the computer's motherboard, transmit information generated by the computer to an external display. Examples include a display (monitor) and a printer.

2.7 WORKING PARTS OF A COMPUTER

For a typical computer to execute a programme effectively, it relies on various internal parts which work together sequentially or simultaneously to execute the task, without these parts or a defect on these parts would render the computer ineffective. These parts include:

2.7.1 CENTRAL PROCESSING UNIT:

In computer science, microscopic circuitry that serves as the main information processor in a computer. A CPU is generally a single microprocessor made from a wafer of semiconducting material, usually silicon, with millions of electrical components on its surface. On a higher level, the CPU is actually a number of interconnected processing units that are each responsible for one aspect of the CPU's function. Standard CPUs contain processing units that interpret and implement software instructions, perform calculations and comparisons, make logical decisions (determining if a statement is true or false based on the rules of Boolean algebra), temporarily store information for use by another of the CPU's processing units, keep track of the current step in the execution of the program, and allow the CPU to communicate with the rest of the computer.

A CPU is similar to a calculator, only much more powerful. The main function of the CPU is to perform arithmetic and logical operations on data taken from memory or on information entered through some device, such as a keyboard, scanner, or joystick. The CPU is controlled by a list of software instructions, called a computer program. Software instructions entering the CPU originate in some form of memory storage device such as a hard disk, floppy disk, CD-ROM, or magnetic tape. These instructions then pass into the computer's main random access memory (RAM), where each instruction is given a unique address, or memory location. The CPU can access specific pieces of data in RAM by specifying the address of the data that it wants.

As a program is executed, data flow from RAM through an interface unit of wires called the bus, which connects the CPU to RAM. The data are then decoded by a processing unit called the instruction decoder that interprets and implements software instructions. From the instruction decoder the data pass to the arithmetic/logic unit (ALU), which performs calculations and comparisons. Data may be stored by the ALU in temporary memory locations called registers where it may be retrieved quickly. The ALU performs specific operations such as addition, multiplication, and conditional tests on the data in its registers, sending the resulting data back to RAM or storing it in another register for further use.

During this process, a unit called the program counter keeps track of each successive instruction to make sure that the program instructions are followed by the CPU in the correct order.

2.7.2 COMPUTER MEMORY (RAM)

To process information electronically, data are stored in a computer in the form of binary digits, or bits, each having two possible representations (0 or 1). If a second bit is added to a single bit of information, the number of representations is doubled, resulting in four possible combinations: 00, 01, 10, or 11. A third bit added to this two-bit representation again doubles the number of combinations, resulting in eight possibilities: 000, 001, 010, 011, 100, 101, 110, or 111. Each time a bit is added, the number of possible patterns is doubled. Eight bits is called a byte; a byte has 256 possible combinations of 0s and 1s.

A byte is a useful quantity in which to store information because it provides enough possible patterns to represent the entire alphabet, in lower and upper cases, as well as numeric digits, punctuation marks, and several character-sized graphics symbols, including non-English characters such as p. A byte also can be interpreted as a pattern that represents a number between 0 and 255. A kilobyte—1,024 bytes—can store about 1,000 characters; a megabyte can store about 1 million characters; a gigabyte can store about 1 billion characters; and a terabyte can store about 1 trillion characters. Computer programmers usually decide how a given byte should be interpreted—that is, as a single character, a character within a string of text, a single number, or part of a larger number. Numbers can represent anything from chemical bonds to dollar figures to colors to sounds.

The physical memory of a computer is either random access memory (RAM), which can be read or changed by the user or computer, or read-only memory (ROM), which can be read by the computer but not altered in any way. One way to store memory is within the circuitry of the computer, usually in tiny computer chips that hold millions of bytes of information. The memory within these computer chips is RAM. Memory also can be stored outside the circuitry of the computer on external storage devices, such as magnetic floppy disks, which can store about 2 megabytes of information; hard drives, which can store gigabytes of information; compact discs (CDs), which can store up to 680 megabytes of information; and digital video discs (DVDs), which can store 8.5 gigabytes of information. A single CD can store nearly as much information as several hundred floppy disks, and some DVDs can hold more than 12 times as much data as a CD.

2.7.3 THE BUS

The bus enables the components in a computer, such as the CPU and the memory circuits, to communicate as program instructions are being carried out. The bus is usually a flat cable with numerous parallel wires. Each wire can carry one bit, so the bus can transmit many bits along the cable at the same time. For example, a 16-bit bus, with 16 parallel wires, allows the simultaneous transmission of 16 bits (2 bytes) of information from one component to another. Early computer designs utilized a single or very few buses. Modern designs typically use many buses, some of them specialized to carry particular forms of data, such as graphics.

2.7.4 OPERATING SYSTEM:

An Operating System is the basic software that controls a computer. The operating system has three major functions: It coordinates and manipulates computer hardware, such as computer memory, printers, disks, keyboard, mouse, and monitor; it organizes files on a variety of storage media, such as floppy disk, hard drive, compact disc, digital video disc, and tape; and it manages hardware errors and the loss of data. Operating systems control different computer processes, such as running a spreadsheet program or accessing information from the computer's memory. One important process is interpreting commands, enabling the user to communicate with the computer. Some command interpreters are text oriented, requiring commands to be typed in or to be selected via function keys on a keyboard. Other command interpreters use graphics and let the user communicate by pointing and clicking on an icon, an on-screen picture that represents a specific command. Beginners generally find graphically oriented interpreters easier to use, but many experienced computer users prefer text-oriented command interpreters. Operating systems are either single-tasking or multitasking. The more primitive single-tasking operating systems can run only one process at a time. For instance, when the computer is printing a document, it cannot start another process or respond to new commands until the printing is completed.

All modern operating systems are multitasking and can run several processes simultaneously. In most computers, however, there is only one central processing unit (CPU; the computational and control unit of the computer), so a multitasking OS creates the illusion of several processes running simultaneously on the CPU. The most common mechanism used to create this illusion is time-slice multitasking, whereby each process is run individually for a fixed period of time. If the process is not completed within the allotted time, it is suspended and another process is run. This exchanging of processes is called context switching. The OS performs the "bookkeeping" that preserves a suspended process. It also has a mechanism, called a scheduler that determines which process will be run next. The scheduler runs short processes quickly to minimize perceptible delay. The processes appear to run simultaneously because the user's sense of time is much slower than the processing speed of the computer.

2.8 COMPUTER ASSEMBLING

The following components are the least components required to assemble a standard desktop personal computer.

Processors, Motherboard, Hard disk, RAM, Cabinet, Floppy Drive, CD Drive, Cards: Display Card (Not needed if On-board display is available on Motherboard) Sound Card (Not needed if On-board sound is available on Motherboard) Other Cards (If Any). Keyboards, Mouse and Monitor.

Before a computer is assembled, the following precautions have to be taken into consideration to avoid mishap during the assembling process

- The motherboard contains sensitive components, which can be easily damaged by static electricity. Therefore the motherboard should remain in its original anti static envelope until required for installation. The person taking it out should wear an anti static wrist strap that is properly grounded. Similar handling precaution are also required for cards.
- While the motherboard has to be fitted at a fixed place inside the PC cabinet, the locations of add-on cards (as and when used) and the drivers (hard disk drive, floppy disk drive, and CD-ROM drive) within the drivers bay of the cabinet can be changed within certain limits. But it is better to place them far away from each other. (The length of the cable provided for interconnections to the motherboard has to be taken into account, as there must be some slack after these are installed and connected.) This will improve the cooling and reduce the chance of electro-magnetic interference between them.
- All the components have to be handled with great care. If a small thing like a screw is dropped on the motherboard, it can damage the delicate circuitry, rendering the Main Board useless.

The following environmental factors have to be also considered

- The place where the Computer is assembled is supposed to be dust free as dust can harm the system.
- The room has to have good ventilation and won't be very hot.

• A flat surface of a good area is supposed to be available when the system is assembled and that the room has enough space to move.

2.9 HOW A COMPUTER IS ASSEMBLED

2.9.1 UNPACKING

.1 cover of cabinet (computer case) is opened

.2 Metal sheet on side of cabinet is opened (this is where motherboard is mounted) and power supply is fixed into computer case.

.3 All spares are unpacked from their boxes

.4 Manuals and Cds/Floppies and other accessories provided with spares are collected.

Fig 2.0 Opened computer cabinet for assembling

2.9.2 MOTHERBOARD MOUNTING

.1 Motherboard is placed properly on the metal sheet in the computer case which matches with motherboard holes.

.2 The risers on the metal sheet is fixed and the spacers is pushed in the holes on the motherboard.

.3 Screws are fixed at the proper places where risers on the motherboard are placed.

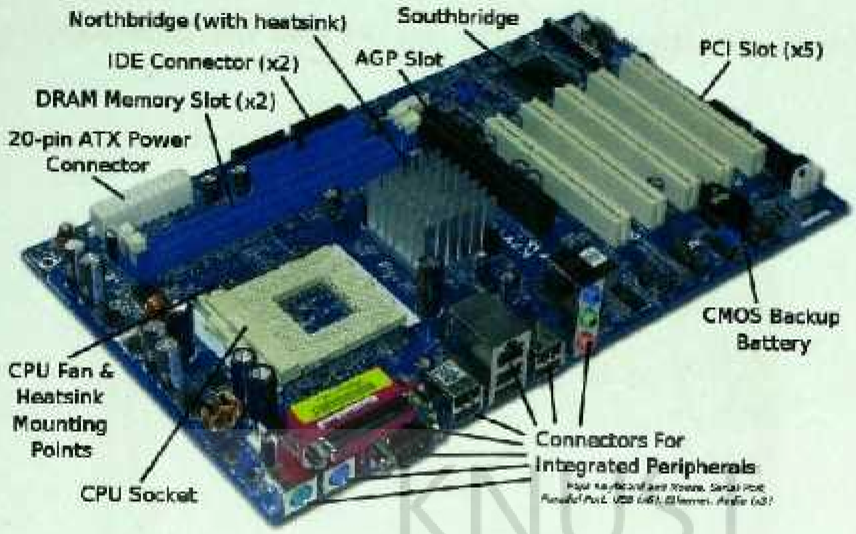

Fig 2.1 Typical mother board showing various slots for installation

2.9.3 CPU INSTALLATON

If the CPU is of SEC type

.1 The CPU supporting stands is fixed on either ends of the slot.

.2 The CPU is pushed in the slot and lock the CPU to the supporting stands.

.3 The power cable is connected on one end to CPU fan and other end to the CPU fan connected on the motherboard.

If the CPU is of PGA type

.1 The socket is unlocked by lifting the locking lever.

.2 The CPU is placed on the socket (the pins are matched with holes) and the CPU is gently placed into place.

.3 The CPU is locked in the socket by pushing down the lever.

.4 A thin layer of Heat Sink Compound is applied on the central portion of the CPU.

.5 The cooling fan is placed over the CPU and locked with metal clips on either side.

.6 Power cord is connected to the fan.

Fig 2.2 CPU being installed on mother board

2.9.4 MEMORY MODULE INSTALLATION

If the RAM is SDRAM

.1the plastic locking levers is tilted outwards on both ends of slot

.2 The memory module is pushed and pressed firmly so that the plastic levers stand straight and lock the module.

If the RAM is EDO

.1 the module is placed in a tilted manner on the slot and push it forward, so that the locking clips make a sound and the metal plate is fixed in the cabinet along with the motherboard, CPU and RAM.

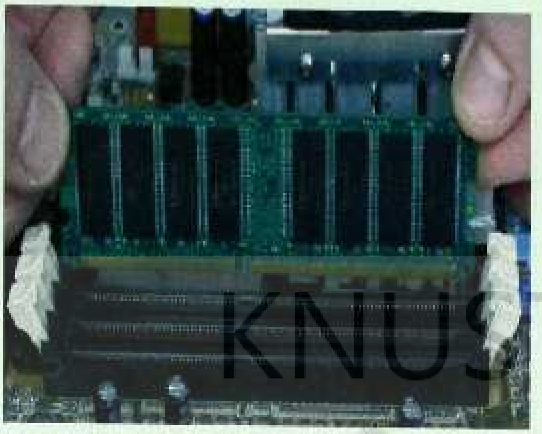

Fig 2.3 Memory being installed on mother board

2.9.5 FIXING THE CONNECTORS

.1 Before any card is pushed or any other device such as hard disk or floppy drive is fitted; the COM1 (9 pin D type – male), COM2 (25 pin D type-male) connectors and LPT (25 pin D type- female) port connector are connected in their proper place. Extra connectors such as display connector and sound connectors etc are connected if available on motherboard.

.2 These connectors are fitted at the back panel in such a way that they do not come in front of the slots provided for cards.

.3 floppy drive is fixed in its proper place if available and data cable is connected and supplied to drive.

.4 CD-ROM is fixed in its proper place. Normally this is fixed in the bottom most slab provided this makes it easy for operating the CD-ROM. Data cable, power supply and analogue audio cable are connected before screws are tightened.

.5 The Hard Disk is fitted ensuring is not to close to the SMPS because the electrostatic field produced from the SMPS may prove fatal to the hard disk or that the pc speaker is also near the hard drive. The screws fixing the hard disk are not tightened too much.

, 6 all other cards are pushed in their proper slots.

.7 All the connectors such as HDD led, Reset switch, Power led, Power ON switch (in case of ATX power supply) is finally connected.

The pc is finally tested and fitted with operating system and other required soft wares.

2.10 ASSEMBLY LINES

An assembly line is a manufacturing process in which parts (usually interchangeable parts) are added to a product in a sequential manner using optimally planned logistics to create a finished product much faster than with handcrafting-type methods. The assembly line developed by Ford Motor Company between 1908 and 1915 made assembly lines famous in the following decade through the social ramifications of mass production, such as the affordability of the Ford Model T and the introduction of high wages for Ford workers. However, the various preconditions for the development at Ford stretched far back into the 19th century, from the gradual realization of the dream of interchange ability, to the concept of reinventing workflow and job descriptions using analytical methods. Ford was the first company to build large factories around the concept. Mass production via assembly lines is widely considered to be the catalyst which initiated the modern consumer culture by making possible low unit-cost for manufactured goods. It is often said that Ford's production system was ingenious because it turned Ford's own workers into new customers. Put another way, Ford innovated its way to a lower price point and by doing so turned a huge potential market into a reality. Not only did this mean that Ford enjoyed much larger demand, but the resulting larger demand also allowed further economies of scale to be exploited, further depressing unit price, which tapped yet another portion of the demand curve. This bootstrapping quality of growth made Ford famous and set an example for other industries.

2.11 HISTORY OF THE ASSEMBLY LINE

The assembly line concept was not "invented" at one time by one person. It has been independently redeveloped throughout history based on logic. Its exponentially larger development at the end of the 19th century and beginning of the 20th occurred among various people over decades, as other aspects of technology allowed. Development of tool path control via jigs, fixtures, and machine tools (such as the screw-cutting lathe and milling machine) during the 19th century provided the prerequisites for the modern assembly line by making interchangeable parts a practical reality. Before the 20th century, most manufactured products were made individually by hand. A single craftsman or team of craftsmen would create each part of a product. They would use their skills and tools such as files and knives to create the individual parts. They would then assemble them into the final product, making cut-and-try changes in the parts until they fit and could work together. The assembly line evolved from these artisanal shops as division of labour and specialization took place. Electrification saw further advances in elementary assembly line production in the early 20th century. As electricity was increasingly used in factories as a more reliable, smoother and more precise form of power than previously available, it provided the means for the evolution of production through the automation of the assembly line. With the creation of unit drive motors, factories could be reorganized and the modern assembly line took shape with the optimal ordering and location of different parts of the production process. Large efficiency gains from assembly line production could then be realized. The transition from prototypical to the modern assembly line thus took place as creativity and logic took advantage of the opportunities that technological changes presented.

