Proposed Lead City Ventures for Lead City University, Ibadan
(A Study of Daylight Considerations in Commercial Hub Design)

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Being a MSc Thesis Submitted to the Department of Architecture, Faculty of Environmental Design and Management, Lead City University, Ibadan, Oyo State, Nigeria

In partial fulfilment of the Requirements of the Award of Master Degree (MSc) in Architecture

2023

Certification

This is to certify that Olusegun Isaac OJELEYE, with matriculation number LCU/PG/002827 carried out this research work with the title "Daylight Considerations in Commercial Hub Design" in the department of Architecture, Faculty of Environmental Design and Management, Lead City University, Ibadan, Oyo State, for the award of Master Degree in Architecture and that this has not been previously submitted.

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Dedication

This research is dedicated to Almighty God, the giver of life and the lifter of men for his grace and mercies upon my life before and especially during the process of carrying out this research work. I also dedicate this to all that contributed and supported this work to make it a success. May God reward you bountifully. I appreciate and celebrate you all.

Acknowledgement

I return all glory and praises to God Almighty for guiding my path from cradle to this present time I say YOU ARE ABLE. My sincere gratitude goes to my wife Olufunke Ojeleye, my children Sasinuoluwa and Tiresimi Ojeleye for the endurance, support and encouragement for a successful post graduate programme. I love you guys.

Also express my sincere gratitude to Dr. (Arc.) Adedire Funmilayo, Dr. (Arc.) Obaleye Oludare my supervisors for guiding me through in hard session of this work. To Arc. Aseyan Babajide, Arc.Olaniyan Martin, Dr. Ayanleke Oluwatosin and all other lecturers for their immense support and selfless effort in ensuring that this research work is successful.

Profound thanks to my mother, mentor, life coach and my covenant friend Dr.(mrs) Adenike Olusolape Olufolaji for absolute parental and moral support mum you are the best. May God grant you long life in good health to enjoy the fruits of your labour.

Finally, to inspirational and unequivocal senior colleagues and friends, Arc. Morenikeji Semiu, Dr. Ogungbemi Kunle, Adeyemo Victor, Akintoye Obasanjo, Adekunle Jelili, for their love and support during this post graduate programme. I also appreciate the efforts of those who in no little measure did through contribution and advice. GOD BLESS YOU ALL

Abstract

Energy efficiency is of paramount importance in commercial structures. The closure of various commercial buildings, primarily attributed to the substantial costs associated with maintenance, particularly in terms of energy expenses, underscores the significance of this issue. This research is centered on the exploration of daylighting techniques within commercial buildings, aiming to enhance their energy efficiency. The study presents an investigation into optimizing daylight utilization in a commercial hub, with the initial objective of mitigating the energy consumption linked to artificial lighting within commercial complexes. The research involves assessing the quantity of natural daylight required for commercial structures, with minimal alterations to architectural designs to mitigate glare within commercial spaces caused by solar radiation. The Daylight Factor (DF) serves as a key metric for gauging the internal natural illumination of these buildings. The results indicate substantial energy savings achievable through the incorporation of daylighting practices and propose adjustments to enhance the natural lighting conditions within buildings. The integration of daylighting techniques in commercial hubs promises a significant reduction in energy costs while simultaneously enhancing user circulation and visual comfort. The rationale for this argument is rooted in an extensive review of relevant literature and case studies. The research methodology employed entails an in-depth examination of existing commercial centers and ventures. Key variables have been diligently scrutinized and applied in the design of a proposed commercial hub, resulting in a substantial reduction in energy consumption. Additionally, the suitability of the site for the proposed building has thoroughly evaluated. In conclusion, the implementation of daylighting strategies during the design and construction phases holds the potential to yield a remarkable reduction of approximately 70% in energy consumption within commercial buildings.

Keywords: Energy Efficiency, Commercial Hub, Daylighting, Glare, Energy Efficiency, Solar Radiation.

Word Count: 277

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Chapter One

Introduction

1.1 Background of the Study

The modern environment grapples with issues related to carbon emissions and the urgent concerns of global warming. Consequently, sustainable design principles and methodologies have been introduced and embraced (Sodiq et al., 2019). Within the realm of energy consumption in buildings, lighting constitutes a significant portion of the overall energy usage (Vaisi and Kharvari, 2019; Babalagama and Pathirana, 2021). This has prompted the exploration of alternative means to curtail energy consumption, particularly through the implementation of daylighting strategies, notably in commercial structures (Ghosh et al., 2021).

Commercial buildings distinguish themselves from residential ones by virtue of their operations predominantly occurring during daylight hours, affording the opportunity to harness natural daylight (Azimi, S., & O'Brien 2022). Consequently, the strategic integration of natural light in non-residential buildings has emerged as a pivotal approach to enhance energy efficiency, minimizing the demands on artificial lighting, heating, and cooling systems within commercial premises (Aydinli, 2000; Lu et al., 2019). Empirical research findings underscore the substantial role of lighting, constituting up to 40% of a building's total energy consumption (Alrubaih, et al., 2013). It is worth noting that commercial buildings are responsible for a significant portion of global electricity consumption, accounting for approximately 19% (Chen et al., 2023). Therefore, substituting a portion of electric lighting with daylighting holds the potential for energy savings and a reduction in environmental harm stemming from resource overexploitation (Cao et al, 2016).

