KWAME NKRUMAH UNIVERSITY OF SCIENCE AMD TECHNOLOGY
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DEPARTMENT OF ARCHITECTURE

TOPIC:

HERBAL DRUG FACILITY, KUMASI

A DESIGN THESIS REPORT SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF THE AWARD OF POST GRADUATE DIPLOMA IN ARCHITECTURE

BY

ODJIDJA TETTEH

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DECLARATION

I hereby declare that this thesis report has been undertaken solely by me and is an original and not a duplicate or plagiarised work. It has resulted from thorough research and logical analysis and synthesis under department staff supervision.

....

Odjidja Tetteh Date

I hereby declare that this work is an original research undertaken by my student and has been done under my supervision

..... 15/07/09

Mr. S.O Afram Date

Certified by

....

Prof. G.W.K Instiful Date

(Head department)

DEDICATION

Dedicated to my mother Miss Cecilia Owusu-Acheaw and the rest of the Family

ACKNOWLEDGEMENT

I give thanks to the Almighty God for his guidance and protection throughout these years of my study

Immense thanks also to my thesis supervisor Mr. S.O Afram for taking me under his wing and guiding me through this thesis.

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Achievements come with great sacrifices, dedication, effort and determination. To myself, Bravo.

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ABSTRACT

The role of medicinal plants in health care delivery in Ghana cannot be overlooked. Unfortunately, the very foundation upon which the medicinal plant species and the traditional health care system survive is threatened by lack of scientifically proven research and safe and quality manufacturing processes.

In order to substantiate claims made by traditional medicine practitioners for various plants in the treatment of certain diseases it is necessary to use modern scientific methods to carry out systematic investigations into the constituents and effects of these plants.

The capacity to provide research facilities for identification, analysis, evaluation and pharmacological studies of plants of medicinal value; provide facilities for clinical trials and consultations with herbal medicine with government backing, is limited to a very few.

Effective monitoring of herbal practices and adequate scientific research to make herbal medicine safe and quality for public use can only be ensured if research centres are setup throughout the country to serve as satellites centres to coordinate research findings and data on various plant species in designated location with the government approved Centre For Scientific Research Into Plant Medicine (CSRPM) with its single branch located at Mampong-Akuapem in the Eastern Region of Ghana.

This thesis largely seeks to propose for an establishment of an herbal drug facility in Kumasi equipped with facilities for research, production and clinical consultations with herbal medicine.

CHAPTER ONE

1.1 INTRODUCTION

Throughout history herbal medicine has played and continues to play a vital role in health care delivery. They are indispensible for human health and provide a great number of remedies required for good health care systems, particularly in developing countries around the world such as Ghana.

In 2003, the World Health Organization (WHO) estimated that 80% of the world's population depended on traditional medicine to meet their primary health care needs and the demand for traditional herbal medicine approximately US $14 billion per year and growing at the rate of 15% to 20% annually. Seven out of every ten people in Africa rely on traditional herbal medicine according to its recent estimations.

According to research done by the Centre for Scientific Research into Plant Medicine (CSRPM) Mampong-Akuapem, 70% of Ghanaians use herbal medicine either because it's easily accessible, cheaper, more convenient or simply believed to be more effective than orthodox medicine, hence the need for the government to research into and develop this sector of health care.

Successive Governments have recognized the importance of medicinal plants in health care delivery in the country thus the various attempts to regulate the practice of traditional medicine and the preparation and sale of herbal medicines. Such initiatives resulted in the establishment of CSRPM, Mampong-Akuapem, the commissioning of the Traditional Medicine Practice Council and the passing of the Traditional Medicine Act in 2000.

1.2 Problem Statement

As orthodox health care and medicine gets increasingly expensive and inaccessible, growing numbers of people are turning towards traditional herbal medicine and health care. In addition to these orthodox medicines being more expensive, majority of the Ghanaian population live in areas where there is no access to these modern orthodox health care facilities thus the first point of call for these people is to see herbal practitioners. Most of these herbal drugs are not certified and raises health safety concerns. In view of these concerns that the Ghana health authorities in collaboration with the traditional health practitioners, WHO, CSRPM, Ghana Food and Drugs Board, Nuguchi Memorial Institute for Medicinal Research have launched a program to help look at the safety, quality and the efficacy of these herbal medicines to ensure that traditional herbal medicine is made safe for public consumption.

Kumasi which is the second populous city in the country and also the capital of the most populous region in Ghana, has over the years achieved the unofficial status as the largest patron of traditional herbal medicine in the country thus there is the need to ensure that herbal drugs that are sold to consumers are safe.

1.3 Objectives

- To establish a government approved modern scientific centre for research into traditional herbal medicine in the northern sector of Ghana capable of conducting and promoting scientific research relating to the improvement of plant medicine and also organize training seminars for herbalists across the country. This centre will serve as a satellite centre for CSRPM.

- To provide a well-established and functioning laboratory to carry out assessment and evaluation of herbal medicines.
- To provide a modern production plant or unit capable of producing large quantities of various dosages of herbal drugs thus reducing the dependence on imported drugs.

1.4 Scope Of Thesis

This thesis largely seeks to set up the basis for the provision of a modern herbal drug facility which will thereby lead to the research and proposal for the design of such a facility in Kumasi.

1.5 Justification

As stated in the 2008 programme of work for the CSRPM there is the need for the setting up of satellite centres across the country to enhance the supervision and operations of traditional medical practitioners and enable extensive research of herbal medicine.

Dr. Kofi Bobi Barimah, Acting Dean of Faculty of Public Health and Allied Sciences of the Catholic University College of Ghana speaking in a forum organized by BUSAC Fund under the theme "traditional medicine in Ghana: practice, preference and problems" stressed the need for the establishment of four satellite centres and ten herbal medicine units across the country to help enhance the operations of practitioners and also enable supervision over their activities.

Ashanti region being the most populous region in the country with the most health care centres in the country (Ghana Health Service), there is the need to provide a centre capable of regulating and monitoring herbal drugs that is provided by primary health care providers in the region. It

should also have the capacity to produce safe and quality herbal drugs to help reduce the dependence on uncertified herbal drugs and foreign imported drugs both in the region and the country as a whole.

There is also the need for a research facility that can support the national health insurance authority's move of adding herbal medicines to the essential medicines list of the national health insurance scheme.

1.6 Target Group

- Traditional medicine practitioners
- Herbal drugs manufacturers
- Patients
- Researchers
- Wholesalers of herbal drugs

1.7 Client

- Ministry of health
- Centre for scientific research into plant medicine (CSRPM)

1.8 Client Brief

The main centre of attention of this design is in three parts:

- Research facility

- Clinical services facility
- Production unit

.9 Financiers

The project with its potential of helping promote traditional health care delivery will be financed primary by the Ministry of Health with contributions of funds, equipment and expertise from other bodies such as

- CSRPM
- WHO
- Traditional medicine practitioners council

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Herbal medicine

Herbal medicine, also called botanical medicine or phytomedicine, refers to the use of any plant's seeds, berries, roots, leaves, bark, or flowers for medicinal purposes. Long practiced outside of conventional medicine, herbalism is becoming more main stream as up-to-date analysis and research show their value in the treatment and prevention of disease. Sometimes the scope of herbal medicine is extended to include fungi and bee products, as well as minerals, shells and certain animal parts.

Many plants synthesize substances that are useful to the maintenance of health in humans and other animals. These include aromatic substances, most of which are phenols or their oxygen-substituted derivatives such as tannins. Many are secondary metabolites, of which at least 12,000 have been isolated, a number estimated to be less than 10% of the total. In many cases, these substances (particularly the alkaloids) serve as plant defence mechanisms against predation by microorganisms, insects, and herbivores. Many of the herbs and spices used by humans to season food yield useful medicinal compounds

2.2 History of herbal medicine

Herbal medicine is a practice that is as old as mankind, and certainly older than agriculture or writing; every human culture on every continent of the Earth has practiced herbal medicine of one form or another. Perhaps best described as "medicinal botany", herbal medicine involves

taking plants, ingesting them, and seeing if some of the elements in the plant have a palliative effect on the symptoms of the ailment.

Herbal remedies have formed the basis of traditional medicine for millennia, and have formed the root of modern pharmacology. Many drugs listed as conventional medications were originally derived from plants. Salicylic acid, a precursor of aspirin, was originally derived from white willow bark and the meadowsweet plant. Cinchona bark is the source of malaria-fighting quinine. Vincristine, used to treat certain types of cancer, comes from periwinkle. The opium poppy yields morphine, codeine, and paregoric, a treatment for diarrhoea Laudanum, a tincture of the opium poppy, was the favoured tranquilizer in Victorian times. Even today, morphine, the most important alkaloid of the opium poppy, remains the standard against which new synthetic pain relievers is measured.

In 2735 B.C., the Chinese emperor Shen Nong wrote an authoritative treatise on herbs that is still in use today. Shen Nong recommended the use of Ma Huang (known as ephedra in the Western world), for example, against respiratory distress. Ephedrine, extracted from ephedra, is widely used as a decongestant, commonly found in synthetic form, pseudoephedrine, in many allergy, sinus, and cold-relief medications produced by large pharmaceutical companies.

Indian Ayurveda medicine has been using herbs such as turmeric and curcumin possibly as early as 1900 B.C. Many other herbs and minerals used in Ayurveda were later described by ancient Indian herbalists such as Charaka and Sushruta during the 1st millenium BC. The Sushruta Samhita attributed to Sushruta in the 6th century BC describes 700 medicinal plants, 64 preparations from mineral sources, and 57 preparations based on animal sources.

The records of King Hammurabi of Babylon (c. 1800 B.C.) include instructions for using medicinal plants. Hammurabi prescribed the use of mint for digestive disorders. Modern research has confirmed that peppermint does indeed relieve nausea and vomiting by mildly anesthetizing the lining of the stomach.

The entire Middle East has a rich history of herbal healing. There are texts surviving from the ancient cultures of Mesopotamia, Egypt, and India that describe and illustrate the use of many medicinal plant products, including castor oil, linseed oil, and white poppies. In the scriptural book of Ezekiel, which dates from the sixth century B.C., there is admonition regarding plant life: "...and the fruit thereof shall be for meat, and leaf thereof for medicine." Egyptian hieroglyphs show physicians of the first and second centuries A.D. treating constipation with senna pods, and using caraway and peppermint to relieve digestive upsets.

The ancient Greeks and Romans made medicinal use of plants. Greek and Roman medicinal practices, as preserved in the writings of Hippocrates and especially Galen, provided the patterns for later western medicine. Hippocrates advocated the use of a few simple herbal drugs, along with fresh air, rest, and proper diet. Galen, on the other hand, recommended large doses of drug mixtures, including plant, animal, and mineral ingredients. The Greek physician compiled the first European treatise on the properties and uses of medicinal plants, *De Materia Medica*. In the first century AD, Dioscorides wrote a compendium of more than 500 plants that remained an authoritative reference into the 17th century. Similarly important for herbalists and botanists of later centuries was the Greek book that founded the science of botany, Theophrastus' *Historia Plantarum*, written in the fourth century B.C.

Throughout the Middle Ages, home-grown botanicals were the only medicines readily available, and for centuries, no self-respecting household would be without a carefully tended and extensively used herb garden. For the most part, herbal healing lore was passed from generation to generation by word of mouth. Mother taught daughter; the village herbalist taught a promising apprentice.

By the seventeenth century, the knowledge of herbal medicine was widely disseminated throughout Europe. In 1649, Nicholas Culpeper wrote *A Physical Directory*, and a few years later produced *The English Physician*. This respected herbal pharmacopeia was one of the first manuals that the layperson could use for health care, and it is still widely referred to and quoted today.

The first U.S. *Pharmacopeia* was published in 1820. This volume included an authoritative listing of herbal drugs, with descriptions of their properties, uses, dosages, and tests of purity. It was periodically revised and became the legal standard for medical compounds in 1906. But as Western medicine evolved from an art to a science in the nineteenth century, information that had at one time been widely available became the domain of comparatively few. Once scientific methods were developed to extract and synthesize the active ingredients in plants, pharmaceutical laboratories took over from providers of medicinal herbs as the producers of drugs. The use of herbs, which for most of history had been mainstream medical practice, began to be considered unscientific, or at least unconventional, and to fall into relative obscurity.

2.3 Types of herbal medicine systems

Use of medicinal plants can be as informal as, for example, culinary use or consumption of an herbal tea or supplement, although the sale of some herbs considered dangerous is often restricted to the public. Sometimes such herbs are provided to professional herbalists by specialist companies. Many herbalists, both professional and amateur, often grow or "wildcraft" their own herbs.

Some researchers trained in both western and traditional Chinese medicine have attempted to deconstruct ancient medical texts in the light of modern science. One idea is that the yin-yang balance, at least with regard to herbs, corresponds to the pro-oxidant and anti-oxidant balance. This interpretation is supported by several investigations of the ORAC ratings of various yin and yang herbs.

Eclectic medicine came out of the vitalist tradition, similar to physiomedicalism and bridged the European and Native American traditions. Cherokee medicine tends to divide herbs into foods, medicines and toxins and to use seven plants in the treatment of disease, which is defined with both spiritual and physiological aspects, according to Cherokee herbalist David Winston.

In India, Ayurvedic medicine has quite complex formulas with 30 or more ingredients, including a sizable number of ingredients that have undergone "alchemical processing", chosen to balance "Vata", "Pitta" or "Kapha."

In addition there are more modern theories of herbal combination like William LeSassier's triune formula which combined Pythagorean imagery with Chinese medicine ideas and resulted in 9

herb formulas which supplemented, drained or neutrally nourished the main organ systems affected and three associated systems.

Many traditional African remedies have performed well in initial laboratory tests to ensure they are not toxic and in tests on animals. Gawo, a herb used in traditional treatments, has been tested in rats by researchers from Nigeria's University of Jos and the National Institute for Pharmaceutical Research and Development. According to research in the African Journal of Biotechnology, Gawo passed tests for toxicity and reduced induced fevers, diarrhoea and inflammation.

2.4 Herbal medicine forms

Traditionally, herbal medicine has been administered over the years in primary and secondary forms.