2.12 THE ASSEMBLY PROCESS

The assembly process adds value to the product being assembled in the factory. The assembly process even though at first sight looks cumbersome, actually takes less time than loading or testing the machine. The assembly process is therefore the backbone of the factory and one major and arguably the major decision taken in designing the factory is to take into consideration how the assembly process will be broken up and what portions would be completed by what part of the work force. In a computer assembly plant factory, the assembly process development can be broken down into two. One of the decisions is whether the assembly process would be serial or parallel. Factors such as the variability of the product, volume of production, assembly process and quality concerns are considered. How different products or variations would be assembled is a decision then taken after the type of assembly process is chosen. Each distinct product or product family can then be given dedicated lines or stations or a single line or generic station can be used to assemble different products at a time.

2.12.1 SERIAL ASSEMBLY

This assembly process is more commonly known as the assembly line. The assembly process is broken into individual steps, and completed by different assemblers in a specific sequence. By either increasing or decreasing the number of steps in the process, demand quantities are met. An increase in the number of steps decreases the cycle time at each individual step this leads to a reduction in the amount of work on an individual unit.

2.12.2 PARALLEL ASSEMBLY

In this assembly structure, the entire assembly process is completed at a single station, with stations replicated based on cycle time in order to meet demand quantities. One or a small group of assemblers is responsible for the entire assembly process for units scheduled for their station.

2.13 CONVEYOR SYSTEMS

A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials. Conveyor systems allow quick and efficient transportation for a wide variety of materials, which make them very popular in the material handling and packaging industries. Many kinds of conveying systems are available, and are used according to the various needs of different industries.

2.13.1 INDUSTRIES THAT USE CONVEYOR SYSTEMS

Conveyor systems are used widespread across a range of industries due to the numerous benefits they provide.

- Conveyors are able to safely transport materials from one level to another, which when done by human labour would be strenuous and expensive.
- They can be installed almost anywhere, and are much safer than using a forklift or other machine to move materials.
- They can move loads of all shapes, sizes and weights. Also, many have advanced safety features that help prevent accidents.

Conveyor systems are commonly used in many industries, including the automotive, agricultural, computer, electronic, food processing, aerospace, pharmaceutical, chemical, bottling and canning, print finishing and packaging. It is important to know how the conveyor system will be used beforehand. Some individual areas that are helpful to consider are the required conveyor operations, such as transportation, accumulation and sorting, the material sizes, weights and shapes and where the loading and pickup points need to be.

2.14 TYPES OF CONVEYORS

Conveyors come in different types mainly depending on the kind of industry and the industrial processes

2.14.1 BELT CONVEYORS

A belt conveyor consists of two or more pulleys, with a continuous loop of material - the conveyor belt - that rotates about them. One or both of the pulleys are powered, moving the belt and the material on the belt forward. The powered pulley is called the drive pulley while the unpowered pulley is called the idler. There are two main industrial classes of belt conveyors; Those in general material handling such as those moving boxes along inside a factory and bulk material handling such as those used to transport industrial and agricultural materials, such as grain, coal, ores, etc. generally in outdoor locations. Material flowing over the belt may be weighed in transit using a beltweigher. Belts with regularly spaced partitions, known as elevator belts, are used for transporting loose materials up steep inclines. Belt Conveyors are used in self-unloading bulk freighters and in live bottom trucks. Conveyor technology is also used in conveyor transport such as moving sidewalks or escalators, as well as on many manufacturing assembly lines. Stores often have conveyor belts at the check-out counter to move shopping items. Ski areas also use conveyor belts to transport skiers up the hill. A wide variety of related conveying machines are available, different as regards principle of operation, means and direction of conveyance, including screw conveyors, vibrating conveyors, pneumatic conveyors, the moving floor system, which uses reciprocating slats to move cargo, and roller conveyor system, which uses a series of powered rollers to convey boxes or pallets.

Fig 2.4 A belt conveyor system

2.14.2 CHAIN CONVEYORS

Chain conveyors utilise a powered continuous chain arrangement, carrying a series of single pendants. The chain arrangement is driven by a motor, and the material suspended on the pendants is conveyed. Many industry sectors use chain conveyor technology in their production lines. The automotive industry commonly uses chain conveyor systems to convey car parts through paint plants. Chain conveyors also have widespread use in the white and brown goods, metal finishing and distribution industries.

Fig 2.5 Packaged product being conveyed on a chain conveyor system

2.14.3 ROLLER CONVEYORS

Roller conveyors consists of small metal tubes placed adjacent to each other and usually rotated by a mechanism beneath, enabling merchandise materials and pallets to be moved from one location to another under human supervision. Roller conveyors are reasonably flexible and can be set up to transport items around curves and up & down gentle vertical slopes. They are commonly used to move relatively large merchandise.

Fig 2.6 Materials being transported on a roller conveyor system

2.14.4 OVERHEAD CONVEYORS

This type of conveyor is characterized by the fact that the transportation path is above the floor of the facility. Overhead conveyors can be non- powered or powered. Non-powered overhead conveyors require employee (manual) power or gravity force to move products from one location to the next. Powered overhead conveyors transport products utilizing a load-carrying mechanism such as a chain that is propelled by an electric motor, air pressure or vacuum. The support for the overhead conveyor system track or monorail can be from the steel or wood ceiling, from the wall or from the floor in which case floor stands or racks are used. With overhead conveyors the items being transported are suspended below the track using various hooks or carriers determined by the weight and type of item or product.

Fig 2.7 An overhead conveyor system

2.15 FACTORY LAYOUTS

The layout of a factory is basically where all the facilities, machines, equipment and staff in the manufacturing operation are placed so as they function together. The way in which materials and other inputs (like people and information) flow through the operation is usually determined by the layout. Any changes in machine positioning in a factory can affect the flow of materials considerably. This in turn can affect the costs and effectiveness of the overall manufacturing operation. The first decision is to take before a layout is chosen is to determine the type of manufacturing operation that must be accommodated. This depends on product volume and variety. At one extreme, the factory will produce a wide variety of bespoke products in small volumes, each of which is different: this is called a 'jobbing' operation. At the other extreme it will produce a continuous stream of identical products in large volumes. The factory might also produce various sized batches of a range of different products between extremes.

2.16 TYPES OF FACTORY LAYOUTS

Factory layouts consist of three basic types namely

- Process layout
- Cell layout
- Product layout

2.16.1 PROCESS LAYOUTS

In process layout, similar manufacturing processes (cutting, drilling, wiring, etc.) are located together to improve utilisation. Different products may require different processes so material flow patterns can be complex. An example is machining parts for aircraft engines. Some processes such as heat treatment need specialist support, like fume extraction, while other processes like machining centres need technical support from machine setters or operators. So the factory will be arranged with heat treatment together in one location and machining centres in another. Different products will follow different routes around the factory.

2.16.2 CELL LAYOUTS

In cell layout, the materials and information entering the operation are pre-selected to move to one part of the operation (or cell) in which all the machines to process these resources are located. After being processed in the cell, the part-finished products may go on to another cell. In effect the cell layout brings some order to the complexity of flow that characterises process layout.

2.16.3 PRODUCT LAYOUTS

Product layout involves locating the machines and equipment so that each product follows a pre-arranged route through a series of processes. The products flow along a line of processes, which is clear, predictable and relatively easy to control. An example is automobile assembly, where almost all variants of the same model require the same sequence of processes.

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CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter describes the various medium through which this research was carried out. Different research approaches and methods were used with its resultant limitations and constraints.

3.2 METHODOLOGY

Various methods were improvised in gathering the various information for the research which included interviews, reading books and articles related to the topic, internet, observations from visit to places of interest and photographs. These can be grouped field research and desk research.

3.2.1 FIELD RESEARCH

Surveys into the area of study were carried out over a period of time. Site surveys were carried out to ensure the critical analysis of the site as to whether it could sustain the project. A survey was also conducted on two computer companies namely Omatek computers Ghana limited and Dealers computers. Various people were interviewed and photographs were taken for visual references. This survey was done to ascertain the demand and use of computers in the country and also the logistics needed in computer assembly.

Case studies

- The first case study was taken at Omatek computers Ghana limited, an existing computer assembly factory in Accra, Ghana. The reasons for this study was to enable me understand the various spaces required and their organisation in a computer assembly plant.

- The second study was taken at Dell PC assembly plant in Penang- Malaysia. The reasons for this study was also to enable me know the various requirements in a computer assembly plant and also some aesthetic features of a computer assembly plant.

3.2.2 DESK RESEARCH

This form of research included reading of books, articles and journals concerning the research topic. The internet was also extensively used to gather data and information on the topic.

3.3 LIMITATIONS AND CONSTRAINTS

Major limitations encountered during the research was the unwillingness of the various computer companies in Ghana to respond to the interviews and hindrances which were put across when the case study was being carried out at Omatek Computers Ghana limited.

CHAPTER FOUR

4.0 RESEARCH FINDINGS AND DISCUSSIONS

4.1 INTRODUCTION

This chapter discusses the various findings that were obtained during the research from case studies and visit to the site.

4.2 CASE STUDY1 – (OMATEK COMPUTERS GHANA LIMITED)

Omatek computers has factories in Ghana and Nigeria factory involved in the production of Computers, Casings and Speakers from Completely-Knocked-Down components out of its Nigeria and Ghana factories. The Factory produces for Omatek Ventures Distribution Limited the Omatek brand of products ranging from: Desktops, Notebooks and Servers.

4.2.1 REASON FOR STUDY

This case study was undertaken to help me understand the general spaces and their relationships in a computer assembly plant.

4.2.2 LOCATION

Omatek Computers Ghana Limited assembles computers locally in Ghana. It is located in ridge in Accra in an area with mixed zoning consisting of civic and residential buildings.

Fig 4.0 View of the main entrance to the factory

4.2.3 SPATIAL ORGANISATION

The following spaces or facilities were located at the factory

- Reception/ Showroom
- Main production hall
- Logistics Room
- Quality check
- Accounts section
- Offices
- Storage

The structure is a single storey building with a little parking space located at the front of the building. The first point of call at Omatek computers Ghana Limited is the reception area which also serves as the show room. Finished products from the factory are displayed in the showroom and takes majority of the space whilst a small corner has been designated as the reception. There is also a further partition within the space which is used as the logistic area. The production hall or main assembly area is located just after the reception, whilst the quality check is also located after the production area; this is where the assembled machines are tested after they are assembled. Within the main production hall, the raw materials used for the production are stored there, whilst a separate storage area for finished goods is located after the production hall and accessed from behind the building. The rest of the spaces located there consist of offices for administration, accounts section and washrooms.

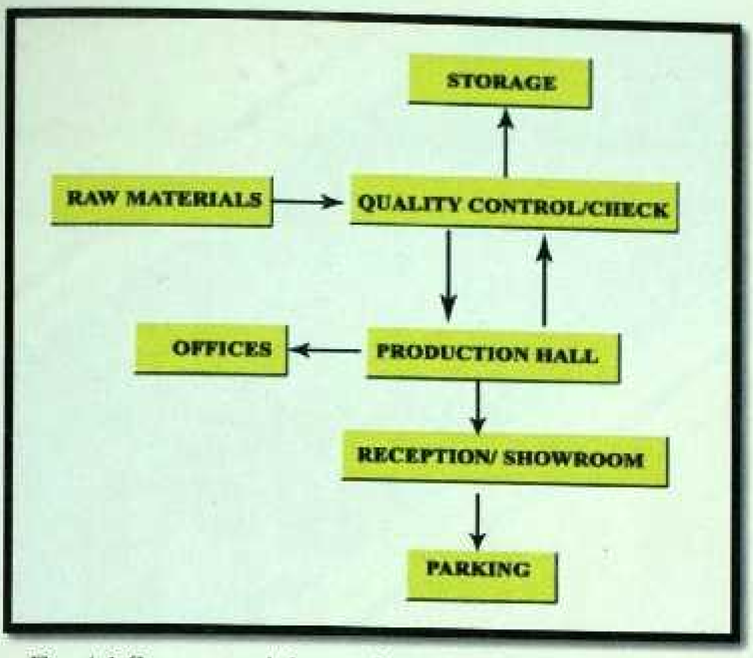


Fig 4.1 Spaces and their relationship/organisation at the factory

Fig 4.2 View of the entrance of the production hall

4.2.4 SECURITY

The form of security employed is in the form of security personnel who monitor activities of workers and visitors to the place. There was no use of other security gadgets such as cctv cameras and metal detectors.

4.2.5 STORAGE

Raw materials are stored within the production hall. But finished products are stored separately in a different space which is accessed from behind the building. Managerial offices and accounts section take up the rest of the spaces. The offices houses personnel who see to the proper administrative running of the factory.

Fig 4.3 View into the production hall

4.3 LESSONS FROM THE STUDY

Different things were observed and documented during the case study. These points have been grouped into two parts mainly the merits and demerits observed at the factory.

4.3.1 MERITS

The use of air condition or artificial ventilation to ensure dust free environment in the production hall. This is necessary in a computer factory since the computer components usually require a controlled environment or temperature for them to function well due to their sensitive nature.

4.3.2 DEMERITS

- Lack of changing rooms for the worker
- Inadequate security example lack of cctv cameras.
- No definite access for both raw materials and finished goods.

- No lobbies (clean lobbies) before entry into production hall
- Lack of ancillary facilities like canteen and restroom.
- Inadequate space for parking

Fig 4.4. Workers in the production hall

Fig4.5. Workers testing finished products

Fig 4.6 View of an assembly process

Fig 4.7 Packaged products in showroom/reception

4.4 CASE STUDY2– (DELL COMPUTER ASSEMBLY PLANT IN PENANG-MALAYSIA)

This facility is located on an island in Penang, Malaysia close to an airport and harbour which facilitates the transportation of raw materials and finished products. The facility has extensive parking both around the facility and another located a few meters away from the assembly plant. The parking spaces around the facility cater for loading and offloading of goods as well as parking for workers and visitors. Access to the facility is secured by two security check points with one overlooking the service parking whilst the other overlooks the parking for staff and visitors. The computer assembly plant consists of one structure which houses the administration, production hall and other ancillary facilities. The administration area and other facilities are located at the front whilst the assembly hall is located behind. The architecture of the structure can be described as post modernism with extensive glazing on the front facade.

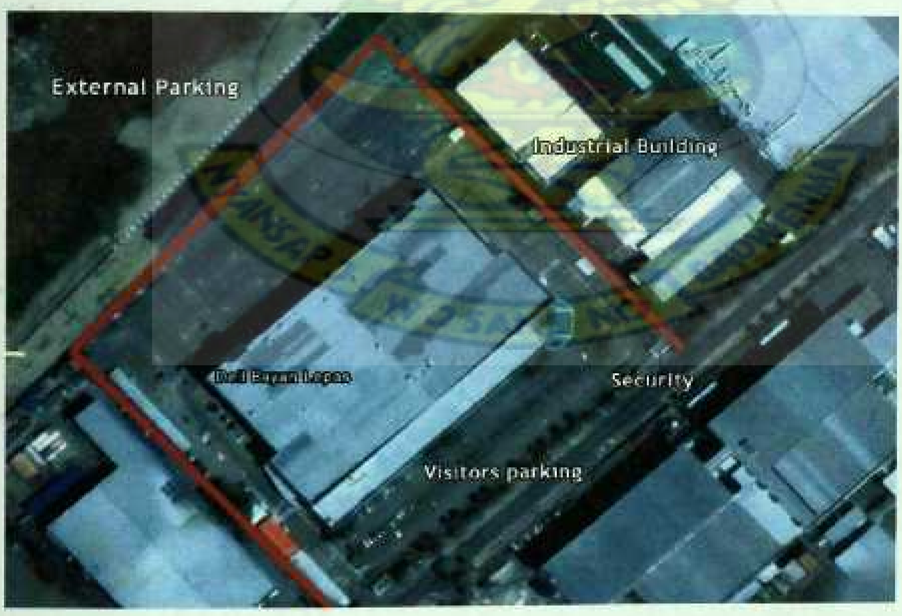


Fig 4.8 Layout of the assembly plant (shown edged red)

Fig 4.9View of entrance into the assembly plant

Fig 4.10 View of parking area

Fig 4.11 View of facade of facility showing glazing

4.5 LESSONS FROM THE STUDY

Different things were observed and documented during the case study. These points have been grouped into two parts mainly the merits and demerits observed at the factory.