The term "daylighting in buildings" refers to the introduction of sunlight into indoor spaces through openings, thereby influencing the interior environment's quality and functionality (Sharaf, 2014; Dolnikova et al., 2020). Its application promotes the utilization of renewable energy sources and cost savings (Tregenza and Mardaljevic, 2018; Alhagla et al., 2019). The incorporation of daylight into commercial settings diminishes the reliance on artificial lighting during daylight hours, fostering a positive work environment that enhances productivity and uplifts spirits (Sarmadi and Mahdavinejad, 2023). When paired with appropriate technologies, daylighting can significantly reduce a building's electricity consumption and notably improve indoor lighting quality (Aderonmu et al., 2019).

Evidence supporting the desirability of daylight is apparent in both research and observations of human behavior and commercial space organization (Whang et al., 2019; He, 2021). Daylighting is generally perceived as beneficial in two key aspects: enhancing occupant well-being and conserving energy. Windows that admit daylight play a crucial role in providing views of the outdoors and connecting indoor spaces with the external environment, beyond their primary function of introducing natural light (Dong and Zhang, 2020; Mesloub et al., 2022). Daylight is valued for its quality, spectral characteristics, and variability. Observations of people's responses to indoor environments suggest that daylight is desirable because it fulfils two fundamental human needs: clear visibility of tasks and surroundings and exposure to environmental stimuli (Hong, 2021). Extended exposure to electric lighting is believed to have adverse effects on health, whereas working in natural daylight is thought to reduce stress and discomfort.

In addition to its advantages for human health and well-being, daylighting's energy-saving potential is substantial (Granqvist et al, 2018). It notably reduces peak electricity demand, a significant advantage for buildings with peak loads occurring during daylight hours. Furthermore, daylight contributes more energy as visible light and less as heat compared to electrical lighting, resulting in reduced cooling loads in buildings occupied during daylight hours (Sarmadi and Mahdavinejad, 2023). Properly integrated into building design and complemented by lighting controls, daylight can significantly diminish the need for artificial lighting. Consequently, daylighting should be viewed as an integral element of sustainable building initiatives (Phillips, 2012).

Daylight inherently provides high illuminance and enables excellent color perception and rendering (Robinson and Selkowitz, 2013; Maleki and Dehghan, 2021). These qualities make daylight conducive to optimal visual performance. Nevertheless, daylight can also produce discomforting glare and intense reflections on screens, both of which can impair visual comfort (Kini et al., 2022). Therefore, the impact of daylight on task performance hinges on how it is managed and delivered. All these considerations necessitate a thoughtful approach to daylighting design for buildings. In this context, this study delves into specific daylighting considerations to determine optimal lighting requirements within a commercial hub.

1.2 Statement of Research Problem

Commercial hubs are specifically designed to host and engage commercial offices, shopping centres, banks, office complexes and establishments in selling goods and services (Velux, 2022). From physical observation, the existing planning layout of Lead City University, Ibadan, Nigeria revealed that commercial activities within the campus are not centralized with no visible zoning criteria, leading to proliferation of pockets of small commercial buildings across the campus. In reality, operating these scattered buildings can be viewed as duplication of energy consumption with each unit requiring similar amounts of energy particularly for lighting to provide safe, healthy, and productive environment for students, employees and retail customers.

Considering the fact that building industry is depleting natural resources beyond sustainability levels, daylighting can play an important role in conserving the energy. Moreover, the importance of this factor is undeniable in human functioning. Several studies have examined daylighting in commercial buildings (Turan *et al*., 2020; Hong, 2021; Maleki and Dehghan, 2021; Li, 2022). However, it was observed that amidst this plethora of studies on daylighting in commercial and office buildings, there is paucity of research on daylighting in shopping malls and commercial hubs with limited research on any aspect of daylighting in commercial spaces in universities and campus environments.

Energy savings, sustainability and minimum maintenance are some of the reasons designers opt for daylighting. Buildings incorporating daylighting can reach an overall energy savings of 15% to 40% (Ahmad *et al*, 2018). Daylighting in buildings is a critical functional requirement in the tropical climate with numerous benefits. On the other hand, poor implementation of daylighting is bound to create high energy consumption and user's discomfort, unlike in the temperate region where solar intensity is lesser (Ayoosu et al., 2022). Studies suggest that daylighting has a direct impact on the well-being, productivity and overall sense of satisfaction of users. However, effective daylighting of spaces does not come without some challenges such as glare, intense heat generation from solar radiation, high light intensity, and so on (Sharaf, 2014; Hosseini *et al*., 2019; Sarmadi and Mahdavinejad, 2023).

Several studies have been conducted on the utilization and feasibility of daylighting in commercial buildings (Sprah and Kosir, 2019; Asfour, 2020; Bas, 2020; Babalagama and Pathirana, 2021; Rawat and Singh; 2021; Kini *et al.,* 2022; Alfano *et al*., 2023). However, the study of the convergence in the application of passive and active daylighting strategies for efficient and effective lighting in shopping malls is a research area that requires studying especially for hot humid climates.

Preliminary observations of the existing commercial centres in Lead City University revealed a number of shortcomings. Poor zoning of the buildings and non-existence of a dedicated area allocated to commercial activities was one of the major shortcomings observed. Throughout the university campus, there is no purpose-built commercial hub but pockets of commercial shopping areas situated at different locations in the university campus. In addition, there is poor utilization of natural lighting in the existing buildings which contribute to user discomfort and over reliance on energy consuming artificial lighting.

In order to address the myriad of challenges that accompany excessive energy consumption due to the proliferation of commercial buildings within the campus on one hand and the constraints associated with the implementation of effective and efficient daylighting strategies on the other hand, it becomes imperative to examine the daylighting requirements for commercial hubs and to design a commercial hub to centralize the commercial activities on the Lead City University Campus. The centralization of the commercial centres through a purposely designed commercial hub will ameliorate these existing challenges and adopt daylighting strategies with immense environmental and ecological benefits.

