Exploration of Architectural Design Elements For Energy Efficiency In Office Buildings

By

Talib Oluwadamilare AKANJI
LCU/PG/002130

Being a Dissertation in the Department of Architecture,
Faculty of Environmental Design and Management,

Submitted to the
School of Postgraduate Studies,
In partial fulfilment of the requirements for the
Award of Master Degree in Architecture (M.Sc. Arch.) in
Lead City University, Ibadan, Oyo state, Nigeria.

Supervisor
Arc. Olamide Martins

2022

Certification

This is to certify that **Talib Oluadare AKANJI** with matriculation number **LG/PG/002130** carried out this research work titled "**Exploration of Architectural Design Elements for Energy Efficiency in Office Buildings**" in the Department of Architecture, Faculty of Environmental Design and Management, Lead City University, Ibadan, for the award of Master Degree (M.Sc.) under the supervision of:

Arc. Olamide Martins

supervisor

Arc. (Dr.) F. Adedire

Head of Department

Dedication

This research is dedicated foremost to Almighty God for his grace and mercy upon my life especially during the process of carrying out the research. I also dedicate this to all people that contributed and supported me to make the research a successful one. I appreciate you all.

ACKNOWLEDGEMENT

I want to express my profound gratitude to the Governing Council as well as the Academic and Administrative staff of Post Graduate College, Lead City University Ibadan, Oyo State for creating the platform on Architecture as an opportunity to allow me proceed in my academic pursuit. I sincerely wish to express my gratitude to every institution where information and data was collected for the completion of the research work.

My enormous regards and thanks go to my supervisor, Arc. Olamide Martin for his guidance and contribution to the writing of this thesis, my Head of Department, Arc. (Dr.) Adedire, O., the Post Graduate Coordinator; Arc (Dr.) Ayanleke, O., for their unrelenting efforts towards the realization of this programme. I gratefully acknowledge all lecturers of the Department of Architecture particularly Arc Ademola, A., Dr. Adegoke, Arc. Fasheun - Motesho, O., A., Arc. Olugbesan, A., Arc. Aseyan, B. and Arc. Olaniyan, M., for their wonderful contributions towards the success of this study. My deep and sincere appreciation also goes to Mr. Agbebiyi, O. who has been up and doing towards the success of the Department of Architecture in general.

I also appreciate my wife, who has been my support all-through and my children for their sacrifice and understanding. I cannot but thank my parents., I sincerely appreciate all my friends and everyone who have impacted positively in making me a success, I say thank you all.

ABSTRACT

Energy efficiency in office building is very important to the user, there has been closure of different offices due to high cost of maintenance especially high cost of energy. This study therefore focuses on exploring the use of architecture design Elements for energy efficiency in office Building. The problem definition being that anthropometry, space articulation, shape, volume, texture, among other architecture Design elements can be used to achieve a healthy and low energy consumption Building that will be user friendly. The argument draws its background to the study of relevant literature and case studies. The methodology used in carrying out this research is case study of existing office Complex studied. variables where properly studied and used in designing a proposed Office Complex which significantly reduces energy Consumption. The site location and its suitability for the proposed building were also studied. In conclusion, by applying Energy efficiency strategies During design and Construction, there is possibility of achieving about 70% lesser drop in energy consumption in Building.

Keyword: Energy, Office Building, Design Elements, Efficiency

Word count: 175

Contents

Chapter One
Introduction

1.1 Background to the Study

The city's buildings are an integral aspect of its overall structure. Regarding lowering environmental impacts and advancing sustainable development objectives, the building and construction sector is at the top of the list. The proportion of the national labour force and the sector's contribution to the GDP is projected to be between 5 and 10 percent (GDP). Moreover, providing housing, transportation, water, and sanitation facilities provides the environment for micro-level social interactions and economic growth (UNEP, 2022).

The major purpose of any organization's office is the execution of administrative tasks required to realise or support the organization's declared mission and strategic plan (Akhimien et al., 2018). One's workplace is a visual depiction of one's function as the brain or leader of a corporation. Since the dawn of humanity, structures have played a key role in the evolution of civilization (Spenser, Robert, Eunkyu, & Andrew, July 2016). In several cities across the world, the skyline is dominated by tall office buildings that represent the city's economic and technical development. (Akhimien et al., 2018).

Several studies have shown a link between the condition of buildings and public health. The built environment is responsible for a significant share of the world's overall energy consumption (approximately 40%), energy-related greenhouse gas emissions (30%), waste (almost 70%), and natural resource usage (60 percent). (UNEP, 2022). According to Pearce and Ahn, one-third of the world's greenhouse gas (GHG) emissions are attributable to the construction industry (2013). (IEA, 1995; Pearce & Ahn, 2013; IEA, 1995) According to Ghiaus, buildings use 40 percent of the world's energy, 16 percent of its freshwater, and 25 percent of its forest wood (2006).

According to Perez-Lombardo et al., buildings utilise the most energy globally compared to other economic sectors (2008). These numbers increase the impacts of climate change, which are disastrous for the ecology and local populations. The increase in temperature, the abrupt occurrence of floods, and rising sea levels are all bad results. Consequently, commercial facilities such as offices must be built with energy efficiency and conservation.

1.2 Problem Statement

Sustainable development and its larger connections to the environment have made the problem of energy use in buildings a focal point of global discourse. Multiple studies (Perez-Lombard, 2008; Brown, 2010; Mu'azu, 2012) demonstrate that the built environment accounts for a disproportionate amount of the world's overall energy use. In the United States, buildings account for up to 48 percent and 76 percent of total energy and power use, respectively (Sector, 2010). The building sector is a significant contributor to global warming.

In addition, research indicates that commercial buildings, particularly office buildings, account for a significant portion of the energy used by buildings in numerous nations, including the United States, Hong Kong, the United Kingdom, and China (Mu'azu, 2012). Therefore, it is more necessary than ever to develop measures to reduce the environmental impact of these buildings' high energy use.

If any of the difficulties mentioned above are addressed or minimised, energy efficiency must be a primary design consideration for office buildings. To reduce the country's excessive energy demand and consumption, Nigeria must immediately apply architectural design aspects that enhance energy efficiency.

1.3 Aim and Objectives

The aim of this study is to explore the use of architectural design elements for energy efficiency in the design of office buildings.

The objectives are:

I. To identify architectural design elements influencing energy efficiency in office building design;

II. To examine how architectural design elements can be manipulated to promote energy efficiency; and

III. To implement the findings from the study in the design of an energy efficiency office building through architectural design elements.

1.4 Research Questions

This research intends to answer the following questions;

I. How do architectural design elements influence energy efficiency?

II. Which architectural design elements aid consumption of energy in office building?

III. How can architectural design elements be used in the design of an office buildings to promote energy efficiency?

1.5 Significance of the Study

This study will help to achieve one of the objectives of the sustainable Development Goals (SDGs) of promoting energy efficiency. It will provide specialist knowledge and become a useful reference to architects in the adoption of architectural design elements in the design of energy efficiency public buildings. This will also encompass the following:

i. The need to identify and document the existing situation;

ii. The need to provide intervention models to ameliorate the existing situation; and

iii. The need to provide frameworks that enhance energy efficiency.

This will aid policy makers in incorporating architectural design elements decisions with reference to energy efficiency in the design of public building not only office building.

1.6 Scope of Study

This research shall focus on architectural design elements, mainly on spatial organization aesthetics, building form, building elements, site planning and landscaping, structural and constructional systems as well as to come up with a good design of an office building that will promote energy efficiency in tropical Climate.

Chapter Two
Literature Review

2.1 Conceptual and Theoretical Issues

This chapter highlights the meaning and origin of the term energy efficient building, an intense review of literature that elaborate the concept of architectural design elements related to energy efficiency. This chapter examines previous studies by many other researchers in this area of study and analyses some of the existing body of literature to find out how the studies were conducted conceptually and theoretically.

2.1.1 Historical Development of Energy Efficiency

Increasing energy efficiency is one way to manage and decrease the growth of energy use. When more work is accomplished with the same amount of energy, or when less work is accomplished with the same amount of energy, we say something is energy efficient. To maximise a building's efficiency, it is necessary to minimise the energy required to maintain a specific degree of occupant comfort, air quality, and other necessities (International Energy Agency IEA, 2015).

Since ancient times, man has been able to harness and modify natural processes to improve the quality of life, and houses and construction methods are only one example. Even if the word "energy efficiency" was not as pervasive as it is now, individuals were already producing and distributing good practise guidelines before the 20th century. As a consequence, the method used to create a house was influenced by previous tests. This strategy was appropriate at the time for improving and sustaining certain construction practises. The intriguing truth is that the renewable energy technologies in use today have ancient predecessors, while each period has introduced new inventions and built upon those of the previous one (Constantin, Tudor, Gabriela-Elena, Horia, & Adrian, 2015). Evidence shows that dwellers of the Carpathian area began partly burying their houses in approximately 5500 BCE to keep a more pleasant temperature inside (Constantin et al., 2015).

Later, the Cappadocians, Essene communities of the Middle East, and Native Americans used the thermal properties of the earth for their comfort and ease. The "badghir" (wind tower) of the Persians (A'zami, 2005) used wind and earth energy in well-planned circuits to keep the inhabitants comfortable. Similarly, Egyptians use "malqaf" (wind catchers) to capture wind energy (Constantin et al., 2015).

Since 1980, when a few buildings started gradually integrating the management of various equipment and systems, the intelligent building idea has been evolving. Initially, building automation systems could only control a single machine at a time, but as time passed, they got more complex and could control many machines simultaneously. Security, HVAC/EC, and electrical functions can be monitored and managed by a single system today. New technologies enable remote monitoring and administration to be implemented using wireless devices and the internet. According to Wang(2010), there have been four distinct phases of the intelligent building era, starting in the 1980s with integrated single function/dedicated systems, continuing through the 1990s with integrated multifunction systems, and entering the present with computer integrated buildings and enterprise network integrated systems (Constantin, Tudor, Gabriela-Elena, Horia, & Adrian, 2015).

2.1.2 Concepts of Energy Efficient Buildings Design

It is feasible to restrict and lower the rise of energy demand if energy efficiency is increased. An item or process is deemed energy efficient if it produces more with the same energy input or maintains the same output with less energy. Reducing the quantity of energy necessary to fulfil the demands of a building's inhabitants for temperature control, ventilation, and lighting may increase the building's efficiency (International Energy Agency IEA, 2015).

Since ancient times, humans have been able to enhance their quality of life by harnessing and adapting natural processes to produce more pleasant living situations, such as the design and building of dwellings. Even though the term "energy efficiency" was not as prevalent as it is now, individuals were already devising and implementing best practise laws before the 20th century. This meant that the process utilised to construct a home was developed based on experience throughout time. This strategy was adequate at the time for enhancing and maintaining certain building techniques. Despite the undeniable fact that each new era has brought new discoveries and enhancements to earlier systems, it is astounding to contemplate that the current renewable energy technologies have historical predecessors (Constantin, Tudor, Gabriela-Elena, Horia, & Adrian, 2015). Evidence suggests that humans in the Carpathian area started partly burying their dwellings about 5500 BCE to maintain a more consistent interior temperature (Constantin et al., 2015).

Later, Essene tribes in the Middle East, the Cappadocians, and Native Americans also constructed their dwellings to use the earth's thermal qualities. The Persian "badghir" (wind tower) furthered these ideas by capturing wind and soil energy in meticulously mapped-out circuits to maintain optimum inside temperatures (A'zami, 2005). Similarly, Egyptians use "malqaf" (wind catchers) to harvest energy from the wind (Constantin et al., 2015).

Since the 1980s, when a limited number of buildings started to gradually integrate the management of diverse equipment and systems, the notion of the intelligent building has emerged. Initially, building automation systems were only capable of controlling a single unit. As technology advanced, however, these systems developed to be able to operate several machines concurrently. Multiple utilities, including security, HVAC/EC, and electricity, may now be monitored and operated by a single system. Due to technological improvements, wireless devices and the internet may now be utilised for remote monitoring and administration. In the history of intelligent buildings, Wang(2010) identifies four distinct epochs, beginning in the 1980s with integrated single function/dedicated systems, continuing through the 1990s with integrated multifunction systems, and reaching the present day with computer-integrated buildings and enterprise network integrated systems (Constantin, Tudor, Gabriela-Elena, Horia, & Adrian, 2015).

2.1.3 Principle and Application of Energy efficiency

Site analysis, site planning, building form, building plan, correct space organisation, building envelope design, material selection, site landscaping, and the use of renewable energy all contribute to the energy efficiency of a structure as a whole. This section describes these key ideas in further detail.

2.1.3.1 Site Selection

Hemisphere, slope, and aspect are all important design considerations. The placement of a building influences its microclimate and, as a result, its energy efficiency. The cost of heating and cooling a structure is affected by factors such as solar exposure, air temperature, air movement, and humidity (Zeybek , 2009).

Figure 2a depicts the many microclimates that might form based on the slope direction. In terms of temperature, the west side of the mountain is the hottest in the summer and the warmest in the winter. The top is the windiest, while the North Slope is the most shady and pleasant location. Low locations are often colder than slopes because cold air flows down and settles there (Lechner, 1991; Izzet and Tülay, 2019).

The best site for a construction in a hilly terrain is on a slope, however this changes with the season and the kind of structure being built.

Climate-wise, sites like those in Figure 2b would be ideal for envelope-dominated structures such as residences and small offices.

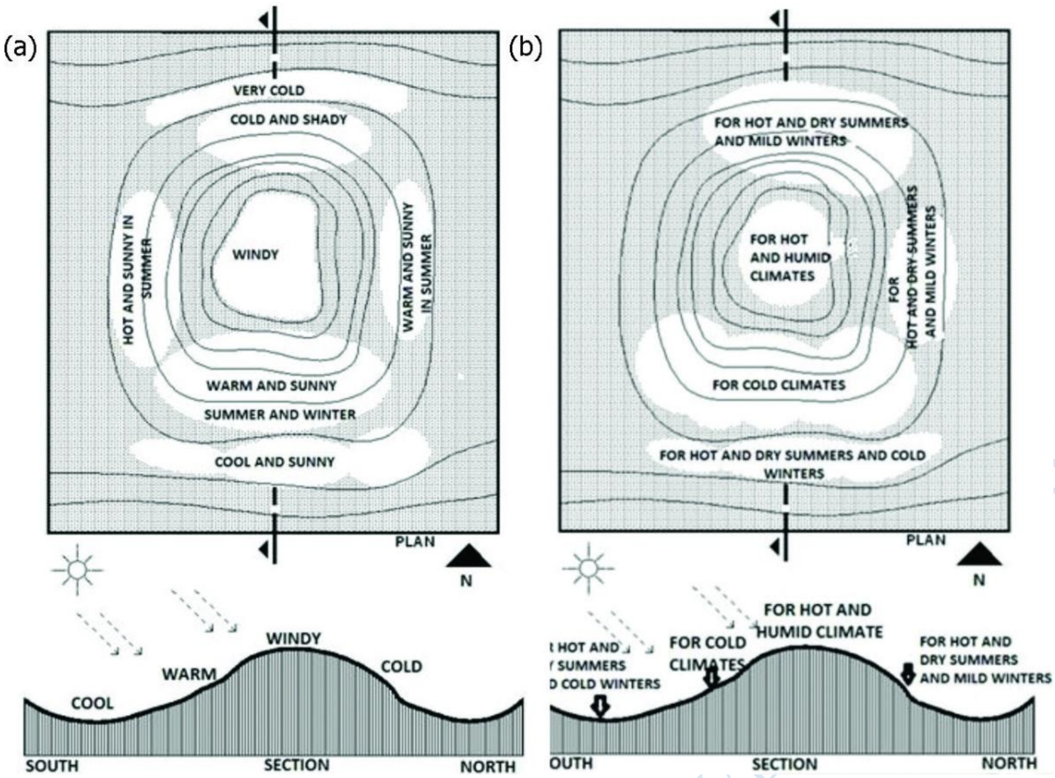


Figure 1 Suitable land for settlement according to the different climate zones [12]. (a) Microclimate around a hill; and (b) preferred building sites around a hill in response to climate for envelope-dominated buildings.
Source: (Lechner, 1991)

location. Low areas tend to be cooler than slopes because cold air drains into them and collects there (Lechner, 1991; Izzet and Tülay, 2019).

Certain sides of a hill may be more ideal for building depending on the weather and the kind of project.

Due to the favourable weather conditions, sites such as those shown in Figure 2b would be appropriate for envelope-dominated buildings such as residences and small offices.

2.1.3.2 Site planning

The distance between buildings determines how much natural light can be utilised within a building and how well artificial breezes may be harnessed.

Throughout the design process, the surroundings of the building should be considered alongside the structure itself.

Distance between buildings is crucial in how effectively they perform in terms of energy usage during real use. Staying in the shadows of nearby buildings minimises a building's exposure to solar radiation while increasing its energy requirements. To take advantage of the sun's rays, the height of a building must be greater than the maximum shade height of surrounding structures. Furthermore, the proximity and orientation of neighbouring structures influence a building's energy efficiency (Izzet & Tülay, 2019).

The total quantity of solar radiation absorbed by a building is determined by the ratio of solar radiation absorbed by the structure's sides. The amount of natural ventilation and heat loss through convection and air shortage are all affected by a building's wind direction. As a result, structures must be oriented to shield themselves from or benefit from the sun and wind, depending on local conditions (Izzet & Tülay, 2019).

2. 1.3.4 Building form

Building height, plan length-to-depth ratio, roof type, roof gradient, front gradient, and bossages are all geometrical characteristics that form a building's design, influencing how much heat is lost or gained. A structure's heat loss-gain may increase or decrease depending on its surroundings' surface area to volume ratio (Izzet & Tülay, 01 July 2019).

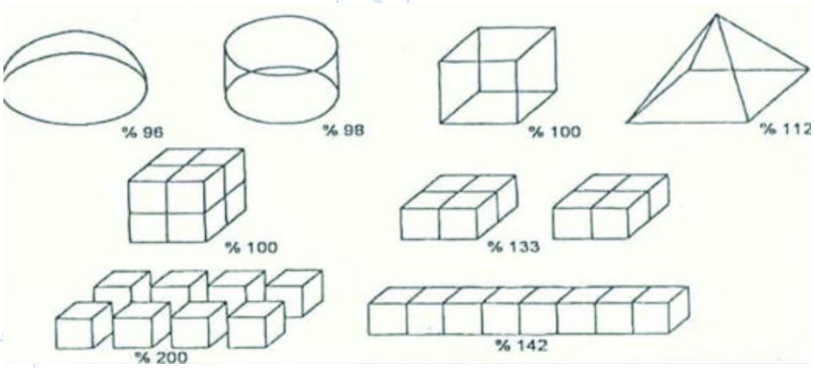
The structure's volume, surface rate, and frontal movements all influence its energy performance. The energy efficiency of a building is related to its shape.

Researchers discovered that masses of the same volume but different forms had drastically different energy performances (Soysal & Konut, 2008). Despite their ostensibly distinct forms, the masses' overall surface areas were comparable in volume.

On the cube's surface, 100 was taken as a reference (Figure 4). The shape of a building is critical in areas with variable weather patterns. Compact designs that limit heat loss are preferred in colder areas. Compact forms and courtyards may limit heat gain while providing appropriate shade and cooling for inhabitants in hot, dry summer climates. In hot-humid climatic zones, long, thin shapes with

Figure 2 Building form-surface relationship
source: (Soysal & Konut , 2008)

their long axis aligned with the direction of the prevailing wind provide the best



cross-ventilation. Compact, more versatile models are ideal for moderate climates.

2.1.3.5 Building plan and appropriate space organization

A building's layout and geometry should be selected with energy efficiency in mind. Buildings should be built to gather as little heat as feasible during the summer and as much heat as possible during the winter. Compared to more intricate floor layouts, squares and rectangles have a smaller surface area, and hence lose and gain less heat. Smaller houses use less energy overall for heating, cooling, and lighting (Yüksek & Esin, Analysis of traditional rural residences in Turkey in terms of energy efficiency, 2013).

According to the conclusions of a research titled "Construction and Energy" undertaken by the German Ministry of Science and Technology (Izzet & Tülay, 01 July 2019), space placement is more beneficial than space orientation for energy efficiency in the planning phase.

By properly designing a building's interior, its energy demands may be reduced. Solar heating may lower heating energy use if it is optimised. However, private parts such as the pantry, bathroom, and toilet may operate as buffer zones, reducing heat loss to the outside. Sun chambers that face south, for instance, may store solar radiation for later use in heating the building (Yüksek & Esin, Analysis of traditional rural dwellings in Turkey in terms of energy efficiency, 2013).

Zoning may be achieved by stratification in building design based on criteria such as buffer zone, sanitary spaces, noise level, lighting level, and heating need. Therefore, it is ideal for highly travelled, all-day-used locations to face south. Planned use of thermal zones and design of interior areas may promote cross-ventilation (Figure 5). Deep designs and the use of too many dividing elements may hinder airflow (Yüksek, 2008).

2.1.3.6 Building envelope

The building envelope is comprised of the walls, floors, roof, and windows/doors that insulate or expose conditioned space to the outside. As an indoor and outdoor reagent, it contributes significantly to lowering energy use (Ylmaz & Akll, 2005). Building envelopes account for just 15–40 percent of the total building cost, but contribute around 60 percent to life cycle expenditures, particularly energy costs (Izzet & Tülay, 01 July 2019). The skin of a building functions as a filter to manage the movement of air, heat, cold, and light between the inside and outside (Izzet & Tülay, 01 July 2019). The winter heat loss and summer heat gain of a building's envelope should be minimised.