4.5.1 MERITS

- Adequate parking
- Good and adequate lighting levels in assembly area.
- Adequate security in place.
- Separate location of service and staff parking.
- Well defined accesses for entry and exit.
- Inadequate space for parking.

4.5.2 DEMERITS

- Extensive use of artificial lighting and mechanical ventilation in the building can lead to high running costs due to the design of the building.
- Lack of adequate soft landscaping. Hard landscaping dominates the factory which can result in excessive solar radiation.

Fig 4.12 View of the assembly hall

Fig 4.13 View of the Testing/Installation area

Fig 4.14 Workers undergoing training

Fig 4.15 Control center at the factory

Fig 4.16 View of showroom

4.6 TECHNICAL STUDIES

One major factor in the design of an industrial structure is how to achieve efficiency in the production or in this case assembly process. Certain requirements must be met if the assembly process is to be efficient and at minimal cost.

4.6.1 SIZES AND SPACES FOR COMPUTER ASSEMBLY HALL

The size and arrangement of equipments in a computer assembly hall is determined by some factors such as

1. The sizes of machine to be used and spaces between them.
2. Allowable distances between the various machines and walls allow movement.
3. The general arrangement of machines which also considers

- The assembling process.
- Movement of workers and other machinery such as trolleys.
- Storage spaces for materials
- Sufficient space for general operation of workers

4.6.2 SIZES AND SPACE REQUIREMENTS FOR MACHINERY

The size and spaces of the assembly hall is usually determined by the size of machinery and number of machines to be used in the assembly process.

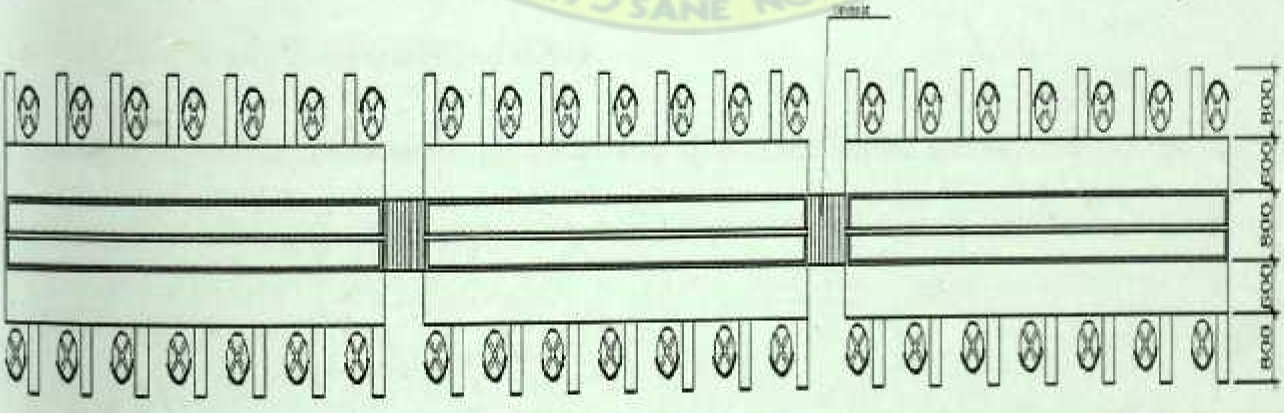
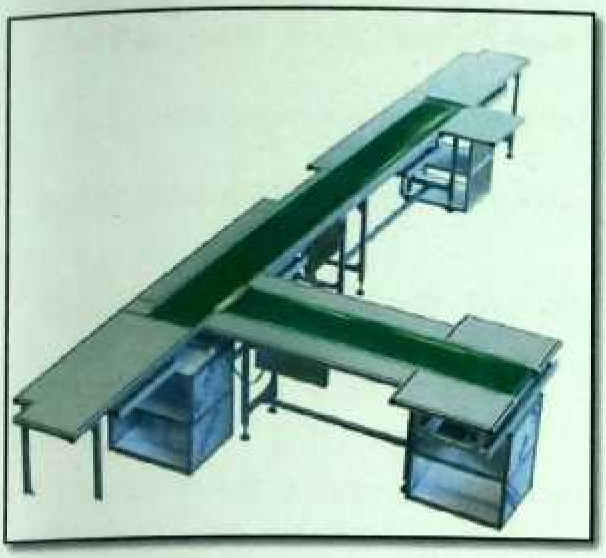


Fig 4.17 Plan of assembly line



Space Requirements:

Height: 900mm

Width of worktop: 800mm

Fig 4.18 Picture showing assembly line

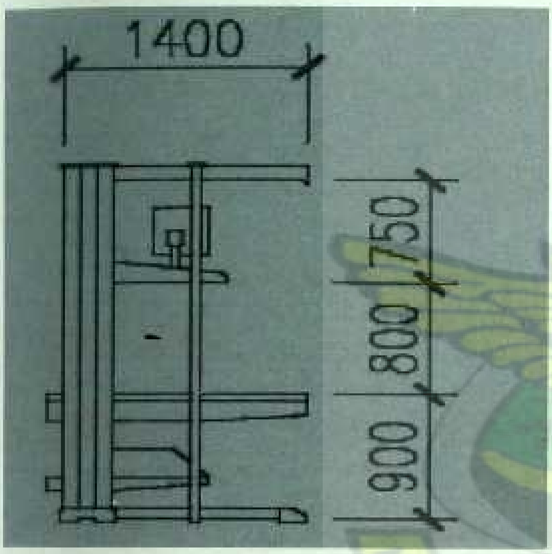


Fig 4.19 Picture showing machinery for testing

4.7 TECHNICAL CONSIDERATIONS

Several technical factors have to be considered due to the nature and function of the facility and sensitivity of the products been produced. These technical factors include the following;

4.7.1 ELECTRICITY

Since the components being assembled into a computer are very sensitive and computers operate on electricity and process data by means of electric signals, the quality and quantity of electricity supplied is very critical.

Where the power supply from the main is not up to the required voltage, step up transformers must be used, and where supply is liable to fluctuation, it is essential to have a 100% standby generator for simultaneous connection.

Electrical power requirements vary according to machine types, size and configuration, but generally are of two basic ranges.

240/415 v _+ 6% at 50 cycles/second _+ 1% or

220/380 v + 6% at 50 cycles/second _+ 1%

Electricity must come from a clean source, which is from a main fuse box.

4.7.2 ENVIRONMENTAL CONTROL

Due to the sensitive nature of the materials or components used, it is very important that the external environment is modified as much as possible to suite the necessary conditions needed by the components to operate effectively. Most of the peripherals operate effectively under normal air condition whilst some, for example central processing unit requires a higher level of environmental control. Provisions would therefore have to be made for air conditions. Acceptable environmental values are as follows;

Temperature: 16^{o}-27^{o} C, at a maximum rate of change of 2.7^{o} C/Hr.

Humidity: 35% - 65% (condensing) at a maximum change rate of 10% /Hr.

Air purity: General requirements are 96 % efficiency at 5 micron punticle. Normal Industrial Filtration (1 micron = 1×10^{-6} meter).Dust control is very important, and must be considered in the choice of materials. It is also recommended that the air conditioning plant for the assembly plant be separated from that for other parts of the building, due to its widely defined units.

4.7.3 SOLAR CONTROL

Due to the nature of the assembling process and equipments and components involved, it is very essential that just the right level of external solar ingress is allowed into the assembly hall. Sun shading devices have to be employed to cut down excessive light to avoid glare and heat. Glazing for the windows can be Zinc coated Aluminium oxide heat reflecting glass which reflects about 70% of solar radiation and converts the remaining 30% into red-bias light which is good for computer assembling since it does not produce glare.

4.7.4 LIGHTING

The level of lighting is very important and must be considered the right amount of lighting for computer assembling is normally achieved by the use of artificial lighting but it has to be augmented by natural lightning to reduce production cost.

4.7.5 ACOUSTICS

Noise levels in the assembly hall have to be considered very critically as some high noise levels can be destructive to some of the components. Noise level must be kept at practical levels for operators comfort at about 50-55 decibels. This can be achieved by segregation in terms of noisy and quiet areas, and also by fixing absorbent materials in the ceiling and floors.

4.7.6 FIRE CONTROL

Safety and efficiency of the factory is very important, fire fighting should be well considered. Fire and smoke detection devices located in air conditioning ducts are suitable and these may switch off machine above a certain volume of smoke.Suitable carbon dioxide (CO^2) appliances must be provided in computer rooms. Preferred systems of detection and fighting are

- Combustion detectors in the computer rooms, ceilings, floors, air conditioning ducts, etc.
- Flow alarm switches, sprinkler systems, and hose lines.

There must be a control panel, on which all critical parts of the building are easily located so that appropriate action can immediately be taken in times of crisis.

4.7.7 SECURITY

Security has to be considered with restriction to various parts of the factory. Workers can be given working gears with various colour coding to ensure they remain at restricted areas designated to them. Entrance to the factory has to have high security and workers searched before and after work. Personnel can be posted to check identification and carry out searches where necessary at vantage points into the building.

4.7.8 SERVICES

Services planning must be made as flexible as possible, to take into account any change in the configuration of a system. Electrical connection and telecommunication modes should suitably be made of a modular nature, so that any changes in the system can be easily catered for.

4.8 SPECIAL STUDY

4.8.1 PHOTO VOLTAIC POWER GENERATION

To cut down cost of production in order to achieve affordability, the facility will not only depend on electricity from the national grid but also on power generated from photovoltaic cells (solar panels). Photovoltaic (PV) or solar cells as they are often referred to are semiconductor devices that convert sunlight into direct current (DC) electricity.

4.8.2 SIZING A PHOTO VOLTAIC SYSTEM

The size of a photovoltaic system depends upon two factors: the electrical requirements of the devices (loads) relying on the system and the amount of sunshine available to power the system. A current photo voltaic panel of dimension 500mm x 900mm generates energy of 50 peak watts, 21.4-17v.Energy required for a normal P.C. (computer) is 150 watts.

4.8.3 HOW PHOTOVOLTAIC SYSTEMS WORK

Solar energy received by the photo voltaic panel is converted to electrical energy. This goes to a charge controller to regulate the power supply, then to a battery (cell) for storage. This then goes to a distribution board, to an inverter to change power from D.C to A.C, then finally to equipment.

4.8.4 WHERE TO INSTALL

Photo Voltaic modules are usually installed on special ground or pole mounting structures away from shade especially during the prime sunlight hours of 9.am to 3pm. Modules may be mounted on rooftops provided that proper building and safety precautions are observed. Tilt for maximum exposure. The annual energy production is high when the array is tilted at the latitude angle. The best possible tilt for a module is one that puts it at right angles to the noontime sun. Special Requirements include area for display of photo voltaic panels and battery bank to house battery (cells), distribution boards and other equipment.

4.9 SITE SELECTION CRITERIA

In choosing a site for the establishment of a computer assembly plant, the following criteria were considered.

Accessibility to Target Group

To make this project more viable, the site selected should be close the main target users of the facility. In this case, the main target users are the general public, institutions, government agencies, and the West African sub region as a whole. The site for the project should therefore be easily assessed from the major sources of the raw materials in this instance, the airport and harbour since the components would be mostly imported.

Size

The site for the project should be big enough to accommodate all facilities that will make the project viable. It should also be big enough to cater for future expansion of the project as population is dynamic.

Services

The site should be well developed with respect to the necessary infrastructural services such as electricity, water and telephone. Tapping them into the new facility will therefore be at a less cost.

Land tenure system

The site should be owned by an individual or an organisation that will be willing to release it for the establishment of such a government project. A state or stool owned land will be more viable.

Zoning

The site should be in an appropriate zoned area to fit into the existing and proposed urban plan. It should also be located in a less busy environment that is away from the Central Business District.

Based on the selection criteria given above, the site in Tema was proposed for the project.

4.10 SITE LOCATION

The site is located in Tema in the Ghana Free Zones site area off the Accra- Aflao road. Tema boasts of many industrial zones and facilities coupled with incentives for working with the Ghana Free Zones Board made Tema as the choice for this project very viable.

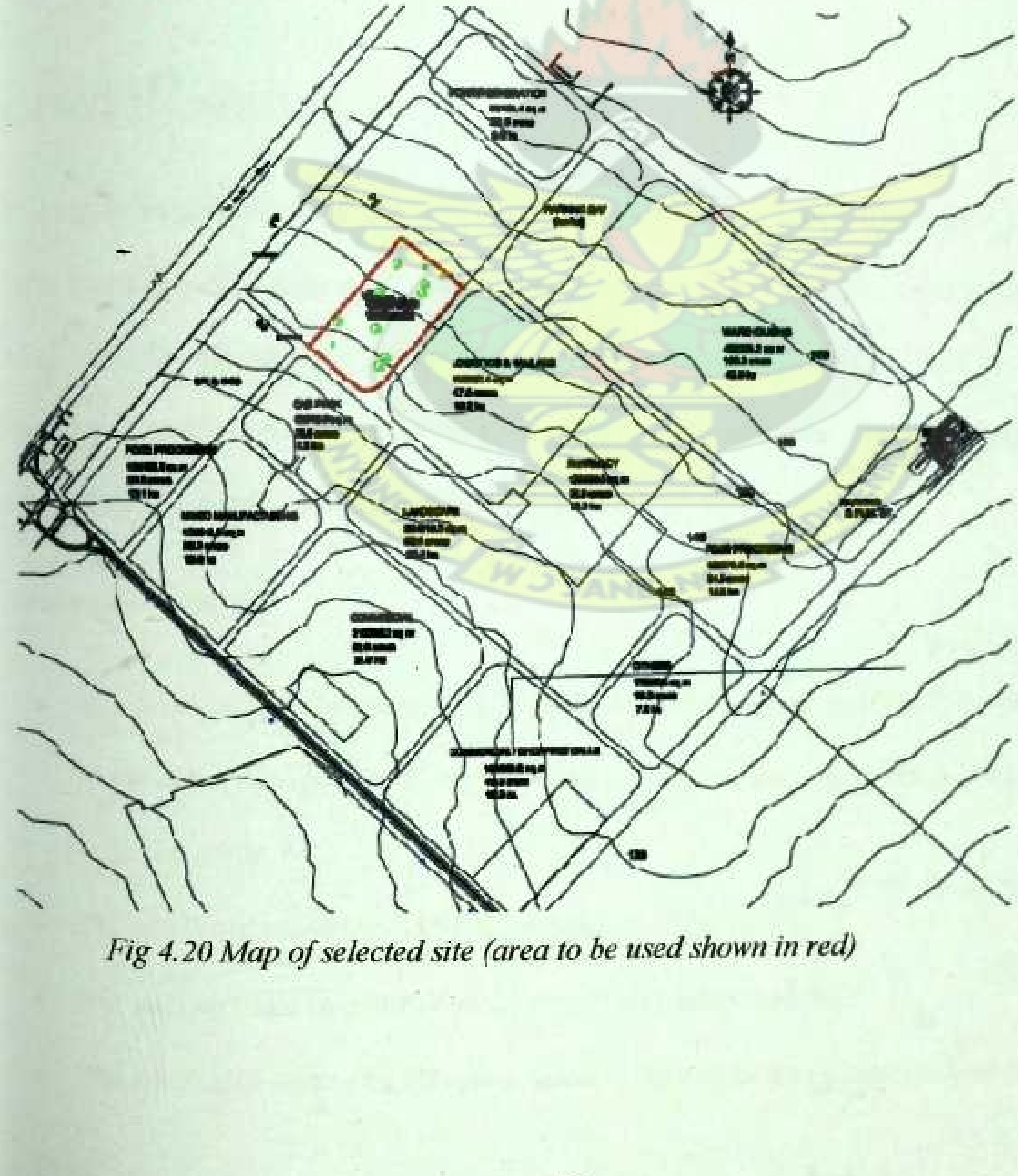


Fig 4.20 Map of selected site (area to be used shown in red)

Fig 4.21 Aerial view of site

4.11 SITE JUSTIFICATIONS

This site is located in Tema just off the Accra - Aflao road a few meters after the Accra – Tema motorway roundabout. The north western part of the site is bounded by the Accra – Aflao road. On the south eastern side of the site is a proposed logistics and haulage zone, whilst a proposed car parking zone bounds the site to the south west. The north eastern side is also bounded by a proposed power generation zone.