This study explored the various strategies, mechanisms and devices to enhance daylighting as well as the design considerations for daylighting that can be adopted in the proposed design of a commercial hub for Lead City University, Ibadan, Nigeria as well as recommendations to drive similar future developments in line with efficient and innovative daylighting.

1.3 Aim and Objectives of Study

The aim of this study is to design a Commercial Hub for Lead City University, Ibadan, exploring and adopting daylighting strategies to reduce the energy consumption and to serve as a guide for future similar developments.

In order to achieve this broad aim, the following objectives have been specified, which are to:

1. examine the historical background of commercial hub design;
2. identify the functional and design considerations for daylighting in commercial hub;
3. examine daylighting design strategies so as to understand its performance parameters and requirements in a commercial Hub;
4. design a user-friendly commercial hub by integrating the most important daylighting design strategies for Lead City University and environment..

1.4 Research Questions

The following under listed research questions have been generated to guide the study:

1. What are the origins and antecedents to commercial hub design?
2. What are the functional design considerations for a commercial hub?
3. What are the daylighting performance parameters and requirements of a commercial hub?
4. How can daylighting systems be integrated in the overall building design process of the commercial hub?

1.5 Scope of the Study

Aspects of daylighting as it relates to functional light, energy consumption and the aesthetic impact of the lighting systems in commercial hubs was the primary focus of this study. Qualitative as well as quantitative aspects of lighting in commercial buildings were examined. The study relied upon secondary data as well as primary data obtained from case study analysis. Four case studies wherein two objects of study were located outside Nigeria and two within the territorial borders of Nigeria were selected.

1.6 Significance of the Study

Studies on strategies for reducing building energy consumption through sustainable daylighting design solutions are been pursued globally (Ayoosu *et al.,* 2022). Considering the amount of energy consumed in lighting commercial buildings the proposed study is invaluable as it attempts to centralize all commercial activities within the university campus so as to drastically reduce energy consumption attributed to the buildings. More so, lighting when planned can be a simple but effective way of enhancing visibility and improving well-being, productivity and overall sense of satisfaction of users for example, students, employees and retail customers, as people have a natural attraction and need for daylight (Aydinli, 2000; Alrubaih, *et al.,* 2013).

Therefore, providing positive psychological experiences should form the basis for buildings designed for the public, hence the need to inquire into successful daylighting design techniques (Burton and Mitchell, 2006). Thus, in line with the view that daylighting can reduce building energy consumption and help improve user experience; it is evidently justifiable to conduct this study and to apply all relevant findings in the design of the proposed Commercial Hub for Lead City University.

1.7 Operational definition of terms

Amplitude: The amplitude of an electromagnetic wave is the height of the wave, measured

Colour: This pertains to the method by which we discern different light wavelengths.

Daylighting involves the controlled introduction of natural light, direct sunlight, and the diffusion of skylight into a building with the aim of reducing the need for electric lighting and conserving energy. It encompasses the strategic placement of windows, skylights, openings, and reflective surfaces to harness sunlight for effective indoor illumination.

Daylight Factor: This quantifies the ratio of the internal light level within a building to the external light level.

Electromagnetic Spectrum: The electromagnetic spectrum encompasses the complete range of frequencies or wavelengths exhibited by electromagnetic waves.

Frequency: Frequency correlates with the number of wavelengths passing a specific point in space within a given time frame.

Glare: Glare denotes intense and dazzling light that can disrupt visual perception.

Lighting: Lighting or illumination refers to the purposeful application of light to achieve practical or aesthetic objectives.

Polarization: Polarization relates to the orientation of the electric field in an electromagnetic wave.

Wavelength: The wavelength of a monochromatic wave denotes the distance between two successive wave crests.

Chapter Two

Literature Review

2.1 Historical Evolution of Shopping Centre

The evolution of shopping places is a social process that evolved with advancements in human civilization (Clark, 2004). The historical evolution of humans can be likened to the evolution of shopping centres, as civilizations evolved with social relationships and stratification of society so did the exchange of goods and services. As early as when prehistoric people began to communicate, exchange of goods and services and commercial trade commenced (Tennant, 2017). People bartered goods and services. The history of long-distance commerce began approximately 150,000 years ago. The earliest trading activities took place at meeting and gathering spaces (Eppli and Benjamin, 1994). The earliest recorded trading was the exchange of obsidian and flint during the stone age in a Neolithic period settlement in southern Anatolia 7500-5000 BC (KOCAGLG, 2010). Evidence revealed that obsidian tools were traded for items such as Mediterranean Sea shells and flint from Syria. From history, trade is one of the drivers of interactions of amongst people and this led to early urbanization.

Although, it has been established that trade commenced during the Neolithic period, the earliest figurative expressions of market place was observed in Egyptian hieroglyphs around 1500 BC as illustrated in Figure 2.1 (McClellan, 2015). However, there is no certainty as to the space or building where the trading activities were carried out from the Egyptian drawings. Early trading did not involve the use of money as money evolved at a later time. The medium of exchange in the earliest civilizations was the barter system (Shaw, 2016).