Primary forms

1. Roots and sub terrain plant parts
2. The mid section of the plant i.e. the bark and the stem of the plant.
3. The leaves, fruits and seeds of the plant.

They are normally prescribed in the raw form to be eaten or chewed and spat out.

Secondary forms

The secondary forms were derivatives of the primary forms. The primary form of the herbal medicine was subjected to mechanical processing and chemical processing, thereby converting them to secondary forms.

Mechanical processing included crushing, grinding, separating, mixing and blending, whiles chemical processing included boiling, leaching, fermenting and mixing.

The resultant forms that the herbal medicine took were decoctions, powders, crushed leaves, and ointments. The packaging was generally poor and handling was burdensome. Preservation of the final product was poor and this led to really short lifespan of the medicine.

With the current trends, the primary forms are now treated and subjected to weighing and contain quality control measures. They are now dried by natural or artificial means to prevent pests. They are now sold in properly sealed polythene bags and paper boxes.

The secondary forms now include tablets and capsules. The decoctions are now more wholesome with improved packaging to help match the competition posed by the imported drugs on the market.

Currently, the dosages and constituents of most of the herbal drugs on the market are listed on the labels fixed to the product.

2.5 Herbal drug terminology

2.5.1 Herbarium

Herbarium is a collection of preserved plant specimens. These specimens may be whole plants or plant parts: these will usually be in a dried form, mounted on a sheet, but depending upon the material may also be kept in alcohol or other preservative. The same term is often used in mycology to describe an equivalent collection of preserved fungi.

The term can also refer to the building where the specimens are stored, or the scientific institute that not only stores but researches these specimens. The specimens in a herbarium are often used as reference material in describing plant taxo; some specimens may be types.

2.5.2 Arboretum

An arboretum is a collection of trees. Related collections include a fruticetum (from the Latin *frutex*, meaning shrub), and a viticetum, a collection of vines. More commonly today, an arboretum is a botanical garden containing living collections of woody plants intended at least partly for scientific study. An arboretum specializing in growing conifers is known as a pinetum.

2.5.3 Decoction

A decoction is a method of extraction by boiling of dissolved chemicals, or herbal or plant material, which may include stems, roots, bark and rhizomes.

Some 'teas' are *decoctions*. Decoctions, however, differ from most teas, infusions or tisanes in those decoctions are usually boiled. Decoction involves first mashing, and then boiling in water to extract oils, volatile organic compounds, and other chemical substances

2.5.4 Phytochemistry

Phytochemistry is the study of phytochemicals. These are chemicals derived from plants. In a narrower sense the terms are often used to describe the large number of secondary metabolic compounds found in plants. Many of these are known to provide protection against insect attacks and plant diseases. They also exhibit a number of protective functions for human consumers.

Techniques commonly used in the field of phytochemistry are extraction, isolation and structural elucidation of natural products, as well as various chromatography techniques.

2.5.5 Tableting

Tableting is the mixture of active substances and excipients, usually in powder form, pressed or compacted into a solid. The excipients include binders, glidants (flow aids) and lubricants to ensure efficient tableting; disintegrants to ensure that the tablet breaks up in the digestive tract; sweeteners or flavours to mask the taste of bad-tasting active ingredients; and pigments to make uncoated tablets visually attractive. A coating may be applied to hide the taste of the tablet's components, to make the tablet smoother and easier to swallow, and to make it more resistant to the environment, extending its shelf life.

2.6 General requirements for production units

Building or buildings used in the manufacture, processing, packing, or holding of herbal drug products should be of suitable size, construction and location to facilitate cleaning, maintenance, and proper operations.

The building must have adequate space for the orderly placement of equipment and materials to prevent mix-ups between different components, drug product containers, closures, labelling, in-process materials, or drug products, and to prevent contamination. The flow of components, drug product containers, closures, labelling, in-process materials, and drug products through the building or buildings must be designed to prevent contamination.

2.7 Environmental and service requirements

There is the need for adequate lighting and ventilation at all spaces. Equipment for adequate control over air pressure, micro-organisms, dust, humidity, and temperature should be provided when appropriate for the manufacture, processing, packing, or holding of herbal drug products and for research activities.

Potable water shall be supplied under continuous positive pressure in a plumbing system free of defects that could contribute contamination to any drug product. Potable water needs to meet the standards prescribed in the Environmental Protection Agency's Primary Drinking Water Regulations. Water not meeting such standards must not be permitted in the potable water system.

Drains shall be of adequate size and, where connected directly to a sewer, shall be provided with an air break or other mechanical device to prevent back-siphonage.

Sewage, trash, and other refuse in and from the building and immediate premises must be disposed of in a safe and sanitary manner either through recycling, incineration etc.

2.8 Laboratory planning, layout and design

Research laboratories are usually in smaller spaces with special equipment and additional rooms for activities such as weighing and measuring centrifuges and auto claves, washing up, climatised and cold storage rooms with constant temperature, photographic rooms/ dark rooms.

Ventilation

Low-pressure or high-pressure systems, the latter are recommended particularly in multi-storey buildings for institutes with higher air requirement in order to reduce the cross-sections of the ducts. Ventilation systems have the highest space requirements of all services. Laboratories where chemicals are used must have artificial air supply and extraction.

Electrical services

Where a high number of connections and special supplies of electricity are required, a separate transformer in the building is essential. Electrical plant must be in a fireproof enclosure without any other cables running through it.

Structure

For adaptability of use, a reinforced concrete frame structure, pre-cast or poured in-situ, is preferable.

Separation is by a system of partitions and suspended ceilings which enclose the rooms. Movable dividing walls should be easy to assemble and have chemical chemical-resistant surfaces. Floor coverings should be water and chemical resistant, without joints and be poor electrical conductors.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

The methods employed in this research include;

Survey and Data collection

- Case studies

  Case studies of similar projects such as the Centre for scientific research into plant medicine, Mampong a modern herbal medicine research and manufacturing centre; Top herbal clinic, Accra a herbal medicine manufacturing facility and treatment clinic which employs modern machinery in its production process; Apak traditional medicine centre, Koforidua, a traditional herbal medicine manufacturing centre which employs indigenous manufacturing equipments and process.

- Technical studies

  Gathering of technical information on various machinery and equipments used in production process, specific spatial and environmental requirements of various spaces and activities.

- Photographic recordings of related subject matter
- Personal observation coupled with visual surveys and discussions with resource persons
- General reading on subject matter

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.

The Design Scheme

This will involve the interpretation of the design in the form of drawings and sketches.

3.1 Case studies

3.1.1 Centre for Scientific Research into Plant Medicine

Fig1. View of the centre from the main entrance

3.1.1.1 Project

The Centre for Scientific Research into Plant Medicine (CSRPM) was established by the government of Ghana in 1975. The centre mainly provided clinical services to patients, collated ethnomedical information on medicinal plants and undertook the establishment of an arboretum for medicinal plants. Basic science research, however, commenced in 1986 with the establishment of the first research laboratory, which in 1991 was separated into two laboratories;

namely, phytochemistry and pharmacology to reflect the nature of research activities carried out in these laboratories.

Currently the services offered by the centre include:

- Quality, safety and efficacy assessments of herbal products for herbal manufacturers and herbalists.
- Clinical consultations and clinical laboratory services to patients.
- Formulation and production of herbal extracts for industries
- Raising of medicinal plant seedlings for sale to out growers.
- Library services to researchers and students

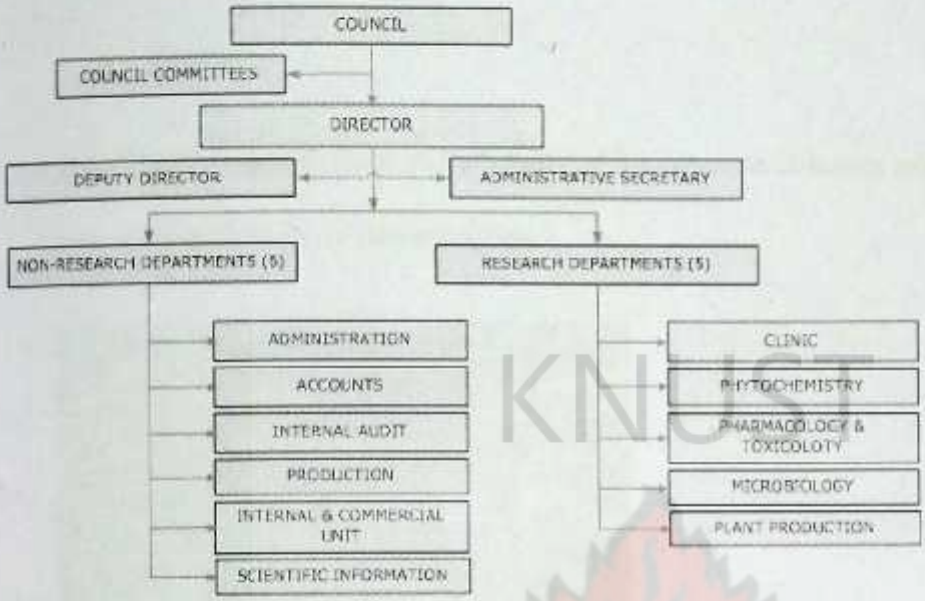
3.1.1.2 Location

The centre is located at Mampong-Akuapem in the Eastern Region of Ghana about a few kilometres from Aburi. The centre is located close to the Mampong government hospital.

3.1.1.3 Standard Operating Procedures (SOPs)

- Preparation of raw materials(chopping, washing, drying(solar driers or sun)
- Milling
- Extraction (boiling or cold solvent)
- Preservation
- Bottling, labelling and packaging
- Storage of finished product.

3.1.1.4 Organisational Structure



3.1.1.5 Specification

- Architectural character/ features

The structures are predominantly two storey height solid block walls with veranda system of circulation. Building typology consists of simple geometric forms with gable roofs hidden by parapets. Building style depicts features of the modernists' style of architecture with straight and simple facades with no sun shading devices.

The building encloses a square courtyard which provides the surrounding spaces with natural lighting and ventilation which is not fully utilized in those spaces.

Windows are all louvered windows with glass louvers and timber frames with flush doors in timber frames for offices and laboratories while glazed doors are used for reception area.

- Structure

Reinforced concrete floor slabs supported by concrete columns and beams of varying sizes with post and beam form of skeletal frame.

Fig2. Post and beam skeletal frame

- Services

Ventilation and lighting of indoor spaces is mostly by artificial means with only outdoor circulation areas such as the veranda making maximum use of the natural light and ventilation, these helps in maintaining the lighting and temperature at desirable conditions at certain areas of the building such as laboratories.

There's the presence of a 230 KVA standby generator to supplement the electricity provided by ECG to ensure that electricity supply is constant. The twelve 10,000 litres polytanks located at the centre ensures that water supplied by GWCL can be stored in large quantities to help in maintaining regular supply.

There is the presence of fire extinguishers at vantage positions to help fight fire outbreaks. Solid waste generated from the centre is handled by an incinerator, whiles the liquid wastes is channelled through an underground drain to join the main drain which flows to a stream.

Fig3. fire extinguishers

Fig4. water reservoirs

Fig5. 230 KVA standby generator

Fig6. incinerator for handling solid waste

- Finishes and Cladding

Floor finish is mostly polished terrazzo with the production area having sand cement screed floor finish. Exterior and interior walls have smooth textured emulsion paint finish with the normal plywood ceiling finished in emulsion paint as well.

- Layout

These are the provisions made at the centre:

- Clinic
- Herbarium
- Arboretum
- Library
- Canteen
- Animal house
- Research Laboratories
- Conference room
- Administrative offices
- Production warehouse
- Production unit
- Incinerator
- Car park
- Storage shed for water tanks

3.1.2 Top Herbal Clinic

3.1.2.1 Project

Top herbal clinic with its herbal manufacturing unit and dispensing clinic is a major player when it comes to herbal medicine in Ghana. Herbal medicines manufactured are distributed through

pharmacies, chemical shops and by mobile vans throughout the Ghana. Drugs manufactured are in the form of tablets, liquids, capsules and ointments. Top herbal clinic was studied to understand the herbal drug manufacturing process with modern equipments and machinery.

3.1.2.2 Location

Top herbal is located at Accra, in the greater-Accra region of Ghana. The dispensing clinic is located at Hatso Agbogba in Accra, with the manufacturing department situated at Oyibi, Accra.

Fig7. Top herbal clinic

3.1.2.3 Specification

- Architectural character/ features

The clinic is a four storey structure with gable roofs and no sun shading devices depicting the modernist style of architecture. The production section consists of a two storey building and two single storey structures which serve as the storage areas, milling area and boiling area. The clinic is raised on a flat land whiles the production section is raised on a fairly gentle slope of land.

Windows are predominantly glazed sliding windows for the clinic and glass louvered windows for the production houses.

The single storey structures of the production unit have honey combs which provide some minimal amount of natural lighting and ventilation.

- Structure

Reinforced concrete floor slabs supported by concrete columns and beams of varying sizes with post and beam form of skeletal frame, except for the milling room and raw materials storage room, which has timber framework and timber walls.

Fig8. Boiling room with its concrete columns and honey combs

- Services

Most of the production spaces with exception of milling area, materials storage area and boiling area rely heavily on artificial ventilation because of the nature of equipments that were used in those spaces.

The presence of water storage tanks and a water pumping machine enabled the storage and constant availability of water supplied by GWCL. There was a stand by generator to serve as back up for power obtained from ECG. Fire protection systems like fire extinguishers were placed at vantage positions within the facility. There was the presence of vacuum pump and compressor for the filling machine and capsule blister. Drains which were mostly underground took waste water outside the premises where it was disposed off, since there was no waste treatment plant.

Fig9. Water reservoir with its water pump

Fig10. Compressor for blistering machine

- Finishes and cladding

Predominantly, polished terrazzo floor finish with emulsion paint finish for both exterior and interior walls whiles the ceiling materials and finishes were varnish polished ply wood.

- Layout

These are provisions made at Top Herbal clinic

- Clinic

- Production ware houses
- Clinical laboratories
- Car park
- Storage area for equipments
- Vending kiosks

3.1.3 Apak Traditional Medicine Centre

3.1.3.1 Project

Apak traditional medicine centre is herbal drug manufacturing centre which combines indigenous means of manufacturing with locally manufactured modern production equipments.

