

GHANA STOCK EXCHANGE, ACCRA

by

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KNUST

**A Thesis submitted to the Department of Architecture,
Kwame Nkrumah University of Science and Technology
in partial fulfillment of the requirements
for the degree of**



MASTER OF ARCHITECTURE

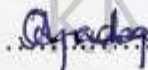
**Faculty of Architecture and Building Technology,
College of Architecture and Planning**

September 2009

DECLARATION

I hereby declare that this submission is my own work towards the MARCH and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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Prof G.W.K Intsiful
(Supervisor)



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DEDICATION

This design thesis is dedicated to:

My parents- Mr. and Mrs. Nunoo and
my sweet junior brother, Philip Nunoo.

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ACKNOWLEDGEMENT

Thanks to the Almighty God for his unconditional favor and everlasting grace.

He has brought me this far in life.

My sincere gratitude goes to Prince Charles Kwabi for his help and guidance during this design thesis.

My deepest appreciation goes to the following personalities who helped in making the design thesis a reality:

Prof. G.W.K Intsiful of KNUST, Kumasi

Mrs. Laryea of SSNIT Development Office, Accra

Gloria (P.R.O) of Marketing Department, Ghana Stock Exchange, Accra.

Hillary of New World Merchandise Ltd, (Brokerage Firm) Accra.



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ABSTRACT

The recent oil discovery offshore on the west of Cape Three Points, Axim by Kosmos Energy Company on 25th February 2008 has increased the desire to invest in Ghana from all over the world. As a result of this, there is a projected boom in Ghana's economy within the next two to five years. A legal environment thus is required which will not only attract but encourage and sustain investors and traders. The estimated economic boom is expected to have an increasing effect on savings, stock trading and investment transactions.

The Ghana Stock Exchange (GSE), the public company responsible for stock transactions in Ghana is currently constrained by limited office space to contain the administration of this expected surge in stock trading. Other institutions working hand in hand with the GSE in stock transactions are found in different distant locations within Accra which makes dealings very dysfunctional and time consuming.

This thesis therefore studies the work, functions and spacial requirements of the GSE , other international stock exchanges and office spaces to propose a suitable office complex for the GSE which would project their image as well as quicken and facilitate investments, stock exchange and financial transactions to match up the anticipated economic development.

The office will also house all the bodies and institutions relevant for stock transactions to quicken and facilitate the processes. Incorporated will be research facilities that encourage education and publicity in the area of savings and investment opportunities which is instrumental in enlightening the public to transform the economy positively.

CHAPTER ONE

1.0 INTRODUCTION

'The propensity to truck, barter and exchange one thing for another is common to all men, and to be found in no other race of animals.'¹

Trading dates back into ancient times from barter to exchange with currencies. As trading developed, economic systems developed alongside and gradually made trading conditions better. One of these systems is capitalism which started in Europe around the 13th century. The main focus was on the exchange of goods rather than on their production. A key element in capitalism is the undertaking of activity in the expectation that it will yield gain in the future with the risk of loss and the possibility of gain.

'Capitalism is a free-market system based on the private ownership of the means of production and distribution of goods, characterized by a free competitive market and motivation by profit.'²

In this economic system, there is freedom, though with some restrictions as to where to invest, what to produce or sell, and what prices to charge as the state protects individual rights. Countries practicing this economic system allow and encourage personal savings and investments to cater for the future. This developed the need for stock trading and investment and the rise of the stock market.

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In the light of keeping businesses running and the economy growing, shares are floated to increase the working capital and eventually the profit and gains of a company. These shares are then traded in various forms of securities on the stock market in the stock exchange for more returns.

A stock exchange therefore is a physical location for the trading of listed securities such as shares and bonds to individuals and organizations seeking to invest their savings or excess funds basically to increase revenue and cater for future expenditure.

Stock Exchanges play a major role in a nation's economy. These include raising capital for businesses and facilitating company growth, mobilizing savings for investment, government capital-raising for development projects and serving as barometer/ indicator of the economy.³

The Ghana Stock Exchange, a public company is responsible for stock trading and investments in Ghana. The market participants are the Securities Exchange Commission, Brokers (16), Registrars (3), Custodians (3), Government Security Dealers (17), Authorized Dealing Members and Listed Companies (36) as at December 2008.⁴

These numbers are anticipated to increase since reputable surveys have rated Ghana as one of the most attractive locations for doing business in Africa. It is therefore in the right direction that the current GSE be given a facelift in terms of an appropriate and conducive office building, housing all market participants to simplify, smoothen and accelerate trading and investments in Ghana; so as to achieve the dream of a golden age of business.

1.1 Problem Statement

The current 5th and 6th floors of the Cedi House in Accra office of the Ghana Stock Exchange (GSE) have become too small for their increasing numbers.

The 'concealed' location of the GSE makes awareness and knowledge on its existence and activities very low, thus investor contribution in up-surfing the equity capital and the GSE all-share-index is low.

The various bodies which help the GSE - market participants are not found in one location in Accra which elongates investment transactions.

It has therefore become very expedient to revamp the current Ghana Stock Exchange by housing all concerned bodies in an apt office complex to attract issuers and investors thus increasing the equity market for sustainable economic development.

1.2 Justification

There is a projected increase in investors and listed companies which will lead to increase in GSE workers, brokers and other market participants in the next two to five years as a result of the following:

- -Discovery of oil on the shores of Ghana
- -increased marketability and ease of financing for companies
- -automation of trading on the trading floor
- -step up in GSE promotional and educational programs
- -Good and ever improving physical and financial infrastructure
- -Ever increasing GSE All-Share Index

This affirms the need for a new office building facility to accommodate all parties involved in trading which will save energy, time and money.

1.3 Objectives

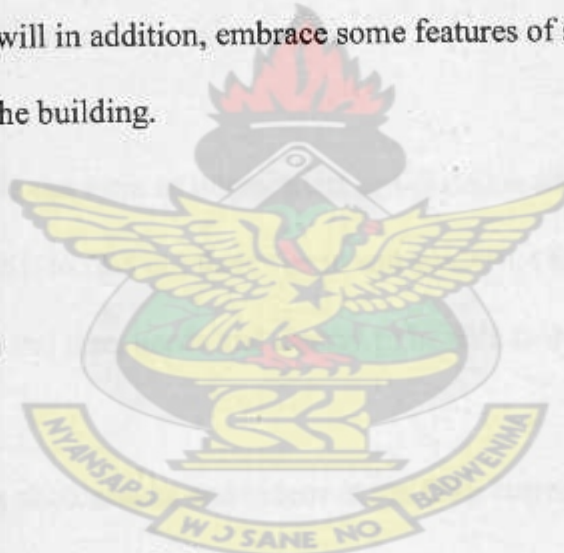
- To originate an architectural icon in the business industry that will enhance the Accra skyline as well as attract tourists, issuers, national and international investors; capable of serving the West African Sub- region while reflecting GSE values and wealth.
- To design a facility that houses all market participants in close proximity with woven in auxiliary facilities that originally take workers away from productive hours of work in the office.
- To create an educative and informative facility that will enlighten and give rise to the awareness of activities of the stock exchange.
- To develop an edifice with convenient and dynamic work spaces in a cool working atmosphere that will encourage innovation and increase productivity.

1.4 Scope

This thesis comprises the design of an office building that will house the Ghana Stock Exchange, Brokerage Firms and corporate institutions or bodies concerned with the assisting, regulating and controlling of trading and dealings of securities in Ghana.

Further, it includes spaces to lecture and educate the public and workers on stock trading and Ghana's financial market.

The design will also comprise parking spaces for staff and public, restaurants and relaxation areas; incorporated with soft landscaping to buff the noise and heat of the urban neighborhood. It will in addition, embrace some features of sustainable design to reduce running cost of the building.



1.5 Client

Ghana Stock Exchange

1.6 Financiers

Government of Ghana; Ministry of Finance

Ghana Stock Exchange

1.7 Target group

Ghana Stock Exchange workers

Stock Brokers

Bankers

Students

General and /or investing public

1.8 Research Methods

This shows the various methods used to research and come out with substantive proposals to meet the needs and requirements of the GSE.

Literature Research

This will take the form of research into the print and electronic media for information concerning the design of a stock exchange and offices in general. Occupancy level of the various spaces, office anthropometrics, administrative hierarchy, storage capacity and lift requirements are some of the areas the research will delve into. These will help to ascertain the work, functions and spacial requirements of a stock exchange and the GSE.

Interactive Research

There will be enquiries in the form of interactions and dialogue with some key representatives of the GSE to find out their vision and goals; not forgetting interviews with the workers to find out their needs and desires to be able to design to suit them.

Audiovisual Research

This will involve taking photographs and videos at the GSE current office to have a fair judgment of their job execution and the various limitations to carve out a better design.

Site Research

There will be an exploration into various sites through visual survey and site analysis to select and justify the most suitable place in accordance with specified requirements derived from the literature research for the execution of the proposed design.

Design Research

There will also be an investigation into various forms and structure designs of high rise buildings, office buildings and prominent stock exchange buildings around the world.

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CHAPTER TWO

2.0 LITERATURE REVIEW

This involves documentation, evaluation and analysis of the information gathered from the literature research about stock trading, investment transactions and office designs to derive proposals that will impact on the development of the proposed GSE.

2.1 Stock Market Overview

An organized financial market where brokers interact to buy and sell stocks and shares is known as the stock market. The stock exchange is the place or building where stock trading actually takes place. It is necessary for a country because it interprets the wealth of their economy and it serves as a barometer for investors.

Alexander Hamilton, the first U.S. Secretary of the Treasury, had studied the stock exchanges in Britain and believed they were essential to building and maintaining a vital and robust economy. ¹

2.2 The need for a Stock Exchange

- A stock exchange assists businesses to raise large sums of long term funds to expand and modernize.
- Business expansions assist in job creation and result in economic wealth for the country through taxes and better goods and services.

- Companies which raise capital from the issue of shares or bonds are able to expand their services, replace equipment and develop new products.
- The Stock Exchange and the market in general create career opportunities for young people in brokerage companies, financial analysis and reporting.
- The Government can borrow money from the public through the stock market by issuing bonds to build infrastructure such as roads, hospitals and schools.²

2.3 The Ghana Stock Exchange

The Exchange was set up with the following objectives:

- To provide the facilities and framework to the public for the purchase and sales of bonds, stocks, shares and other securities.
- To control the granting of quotations on the securities market in respect of bonds, shares and other securities of any company, corporation, government, municipality, local authority or other body corporate
- To co-ordinate the stock dealing activities of members and facilitate the exchange of information including prices of securities listed for their mutual advantages and for the benefit of their clients
- To co-operate with associations of stockbrokers and Stock Exchanges in other countries, and to obtain and make available to members information and facilities likely to be useful to them or to their clients.³

2.3.1 Brief History

In February 1989, a 10 - member National Committee, under the Chairmanship of Dr. G.K. Agama, then Governor of the Bank of Ghana, was set up by the Government.

The work of the committee was to consolidate all previous work connected to the Stock Exchange project and to fashion out modalities towards the actual establishment of the Exchange. As a result of the work of the committee, the Stock Exchange was established in July 1989 as a private company limited by guarantee under the Companies Code, 1963. It was given recognition as an authorized Stock Exchange under the Stock Exchange Act of 1971 (Act 384) in October 1990. ⁴

2.3.2 Bonds or Stocks

Stock is a share in the ownership of a company representing a claim on the company's assets and earnings. ⁵

2.3.3 Structure and Functions

Membership: There are Licensed dealing Members (LDMs) and Associate Members.

An LDM is a corporate body licensed by the Exchange to deal in all securities. An Associate member is an individual or corporate body, which has satisfied the Exchange's membership requirements but is not licensed to deal in securities. ⁶

Trading Method: GSE uses the Continuous Auction Trading system on the floor of the Exchange. This system has been automated since January 2009.

Trading Days and Hours: Floor trading takes place every working day from 9:30 to 10:00 hrs (GMT) for pre-opening and 10.00 hrs to 12.00 hrs (GMT) for main trading.

Clearing & Settlement: Settlement of trade is automated and it occurs three business days after the trade date (T+3) by delivery versus payment (DVP).

Trading Volume share volume traded between January to Dec, 2007 was 287.22million

Market Index: The GSE All-Share Index comprises all listed equities on GSE with 100 base average capitalization covering November 12, 1990 to December 31, 1993.

Market Capitalization This indicates the value of all the listed companies. As at Dec 31st, 2007 the total market capitalization of the Exchange was GHC 12,368.6 million.⁷

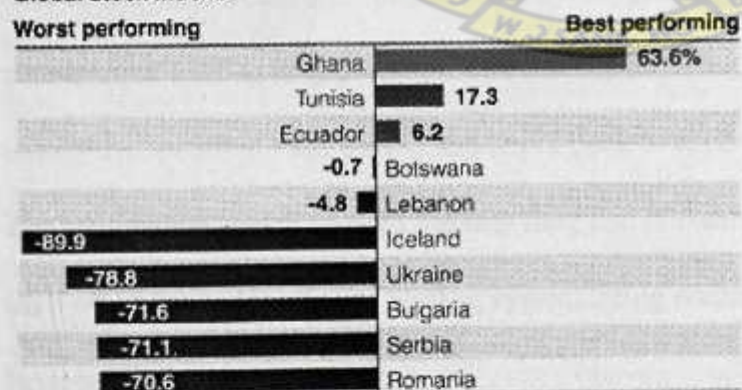
2.4 Market Participants

These are bodies which aid in stock transactions. They are anticipated to increase since reputable surveys have rated Ghana as one of the best performing countries in Africa.

Ghana Stock Market Leads World Indexes

Ghana's stock market is the world's top performer after an offshore oil discovery, rising commodity prices and government spending sent it up 64 percent this year.

Global stock indexes*



*As of 2pm

Bloomberg

Fig.2.1 Ghana's trading performance with other countries

Source: <http://www.ListofAfricanstockexchanges-SkyscraperCity.mht>

The Securities and Exchange Commission

It carries out regular inspection of Licensed Dealing Members' operations and books.

Listed companies submit annual and quarterly financial statements to SEC and the GSE.

It has the surveillance, registering, licensing, authorizing and legal departments.

Brokers

These are specially trained people who negotiate on behalf of their clients or companies on the stock market. In Ghana one has to pass through the securities course run by the GSE before qualifying to operate as a broker. Investors cannot trade directly in Ghana and thus have to do this through a broker. Brokers operate on the trading floor.

2.5 Relevant Spaces

The stock exchange has special spaces that are relevant for the kind of work that goes on in there which may not be in traditional office buildings. Below are some examples.

The Trading Floor

One of the most important spaces in the stock exchange building is the trading floor where stock trading is carried out. The trading floor has brokers who come in to trade within the specified time period and leave back to their various offices or companies.

The brokers are seated in such manner they can communicate and be able to trade with each other depending on the trading system being employed by the country.

Investor lounge

Investors may or may not enter the trading floor depending on the country. An investor lounge is prepared to host investors for discussions about their investment portfolios.

Public Gallery

This seat the general public to witness trading on the trading floor.

Media room

The media is given a place to be able to take coverage of stock trading on the trading floor for the general public.

Archive Space

Historically valuable material like photographs, videos and sound recordings are preserved and presented in exhibitions and programs to market the exchange. The progress of the exchange is documented and properly stored for future reference.

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2.6 Work Pattern

The administrative work in the stock exchange is fast and dynamic. This means the work space need be adequately lighted and information boards adequately displayed for workers to quickly identify any change and make the necessary associated changes. Interior space should be able to aid in thinking fast and re-energizing the mind without fatigue. Transitions in visual stimuli help to process information.⁸ A blend of different views helps to stimulate the mind. Workers have proven to be happier, more energized and creative in beautiful spaces; they get bored and distracted easily in unattractive spaces.⁹

The floor finish should be able to comfortably support workers quick movements to and away from desks.

Air quality is another factor that affects workers performance.

The brains use up about 20% of all the oxygen that our bodies absorb.¹⁰

Either the space is well conditioned or there is an effective constant supply of natural ventilation. Plants improve air quality. Natural plants have a high tendency to increase humidity as well as control dust and other irritating particles.¹¹

Exposure to natural light has a positive effect on health and well-being.¹²

Direct sunlight and bright indirect light disturb computer work. Window blinds help adjust the amount of daylight.¹³

2.7 Security

Security is one prime issue in the stock exchange. Information confirming stock deals and payments are treated with high level of security. Instruments such as metal detectors, turnstiles and CCTV are used to check users of the facility. Accesses and parking should be security alert. There need to be a mechanism that checks and counts the entry and exit of cars and people into the facility for the records. Integrating landscape features into security elements can transform them into visually appealing assets that support the vitality of the urban streetscape. Planters can be a solution for security control as long as they are well designed and maintained.¹⁴

2.8 Fire Safety

Automatic sprinklers are the most effective and reliable means to protect high-rise buildings.¹⁵ Pre-fire plans to the fire department will enable them have knowledge about the building, occupancies and locations of fire fighting devices employed. Variegated exterior facades and larger noncombustible spandrels significantly reduce exterior fire spread effects by increasing the distance radiant and conductive heat must travel to stress exterior windows and to heat materials inside the windows on floors above the fire.¹⁶

2.9 Impact of Information Technology

In late 2007 the NYSE closed the rooms created by the 1969 and 1988 expansions due to the declining number of traders on the floor as a result of increased electronic trading.¹⁷ The advantage of this system is its fastness and accuracy with account information and the benefit of seating more brokers within the trading floor.

2.10 Structural System

Buildings fail because of 'progressive collapse'; in which damage to a relatively small portion triggers a chain reaction or triggered by the floor system disengaging from its supports over all or part of the building footprint at a localized storey level, as appeared to be the case for the World Trade Center towers.¹⁸

Designers can enhance safety by specifying structural systems that have smaller bay areas to increase the numbers of girders and columns available to support the floor system. This, and floor systems that are well connected to the supporting superstructure, will result in buildings with high force redundancy and enhanced load-path safety against progressive collapse.¹⁹

There is a cost involved in making safer buildings. Tenants of high-rise office buildings will pay higher annual lease rates in exchange for the peace of mind of knowing that the structure they occupy has been specifically designed to have enhanced safety against failure under abnormal loading. It is shown that designs with the most profit potential and those with the most safety potential correspond to buildings that also are the least safe and the least profitable, respectively.²⁰

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CHAPTER THREE

3.0 RESEARCH METHODS

This chapter uses the case study method of research to ascertain the basic functions of the stock exchange and to determine the spaces required for such a facility.

Secondly, it investigates a high rise office building in Ghana-Ridge Towers and studies modern trends in high rise building forms to establish the best form of design.

The chapter concludes with technical studies on foundation, structure and services of high rise buildings; elements and materials used in energy-efficient buildings to guide in making the design cost-effective to run.

3.1 Ghana Stock Exchange, Accra

The Ghana Stock Exchange in the 5th and 6th floors of the Cedi House in Accra, was formally in the Bank of Ghana Building but has been in its present location since the construction of the Cedi House. In 2009, it automated the trading system, which is strictly going by internet and computers with less manual written work.

3.1.1 The fifth floor

Four lifts and two opposite stairs take one to the open lobby which leads to the trading floor on the right and administration on the left. The administration consists of the reception, two visitor's court and offices. Bordering the trading floor are offices directly related to trading. The largest space is the two volume trading floor where brokers sit or stand during trading. The trading floor however suffered from a fire outbreak which occurred some few days after the automation switch in December 2008.