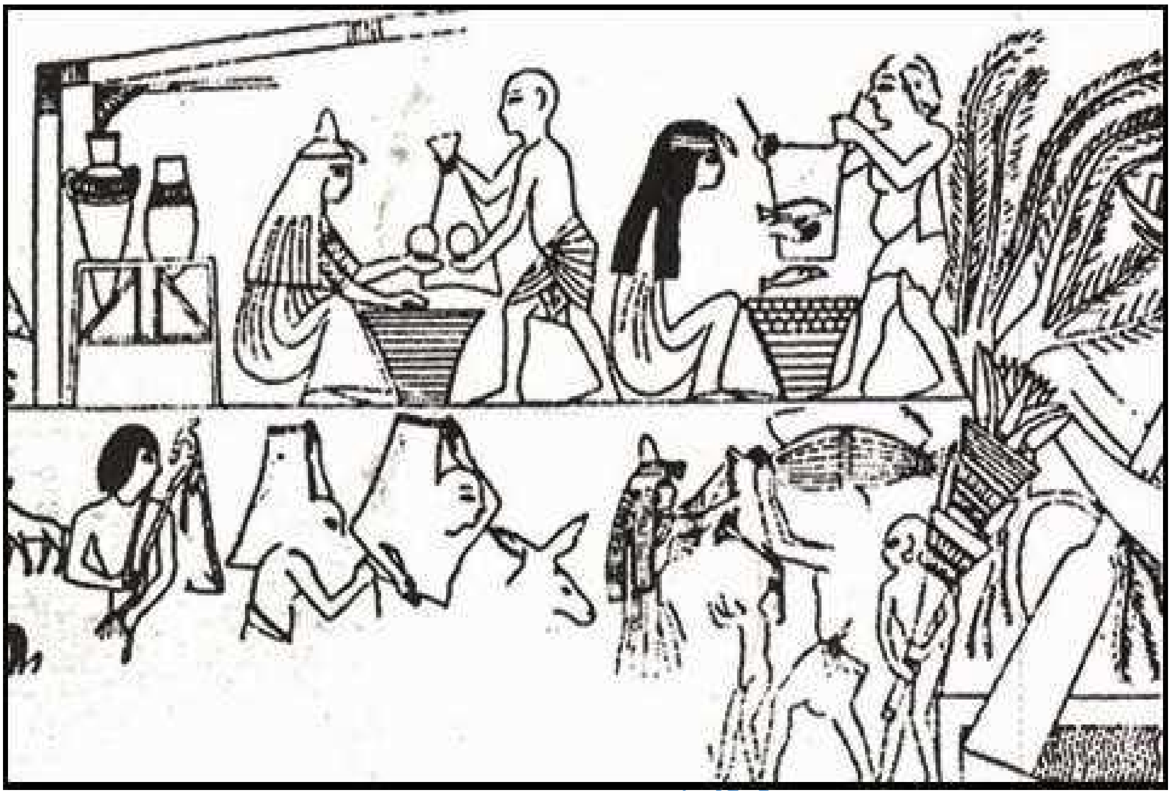

Figure 2.1: Drawing of Market at Thebes Egypt
Source: Kocaili, 2010

According to Herodotus the famous Greek historian, the Lydians, an Iron Age kingdom of western Asia Minor located in the modern Turkish provinces of Manisa and inland Izmir introduced the use of gold and silver coins as a medium of exchange in the seventh century BC. A typical Lydian coin is illustrated in Figure 2.2. The utilization of gold and silver coins by the Lydians was a milestone in the economic and financial history of human financial and economic interactions (Team, 2016). In addition, it was recorded that the Lydians were the first to establish retail shops in permanent locations. Asides the Lydians, there were also records of trade in salt, fish, cattle, horse, and silk by the Chinese through the famous Silk Road with goods from China traded in Greece. Several other civilizations thereafter engaged in trading activities as discussed in the subsequent sections.

Figure 2.2: Lydian Coin Sixth Century BC
Source: Kocaili, 2010

2.1.1 The Greek Agora, Roman Forum and Eastern Bazaar

By 800 BC in ancient Greece, people had developed markets with merchants selling their wares in the Agora in the city centre. The Greek Agora was not only a place to trade but to socialize and participate in government. The Agora was an open place of assembly in ancient Greek city-states as it was a place for daily communications as well as formal and informal assembly (Davenport *et al*, 2005). The Agora was the genesis of modern urban space. The Agora provided an open-air often tented market place of a city where merchants sold their goods and craftsmen fabricated and sold their wares.

The Agora was located on the crossings of main roads of the city at the city centre and surrounded by public buildings. One of the most important parts of the Agora was the Stoa which comprised covered walkways or porticos for public use. On market days, Greek merchants spread their wares under the colonnades of the Stoa on mats or temporary stalls in order to allow other public activities such as voting, debates, public displays, sports and parades to take place outside market days.

According to their planning, design and functions, the Greek Agora and Stoa can be perceived as the forerunners of the Roman Forum and Eastern Bazaar. The Roman Forum is the market place or public place in an ancient Roman city. It was the centre of judicial and business affairs as well as a place of assembly for the people. Similar to the Greek Agora, cities during the Roman era had the central open space and forum which was the centre of civic life surrounded by temples, basilicas, bathhouses and state buildings. The Forum provided a place for shopping and other activities.

The Roman Forum was a rectangular courtyard surrounded by shops located on the axis between the basilica and the capitol. This plan was repeated throughout the Roman Empire as new towns and municipalities were planned as miniature Romes. The major forum was called the Forum Romanum with others such as the Forum Caesaris, Forum Trajani, Forum Boarium (cattle market), Forum Piscarium (fish market), Forum Holitorium (vegetable market) and Forum Suarium (hog market).