3.1.3.2 Location

The centre is located at Koforidua in the eastern region along the Koforidua Newtown – Ada road.

Fig11. Single storey structures scattered across the site

3.1.3.3 Herbal medicine manufacturing process

- Fresh raw materials arrive from suppliers
- Raw materials are sorted out and stored
- Fresh materials are washed and dried or dried without washing depending on the material and its purpose
- Dried materials are bagged and tagged, separating herbs from roots and barks and kept at storage rooms.
- Milling of materials
- Boiling of measured quantity of materials.
- Cooling of liquid
- Sieving of cooled liquid.
- Bottling, labelling and packaging
- Storage

3.1.3.4 Specification

- Architectural character / features

Single storey structures scattered across the site with an average room area of 36 m^2. Structures have no linkage. Doors are wooden panel doors with windows been a mixture of glass louvered windows and timber louvered double swing windows depending on the use of the space.

Fig12. Single storey structure with its timber doors and windows

- Structure

Sand crete block solid walls construction with gable roofs and concrete columns. Milling room is made of solid block walls with timber columns and posts.

Fig13. Timber roof supports

Fig14. Solid sand crete walls with gable roof

- Services

The facility depends solely on energy supplied by ECG and has no stand by generator. Burners for boiling are powered solely with LPG. There are three storage tanks for storing water supplied

by G.W.C.L; this water is not treated before use for production process. The non existence of a waste treatment plant results in the burning of solid wastes and the disposal of liquid waste at the burning area without any treatment.

The facility depends solely on natural ventilation and lighting, artificial lighting supplements are used only when production times stretches to the evening.

The centre lacks fire prevention systems such as extinguishers, sprinklers etc.

Fig15. Water storage and LPG tank

Fig16. Site for burning solid waste

- Finishes and cladding

With the exception of the milling room, all spaces have polished Terrazzo floor finish. Both exterior walls and interior walls have emulsion paint finish.

- Layout

The following is the inventory of structure at the centre

- Storage rooms

- Milling room
- Production room
- Bottling, labelling and packaging room
- Drying platform
- Washroom

3.2 Technical studies

3.2.1 Production machines and their functions

- Rotary tablet press: compresses granules into tablets. Measures 1200mm x 1000mm and weighs around 200 kg.
- Bottling machine: full automatic washing, filling, capping of bottles. Capacity ranges from 2,000 – 30,000 bottles per hour depending on model. Measures 3000mm x 1800mm x 1500mm with a weight of 750 kg.
- Blister machine: development of plastic and aluminium blister packaging. Measures 1350mm x 800mm.
- Hammer mill: grinding of plant materials such as barks, herbs, stems etc.
- Roller mill: grinding of materials in the manufacture of ointments, powders etc.
- Mixing machine: intimate mixing of wet and dry materials
- Coating pan: coating of tablets
- Film and sugar coating machines: coating of pills and tablets with organic film. Measures 1200mm x 1050mm.

- Storage vessel: storing solutions after extraction and addition of preservatives stage.
- Granulator: compressing granules into tablets.

3.2.2 Environmental quality requirements of various work places.

Accommodation	Temperature °c	Humidity levels
Store (raw materials)	Normal room temperature	Low 50 %
Sorting and preparation	-ditto-	Normal 75%
Quality control	25	50%
Tableting and Capsuling room	-ditto-	50%
Packaging room	25	50%
Store (finished products)	25	50%
offices	Normal room temperature	50%

CHAPTER FOUR

4.0 FINDINGS AND DISCUSSIONS

4.1 Findings

The following conclusions were drawn from the case studies done

- Location

Various facilities were sited in appropriately zoned areas emphasizing the need to locate the facility in areas where there is easy access to transportation, services, raw materials and target group.

- Spatial organisation

There is the need for proper spatial arrangement to facilitate activities thus reducing production time and improving efficiency.

- Parking

Zoning of parking spaces is needed to ensure easy movements through the facility. Service entry and exits points as much as possible should be separated from staff and visitors entry and exit points to prevent

- Provision of adequately sized storage facilities is essential.
- Security

Security should be provided at entry and exit points as well as within production areas to prevent theft and ensure supervision.

- Quality control

Proper scrutiny of finished goods is essential to ensure that consumers receive safe and quality drugs.

4.2 Case studies

4.2.1 Centre for scientific research into plant medicine, Mampong

Merits

- Steep sloping site has ensured good draining of the site
- Design facilitates access to the public areas
- Well defined parking area
- Open courtyard enhances natural ventilation and lighting into the building
- Adequate landscaping and greenery

Demerits

- Excessive use of artificial lighting
- The structure is orientated with the longer side facing east and west.
- Difficulty in locating administration block.
- No changing facility for staff at the production unit.

4.2.2 Top herbal clinic, Accra

Merits

- The use of sand crete solid walls as predominate building material will ensure long life span of the building.

Demerits

- Lack of well demarcated car park
- Segregation of various sections of the production unit makes flow of activities and circulation difficult.
- The sitting of the clinic at a different location from the production section increases production cost due to transportation of finished goods to the clinic.

4.2.3 Apak traditional medicine centre, Koforidua

Merits

- Massive use of natural ventilation and lighting
- Sizeable land for activities

Demerits

- Segregation of various sections of the production unit makes flow of activities and circulation difficult.
- Inadequate storage spaces for raw and semi-processed materials.
- No welfare facilities for workers.

- No defined parking area.

4.3 Site

Kumasi is popularly regarded as the largest consumer of herbal medicine and also its location in the tropical rain forest zone makes it a viable choice for site location for this project. Kumasi is also the home to the only institution that offers degree a programme in herbal medicine.

4.3.1 Site Selection Criteria and Justification

In choosing a site for the establishment of herbal drug facility, the following criteria were considered.

Size

The site for the project should be sizeable enough to house all the facilities that will be provided and should have available for the establishment of a small arboretum.

Accessibility to target group

Locating the facility close to its target group will go a long way to make the project very feasible. Drug manufacturers, herbal medicine practitioners, researchers, students and patients are the target groups. The site should therefore be easily accessible by these groups.

Services

The presence of basic infrastructural services such as electricity, water and telecommunication services will help reduce the cost involved in establishing the facility.

Zoning

The site should be located in an appropriately zoned area fit for such a facility. A light industrial zoned area with low levels of pollution.

Land tenure system

The site should be owned by groups or individuals who will be willing to offer the site up for the setting up of a government project.

Proximity to raw materials

The site should be located close to its raw materials source, thus reducing transportation cost

Based on the above criteria two sites were selected for this project.

Site 1

The site is located at the light industrial zoned area of Ayigya off the main Kumasi-Accra road. The site is bounded on the northern side by Asokore –Mampong, on the eastern side by Kentinkrono and on the western side by the Ayigya community.

Advantages

- Sizeable land capable of housing various facilities
- Presence of infrastructural services such as electricity, water and telephone
- Fertile land which will support the growing of an arboretum
- Close to the herbal medicine department of KNUST.
- Sloping nature of site could aid in the draining of the facility

Disadvantages

- Access routes not fully developed
- Slope could create problems during the construction of the production unit.

Fig17. Location of the site within the Ayigya zone

Site 2

The site is located at the Sokoban Wood village.

Advantages

- Presence of infrastructural services

- Access to emerging market
- Easy access to raw materials
- Fertile land

Disadvantages

- Polluted environment created by nearby wood processing factories
- Undeveloped access routes
- Site is not sizeable enough
- Distance from KNUST compared to the first site is longer.

Fig18. The site within the wood village layout

The chosen site is **site 2** due to its few demerits.

4.3.2 Site Inventory and Analysis

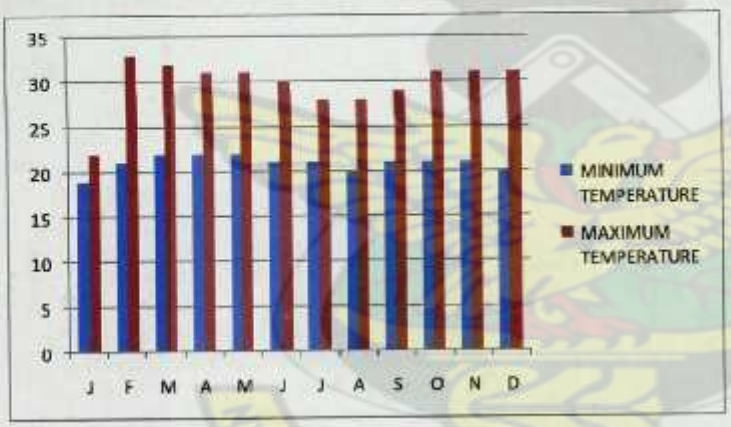
The inventory consists of survey conducted to know the physical conditions on the site. They were studied to know the merits and demerits that could be taken advantage of or discarded to help come up with a good design.

The site covers a total area of 59,500 square metres.

4.3.2.1 Climate

Temperature

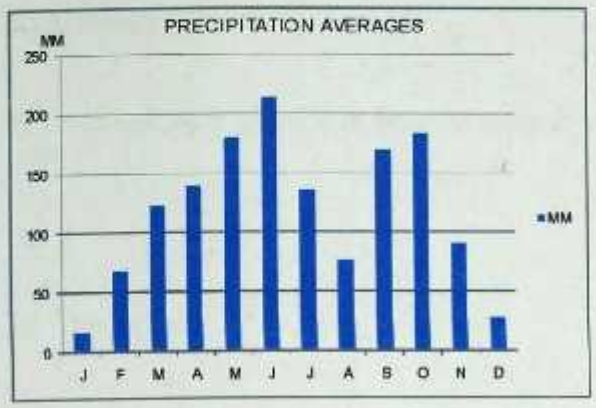
Average minimum and maximum temperatures are 22°C and 35°C respectively.



Source: Ghana Meteorological Services Department

Rainfall

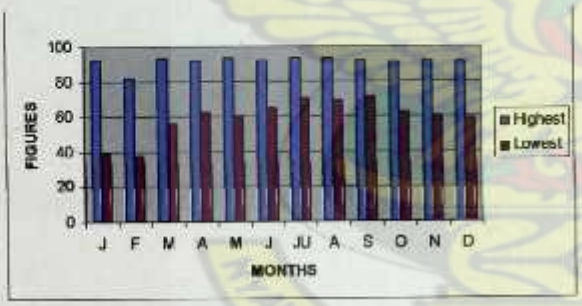
Rainfall is high throughout the year with an annual total rainfall between 890mm and 1500mm.



Source: Ghana Meteorological Services Department

Relative humidity

Relative humidity is usually between 75% and 85%. The chart shows relative humidity values of 2008.



Source: Ghana Meteorological Services Department

Air circulation

Air velocity of 6.6 m/s with a prevailing south western direction

4.3.2.2 Geology

Sandy loam soil with good load bearing capacity within the forest ochrosols zone of Ghana.

4.3.2.3 Topography

Site slopes downwards towards the north eastern corner of the site with a drop of 5 metres averagely every 45 metres. Slope gradient is 1: 9.

4.3.2.4 Vegetation

Site supports plant life. Existing plants on site includes grass, shrubs, trees and cassava.

4.3.2.5 Existing structures

The entire site is covered with vegetation.

4.3.2.6 Responses

Plants and grass will be grown to check erosion, whiles constructed drains will be well located to direct run offs due to heavy rainfall. There is the need for proper orientation, cross ventilation and shading to help keep temperatures at comfortable levels for occupants, materials and finished goods. All proposed roads around the site will have to be developed to enhance accessibility.

4.3.3 Site Peripheral Studies

This involves the existing land use pattern on and around the site. This is studied to know how various structures around the site will affect the project.

The Charismatic Christian Church (C.C.C) building, multipurpose hall and school building are located on southern boundary of the site. Located on the western boundary are Kojach Pharmacy, a warehouse and a walled plot belonging to the Presbyterian Church. These are all possible noise sources as such noise sensitive areas of the design must be sited away from these areas. Bounded on the eastern and northern side are farmlands, this provides a good location for the arboretum; placing it in its natural habit.

Fig19. C.C.C Church building

Fig20. C.C.C multipurpose hall

Fig21. C.C.C uncompleted school building

Fig22. Presbyterian Church walled site

Fig23. Kojach Pharmacy building

Fig24. Warehouses

Fig25. Undeveloped areas with vegetation

Fig26. Farmlands

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

These conclusions were drawn from thorough discussion of findings gathered during research resulting in these proposals which have been interpreted in the form of drawings and sketches.

5.2 Developed brief and Accommodation schedule

This developed brief and accommodation schedule was influenced by the clients brief as well as the need to make the facility comfortable for its users. The final accommodation schedule and brief are as follows:

Research unit

Facility	Number	Area(sq. Metres)
Herbarium	1	150
Laboratories	3	480
Animal house	1	540
Offices	1	14
Washrooms	1	45
Arboretum	1	29,068
Staff room	2	127.5
	Total area	30424.5

Production unit

Facility	Number	Area(sq. Metres)
Storage rooms(raw materials)	6	256.5
Storage room(finished goods)	2	165
Storage room(equipments)	2	50
General store	5	116.5
Milling room	1	25
Washing/drying area	1	52
Granulation room	1	57
Bolting area	1	200
Tableting room	1	33
Capsuling room	1	25
Tube filling room	1	25
Blistering room	1	25
Bottling area	1	40
Weighing/mixing room	1	15
Packaging room	2	120
Security/ clocking area	2	18

Offices	2	26.5
Sorting area	2	40
Changing rooms/ washing rooms	1	52
Staff room	1	35
Quality control	2	55
	Total area	1431.5

Clinical services unit

Facility	Number	Area(sq. Metres)
Outpatient department	1	160
Consulting rooms	2	30
Laboratory	1	56
Dispensary + store	1	85
Wards	2	153
Washrooms	2	37
Storage rooms	2	28
Day area	1	40
	Total area	589

Administrative unit

Facility	Number	Area(sq. Metres)
Offices	12	270
Staff common room	1	40
Library	1	80
Conference room	1	80
Computer room	1	80
Washrooms	2	48
Storage rooms	2	21
Lecture room	1	80
Entrance foyer + Reception	1	160
Secretarial services	1	40
	Total area	899

Ancillary facilities

Facility	Number	Area(sq. Metres)
Canteen	1	240
Staff and public parking	1	2574
Service parking	3	2000

Security post	2	18
Water treatment plant	1	40
Waste treatment plant	1	40
	Total area	5482

5.3 Philosophy and concepts of the design

5.3.1 Philosophy

"*...**quality, safe, efficacious herbal hub**. Restoring trust in herbal medicine through safe, efficient and sufficient scientific research in a conducive environment buttressed by an activity facilitating structure*"

5.3.2 Concepts

Integration: The process of combining two or more things so that they work together. Effectively combining structures with different functions, to make a single unit so that they can work together as a whole to achieve desired results.