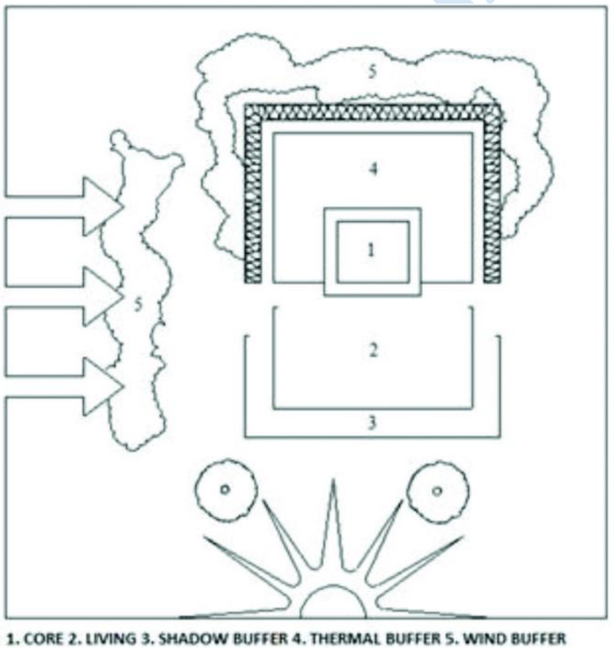


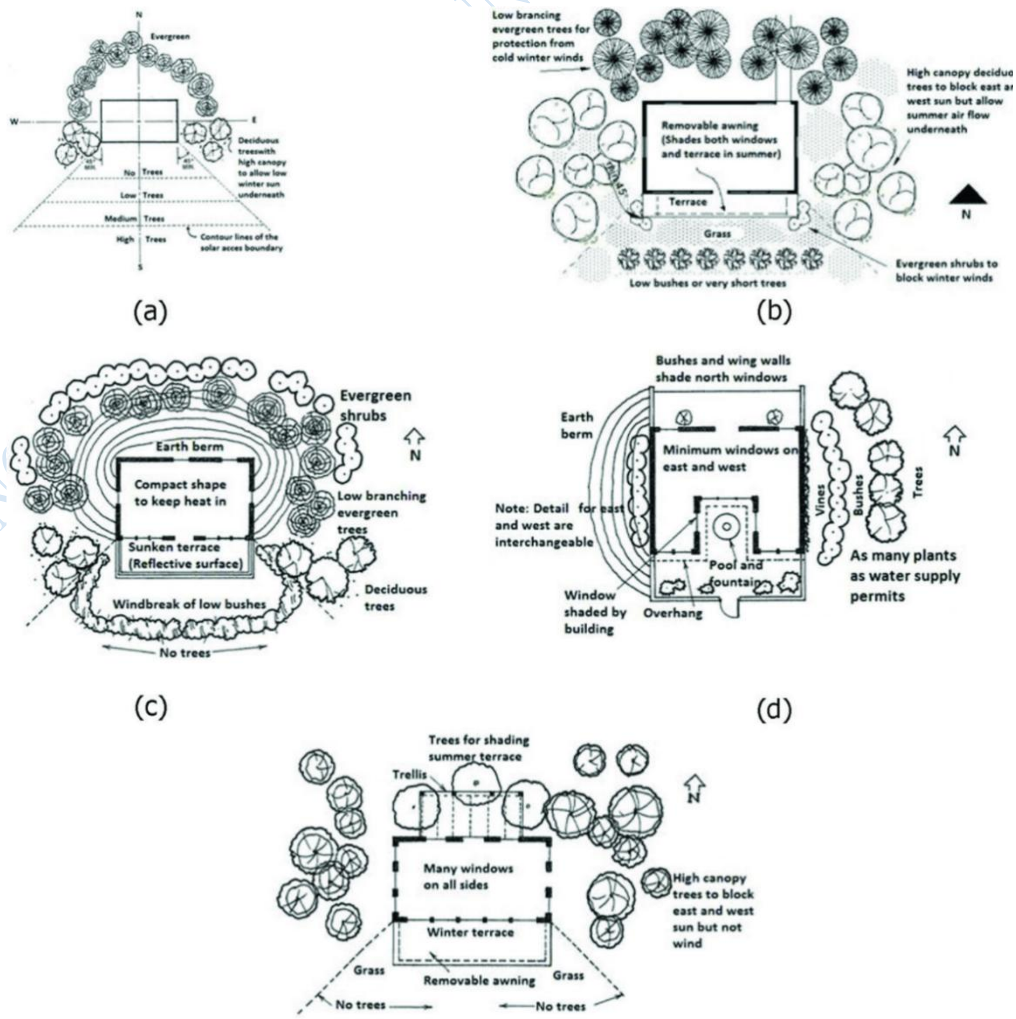
Figure 3 Spatial zoning
source: (Izzet & Tülay , 01 July 2019)

2.1.3.8 Energy-efficient landscape design

It is feasible to save up to 30% on energy costs for heating and cooling throughout the summer and winter seasons by designing an energy-efficient landscape [34].

The cooling effect of outdoor and grass floors is achieved by vapour transmission. Materials that store heat in their bodies, such as asphalt, continue to expand heat after the sun sets, increasing nighttime radiations. Among the measures to be taken to decrease cooling costs include the use of materials that retain heat and reflect light little, as well as screening them from direct sun rays (Izzet & Tülay, 01 July 2019).

The energy-saving landscape methods vary by area. Figure 6 depicts a collection



Landscape design strategies for four climatic zones (cold, hot, dry, and humid) are depicted in Figure 6 6 [12]. (a) landscaping practises for a milder climate, (b) the standard tree-planting logic for most countries [12]. For example, (c) landscaping strategies for very cold regions, (d) landscaping techniques for hot and dry climates, and (e) landscaping techniques for hot and humid climates.
original source (Izzet & Tülay, 01 July 2019)

of landscaping methods organised by area and significance.

2.1.3.9 Usage renewable energy resource

The continuous replenishment nature of renewable energy sources such as the sun, wind, biomass, biogas, geothermal energy, hydro, wood, ocean thermal, ebb and flow, wave, and sea flows may assist all life on Earth.

Both passive and active tactics may be applied to obtain the advantages of renewable energy sources.

Passive ways for harvesting renewable energy sources:

Subsidized or unassisted heating: Passive solar heating systems may be classified depending on how the solar array is linked to the building. Passive solar heating systems are classified into three types: direct gain, indirect gain, and isolated gain (Izzet & Tülay, 01 July 2019). Passive solar heating, as the name indicates, involves using the sun's rays to warm the inside of a structure. Windows in the passive solar construction with direct gain systems enable winter light to stream directly into the living area. These solar gains may be utilised immediately to complement the building's heating system or stored as a thermal mass for later use. The following properties are common in direct gain structures:

1. This need plenty of south-facing windows in the northern hemisphere to allow in the winter light.
2. Utilizing thermal mass inside the insulating envelope to mitigate temperature changes
3. With a properly positioned overhang above the south window, the glass may be shielded from the sun's rays during the summer while still receiving lower-angle winter sun.
4. Reducee nighttime heat loss

A direct gain construction allows natural light to enter via windows. Massive interior surfaces absorb this energy and release it as heat (often concrete floors and brick walls). Some of the surface heat is instantly transmitted back into the room. As shown in the Figures, the leftover heat is gradually transported into the thermal mass, which heats up; at night, the heated mass is discharged back into the interior.

7and **8** (Izzet & Tülay , 01 July 2019).

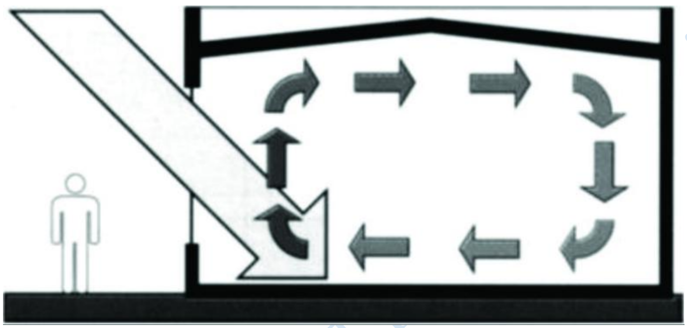


Figure 4 Direct gain schematic
source: (Izzet & Tülay , 01 July 2019)

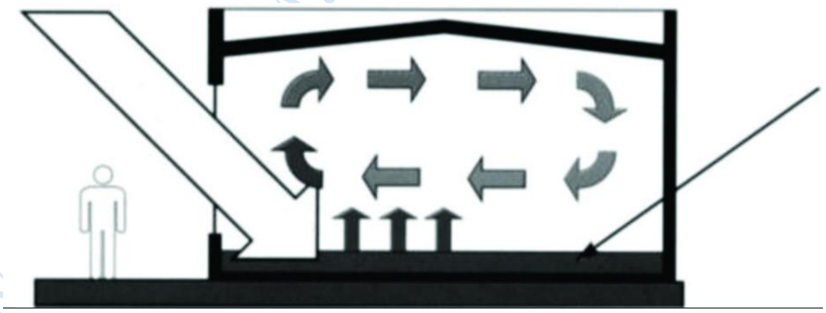


Figure 9 Direct gain plus storage schematic
source: (Izzet & Tülay , 01 July 2019)

Indirect gain systems: The thermal storage for a passive solar system with indirect gain is situated between the façade and the interior areas. Buildings may absorb and store heat in an external wall or on the roof (with water or brick/concrete) and then release that heat into the inside, as shown in Figure 9 (Izzet & Tülay, 2019).

Isolated gain systems: The solar collection and storage in a passive solar design with separated gain are intended to avoid heat transmission from the outside to the inside of a building. In most isolated gain systems, a sunspace is used. The facilities utilised for collecting and storage are not thermally linked to the actual living rooms. Figure 10 (Izzet & Tülay, 2019) defines a sunspace as "a room next to or connected with the outside of a building in which the room temperature may

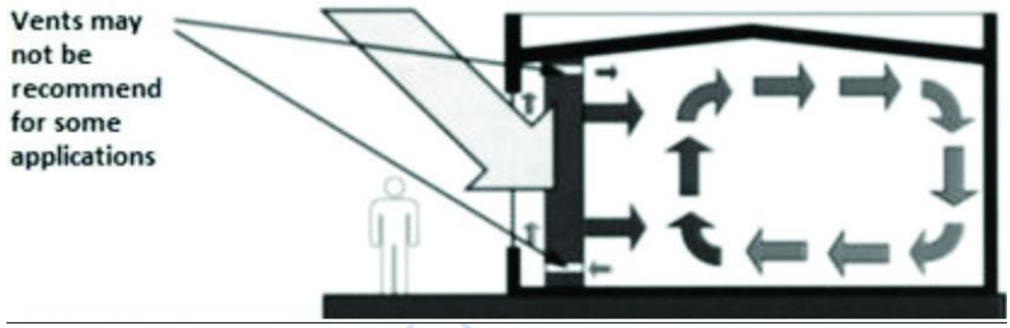


Figure 9: Indirect gain schematic
(Izzet & Tülay , 01 July 2019)

rise and fall beyond the thermal comfort zone."

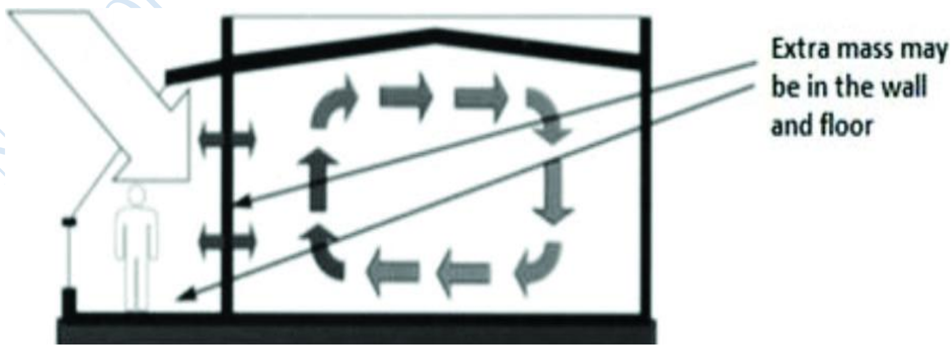


Figure 5 Sunspace schematic
(Izzet & Tülay , 01 July 2019)

There are various forms of passive solar heating, each suited to a certain use. Passive cooling, on the other hand, makes more sense when regarded as a group of disciplines that investigate basic heat sinks. While this structure benefits academics and innovators, it may be inconvenient for designers and policymakers since many practical systems need more than one heat sink (Izzet & Tülay, 2019). Nonetheless, we shall clarify what we mean by passive cooling.

To produce this ventilation cooling effect, warm interior air is removed and replaced with cooler exterior air. Convection and evaporation cool people's bodies by directing moving air over them. In passive applications, wind or the stack effect often provides the required airflow. Figures 11-13 from (Izzet & Tülay, 2019) show how fans may help with movement in hybrid applications.

Because all objects inside a building emit and absorb varied quantities of radiant radiation, they are excellent for use in passive cooling systems. Radiation may cool objects within structures if the net flow is directed outside the structure. The quantity of long-wave infrared radiation emitted by a structure at night is much more than that of a clear sky. As a result, as seen in Figure 14 (Izzet & Tülay, 2019), there is a net outflow into space.

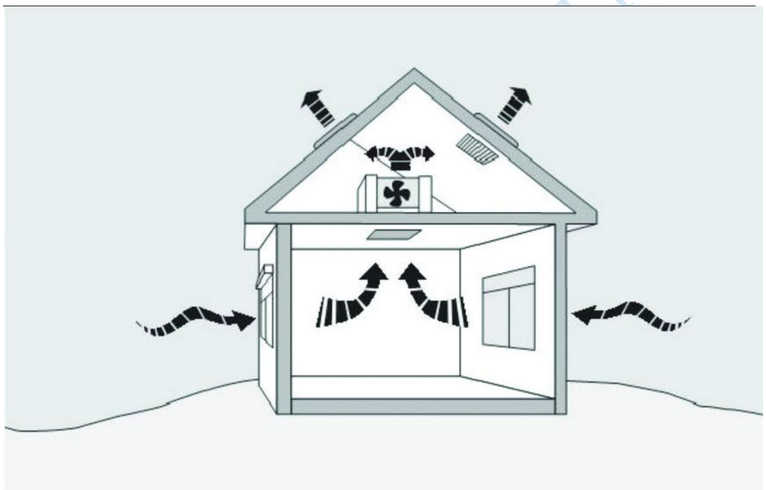
The temperature within buildings may be reduced by creating evaporative cooling using water features such as fountains, cascades, or ponds. Because water evaporates, heat is lost, making the air colder. The process through which water absorbs sensible heat from its surroundings and releases it as water vapour is known as evaporation.

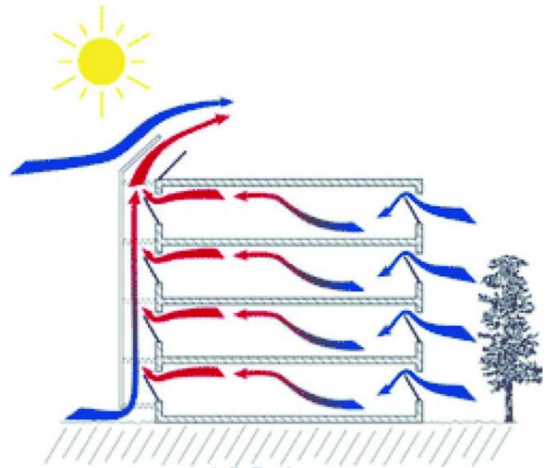
The transition of sensible heat into latent heat causes the temperature to fall. There are two approaches to using this phenomenon to cool interior environments.

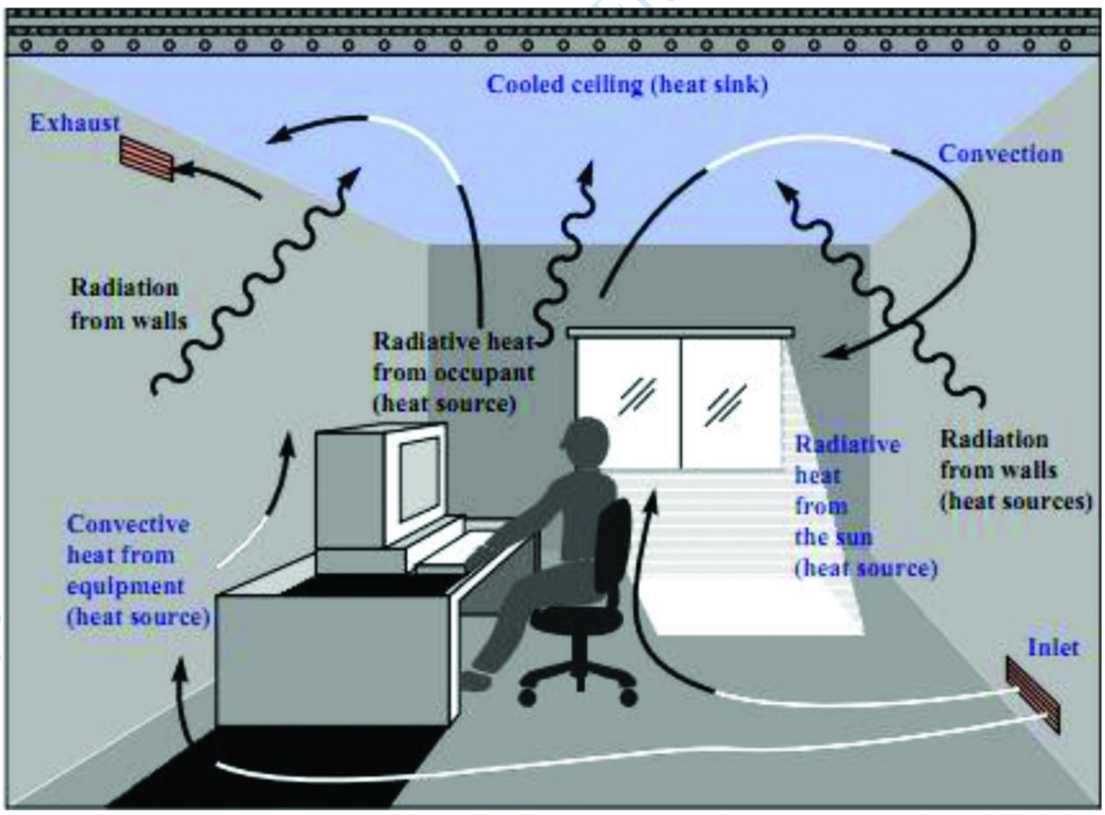
If the water evaporates within the structure or fresh air intake, the air will be chilled and humidified.

This approach is known as direct evaporative cooling.

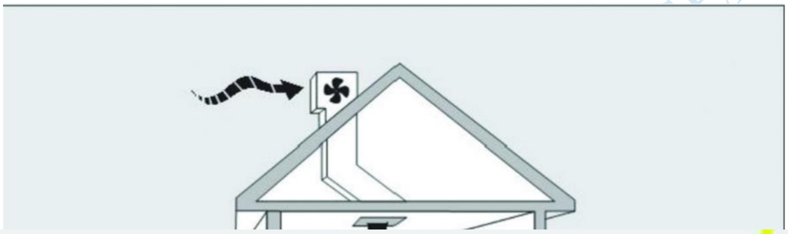
If, on the other hand, the building or interior air is cooled by evaporation without being humidified, the approach is known as indirect evaporative cooling, as seen in Figure 15.(Izzet & Tülay , 01 July 2019).

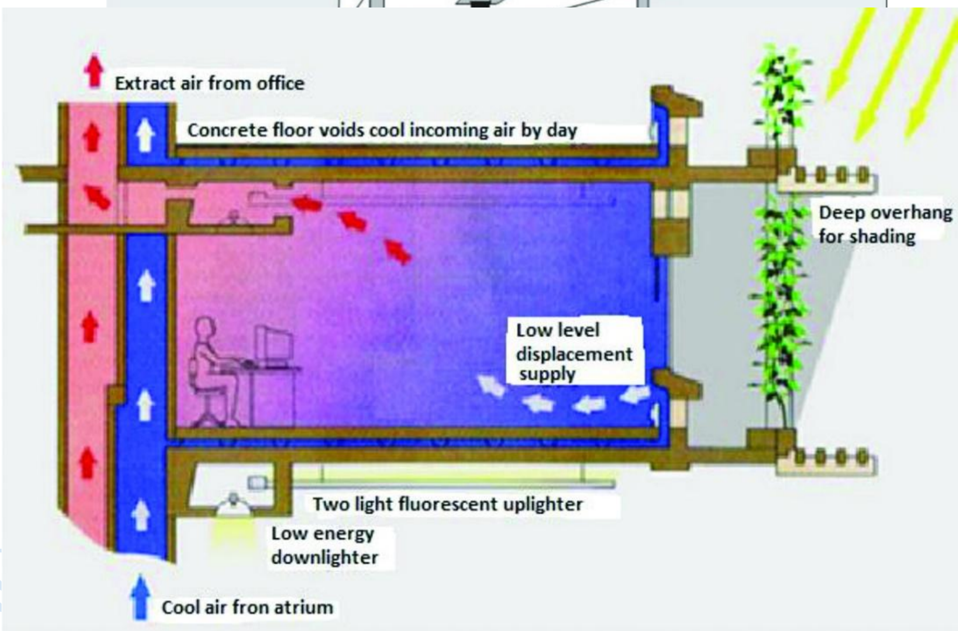





Cooled ceiling (heat sink)
Exhaust
Convection
Radiation
from walls
Radiative heat
from occupant
(heat source)
Radiative
heat
from
the sun
(heat source)
Radiation
from walls
(heat sources)
Convective
heat from
equipment
(heat source)
Inlet

Dehumidification is the process of lowering an interior environment's relative humidity by lowering the concentration of water vapour in the air by condensation, evaporation, or ventilation. Because they entail the exchange of latent heat in the air for the sensible heat of water droplets on surfaces, desiccation and condensation are adiabatic heating processes (Izzet & Tülay , 01 July 2019).