Advantages of the site

- The proximity of the site to the Harbour and International Airport. The site is linked to the sea and airport by first class roads, therefore, the assembled computers can be exported easily.
- The site is big enough to allow for expansion in the future.
- It is well serviced in terms of electricity, water, telephone etc
- The site is also owned by the government. This will make acquisition less difficult.

- Location of plant in the area enables plant to benefit from Export Processing Zone incentives, such as exemption from exportation taxes.

Disadvantages of the site

- Presence of sometimes heavy vehicular traffic at the Accra - Tema motorway round about.

4.12 SITE INVENTORY AND ANALYSIS

Site inventory consists of reconnaissance survey initially conducted to know the physical conditions on the site. The following conditions were studied thoroughly to be conversant with the various constraints and opportunities that could be taken advantage of or discarded to make way for a good and effective design.

Size: The site occupies an area of approximately 68900 square meters.

4.12.1 GEOLOGY

Soil Type: the site is located in a municipality known to be underlain with Precambrian rocks and metamorphic rocks mainly consisting of granite and schist. Soil is composed of sand stone and clay. It is reddish-brown in colour and has good bearing capacity

4.12.2 VEGETATION

The site is within the dry equatorial zone of Ghana. The municipality has two broad vegetational zones comprising shrub lands and grasslands. The site supports plant life. The entire site is covered with grass and a few trees.

Fig 4.22 Picture showing vegetation on site

4.12.3 SITE CLIMATE

The site located within the dry coastal savannah region of Ghana is characterized by dry climatic conditions. temperatures are quite high all year round. The following charts are the data for temperature, rainfall and relative humidity for the year 2008.

Temperature: Annual mean temperature for the year 2008 was 27°C.

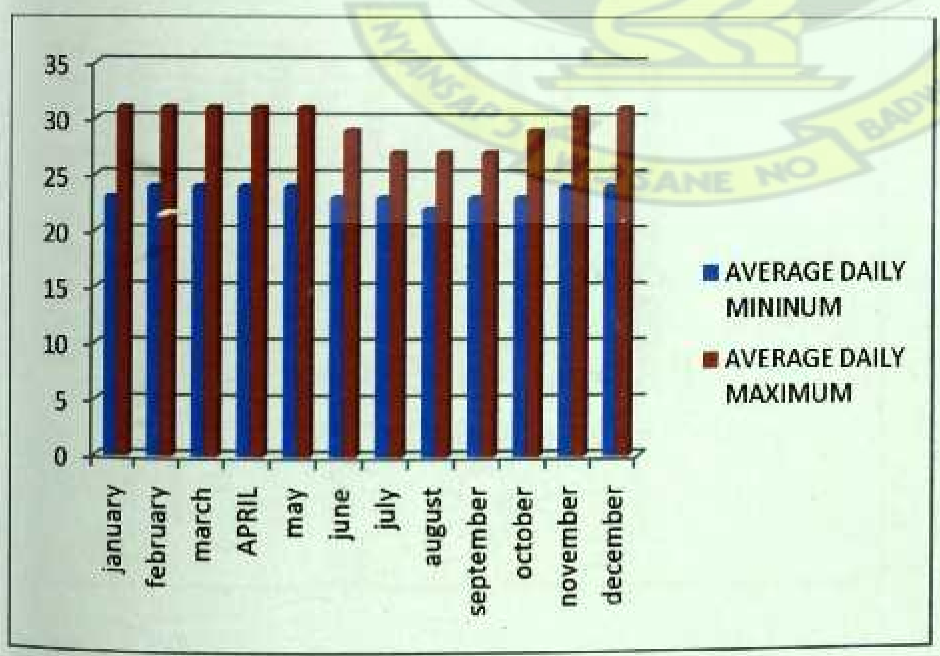


Fig 4.23 Temperature chart for the year 2008

***Rainfall* :** Rainfall varies throughout the year. Annual total rainfall is between 200mm and 18000mm

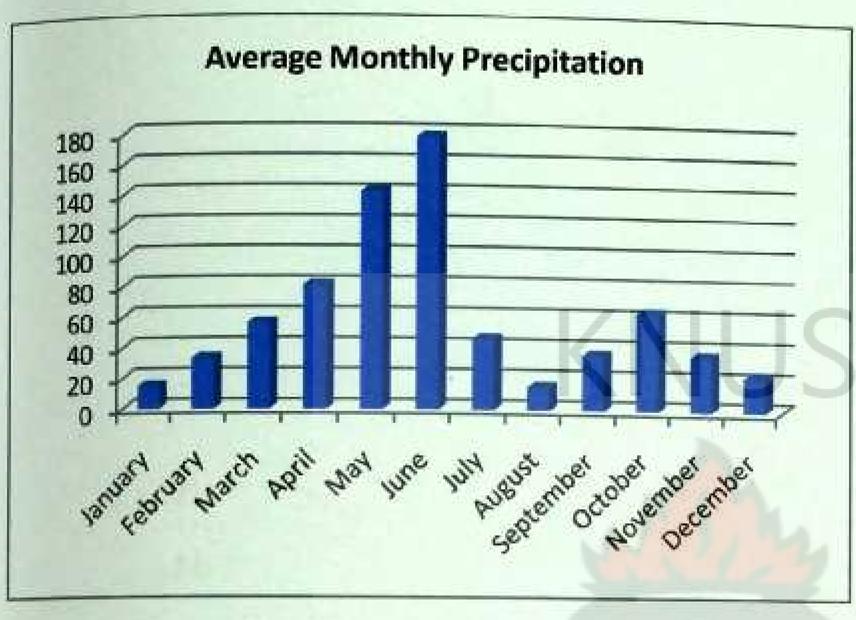


Fig 4.24 Rainfall chart for the year 2008

Relative Humidity: Relative humidity is usually high. The chart below shoes the average relative humidity for the year 2008.

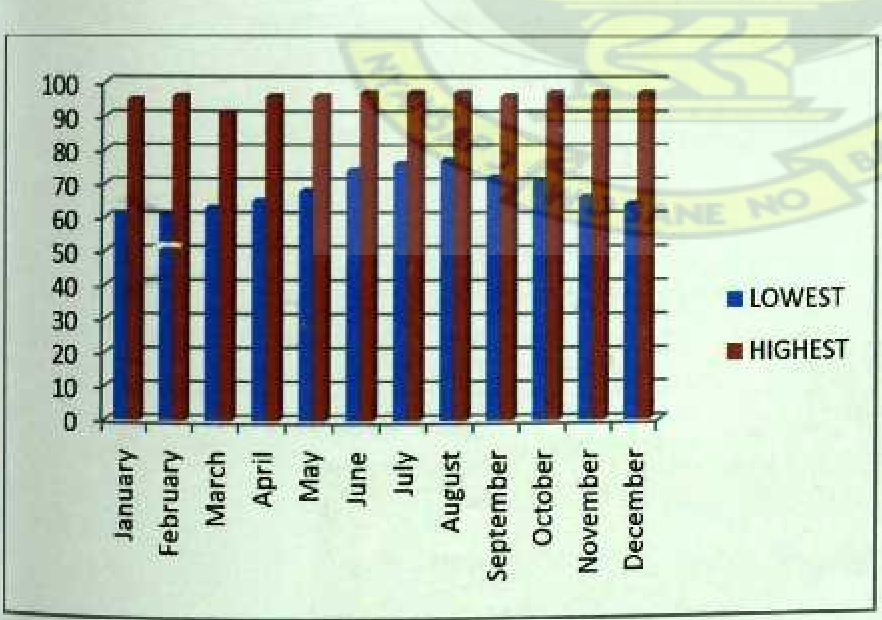


Fig 4.25Relative humidity chart for the year 2008

4.12.4 SITE TOPOGRAPHY

A section through the site shows that the site is generally flat with a gentle slope towards the south western end.

Fig 4.26 Selected Site

Fig 4.27 Section through the site

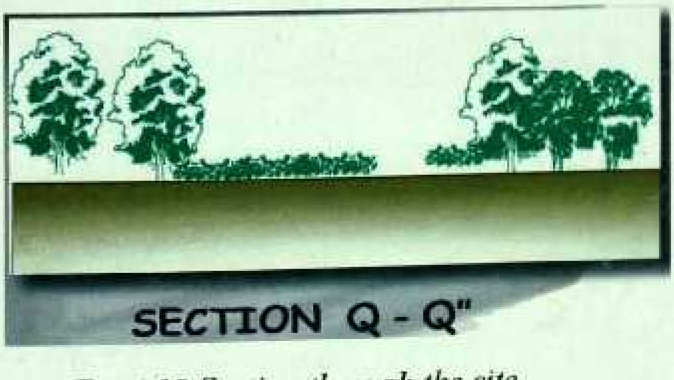


Fig 4.28 Section through the site

4.12.5 EXISTING STRUCTURES

There are few existing structures around the site because the zone is now being developed there are however some existing structures in the industrial area.

4.12.6 SITE PERIPHERAL STUDIES

This involves the existing land use pattern on and around the site .This study was taken in order to take into consederation, the existing structures and features on the site durig the design stage.

Fig 4.29 The Accra- Aflao road which bounds the north western part of the site

Fig 4.30 Garment manufacturing factory located at the south eastern portion of the site

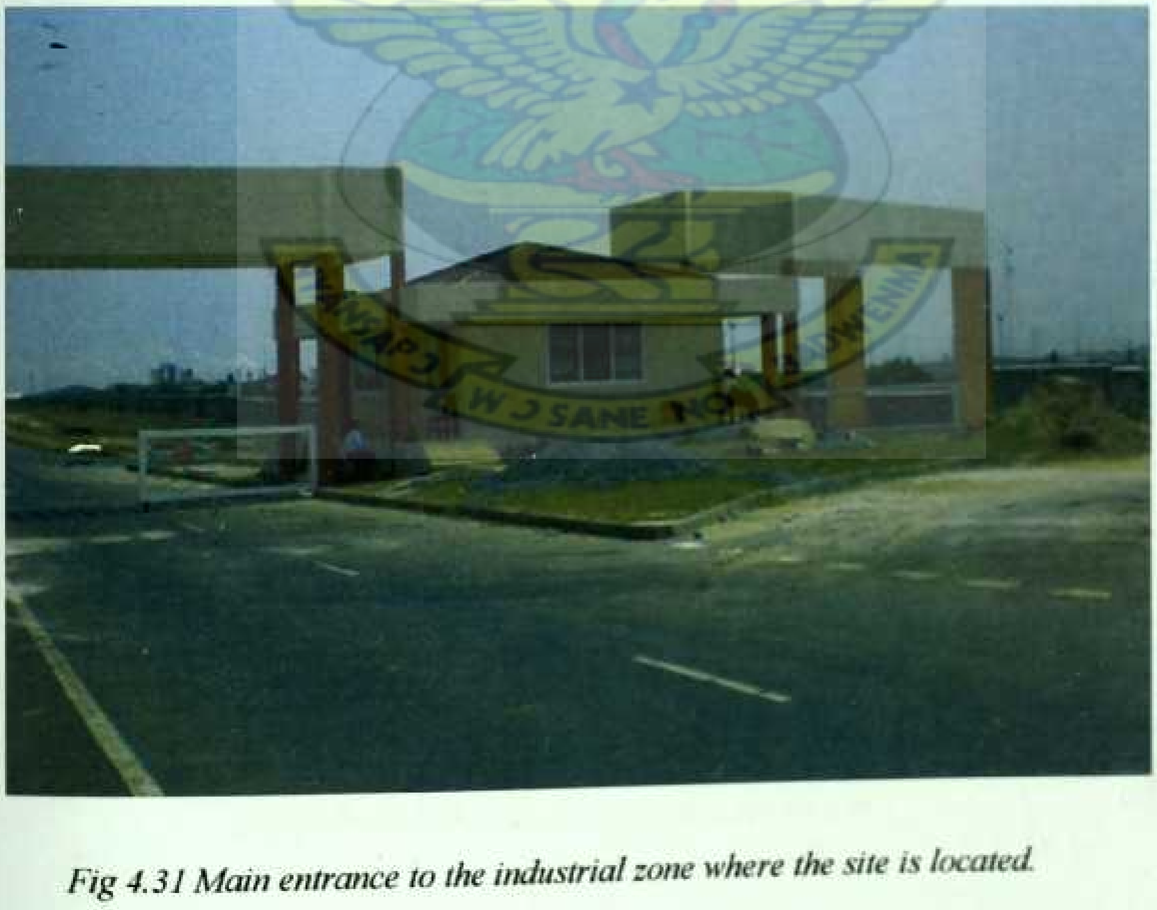


Fig 4.31 Main entrance to the industrial zone where the site is located.

*Fig 4.32 **Overhead** water tank located at the south eastern end of the industrial zone is to augment water supply to the industries located in the zone.*

Fig 4.33 Oil storage area for the Tema Oil Refinery is located across the Accra- Aflao road which bounds the site at the north western end.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 DESIGN EVOLUTION

The evolution of the design of the assembly plant was achieved as a result various studies which were done and documented in the preceding chapters. The design was also achieved with the brief of the client in mind.

5.2 DEVELOPED BRIEF

Administration

The spaces within the administration block includes the following; reception/ waiting area, conference room, boardroom, showroom, offices and after sales service unit.

Production block

The production block has the following spaces; main assembly hall, storage for raw materials and finished products, changing rooms, first aid room, security checks and offices.

Canteen

The canteen includes the following spaces; kitchen, eating area, office, changing rooms and kitchen yard.

Training school

The educational facility has the following spaces; workshop/research, lecture rooms, and maintenance.