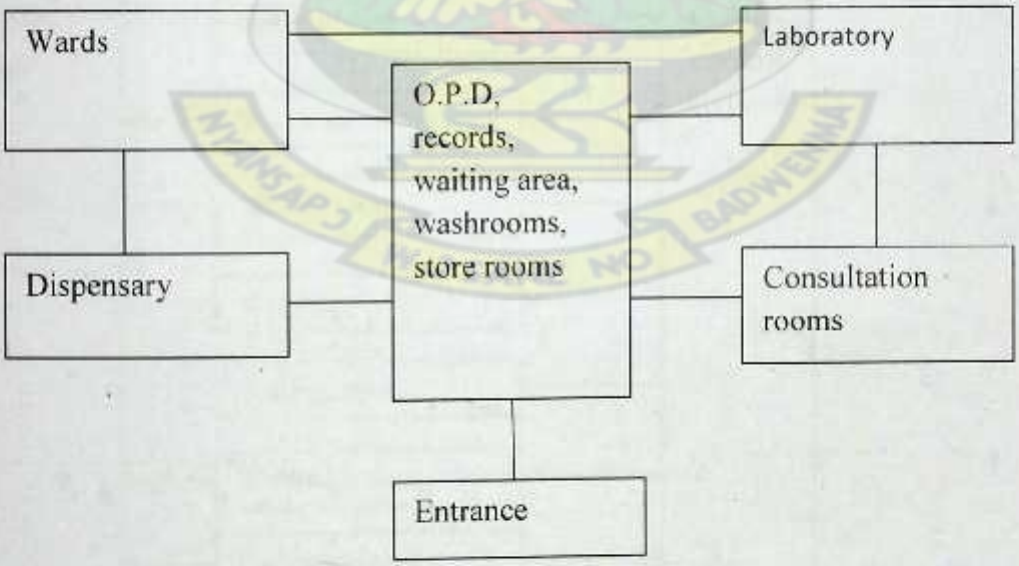
The combination of effective herbal medicine research, herbal drug production and safe clinical consultations with herbal medicine treatment to provide a trusted primary health care delivery.

Simplicity in form, sound functional relationships, uniformity in geometry, and flow in activities are the design consideration which will help in achieving this integration which. To achieve an activity facilitating design it is essential that various spaces are laid out in a simple manner of order to prevent breaks in activities and also functionally related spaces positioned close to each other to enhance flow.

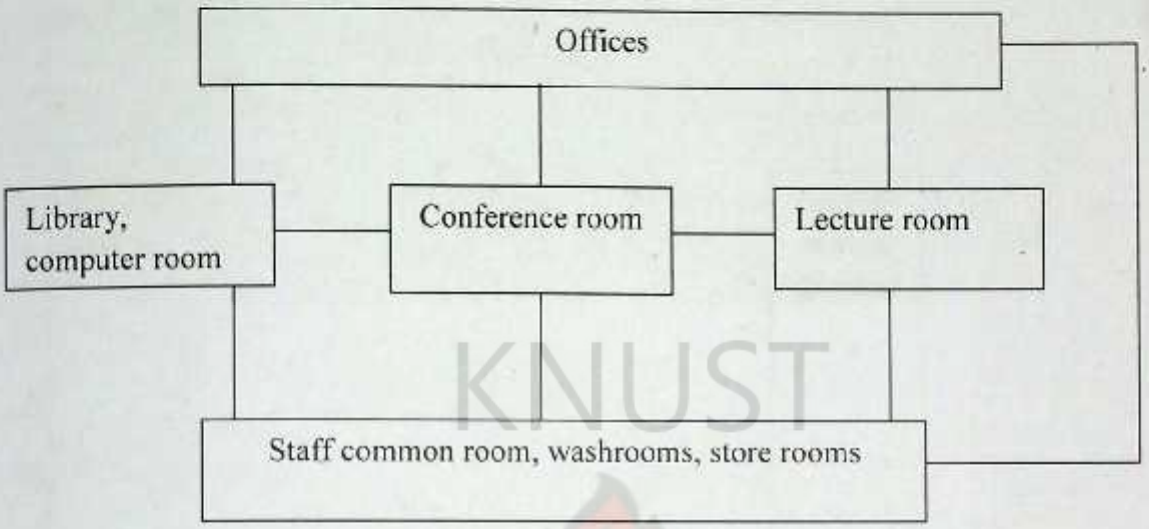
These concepts reflect architecturally through the use of suitable construction, suitable size of structure, regular building shape or geometry, flexibility in zoning as well as an environmentally safe structure.

5.4 General functional relationships

Clinical services unit

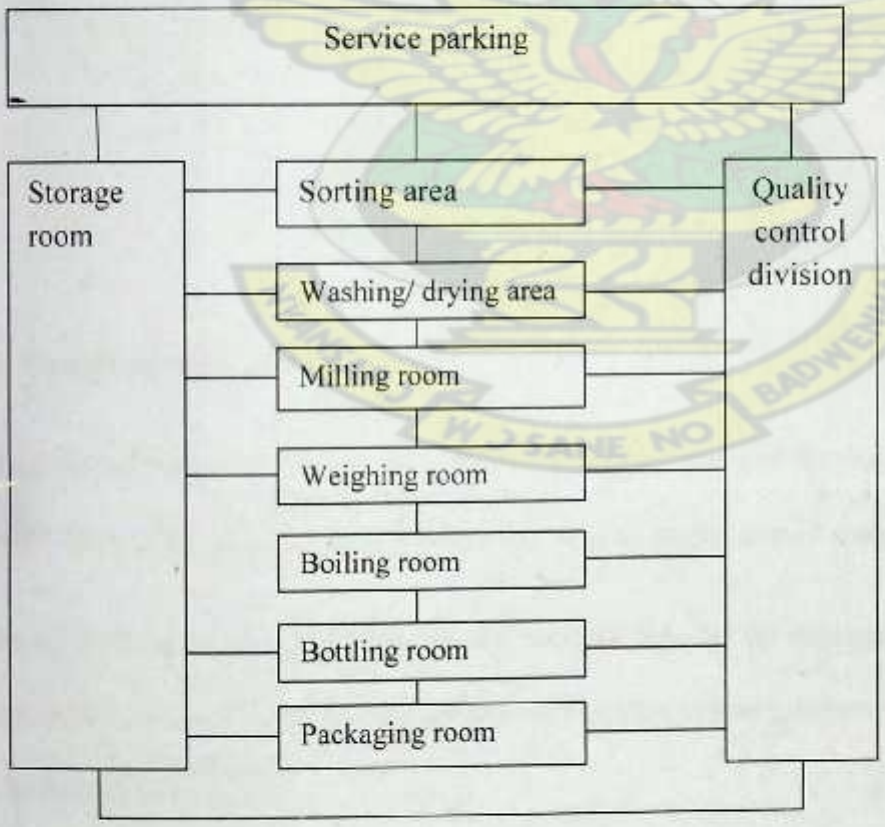


Administrative unit

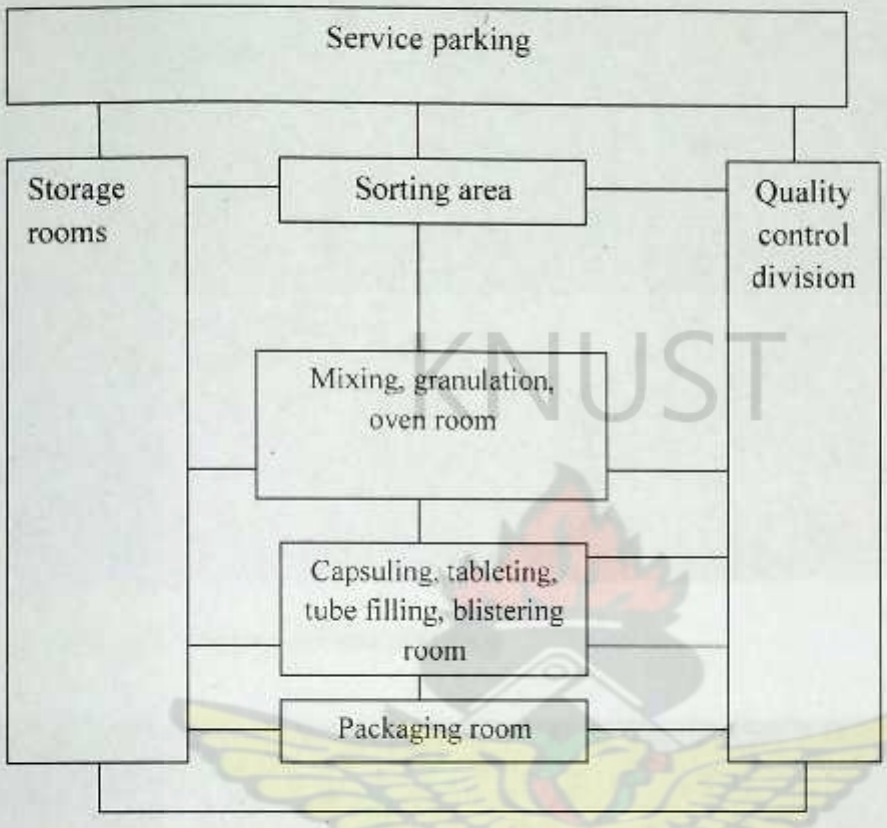


Production unit

Liquids section



Tablets, capsules and ointments section



5.5 Conceptual Site Planning

The entire planning of the site was influenced by the nature of the site (slope), the north and south orientation, nearby structures and the need to locate related spaces close to each other.

The nature of activities in the facility and security requires for segregation of some sections but also requires linkage between the various sections for support, supervision and circulation of information or products.