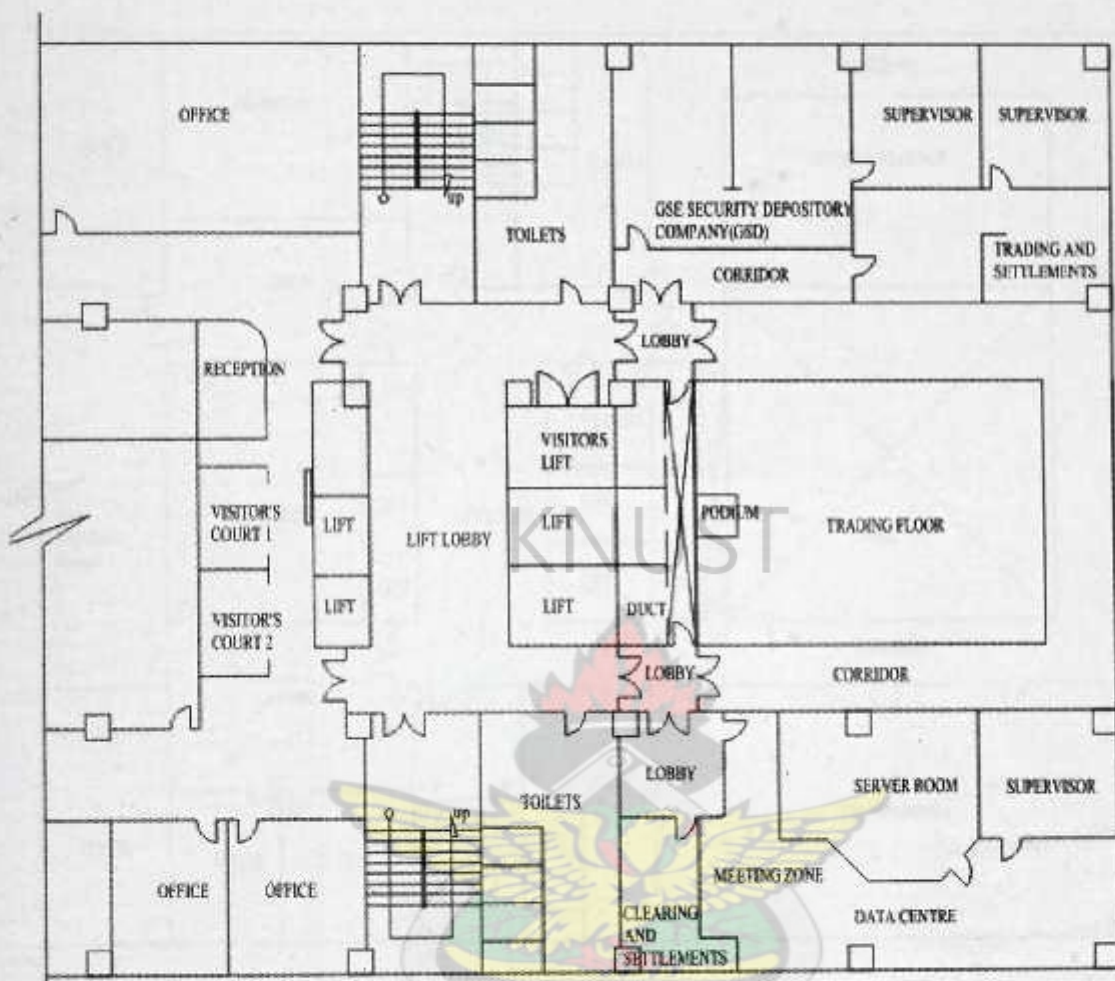


Fig. 3.1 Schematic diagram of the Ghana Stock Exchange floor 1.

Source: Author

3.1.2 The sixth floor

On the left of the lift lobby are the library, education and marketing departments as well as the old trading room; currently being used for trading to enable repair works on the main trading floor. On the right are the investors lounge and the training room for securities students. The GSE organizes securities courses thrice a year, 3months each for anyone with a tertiary education background seeking for knowledge or aspiring to be a broker.

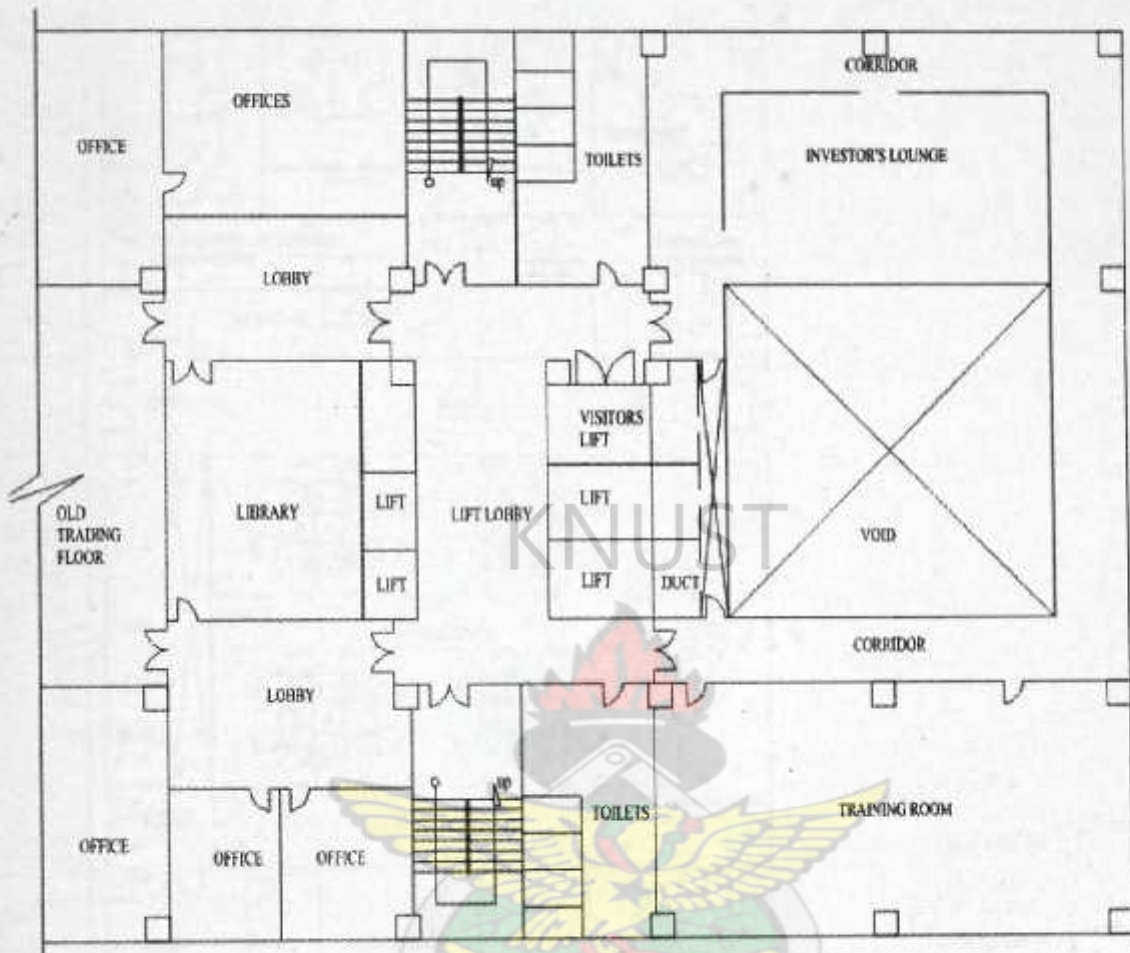


Fig. 3.2 Schematic diagram of the Ghana Stock Exchange floor2

Source: Author

3.1.3 Furniture arrangements

Furniture arrangement is important in designing office spaces since it affects the psychology of the worker. The office spaces have custom made L-shaped desks with a curve at the vertex. The chairs employed are swivel chairs with enough circulation spaces around each work station. The trading room has five octagonal desks with each of the eight sides occupied by a broker. The technical stand is in the middle.

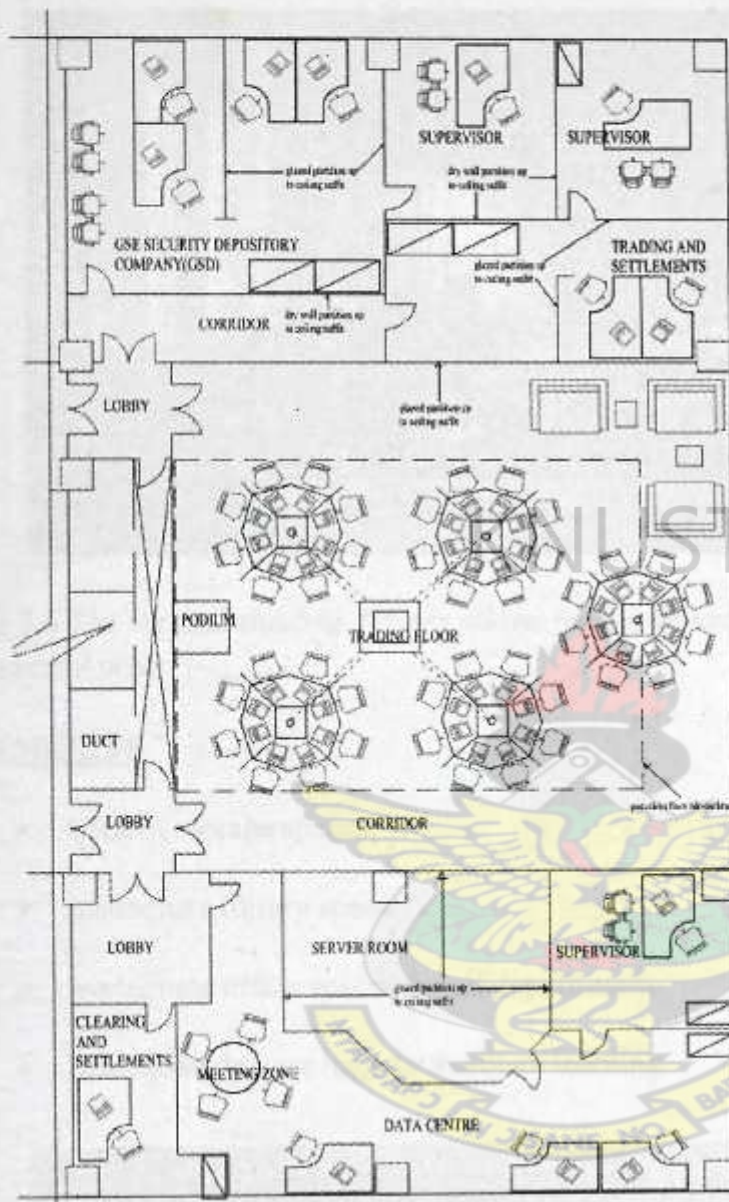


Fig.3.3 The first floor plan of the GSE showing furniture layout

Source: Author

MERITS

- The vertical shading devices employed for the building allows for maximum natural day lighting, shading and ventilation in the office spaces and lift lobbies.
- There are emergency exits, fire alarms, water hose and fire extinguishers on every floor.
- Security cameras monitor activities of workers and the public at vantage points.



Fig.3.4 The vertical shading devices allows for maximum natural day lighting.
Source: Author

DEMERITS

- Lack of storage spaces.
- Inadequate library space
- Inadequate office spaces for all departments.
- Inadequate lecture halls to facilitate learning.



Fig. 3.5 Lack of storage space
Source: Author

3.2 Stock Exchanges Around the world

3.2.1 New York Stock Exchange, USA

Architect: George B Post, Pediment by JQA Ward and Paul Bartlett.

Location: 8 Broad Street, between Wall Street and Exchange Place

Date: 1903 Style: Neo-Classicism 2

Construction: The New York Stock Exchange building opened at 18 Broad Street on April 22, 1903 at a cost of \$4 million. The trading floor was one of the largest volumes of space in the city at the time measuring 109 x 140 feet (33 x 42.5 m) and its marble walls rise 72 feet to meet the ornate gilt ceiling.¹ The main façade features a classical design-22 foot figure, representing the sources of American prosperity. The waves on either extreme of the pediment symbolize the ocean-to-ocean influence of the Exchange. The 6 massive Corinthian columns across its Broad Street façade impart a feeling of substance and stability the embodiment of the nation's growth and prosperity.² Annunciator boards on each end wall of the trading floor are used to page members.



Fig.3.6 The exterior of the NYSE

Source: www.nycnasa.com/New_York_Architecture/Images-NEW_YORK_STOCK_EXCHANGE.mht

3.2.2 Frankfurt Stock Exchange, Germany

With the advent of electronic trading platforms, large trading floors are giving way for smaller automated floors. An example was done at the Frankfurt Stock Exchange. The furniture arrangement was changed from linear to circular for the automation switch.

The occupancy level in the new trading floor is 30% more. The display board is placed along the balustrade on the above floors.

Merits of the electronic trading Floor

- More convenient broker cubicles
- Ease of circulation
- Comfortable over the counter dealings between brokers and investors
- The walls have been toned down from deep brown to light brown to make the floor brighter



Fig.3.7a The old linear trading floor

Source:http://deutscheboerse.com/dbag/dispatch/en/kir/gdb_navigation/about_us/20_FW_B_Frankfurt_Stock_Exchange/75_Modernization_Floor/Content_Fileshorizontal=page3



Fig3.7b. The new automated trading floor

Source: http://deutscheboerse.com/dbag/dispatch/en/kir/gdb_navigation/about_us/20FWB_Frankfurt_Stock_Exchange/75_Modernization_Floor/Content_Fileshorizontal

3.2.3 Abu Dhabi Stock Exchange Building, Dubai

On June 6, 2008 the Goettsch Partners (GP) were commissioned by Mubadala Development Company to design Sowwah Square, a new business center on Abu Dhabi's Sowwah Island in the United Arab Emirates.³ The project totals 3,125,500 square feet of office space and features the iconic stock exchange building surrounded by four office towers, all overlooking the water. The business center includes a 233,000-square-foot stock exchange building, four Class A office towers totaling 2,892,500 square feet, parking for 5,200 cars and 250,000 square feet of retail.⁴

As the headquarters of the Abu Dhabi Securities Exchange, the stock exchange building is an iconic, four-level facility. Glass-enclosed with a roof the size of a football field, the building rises 90 feet above a 160-foot-diameter water feature on massive stone piers.

The four granite piers house the stairs, mechanical risers and service elements for the exchange. The building projects an image of strength and solidity as it overlooks the water facing back toward the city's existing downtown. Four office towers frame the stock exchange building: two at 31 stories and the other two at 37 stories.⁵

The first full office floor of each building starts 110 feet above the ground level, providing a highly transparent, open lobby and elevating the views on all tenant floors.

A landscaped plaza connects the four buildings and the exchange at grade.

Beneath the plaza, a two-story retail podium weaves through the development, providing upscale shopping along the waterfront. At the north and south boundaries of the site, two parking structures, partially submerged, serve the complex with more than 2,600 parking spaces each. Sustainable integrated initiatives include:

1. Ventilated, double-skin facades to insulate the buildings against extreme temperatures
2. Active and passive solar shading to further control light and heat gain
3. 27,500 square feet of photovoltaic panels to capture solar power
4. Condensation collection from cooling coils to supply water.
5. Active lighting controls to balance natural and artificial light.⁶



Fig. 3.8 The proposed Abu Dhabi Stock Exchange with offices

Source: <http://www.Abu Dhabi Sowwah Square.mht>

3.2.4 Nigeria Stock Exchange, Nigeria

This is the exchange with the biggest listed companies and largest market in West Africa. Its market capitalization for the year 2007 was \$150 billion.⁷

The building tower is designed in the international style with shaded windows. The interior trading floor has a linear arrangement with the brokers sitting face to face behind their computers. The occupancy of the trading floor is about fifty brokers.

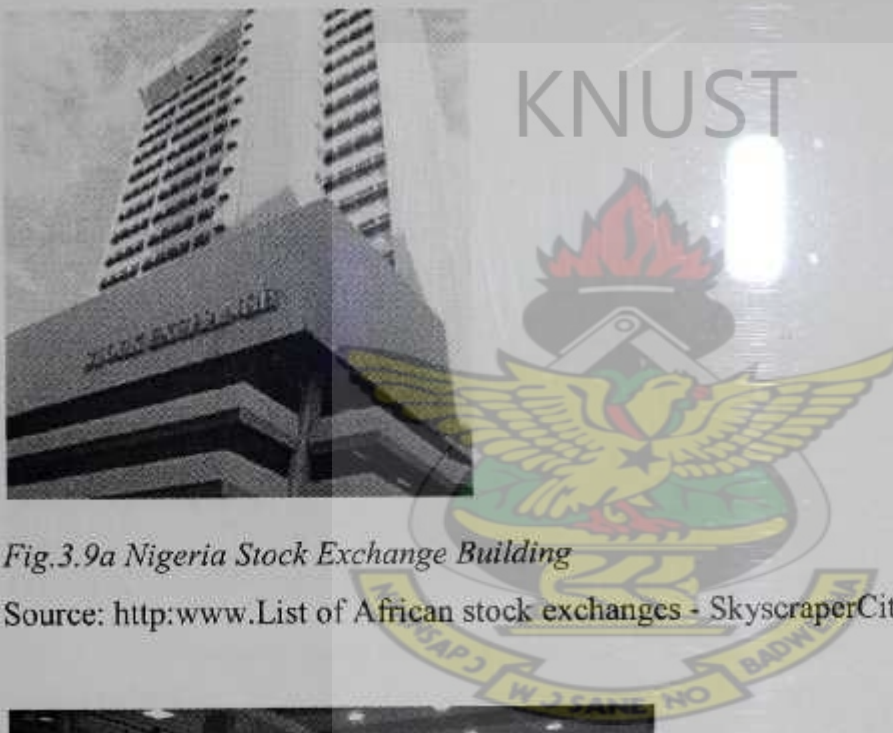


Fig.3.9a Nigeria Stock Exchange Building

Source: <http://www.List of African stock exchanges - SkyscraperCity.mht>



Fig. 3.9b The Nigeria Stock Exchange trading floor.

Source: <http://www.List of African stock exchanges - SkyscraperCity.mht>

3.3 The Ridge Towers, Accra

This study of an office building was conducted to learn the problems associated with office design in Ghana and to improve upon it.

Designers: Modula Grup

Location: Ambassador Area

Client: SSNIT, Ghana

Purpose: Office Building

Height: 15 floors

Date constructed: November 1993



Fig. 3.10a Exterior view of the Ridge Towers

Source: Author

DEMERITS

- No planned parking for cycles
- Extreme day lighting and heat due to extensive glazing leading to elevated air-conditioning services
- Restaurant seen as far and expensive
- Integrated service installations bring cost sharing problems among tenants.

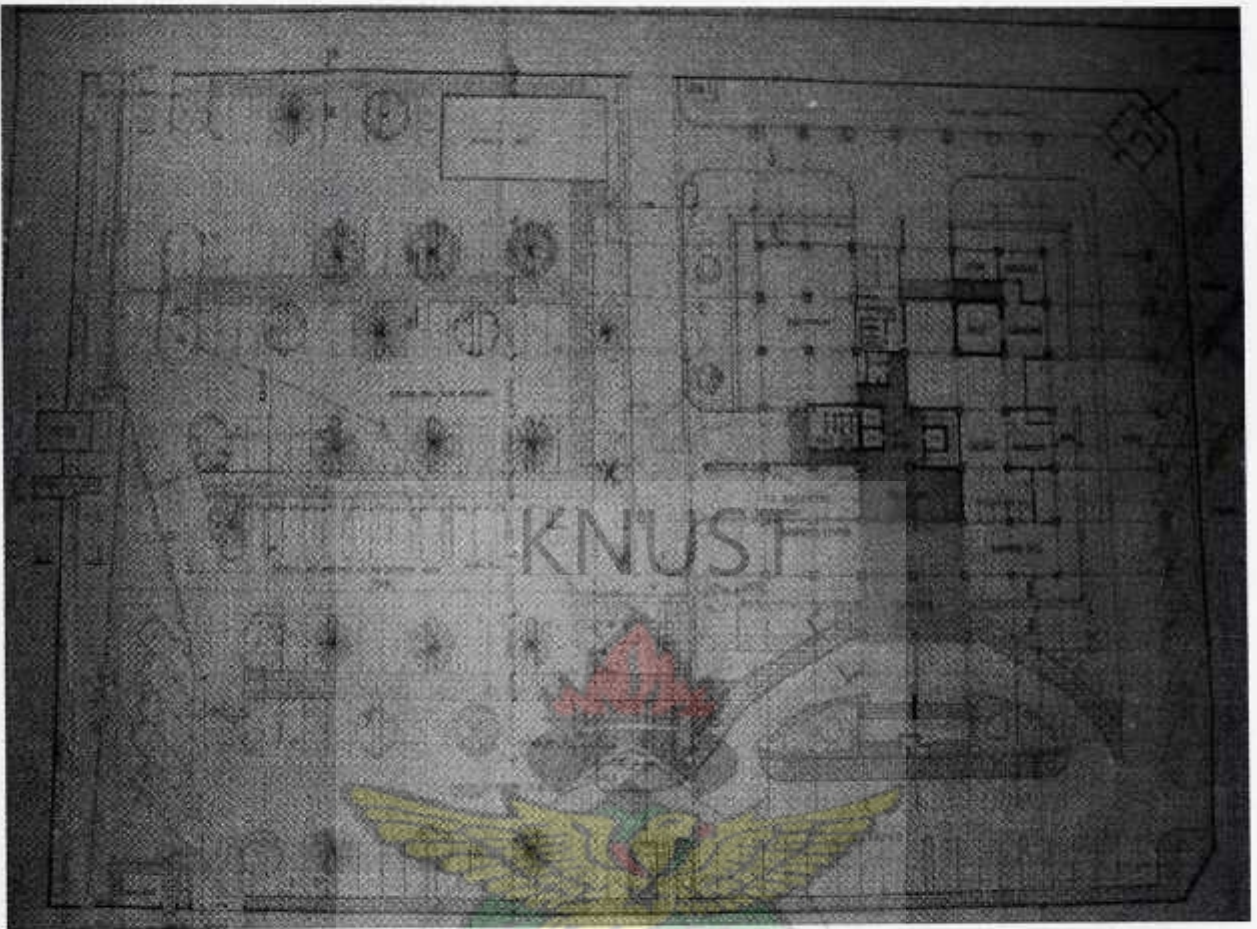


Fig.3.10b The Ground floor plan

Source: Author

MERITS

- Attractive form with culturally decorated facades
- The central core used as stairs and lifts supports the structure of the building
- Water storage and parking in basement
- Generator house at a distant from the building saves vibrations and heat transfer
- Well landscaped car park
- Celebrated entrance
- Escape stair and fire fighting gadgets on each floor
- Spacious, well lit and ventilated lift lobby