Forum Trajani also known as Trojan's Market was an important milestone in the evolution of shopping places as it provided a new image for Roman urban design. The Forum Trajani was a revolutionary complex of vaulted spaces for commercial and social purposes built by Apollodrus of Damascus in AD 100-10 in the time of Emperor Trajan. It is probably one of the first collections of defined shops largely under cover and arranged on multiple floors as illustrated in Figure 2.3. The upper floors were used for offices and the lower levels had shops selling oil, seafood, wine, groceries, vegetables, fruits and fabrics.

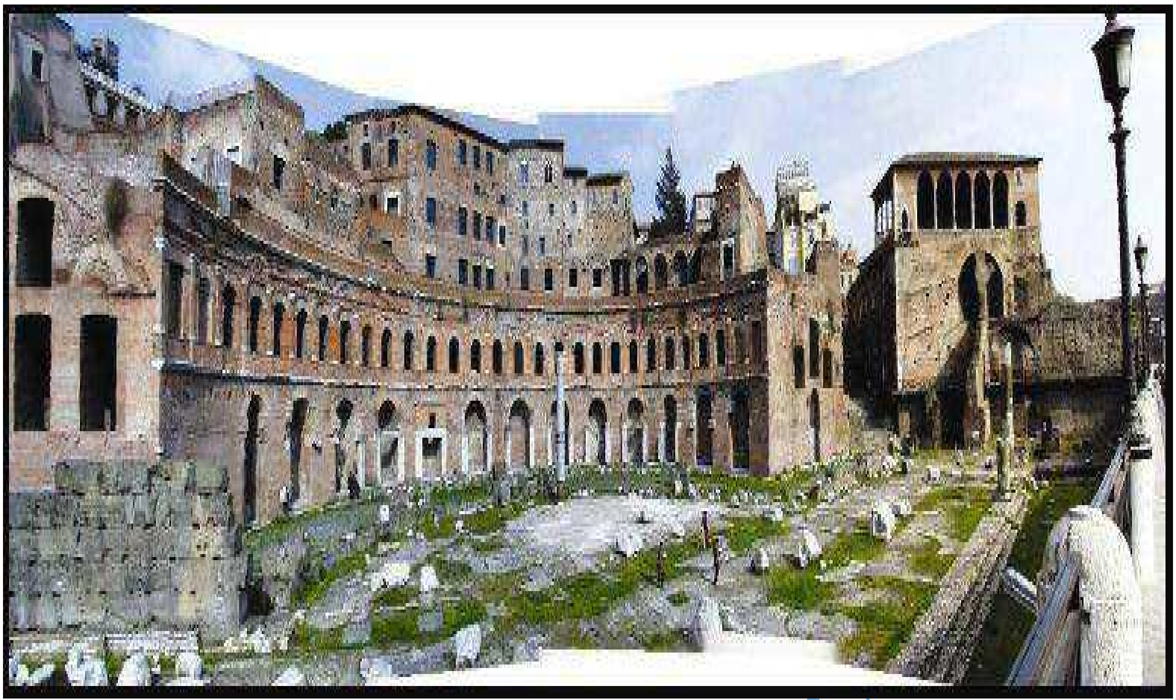

Figure 2.3: Forum Trajani
Source: Kocaili, 2010

The Bazaar first appeared in the Middle east around the fourth century along the important trade routes for foreign and exotic goods (Yeganeh and Almasi, 2016). Specially designated trading areas in the cities served as areas for the establishment of the first bazaars. The Bazaar was not just a trading centre as it served as the social, religious and financial centre for the city. The Eastern Bazaar is a function designed permanent merchandizing area, market place, or street of shops where goods and services are exchanged or sold. The traditional Eastern Bazaar comprise shops in vaulted streets closed by doors at each end facing into a covered street or internal space.

The Bazaar is the percussor for the modern-day supermarket and shopping mall with great influence on the economic development and centralization in modern cities across the world. The Bazaar continues to develop and modernize externally while its internal character and purpose remains the same. As such, the bazaar maintains its place in modern society.

2.1.2 Medieval Market Hall and Town Hall

After the fall of the Western Roman Empire, Western Europe descended into about 500 years of dark ages with decline in public activities shopping inclusive. The large-scale retail environment of the Roman Forum was not re-attained until several centuries later. After the dark ages, the Middle Ages witnessed the rebirth of urbanization in Europe and towns began to reappear again alongside the castles, forts and abbeys eventually broadening into trading centres (Magnusson, 2003).

In these medieval towns, the market and town hall evolved as the heart of trading and business activity located alongside the market square at the town centre. The early market and town hall buildings combined two main activities on different floors (Figure 2.4). The upper floors were for administrative activities while the ground floor was an open space under the columns supporting the suspended floor used as an extension of the market square wherein wares were displayed on removable stalls. In later years, the ground floors were arranged into a group of small shops and this defined the future of outward facing collections of shops which formed the basis of shop-lined streets observable throughout Europe in later centuries.

Figure 2.4: Pallazo del Broletto, Como, Italy - 1215

Source: Kocaili, 2010

2.1.3 Shopping Street, Shopping Arcade and Department Stores

The street has often been perceived as a "consumption landscape" as it is important to the experience of urban life (Barnes, 2006). By the eighteenth century as a result of the rise of the bourgeoisie, the shopping streets developed in Europe. Prior to the industrial revolution, the market places in cities were no longer sufficient for the evolving trade as a result, streets iin the central areas of cities starting from Italy were lined with shops, pubs, and coffee shops. The shops were organized by the type of goods sold, for instance, Bread Street and Milk Street in London. The shopping street is an organic development whereby the ground floors of street facing buildings were gradually converted into shops. The shopping street was the forerunner to the shopping arcade as the traffic on the streets transformed from a pedestrian, horse-drawn carriage to the automobile thereby becoming hostile to street shopping.