Mass Effect Cooling: The practise of employing thermal storage to take heat from a specific region during the hottest period of a cyclical temperature cycle and then releasing it when temperatures decrease is referred to as "mass effect cooling." Figure 16 depicts daily-cycle mass-effect cooling as night flushing, in which cold night air is pumped through a building to exhaust heat stored throughout the day in enormous floors and walls. (Izzet & Tülay , 01 July 2019).

2.2 Definition of Office

An office space is defined as a facility suited for the performance of managerial and administrative duties, as well as those of accounting, marketing, information processing, consulting, human resource management, banking, insurance, teaching, and healthcare (BOMA Best, 2013).

2.2.1 Design Considerations for Office Buildings

The Whole Building Design Guide (2010) detailed the common characteristics of Office Buildings, including the list of appropriate design goals as mentioned below.

2.2.1.1 Cost-Effective

The worth of a high-performing workplace may be quantified in terms of lives saved. When it comes to optimising a building's performance, owners may need to be willing to invest more money up front in order to save money on operations and maintenance in the long term. When appropriately utilised throughout the design phase of a building's development, value engineering analyses different design choices to enhance the estimated cost/worth ratio of projects. Contractors are motivated to apply their specialised "know-how" to suggest changes during construction that cut expenditures while maintaining or increasing quality, value, or functional performance via shared savings.

2.2.1.2 Functional/Operational

Tenant Requirements

When developing the building's layout, all of the tenants' requirements must be considered. Consider organisational and group size, growth potential, long-term consistency of need, group assembly requirements, electronic equipment and technology demands, acoustical needs, unique floor loading and filing/storage needs, special utility services, and desired public image. Logistics, including requirements for loading, filing, and storage; utility services; material handling and operational process flows; health concerns; transportation requirements and modes; and financial objectives.

Flexibility

- Effective workplaces should be able to accommodate new layouts and design schemes with relative ease. Infrastructure, interior systems, and office furniture must be adaptive in the face of change caused by management reorganisation, employee changes, revisions to business models, or the introduction of new technology.
- Raised flooring enabling easy access to cabling and power distribution, as well as improved air distribution capabilities to accommodate individual occupant comfort, should be considered.
- Some of the features that should be included include modular and managed wiring and buses, conference hubs, and plug-and-play floor boxes for power, data, phone, and fibre.

2.3 Architectural Design Elements

Elements are the basic building components that must be included in every design or creative expression. There are universal design guidelines and elements that assist in defining the creative process. Users who understand these aspects are better equipped to create a well-rounded and enticing experience. All architects, designers, compositors use architectural design aspects, and creative artists, whether they work on the interior or outside of a structure. Using them properly can help artists bring their thoughts to life via their work. Certain inescapable features are required to build a competent and creative architectural design, just as vital environmental variables are required for human survival. The following elements are required for attaining design harmony via meticulous attention to detail.

2.3.1 Colour

The selection and implementation of colour schemes are of utmost significance in design. It is possible to create aesthetically pleasing structures and interiors by carefully considering colour palettes. This design element allows for the expression of day and night, light and dark, intensity, and force. This component of design includes colour choices, colour wheels, and colour palettes.

However, adding colour is not a solution for bad layout.

A residence with white siding, a white roof,and/or reflective coatings reflects radiant energy away from the inside. Even the palest tint of grey is preferred than blue or green. Therefore, using bright colours and reflective coatings may save money on air conditioning costs.

2.3.2 Light

Light, like colour, is an essential and essential element in the design of both indoor and outdoor places. Artificially created or naturally occurring illumination may be used for aesthetic reasons. Numerous elements of a design may be modified by just altering the lighting and compositions in which they are employed. Utilizing door and window location simulates natural lighting. Using solely natural light in your compositions will provide breathtaking outcomes for your viewers.

Improving illumination quality and efficiency is a top priority when planning for energy efficiency in indoor and outdoor lighting. When constructing a new house, include lighting in the overall design.

Consider some key design concepts and procedures for developing energy-efficient indoor lighting.

The following are energy-efficient lighting design principles:

• Maximize the use of natural lighting

• More light is not always better: light quality is just as important as quantity

• Align the amount and quality of light with the function being performed

• Install task lighting where necessary and limit ambient lighting in other areas

• Employ lighting components, controls, and systems that conserve energy (e.g., timers, occupancy sensors, and connected home applications) (i.e., timers, occupancy sensors and connected home apps)

Here are some basic techniques for producing energy-efficient indoor lighting:

- Use ENERGY STAR®-qualified light fixtures and light bulbs
- Install LED light fixtures for all commonly used ceiling and wall-mounted lights, particularly those that will be on for more than 2 hours per day, such as those in the kitchen and living room, bathroom, corridor, and other high-use areas.
- Instead of using fluorescent or LED replacement bulbs in existing incandescent fixtures, consider installing ENERGY STAR-certified LED fixtures.

- Use LEDs in all LED-compatible portable lighting fixtures
- Use timers, occupancy sensors, or networked home technologies to automatically turn the lights on and off as needed.
- Consider using wall surfaces with lighter hues to reduce the need for artificial lighting.
- When installing recessed lighting in a ceiling with an unconditioned space above it, use only Underwriter's Laboratory (UL)-approved, airtight, IC (insulation contact)-rated, and ASTM E283-compliant fixtures.

2.3.3 Material

The diversity of building materials used in construction has increased as manufacturing processes have developed. Architectural styles have also evolved, capitalising on and sometimes pushing the boundaries of new materials and compositions.

Architects and engineers must choose low embodied energy materials for climate change mitigation and economic savings. The embodied energy of construction material is the entire amount of energy consumed in its extraction, processing, production, transportation, and management.

Construction materials with low embodied energy include fly ash bricks, fibre-reinforced bricks, woods, stabilised adobe blocks, and cement-replacement materials such as silica fume, slag, and fly ash by-products of industries. Contractors are increasingly turning to these materials in various regions of the globe, including the Middle East, Europe, the United States, the United Kingdom, and India. Table 1 shows the embodied energy of popular building materials.

Table-1: Embodied Primary Energy of Building Materials

Construction material	**Primary energy input,**	**Ranking**

	MJ/kg	
Fly ash, volcanic ash, sand, aggregate, adobe, soil	>0.5	Low energy
Timber (sawn)	0.1–5	Medium energy
Sand-lime brick	0.8–1.2	
Precast	1.5–8	
Blocks	0.8–3.5	
In situ concrete	0.8–1.5	
Gypsum plaster	1–4	
Clay bricks and tiles	2–7	
Lime	3–5	
Plasterboard	8–10	High energy
Cement	5–8	
Glass	12–25	
Lead, zinc	25+	
Steel	20–60	
Stainless steel	100	Very high energy
Copper	100+	
Plastics	50–100	
Aluminum	200–250	

2.3.4 Shape/Form

The shape is equally important to creativity and insight when developing a structure. There are several forms categories, including geometric, abstract, and organic. What the element is like depends on the form it is put into during usage or production. Both the two- and three-dimensional forms are viable alternatives. Users can utilise shapes to educate and deepen the design by employing a variety of shapes for various structures or using the same shapes for several related things. One of the "initial" effects of a construction solution is the feeling it elicits in the observer. The architect may use his or her knowledge of how different shapes and forms impact people to get the desired effect.

2.3.5 Mass

In architectural practise, the volume of a design solution is its three-dimensionality. In this scenario, the element represents the overall form's blocky, geometric design. Every construction project begins with a block, an outline, or a sculptural shape. This basic form is referred to as mass. The massing of a building has a considerable impact on how it appears and how people respond to a design solution.

2.3.6 Texture

The texture of an object's exterior may be adjusted to affect its aesthetic attractiveness. There are two ways to perceive architectural texture: visually and physically. Texture refers to how something feels to the touch, including how smooth, rough, soft, etc.

Architects must consider texture while creating a building since it determines the initial impression of the construction. By altering the texture's density, several effects may be obtained. Transitioning from a smooth to a rough surface may trigger a broad range of emotional reactions, including warmth and connection.

The texture is related to the hardness and heat retention of the material. Due to their low heat retention, smooth surfaces are often uncomfortable to grasp despite their seeming coldness. In its logical extreme, rough surfaces may trap heat, resulting in an opposite but unpleasant feeling. Rougher textures might be seen as softer, but smooth textures are always perceived as more rigid (even though they may be harder than smooth textures.).

2.4 Energy Efficient Buildings

Geissler et al. (2018) discovered that the demand for energy-efficient buildings is stronger than ever due to the fast growth in urban temperatures and the danger of global warming and climate change. According to Gosztonyi, further effects of climate change include overheated interior environments and discomfort (2010). This is due to a rise in solar radiation reaching buildings via cracks in their walls, roofs, and materials.

Thermal and visual comfort are two amenities that residents of a structure should enjoy. This lends credence to El-Darwish and Gomaa's(2017) assertion that building professionals have become more aware of climate change and related issues regarding energy use in buildings, as well as their ability to ensure that energy is used efficiently to provide occupants with acceptable levels of thermal and visual comfort.

2.4.1 Energy Efficiency Design Strategies in office Building

According to the findings, numerous technologies exist that make energy-efficient buildings possible. Energy-efficient buildings require less energy for essential services such as lighting, heating, and cooling since they were constructed with these functions in mind from the outset. Throughout the planning phases of a project, energy-efficient design ideas may be included in new construction or existing buildings. According to Day & Gunderson (2015), building regulations and corporate policies that prioritise environmental preservation have led to a surge in the popularity of energy-efficient design solutions for buildings in general and office buildings in particular.

According to Nwofe, an energy-efficient building would use less electricity to cool and light its interior while still assuring the safety and comfort of its people. Specifically, the strategies above may ensure that buildings use less energy while providing their inhabitants with greatly enhanced thermal and visual comfort. Consequently, Table 1 offers an overview of the different methodologies.

SN	Energy Efficiency Design Strategies	Description
1	Building skin	The physical separator between the conditione and unconditioned environment of a building
2	Shape of Building	Configuration of a building
3	Building Form	The point of contact between mass and space
4	Building orientation	Position of building relating it to sun and wir direction.
5	Specification of Energy Efficient Building Materials	Materials that takes less energy
6	Building Plan and Appropriate Space Organisation	Space plan will also define the circulatio patterns that show how people will mov through the space

7	Selection of Site	Choosing of the most appropriate site .
8	Landscape Design	A landscape that reduce energy intake [illegible] buildings

Chapter Three
Research methodology

3.1 Research Design

This section involves the method adopted to assess the approaches used to source information and the study of the proposed building type base on the literature reviewed.

The study encompasses the exploration of architectural design element for energy efficiency in the office building.

The goal of this study is to explore architectural design element for energy efficiency in office building. The explorative method is selected for the study because it is proper when the focusing study is to examine the peculiarity of a region. In this study, it becomes clear that it is qualitative in nature; this is due to the difficulty of the subject and the difficulty by which perception is quantified. Thus, it is important to understand what makes an office building an energy efficient building before trying to quantify it and its underlying factors.

3.2 Case Study method

A case is a chronologically and geographically isolated event (Johansson, 2003). Veal (2006) notes that a case study may refer to both a research method and an analytical unit since it involves the assessment of unique occurrences (cases) of the investigated topic. Understanding a complicated instance via in-depth description and examination of the instance in connection to its surroundings is the purpose of case studies (the United States General Accounting Office, 1990). This research will apply an empirical method to gather data on a small number of instances that meet some of the topic's distinguishing qualities. The basis for these conclusions is a mixed qualitative case study analysis and a thorough examination of relevant published and grey literature. In this case study, we analyse social interaction based on its qualities.

3.2.1 Case Studies Selection Criteria

According to Schon (1991), architectural processes depend on a knowledge repertoire of circumstances from direct experience or established precedents. Veal(2006) discovered that picking examples for a case study was comparable to sampling in quantitative research; in both situations, the cases were selected on purpose. In light of these studies, Oluigbo(2010) suggested that identifying instances necessitates possessing certain intrinsic qualities that pertain to the issue under consideration.

I carefully selected the case studies that would serve as the foundation of my thesis.

- As a building with adequate analysis in scope of facilities required to make it operate as an office building.

- As a facility that has employed the concept of energy efficiency strategies.

3.3 Data Collection

Case studies for theoretical study in Architecture may need the use of common data collecting techniques (Oluigbo, 2010). These techniques include, among others, observation and participant observation, visual survey and checklist, interviews, questionnaire, models and simulation, and scientific measuring devices. For the purpose of this research, visual survey interview, questionnaire and checklists analysis based on the assessment of the level of successful place for social interaction on the selected case studies were adopted.

3.3.1 Instrument of Data Collection

Case study methodology will include the use of many data collection sources to adequately capture the complexity of instances (Yin, 2003; Veal, 2006; Johansson, 2003). Depending on the nature of the investigation at hand, the Visual Survey used here may be depicted in several ways. Photographs of important case studies to evaluate energy-efficient office building strategies and the extent to which they were really applied. Some case study components were also outlined. Using these illustrations, we can determine how different case studies use space. The variables of design element considered in architecture in connection to kinds of public buildings will also be mentioned in field form. In addition, the existence and kinds of supplementary amenities in the inspected region will be noted.

3.3.2 Procedure for Data Collection

In order to gather this information, we examined office buildings in our backyard and throughout the globe, taking notes on the visual features of the structures and sketching their floor plans. The analysis of the data acquired via visual survey and observation is based on descriptive narratives of what was seen and reported utilising data collecting methods. This description covered primarily three aspects;

a) Site planning and landscaping
b) Building envelope and material types
c) Building form and shapes

3.4 Operationalization of Variables

From the review of literature highlighting methodological approaches to case study researches on office complex and energy efficiencies, it is apparent that irrespective of organizing framework, methodological and philosophical differences the strategies for designing an energy efficiency building generally comprises:

- Building Envelope
- Building Shape/Form
- Site Planning/Landscape
- Energy Efficiency Material
- Spatial Concept

In line with the strategies for designing energy efficient buildings the following variables will be adopted.

a) Site planning and landscaping
b) Building envelope and material types
c) Building Orientation and Form

3.5 Case Study Analysis

3.5.1 Heritage Place, Lagos.

Heritage Place is a world-class development situated in the heart of Lagos's business and retail centre, close to the city's most recognisable attractions. With its cutting-edge design and construction, this eco-friendly building is one of the most innovative buildings in Nigeria.

Heritage Place will eventually be one of Lagos' most conspicuous and readily accessible monuments. It is located in the centre of Lagos, near the junction of

Figure 3.1 : Exterior View of the office Building

Source : google

Laggard Avenue and Kingsway Road.Heritage Place will eventually be one of Lagos' most conspicuous and readily accessible monuments. It is located in the centre of Lagos, near the junction of Laggard Avenue and Kingsway Road.

3.5.1.1 Site Planning and Landscaping

The building's 1,450 parking spaces and 14,500 square feet of business space make it quite a spectacle. Green features include a 30–40% reduction in energy use, a double-volume welcome, suspended ceilings, elevated floors, a café and coffee shop, a plaza, and customisable floor plate sizes ranging from 450–2,000 square metres. Built to globally recognised Grade 'A' standards, the broad floor layouts are extremely adaptable to the demands of modern tenants. A new standard for Nigerian architecture on account of its distinctive design, prestigious location, and industry-leading specs. Heritage Place aspires to become synonymous with innovative, eco-friendly business.

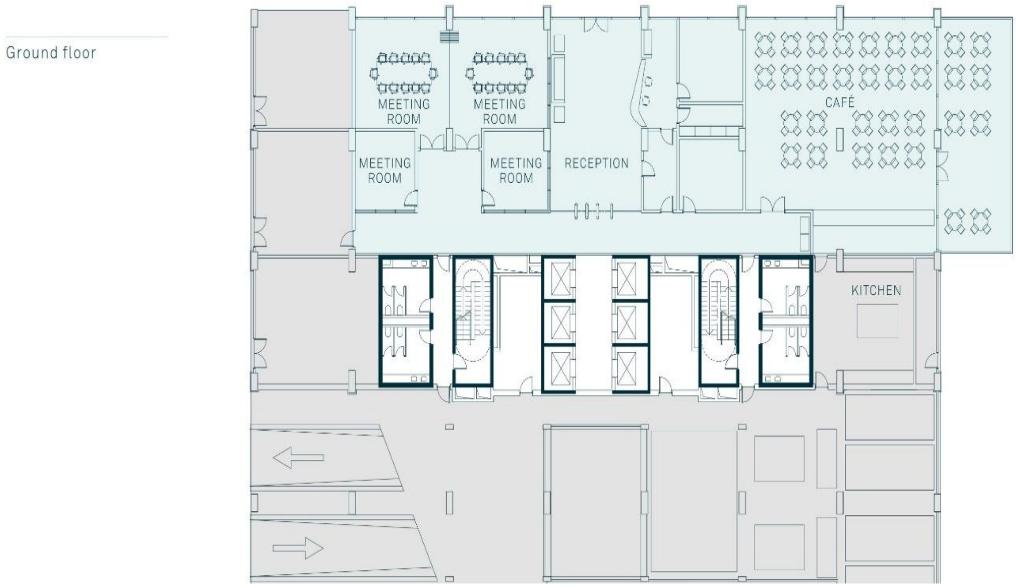


Figure 3.2 : Ground Floor Plan

Source ; Google

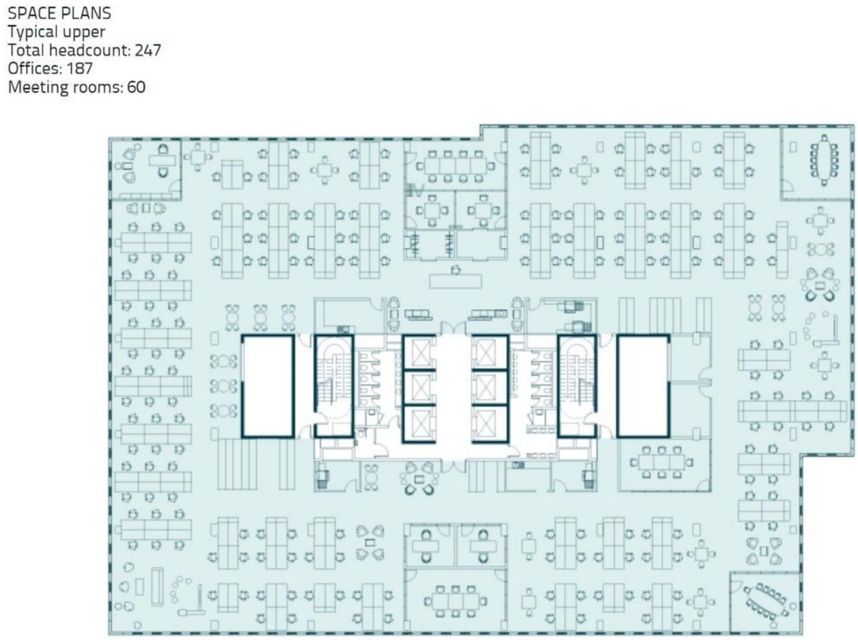
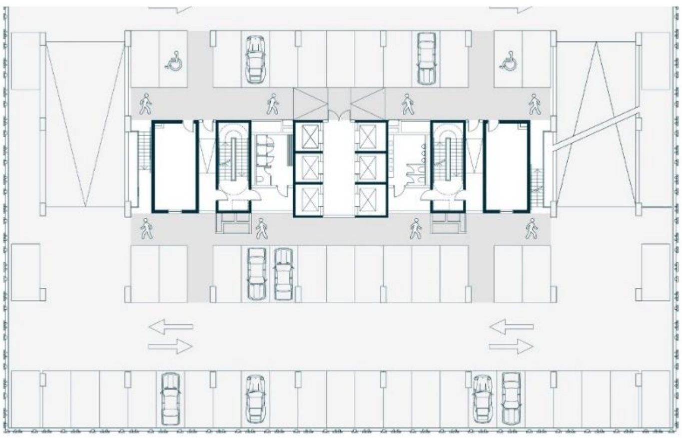


Figure 3.2 : Upper Plan

Source ; Google

Figure 3.2 : Typical Car Park

Source ; Google



3.5.1.2 Building Envelope and Material Types

Heritage Place is the first commercial building in Lagos to be designed and built to LEED standards, and it uses cutting-edge environmental technology to meet and exceed current and future environmental requirements. The external thermal envelope and high-efficiency windows help keep the building cooler in the summer.

Figure 3.2 : Elevation

Source ; Google

3.5.1.3 Building Orientation and Form

The structure's location and form let sufficient fresh air and light to penetrate while keeping the inside reasonably cool and shady from the sun.

Plate I: Sectional Perspective View

Source : google

Other Features includes:-

- Rainwater is collected and reused in the watering of the gardens, condensate is recovered from the building's cooling units, and precise control systems are installed in the bathroom facilities to minimise water waste.
- Automatic presence detectors and high-efficiency lights decrease and replenish energy on demand.
- High-efficiency lighting and automatic presence detection.
- Ventilation rates, material quality, and outside views enhance the thermal and visual comfort of the occupants and the quality of the interior air.