- Terrace on 14th floor for relaxation & socializing
- Well shaded executive bar
- Well treated interiors gives an executive finish
- Services hidden on roof
- Public and service entrance and exits
- Air-condition shaft well treated with grille

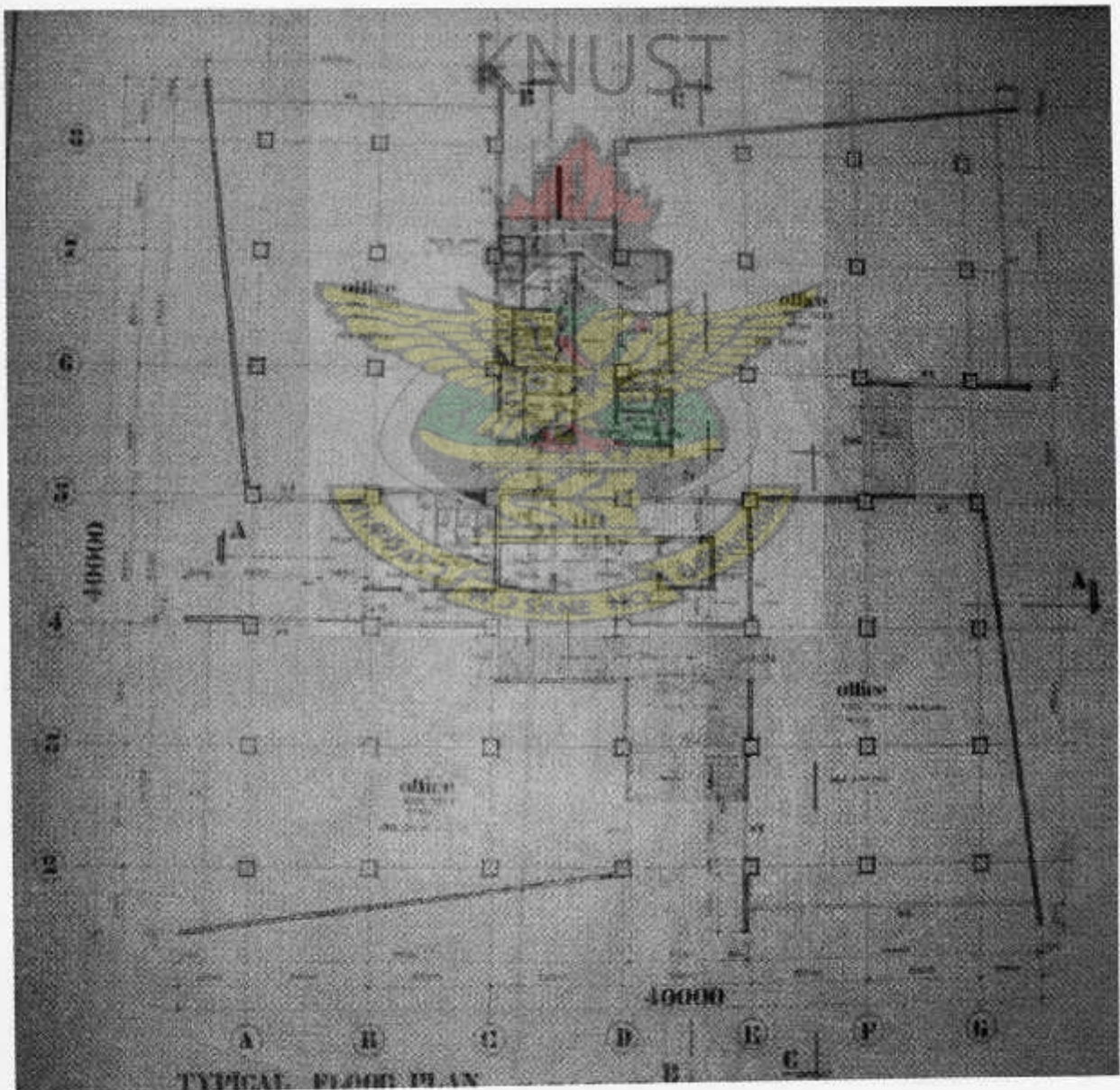


Fig 3.10c Typical floor plan

Source: Author

3.4 High rise building forms

The form of a high rise building is noticed from almost all distances thus has to be striking and attractive to be well appreciated. Most high-rise buildings intended to be icons feature twisted façades to give identity to major urban schemes.⁸

3.4.1 Twisters

A twister is a building with floors that lie horizontally rotated around a vertical axis usually positioned in the center of the floor plan. Often there is a cylindrical core, around which floor wings lie. The structural members, mullions, and contours all circle helically upward around the rotation axis, resulting in a non-orthogonal superstructure.

Some structural elements (like cores with elevators) may be aligned vertically, close to the axis of rotation. Basically, interior walls are not aligned with the ones of the floors above or under. The common parameters that vary are shape of floor, direction and degree of rotation. The scaling of floor plans is in one or two directions.⁹

3.4.2 Turning Torso

Height: 190m (623ft), 54 stories

Designer: Santiago Calatrava

Inaugurated: 2005

Client: Hsb, Sweden

Office Space: 4000m²

Housing Space: 13,500m²

Location: Redeveloped former shipping industry area of Malmö (Sweden)

Structure: The 90° twisted tower obtains stability from a central cylindrical concrete core. Most weight of the concrete floors rest on the core.¹⁰

The building comprises nine cubes twisting skywards. The lower stories contain offices and from the fourteenth floor contain 147 apartments.

Shared tenant facilities include a wine cellar, conference center, viewing platform, whirlpool, gymnasium, sauna and guestroom.¹¹

Foundation construction

The foundation shoring was performed using sheet piling driven down to bedrock (approx. 15 meters below grade) and supported by four internal compression rings. The foundation structure consists of a cylindrical foundation box with a diameter of 30 meters and a depth of 15 meters. The foundation slab rests on the limestone bedrock and is 7 meters thick with 5000 m² concrete.¹²

How it is built

HSB Turning Torso is built in reinforced concrete. The structure in the vertical direction is composed of central core supported by a foundation slab and at the apex of each floor is a concrete column supported by a pile foundation. The central core has an inner diameter of 10.6 meters and the core walls are 2.5 meters thick on the ground floor and only 0.4 meters on the top floor. The horizontal structural elements consist of nine conical slabs wherein half the circumference of each slab cantilevers from the core. The remaining triangular part of the slab is supported by the apex column and the central core. The five upper 'normal' slabs (in each cube) are supported by 11 structural steel columns located at the slab edge which then transfer the loads into the conical slab below. The concrete core is stiffened by an exoskeleton steel truss, which is erected on the outside of the building and exhibits the same torsional clockwise rotation like the building itself.¹³

The exoskeleton truss consists of a spine column at the tip of the floor plan and horizontal and diagonal truss elements that reach to each side of the fully glazed spine. In addition stabilizer elements connect between the floor slabs and the spine column. As a simplification, it can be stated that the concrete core can carry the total wind load without exoskeleton steel truss. However, the steel truss is active in certain wind directions and is designed to reduce wind displacements.¹⁴

How waste is sorted

The tower is powered by 100% locally produced renewable energy through a wind-power park and solar cells, and waste is managed through individual organic waste grinders that sends the material to a decomposition plant where it is turned into "biogas". This biogas can then be used instead of natural gas for gas cookers, fuel for vehicles, or production of district heating.¹⁵ Organic waste will be ground in the kitchen waste disposal unit and transported through separate pipes for decomposition and biogas production. The rest of the waste will be sorted and recycled.¹⁶

Fire Safety

All security systems have independent reserve power supplies. The entire HSB Turning Torso is equipped with sprinkler systems with double water supply system and its own emergency power supply. One of the lifts is designed especially for evacuation purposes and use by rescue personnel and is equipped with emergency power supply.¹⁷ Consisting of nine twisting steel cubes, the gleaming building spirals into the air offering unparalleled views.

The façade is made of 2,800 aluminum panels and 2,250 glass windows that each merit special fabrication in order to make the building as structurally sound as possible. In order to follow the turning of the building, each panel leans either inward (on the west side of the building) or outward (on the east side) from a range of 0 to 7 degrees. Included in the rent is a window washing service that uses a state of the art crane to keep the outside nicely polished.¹⁸

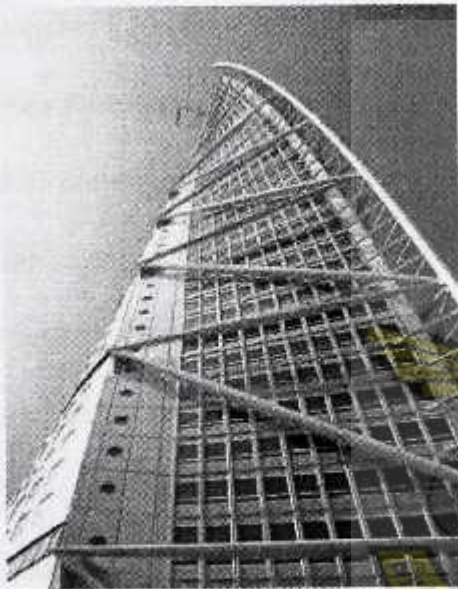


Fig. 3.11 The external truss of the Turning Torso

Source: http://www.hsb_turning_torso.html

3.5 Parking Ratios

Floor to car park index; for every 1000m² =20-40 cars for banks/offices

ANALYSIS

15065m²=300-500cars

Therefore approximately

250 parking lots for staff and

150 parking lots for public.

3.6 Structure of high rise buildings

The structure and framework of high rise buildings are usually designed to cater for up thrust loads, torsion and wind loads.

3.6.1 Foundation Systems

The foundation of any high rise building is very important since it serves as the major support to prevent collapse.

Pile Foundation

Pile foundations are used in areas of expansive or collapsible soils to resist undesirable seasonal movements of the foundations. Piles are relatively long, slender members that transmit foundation loads through soil strata of low bearing capacity to deeper soil or rock strata having a high bearing capacity. Piles also anchor structures against uplift forces and assist in resisting lateral and overturning forces.

Damp-proofing and tanking

This is a mechanism used in the foundation to prevent water from getting into the basement; usually in soils with high or predominant water table.

3.6.2 Space Frames

This structural system is used for very long spans. It can support spans of at least 80-100metres.¹⁹

As a result of the high level of static redundancy of space frames, the failure of a single member as a result of fire will not lead to the collapse of the structure.

3.6.3 The Truss System

Trussing is an important structural device used to achieve spans with less weighty construction. Spanning systems of almost any shape can be subdivided into triangles, the sides of which can be made of any appropriate material—wood, rolled steel, or tubing—and assembled using suitable end connections. Each separate part is then subject only to either compressive or tensile stress.

3.7 Green Architecture

Sustainable architecture has become part of modern buildings to get LEED certification. This involves the use of recycled materials or elements that are easily sustainable and minimizes the running cost of the building.

3.7.1 Ptfte Teflon-Coated Fibre Glass Membrane

Shape: This membrane can be formed into infinite number of shapes from flamboyant, dynamic structures to a very subdued inconspicuous dome or barrel vault shape. From soft to rigid angular folds, the membrane's flexibility allows to design the shape best suited to a project's overall concept.²⁰

Translucency and Aesthetics: During daylight, the membrane appears bright and opaque creating an icon attracting from a distance. With nighttime backlighting, the fabric emits an ambient glow that also creates a strong visual anchor. The structure becomes a welcoming beacon and instant landmark destination. The membranes translucency creates gently diffused natural lighting that reduces illumination and heating/cooling costs and serves to protect interior environments from harmful UV exposure.

The membrane acts as the finished ceiling reducing finishing costs.²¹

Maintenance: Teflon-coated fiberglass membrane structures exhibit durability and weather resistant factors. Projects utilizing ptfe membrane have an excess of 30+ years life cycle. Membrane roofs weigh far less than conventional roofing systems resulting in reduced structural steel components.

It is non-flammable and has fire resistant properties.²²

Ptfe has non-stick properties of the teflon coating, the membrane is immune to chemical attachment by pollutants.²³

Dust, dirt, ash, etc., that settles upon a teflon-coated membrane roof, can be washed off with water – usually with natural rainfall.

3.7.2 Photovoltaic

Photovoltaic (PV) is an elegant means of producing electricity directly from the sun, without concern for energy supply or environmental harm. These devices make electricity silently with no maintenance, no pollution, and no depletion of materials.

A Building Integrated Photovoltaic (BIPV) system consists of integrating photovoltaic modules into the building envelope, such as the roof or the façade.

By simultaneously serving as building envelope material and power generator, BIPV systems can provide savings in materials and electricity costs, reduce use of fossil fuels and add architectural interest to the building.

The solar contribution reduces energy costs while the exported solar electricity helps support the time of its greatest demand.²⁴

3.7.3 Solar Panels

The panels are usually angled on a rooftop to convert sunlight directly into electricity.

The solar panels contain semiconducting materials thus when light strikes the material, electrons move from one layer of the material to another, forming an electric current.

3.7.4 Ice Storage Air Conditioning System

Chilled water in the ice tank forms a layer of ice around the refrigerant pipe (supplied by the refrigerant machine). As chilled water at about 35°F is removed from the tank, it enters a heat exchanger, so that its temperature is closer to 45°F for distribution to cooling coils throughout the building.

3.7.5 Underground rainwater harvesting System.

Rainwater can be filtered and stored to cater for water shortage periods thereby ensuring there is a constant flow of water especially in the sanitary areas.

3.7.6 Flexible Pipes

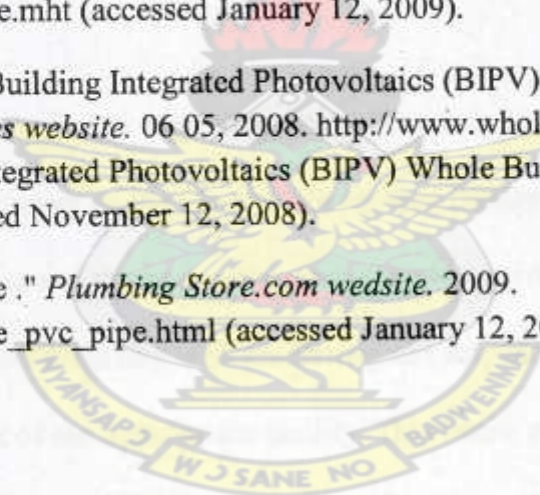
Advantages of using flexible pipes

- ✓ coils for storage and conforms to almost any contour
- ✓ same sizing as 'standard' (most common) schedule PVC pipes.
- ✓ 2" pipe has a bend radius of about 4 feet and 1/2" of about 2 1/2 feet.
- ✓ Increased capacity for expansion makes pipes more burst resistant.
- ✓ Suitable for use with hot or cold water.
- ✓ has less heat loss compared to copper and steel piping.²⁵

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CHAPTER FOUR

4.0 RESULTS AND DESIGN

The following are the deductions made from the research which will impact on the development of the proposed facility.

1. The GSE is a significant source of investment and direct employment and will contribute significantly to the growth of Ghana's economy; thus, prominence should be placed on increasing their awareness and functions to the general public.
2. Greater organization of market participants in investment transactions is needed through the development of the appropriate secured facility and environment.
3. Lighting, ventilation and views greatly affect the productivity of office workers.
4. The present GSE has difficulty with predicting and responding to peak demand savings due to lack of the appropriate facility. This limits effective functioning.
5. There need not be a compromise on cost for safety since all high rise buildings are relatively costly; rather there should be emphasis on safety of structure and fire control measures.
6. Natural day lighting and ventilation is essential especially in the tropics to increase the comfort of workers and reduce running cost as a result of decreased artificial systems.
7. Restaurants and rest areas placed so high in the building discourages people from patronizing it.

8. Goods lift separated from human lifts provides the opportunity to adequately check all goods and effectively transport them.
9. Emergency exists and fire fighting gadgets are to be at vantage, easily accessible points in the corridors and lobbies to prevent suffocation in the event of fire.
10. The design treatment of interior office spaces helps market the aims and visions of a company to the visiting public. Impressions to be created in the minds of clients are to be considered when designing.
11. Generators are placed away from the main building due to vibrations and noise. Fuel and fueling mechanisms are considered to be done away from the public circulation areas.
12. The central core of most high rise buildings is reinforced to support the structure.
13. Tenants should have access to their individual meters for verifications.
14. Security rules highlight separate entrances for staff and public in the stock exchange buildings.
15. There is emphasis on the incorporation of sustainable designs in modern buildings for international certification.

4.1 Developed Brief

The case and technical studies informed the various spaces needed in the proposed GSE.



Basement Parking	Lawyers Chambers
Basement Storage	Legal Offices/Consultancy
Ground Level Parking	Ministry Of Finance, Securities
Retail	Department
Breakfast Niche	Bank of Ghana, Securities Department
Enquiry/Reception	Lettable Office Spaces
Visitors Lounge	Sanitary
Gallery	Circulation
Library	Service Core
Internet Café	Brokerage Firms
Conference Room	Trading Floors
Lecture Theater	Investors Lounge
Staff Offices	VIP Lounge
Restaurant	Boardrooms
Breakfast Shed	Ghana Stock Exchange Departments
Staff Lounge	Securities Exchange Commission
Ghana Commercial Bank	Offices

4.1.1 Floor Distribution

This is a schematic representation of how the various spaces are going to be vertically distributed in the proposed high rise office building.