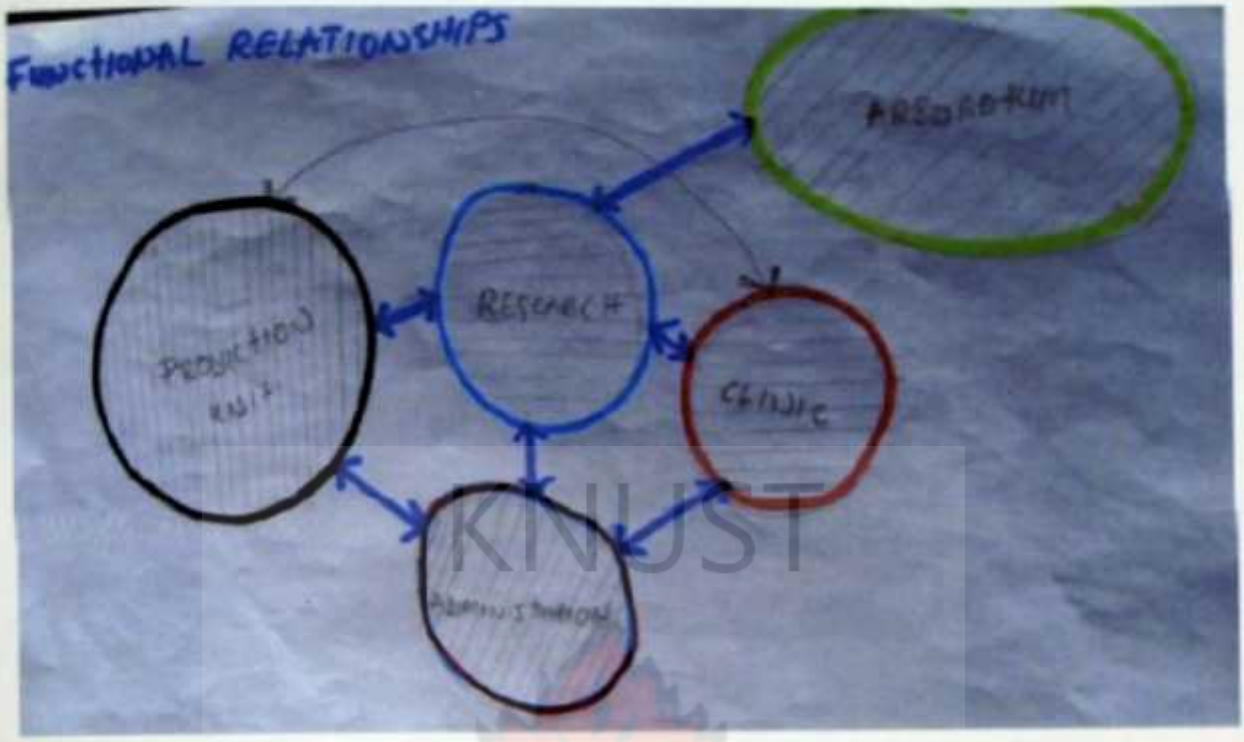


Fig27. Stage 1: conceptual site planning

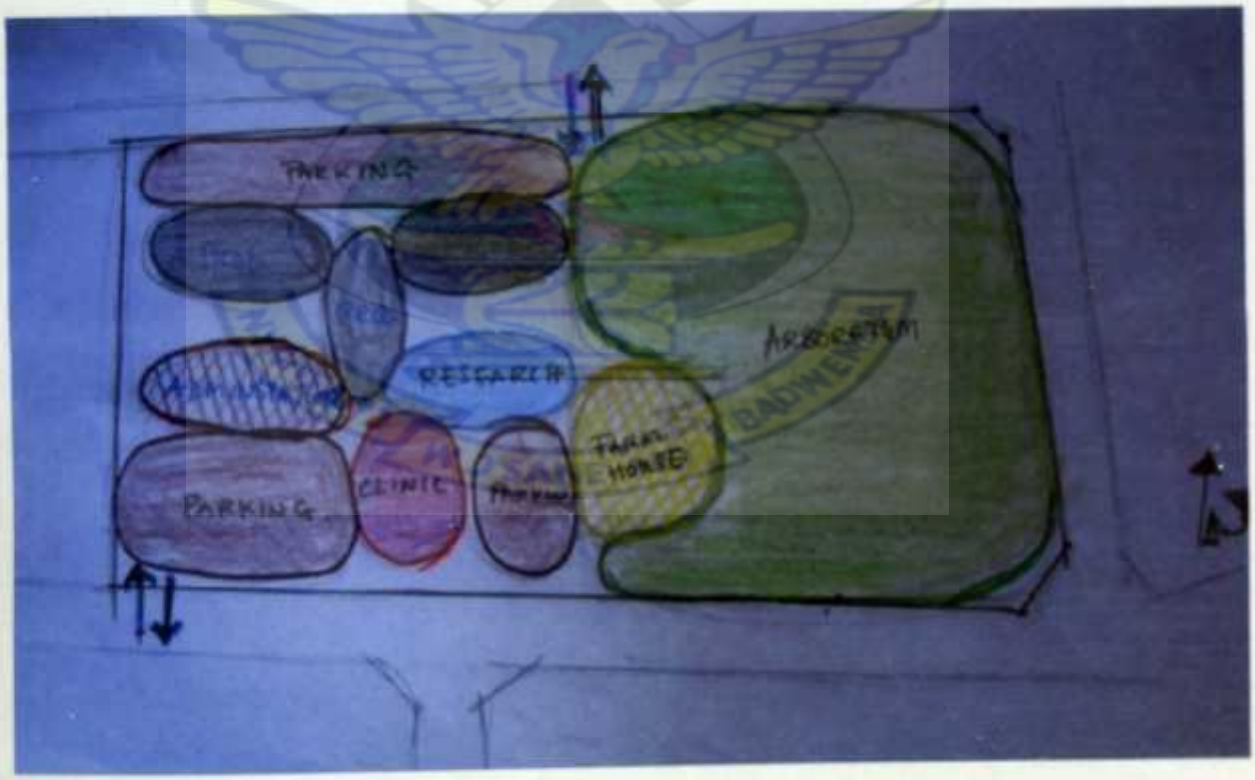


Fig28. Stage 2: conceptual site planning

Adaptation of the courtyard system helped in locating these functionally related spaces together and also allowed for cross ventilation and the maximum utilization of natural lighting.

Entry and exit point for vehicles (staff and visitors) and pedestrians was taken from the southern side of the site which is also the highest point of the site. Since these vehicles were mostly small ones climbing the slope and descending poses no threat. The entry and exit point for the service vehicles was taken from the northern side which is on the lower end of the slope. This makes it easier for heavy service vehicles to access the site. The bid to provide security resulted in two entry points, one for service vehicles and the other for pedestrians and vehicles of staff and visitors. This can be seen from the site layout and block plan.

Parking on the site has been planned taking into consideration its functionality. Parking for staff and visitors has been located directly in front of the facility and has a separate entrance from the service parking of the production, research and clinic areas to prevent people from wandering into these areas which are private. With its single entry and exit point movement becomes easier.

The location of a ware house on the western side of the site prompted the positioning of the clinic, research area and the arboretum on the eastern side. The arboretum was located on the extreme east side of the site which also happens to be the lowest point of the site. Its location on the lowest part tends to attracts view from the other facilities on the high ground such as the clinic, the research block and the administration. Location of these facilities on the high grounds also tends to facilitate drainage.

By usage the facility has been zoned into public, semi public and private spaces with the separation point for staff and visitors being the entrance foyer. The administration block's conference room, lecture room falls under the public spaces as well as the clinic and cafeteria.

The semi public spaces include the library, computer room and the herbarium which is available to staff, researchers or students. These public spaces are easily accessible from the entrance foyer or the car park. The private areas which are located at the extreme end of the site or on upper flows include the production section, the animal house, the research laboratories and the arboretum.

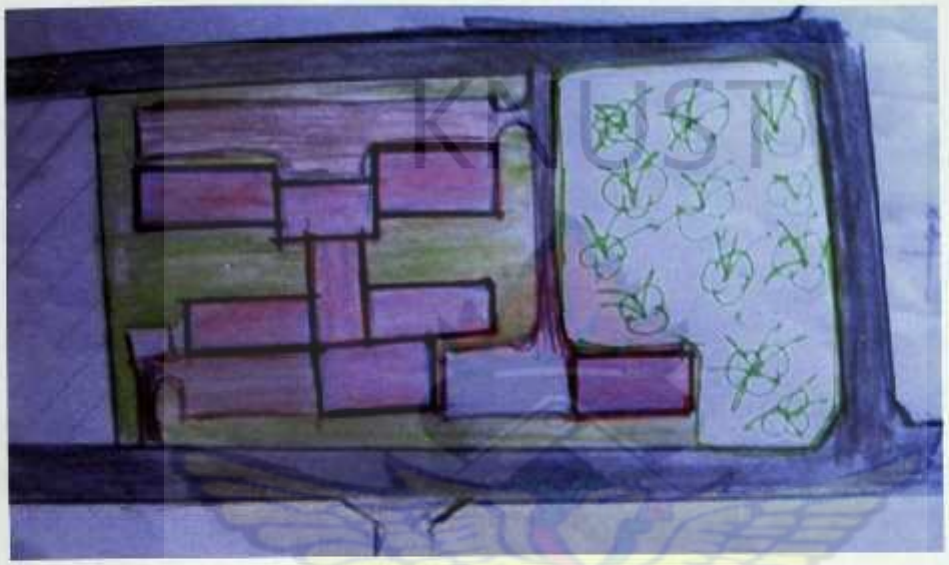


Fig29. Site planning

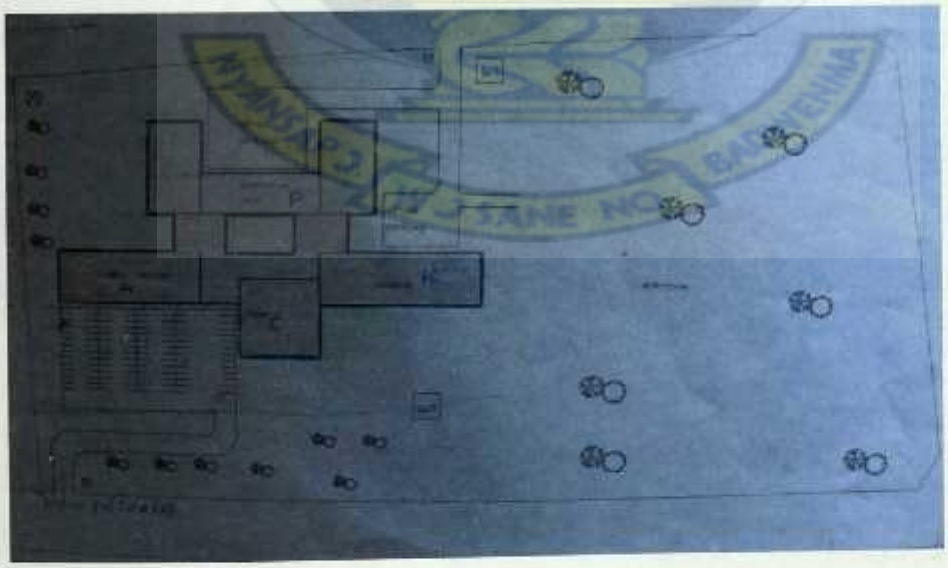


Fig30. Conceptual design layout

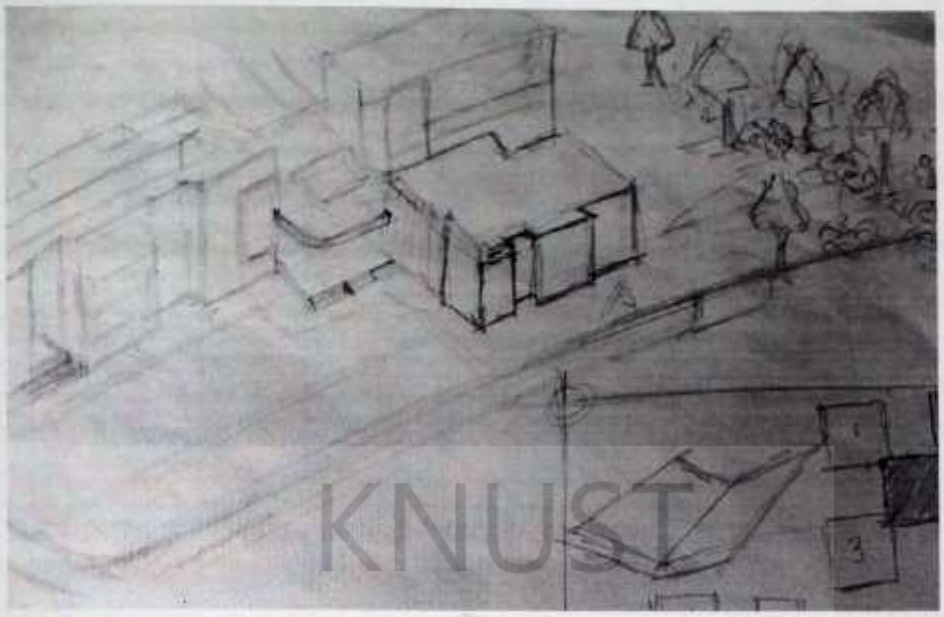


Fig31. Design sketches

5.6 The Design

The site covers an approximately 59,500 square metres. With an establishment of an arboretum in mind less than 50% of the site must be used for the construction of the various structures with the rest being allocated for the arboretum and future expansion. The suitable size of the site and the activities of various spaces influenced the decision to go a maximum of two floors.

The primary structure of the building varies from 5m x 8m grid for the administration block and 10m x 10m for the research block and production unit.

The southern façade has been designed to reflect its importance as having the main entrance of the facility. The location of the facility about 50m from the road located on the southern side which is also the main entrance route gives it an unobstructed view from the top of the slope.

The entrance located close to the staff and public parking opens in to a large foyer from where the reception, clinic and administration block could be accessed. The canteen has its main entrance from the car park; this gives the public access to the canteen without necessarily interfering with the activities in the place. There is a separate entrance for workers which could be accessed from the Administration Block.

The Production Unit has been located at the extreme end away from the other facilities to ensure that people in the Clinic and Administrative Block are not disturbed by the noise produced by the machinery and also to check security and ensure hygiene.

Stairs and lifts has been strategically position in each section of the building that requires vertical movement, with all stairs covered on one side by curtain walls with windows that open outside. This could be very useful in times of fire outbreaks.

Spatial disposition has been carefully done in such a manner that the public accessed areas like canteen, clinic, conference room, lecture room are located on the ground floor whereas semi secluded areas like libraries, laboratories, office are located on the top floor. These spaces have also been positioned to keep them away from potential noise sources.

Sanitary facilities have been located in each section to facilitate easy accessibility.

The dominant roof type is gable roof with a parapet wall. Massive use of fins helps facilitate ventilation and the introduction of natural lighting into various spaces.

NB: Refer to appendix for drawings and three dimensional representations of the proposed design.

5.7 Services

5.7.1 Electricity

Electricity is tapped from the national grid to a transformer and a generator housed on the site for an automatic power switch, in case of any power outage. This is then sent to the distribution board in the switch room. The quality and constant supply of electricity is crucial for the operation of research equipments and some production equipments.

5.7.2 Lighting

Massive use of day lighting is employed throughout the facility with minimal artificial lighting supplements in some areas.

Courtyards and an atrium have been incorporated in the design to effectively bring daylight to the building interior. Glazing materials for windows also allow an appreciable amount of light into interior spaces.

The artificial lighting system of the building consists of fluorescent lamps and incandescent emergency lights.

5.7.3 Ventilation

As a measure of prudence in a tropical climate, the facility has been primarily designed around architectural principles which will enable a full operation on natural ventilation. Principles

employed include; stack ventilation (low air inlet and high air outlets, high roof volumes, etc), creation of voids and the use of courtyards.

The building is fitted with a zoned air conditioning system. It is, however, divided into zones with similar conditions. Units receive an air supply conditioned to an average temperature and humidity from these split systems. Production areas such as the tableting room, capsuling room, tube filling room and blistering room; microbiology research laboratory and some spaces within the animal house are fitted with air conditioning units because of the equipments used in those areas and the nature of operations.

5.7.4 Fire Protection

Fire controls systems such as smoke detectors and fire alarms systems are located in various spaces. The electrical system where the building has been sectioned into independent load centres act as fire protection. Hence, electrically induced fire outbreak can be prevented from one area to other.

In spite of the fire resistant advantages associated with space grid structures, the steel members are coated with intumescing substances. These substances foam into highly insulating substances that protect the members during a fire outbreak.

Fire alarms are installed at strategic locations while sprinklers are also fixed in the ceiling of rooms. Powder hydrants are fixed in some rooms instead of sprinklers to protect life and property in an event of fire outbreak since water might destroy the property being kept in those rooms.

Fire extinguishers also located at strategic intervals within the facility is an additional source of fire control.

Other fire precautionary measures like hydrants are located round the facility and within the courtyards.

5.7.5 Security Control

Two forms of security risks are taken care of in the facility. These are petty theft and vandalism by workers and visitors during the day as well as burglary during the night. During the shutdown times and at night, major entrances will be locked and alarm systems enabled. During working hours CCTV's will be used in the production hall to check theft and supervision of workers.

Security check points have been provided at major exit and entrance points to check movement of people and vehicles. Entrances to restricted zones such as the production section have security posts. Night patrol in and around the facility will be in place.

5.7.6 Communication systems

Telephone signals will be tapped from the main box off the site into the switch room. A central telephone exchange system will be located from which all other spaces in the facility will be inter-connected.

All the computers in the building will be networked under a Local Area Network (LAN) system.