5.3 ACCOMMODATION SCHEDULE

The final accommodation schedule took into account requirements of the client and also the need of individuals, and various users of the facility. The final accommodation schedule is as follows:

Administration

Facility	Area(Sq. meters)
Reception/ Waiting area	250
Conference room	180
Boardroom	51
Showroom	305
General Offices	127
Security/ monitoring room	35
Manager's office(Quality Control)	35
Manager's office (Packaging)	35
Manager's office (Inspection)	35
Manager's office (Storage)	35
General manager's office	35
Human resource manager's office	35
C.E.O and Secretary's office	56
Marketing Department	50
Finance office	77.5
Sanitary areas	140
Total	**1481.5**

After Sales Service

Facility	Area(Sq. meters)
Store	77

Spare parts	25
Trouble shooting and sales hall	180
Repairs / After sales servicing	60
Sanitary area	6
Total	**348**

Production Block

Facility	Area(Sq. meters)
Raw material storage	400
Quality control	110
Trolley and tools room	80
Main assembly hall	2120
Managers Office	22.5
Security/ clock in	35
Supervisors office	22.5
Battery/ electrical room	22.5
Entrance lobbies	30
Final testing area	226
Packaging area	260
Finished products storage	316
Changing rooms	90
Sanitary	60
Total	**3794.5**

Canteen

Facility	Area(Sq. meters)
Kitchen	58
Eating area	360
Kitchen yard	31
Matrons office	7.5
Servery	8
Changing rooms	8
Sanitary	7.5
Total	**480**

Training School

Facility	Area(Sq. meters)
Workshop / research	160
Training	160
First aid	80
Sanitary	8
Maintenance	80
Total	**488**

5.4 DESIGN PHILOSOPHY AND CONCEPT

The world is now moving at a fast pace due to the availability of computers which enhances everyday life. Computer technology enables task to be executed very easily and has improved lives across the world. But computers are somehow beyond the reach of average Ghanaians due to the high cost. There is therefore the need to somehow make computers affordable resulting in technological advancements. It was based on this assertion that a design philosophy was chosen for the design; the philosophy for the design is **"impacting society with affordable technology''.** In other words the design of the plant and its running would help make computers assembled locally affordable. To help achieve this various concepts were used. The first concept was to make the design as simple as possible therefore simple forms were employed avoiding the use of unnecessary elements and also a photo-voltaic system employed to help reduce production cost. Another concept was to make the design iconic and adopting the principle that materials and functional requirements determine the results of a design

5.5 CONCEPTUAL SITE PLANNING

The site was planned based on a general principle of separating or zoning the facility into two basic areas which are the private and public zones. The public zones are easily accessible by the workers of the factory and the public whilst the private zones are restricted areas. The public areas include:

- The Administration block
- Show room
- Sales center
- Educational facility
- Canteen
- Parking areas

While the private areas include:

- Production factory

- Service areas
- Quality control
- Power house

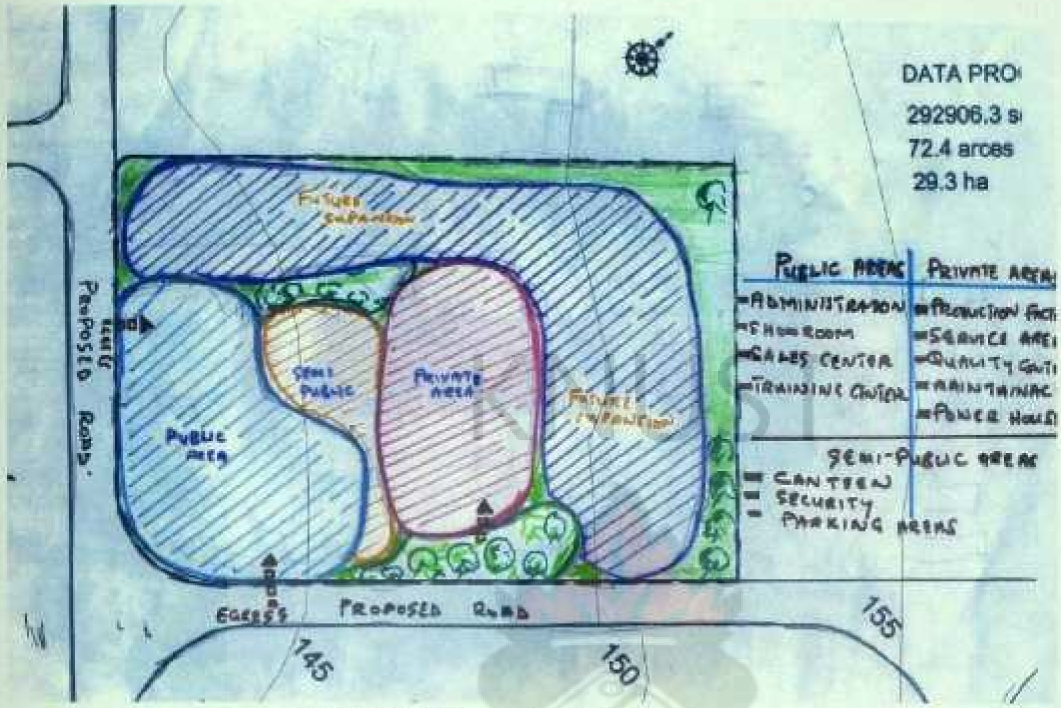


Fig 5.0 Site planning (zoning)

The next task after the segregation of the spaces was to plan the site and organise a layout. Accesses to the facility could be taken by the roads bounding the site. The site is bounded by two main road to the south eastern and south western portions of the site. The roads are proposed roads and accesses to the site would be taken from both roads in order to segregate the accesses to private access and public access. The planning further led to two responses; Options A and B.

5.5.1 OPTION A

With this option the assembly hall or factory is located behind the administration block. The administration block is the main focus of the facility from the bounding roads. The parking for visitors and workers is located at the southern end and accessed from both roads bounding the site. The service area for the factory is just located from the road bounding the site to the south western end.The merits for this option include the strategic location of the factory, good location for parking for visitors and workers and separate parking for the factory. The demerits for this option includes the closeness of the service parking of the factory to the main road, lack of adequate parking for raw materials and finished products for the factory and factory is overshadowed by administration block. Too many accesses to the facility which can create security problems.

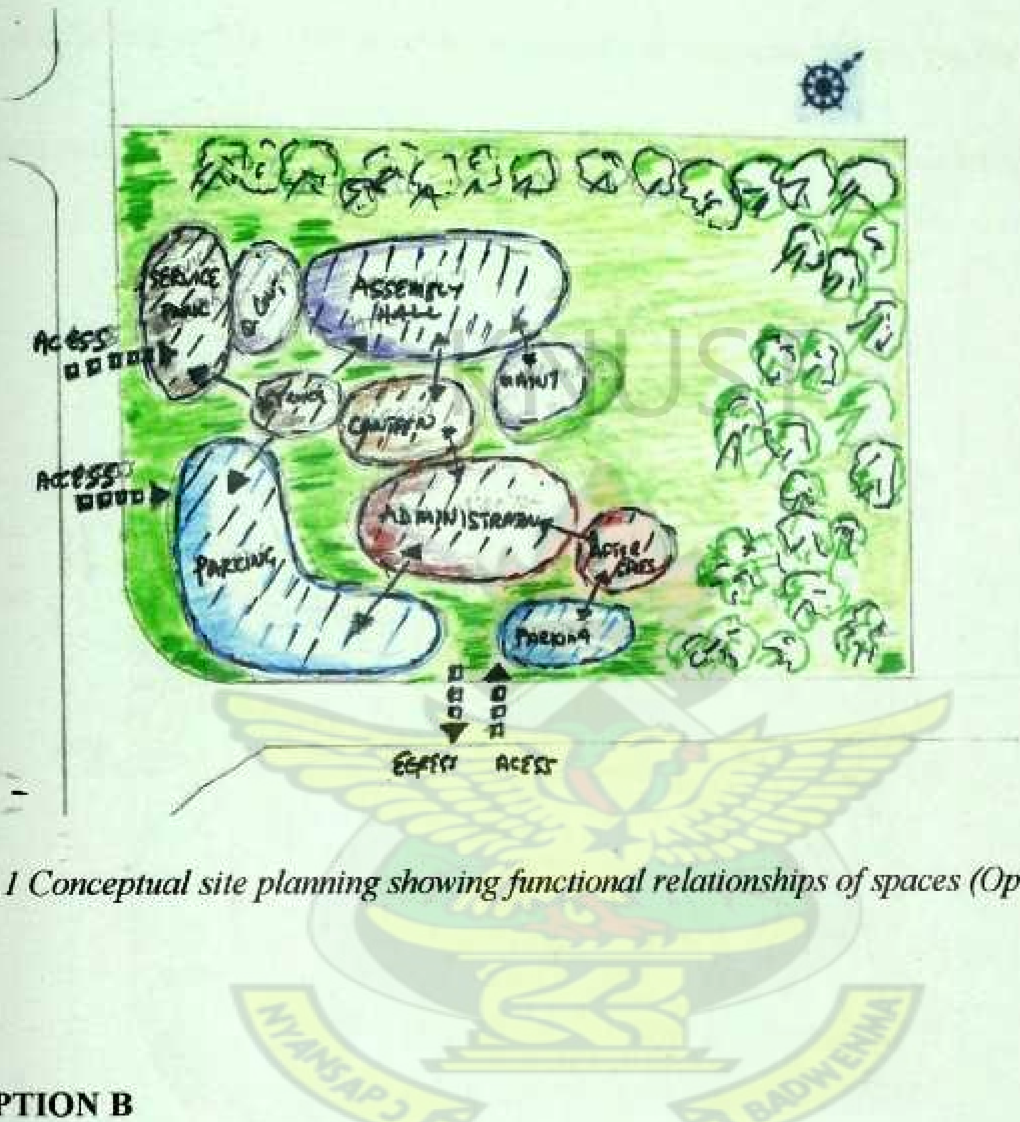


Fig 5.1 Conceptual site planning showing functional relationships of spaces (Option A)

5.5.2 OPTION B

This option was achieved after reviewing the positive and negative aspects of the former option (option A) with the zoning of public and private areas in mind. The administration block serves as buffer to the production factory whilst parking for visitors and staff is located at the southern end of the site which has been zoned as a public area. A separate and private access is taken from the road bounding the site to the south eastern end which only accesses the factory which has a separate service parking. The administration block has clear view towards the factory which can enhance supervision.

The merits of this option include; good location of service parking for the factory, separate parking for visitors, good location for administration block and assembly hall, and controlled number of entrances into the facility.

The demerit for this option is the separate location of the maintenance from the main factory.

This option was finally settled on and improved upon since its merits far outweighed that of Option A .

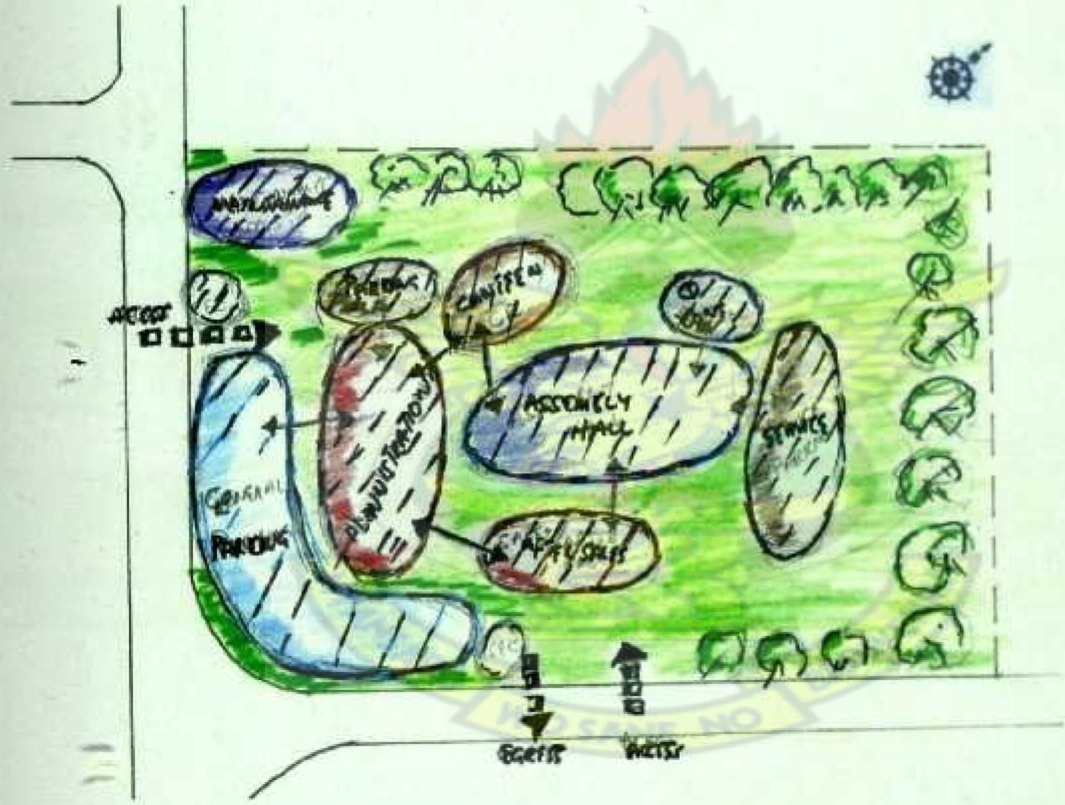
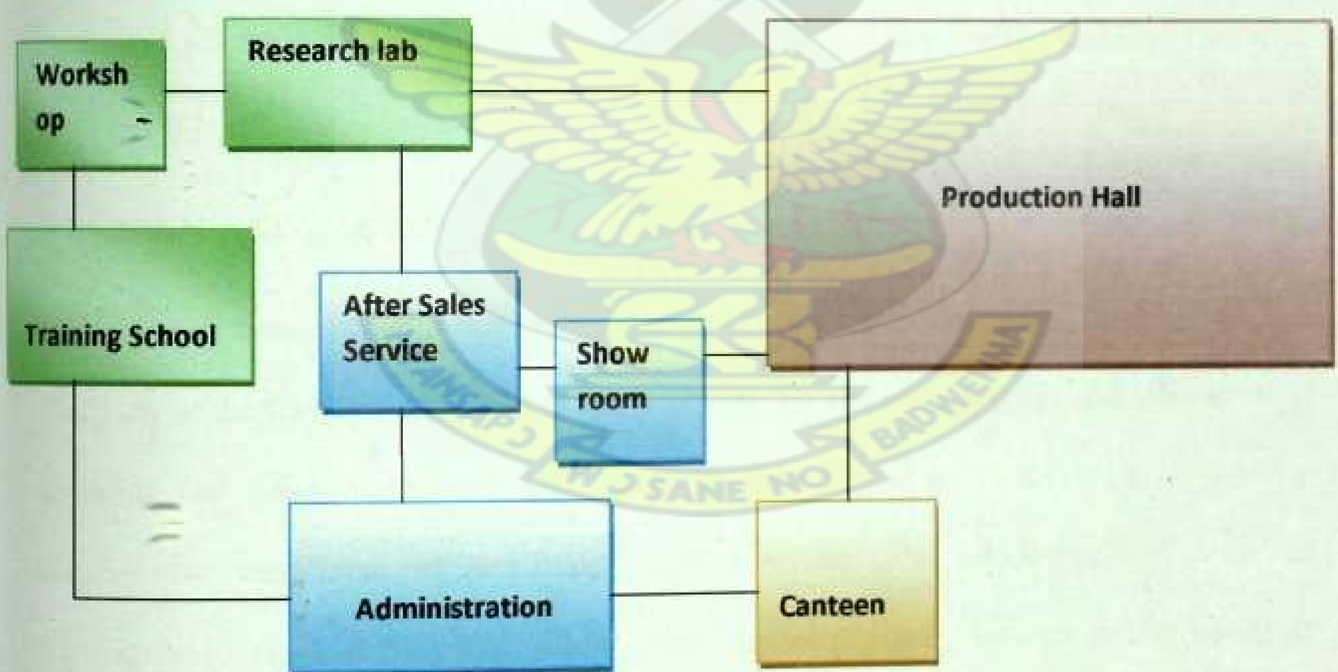


Fig 5.2 Conceptual site planning showing functional relationships of spaces (Option B)

Fig 5.3 Initial response for Option B

5.6 GENERAL FUNCTIONAL RELATIONSHIP



5.7 DESIGN CONSIDERATIONS

Various considerations were taken in respect of the design since a computer assembly plant needs some special factors to be considered. These considerations are explained below:

5.7.1 DUST CONTROL

Dust was a major factor considered when the factory was being designed since the computer components are very sensitive and dust could damage them. A clean lobby or entrance lobby was introduced at the main entrance to minimize the amount of dust entering the factory since it is a controlled environment. Artificial ventilation in the form of air-condition was also employed in the factory in order to also minimize dust.

5.7.2 CHARACTER AND IDENTITY

Some prerequisite conditions is normally needed to ensure good conditions for work and components in a computer assembly plant and these conditions can help define the character of the building, for example considerations have to be made for machinery used in the factory which might require double volume floors. With the design concept as basis simple gable roofs were employed for the whole facility to give the various structures a common character and identity.