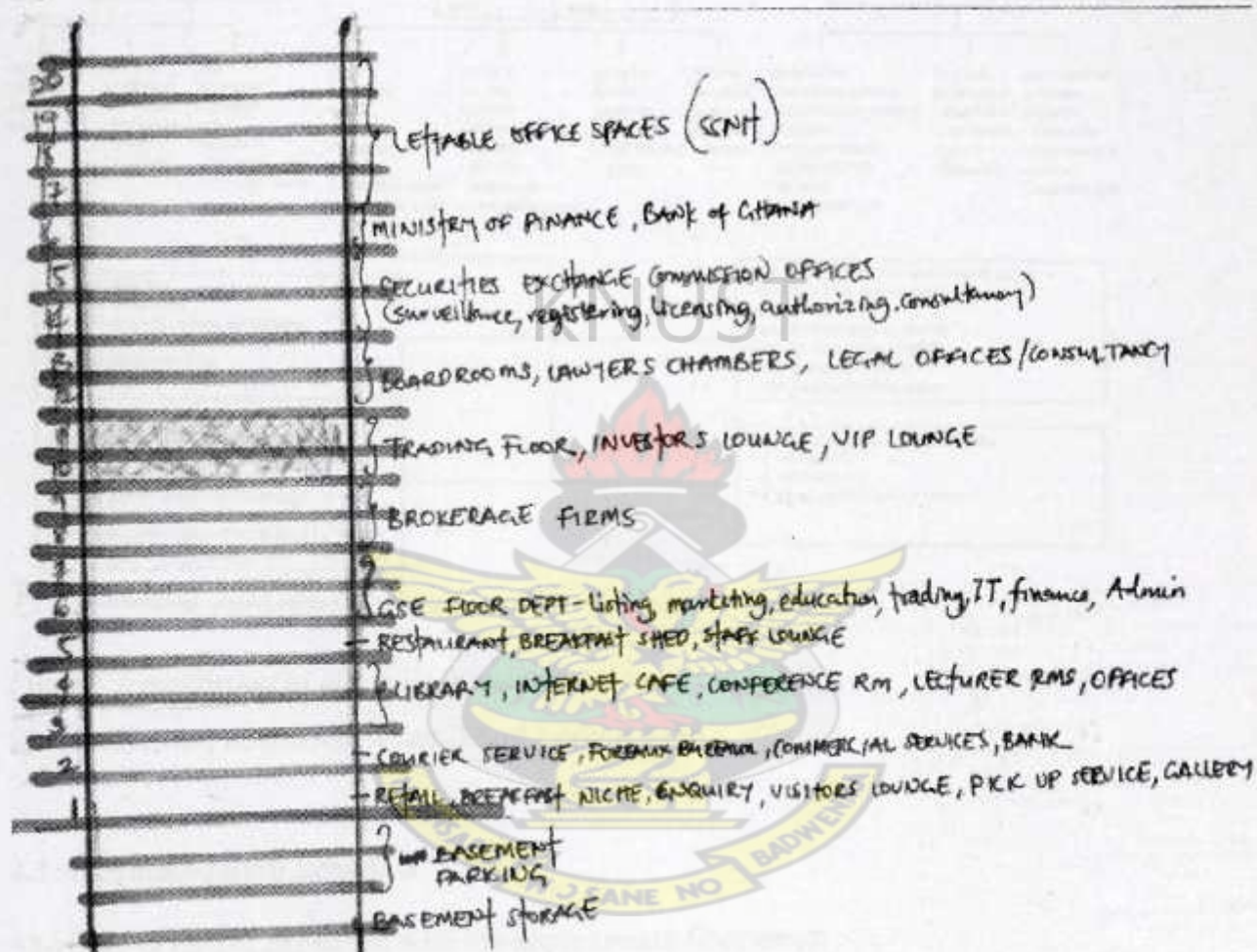
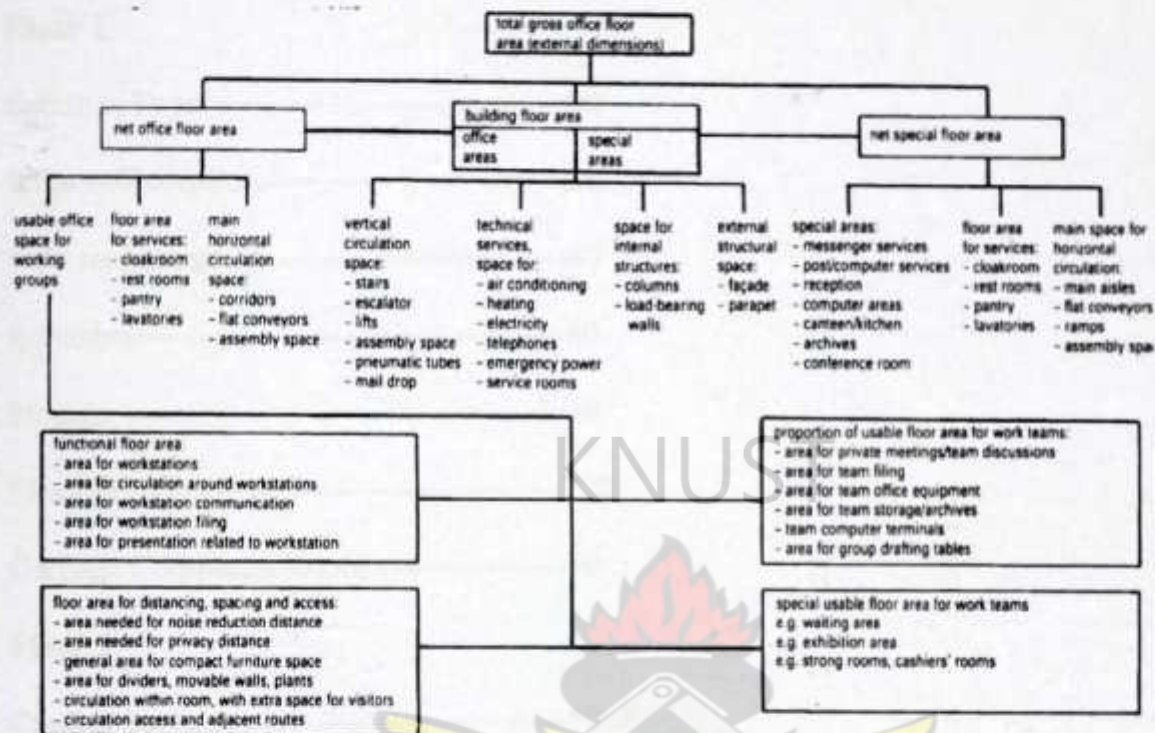


Fig4.1 floor distribution (cross section)

4.2 Functional Relationship Diagram



2 Organisational arrangement of floor areas in office buildings

Fig.4.2 organization of office floor spaces

Source: Neufert Architects' Data, Third Edition p336

4.3 Accommodation Schedule

The brief is further expanded with the approximate floor areas.

Space	m ²
Basement	
Storage (Plants/Equipment) -----	500
Service Yard-----	60
Public Parking-----	1500
Staff Parking-----	3450
Bicycle Parking-----	40

Space m²

Floor 1

Entrance Foyer-----	50
Enquiry/Reception-----	30
Visitors Lounge-----	40
Bookshop-----	80
Storage-----	30
Flexible Gallery-----	700
Garbage Compacter Room-----	50

Floor 2

Courier Service-----	50
Business Center-----	50
Media Room-----	50
Bank-----	100
Forex Bureau-----	25

Floor 3

Library-----	70
Internet Café-----	70
Audio Visual Studio-----	50

Floor 4

Conference Room-----	800
Lecture Rooms-----	800
Staff Offices-----	100

Space m²

FLOOR 5

Restaurant-----80
 Breakfast Niche-----50
 Cafeteria-----70

Floor 6-7

GSE Department Offices-----700

Floor 8-9

Brokerage Firms-----700

Floor 10-11

Trading Floor-----800
 Investors Lounge-----120
 Vip Lounge-----50

Floor 12-13

Lawyers Chambers-----100
 Legal Offices-----100

Floor 14-15

S.E.C Department Offices-----700

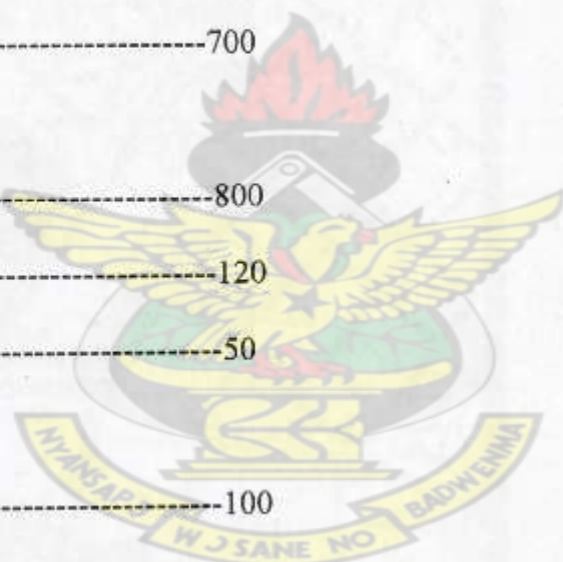
Floor 16

Ministry of Finance Stock Office-----200
 Bank of Ghana Stock Office-----200

Floor 17-20

Lettable Offices-----2500

TOTAL-----15,065



4.4 Site Location

The site is located in the Ridge Area in the Greater Accra Region of Ghana, specifically in the Ambassador Area. To its extreme south are the Ghana National Theatre and the Cedi House.

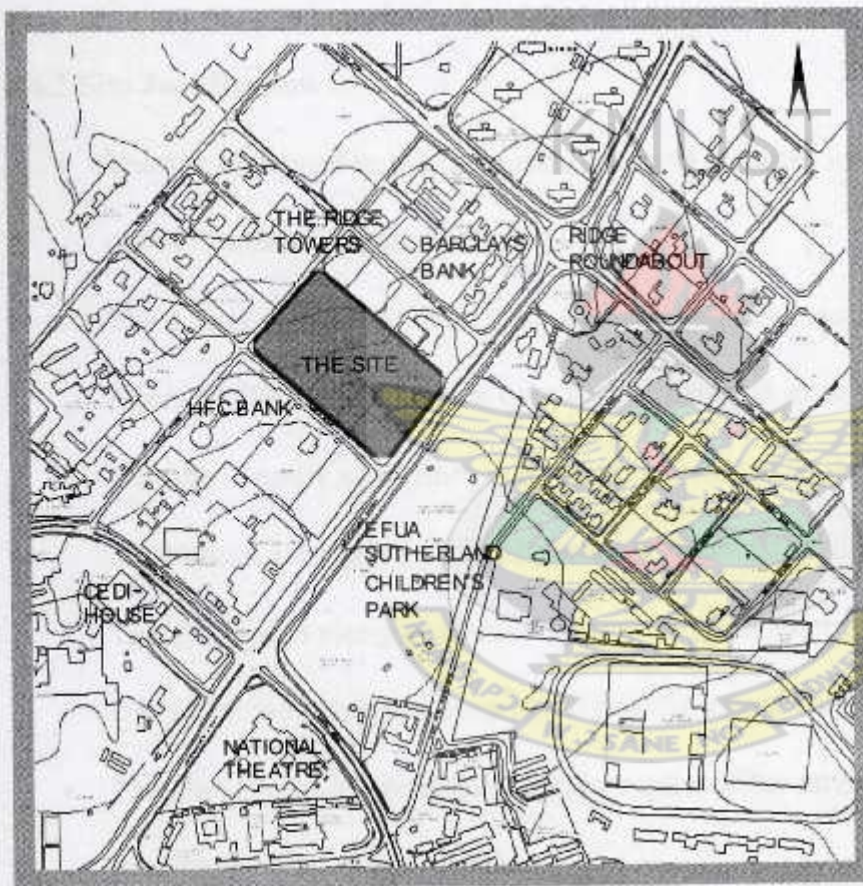


Fig.4.3 Map of Accra showing Ridge Area

Source: Survey Department, Ghana Town and Country Planning (2009)

4.4.1 Site Description

It is roughly rectangular and skewed about 30° from the true north. It measures about 110.2 meters on its shorter side and 170.6 meters on its longest side. The boundaries include:

North: Ridge Towers, Sixth Avenue and a SSNIT Multi-storey car park

South: Efua Sutherland Children's Park, Independence Avenue

East: Barclays Bank, Sudan Road

West: Hfc Bank, University of Ghana Business School, Libya Road

Area: $110.2\text{m} \times 170.6\text{m} = 18,800.12\text{m}^2$

4.4.2 Site Justification

- The site is located in the civic zone of Accra, situated in the administrative centre of the Central Business District (CBD)
- The area is gradually turning into the Economic Business Environment since the Accra central has been taken over by hawkers and extreme noise.
- The site is easily accessible to a greater number of banks, companies and related institutions in terms of proximity and communication lines.
- The site is also along a ceremonial primary road-Independence Avenue which can add some value and ceremonial significance to the building to be designed.
- The site is most importantly found in a quiet office environment which is very necessary for an office building.

4.4.3 Site Inventory

Neighborhood Character The neighborhood is characterized by predominantly high rise office buildings, maintained by Broll Ghana. These buildings include Ridge Towers-14 Floors, Vector Morrison Tower-17floors, Cedi House-12floors, Heritage Towers-16floors and a Multi- Storey Car Park-5floors.

Topography It is undulating with degree of slope between 5°-7°. The site slightly slopes from north to south and from west to east.



Fig.4.4 schematic section through site

Source: Author

Soil Loamy sand

Drainage There are adequate covered drains at the western and south-eastern borders.

Vehicular Circulation The site is boarded by 2 secondary and 1 primary roads. Traffic is heavy between the hours of 7:00am and 8:30am, goes down from 9:00am-1:00pm during working hours and then gets heavy again from 4:30pm to about 7:30pm. Traffic is slightly raised however from 1:00pm-2:30pm during lunch breaks. There are two main accesses to the site, these are:

1. From Independence Avenue too Libya Road. This is the most frequently used for entry and it gives a better view of the site.
2. From Liberia Road through Sixth Avenue to Libya Road which is most frequently used for exit from site. There is an existing lay by at the south eastern boarder for drop offs. Transportation to the site by commuters in percentages is as follows:

By public bus-36%,

By private cars 54%,

By bicycles and motorcycles 10%.

Micro- climate The area is cool for a greater part of the day due to the numerous trees and sunny at the northern portion due to the bareness of the land at that side.

Spaces and Senses There is noise from the Independent Avenue due to the movement of cars, rustling leaves from the trees around and the children's park during programs.

There is however an experience of lovely breeze on the southern portion.

Existing Site Functions The site currently has squatters living in an abandoned building located in the south currently fenced to prevent encroaching. There are food vendors on the northern side, along the sixth avenue basically to sell food to the construction workers around.

Pockets of small scale economic activities like space to space, lottery and snack stands are found at vantage points along the roads in the area.

Legal Restrictions The area allows for only civic and/or administrative buildings which should not be less than 4 floors.

Existing Structures There are about 1.5metre paved walkways surrounding the site. The adjacent GCB site is walled on the eastern side with a fenced temporal car park on north eastern side of the site.

Vegetation There is the presence of grass, shrubs and shady trees at the southern portion of the site. The south eastern border of the site has huge shady trees.

Utilities There is the presence of water lines, electric and telephone poles on western boarder of the site. Rent levels range from \$15 to \$16 per square metre.

Views Pleasant views are to and from the south eastern, south western and north western sides. Unpleasant views exist to the north eastern side of the site.

Relevant Existing Buildings Well notable buildings around site include the University of Ghana Business School, Hfc bank, SSNIT Multi-storey car park, Ridge Towers, Valco Trust House, Gt Bank, Barclays Bank, EcoBank, Vector Morrison Towers, Cedi House, Pyramid House, National Theater, Cocoa Clinic at Mobile House, Ridge Hospital, Sports Club and the Ridge School.

4.4.4 Site Analysis and Proposals

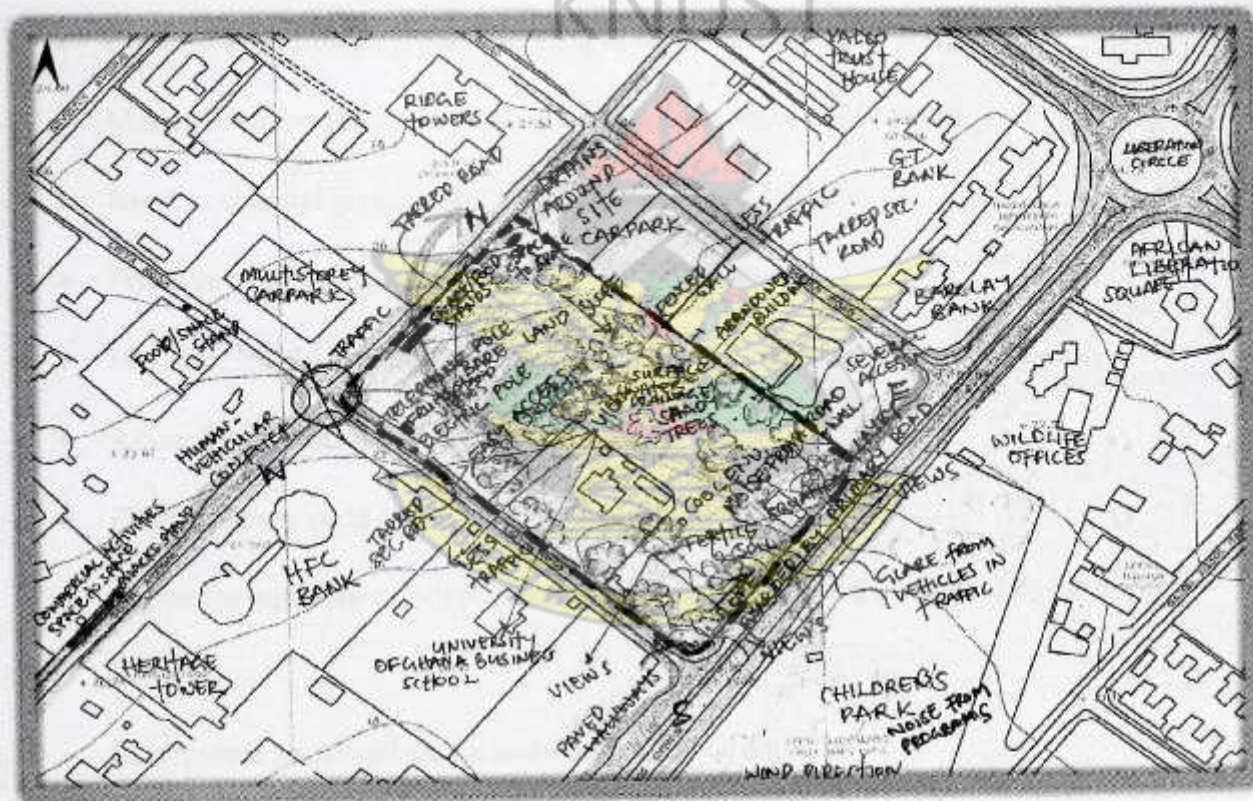


Fig.4.5 site analysis

Source: Author

The following are proposals suggested, following the site analysis above.

- Maintain neighborhood character by going high rise for office complex
- Take advantage of high rise building to create basement for stability
- Consider placing building in the northern bare area and parking in the southern shady cool areas
- Save southern fertile soil by creating extensive landscaping
- Maintain tree cover to improve micro-climate of the place.
- Create site and underground parking to cater for numerous private cars
- Make provision for cycle parking on site in the cool shady south
- Need to channel waste water to south east or west drains
- Preserve shady tall trees to buff noise from street
- Maintain lovely breeze by retaining most of the trees in the south and east.
- Allow for pedestrian access to site from lay by
- Entry to site should be far from crossroads to reduce conflicts.
- Allow for entry from independent avenue to Libya Road to appreciate building better
- Incorporate retail and snack activities in the building
- Screen unpleasant views on north east by maintaining trees
- Consider using the walled barrier for service yard
- Allow for tapping utilities from the western boarder

4.5 Design philosophy

This design seeks to create an office complex that can house all concerned bodies. It also seeks to help the Ghana stock exchange in its aim of creating awareness by designing an intriguing edifice to attract the public to the facility. It aims to stand out to attract people as well as sit in with the surrounding buildings and site location.

The philosophy thus carved out is **“SITTING IN, STANDING OUT”**

4.5.1 Design concept

Sitting In

Architecturally, the design is going to depict ‘sitting in’ by

- Being located within civic administrative zone in the capital-Accra
- Being located within the high rise buildings zone in Accra
- Having proximity to concerned investment bodies and banks

Standing Out

Again, the office complex will stand out by having the following features:

- Highest building in the zone between 20-25 floors.
- Captivating form and structure-twisting tower
- Gold and white elegant exteriors and interiors
- Extensive landscaping
- Breakfast niche
- Sand filter storage of underground water system
- Ice storage tanks for air conditioning

4.5.2 Conceptual Site Planning

4.5.2a Option 1



Fig.4.6 conceptual option1

Source: Author

Reasons for option 1

- The lowest point of slope of the site, that is the south eastern houses the services
- The landscaping and parking buffs noise from streets around site
- Services are lined for easy access and screened by staff parking
- Underground water storage is placed close to building for easy channeling of water from the roof.
- The generator has been placed at a distance from the main building to save vibrations and heat transfer
- Extensive landscaping has been designed around structure to compliment hard landscaping

Demerits

- The Independence Avenue entry does not solve for parking for staff since that road is almost always busy and chocked with traffic.
- The width of entry road is too narrow to allow for a free flow of entry and exit of vehicles.

4.5.2b Option 2



Fig.4.7 conceptual option 2

Source: Author

Reasons for Option2

- The landscaping and parking buffs noise from streets on south eastern and north western borders of the site
- The services are lined for easy access and screened by the staff parking

- Underground water storage is placed close to building for easy channeling of water from roof
- The generator is at a distance from building to save vibrations and heat transfer.

From the above options, option 2 was chosen due to the following advantages:

- The public are most likely to use the ceremonial road-Independence Avenue due to attractive views.
- It will be more convenient for the staff to use the Sixth Avenue due to less traffic
- Services can be easily accessed from the less busy sixth avenue road.
- Most service lines run along the sixth avenue so tapping will be very convenient.
- The service yard is adequately screened off the public view.

Option 2 was further developed into the layout below.