5.7.7 Water Supply

Water will be tapped from the mains to the site via a PVC pipe into a storage tank at the water treatment facility where it is treated again to meet the safety requirements necessary for production, clinical activities and research work. With the help of pneumatic pumps it will then be pumped into storage tanks strategically located and then redistributed by gravity to the various spaces of the building.

5.7.8 Waste Disposal

A central waste disposal plant has been provided to treat solid and liquids waste produced at the facility before it is carried away from the site. Soil waste either solid or liquid is carried away through ducts and a series of manholes into a septic tank to be located on site.

Surface drains will take care of storm water. A network of covered and open drains along the slope will discharge into the main storm drains which will be constructed around the site.

5.8 Construction Technology

5.8.1 Structural System

The construction system comprises of a combination of concrete slabs and columns and concrete beams. Steel trusses have been employed for the roofs because of the spanning intervals. Regular geometric shaped buildings which allowed for simple post and beam skeletal frames.

5.8.2 Materials

The structural systems are concrete and also steel for the roofing system. Concrete has a high fire rating ratio. However, steel is known to possess a low fire rating (less than two hours). Truss structures are chosen for the roof. The space grids are redundant structures i.e. failure of a member does not significantly affect the whole structure as the excess load due to the failure is effectively redistributed to all the members.

Furthermore, the porous nature of space grids coupled with the overall lightness of its members makes the build up of heat to distressing levels very difficult. The steel members are stainless and are coated with anti dust substances. By this, corrosion is effectively taken care of.

Walls

Concrete masonry as well as brickwork finishes is employed on exterior walls as part of external landscaping. Wall cladding makes use of combination of concrete masonry units, rough textured sand wall cladding and facing tiles. Walls in areas such as research and production units have been finished in such a way as not to attract dust.

Ceiling

Ceiling is mostly exposed concrete with emulsion paint finish with few areas having Plastic T&G panelling.

Floors

The type of flooring depends on the activities of the space and its required strength.

Floors for production spaces such as milling or granulation room, boiling room must have high load bearing strength and be able to resist vibration whiles floors for spaces such as the laboratories must not attract dust and should be sound absorbent.

Pavement materials such as concrete blocks, stone finishes are employed. Materials used for steps, ramps and retaining wall definition are consistent with general hard landscape finishes.

Roofing

Enamel coated long span aluminium roofing sheets on steel trusses.

Windows

Even though conscious effort was made to use glass curtain wall only on north and south facades of the structure, control of solar ingress into the facility remains critical. Both vertical and horizontal shading devices have been used on the facades of the facility.

Doors

Laminated glass in aluminium frames and wooden panel doors in timber frames and also coated steel rolling doors.

5.9 Costing

The estimated cost of the building was determined by using the approximate estimation method of costing and also studying the cost of similar projects and also keeping in mind the rate of inflation. The costing provides the client a fair idea of the financial requirements of such a project.

Taken into consideration the cost of local construction materials and labour and existing records and predictions of cost estimates of the current building projects, the cost per square metre of construction was tagged at GH¢450.

Cost Estimate for the Proposed Herbal Drug Facility

Research unit

Facility	Area m^2	Cost per m^2 (GH ¢)	Cost of total area (GH ¢)
Herbarium	150	450	67500
Laboratories	480	450	216000
Animal house	540	450	243000
Offices	14	450	6300
Washrooms	45	450	20250
Staff room	127.5	450	57375
		Total cost	610425

Production unit

Facility	Area m^2	Cost per m^2 (GH ¢)	Cost of total area (GH ¢)
Storage rooms(raw materials)	256.5	450	115425
Storage room(finished goods)	165	450	74250
Storage room(equipments)	50	450	22500
General store	116.5	450	52425
Milling room	25	450	11250
Washing/drying area	52	450	23400
Granulation room	57	450	25650
Boiling area	200	450	90000
Tableting room	33	450	14850
Capsuling room	25	450	11250
Tube filling room	25	450	11250
Blistering room	25	450	11250
Bottling area	40	450	18000
Weighing/mixing room	15	450	6750
Packaging room	120	450	54000

Security/ clocking area	18	450	8100
Offices	26.5	450	11925
Sorting area	40	450	18000
Changing rooms/ washing rooms	52	450	23400
Staff room	35	450	15750
Quality control	55	450	24750
		Total cost	644175

Clinical services unit

Facility	Area m^2	Cost per m^2 (GH ¢)	Cost of total area (GH ¢)
Outpatient department	160	450	72000
Consulting rooms	30	450	13500
Laboratory	56	450	25200
Dispensary + store	85	450	38250
Wards	153	450	68850
Washrooms	37	450	16650
Storage rooms	28	450	12600

Day area	40	450	18000
		Total cost	265050

Administrative unit

Facility	Area m^2	Cost per m^2 (GH ¢)	Cost of total area (GH ¢)
Offices	270	450	121500
Staff common room	40	450	18000
Library	80	450	36000
Conference room	80	450	36000
Computer room	80	450	36000
Washrooms	48	450	21600
Storage rooms	21	450	9450
Lecture room	80	450	36000
Entrance foyer + Reception	160	450	72000
Secretarial services	40	450	18000
		Total cost	404550

Ancillary facilities

Facility	Area m^2	Cost per m^2 (GH ¢)	Cost of total area (GH ¢)
Canteen	240	450	108000
Staff and public parking	2574	450	1158300
Service parking	2000	450	900000
Security post	18	450	8100
Water and Waste treatment plant	80	450	36000
External works (paving)	225	300	67500
		Total cost	2277900

Total cost of the structure for the proposed project is **GH ¢4,202,100**.

5.10 Recommendations

Despite the use of herbal medicine over centuries ago only a relatively small number of plant species has been studied for possible medicinal applications. Safety and efficacy data are available for an even smaller number of plants, their extracts and active ingredients

With 70% of the country`s population relying on herbal medicine, a herbal drug facility with capacity to research, produce and give consultations is certainly a viable project that will go a long way to improve the quality of health care delivery in the country.

The facility will be oriented towards herbal medicine research, production, education and treatments. With improvements in the quality and efficacy of these locally manufactured herbal drugs manufactured drugs there could be a significant drop in the importation of drugs.

Training and seminars provided by the facility for practitioners will guarantee improvements in the technical and scientific knowhow of these otherwise indigenous practitioners.

Improvement in the quality of herbal medicine to meet modern health demands ensures that it remains a natural choice for all.

Observations made during data collection time of this thesis have necessitated some recommendations.

- Effective monitoring of herbal practices and adequate scientific research to make herbal medicine safe and quality for public use can only be ensured if research centres are setup throughout the country to serve as satellites centres to coordinate research findings and data on various plant species in designated location with the government approved Centre

For Scientific Research Into Plant Medicine (CSRPM) with its single branch located at Mampong-Akuapem in the Eastern Region of Ghana.

- Private herbal drug production houses or clinic should be giving the needed logistical support to ensure that produced drugs and level of health care delivery meet approved standards.
- Strict laws requiring the scientific testing and certifications of all claims made by herbal medicine practitioners regarding their drugs.
- Organizing seminars and educational workshops on regular basis to educate herbal practitioners and consumers on healthy drug practices.

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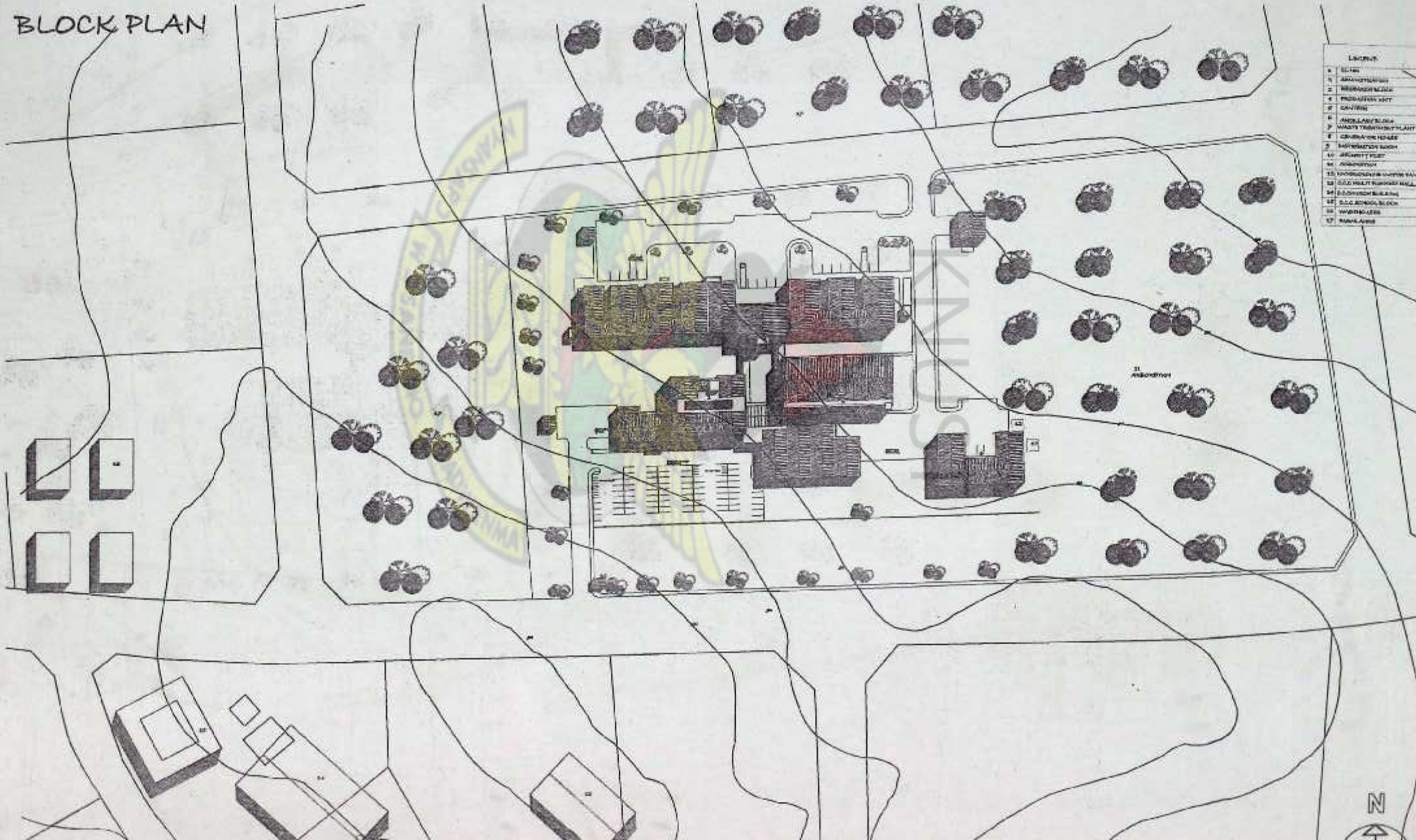
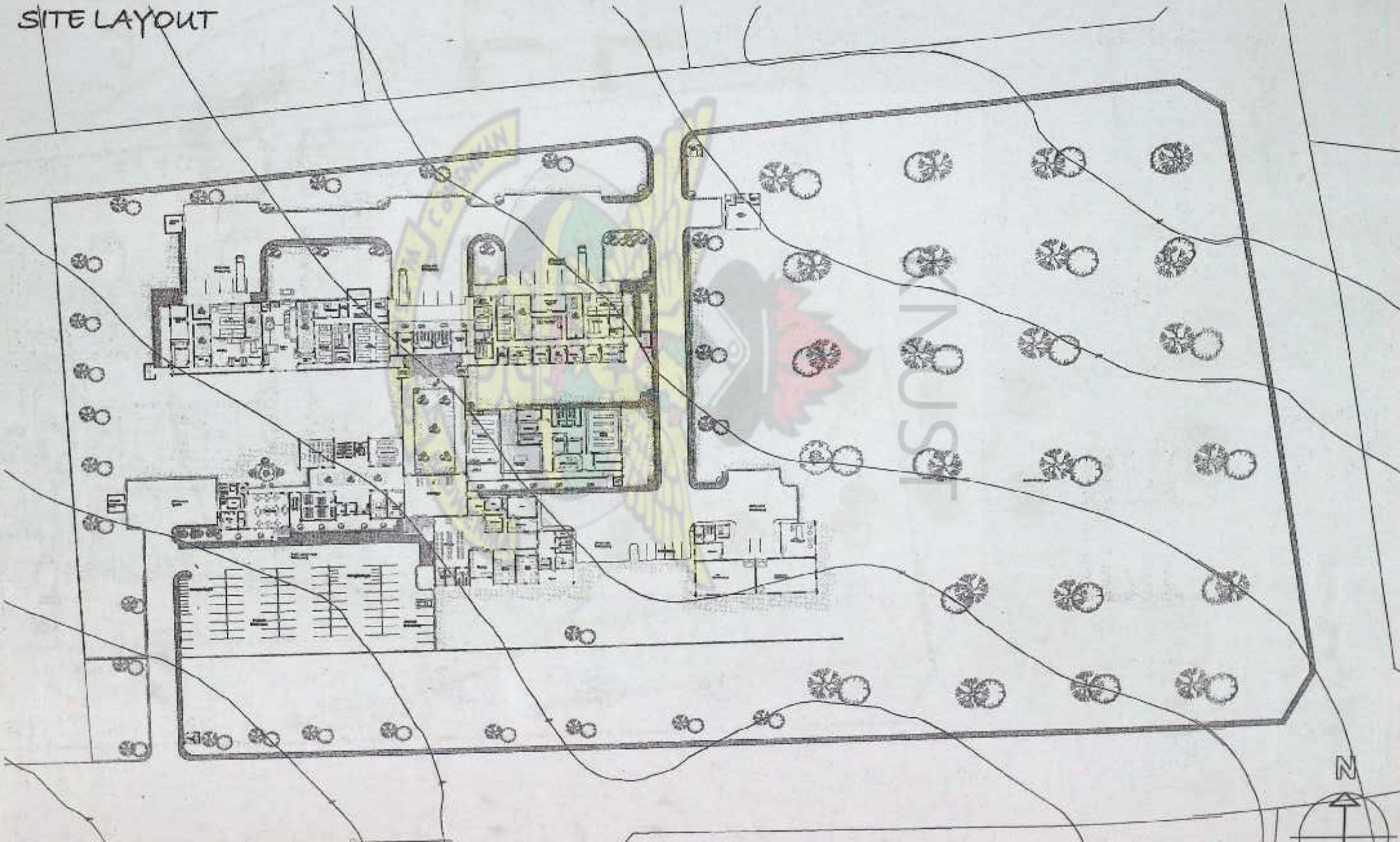
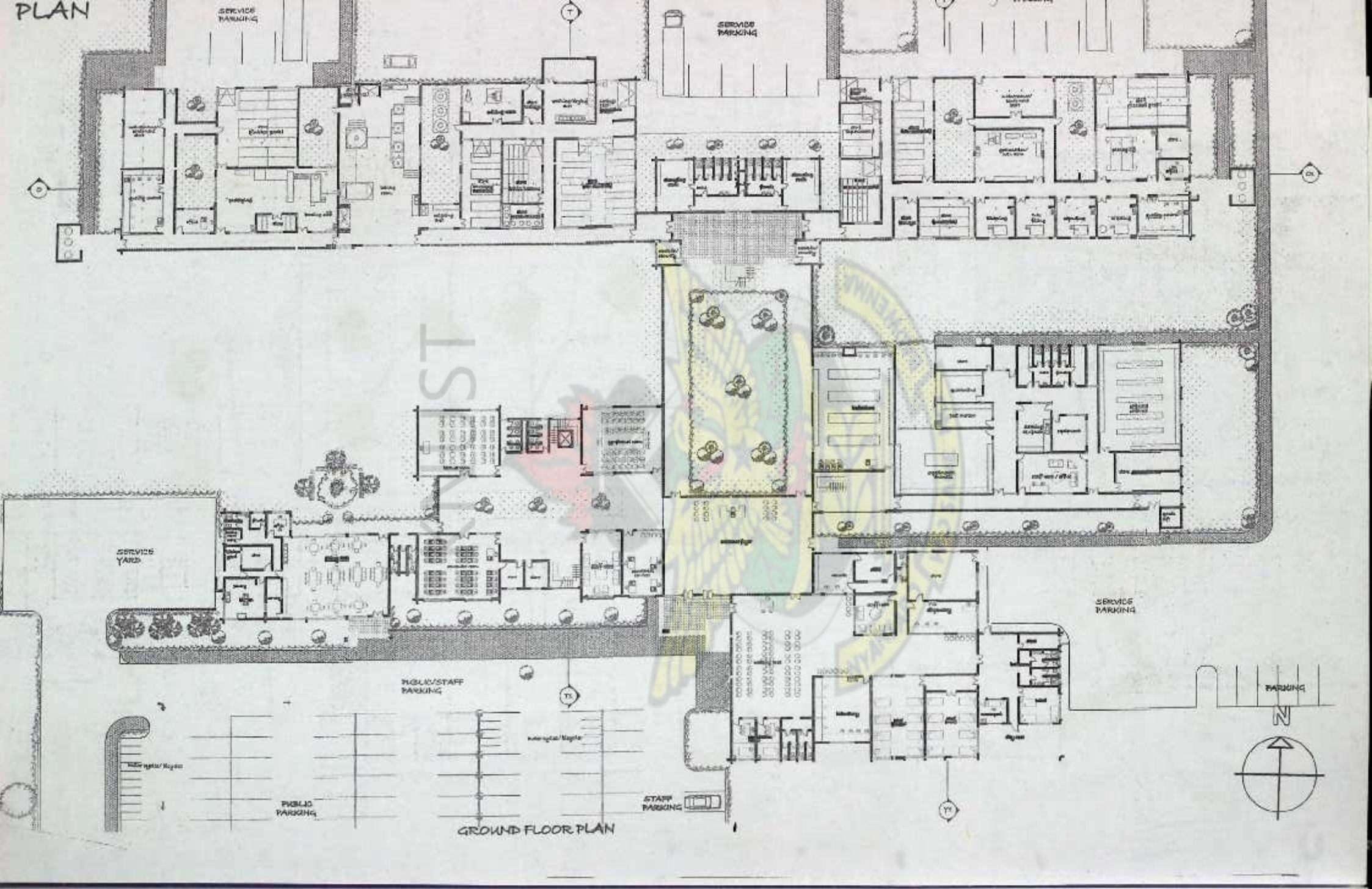
BLOCK PLAN