- Heat recovery by use of the centralised ventilation system (cooling).
- Utilizing rainwater collection and condensate recovery from cooling systems to reduce potable water consumption.
- Utilization of collected water for toilet flushing and irrigation.
- Hand-wash basins and urinals with motion sensors contribute to a reduction in potable water usage.
- Storm water attenuation to handle a storm that occurs once every twenty years.
- Proposed attenuation tank to reduce discharge/flow rates of sewage and storm water to Lugard Road's municipal sewers

Table 1: Checklist Assessment Criteria for Energy efficient building

S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
1	Building envelope	Suitability of the materials to the climate					●	High efficiency glazing a external thermal envelope
		Use of external Insulation					●	
		Use of smooth surface Finishes					●	
		Use of light colours					●	
2	Natural lighting	Wall to window ratio (40%)					●	The interior naturally lit w large glazed panel
		Use of spectrally selected glass					●	

3	Natural ventilation	Use of openable Windows			●			The use of openable casement windows,
4	Site and external spaces	Use of interwoven Landscape		●				Not enough landscaping.
		Use of impervious Surfaces			●			
5	Building form	Large building surface Area					●	Appropriate building form based on climate
6	Building orientation	Sun orientation; E-W					●	The optimum orientation is NW-SE
		Wind orientation; SW-					●	
7	Wall/Window shading	Use of horizontal and				●		There is outdoor area green area and presence overhang
		Use of interior blinds				●		
		Use of recessed walls		●				
		Use of overhangs			●			
		Use of plants		●				
8	Existing energy	Use of PV cells			●			Automatic presen detectors/sensors and hi efficiency lighting.
		Use of natural gas			●			

3.5.2 Nestoil tower, lagos Tower

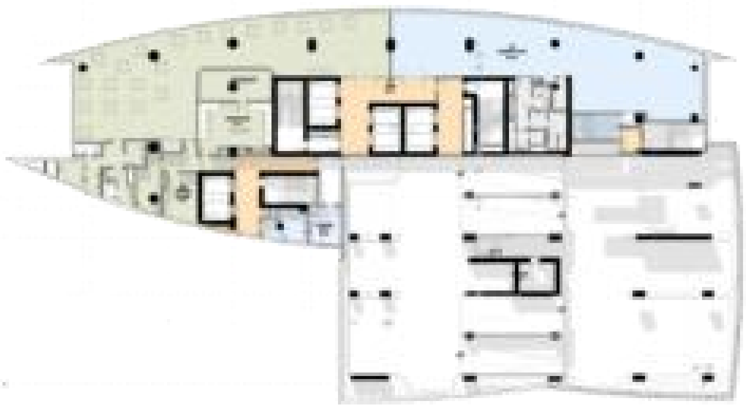
Featuring breathtaking views of Eko Atlantic City and the Atlantic Ocean, the Nestoil Tower is a one-of-a-kind office building at a prime location at the crossroads of two major commercial areas (Akin Adesola Street and Saka Tinubu Street) on Victoria Island in Lagos.

The project's intended tenants are fast-growing corporations, international industries, and financial institutions that value prominence in their respective markets and want to improve their brand's visibility. Nestoil Tower is a high-tech office building located on 3,900 square metres of land, with 10,000 square metres of rentable commercial space spread over 15 stories. Room Sizes From 231 Square Feet To 810 Square Feet

3.5.2.1 Site Planning and Landscaping

Gross floor space of the 15-story, mixed-use skyscraper is 32,300 square metres, which includes a generator cage, gatehouse, and technical basement. There include apartments, offices, a café, and a conference room. In addition, a helipad

and 230 parking spaces are provided inside the building's multilevel parking garage..



Second Office Floor

- Business Suite of 213 m2
- Restrooms with disabled facilities
- Kitchenette
- Plug And Play Internet Facilit
- Parking floor, 24 cars on split levels
- Central canteen area

2.

3.

- Open office floor of 541 m2
- Restrooms with disabled facilities

10th Floor

- Flexible office spaces from 15 – 72 m2
- Restrooms with disabled facilities
- Kitchenette
- Plug And Play Internet Facility
- Fully equipped gym

3.5.2.2 Building Orientation and Form

The main architectural idea revolves on the building's sweeping curving front, which is highlighted by horizontal tubular characteristics. The cutting-edge contemporary composition of the structure is completed with a surround of solid white metal panels along the curving curtain walls..

Figure 3.2 : Elevation

Source ; Google

Table 2: Checklist Assessment Criteria for Energy Effiecient Building

S/N	Variables	Checklist	Level of application 1	2	3	4	5	Remark
1	Building envelope	Suitability of the materials to the climate					●	The exterior were m covered with double curta wall.
		Use of external insulation				●		
		Use of smooth surface finishes					●	
		Use of light colours					●	
2	Natural lighting	Wall to window ratio (40%)					●	Interior spaces were l through double curtain wal
		Use of spectrally selected glass					●	
3	Natural ventilation	Use of openable windows			●			The use of openabl projected windows, but
4	Site and external spaces	Use of interwoven landscape			●			Few soft landscaping.
		Use of impervious surfaces			●			
5	Building form	Large building surface area					●	gentle curved surfaces high performance glazi
6	Building orientation	Sun orientation; E-W					●	The optimum orientation is NW-SE
		Wind orientation; SW-					●	
7	Wall/Window shading	Use of horizontal and			●			
		Use of interior blinds			●			
		Use of recessed walls			●			
		Use of overhangs			●			

		Use of plants		●			
8	Existing energy	Use of PV cells			●		
		Use of natural gas			●		

3.5.3 Hudson Commons, Newyork.

The original Hudson Commons structure, built in 1962, was an eight-story warehouse; an additional seventeen storeys were added on top of the black masonry-clad tower, resulting in 700,000 square feet of new office space for the neighbourhood. This repositioned LEED Platinum office skyscraper at the

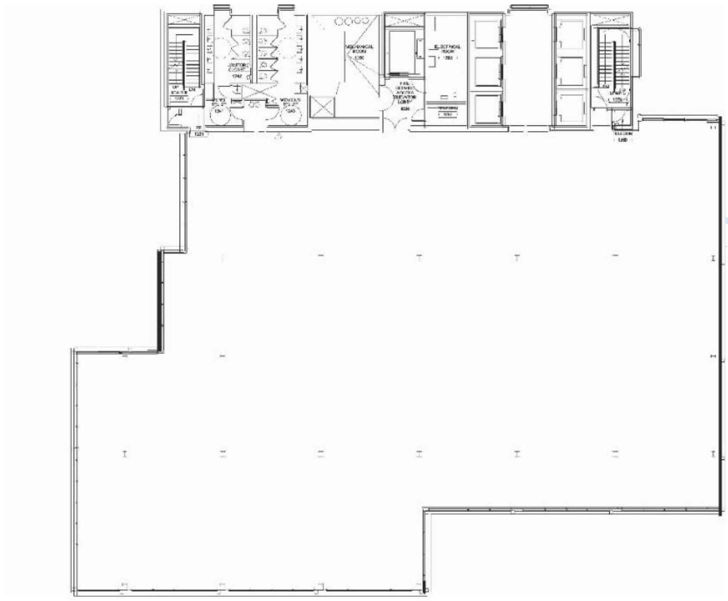
Figure 3.2 : Aerial view

Source ; Google

entrance to the Hudson Yards submarket retains the character of the site and surrounding neighbourhood.

3.5.3.1 Site Planning and Landscaping

This building has around 350 parking spaces and 14 stories of office space. This building is a paragon of sustainability, with features such as a double-volume lobby, suspended ceilings, raised floors, a café and coffee shop, plaza, and customizable floor plate sizes ranging from 450 to 2,000 square metres. The vast floor layouts, designed to globally recognised Grade 'A' standards, provide great space, efficiency, and flexibility to contemporary tenants. Its distinctive design, superb location, and cutting-edge facilities set a new standard for the built



environment in Nigeria. Heritage Place will soon be associated with cutting-edge, environmentally friendly business.

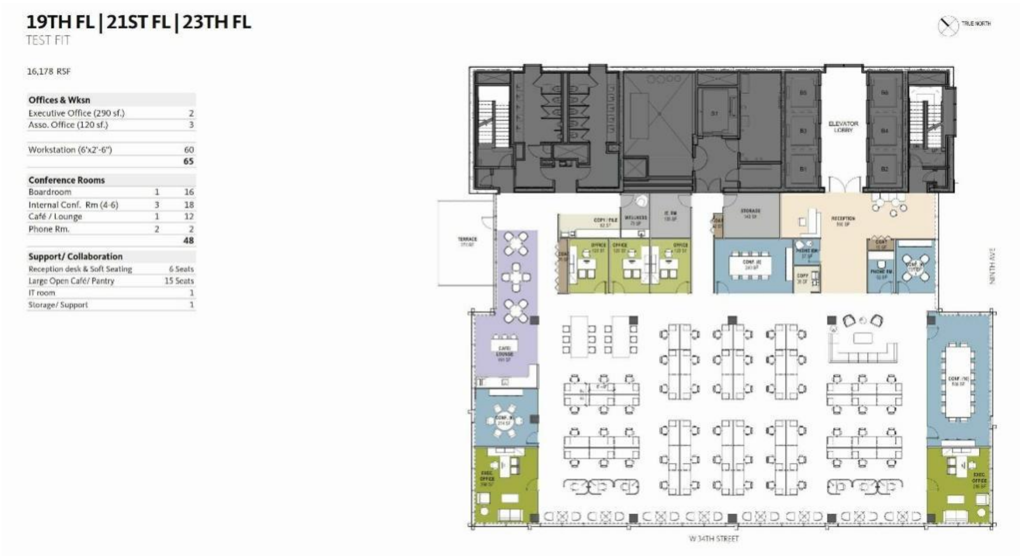


Figure 3.2 : Floor Plan

Source ; Google

3.5.3.2 Building Envelope and Material Types

Heritage Place is the first commercial building in Lagos to be accredited by Leadership in Energy and Environmental Design as both ecologically friendly in design and construction (LEED). Windows with high energy efficiency and an

outside thermal envelope assist keep a building cooler with reduced energy use..

3.5.3.3 Building Orientation and Form

The building's orientation and form has a large surface area which maximises natural light and ventilation, and minimises solar exposure, reducing the energy requirements for cooling, heating and air quality systems.

Figure 3.2 : street view

Source ; Google

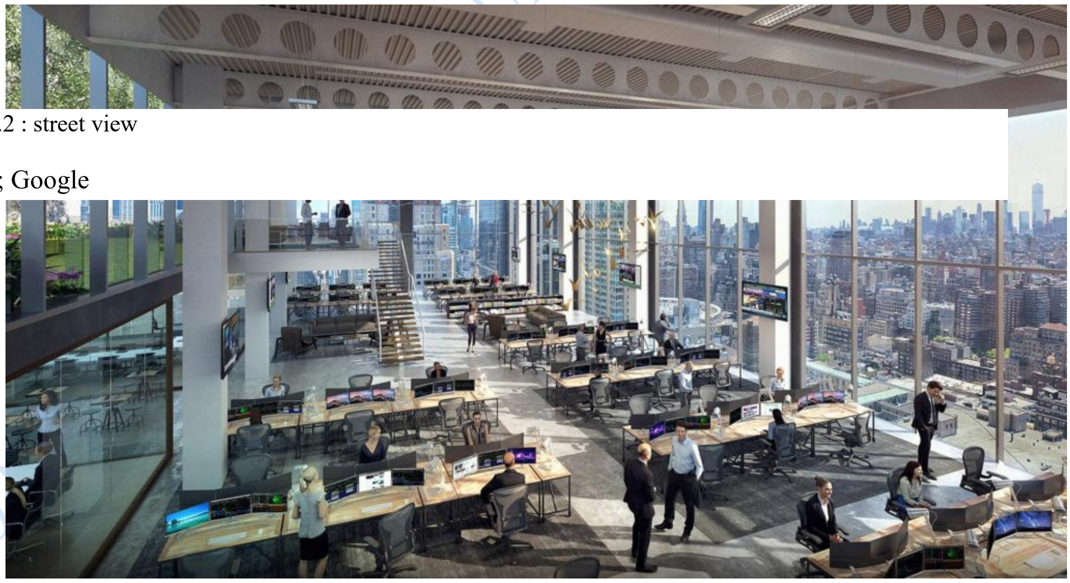


Figure 3.2 : office interior view

Source ; Google

S/N	Variables	Checklist	Level of application 1	2	3	4	5	Remark
1	Building envelope	Suitability of the materials to the climate					●	
		Use of external Insulation				●		
		Use of smooth surface Finishes					●	
		Use of light colours					●	
2	Natural lighting	Wall to window ratio (40%)					●	Interior spaces were l through windows, howev this appears inadequate d
		Use of spectrally selected glass					●	
3	Natural ventilation	Use of openable Windows			●			The use of openabl casement windows, b
4	Site and external spaces	Use of interwoven Landscape			●			No soft landscaping.
		Use of impervious Surfaces			●			
5	Building form	Large building surface Area					●	Appropriate building forn based on climate
6	Building orientation	Sun orientation; E-W					●	The optimum orientation is NW-SE
		Wind orientation; SW-					●	
7	Wall/Window shading	Use of horizontal and				●		No wall shading, no tall trees, no plants or overhangs at some areas the building. Veneti blinds were used
		Use of interior blinds				●		
		Use of recessed walls				●		
		Use of overhangs				●		
		Use of plants				●		

8	Existing energy	Use of PV cells	●					
		Use of natural gas		●				

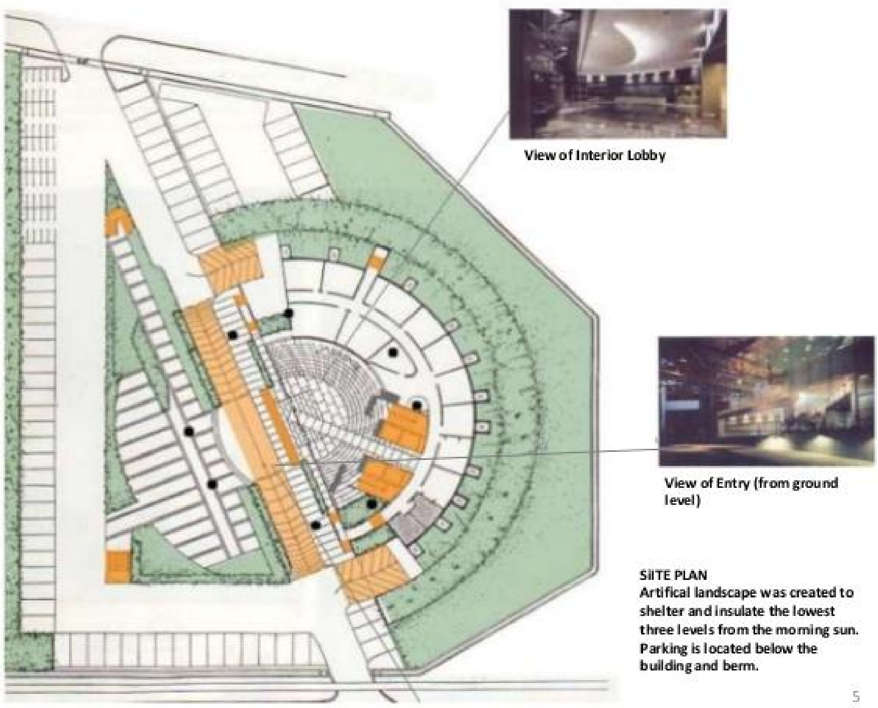
3.5.4 Mesiniaga Tower, Malaysia

Subang Jaya, Selangor, Malaysia is home to the modern Mesiniaga Tower, often known as the IBM tower. Ownership of the company belongs to Mesiniaga Berhad. Conveniently located near Subang Parade and Empire Subang is where you will find this building. This cutting-edge structure was built between 1990 and 1992. After it was finished, architect Ken Yeang's extensive investigation of bio-climatic design principles was honoured with the Aga Khan Award for

Architecture in 1995. The building's 12,345.69 square metres of floor space and extension potential span 15 stories.

3.5.4.1 Site Planning and Landscaping

Heritage Place is the first commercial building in Lagos to get Leadership in Energy and Environmental Design (LEED) certification for environmental friendliness (LEED). Together, high-efficiency windows and an outside thermal envelope keep a structure cool while using minimum extra cooling energy. The building brings together the principle of bio-climatic approach to the design of



tall buildings developed over previous decade by ken Yeang's firm

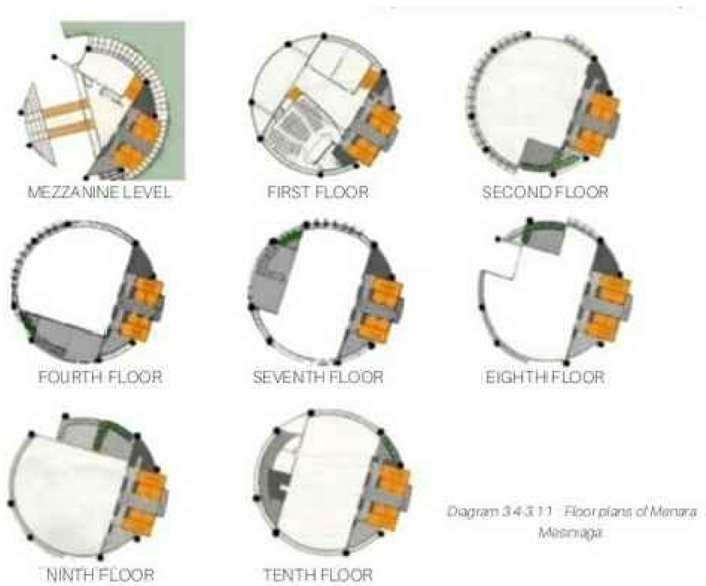
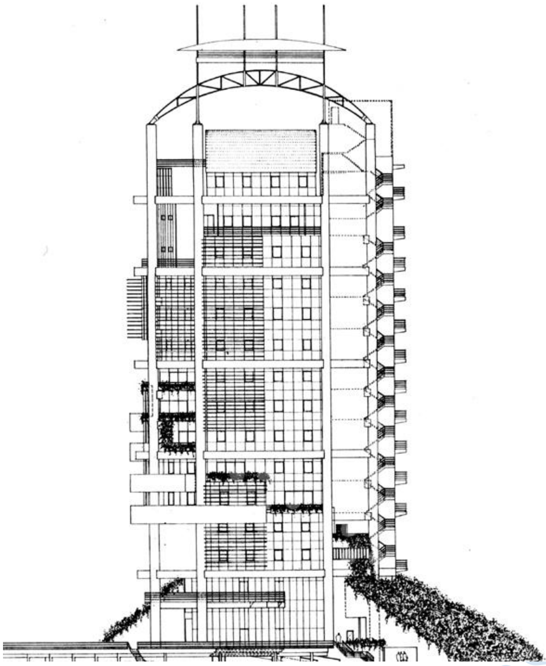


Plate II: Car Park Floor Plan



3.5.4.2 Building Envelope and Material Types

Heritage Place is the first commercial building in Lagos to be accredited by Leadership in Energy and Environmental Design as both ecologically friendly in design and construction (LEED). The building is characterized with High efficiency glazing and external thermal envelope which reduce demand on

cooling requirements.

3.5.4.3 Building Orientation and Form

The orientation and shape of the structure allow for plenty of natural light and ventilation while limiting the building's exposure to the sun, cutting down on the amount of energy needed to maintain comfortable inside temperatures and air quality. The use of aluminium louvres on the building's exterior reduces the amount of heat the building absorbs from the sun. The equatorial solar route is represented by the louvres' placement: narrow strip louvres screen the north and south facades, which get the least direct sunlight, while large bands of metal practically cover the full window on the west.

A crown of tubular steel is planned for the top of the tower to hold solar panels in the future to help meet the building's increasing electrical demands. The rooftop pool and entertainment area are both kept cool and protected by this crown.

S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
1	Building envelope	Suitability of the materials to the climate					●	
		Use of external insulation				●		
		Use of smooth surface finishes					●	

		Use of light colours					●	
2	Natural lighting	Wall to window ratio (40%)					●	Interior spaces were l through windows, howev this appears inadequate d
		Use of spectrally selected glass					●	
3	Natural ventilation	Use of openable windows			●			The use of openabl casement windows, b
4	Site and external spaces	Use of interwoven landscape			●			soft landscaping.
		Use of impervious surfaces			●			
5	Building form	Large building surface area					●	Appropriate building form based on climate
6	Building orientation	Sun orientation; E-W					●	The optimum orientation is NW-SE
		Wind orientation; SW-					●	
7	Wall/Window shading	Use of horizontal and					●	
		Use of interior blinds					●	
		Use of recessed walls					●	
		Use of overhangs					●	
		Use of plants					●	
8	Existing energy	Use of PV cells			●			
		Use of natural gas				●		

3.5.5 Bank of America Tower, Newyork

One Bryant Park, formerly known as the Bank of America Building, is widely recognised as one of the world's greenest and most resource-conserving structures. This Bank of America headquarters, situated at the northwest corner of Bryant

Park, is a "green" structure that houses both public services and the safe and sound transaction of banking business. With its groundbreaking approach to water and energy conservation, material efficiency, and interior environment quality, One Bryant Park marks a paradigm shift in the way we think about contemporary building design. When completed, it will be the first office building of its kind to ever get LEED Platinum certification worldwide.