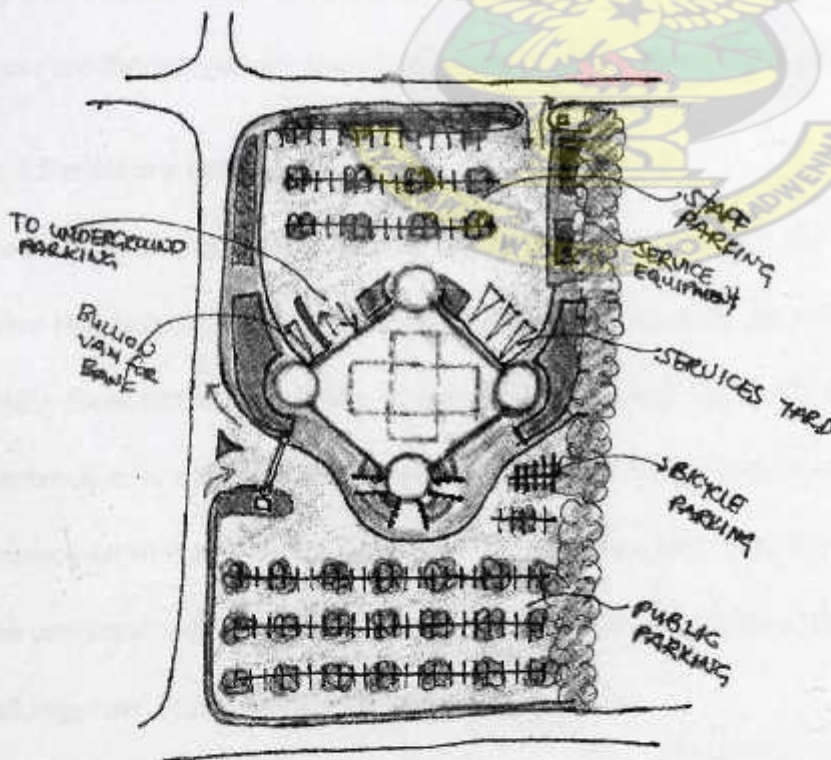


Fig.4.8 chosen option 2 layout

Source: Author

4.6 The Design

One of the main aims of the design was to give an identity to the Ghana Stock Exchange. This was thus tried to be depicted in the building form. Exchanges are not stable, they change based on the forces of demand and supply. This dynamic nature of exchanges informed the choosing of Dynamic Architectural style for the design.

Dynamic Architecture has main features of movement; either moving or seem to be moving. It adds a fourth dimension to architecture; Time, which is very important in the stock exchange world since time is money.

Again, dynamic architecture depicts the future and ensures green buildings in design. It urges the use of natural and recyclable materials for construction and finishes to improve the energy efficiency of the building. It further encourages sustainability which is very important in reducing the running and maintenance cost of the building.

These are the reasons for deciding on the twisting tower form of dynamic architecture.

4.6.1 Structure and Form

The reinforced concrete or structural steel frame has become the standard solution for office buildings. The core of the building is considered to constitute a vertical cantilever rigidly fixed to the foundation structure. Even though the reinforced concrete construction is considered to be cheaper by 15-30% the cost of steel construction, a greater part of the structure is in steel due to the seismic nature of the site.

The proposed Ghana Stock Exchange Tower consists of three levels of basement parking, two-level podium and 19 twisting floors.

The 19 floors shift from each preceding one by 5° in a clockwise direction.

The first one lies at 0° to the horizontal and the last one is at 90° giving an 'X' symbol in the plan view; to symbolize exchange. The basement is reinforced in concrete and treated with water-proof materials since the soil has a high water table. The first level is 4m in height and the preceding levels are 3m in height. Damp-proofing and tanking are applied in the construction of the foundation to prevent water from getting into the basement. Pile foundation is suggested with piles tied together with a box slab in order to anchor it against uplift/earthquake forces. The podium is double volume at most parts with a clear height of 8m - 4m for each floor. With the intension of avoiding internal columns to give free open spaces, space frame technology is adapted for the podium roof slab. Noise transfer is however catered for in the design of the adjacent ceiling and wall. There is however 12 columns positioned at the peripherals to transfer loads to the basement.

4.6.1a Twisting Tower

The 19 twisting floors rotate around a central cylindrical reinforced concrete core which goes down to the basement and with a cylindrical foundation box. The floors are support structures consisting of steel decking on I-section steel beams and girders connected to beam and column trusses. The core is further stiffened by an exoskeletal truss at both ends of the twisting floors. It consists of a spine column, horizontal and diagonal truss elements in tension. The diagonal truss braces every 2 horizontal truss stiffeners fixed to the reinforcement in the adjacent shear wall. Horizontal stabilizer elements connect the main spine to another spine every 4m to give it more stability. The exoskeletal truss is to protect the building against wind loads and seismic activity. In cases of an earth tremor, the building will at most sway and not break or collapse.

The loads carried down by the internal columns of the box truss and the exoskeleton are spread through a reinforced padding lying directly beneath the twisting floors; to the space frame of the podium level and further to the end columns and to the earth.

4.6.2 Block Plan

The public access to the site is on the south and it leads to an extensive parking well landscaped and shaded with trees. The entrance to the building has a welcoming flying roof (a feature of dynamic architecture) consisting of a metal framework clad with glass sheet and held in tension by metal strings fixed to a shear parapet wall above.

The staff access is on the north with a few parking spaces since majority of the staff are expected to park in the basement which is easily accessible from this entry. This entry also leads to the service yard, generator house and underground water storage.

The staff entrance drive through is covered with a pergola partly clad with glass sheets and partly covered with artificial plants. The pergola is supported by 3 columns clad with stones and stiffened with metal strings.

4.6.3 Plans

The plan evolved from the symbol of the Ghana Stock Exchange which is an African symbol meaning integrity. The basement comprises mainly of parking lots and the garbage compactor and storage rooms. The core houses 3 lifts, a goods lift, a chute, storage and service rooms as well as the staircase which doubles as the escape stair since it is fire rated. On the extremes of the first podium level are a bank and a bookshop on either side with separate entries.

From the entrance foyer of the public entry, a person is ushered into the reception/enquiry section which has a waiting lounge on the right and an ICT centre on the left. The ICT center is for quick internet transactions and e-banking. There is a telephone section for telephone banking and internal communication.

The plant/equipment room on the extreme north is easily accessed from the service yard and is to house all forms of machines needed to keep the building running. It is however clad with sound insulating materials so as not to disturb the adjacent spaces.

The staff entrance is commenced with a breakfast niche next to the terrace.

The second podium level consists of a gallery/ exhibition room, courier and secretarial services department together with a Forex bureau.

The first twisting level has a cafeteria and a restaurant. These areas lead to an open roof relaxation area accessed through the lounge on the corridor. The plants and landscaping employed here are all artificial for easy maintenance. There are solar panels positioned at the extreme ends of the podium roof with a service room below.

The rest of the twisting floors, rectangular in shape consist mainly of two office spaces separated by the core. It includes conference/lecture, library and meeting rooms.

The twisting level 8 rotated at 35° to the horizontal is the trading floor. The floor above is the investors and VIP lounge, media base and open gallery.

The 19th floor has the motor room above it which features the height light.

4.6.4 Elevations

Since the architectural style employed is dynamic architecture, the floors appear to be moving- twisting. Each rotating floor is fully glazed on its longer sides which are recessed back about 700mm for shading purposes. The shorter sides are shear walls.

The long stretch of glazing is broken by metal grills which allow daylighting and natural ventilation into the corridors and cover the sanitary windows.

4.6.5 Interiors

Gold, white and blue are the colors employed in the interiors of the building. The walls are of white panels with gold colored floor tiles. The furniture is either brownish gold or bluish gold to reinstate the identity of the GSE.

4.6.6 Materials

Walls- Plastered sandcrete blocks with white paint. Interior partitions are of plaster board panels of 70mm in thickness also painted white.

Structure- I-section steel beams and girders and steel truss system with steel string stiffeners and stabilizers.

Doors- Furnished timber frames with glass paneling

Windows- Furnished timber frames with glass in-fills.

Curtain walls- 1200x900mm glazing component for the podium level and 700x900mm for the twisting floors

Floors- gold/brownish gold colored ceramic tiles for main spaces, non-slip tiles for sanitary spaces, design terrazzo for corridors.

Balustrades- Aluminum base metal balusters and railings with glass panels designed with the GSE symbol

Shading grills- Aluminum base metal

Roof- concrete roof with solar slabs

4.7 Services

The central core is used as the main service channel. Plumbing, mechanic, electrical and telephone vertical ducts are situated on the right half of the central core. The plumbing duct houses pipes for water supply and distribution while the mechanic duct handles air-conditioning pipes. The electrical duct contains electrical wiring systems and the telephone duct has solely telecommunication security systems. Sanitary ducts contain sewage and soil water pipes. The service ducts are separated to achieve a high level of monitoring and safety in the building. The various services are tapped at each floor horizontally through the ceiling spaces. There is one metre (1000mm) service band between every two floors-500mm above a floor plus 500mm below the preceding floor.

4.7.1 Electricity

The main 11kv main electricity supply runs along the Sixth Avenue Street, on the western border of the site. It will be tapped to the transformer and controlled from the adjacent power control room. The controlled electrical power is then supplied to the rest of the building southwards through the electrical duct. The electrical duct room serves as the intake panel room to redistribute power to the various floors. Tenants can easily check their electricity meters from the duct room. The very sensitive areas are however well concealed from the public and tenants. To ensure continuous power supply, a standby generator set is provided east of the control room for easy switch over. The fuel tank is located east of the generator for easy access to refill and supply.

4.7.2 Water supply

Cold water is tapped from Ghana Water Company mains along the Sixth Avenue Street. By the use of stop-valve, water is conveyed to various areas under pressure in ducts. Hot water is supplied to the kitchens through copper pipes fitted with heaters. Rainwater will be collected from the exposed portions of the twisting floors into P.V.C pipes to be distilled and stored underground. This will then be re-pumped back into the building for flushing and cleaning.

4.7.3 Telecommunication

Telecommunication services are tapped from the Ghana Telecom duct route along the Libya Road around the southern public entrance.

4.7.4 Mechanical ventilation

The curtain walls have operable windows to allow in natural ventilation. Mechanical ventilation is provided to complement the natural ventilation. The ice storage air conditioning system which is centralized is used due to the extensive use of glass for the facade. The ice cool tanks are placed in the equipment room and connected to the mechanical duct from which conditioned air will be supplied to the various floors. This system has proven to be cost effective as compared to the traditional air-conditioning system since it uses less power to condition and supply the air.

Extractor fans have been fitted in the sanitary areas to ensure suitable air quality levels at all times. In situations where the extractor fans fail, the sanitary windows can be opened for the south west winds to blow across.

4.7.5 Mechanical Conveyors

There is the provision of one central stair; one goods lift and 4 lifts to take care of vertical circulation. The lift just adjoining the stairs has been designed with extra security features to be used by special guests and visitors touring the GSE. The other 3 lifts are used daily by workers and the public. The fourth lift is used during very peak demand hours and is well monitored.

4.7.6 Emergency and fire fighting provision

The central core has been constructed of 2hour fire rating concrete core. This therefore makes it able to combat fire for up to 2 hours. The stairs and reserve lift have reserve power supply system and thus serves as fire escape. Evacuation lighting fixed at vantage points with reserve power flashes to give direction in case of fire outbreak to emergency exits. There is the provision of fire protection equipment –fire extinguishers, sprinklers, smoke detectors and fire hose on every floor. The turnstiles have been designed to rail to give way for exit during emergency situations. Fire hydrants are located in a loop system about 25metres around the building with a different water supply system to combat fire.

4.7.7 Refuse Disposal

The central core has a chute to transfer refuse to the first basement level which is compacted before stored to wait for collection by trucks.

4.7.8 Soil, surface and waste water drainage

The central sewage line runs along the Independence Avenue Street. Soil and waste water is drained down eastwards to the sewage line from the sanitary ducts.

Surface water slopes into the covered drains on the west and east borders of the site.

4.8 Landscaping

Landscaping surges the aesthetical appreciation of the building in its environment.

The soft landscaping helps cool the micro environment whiles hard landscaping defines and regulates the circulation pattern around the building. The following are the landscaping measures to be incorporated in the design.

- Potted plants will be placed at vantage points within the office spaces.
- Corridors and lobbies will be decorated with flowers and ornamental plants.
- The car parks are going to receive heavy duty pavement blocks with pronounce kerbs. It will be well integrated with shady trees, plants and lawns.
- Walkways will be treated with pavement blocks.
- Two medium sized ponds with fountains opposite each other will be placed at the public entrance to give a welcoming entrance.
- Shady trees will be planted along the eastern border to reduce the noise levels that will get to the facility as well as screen off the adjacent undeveloped site.
- To encourage relaxation and interaction, garden seats and tables will be placed in the lawn next to the bookshop around the east border and in the lawn along the south east border under the shady screening trees for the public.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

In the words of office design consultant and author Francis Duffy, "The office building is one of the great icons of the twentieth century. Office towers dominate the skylines of cities in every continent... [As] the most visible index of economic activity, of social, technological, and financial progress, they have come to symbolize much of what this century has been about."¹

This true fact impels for great care in designing offices since a great number of the country's working force spend most of the hours of the day in offices spaces.

For the proposed Ghana Stock Exchange Building, it will greatly satisfy its users if it benefits from an integrated design approach in construction and maintenance.

This will help realize a high-performance office building that will offer the owners and users increased worker satisfaction and productivity, improved health, greater flexibility, enhanced energy and environmental performance.

The twisting tower form is a futuristic feature which will create attention for the GSE.

Considering the aim and goal of the GSE to promote and publicize their activities, the construction of this magnificent building will accelerate this vision.

With the current surge of the GSE in the international financial world, a more spacious, elaborate and conducive office building will step up their work output and productivity levels.

5.1 Costing

This is an estimate that gives the client an overview of the cost of the project. The cost per square meter of high rise buildings with a high level of finish is estimated to be \$1500 in Ghana as at September 2009.

Hence,

$$\begin{aligned}\text{Basement} & \text{-----} 5550\text{m}^2 \times \$1500 \\ & = \$8,325,000\end{aligned}$$

$$\begin{aligned}\text{Floor 1} & \text{-----} 980\text{m}^2 \times \$1500 \\ & = \$1,470,000\end{aligned}$$

$$\begin{aligned}\text{Floor 2} & \text{-----} 275\text{m}^2 \times \$1500 \\ & = \$412,500\end{aligned}$$

$$\begin{aligned}\text{Floor 3} & \text{-----} 190\text{m}^2 \times \$1500 \\ & = \$285,000\end{aligned}$$

$$\begin{aligned}\text{Floor 4} & \text{-----} 1700\text{m}^2 \times \$1500 \\ & = \$2,550,000\end{aligned}$$

$$\begin{aligned}\text{Floor 5} & \text{-----} 200\text{m}^2 \times \$1500 \\ & = \$300,000\end{aligned}$$

$$\begin{aligned}\text{Floor 6-7} & \text{-----} 700\text{m}^2 \times \$1500 \\ & = \$1,050,000\end{aligned}$$

$$\begin{aligned}\text{Floor 8-9} & \text{-----} 700\text{m}^2 \times \$1500 \\ & = \$1,050,000\end{aligned}$$

Floor 10-11-----970m² x \$1500

= \$1,455,000

Floor 12-13-----200m² x \$1500

= \$300,000

Floor 14-15-----700m² x \$1500

= \$1,050,000

Floor 16-----400m² x \$1500

= \$600,000

Floor 17-20-----2500m² x \$1500

= \$3,750,000

Grand Total-----5550m² x \$1500

= \$22,597,500

Since the exchange rate as at September 2009 is \$1=GH¢1.5

~ GH¢33,896,250

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KNUST

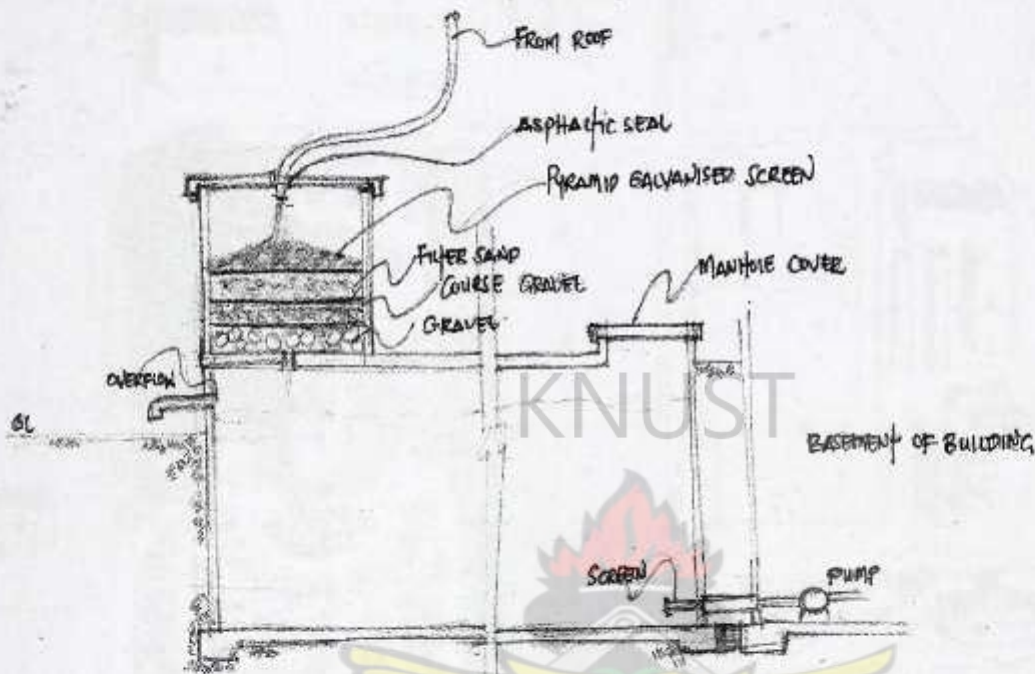


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APPENDICES

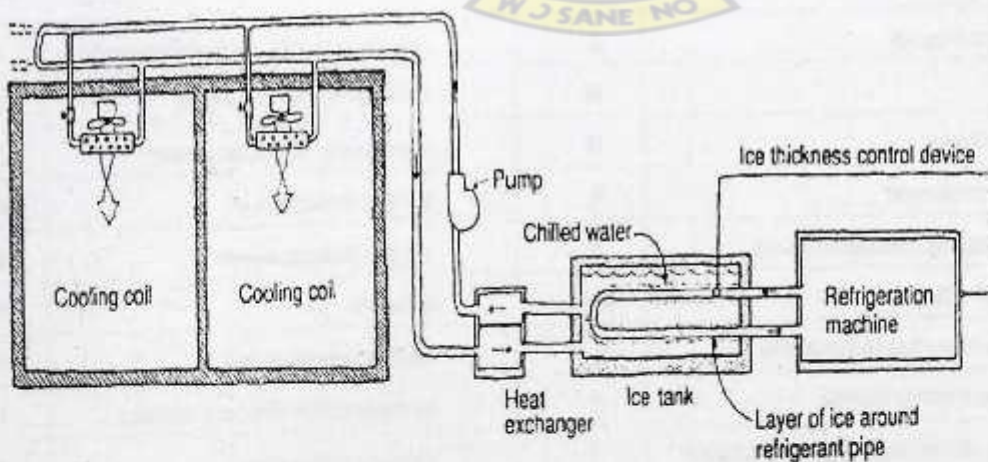
Appendix 1



Schematic diagram showing how rainwater is sand filtered before stored.

Source: Thermal Control (2000) p527

Appendix 2



Schematic diagram showing ice storage air-conditioning system.