Arcades are an important milestone in the evolution of shopping centres as it was the first European building planned solely to accommodate a collection of shops for trading activities (Reikli, 2012). The arcade is primarily a pedestrian thoroughfare bordered or bounded by a building with an interior space that can be traversed for shopping activities. It is essentially a roofed-in gallery, an arched or covered passageway usually with shops on each side similar to an Eastern Bazaar. Arcades reflect and inspire the utopian ideals projected by the social visionaries of the nineteenth century with the incorporation of glass and steel design in the galleries as illustrated in Figure 2.5 (Mackay, 1985). These galleries were typically a fusion of glass and steel.

Figure 2.5: Galleria Umberto, Naples, Italy
Source: Kocaili, 2010

Department stores evolved from the shopping arcades and the bazaar stores during the late eighteenth century. A fundamental trading principle espoused by the department stores was the fixed prices for goods. The department stores eliminated the bargaining and pricing of goods by merchants and customers as consumers just walked up to an item with its priced fixed and decide to purchase or not. It also afforded a quick comparison of prices for similar products by different manufacturers. The department store as it names implies comprised several departments selling different categories of products. As such, the department store provides a shopping experience that provided opportunity to purchase a wide range of products at one location.

The Department stores sold fancy goods ranging from fine fabrics, millinery, lingerie, shoes, dresses and staple items. As a matter of fact, the department store evolved as the centre for fashion, luxury and household products exhibitions. They were built on multiple floors typically with glazed skylights over a central hall with interconnected spaces for trading and exhibition as exemplified in the illustrations of the Crystal Palace in London, England and the Karum AVM in Ankara, Turkey depicted in Figure 2.6. By the latter years of the eighteenth and the early years of the nineteenth century, it became a norm for department stores to have an open metal framed interior with glazing; a characteristic they shared with exhibition halls. The Crystal Palace in London, England which was designed by the British Architect Joseph Paxton in 1851, was an inspirational prototype as its arcade concept from a glass-covered street to a glass building and a container of landscape. Most of the contemporary shopping malls possess striking visual similarities to the Crystal Palace in terms of their barrel-vaulted ceiling, garden-like interiors and sensory stimulation (Young, 2015).

Figure 2.6: Crystal Palace in London, England and the Karum AVM in Ankara, Turkey
Source: Kocaili, 2010

2.1.4 Chain Stores and Supermarkets

Prior to the advent of the shopping mall, there were further developments alongside the department stores, these were the chain stores and supermarkets (Eppli and Benjamin, 1994). These shopping places were deliberately planned and developed in a coordinated manner of retail use in order to create either a single building or an organized group of physically separated retail stores with common arrangements. It was observed that chain stores had advantages over the department store as chain stores were able to harvest the benefits of centralized buying during a period when most department stores were still independent concerns. Before the proliferation of chain stores like Walmart or Marks and Spencer, each town had its own collection of individual and unique stores peculiar to the town or neighbourhood.

Chain stores gained ascendancy over the department stores as a result of the advancement in the transportation systems such as the railways and inter-city highways which afforded easy distribution of goods from central warehouses to the network of stores. The first notable chain store company was founded in London by Henry Walton Smith and was the British owned W.H. Smith. The company took advantage of the railway boom by opening news stands on railway stations starting in 1848. The company became renowned for its chain of high street, railway station, airport, hospital and motorway service stations selling books, stationery magazines, newspapers, and entertainment products (Birkin *et al*, 2010). One of W.H. Smith store at Waterloo Station in London, England is depicted in Figure 2.7.

Figure 2.7: W.H. Smith Store at Waterloo Station, London, England
Source: Kocaili, 2010

2.1.5 Shopping Mall and Commercial Hub

The concept of malls serving as central hubs for customers to access various merchants has a historical precedent dating back to the Agoras of Ancient Greece. Nevertheless, the contemporary notion of malls, characterized by physically constructed stores clustered together in a single location with shared amenities, emerged in the 20th century. The inaugural shopping mall, technically speaking, was an open-air shopping plaza that made its debut in 1922 in Kansas City, United States (Mahmoud, 2019). However, the first enclosed, open-air shopping mall that closely resembles our current understanding of malls was the Northgate Shopping Mall in Seattle, United States (see Figure 2.8).

Figure 2.8: Northgate Shopping Mall, Seattle, United States
Source: Kocaili, 2010

The Northgate Shopping Mall introduced the concept of arranging shops on either side of an elongated pedestrian walkway, serving as a model for subsequent suburban malls. Typically, these malls were anchored by a large department store, surrounded by a cluster of other shops. The expansion of these shopping canters was closely linked to the proliferation of automobiles. With cars becoming accessible to the general population, more people began moving away from cities and commuting from suburban areas (Robertson, 1997).

The shopping mall, shopping centre, or shopping plaza essentially represented a 20th-century adaptation of the historical marketplace, with provisions made for accommodating automobiles (Marve et al., 2020). A shopping mall is a collection of independent retail stores, services, and a parking area that is conceptualized, constructed, and managed as a unified entity by a management company. These malls may also include restaurants, banks, theatres, professional offices, service stations, and other establishments. The mall was envisioned as a cultural and social hub where individuals could not only shop but also engage in various activities. By 1960, there were over 4,500 malls, accounting for 14% of all retail sales in the United States.