5.7.3 FORM AND LAYOUT

The form and layout of the factory and entire facility was also considered during the design. The form of the factory was basically influenced by the assembly process and movement of incoming and finished products. The form was chosen in order to as much as possible enhance the movement of equipments and materials. The other facilities such as administration block and training school were also strategically located in the layout to enhance productivity.

5.7.4 CIRCULATION

Another critical factor considered was circulation. Accesses to the facility are well defined with the main access leading to the general car park. Another private access was created which leads to the factory in order to service the facility. Clean lobbies which are fixed with electro- static filters are used as buffer spaces in the factory. Walkways also link the various structures in the facility.

5.8 THE DESIGN

Most factory designs are designed with function rather than aesthetics being the main driving force behind the design. The layout of the design therefore has functionality considered as the first backbone of the design. The site covers an area of approximately 68,000 square meters and considerations for future expansion was considered during the design. The facility was therefore located mostly to the southern end of the site considering the shape of the site leaving the other areas for future expansion. The facility consists of four main blocks or sections. These facilities work together to achieve a common goal of an effective computer assembly plant. The sections include the main factory, a training school and workshop, the canteen and the administration block which also houses the showroom and sales and after sales service unit and conference facility. These sections range between a single storey and the maximum being double storey.

5.8.1 ADMINISTRATION BLOCK

The administration block is the main structure of the facility which houses basically offices and other facilities for the computer assembly plant. The administration block is located at the southern end of the site close to the parking area for workers and visitors. It consists of two floors. The ground floor consists of the reception area, six offices for administration, security monitoring room and sanitary areas. The showroom and sales and after sales service unit is also located on the ground floor of the administration block. The first floor of the block can be accessed by two different stairs with the main stairs located near the main entrance at the reception area whilst another stair is also located at the south western end near the sanitary area. The first floor of the administration block houses a conference room, boardroom and six other offices notably the office of the C.E.O. the first floor also includes sanitary areas.

5.8.2 TRAINING SCHOOL

The training school augments the computer assembly plant and it is accessible by both the public and workers of the plant. Training of workers would take place in the facility in order to help them achieve new skills and move along with technological advancement. The training school is located at the south western end of the site close to the administration block. The training school is a two storey a structure which basically houses lecture rooms and labs. The ground floor consists of a workshop, training registry, maintenance section, research lab, three lecture rooms and sanitary areas. The first floor of the facility is accessed by a main stair located at the south eastern entrance near the training registry. The first floor of the facility houses three lecture rooms, staff lounge and a library.

5.8.3 CANTEEN

The canteen which services the workers and visitors is located next to the administration block and close to the factory since majority of the workers would be working in the factory. The canteen was also located there in order to take its service accesses from the main service road which also services the factory and as such prevent too many unnecessary vehicular accesses to the facility. The canteen is a single storey structure and includes the kitchen, pantry, sanitary, changing rooms, servery, service yard matron's office and eating area capable of seating over one hundred people. The canteen has four accesses with three accesses to the eating area. Two accesses to the eating area are located at the northern and north eastern area whilst another is located at the southern end. The private areas of the canteen which include the kitchen is accessed by a main entrance located in the service yard and can also be accessed by a door located near the eating area. An open area is located in between the canteen and the factory where workers can relax after meals before proceeding to continue their work.

5.8.4 PRODUCTION BLOCK / FACTORY

The main production block where the assembling of the computers takes place. The factory consists of two storage areas, for incoming materials and finished products, a main assembling hall which also houses offices, first aid room and security monitoring, changing rooms and sanitary. The factory is located at the northern end of the site close to the other facilities. Workers access the factory from the north eastern of the factory. The main entrance is located centrally and opens into a corridor which in turn leads to an entrance lobby or clean lobby which was created in order to regulate the environment within the main production hall. The changing rooms for both male and female workers are located near the entrance to enable the workers to change before they are clocked in into the factory. The storage spaces or ware houses were located strategically with the computer assembly process in mind. The storage for the incoming materials is separated from the finished products storage and is located at the northern portion of the facility. The storage area houses racks and cabinets where the raw materials are stored and it also houses a portion for storage of waste or defective materials. An access door from the incoming materials storage leads into the quality control area where the stored materials are checked or tested for defects before they are used for the assembly. The main assembly hall also houses equipments for the computer assembly, these equipments consists of conveyors and working surfaces for the assembly. A tools and trolleys room is also located next to the quality control section; tools are kept here after each day's work. The factory is a single storey structure but has a double volume. The extra volume helps in accommodating a mezzanine floor which houses five offices and security room for effective control of the assembly process. A testing area and packaging area is also located within the main assembly hall. The packaging area also houses a partition where the packaging materials are stored. An access leads from the packaging area to the finished products storage where the assembled computers are stored.

5.8.5 ANCILLARY FACILITIES

The ancillary facilities of the computer assembly plant include the power house. This structure located at the northern part of the facility close to the factory houses the power plant, the air condition plant and sanitary and rest area for the drivers. An office is also located here to issue clearance for the drivers to exit the facility. The air condition plant supplies air condition to the factory and offices. Other ancillary facilities include three security houses which are located at the major vehicular entry and exit points into the facility. The security house consists of a space and sanitary to accommodate at least two security personnel.

5.9 SERVICES

Critical to the survival and existence of a structure is its services. Even though the structure itself has a long life expectancy, equipments used in the structure eventually wear out and thus needs replacement or servicing. With this consideration in mind, mechanical equipments, lobbies, stairs, washrooms and ducts which might eventually require some form of servicing were strategically located in order to allow easy access to these areas to carry out the necessary servicing and avoid disrupting effective work.Electrical connections and telecommunication modes were of a modular nature to allow future changes in the system to be catered for. Communication cables are housed in floor trunking. The telecommunication cables in the various structures were also protected from water.

5.9.1 ELECTRICITY

Three phase electric power is tapped from the National Grid to a transformer in the power house on the site for an automatic power switch in case of any power outage. This is then sent to the distribution boards in the various structures for distribution. When the power supply from the mains is not up to the required voltage, step up transformers is used and when there is power fluctuation the backup generator in the power house takes over this generator can run for at least thirty minutes during which an ordered shut down would have been done. This is essential to prevent data loss or damage to components due to power fluctuation. Power generated by photo voltaic cells is also used to supplement power from the national grid in the main factory.

5.9.2 LIGHTING

Lighting administrated in the various structures is partly natural and artificial. Day lighting has been explored to reduce electric energy consumption. The various structures are well designed to achieve the use of day lighting with the use of artificial lighting mainly supplementary and aesthetic. Courtyard system was incorporated in the training school to achieve maximum use of day lighting. Glazing materials for windows also allow an appreciable amount of light into interior spaces. The factory relies heavily on artificial lightning to help achieve the correct amount of lighting level due to the nature of the work that goes on there. This is however augmented with the use of solar energy or photovoltaic cells to help reduce the cost of using the artificial lights mainly on the national electricity grid. The artificial lighting employed in the structures consists of fluorescent lamps and energy efficient bulbs. To take care of excess day lighting and glare, various modes of sun shading devices were used to control the amount of natural light that enters a space and also the heat that comes with it. Generally the lighting requirement for use in a computer room must be bright and shadow-less. The general levels achieved should be at least 30-35ft, Candles (10) (322.92 lux-376.74 lux)

5.9.3 VENTILATION

Ventilation system used in the entire facility differs from structure to structure. But ventilation is in the form of natural ventilation augmented with artificial ventilation in the form of air conditioning. The factory relies on artificial ventilation or air condition due to the nature of the work and the components being used for the work since computer systems require a fairly high degree of environmental control for optimum functioning. The building is fitted with a central air conditioning system. The building receives an air supply conditioned to the required temperature and humidity from a central air condition plant and distributed through various vents in the ceiling of the structure. The eating area of the canteen augments the natural ventilation through the various windows provided with the use of ceiling fans to help circulate the air through the space. The administration block also augments natural ventilation with air condition supplied to the various spaces within the structure. The training school also augments natural ventilation with the use of ceiling fans in the various lecture rooms whilst the laboratories use air condition to help achieve the correct temperature and humidity level needed for the components and equipments work effectively. Generally, computer systems require a fairly degree of environmental control for optimum performance. Many peripheral units can operate in normal air conditioned room example printers, and visual display but other computer components such as disk tapes, motherboards and central processors require a higher level of environmental control before and during the assembly process. Due to this, air condition is the best choice for ventilating the computer assembly plant and should be able to regulate the environment suitable for both workers and computers.

5.9.4 INFORMATION AND COMMUNICATION SYSTEMS

Communication lines are also tapped from Ghana telecom lines close to the site and also the use of radio and satellite phones as a means of communication. Another form of communication used within the facility is the PABX (private automated branch exchange) system for internal communication within the assembly plant. Such communication systems help save time and money. Communication cables are housed in floor trunking and false floors. Information systems such as the internet, radios and television among others are used to provide both the workers and customers with needed information and news. There also other avenues of sources of information such internet cafes and bulletin boards in the design to foster the spread of information.

5.9.5 FIRE PROTECTION

The prevention and controlling of fire outbreaks is very important and care was taken to fifth fire. Fire resistant materials are used throughout the design in the interior of the spaces. Other measures include provision of fire hydrants in the entire facility whilst extinguishers are also provided within the individual buildings. Emergency exits have also been provided in strategic places to help are live in case of emergency.

5.9.6 WATER

The main source of water supply to the facility is tapped from the Ghana Water Company lines located near the site. A large overhead water tank located in the area the project is located also augments water supply to the facility.

5.9.7 SECURITY

The provision of adequate security is very important for the success of the plant. Various security measures are put in place to ensure maximum security of the facilities. Sophisticated electronic security systems such CCTV (close circuit television) cameras is placed at strategic points within the assembly hall and also outside to ensure security. This is monitored by well trained staff in various security monitoring rooms located in the facility. Security locks which require codes are also used to secure the doors to ensure entry to only authorised people. Security personnel located in security posts also ensure adequate security around the facility. Security lights is also provided to light to the facility at night to ensure security.

5.9.8 WASTE DISPOSAL

Solid waste from the various structures in the facility is catered for by a central waste disposal septic tank located on site. Liquid waste from sinks and the kitchen is also channelled into gutters. Various waste bins are also placed strategically to ensure a clean environment.

5.9.9 DRAINAGE

Surface drainage is also employed through the use of underground drainage pipes into gutters located within the facility. The use of both covered and open drains to collect surface water is also used.

5.10 CONSTRUCTION TECHNOLOGY

The design was achieved taking a lot of principles and construction technology into mind. The use of materials was carefully considered to ensure that conditions are suitable for work.

5.10.1 STRUCTURAL SYSTEM

The structure is basically in steel and concrete. Most of the floors were made of reinforced concrete. Concrete has a high fire rating ratio. The structural system employed is the post and beam construction with reinforced concrete columns which are tied together with beams. The partitioning of the various spaces is also achieved with the use of non-load bearing walls.

Floors

The type of floors used depended on the required strength, and cabling connections beneath the machines. The cabling connections were made beneath the floors. The flooring materials used were resilient and do not attract dust and sound absorbent. A static free carpet was used in the entrance lobby of the computer assembly factory ensuring that the main assembly hall was static free.

Roofing

Trusses are used for the roofing of all the various structures within the facility. Steel trusses were used for the bigger spans such as the production factory, whilst timber trusses were used for smller spans such as the administration block.

Ceiling

Most lighting and air condition fittings were housed in the ceilings of the various facilities. The ceiling material used in the factory was sound absorbent and had static free qualities. Other ceiling materials of aesthetic values were used in the public areas such as the reception and show room.

Walls

The walls used in the facility were basically sandcrete blocks. The factory had walls which were coated to have a static free and do not attract dust and also have sound absorbent qualities.

5.10.2 FINISHES

The finishes used in the facility were also very critical in the design since they also affect the production one way or the other. The various finishes for the entire facility differed from structure to structure and was basically dependent on what went on in the facility. Ceilings for the offices were of t&g whilst other places such as the conference room were made of acoustic tiles. Gres non slip tile which is dust free, resilient was specified for the computer lecture room in the training school. Other areas like the reception and entrance foyer is finished with polished granite tiles. Portions of the elevations are finished with curtain walling. The material for the curtain walling is Zinc coated Aluminium oxide heat reflecting glass.

5.10.3 SOLAR CONTROL

The orientation of the structure on the site necessitated complete control of solar ingress into the various facilities to help achieve human comfort and optimal equipment performance. Sun shading devises were used extensively in the facilities to ensure that only a limited and correct amount of light and heat were allowed into a space. The curtain walls used in the facility is made of is Zinc coated Aluminium oxide heat reflecting glass which reflects about 70% of the solar radiation incident on it and converts the remaining 30% into a red bias light. The red bias light is very good for computer fitted rooms since it does not create glare.

5.11 COST ESTIMATES

The preliminary cost of the project was estimated based on the prevailing market rate of GH¢340 per square metre. The cost of the project was estimated using the approximate estimation method. The approximate estimation method involves calculating the unit cost per floor area and the probable total cost of the facility is then obtained by multiplying the total floor area by the calculated rate.

The costing is also aimed at giving the client a fair idea about the financial investment the project will need.

Based on the current market trends a unit of GH¢340 per square metre was used for the calculation.

Facility	**area m^2**	**cost (GH¢)**
Administration	1481.5	1481.5 x 340 = 503710
After Sales Service	348	348 x 340 = 118320
Production factory	3794.5	3794.5 x 340 = 1290130
Canteen	480	480 x 340 = 163200
Training school	488	488 x 340 = 165920

Total Cost = 2241280 GH¢

5.12 CONCLUSION

The major role information and communication technology which has computers as their backbone is playing in the world now cannot be underestimated. ICT has led to globalization and liberalization of the world economies with immense benefits to the world. It is with this idea that computer literacy is on the ascendancy in the country with the government actively encouraging and promoting information and communication technology through many policies such as the "one laptop per child Project". The establishment of a local computer assembly plant in the country is there a step in the right direction since it would make computers affordable and therefore modernise the Ghanaian economy with its resultant benefits.