Source: Thermal Control (2000) p423

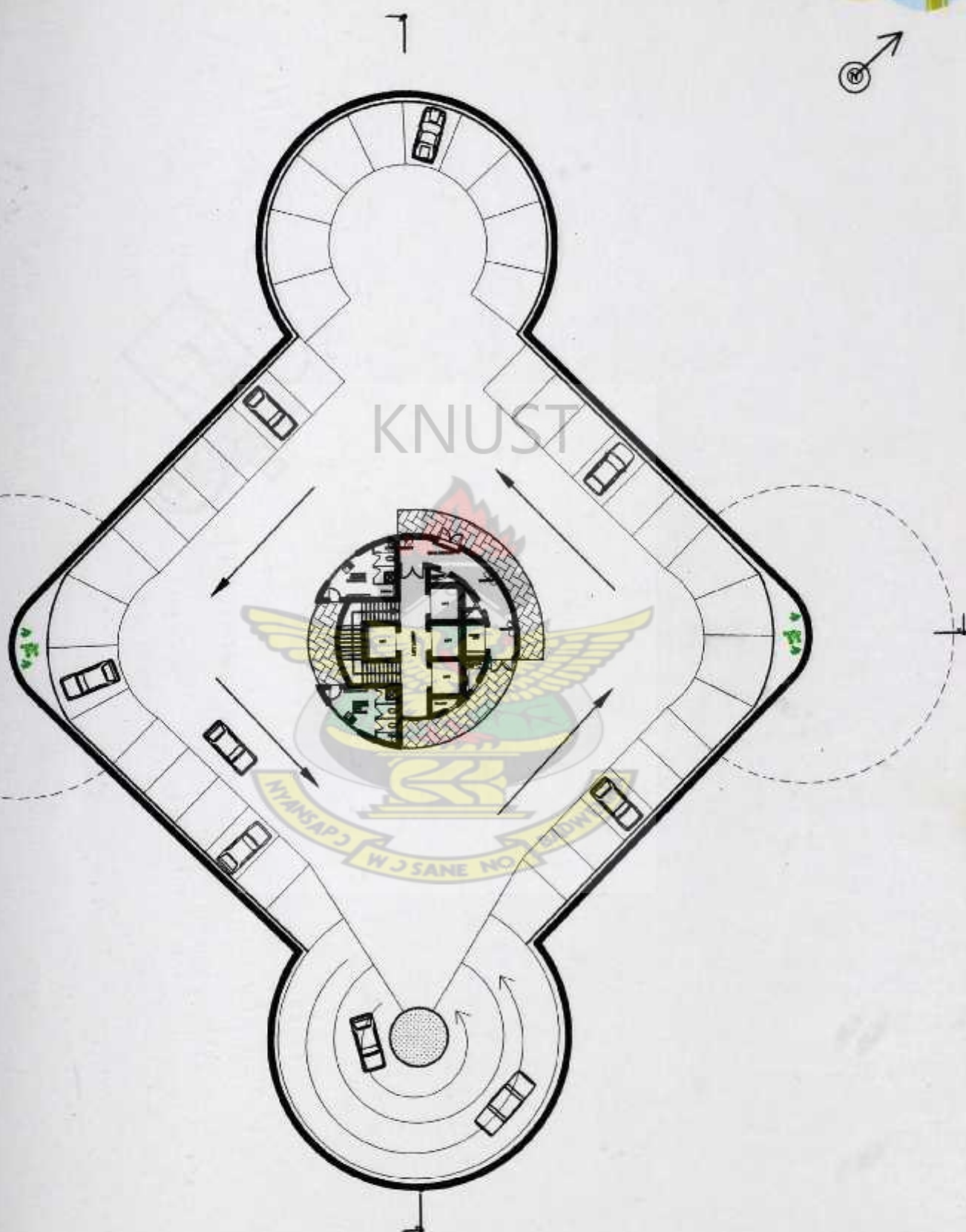


LEGEND

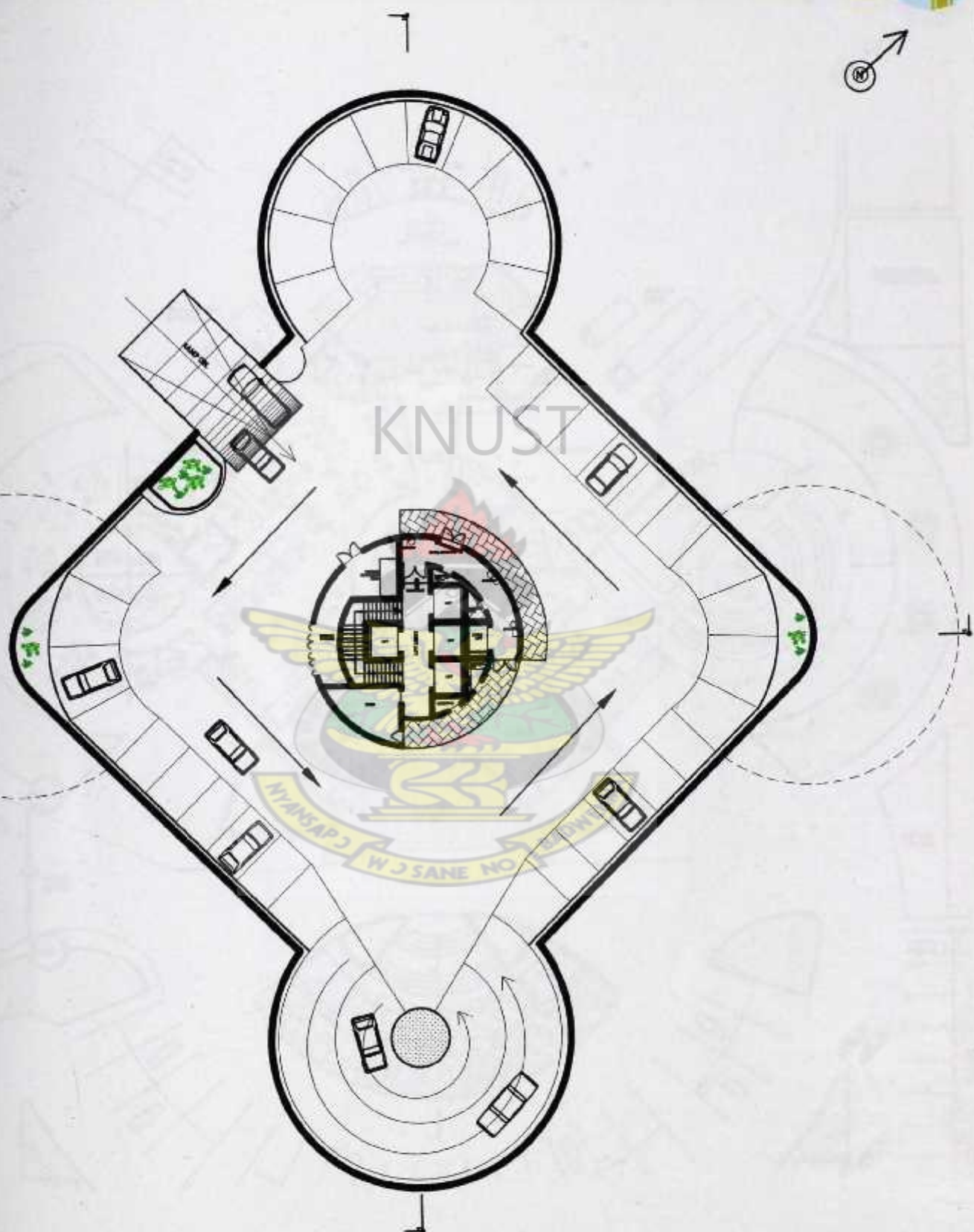
A	PROPOSED TWISTING EXCHANGE TOWERS	L	VALCO TRUST HOUSE
B	GENERATOR/MACHINE HOUSE	M	GT BANK
C	UNDERGROUND WATER STORAGE	N	BARCLAYS BANK
D	MOTOR CYCLE PARKING	P	TEMPORARY PARKING
E	LEGON BUSINESS SCHOOL	Q	EFUA SUTHERLAND CHILDREN'S PARK
F	HFC BANK	R	LIBERATION CIRCLE
G	MULTI-STOREY CARPARK	S	OFFICE, GHANA OLYMPIC COMMITTEE
J	PARKING FOR SSNIT OFFICE COMPLEX	T	AFRICAN LIBERATION SQUARE
K	SSNIT OFFICE COMPLEX	V	OFFICE, NATIONAL COMMISSION ON CHILDREN