3.5.5.1 Site Planning and Landscaping

In total, the building's 14,500 square feet of office space and 350 parking spots make it quite a sight. Reduced energy use by 30–40 percent, a café and coffee shop, plaza, and adaptable floor plate sizes ranging from 450–2,000 square metres are just some of the sustainable features. The expansive floor plans are built to globally recognised Grade 'A' standards, making them highly adaptable to the needs of today's tenants. A new benchmark for Nigerian architecture, thanks to its distinctive design, premium location, and industry-leading specifications. Heritage Place is aiming to become a byword for cutting-edge, eco-friendly enterprise.

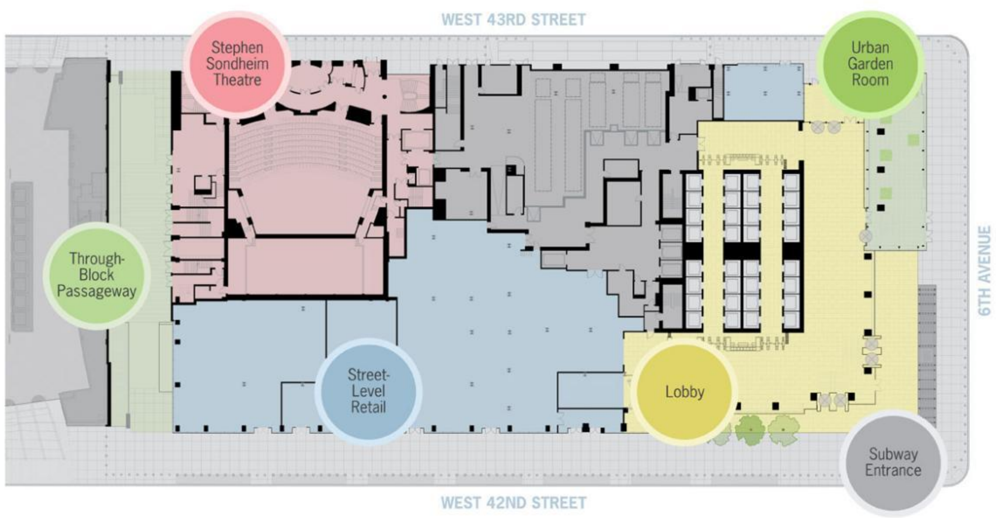
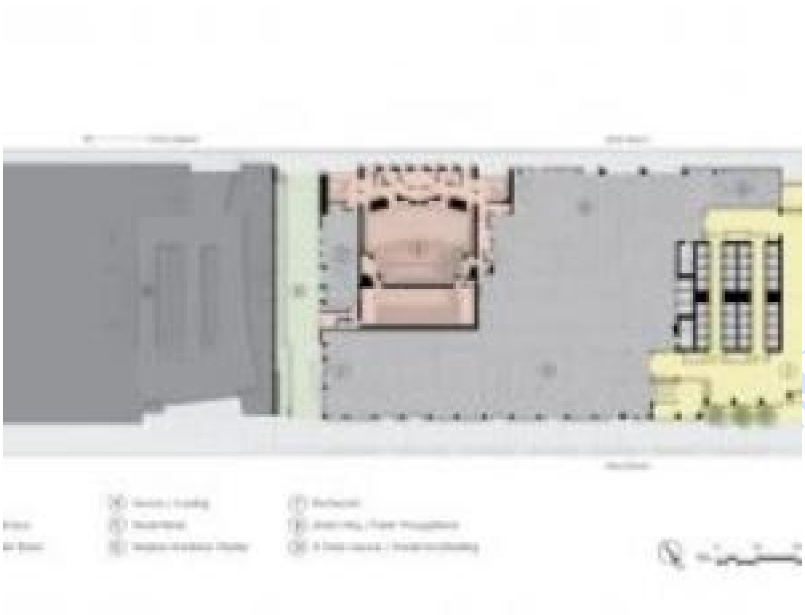


Plate III: Car Park Floor Plan




3.5.5.2 Building Envelope and Material Types

The tower uses environmentally friendly building materials, 87% is constructed with recycled material, even concrete is prepared with 45% recycled content, in this case, blast furnace slag. The building is wrapped with floor-to-ceiling windows that optimize natural lighting. The tower has its own rainwater collection system in addition to the wastewater recycling mechanism.

The skyscraper of glass, steel and aluminum is partly inspired by the particular site of its immediate location and its wider urban context. For its construction, 25,000tn of structural steel manufactured by eight companies and a careful design of columns were necessary.

The skyscraper employs ecologically friendly construction materials, 87 percent is created with recycled material, even concrete is produced with 45 percent recycled content, in this instance, blast furnace slag. The building is covered with floor-to-ceiling windows that maximise natural illumination. In addition to a

wastewater recycling mechanism, the tower also has its own rainwater collection system.

The glass, steel, and aluminium skyscraper takes some design cues from its immediate surroundings and the larger urban setting. 25,000 tonnes of structural steel produced by eight different companies and a well-thought-out column layout were required for its construction.

3.5.5.3 Building Orientation and Form

The tower's emphasis shifts as it climbs above the straight lines of the street, resulting in a more vertically proportioned building with more glass facing the sun. The building has an area of 195.096m2 allocated to offices in a

contemporary style.

The four corners of the building begin to lean inward, toward the core, at shallow angles of around seven degrees, somewhere about Floor 18 and continue all the way up to the top of the curtain wall (on average). The volume is made to seem lighter and more dynamic since each sloping corner starts on a different level, and each sloping surface is skewed at a different angle, roughly 20 degrees. This addition not only expands the viewing axis from inside, which are generally constrained by the standard New York block grid, but also increases natural daylight and air quality in the street area below. The structure resembles a massive quartz crystal because to its clear colour and sloping, irregular facades.

Angled vistas around and through the Midtown skyscraper jungle are made possible by the resultant facets. The building's southeast face faces Bryant Park and has a deep double wall that extends the entire height of the structure in that direction. The sun and moon's rays play over the tower's faceted glass architecture, creating dynamic sculptures of sharp folds and precise vertical lines.

S/N	Variables	Checklist	Level of application					Remark
			1	2	3	4	5	
1	Building envelope	Suitability of the materials to the climate					●	
		Use of external insulation				●		
		Use of smooth surface finishes					●	
		Use of light colours					●	
2	Natural lighting	Wall to window ratio (40%)					●	
		Use of spectrally selected glass					●	
3	Natural ventilation	Use of openable windows			●			
4	Site and external spaces	Use of interwoven landscape			●			No soft landscaping.
		Use of impervious surfaces			●			
5	Building form	Large building surface area					●	Appropriate building forn based on climate
6	Building orientation	Sun orientation; E-W					●	The optimum orientation is NW-SE
		Wind orientation; SW-					●	
7	Wall/Window shading	Use of horizontal and				●		
		Use of interior blinds				●		
		Use of recessed walls				●		
		Use of overhangs				●		

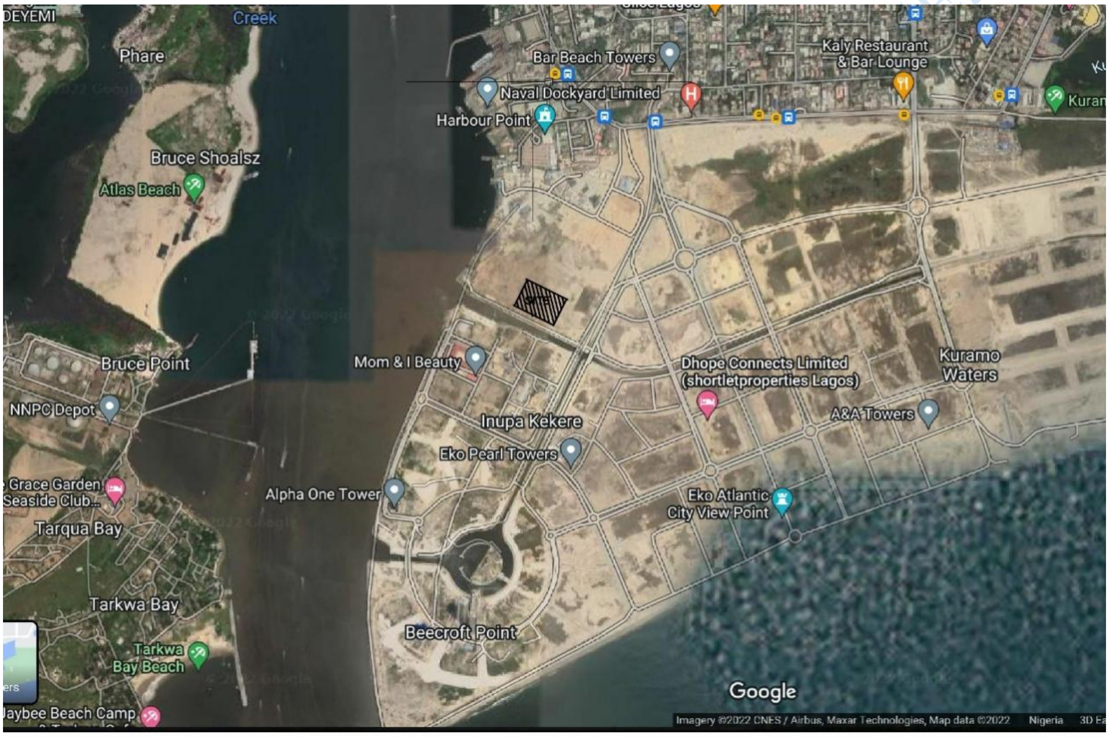
		Use of plants				●	
8	Existing energy	Use of PV cells				●	
		Use of natural gas				●	

Chapter Four
Site Analysis and Design Synthesis

4.1. Study Area

4.1.1. Site Location

The site is located in Eko Atlantic City, Eko Blvd, Victoria Island, Lagos States. The site is very close to Eko Pearl Towers and like 4min drive from the Eko hotel.



4.1.2 Site Selection Criteria

Site selection for this project is very important, has it greatly affects the functional use of the facility, for the effective site selection, certain criteria were considered in selecting the site;

I. Land use: In Lagos State there is strict compliance with the land use as been designed in the city's master plan.

II. Accessibility: The land should be accessible easily by most intended user of the facility through vehicle,water way and pedestrian.

III. Services: The site should have some existing services like water reticulation, and electricity.

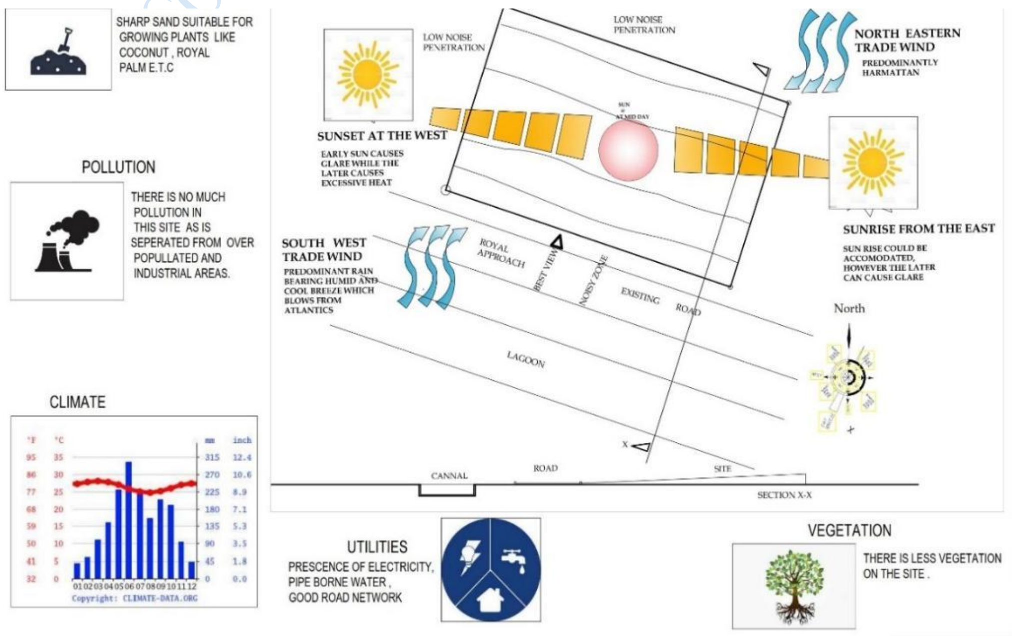
IV. Proximity to residential Area.

V. Topography: The topography of the site is expected to have a relatively gentle slope so as to enhance the outdoor activities and to reduce cost of constructing the outdoor pitches.

VI. Expansion Possibilities: The site should be easy to accommodate more outdoor activities as need of the user increases

4.1.3 Site Analysis

The site has some physical characteristics that needed to be documented for the purpose of proper and effective design and to be able to maximize the full potentials of the site.



Site Accessibility

The site has easy and convenient access for both vehicular Water Way and pedestrian. The site is accessable from the major road that runs through Lagos.

Nearness to Public Utilities

There are basic infrastructures in place e.g., Good Roads, Electricity, Water, Telecommunications, Security etc.

Drainage and Topography

The site has a gentle slope spread evenly throughout. Drainages are also in place for water collection.

Vegetation

Lagos is located within the tropics, hence it enjoys two distinct season which are the cold and dry seasons. This enables a wide range of vegetation ranging from thick undergrowth, short grasses to evergreen trees in the site's immediate vicinity. Soil is sandy, and it is low bearing capacity.

Soil Condition

It has a Loose Sandy soil with good sub-surface condition for construction and landscaping. It gives satisfactory geological and soil condition with no rock crops.

Wind Direction

The north-east trade wind brings cold, dust, harmattan and these cause discomfort. The south west trade wind brings cold humidity which gives comforting effect to the people. Proper ventilation is considered as part of the building effective arrangement. The building´s long sides (east and west) elevations are positioned such that they receive the maximum amount of air. The shorter sides of the proposed mall face the direction of the north-east trade wind

4.2 Project Analysis and Design Synthesis

4.2.1 Brief Analysis

There is High demand for office spaces in Lagos State due to the high population and Administrative. Also there is high need for energy efficient spaces that could reduce cost of running an office. Urban prime ltd an estate developer is proposing to build a lettable office complex to meet peoples demand. The facility is to be built and each office spaces are for sale for interested companies.

4.2.2. Brief Development

Some spaces were found to be common to all the five case studies examined in this study. These spaces were studied critically to determine the standard required, the number of units per people, their capacity and exact function they perform in an Office design. These spaces are;

- Indoor parking
- Outdoor parking
- Convenience
- Reception
- Waiting Area
- Mechanical Room
- Electrical Room
- Circulation Area
- Restaurant
- Offices
- Outdoor Sitting Area

- Service circulation
- Security post
- Maintenance, electrical and IT department

4.2.3. Design Consideration

4.2.3.1 Site planning and landscaping

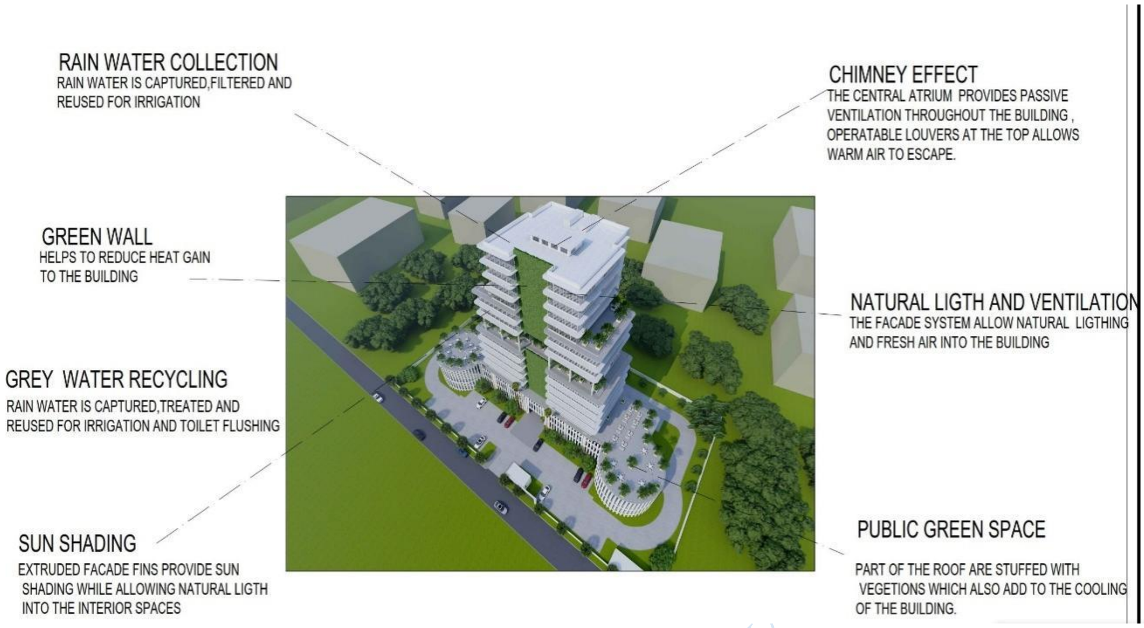
The site planning was carefully planned to accommodate the outdoor activities in relation to the indoor facilities for easier use of both facilities simultaneously, vehicular movement and pedestrian movement were clearly separated . Longer Side of the building was positioned to Face North -South Direction to minimize solar gain into the Building. Enough greens are also introduced to cool and also provide fresh air For the Office Complex.

4.2.3.2 Spatial Organization

Most of the spaces were allocated based on standards for the offices and the anthropometry of the human being in relation to the activity within the spaces.

4.2.3.3 Energy Efficiency Strategies

Energy Efficiency strategies are used in the design of the office complex to a large extent.



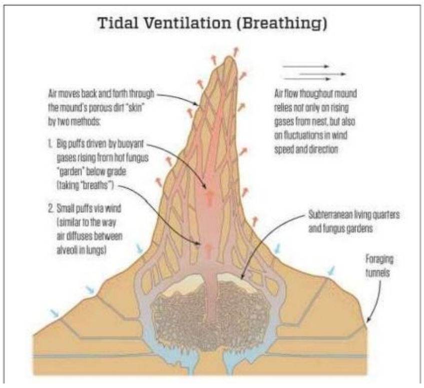
4.2.4 Conceptual Devlopment

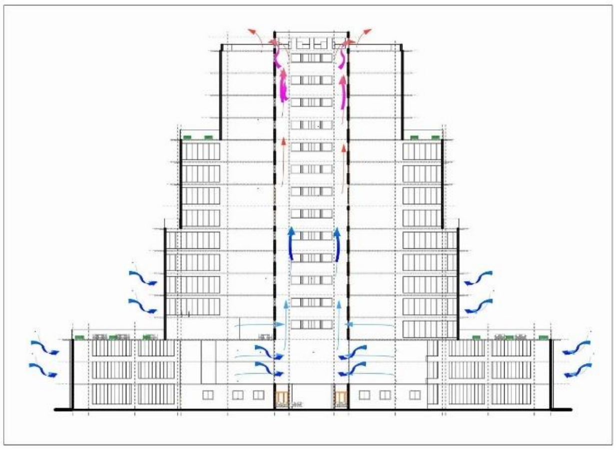
Design Concept is generated from a termite Mould. Termites mould are known for regulating internal temperature by natural means. The complex is designed using stack effect method to regulate internal temperature.

DESIGN CONCEPT

TERMITE MOULD

TERMITES MOUNDS ARE CONSTRUCTED LIKE CHIMNEY. THE CENTRAL CHIMNEY IS CONNECTED TO SERIES OF TUNNEL AND PASSAGES BELOW . COMFORTABLE INTERNAL TEMPERATURE IS MAINTAINED BY DIFFERENCE IN INLET AND OUTLET AIR PRESSURE. THE PROPOSED OFFICE COMPLEX WAS MODELLED USING THE SAME THECNICS TO REGULATE INTERNAL TEMPERATURE.





4.2.6 Space Allocation / Schedule of Accomodation

4.2.7 Construction Methods and materials

The method of construction to be adopted is the frame framing system for the civil work, most other component should be fabricated on site and placed in the right position. The steel work will be prefabricated and placed in position, while the aluminium works will be done by tower aluminium Nigeria and brought to site completed with proper specification. Due to the nature of the site soil, pile Foundation ith deep pile columns will be used to support the building. All wiring and piping should be by conduit and the water supply pipes should be ppr pipes with less joints and thus reducing leakages.

The external work will be properly completed, with trees planted and well-guarded for it to nurture, walk ways will be put in place with concrete paving stone.

The material for construction will be predominantly concrete, steel and glass will be used in some areas.

. Reinforced Concrete

The high structural strength of concrete (especially when reinforced with steel) makes it the perfect' material for the structural. The fluidity of reinforced concrete makes it a good construction material for curved, slanted walls.

Steel

Steel offers many advantages, primarily high strength and ductility. It is also durable if protected from corrosion. Relatively, the higher yield stress of steel all ows for smaller sections and its lower weight reduces foundation requirement.

4.2.8 Building Services

4.2.8.1 Water supply

The site has access to water supply from Eko Atlantic water Board, however t here will be provision for ground water tank and overhead water tank for the purpose of storage. Duct are located close to the wet areas of the building. The ducts are wide enough to be accessible from the back for easy maintenance.

4.2.8.2 Power supply

Power shall be tapped from the Power Holding Company of Nigeria (PHCN)'s national grid. However, the design shall also cater for its own power needs. There is provision for building integrated photovoltaic panel for alternative power source. Transformer will also be installed on the site because of the amount of power needed by the facility.