Shopping malls typically fall into three categories: neighbourhood, community, or regional. The smallest type, the neighbourhood centre, typically centres around a supermarket, complemented by daily convenience stores such as pharmacies, shoe repair shops, laundries, and dry cleaners. On the other end of the size spectrum, regional shopping centres offer a comprehensive range of shopping services comparable to those found in a small downtown area. They typically feature at least one large department store, often several, and numerous specialty shops and boutiques. Additionally, there are usually several restaurants and, possibly, a movie theatre. Services catering to immediate day-to-day needs are typically minimized. On larger sites, you might also find motels, medical centres, or office buildings (Pitt and Musa, 2009).

In contrast, commercial hubs are purposefully designed to host a variety of commercial entities, including commercial offices, shopping centres, banks, office complexes, and service providers (Velux, 2022). Commercial hubs go beyond the shopping mall concept by accommodating a wide range of commercial activities in addition to shopping. Unlike the shopping mall, which is typically a homogeneous entity, the commercial hub is a complex and diverse facility that provides various spaces for the exchange of goods and services.

2.2 Design Features of Commercial Hub

A commercial hub is a heterogeneous and complex facility involving a number of retail, shopping and office spaces (Golany and Ojima, 1996). The variations in the usage pattern, energy intensity and construction techniques make designing a commercial hub a complex endeavour. To better understand the concept, a commercial hub could be regarded as a type of organism that consists of multiple isolated systems, each of which plays a role in its overall health. These systems must operate in tandem, responding to and communicating with one another in order for the building to perform as designed (ACBI, 2022). Therefore, when designing a commercial hub, it is important to understand how each of these systems is linked within a complex system so an integrated, whole-building design approach can be developed. As such, understanding this building type as a complex system means appreciating how the various components interact together and affect overall performance, durability, safety, health and comfort (Al Horr *et al*, 2019).

Typically, a commercial hub is designed to melting pot of commercial activities. It consists of commercial development (shopping, office, public open space, car park); civic spaces for arts and cultural uses; and space to enhance connectivity through multi-level pedestrian network and traffic circulation.

2.2.1 The Design of Shopping Centre

Shopping is a regular activity for most individuals. However, due to time constraints, there is a growing need for shopping complexes that also incorporate office spaces, providing a convenient one-stop solution to save valuable time (Marve et al., 2020).

Shopping center buildings are typically classified into four size categories: small, medium, large, and very large (Toleikyte et al., 2016). This classification is based on statistics from the International Council of Shopping Centres (ICSC), which divides traditional shopping centers into the following scheme sizes: very large (80,000 m² and above), large (40,000–79,999 m²), medium (20,000–39,999 m²), and small (5,000–19,999 m²) (ICSC, 2008).

We are currently analyzing the composition of small, medium, large, and very large buildings. Table 2.1 illustrates the typical makeup of these shopping center categories, based on a review of relevant literature and an analysis of European shopping centers, as detailed below.

Table 2.1: Shopping Centre store composition

	Shop Types				
Building	SHP	CMA	MDS	RST / WRH	(Other

categories	(Retail stores: clothing, hobby, home)	(Common area)	(Medium stores, big size stores, supermarkets)	(Restaurant, cafes, Food courts)	services: ware-house, Service rooms etc.)
Small	36%	25%	20%	8%	11%
Medium	42%	25%	15%	9%	9%
Large	50%	25%	9%	10%	6%
Very large	54%	25%	6%	12%	3%

Source: Adapted from Steen and Strøm (2012); Unibail-Rodamco (2013); ECE (2013); Intu Gr. (2013); Britishland (2014); IGD (2014).

The distribution of shop categories and their respective sizes plays a crucial role in determining the overall profitability of the building, as well as the energy consumption required for lighting. We have identified the following types of shops: SHP (encompassing retail stores, including clothing, hobby, and home goods), CMA (common areas), MDS (medium and large-sized supermarkets), RST (restaurants and cafes), and WRH (warehouses and other service facilities). For each of these shop types, we have computed the specific power consumption and the daily duration of lighting use, as detailed in Table 2.2.

Table 2.2: Specific power consumption for different shop types for lighting

	Shop Types				
Building categories	SHP (Retail stores: clothing, hobby, home)	CMA (Common area)	MDS (Medium stores, big size stores, super-markets)	RST WRH (Restaurant, cafes, food courts)	(Other services: warehouse, Service rooms etc.)
Small	36%	25%	20%	8%	11%

Source: ASHRE Standard 90; Schönberger, Galvez Martos, and Styles (2013); Westphalen, and Koszalinski; Goetzler *et al,* (2009).

2.2.2 The Design of the Restaurant

Prior to the establishment of any restaurant, a meticulous organizational plan should be devised. It is imperative to determine the menu, specifying the types of meals offered, their quality, and portion sizes. Before finalizing the layout, it is crucial to have a clear understanding of the expected number of patrons, their characteristics, and the diversity among customers. The primary area of focus in a restaurant is the dining room, and its amenities and design should align with the specific nature of the operation.