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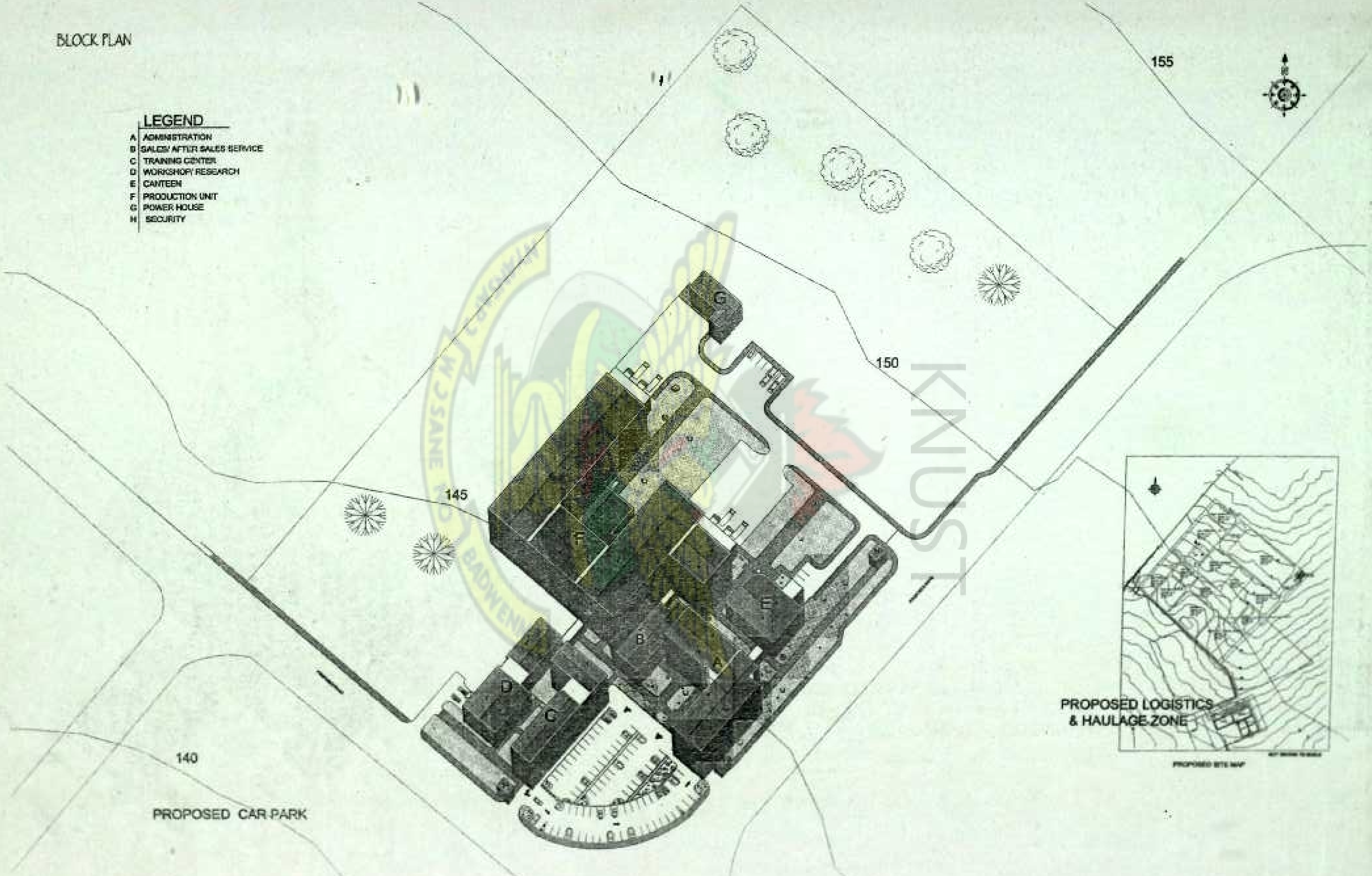
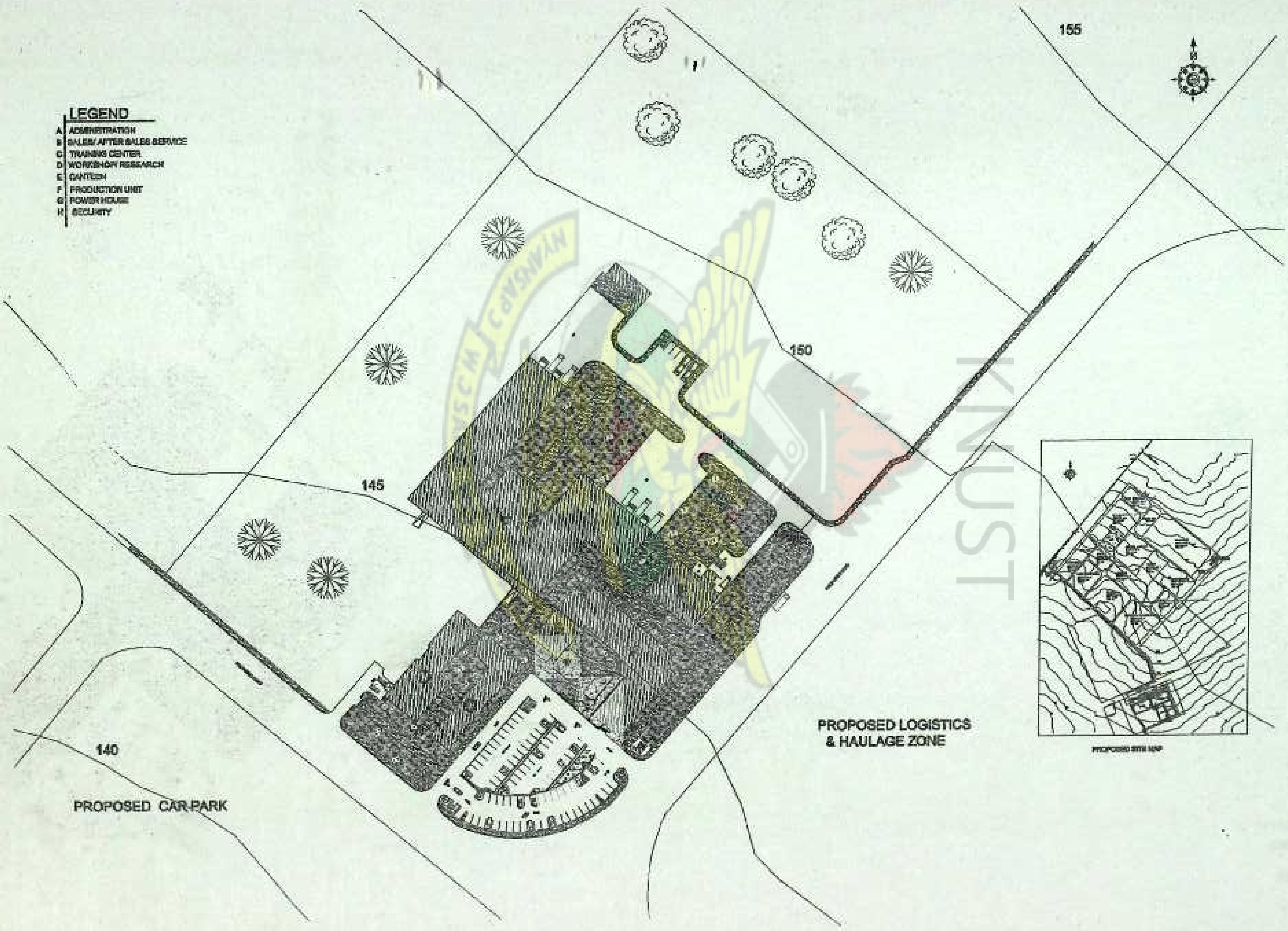
14. http://www.ghanaweb.com
15. http://www.zdnet.com

APPENDIX (ARCHITECTURAL DRAWINGS)

BLOCK PLAN


LEGEND
A ADMINISTRATION
B SALES/ AFTER SALES SERVICE
C TRAINING CENTER
D WORKSHOP/ RESEARCH
E CANTEEN
F PRODUCTION UNIT
G POWER HOUSE
H SECURITY
155
150
145
140
A
B
C
D
E
F
G
PROPOSED CAR PARK
PROPOSED LOGISTICS
& HAULAGE ZONE
PROPOSED SITE MAP



LEGEND
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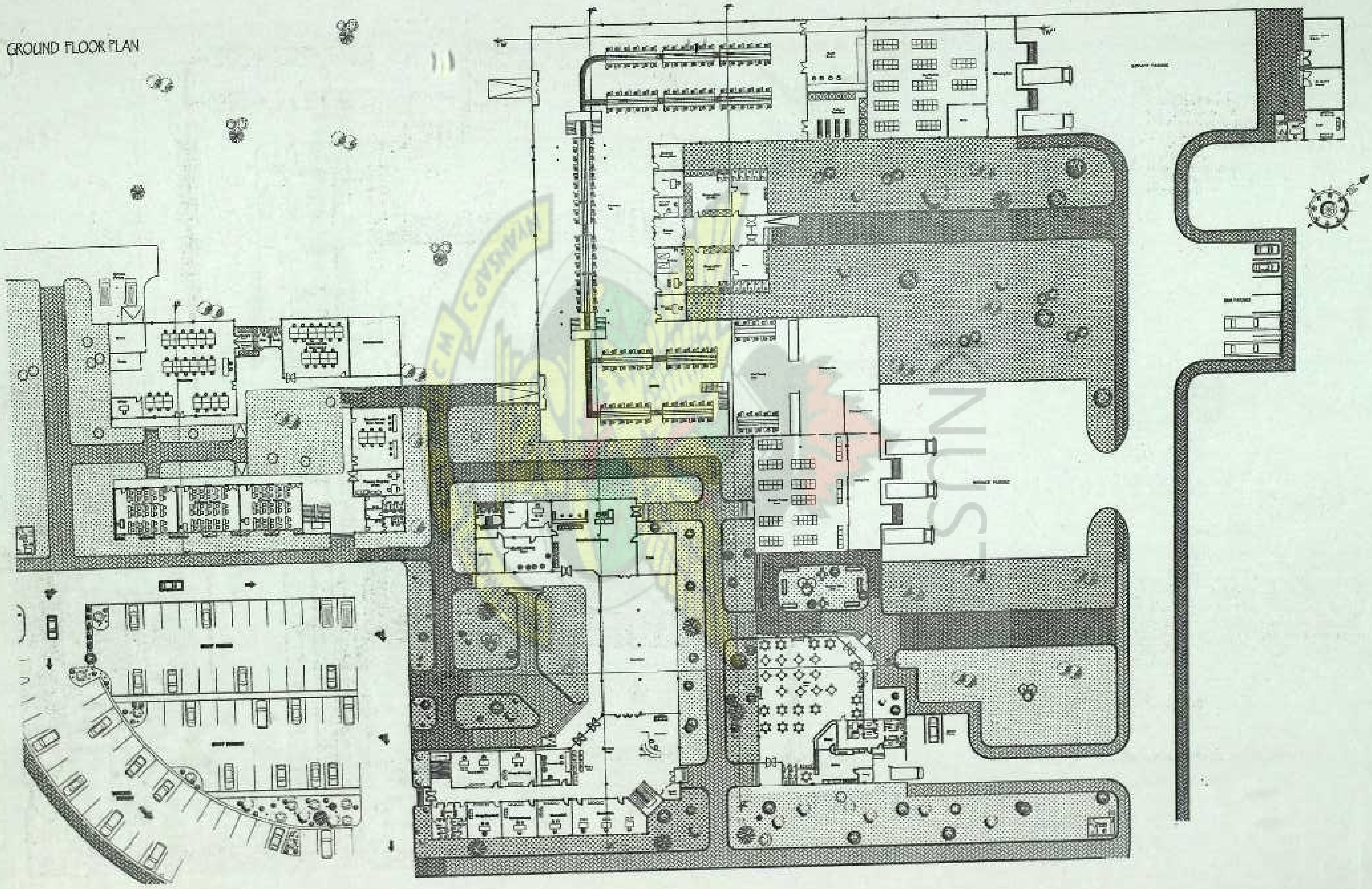
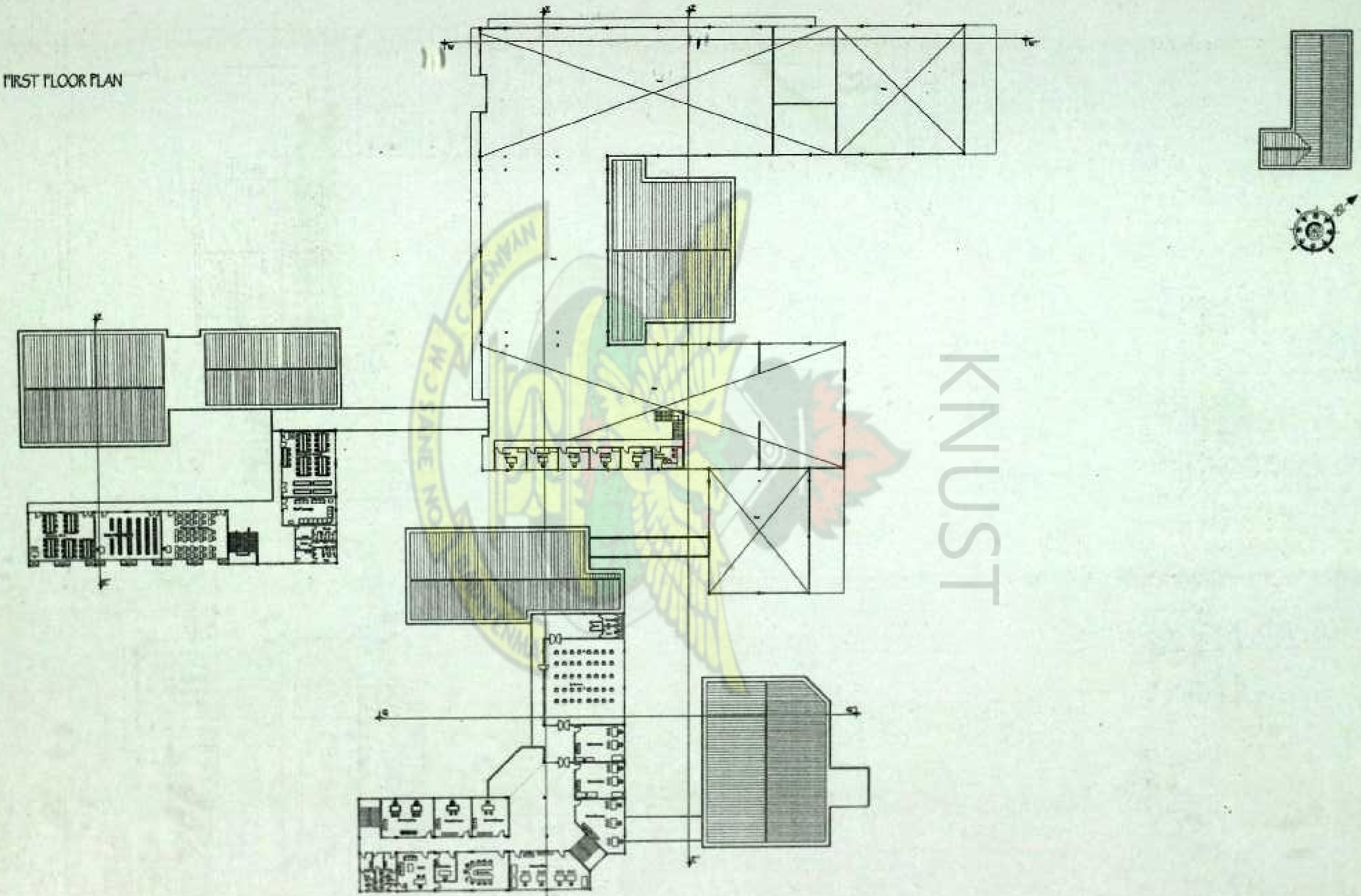
E CANTEEN
F PRODUCTION UNIT
G POWER HOUSE
H SECURITY
155
150
145
140
PROPOSED LOGISTICS
& HAULAGE ZONE
PROPOSED CAR PARK