4.2.8.3 Refuse disposal

The building has a shoot for refuse disposal from each floor, this is an enclosed place were the refuse will be thrown form each floor and collected on the ground floor to avoid littering of all the space. From here it's going to be taking to site waste disposal prior to when the disposal agency will come for the final disposal

4.2.8.4 Waste water and sewage disposal

Waste water from water closets should be drain through the central sewer line to the sewage treatment plant for treatment and subsequently disposed environmental board

4.2.8.5 Fire fighting system

Fire hydrants for easy water collection by fire fighters, fire extinguisher should be strategically located on the corridors, smoke detectors water sprinklers should be provided in each space and corridors,

Chapter 5
Conclusion and recommendation

project appraisal

The research work is built on the subject of energy efficiency in office Building, the problem definition being that architectural design elements can offer a better methodology towards achieving Energy efficiency within the Building. The argument draws its background to the study of Office Complex within and outside Nigeria .

Review of relevant literature on the issue of Energy efficiency in having a conceptual framework in which architectural design elements can be applicable. Certain key Strategies such as Site planning and landscaping , Building envelope and material types, Building Orientation, Form and ventilation among others were highlighted and discussed in the research to achieve Energy efficient office complex. Case studies were analysed using specific variables directly related to the subject of the research as well as the use of structured questionnaire to user and maintenance staffs to aid in acquiring more information about the Study. Findings from the literature review, questionnaire as well as the five areas studied were thus used in generating a design and planning concepts for the proposed Office complex.

Conclusion

The problems associated with Energy efficiency in office Buildings has overtime not been addressed properly, thus architects and designers are beckon to address the issue from the design stage, as this will make the facility to consume less energy. This is first done by applying Energy efficiency strategies During design and Construction, there is possibility of achieving about 70% lesser drop in energy consumption within the facility

Recommendation

From the Study conducted, the major findings suggests that with a comprehensive Energy analysis by the architects and subsequent problem solving approach from the drawing board will provide a better recourse to address the issue of Energy efficiency and how these problems can be avoided in the future. Therefore the following recommendations should be applied;

i. The Architects and designers should be enlightened on the complexity of Buildings and sensitivity to Energy consumption.
ii. Adequate Natural Ventilation and lighting should be employed to enhance energy efficiency.
iii. The Architects and other Building professionals should be mandated to apply Energy efficiency strategies During design and Construction

References

A'zami, A. (2005). Badgir in traditional Iranian architecture. *Proceedings of international on passive and low energy cooling for the built environment,.* Santorini, Greece.

Akhimien, N. G., Isiwele, A. J., & and Adamolekun, M. (January 2018). The imperatives of Energy efficient buildings to the built environment. *International Journal of Engineering and Technology*, 109.

Arınç, U., & Enerji , V. (2013,). *Principles of Settlement and Design of Energy Efficient Buildings.* Ankara,.

Berköz, E., Küçükdoğu, M., Yılmaz, & Enerji , E. (1995). *Energy Efficient Housing and Settlement Design* . İstanbul; : TÜBİTAK, INTAG 201,.

Brown, G. (2010). *Architecture Industry; A hidden Culprit in Global Warming.* Retrieved from http://architecturalevangelist.com/green-architecture/the-architecture-industry-a-hidden-culprit-to-global-warming.html

Chen SY, Chu CY, Cheng MJ, & Lin CY. . (2009). The autonomous house: a bio-hydrogen based energy self-sufficient approach. . *Int J Environ Res Public Health* , 6(4):1515–29.

Constantin, I., Tudor , B., Gabriela-Elena, V., Horia, N., & Adrian, B. (2015). The historical evolution of the energy efficient buildings. *Renewable and Sustainable Energy Reviews*, 49 (2015) 243–253.

Davenport, C. (2018). *Major climate report describes a strong risk of crisis as early as 2040.* . The New York Times,.

Day, J. K., & Gunderson, D. E. (2015). Understanding high performance buildings: The link between occupant knowledge of passive design systems, corresponding behaviours, occupant comfort and environmental satisfaction. *Building and Environment,*, 84, 114-124. .

El-Darwish, I., & Gomaa, M. (2017). Retrofitting strategy for building envelopes to achieve energy efficiency. . *Alexandria Engineering Journal,*, 56(4), 579-589.

Emokpae, E., Isidore, C. E., Eziyi , I., & Anthony , B. S. (March 2021). Energy Efficiency Design Strategies in Office Buildings: A Literature Review. *IOP Conference Series Earth and Environmental Science* , DOI: 10.1088/1755-1315/665/1/012025.

Furr JE, Kibert NC, Mayer JT, & Sentman SD. (2009.). *Green building and sustainable development: the practical legal guide.* Chicago: ABA Publishing.

Geissler, S., Österreicher, D., & Macharm, E. (2018). Transition towards energy efficiency:Developing the Nigerian building energy efficiency code. In *Sustainability,* (pp. 10(8), 2620).

Gosztonyi, S., Brychta, M., & Gruber, P. (2010). Challenging the engineering view:comparative analysis of technological and biological functions targeting energy efficient facade systems. In *WIT Transactions on Ecology and the Environment* (pp. 138, 491-502.).

Hahne, E. (2000). The ITW solar heating system: an oldtimer fully in action. . In *Sol Energy* (pp. 69(6):469–93.).

Hong, T., Taylor-Lange, S. C., D'Oca , S., & Yan, D. (2016). Advances in research and applications of energy-related occupant behavior in buildings. *Energy and buildings*, 116, 694-702.

Hor , K., & Rahmat , M. K. (2018). Analysis and recommendations for building energy efficiency financing in Malaysia. In *Energy Efficiency* (pp. 11(1), 79-95.).

Izzet , Y., & Tülay , T. K. (01 July 2019). Energy-Efficient Building Design in the Context of Building Life Cycle. *Energy Efficient Buildings*, Chapter 5.

Klingenberg, K. (2008). Passive house concept. In *history and economic opportunities for the US building sector.* . The Passive House Institute US (PHIUS).

Lechner, N. (1991). *Heating, Cooling, Lighting Design Methods for Architects, Canada.* John Wiley Sons .

Levine, M., Ürge-Vorsatz, K., Blok, L., Geng, D., Harvey, S., Lang, G., . . . Yoshino . (2007). *Residential and commercial buildings. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment.* Cambridge University Press.

Mu'azu, A. I. (September 2012). Scenario of Energy Consumption of Office . *International Journal of Science and Advanced Technology (ISSN 2221-8386)*, Volume 2 No 9 .

Nwofe, P. A. (2014). Need for energy efficient buildings in Nigeria. *International Journal of Energy and Environmental Research,*, 2(3), 1-9.Occupational Safety and 174, 672-681.

Olgyay , V. (1969). *Design with Climate Bioclimatic Approach to Architectural Regionalism,* . Princeton, New Jersey:: Princeton University Press.

Özdemir, B., & Sürdürülebilir , Ç. O. (2005). *Energy efficient building design as passive systems for a sustainable environment.* stanbul: Istanbul Technical University, Graduate School of Engineering and Sciences.

Perez-Lombard, L. J. (2008). A review on buildings energy consumption information. Energy and Buildings.

Raji, B., Tenpierik, M., & van den Dobbelsteen, A. (2017). Early-stage design considerations for the energy-efficiency of high-rise office buildings. In *Sustainability* (pp. 9(4), 623.).

Sector. (2010, December 18). *Total Energy Consumption in US*. Retrieved from Architecture 2030.: http://architecture2030.org/the_problem/buildings_problem_why

Soysal, S., & Konut , B. T. (2008). *Relation Between Design Parameters and Energy Consumption in Housing Buildings.* Ankara: Gazi University.

Spenser , R., Robert , S., Eunkyu , L., & Andrew , K. (July 2016). Demand for Green Buildings: Office Tenants' Stated Willingness-to-Pay for Green Features. *Journal of Real Estate Research*.

Spitler, J. (2006). Building performance simulation: the now and the not yet. . In *HVAC Res* (pp. 12(3a):549–51.).

UNEP. (2022). *Sustainable Buildings*. Retrieved from UN EVIRONMENT PROGRAMME UNEP: https://www.unep.org/explore-topics/resource-efficiency/what-we-do/cities/sustainable-buildings

Vale, B., & Vale , R. (1975). *The autonomous house: design and planning for self sufficiency.* London: T;: hames and Hudson.

Vale, B., & Vale , R. (1997). Ecological Architecture: The Cutting Edge? . *In: Proceedings of Solar 97 – Australian and New Zealand Solar Energy Society, Canberra, Australia;* , p. paper 72.

Yılmaz, a., & Akıllı , B. (2005). *Smart Buildings and Renewable Energy.* 23–26 Kasım 2005, İzmir, pp. 1–8.: 7. Ulusal Tesisat Mühendisliği Konferansı.

Yüksek, I. (2008). *A Study on Ecological Assessment in Traditional Anatolian Architecture (A Case Study: Rural Area of Kırklareli Province).* Trakya University.

Yüksek, I., & Esin, T. (2013). Analysis of traditional rural houses in Turkey in terms of energy efficiency. *International Journal of Sustainable Energy*, 32(6):643–658.

Zeybek , Ö. (2009). *Energy Savings of Primary School Building in Turkey Through Energy Efficient Renovation Strategies in Building Envelope.* Istanbul: İstanbul: Technical University, Institute of Science and Technology;.

Appendixes

Appendix I Presentation Drawings

Appendix II Working Drawings

Appendix I Presentation Drawings

ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130

PROPOSED OFFICE COMPLEX, LAGOS STATE

DRAWING TITLE
3D VIEW

SCALE :

Sheet No.
D 01

ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130

PROPOSED OFFICE COMPLEX, LAGOS STATE

DRAWING TITLE
3D VIEW

SCALE :

Sheet No.
D 02

ARC 731 AKANJI TALIB OLUWADARE LCU/PG/002130	PROPOSED OFFICE COMPLEX, LAGOS STATE	DRAWING TITLE 3D VIEW	SCALE :	Sheet No. D 03

ARC 731 AKANJI TALIB OLUWADARE LCU/PG/002130	PROPOSED OFFICE COMPLEX, LAGOS STATE	DRAWING TITLE 3D VIEW	SCALE :	Sheet No. D 04

ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130

PROPOSED OFFICE COMPLEX, LAGOS STATE

DRAWING TITLE
3D VIEW

SCALE :

Sheet No.
D 08

ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130

PROPOSED OFFICE COMPLEX, LAGOS STATE

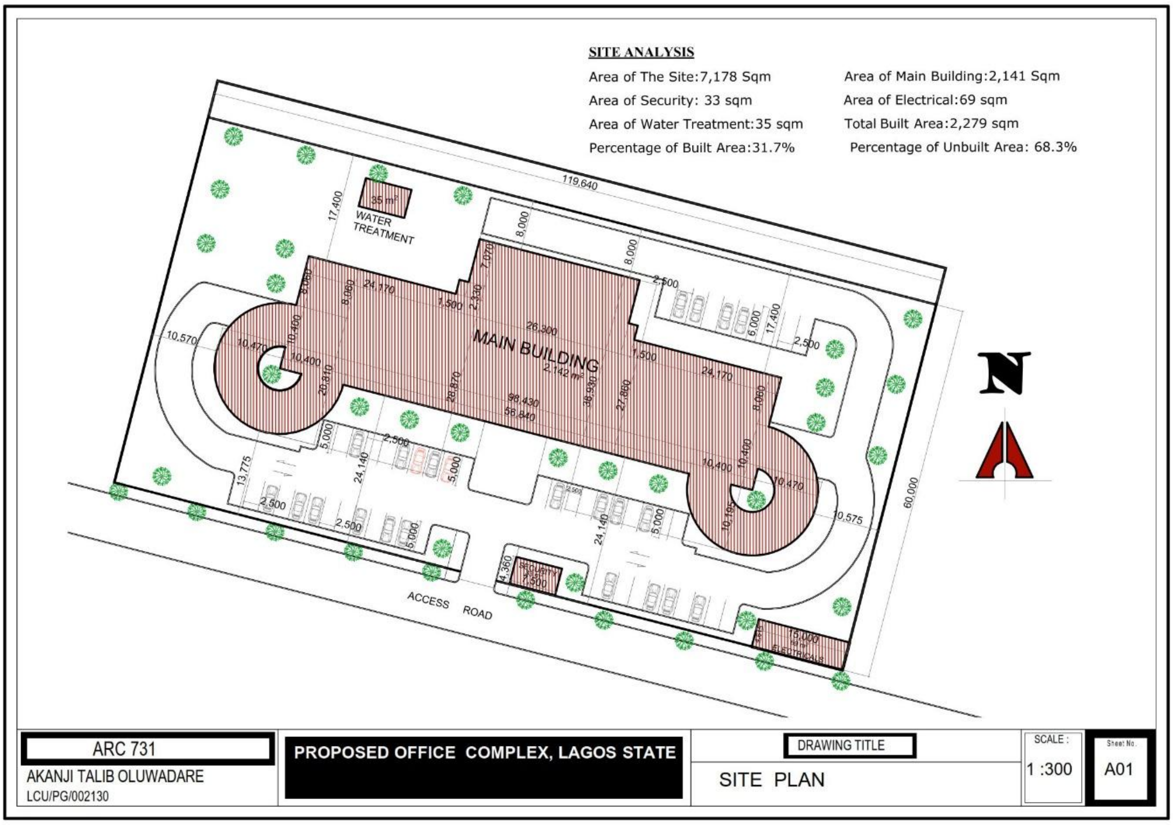
DRAWING TITLE
3D VIEW

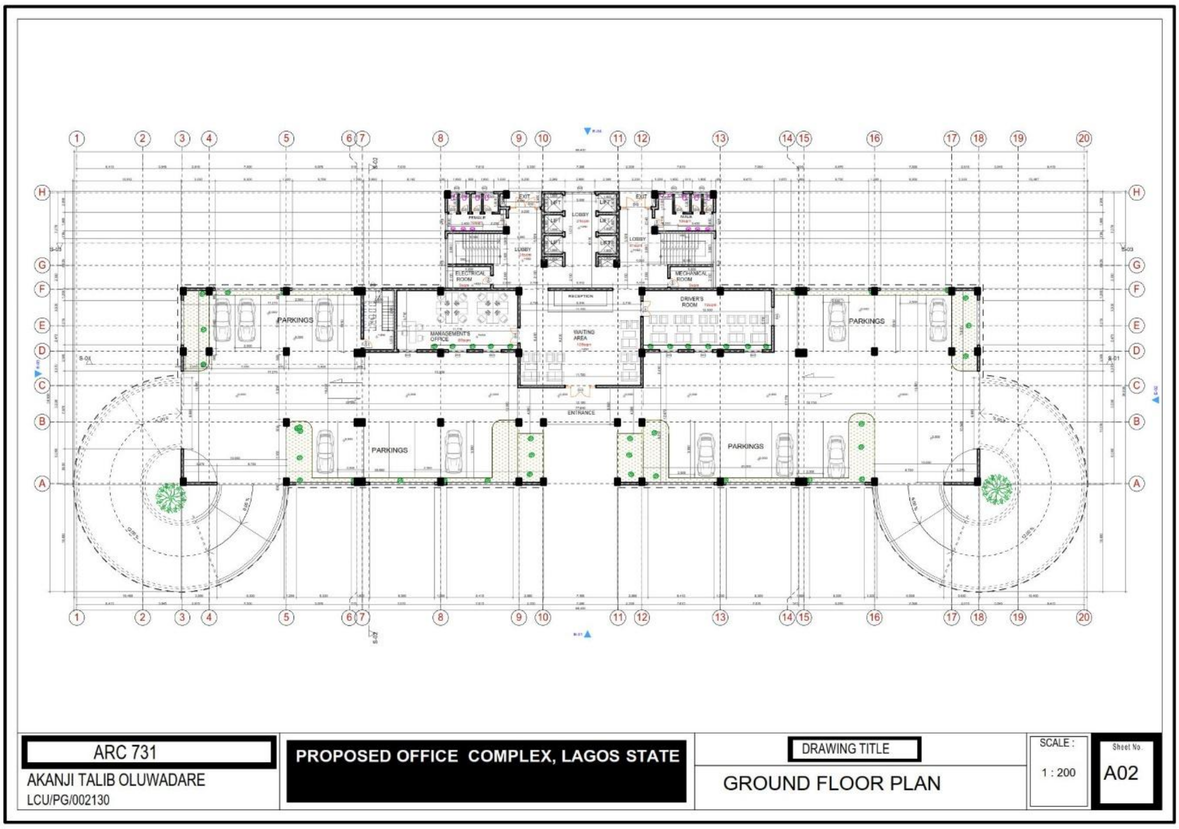
SCALE :