SITE LAYOUT




PLAN
SERVICE PARKING
SERVICE PARKING
SERVICE YARD
PUBLIC/STAFF PARKING
SERVICE PARKING
PARKING
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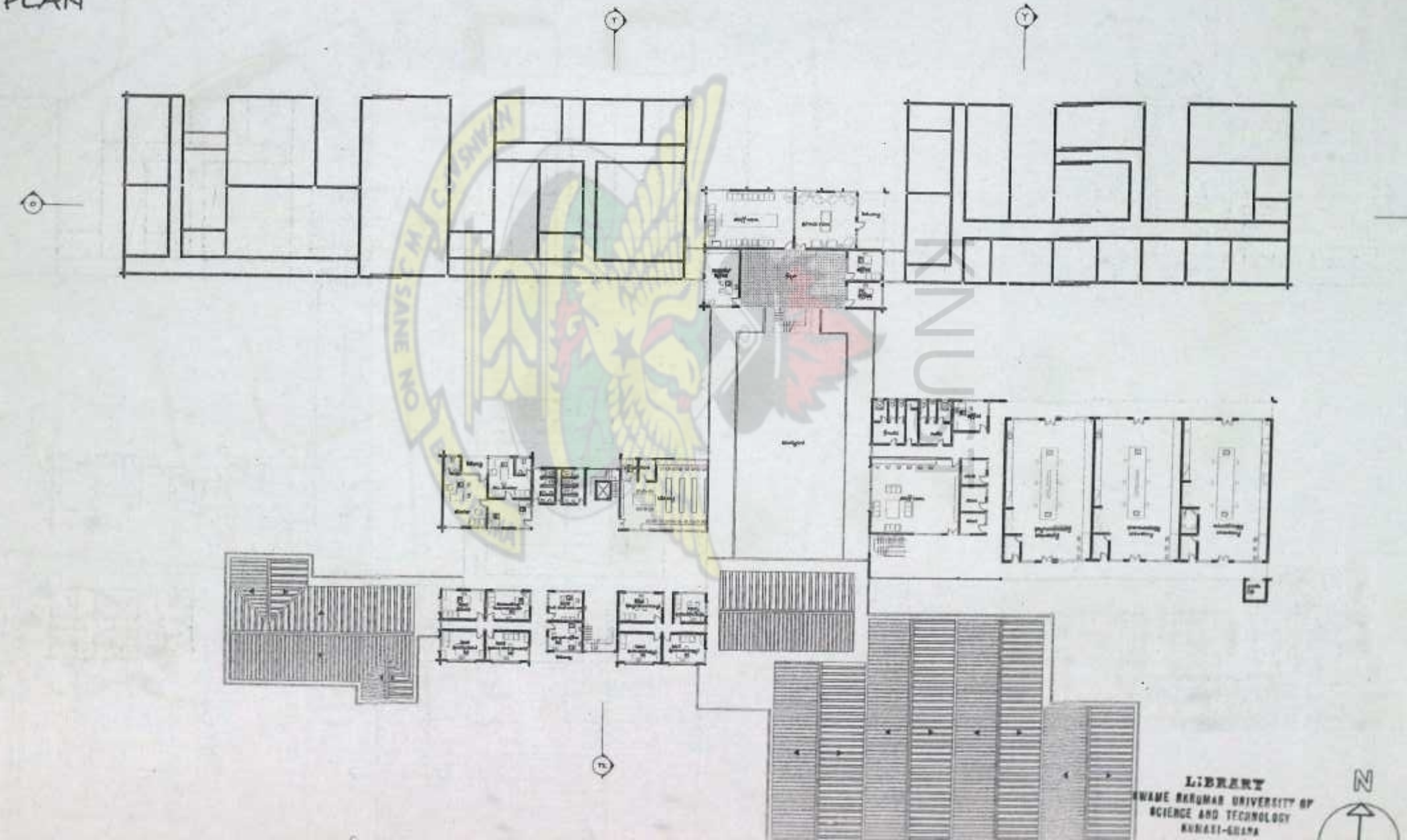
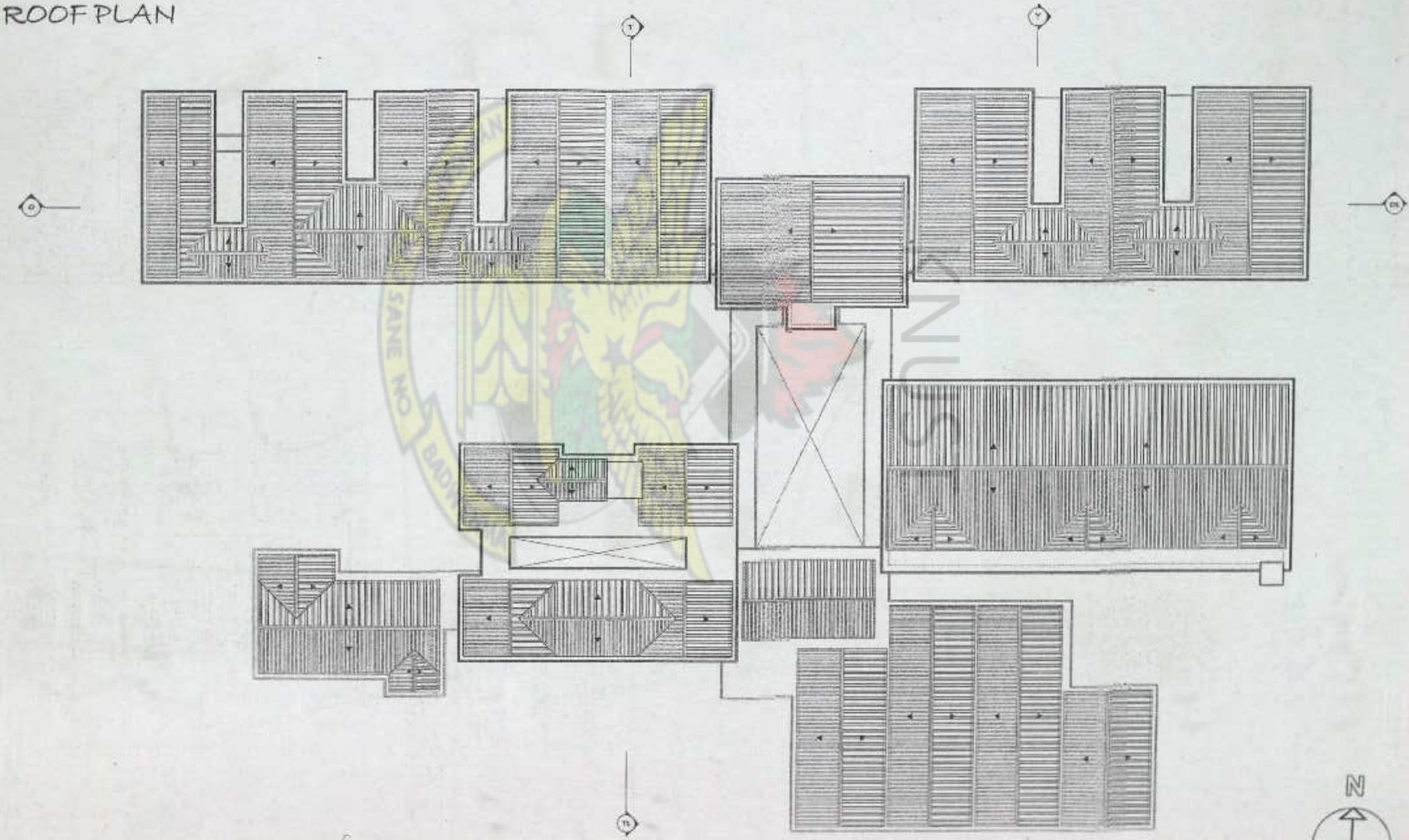
PUBLIC PARKING
STAFF PARKING
GROUND FLOOR PLAN