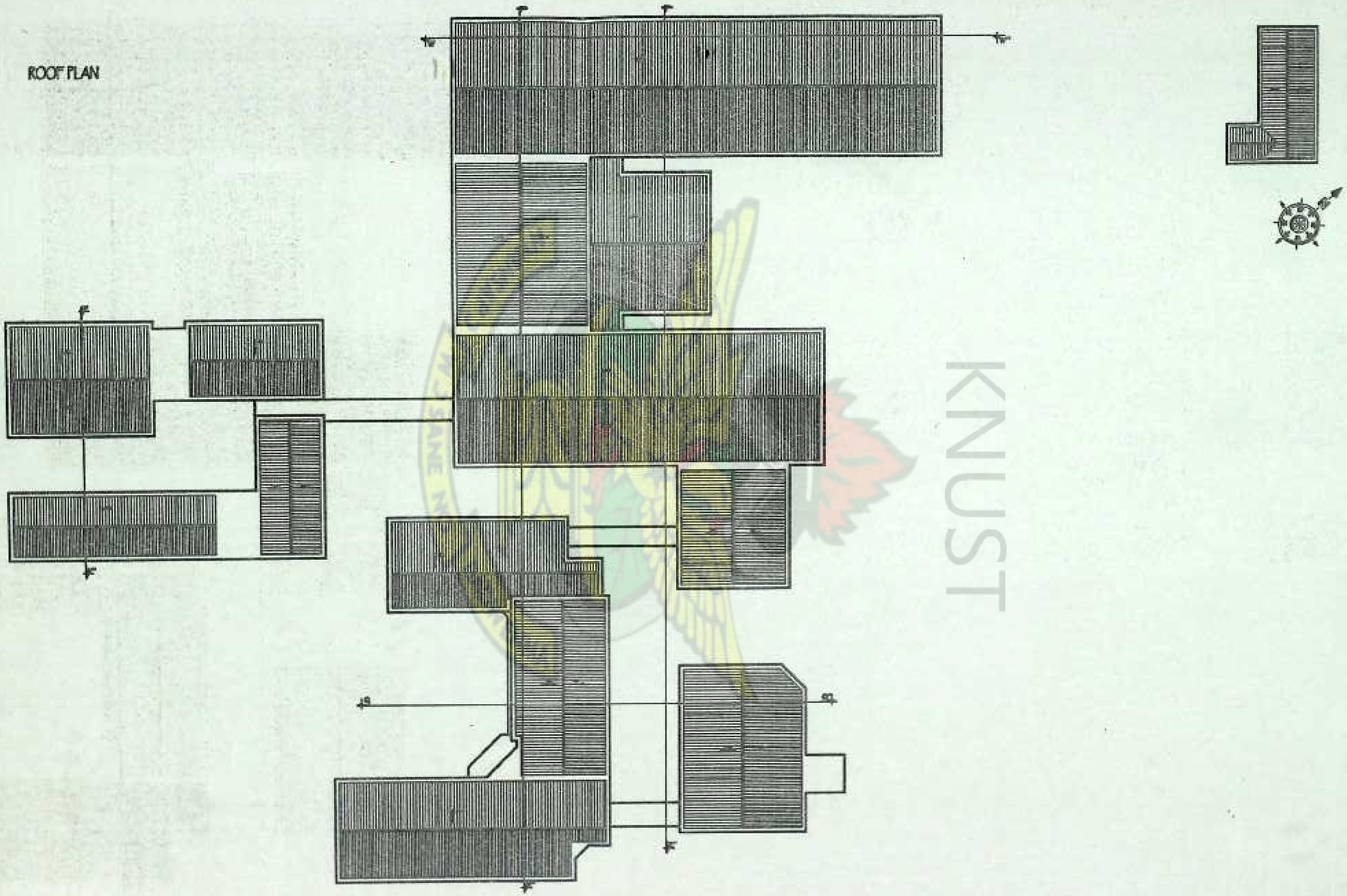
GROUND FLOOR PLAN



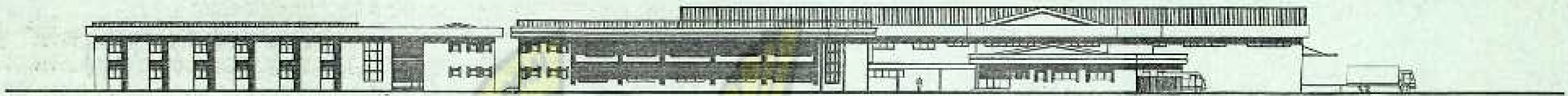
FIRST FLOOR PLAN



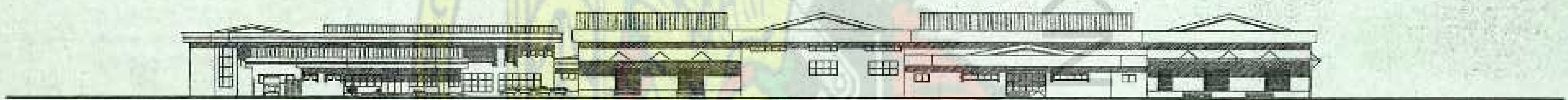
ROOF PLAN



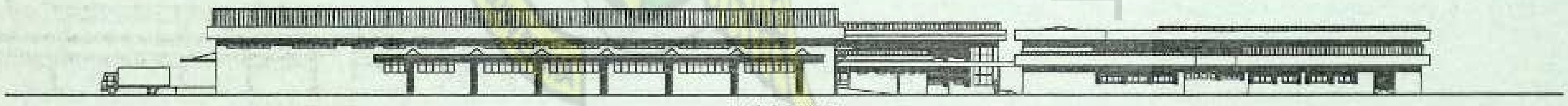
ELEVATIONS



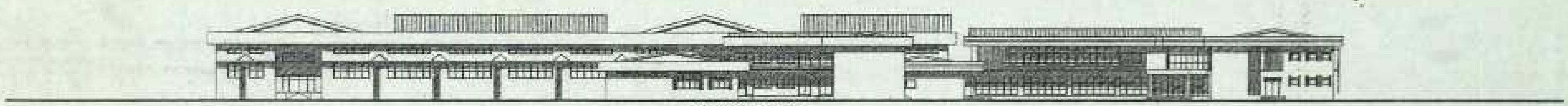
SOUTH EAST ELEVATION



NORTH EAST ELEVATION

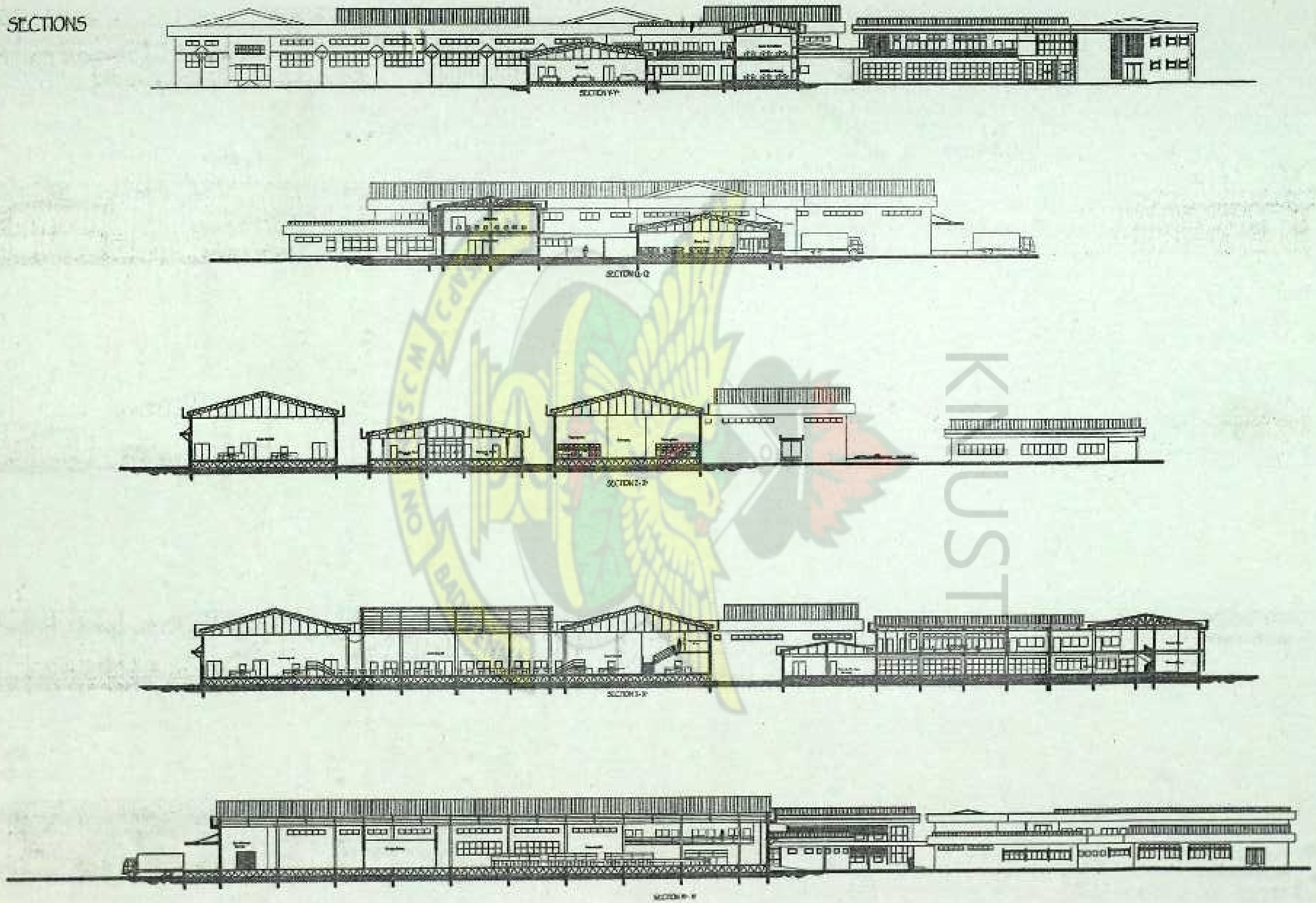


NORTH WEST ELEVATION

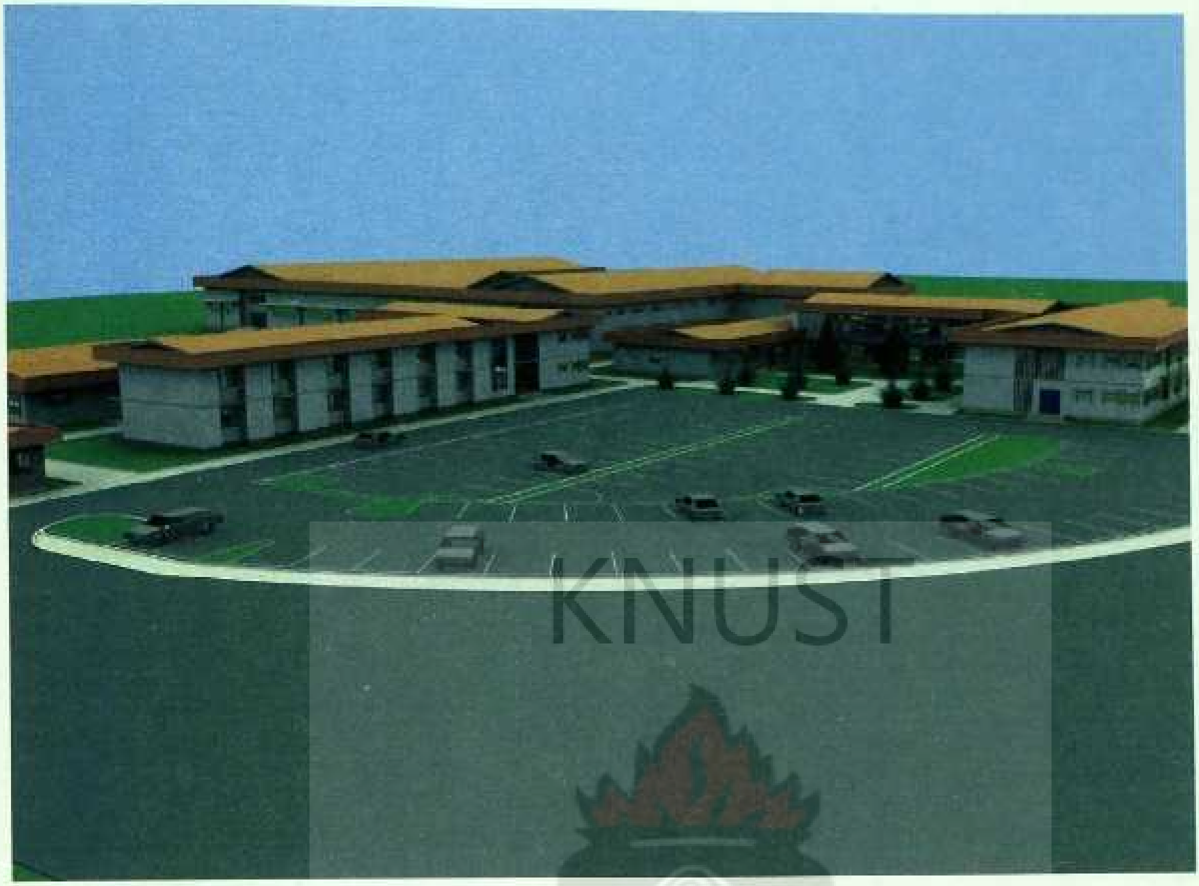


SOUTH WEST ELEVATION

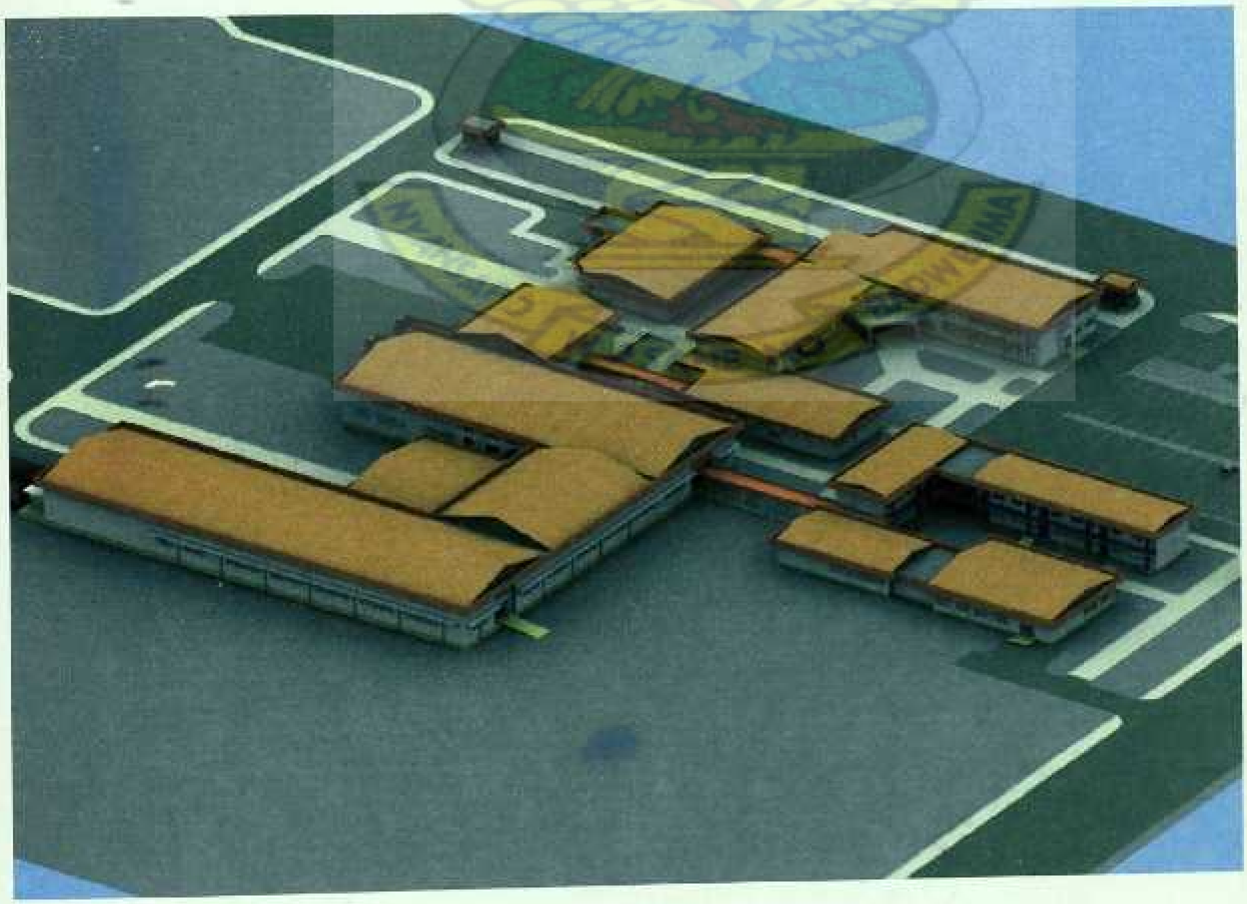
SECTIONS



3D IMPRESSIONS



View towards the training school and administration block.



Aerial view from the northwestern end of the site

3D IMPRESSIONS

Aerial view of entire facility from the southern of the site.

View towards the administration block and after sales service block