BLOCK PLAN

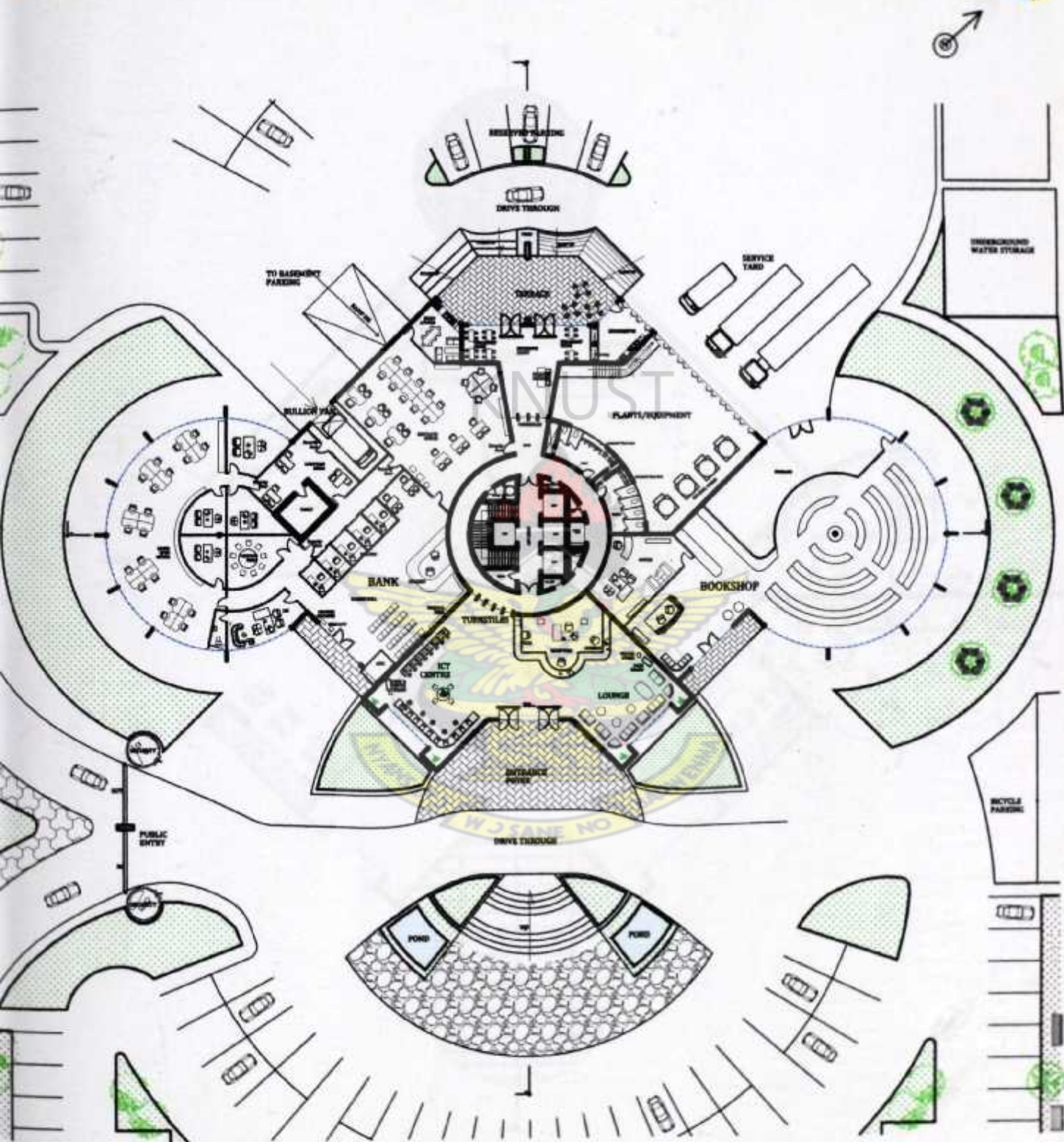
LAYOUT



TYPICAL BASEMENT LEVEL 2 & 3

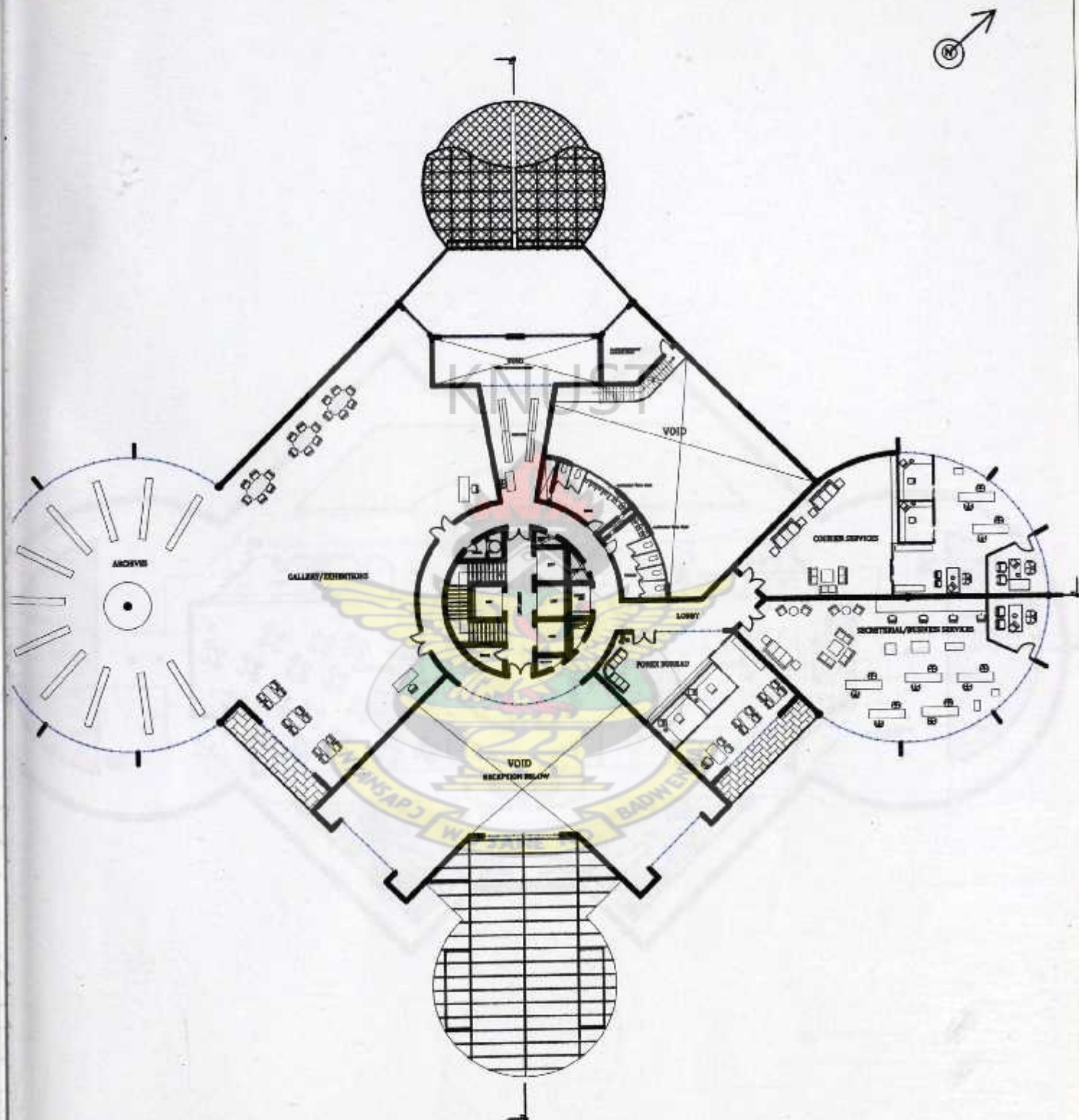


BASEMENT LEVEL 1

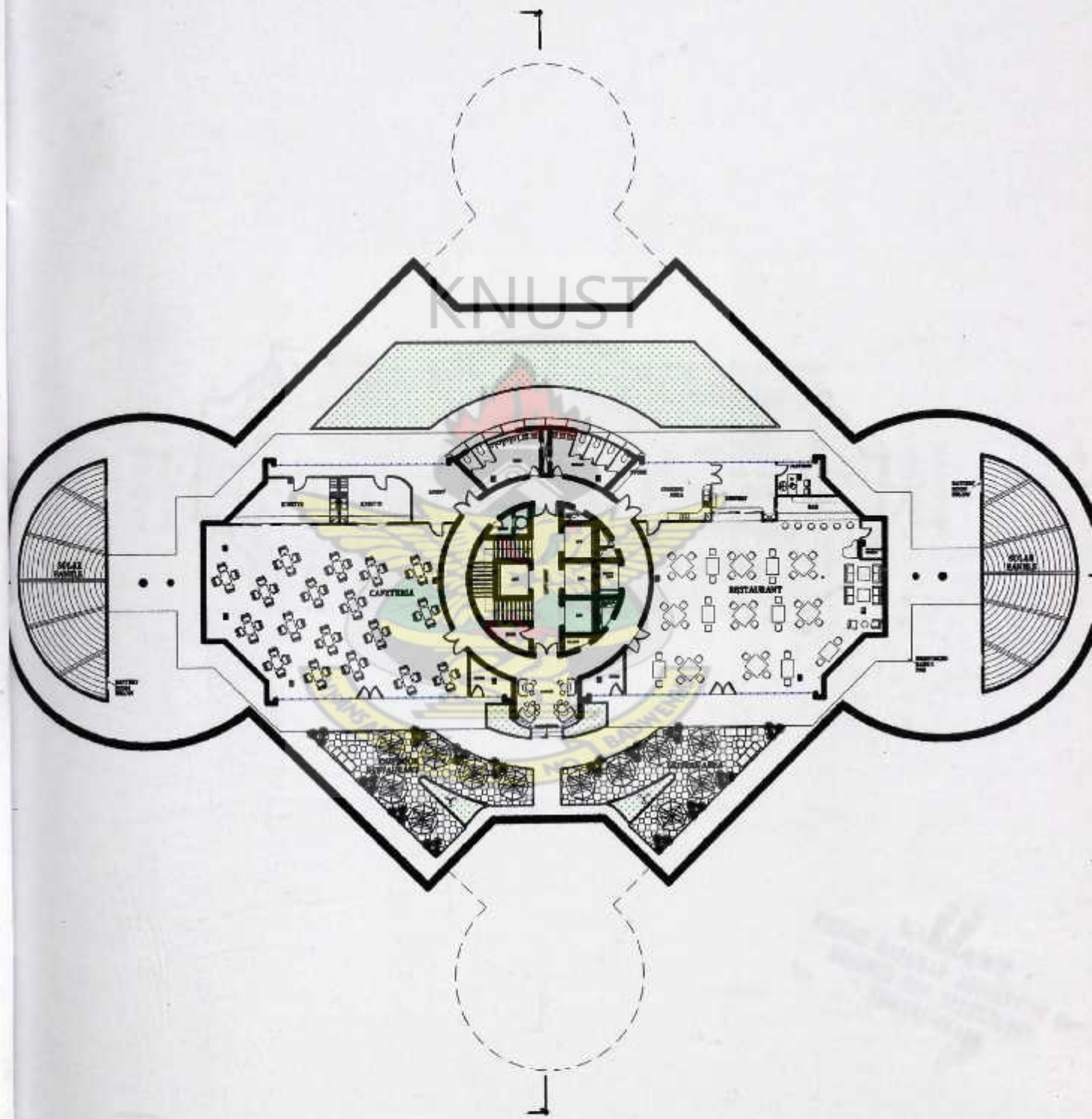


PODIUM LEVEL 1

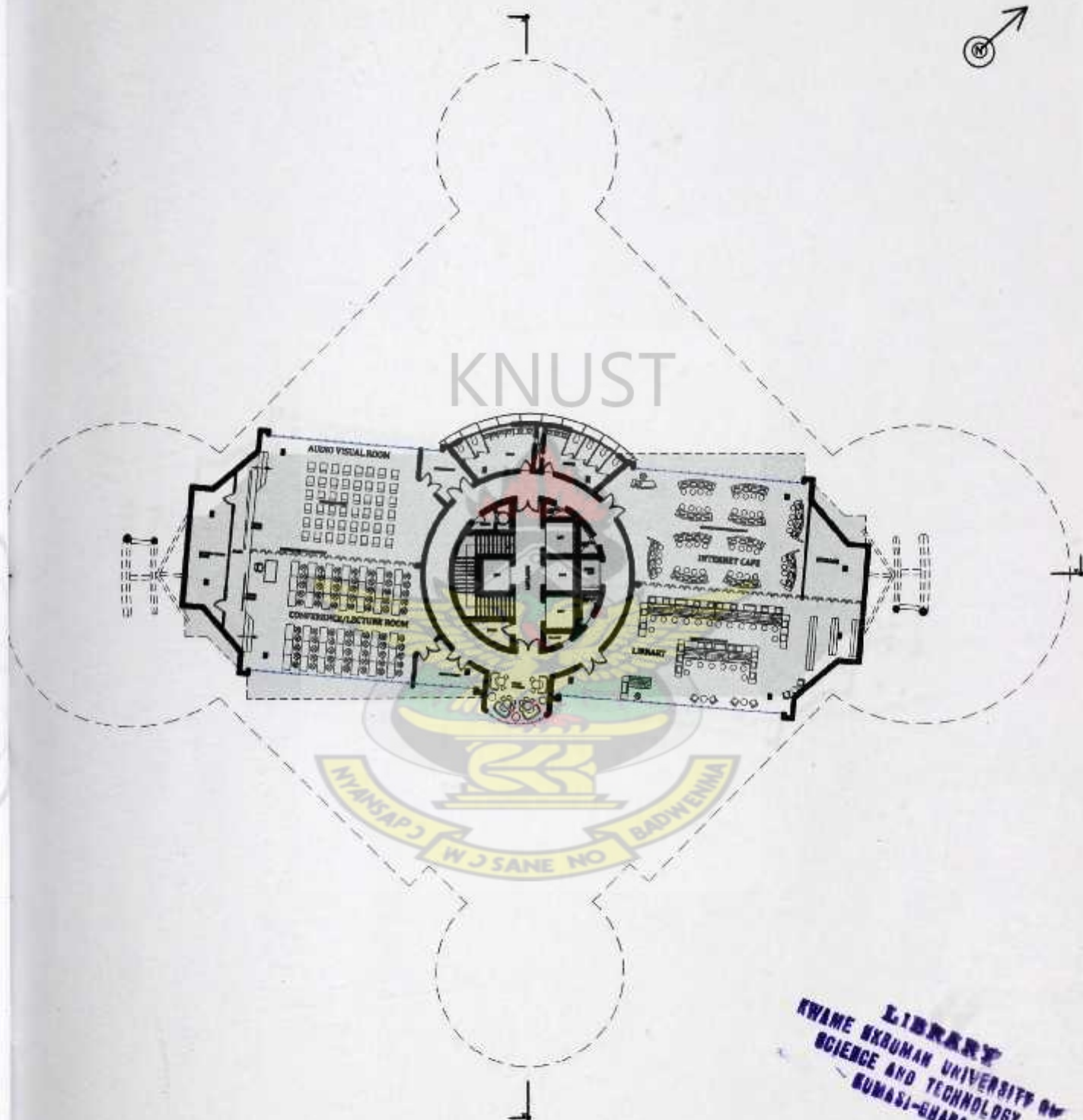
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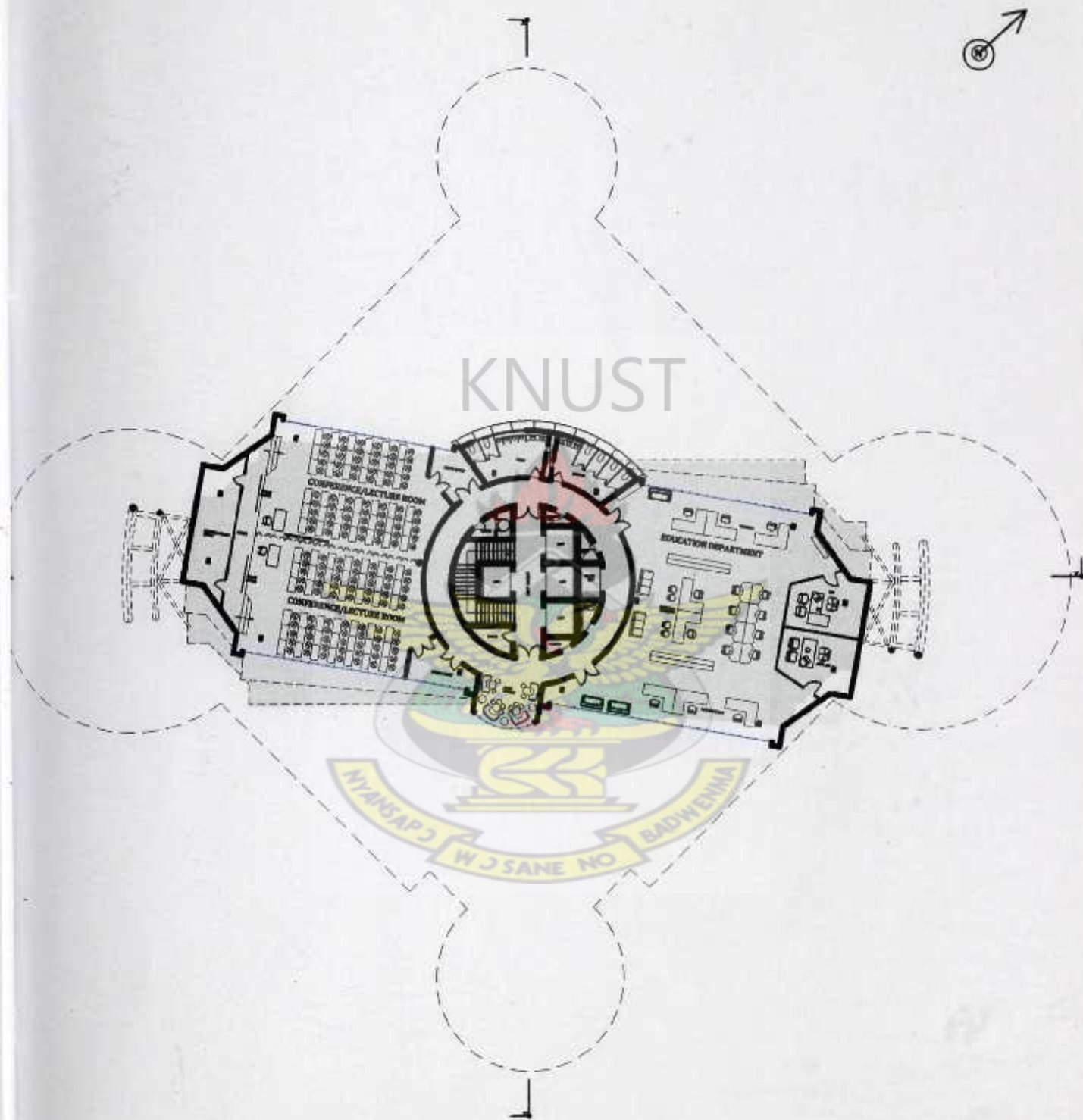
PODIUM LEVEL 2