PLAN



ROOF PLAN

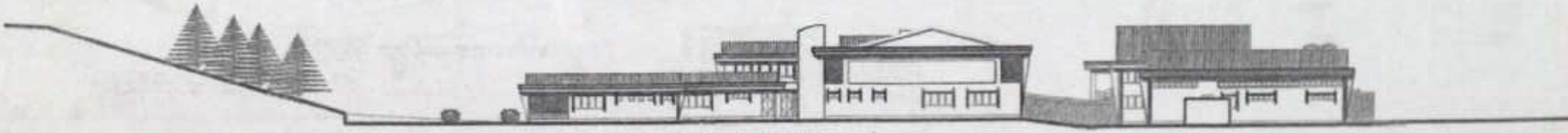


ELEVATIONS

SOUTH ELEVATION

WEST ELEVATION

NORTH ELEVATION

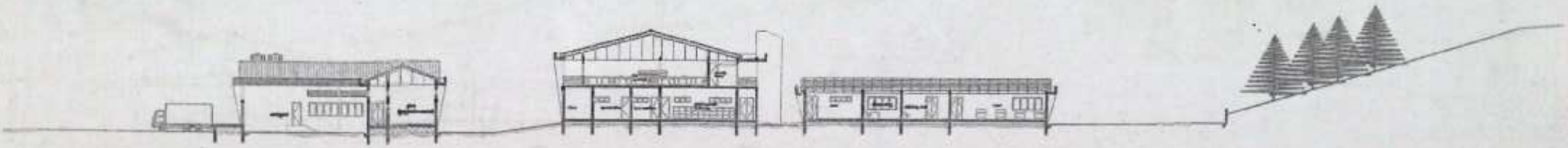


EAST ELEVATION

SECTIONS

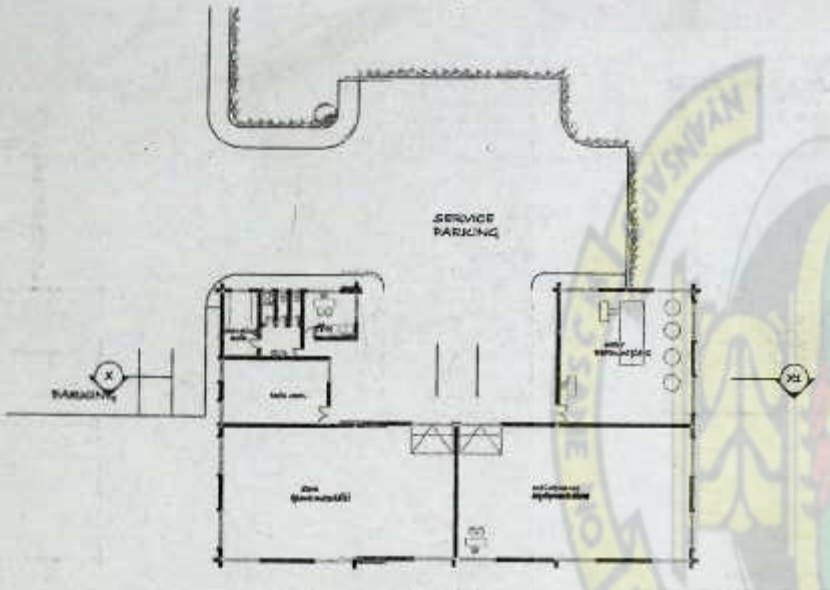
SECTION O-O1

SECTION T-T1



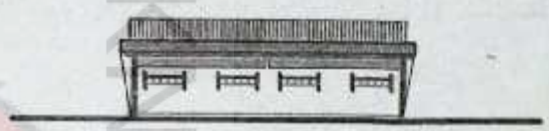
SECTION Y-Y1

ANCILLARY BLOCK



PLAN

NORTH ELEVATION



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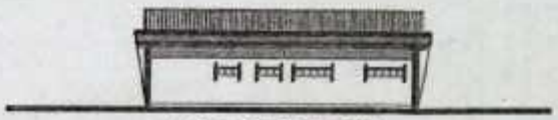
SOUTH ELEVATION



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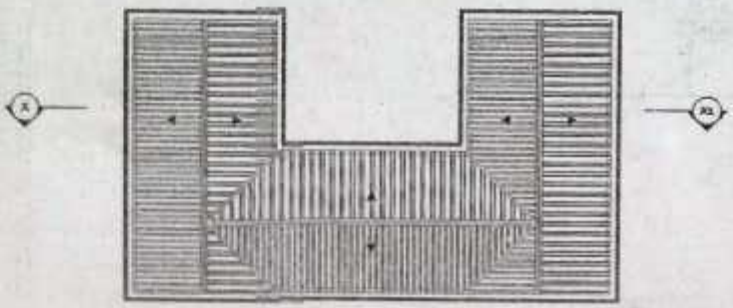
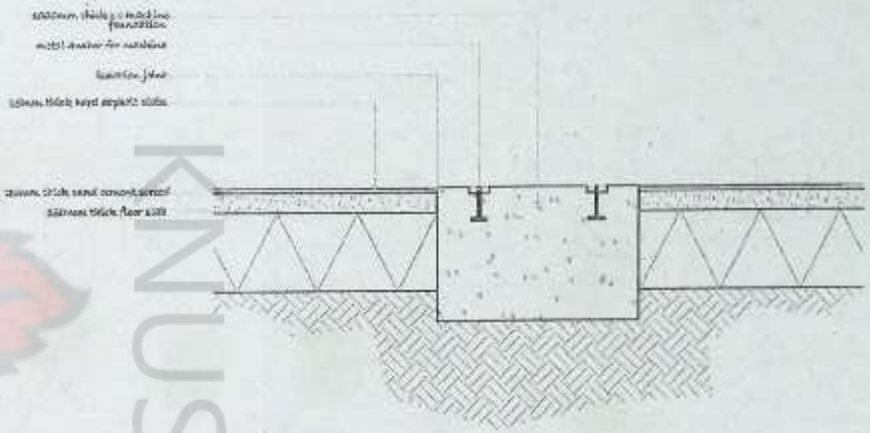


ROOF PLAN

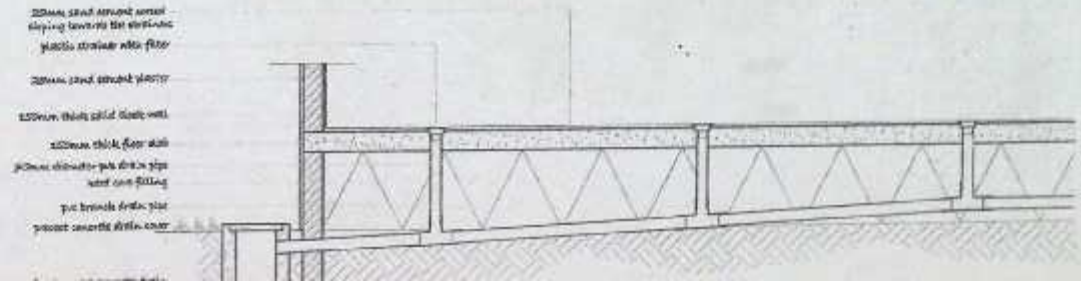
DETAILS

RETAINING WALL/EXTERNAL WORKS

MACHINERY FOUNDATION SLAB

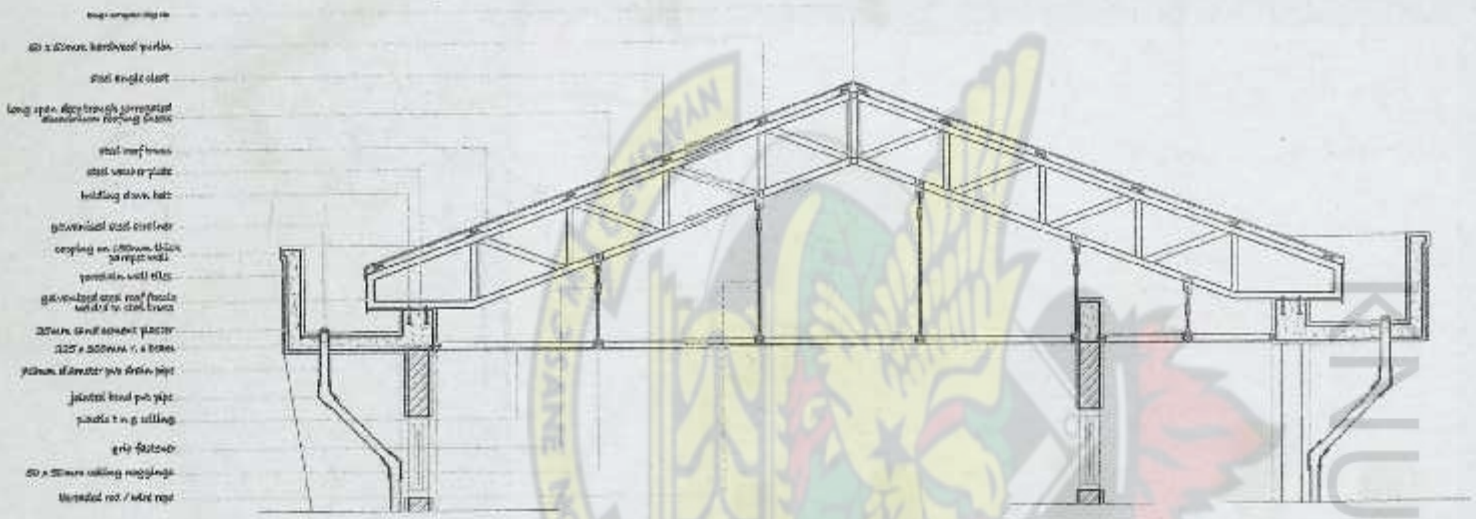


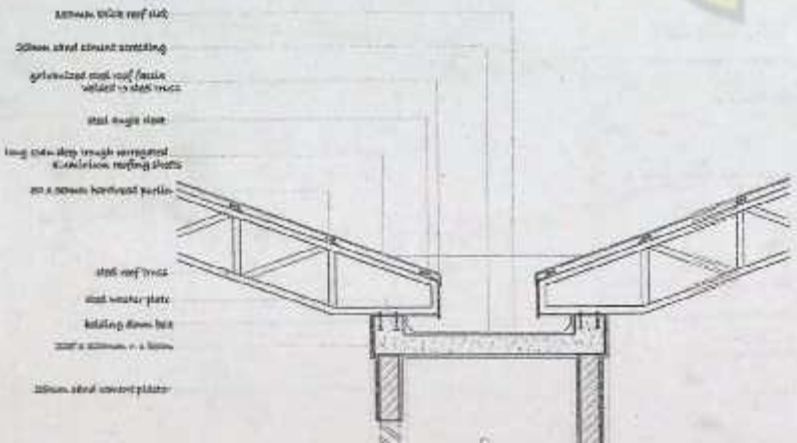
FACTORY FLOOR DRAINAGE DETAIL

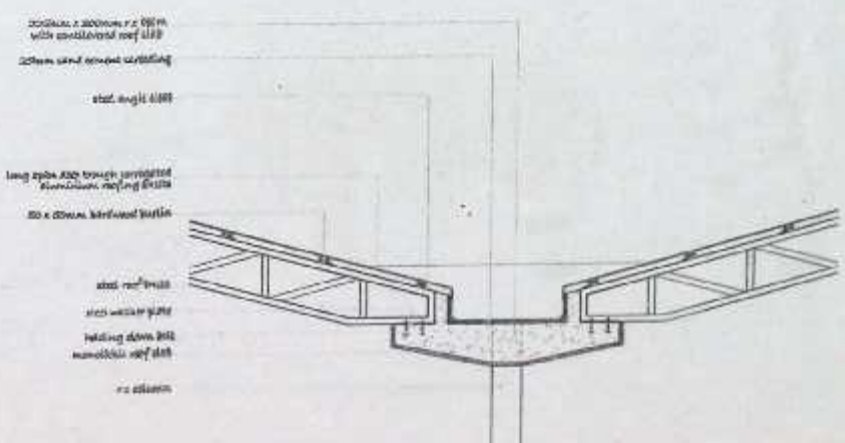


DETAILS

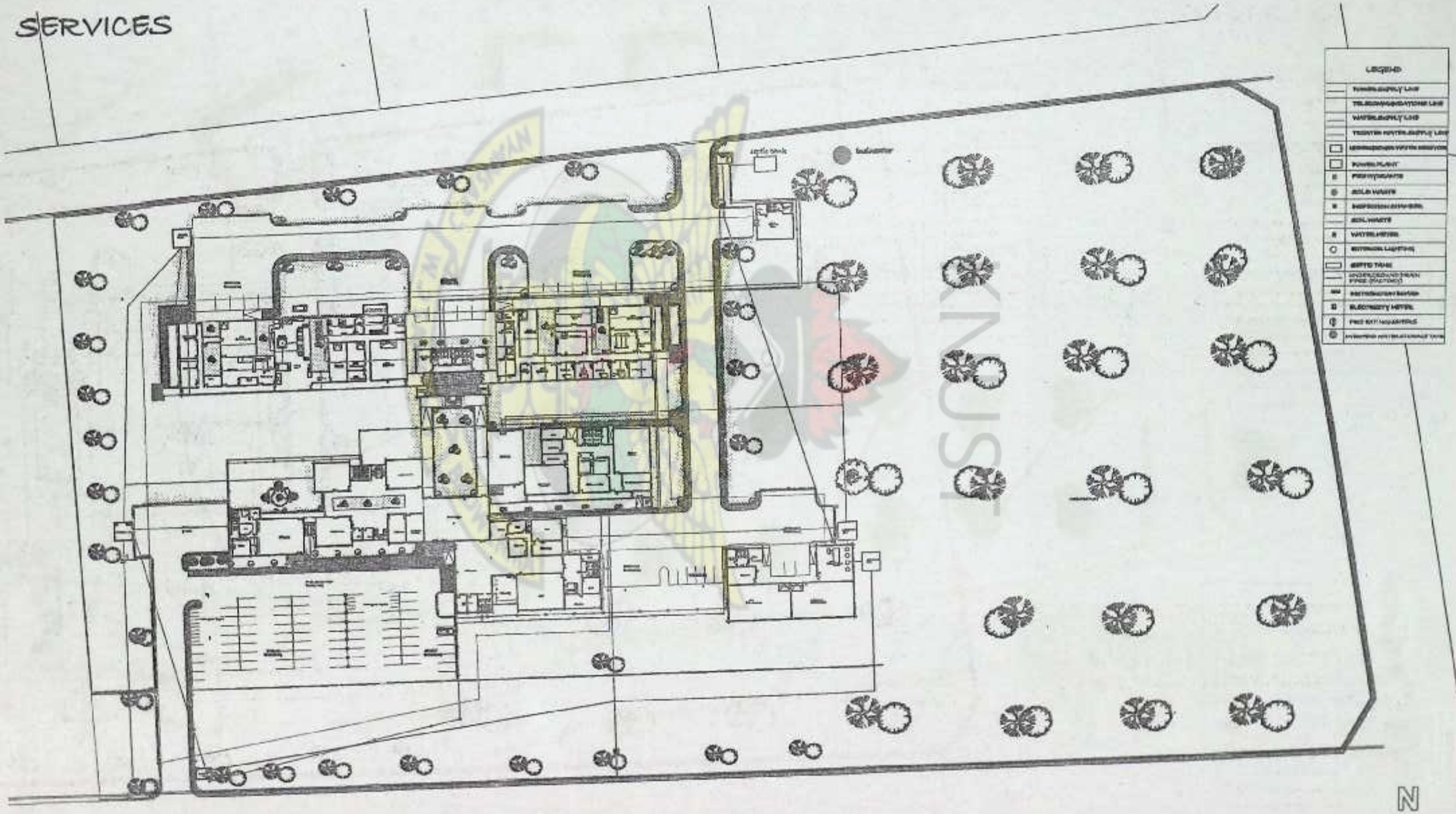
ROOF DETAILS







SERVICES



SERVICES (LANDSCAPE LAYOUT)