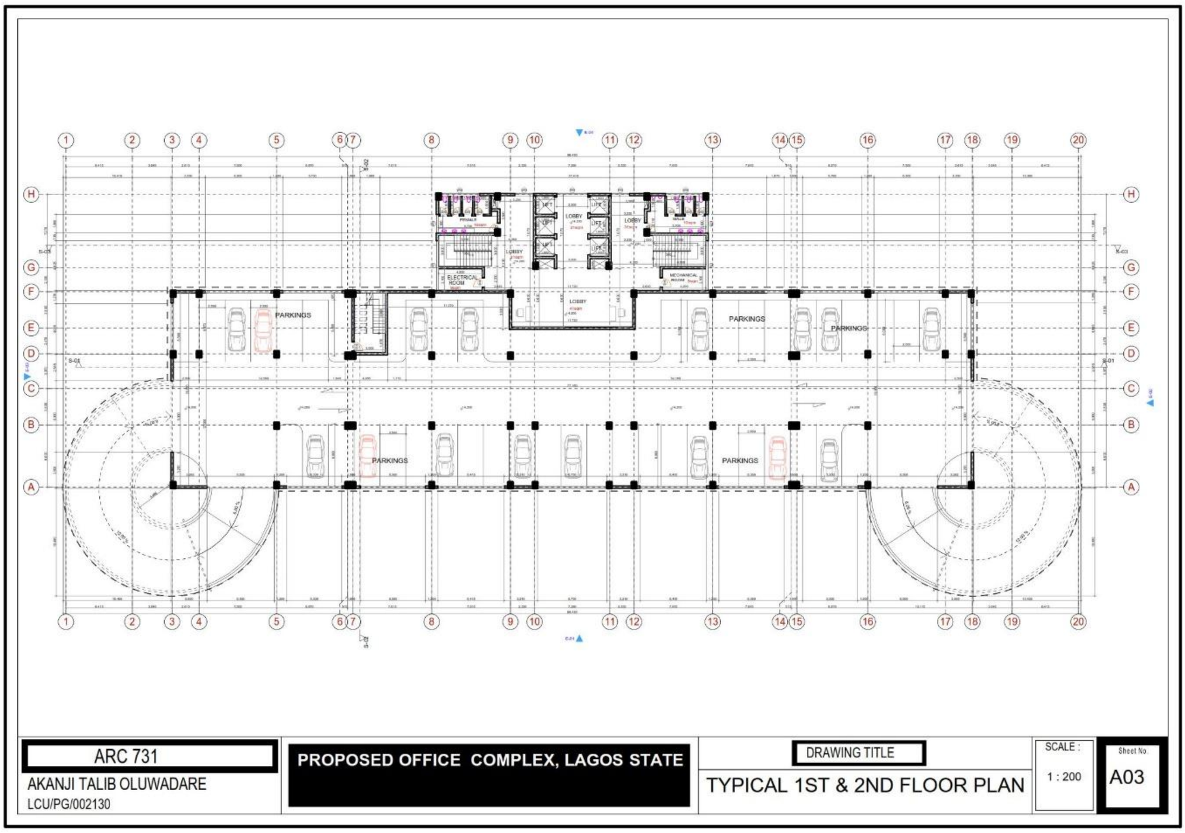
Sheet No.
D 09

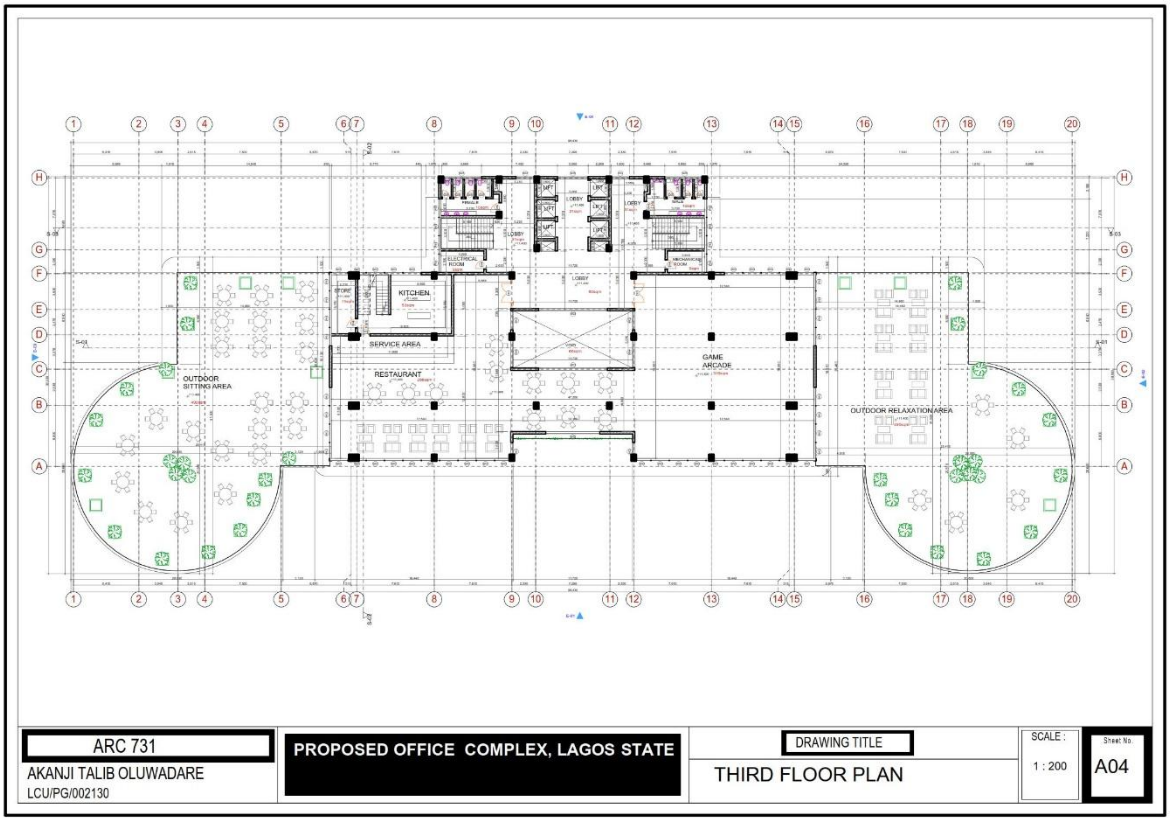
Appendix II Working

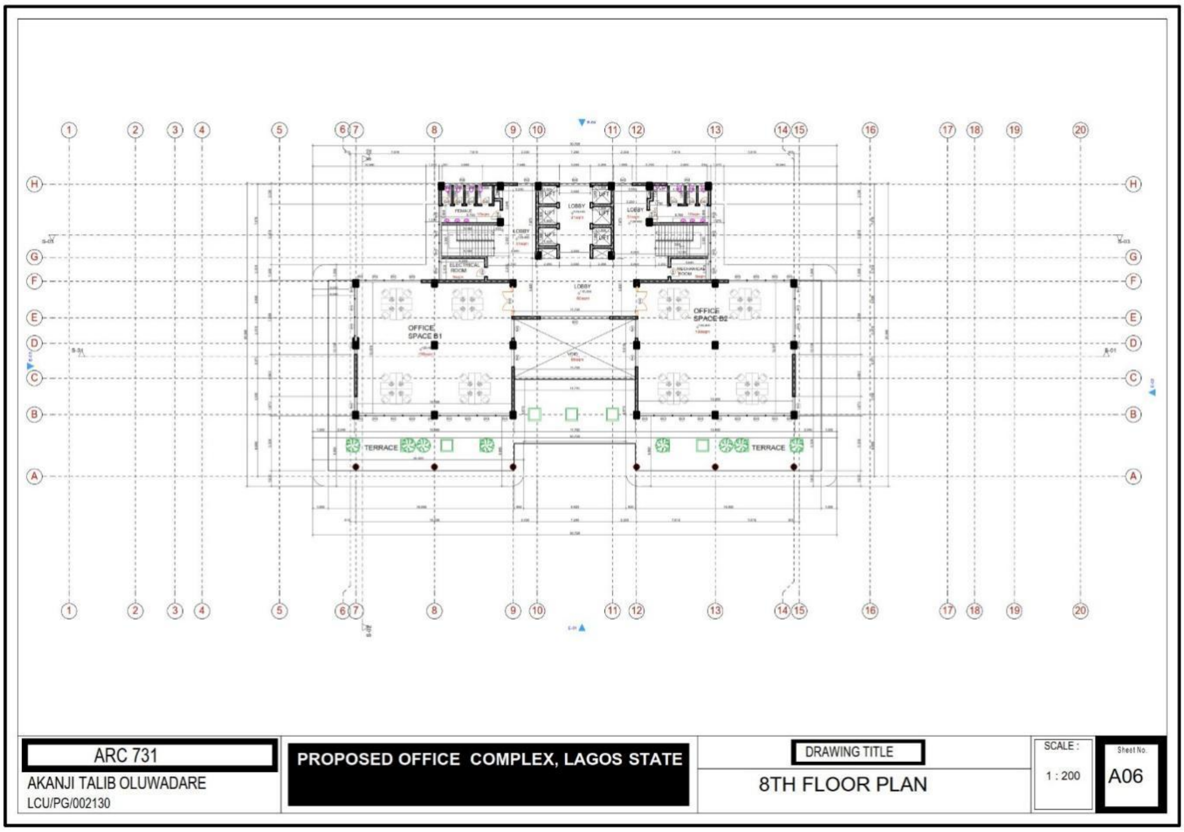
Drawings

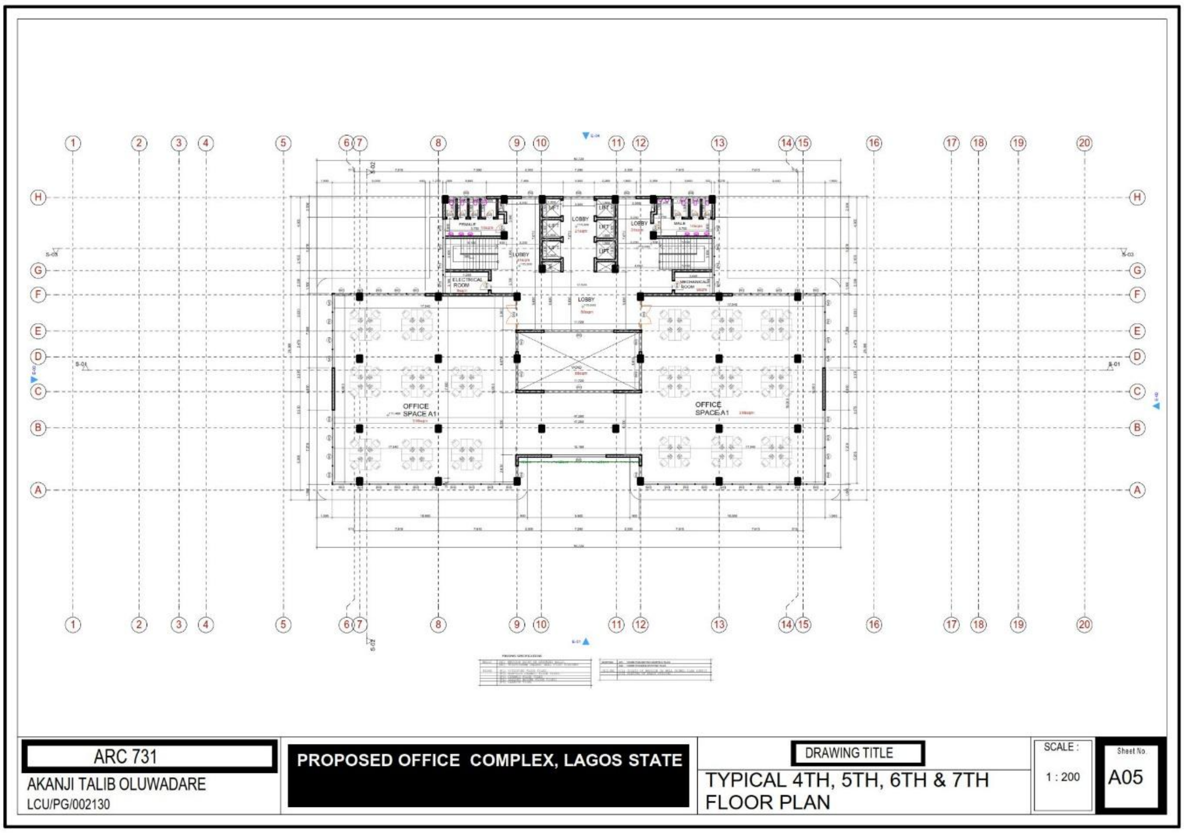


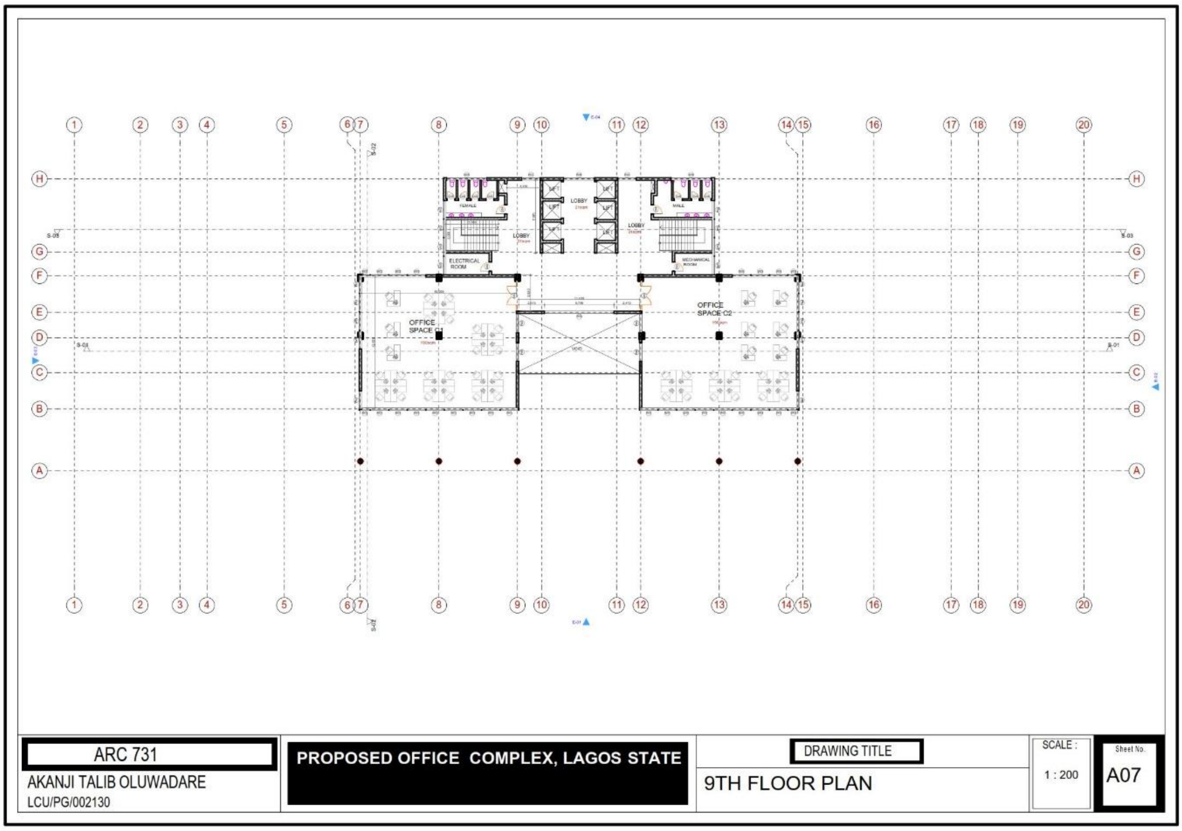

ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130
PROPOSED OFFICE COMPLEX, LAGOS STATE
DRAWING TITLE
GROUND FLOOR PLAN
SCALE :
1 : 200
Sheet No.
A02

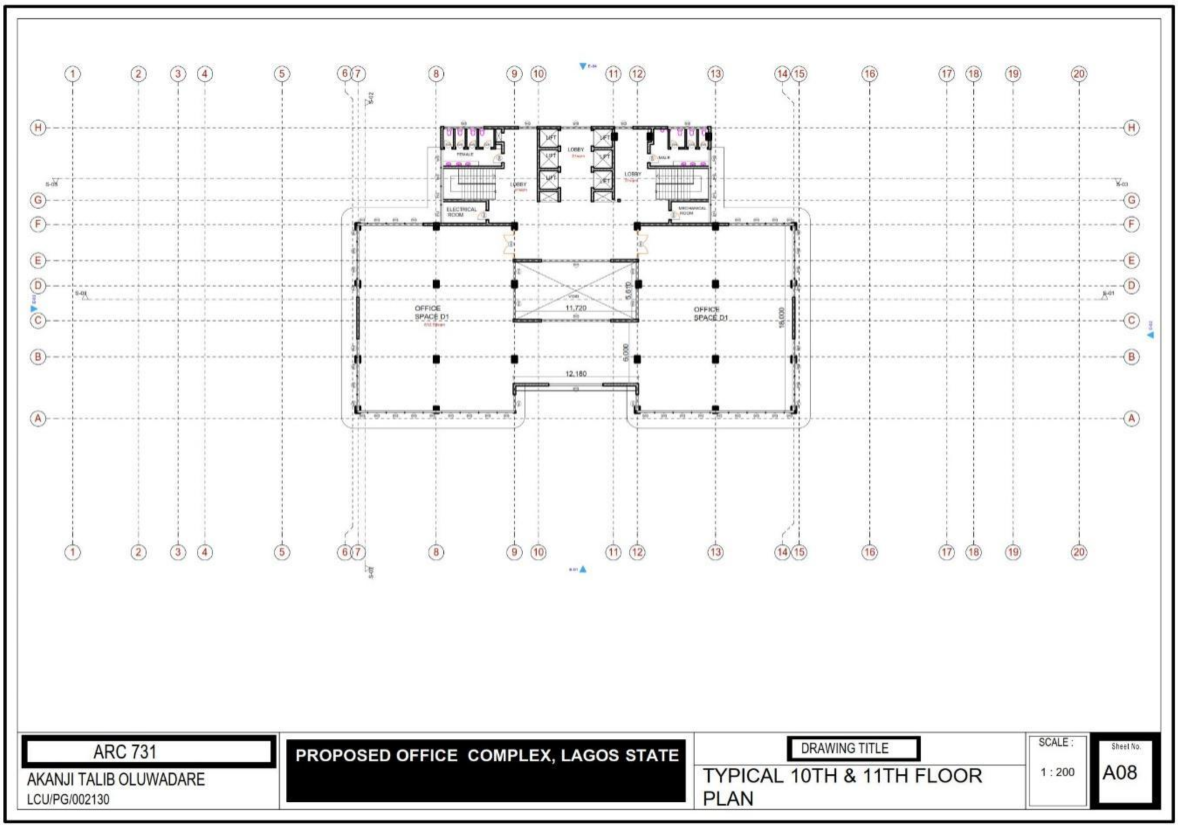

ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130
PROPOSED OFFICE COMPLEX, LAGOS STATE
DRAWING TITLE
TYPICAL 1ST & 2ND FLOOR PLAN
SCALE :
1 : 200
Sheet No.
A03

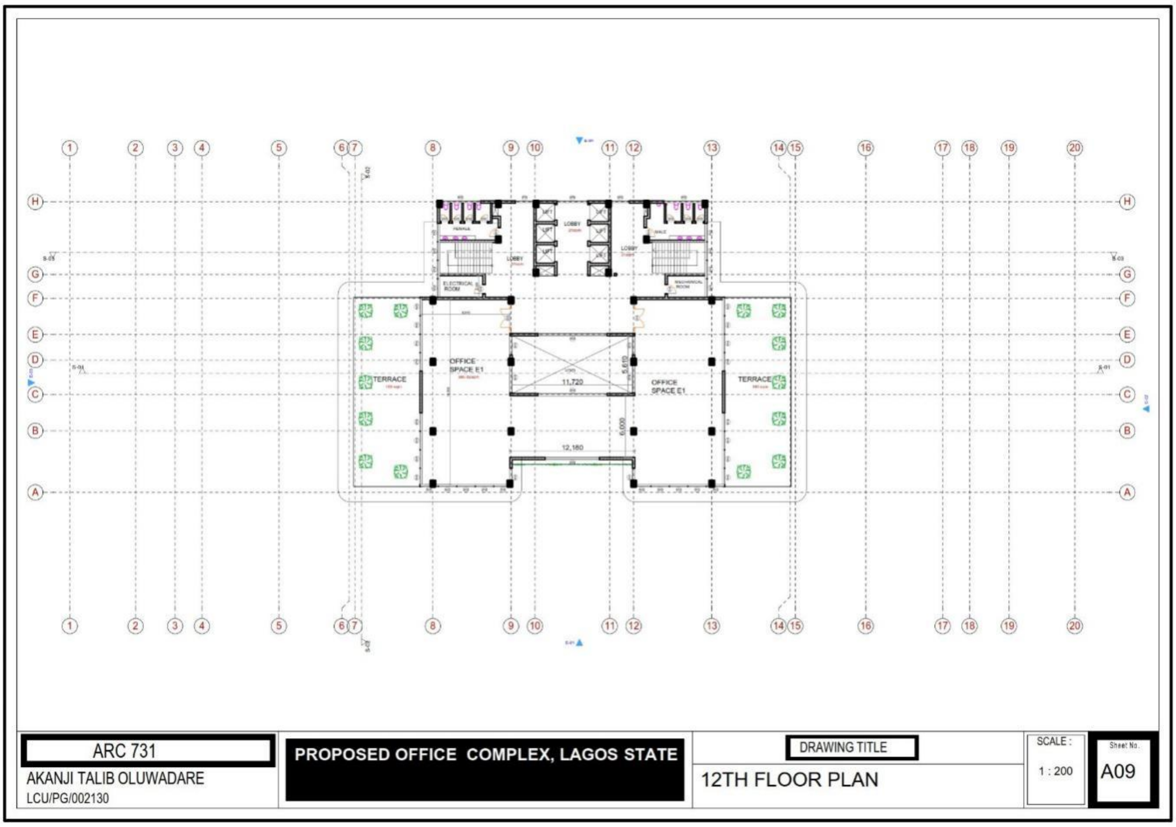

OUTDOOR SITTING AREA
KITCHEN
STORE
SERVICE AREA
RESTAURANT
LOBBY
GAME ARCADE
OUTDOOR RELAXATION AREA
ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130
PROPOSED OFFICE COMPLEX, LAGOS STATE
DRAWING TITLE
THIRD FLOOR PLAN
SCALE :
1 : 200
Sheet No.
A04

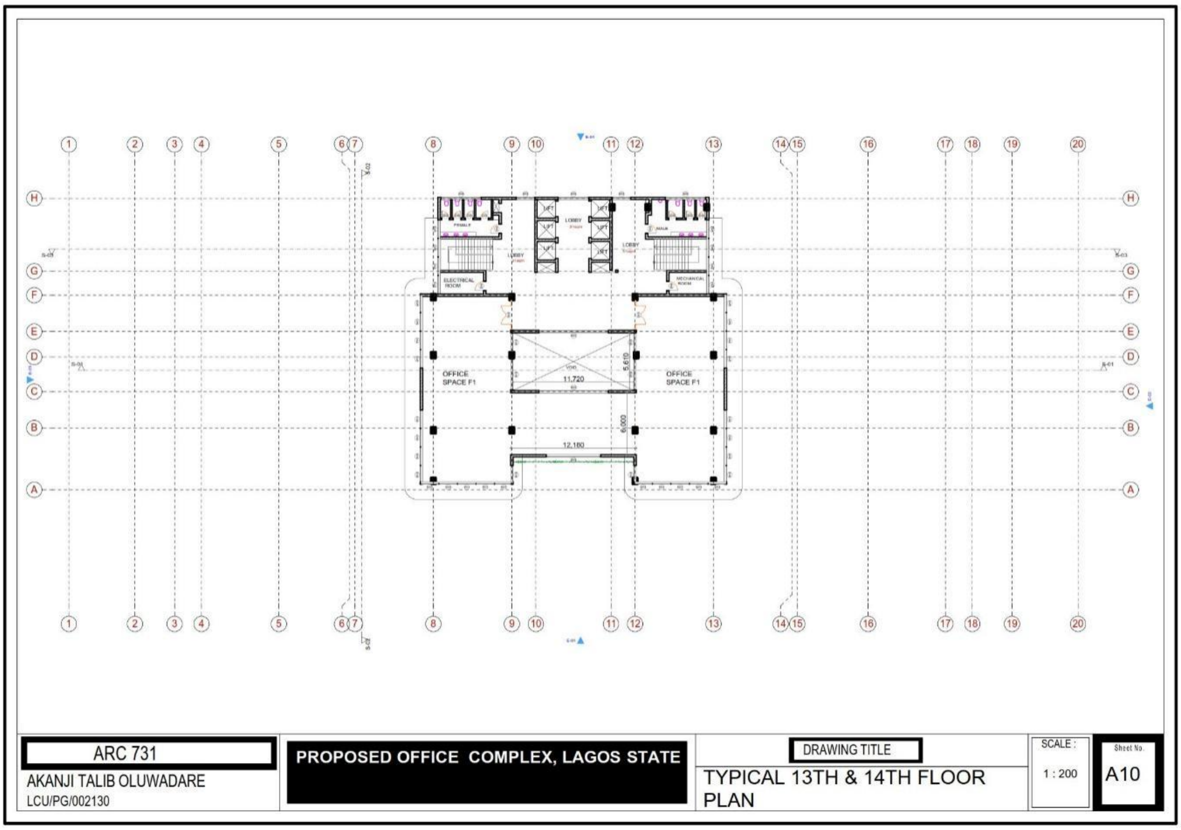

OFFICE SPACE B1
OFFICE SPACE B2
LOBBY
TERRACE
TERRACE
ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130
PROPOSED OFFICE COMPLEX, LAGOS STATE
DRAWING TITLE
8TH FLOOR PLAN
SCALE :
1 : 200
Sheet No.
A06