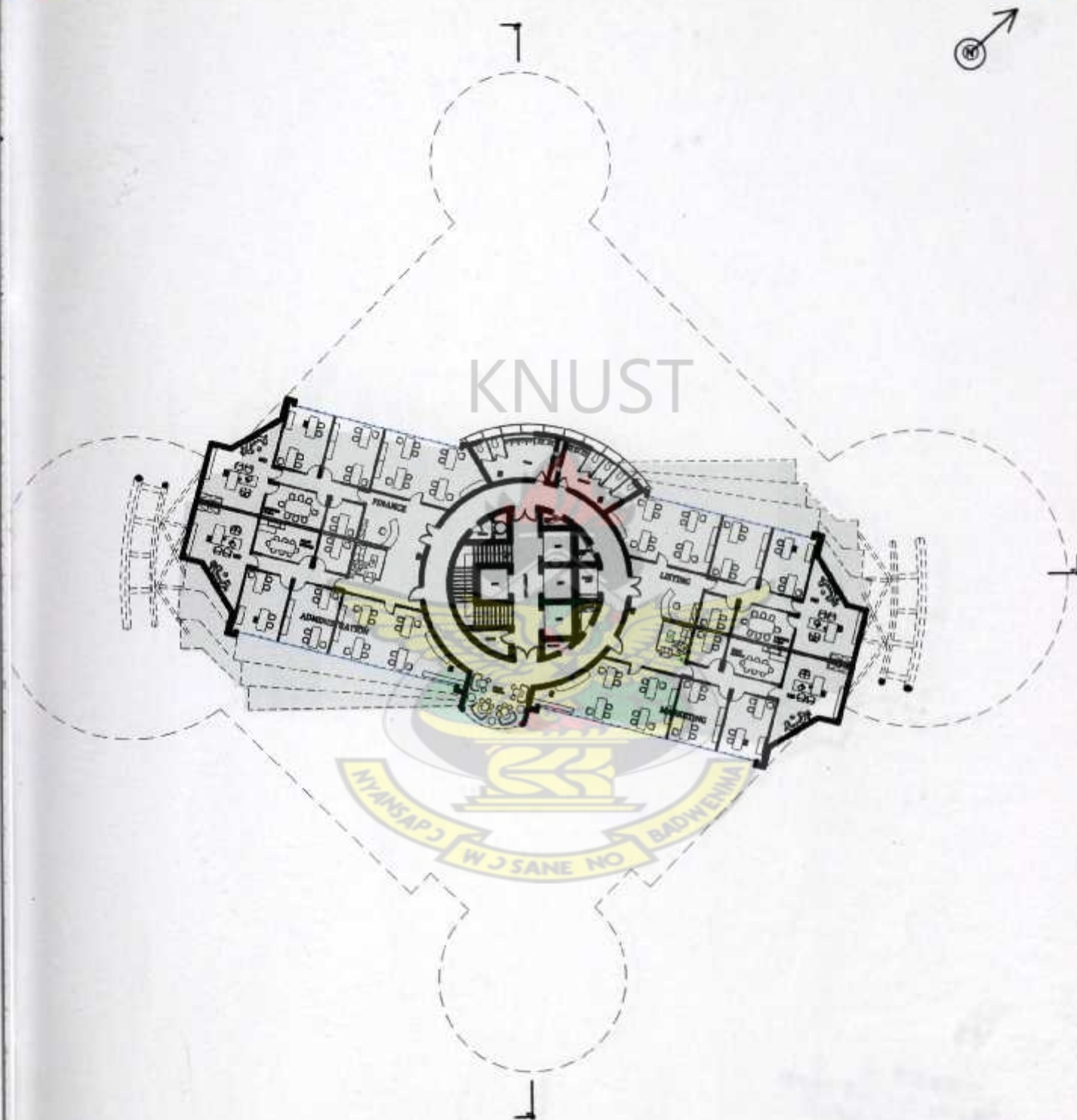
TWISTING LEVEL 1-0°



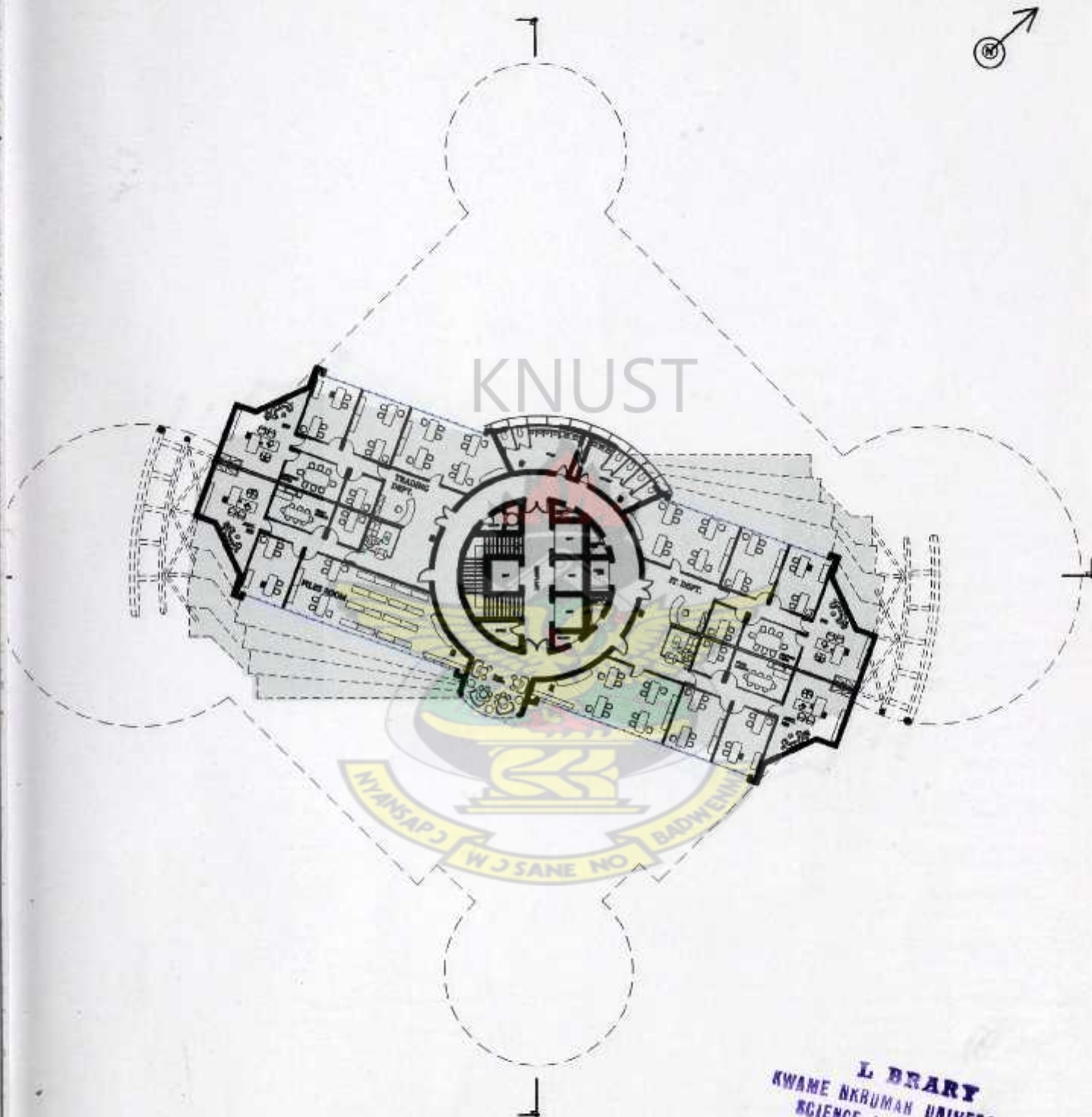
TWISTING LEVEL 2-5°



TWISTING LEVEL 3-10°

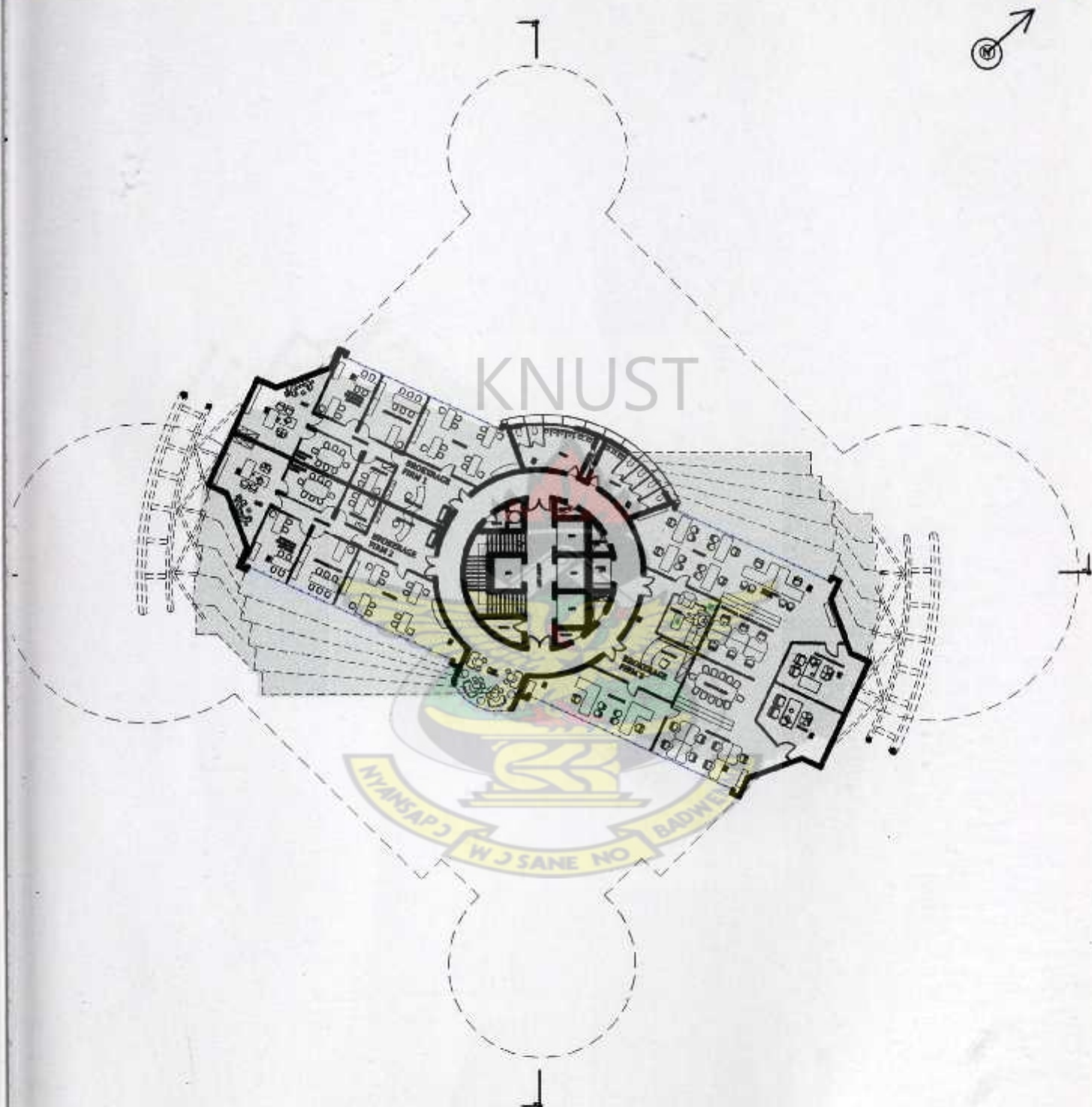


TWISTING LEVEL 4-15°

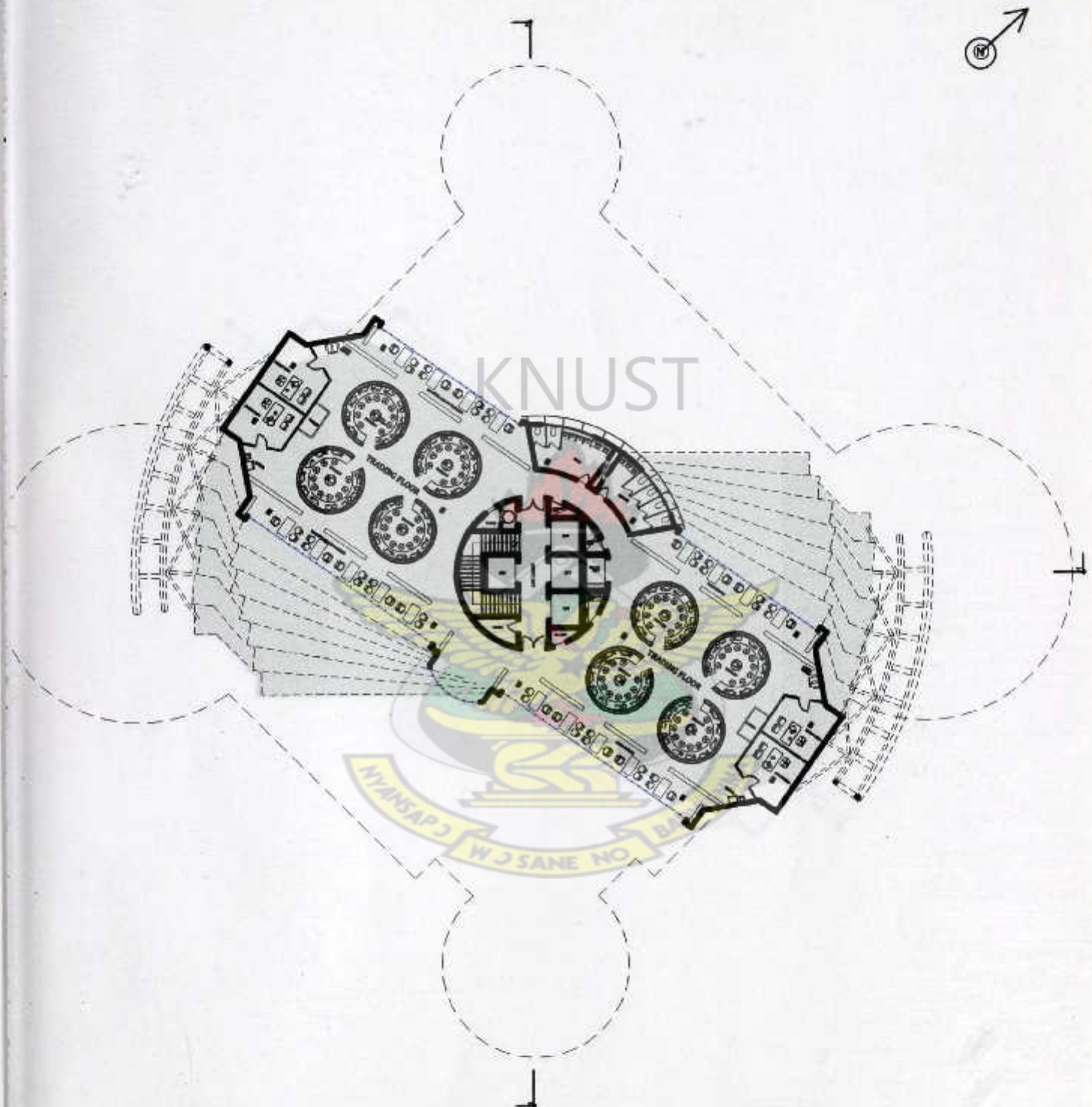


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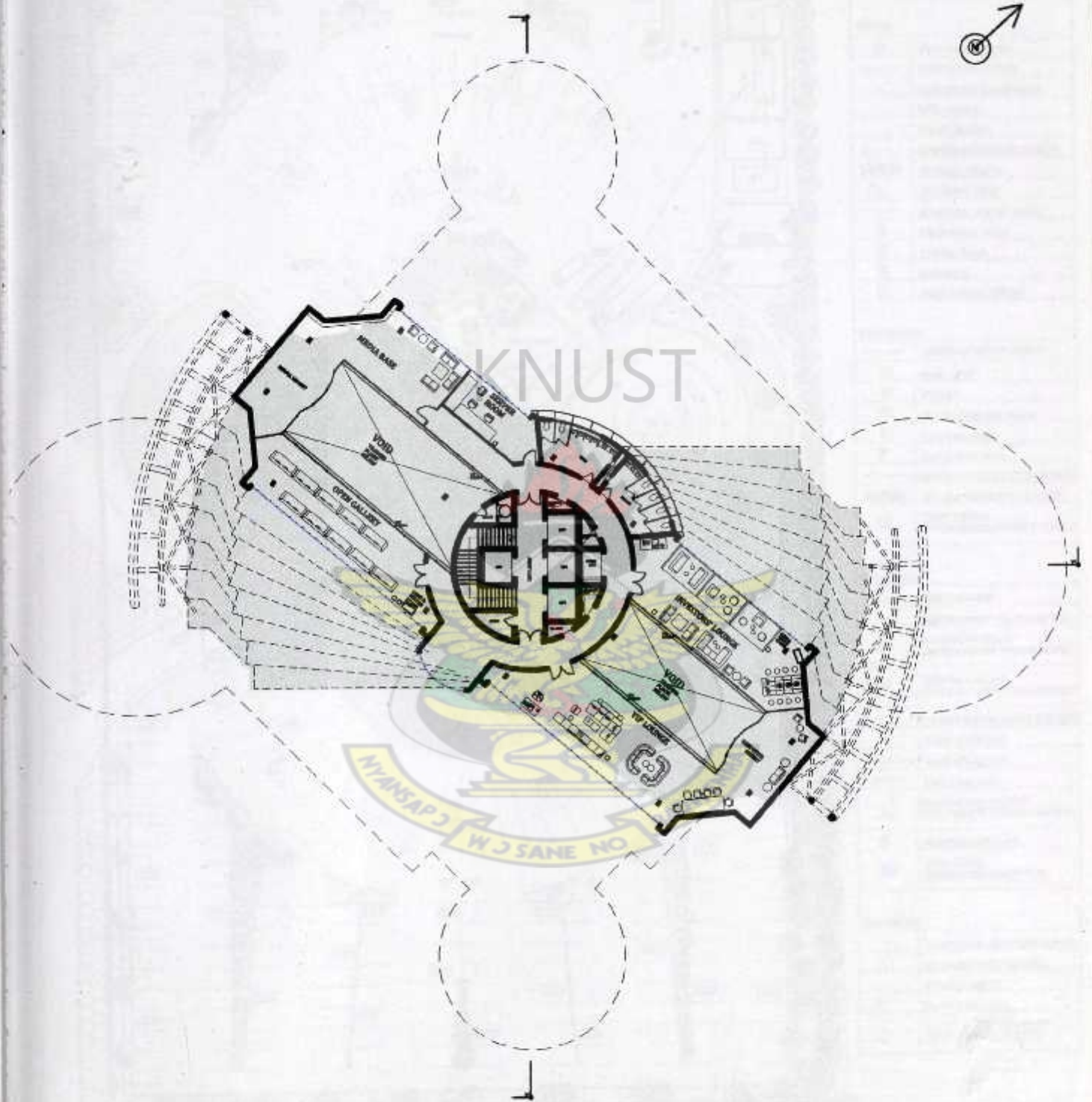
TWISTING LEVEL 5-20°



TWISTING LEVEL 6-25°



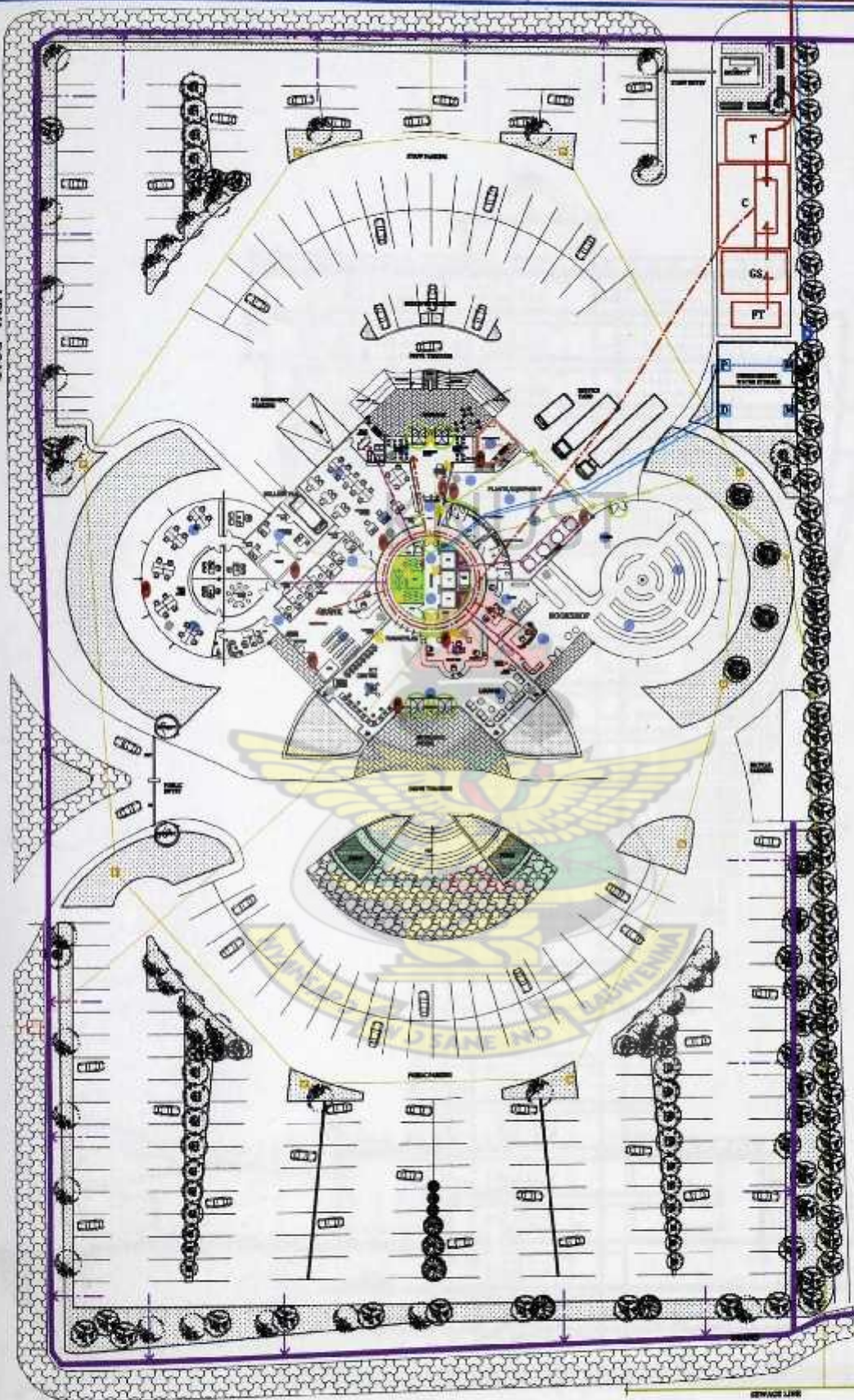
TWISTING LEVEL 8-35°



TWISTING LEVEL 9-40°

SIXTH AVENUE

LIBYA ROAD



LEGEND

WATER

	MAIN WATER METER
	MAIN WATER SUPPLY
	RAIN WATER HARVESTING
	SOIL WATER
	WASTE WATER
	SURFACE RUN-OFF TO DRAINS
	COVERED DRAINS
	PLUMBING DUCT
	AIR-CONDITIONER SUPPLY
	MECHANICAL DUCT
	DISTILLATION
	MANHOLE
	WATER PUMP SYSTEM

ELECTRICITY

	11KV ELECTRICITY SUPPLY
	FUEL TANK
	GENSET
	POWER CONTROL ROOM
	TRANSFORMER
	ELECTRICAL DUCT
	CONTROLLED ELECTRICITY SUPPLY
	METERS FOR FLOOR TENANTS
	CCTV CAMERA (WITH RESERVE POWER SUPPLY)

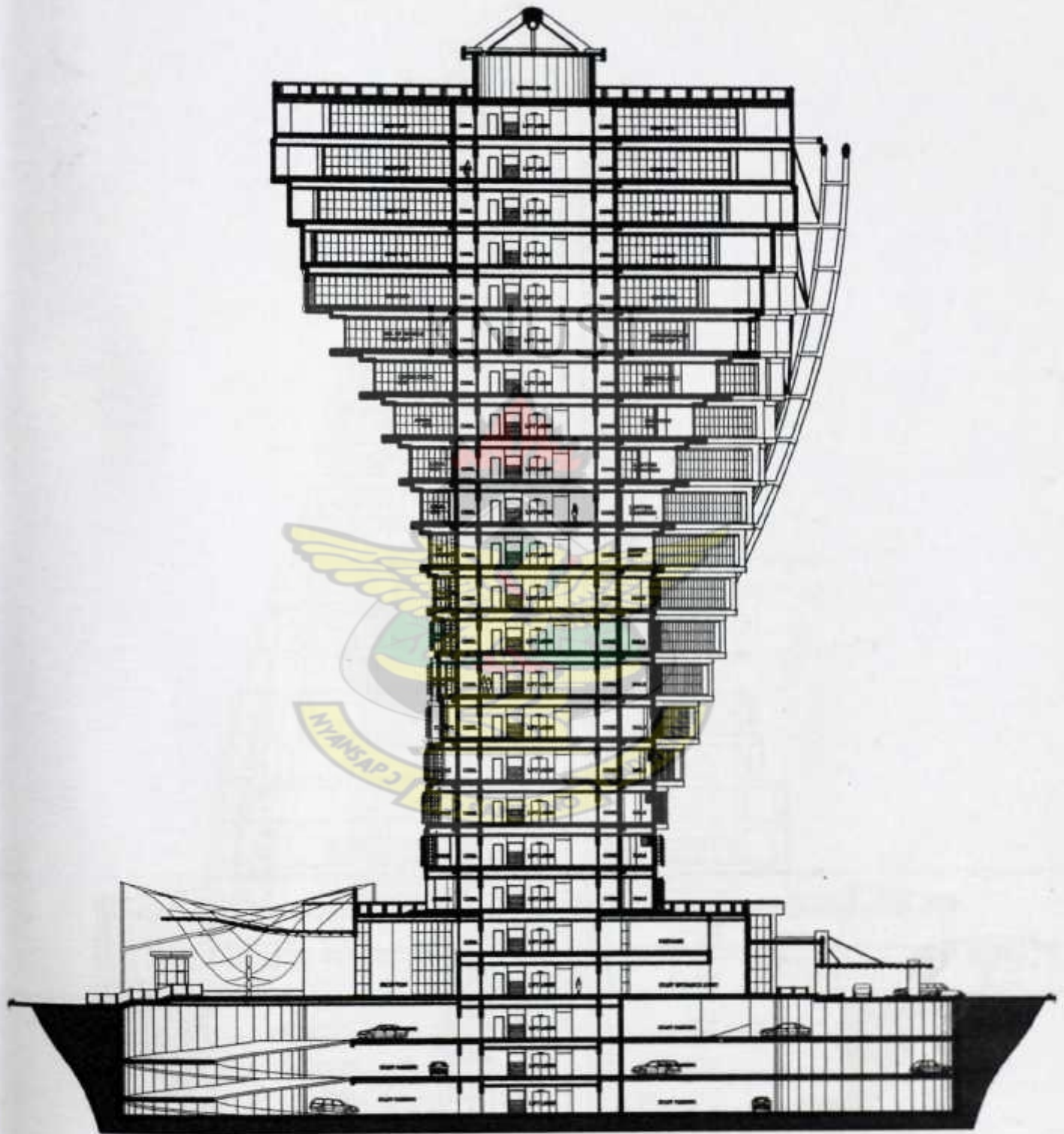
FIRE SAFETY

	FIRE HYDRANT
	FIRE HYDRANT WATER SUPPLY
	FIRE ESCAPE STAIR (WITH RESERVE POWER SUPPLY)
	FIRE ESCAPE LIFT (WITH RESERVE POWER SUPPLY)
	2HR FIRE RATING CONCRETE CORNER
	EMERGENCY EXIT
	TURNSTILES RAIL
	FIRE HOSE RAIL
	EVACUATION LIGHTING (WITH RESERVE POWER SUPPLY)
	FIRE EXTINGUISHER
	SPRINKLERS (DOUBLE WATER SUPPLY)

TELEPHONE

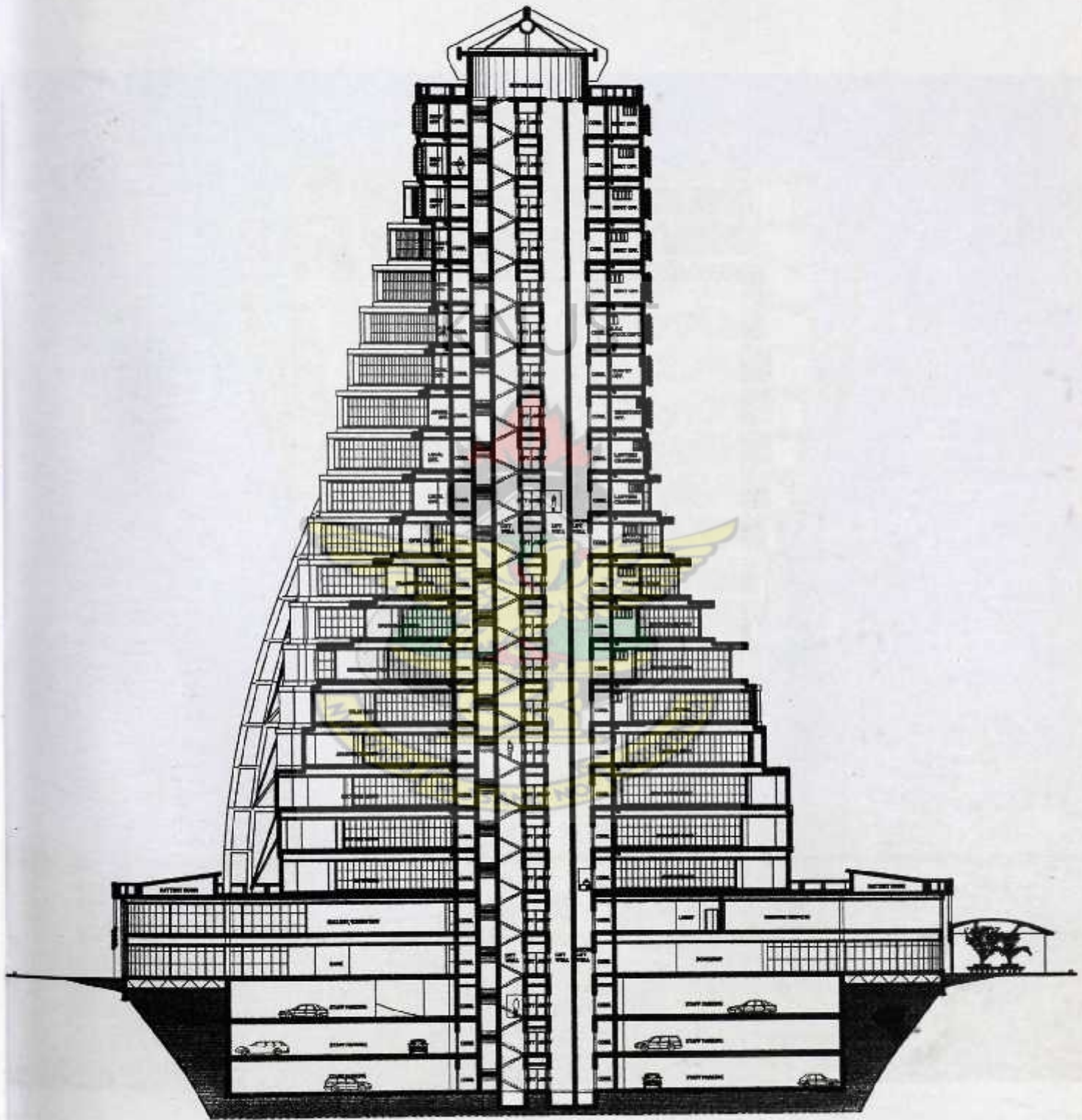
	TELEPHONE /INTERNET SUPPLY
	GT INSPECTION CHAMBER
	GT DUCT ROUTE
	TELEPHONE DUCT
	SERVICES CONTROL ROOM (ABOVE KITCHENNETTE)

SERVICE LAYOUT



SECTION X-X'

SECTIONS



SECTION Y-Y'



NORTH EAST ELEVATION



SOUTH EAST ELEVATION



VISITORS LOUNGE -PODIUM LEVEL 1



ICT CENTRE -PODIUM LEVEL 1



TRADING FLOOR-TWISTING LEVEL 8



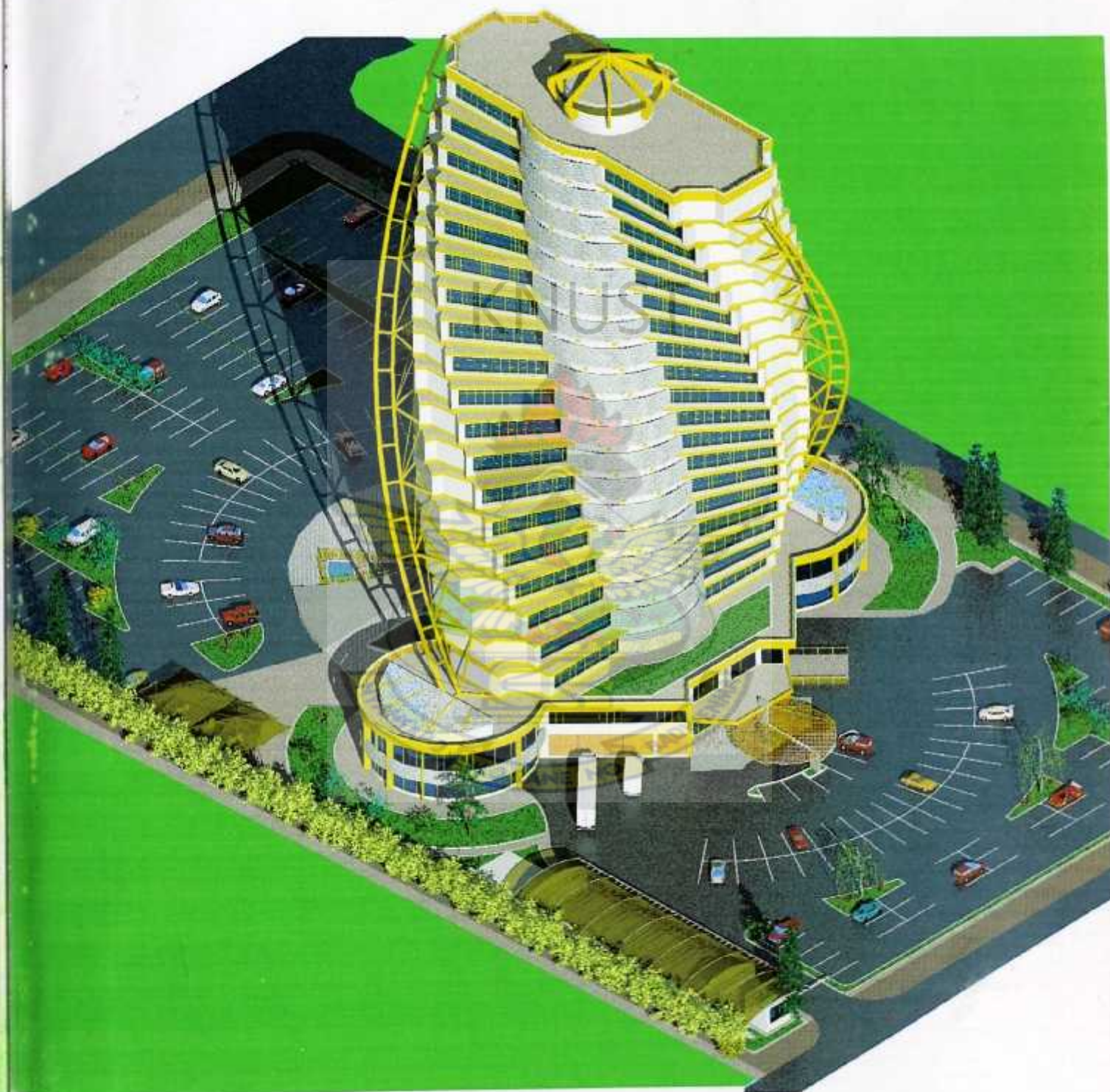
LECTURE ROOM-
TWISTING LEVEL 1&2



RECEPTION-PODIUM LEVEL 1



EASTERN ISOMETRIC VIEW



WESTERN ISOMETRIC VIEW