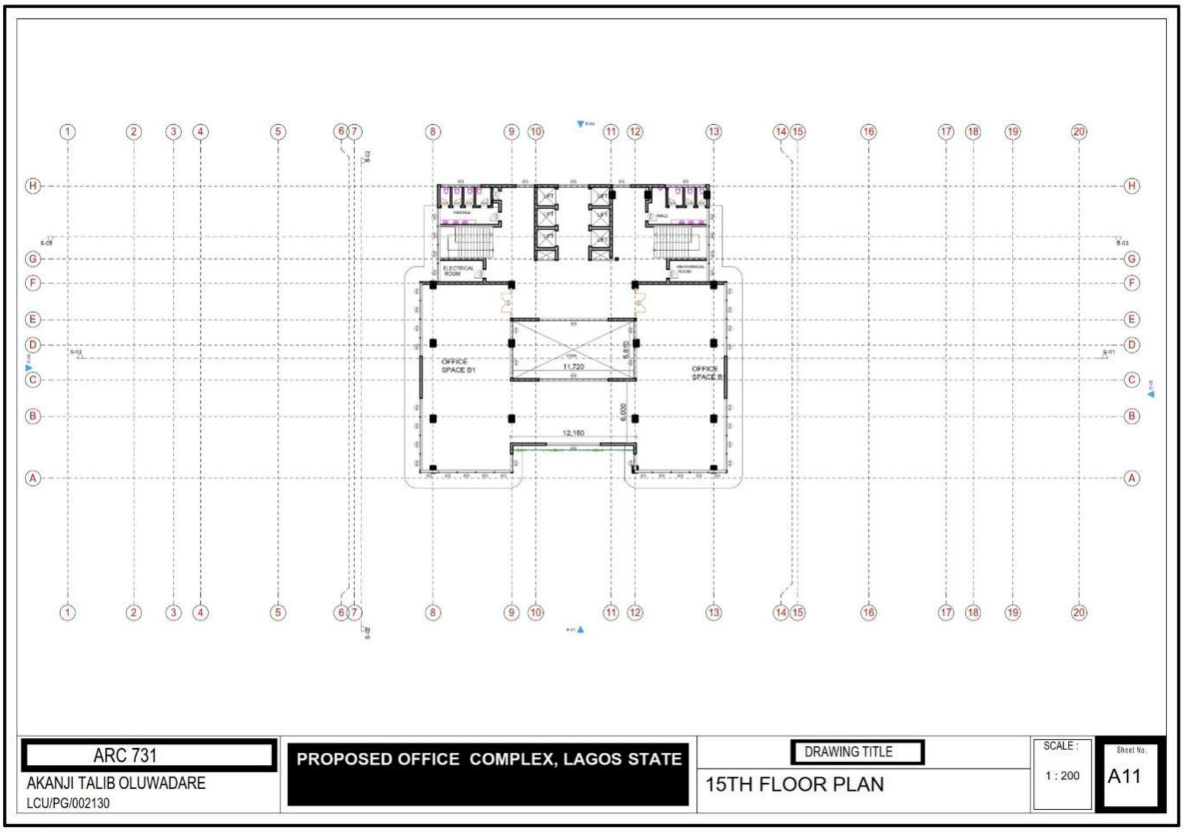

OFFICE SPACE A1
OFFICE SPACE A1
LOBBY
ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130
PROPOSED OFFICE COMPLEX, LAGOS STATE
DRAWING TITLE
TYPICAL 4TH, 5TH, 6TH & 7TH FLOOR PLAN
SCALE :
1 : 200
Sheet No.
A05

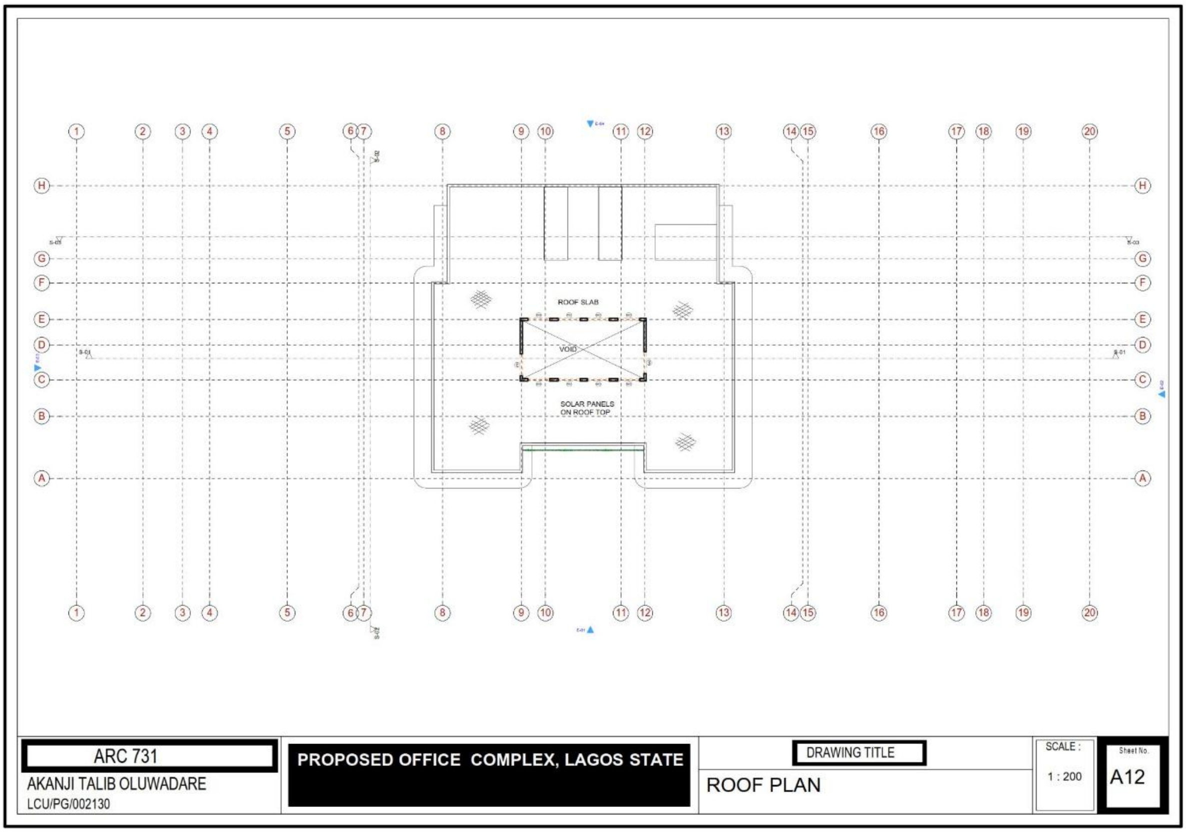

ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130
PROPOSED OFFICE COMPLEX, LAGOS STATE
DRAWING TITLE
9TH FLOOR PLAN
SCALE :
1 : 200
Sheet No.
A07

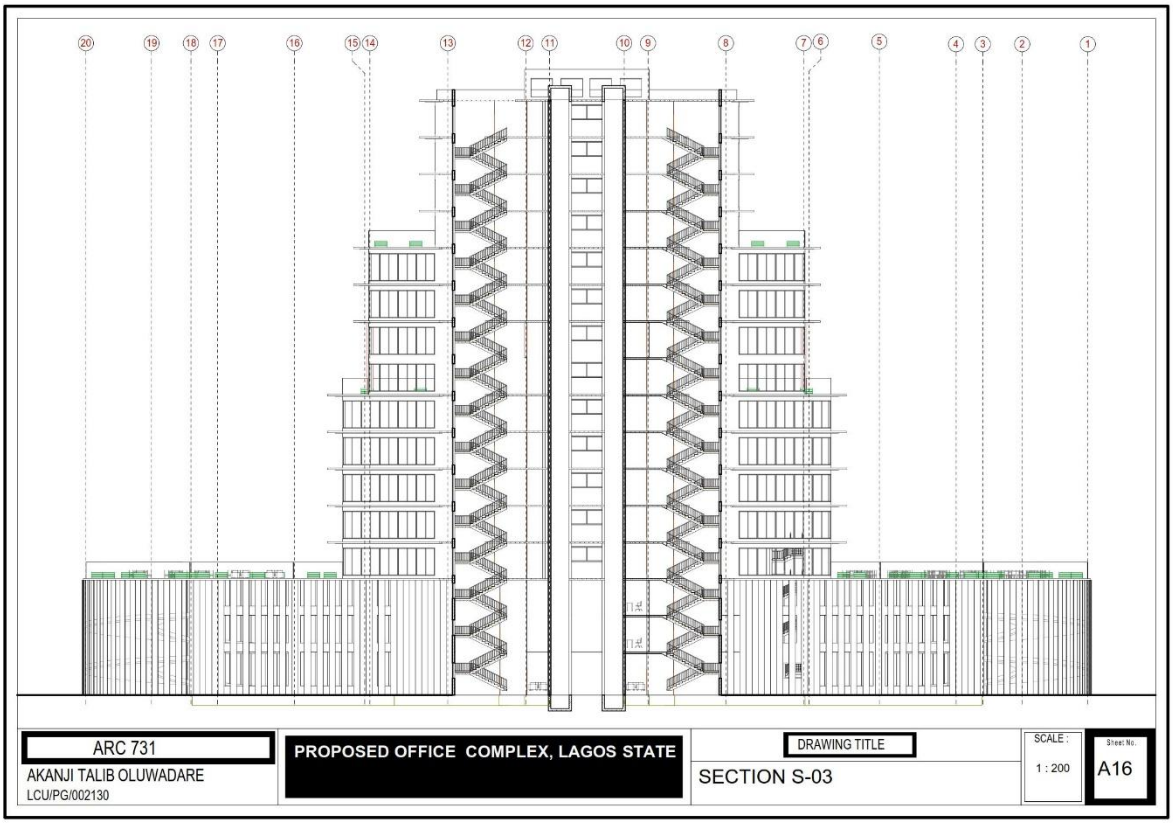

ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130
PROPOSED OFFICE COMPLEX, LAGOS STATE
DRAWING TITLE
TYPICAL 10TH & 11TH FLOOR PLAN
SCALE :
1 : 200
Sheet No.
A08

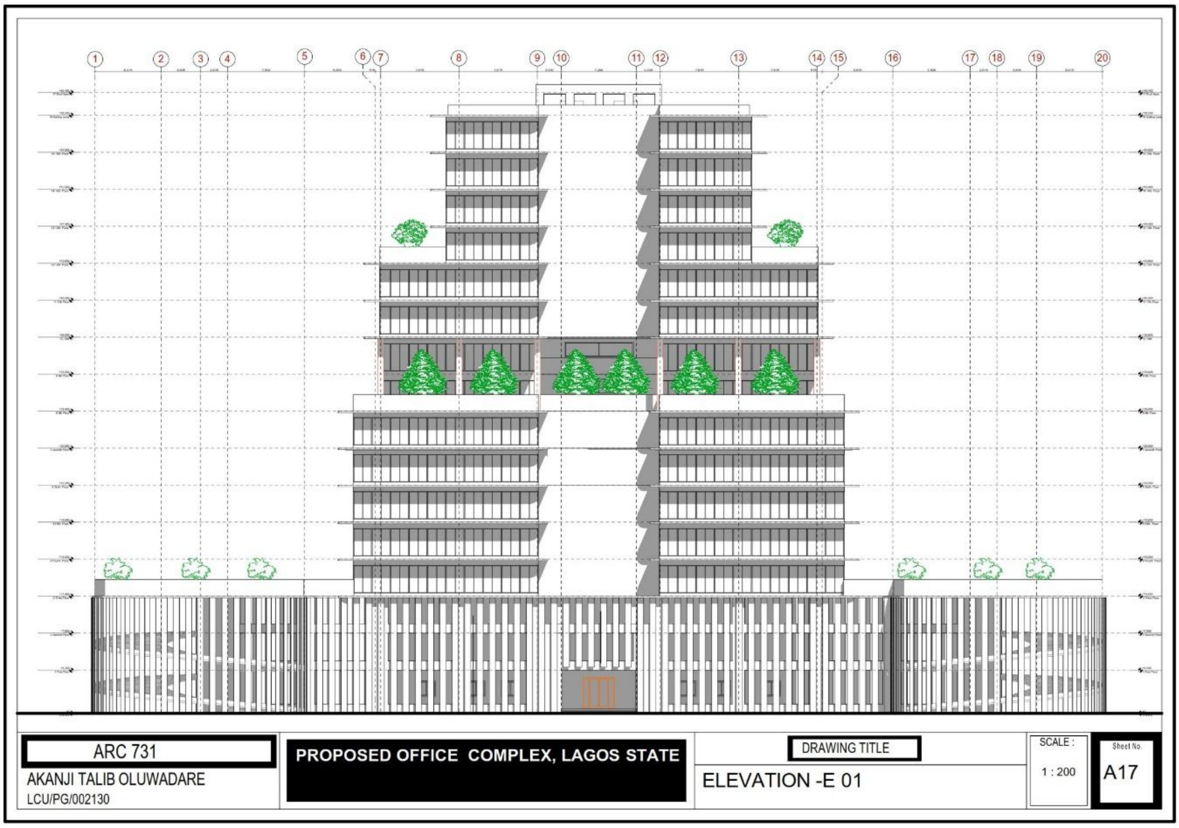

TERRACE
OFFICE SPACE E1
VOID
11,720
12,160
5,610
6,000
OFFICE SPACE E1
TERRACE
LOBBY
LIFT
ELECTRICAL ROOM
MECHANICAL ROOM
ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130
PROPOSED OFFICE COMPLEX, LAGOS STATE
DRAWING TITLE
12TH FLOOR PLAN
SCALE :
1 : 200
Sheet No.
A09

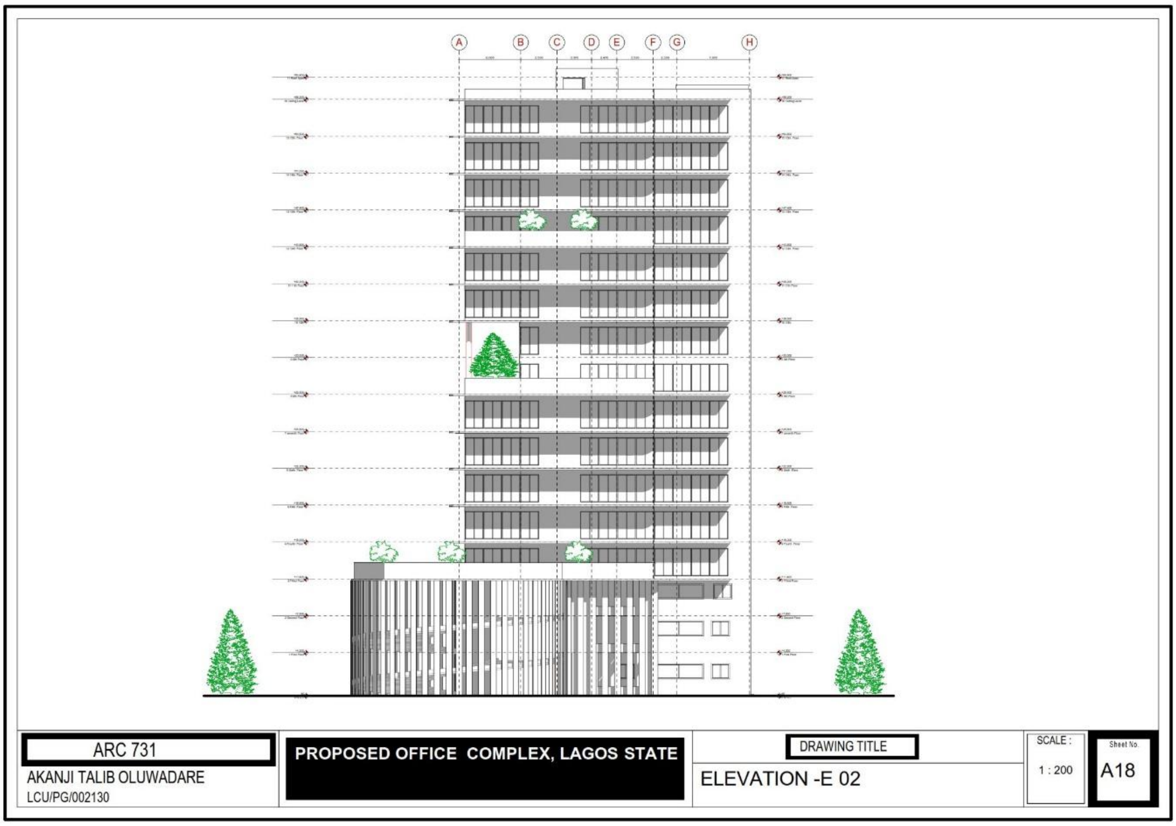

OFFICE SPACE F1
VOID
11,720
12,160
5,610
6,000
OFFICE SPACE F1
LOBBY
LIFT
ELECTRICAL ROOM
MECHANICAL ROOM
ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130
PROPOSED OFFICE COMPLEX, LAGOS STATE
DRAWING TITLE
TYPICAL 13TH & 14TH FLOOR PLAN
SCALE :
1 : 200
Sheet No.
A10


ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130
PROPOSED OFFICE COMPLEX, LAGOS STATE
DRAWING TITLE
15TH FLOOR PLAN
SCALE :
1 : 200
Sheet No.
A11
OFFICE SPACE B1
OFFICE SPACE B
ELECTRICAL ROOM
MECHANICAL ROOM
11,720
12,160
6,000

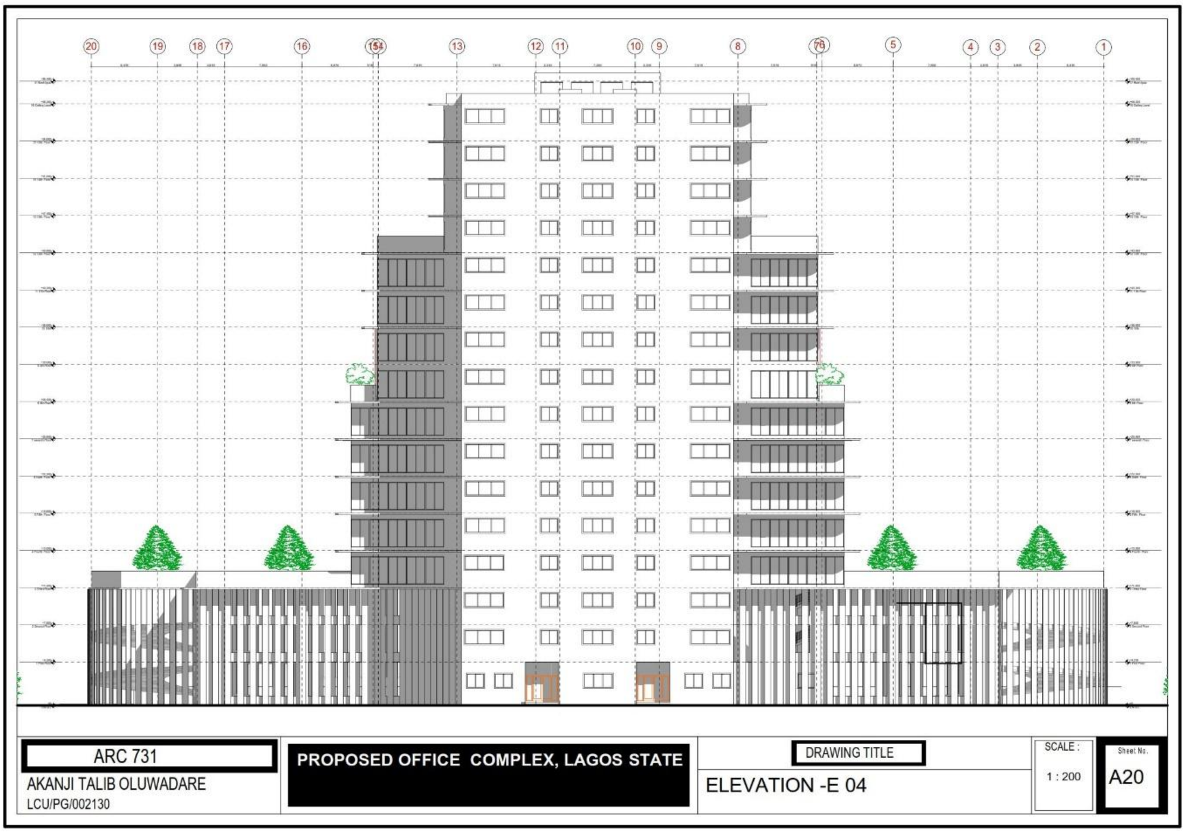

ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130
PROPOSED OFFICE COMPLEX, LAGOS STATE
DRAWING TITLE
ROOF PLAN
SCALE :
1 : 200
Sheet No.
A12
ROOF SLAB
Void
SOLAR PANELS ON ROOF TOP


ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130
PROPOSED OFFICE COMPLEX, LAGOS STATE
DRAWING TITLE
SECTION S-03
SCALE :
1 : 200
Sheet No.
A16


ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130
PROPOSED OFFICE COMPLEX, LAGOS STATE
DRAWING TITLE
ELEVATION -E 01
SCALE :
1 : 200
Sheet No.
A17



ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130
PROPOSED OFFICE COMPLEX, LAGOS STATE
DRAWING TITLE
ELEVATION -E 02
SCALE :
1 : 200
Sheet No.
A18



ARC 731
AKANJI TALIB OLUWADARE
LCU/PG/002130
PROPOSED OFFICE COMPLEX, LAGOS STATE
DRAWING TITLE
ELEVATION -E 04
SCALE :
1 : 200
Sheet No.
A20