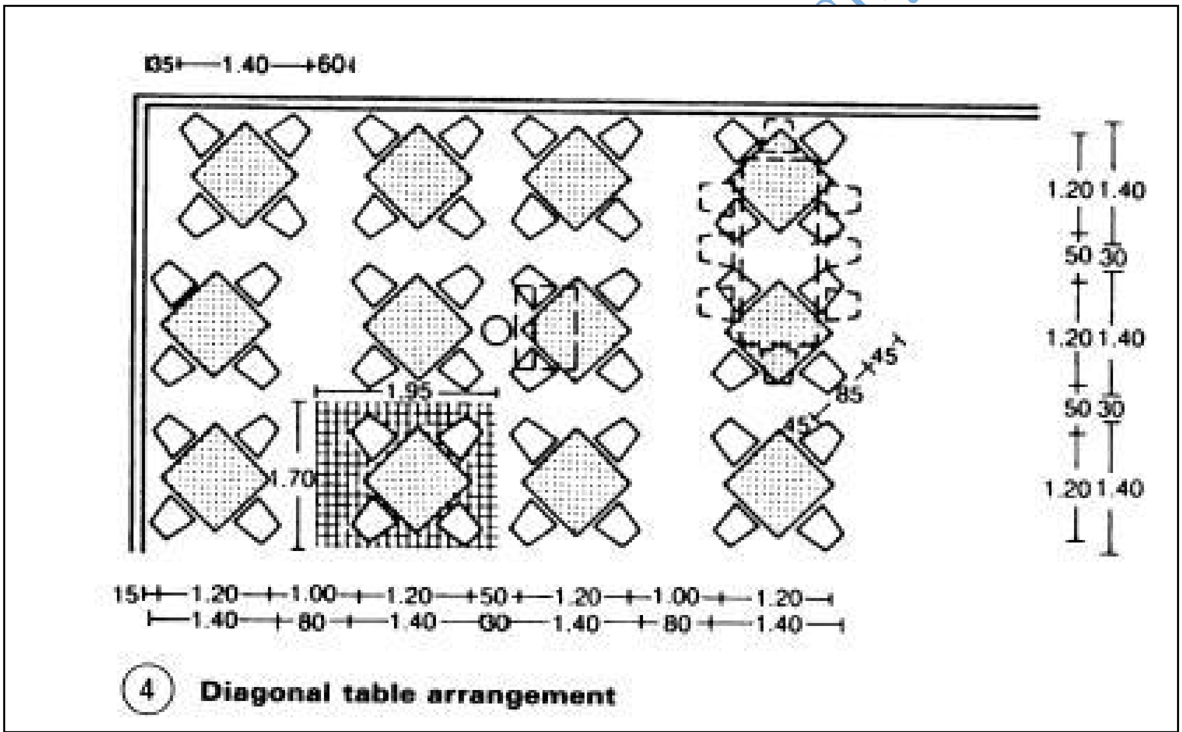

Figure 2.9: Table arrangement
Source: Architects' data (2008)

A number of additional tables and chairs should be available for flexible table groupings. If appropriate, provide special tables for regular customers. The kitchen, store rooms, delivery points, toilets and other service areas should be grouped around the dining room.

2.2.3 The Design of Public Open Spaces

History demonstrates that humans have relied on the natural environment for food, shelter, and survival for countless centuries. This enduring connection between humans and nature has shaped our existence over an extended period. The benefits we derive from nature are contingent on the interaction between individuals and their environment, which can yield both positive and negative outcomes (Bratman et al., 2012). A positive encounter with nature can lead to favourable psychological responses.

Incorporating green spaces within a commercial hub should be seen as a means to complement the constructed areas of the facility. The objective is to transform both built and unbuilt spaces into sources of inspiration and motivation, ultimately enhancing productivity. This approach does not diminish the importance of constructed spaces in commercial centres; instead, it underscores the synergy between built and green spaces in enhancing the overall functionality of the environment (Isaac, 2016). Consequently, this research explores various types of natural outdoor spaces and examines the layout and architectural design of commercial centres, as both elements contribute to the composition of the proposed commercial hub.

The concept of Biophilia finds expression in the built environment through the application of design principles that resonate with nature; this is known as biophilic design. Biophilic design principles, as outlined by Kellert (2008), can be integrated into buildings and spaces to foster a deeper connection between humans and nature. These principles encompass environmental features, natural shapes and forms, natural patterns and processes, light and space, place-based relationships, and evolved human-nature relationships (Kellert, 2008). Some of these principles play a role in how nature can harmonize with built environments.

For instance, creating a 'sense of place' in architectural design refers to establishing a connection between designed spaces and their geographical context, as well as considering how these spaces can positively impact their users. In this study, the natural environment is viewed as a space that contributes to shaping a sense of place. Day (2002) emphasizes that form and space influence individuals and communities while fostering growth on social and individual levels. Our response to our surroundings is rooted in a deeper connection beyond mere preference. Architectural considerations such as air quality, sound, color, form, and temperature are vital when designing structures for specific locations to create a sense of place for users (Sassi, 2006; Day, 2002).

A sense of place is nurtured through the user experience within the spaces of that place. Therefore, the built environment within the commercial hub should encapsulate the essence of its users through its design to prevent a sense of place lessness.

2.2.4 The Design of Car Parks

The design of parking facilities, whether they are underground, in basements, or part of multi-function buildings, is a common practice. Oftentimes, visitors form their initial impressions of a facility based on its parking area, as this is often the first element they encounter (Chu et al., 2002). The implications of this are evident. While car parks are typically located in city centers and towns, they are also found in airports, shopping centers, conference venues, hotels, residential developments, workplaces (both offices and factories), entertainment venues, train stations, and sports complexes (Marve et al., 2020). Certain characteristics are universally applicable to all these settings and are essential for a car park to fulfill its purpose. It should be easy for potential users to identify a parking facility and locate its entrance. In a commercial hub, it is advantageous if a car park can be readily recognized for its intended function.

When a development necessitates a parking facility, it is generally preferable to incorporate its design into the overall development plan. This approach allows for the possibility of designing the car park as an integral part of the facility or as a separate yet seamlessly integrated structure within the development.

2.3 Daylighting Design Strategies for A Commercial Hub

Daylighting is the use of light from the sun and sky to complement or replace electric light (Robinson and Selkowitz, 2013; Jain *et al.*, 2022). This process involves the use of appropriate fenestration and lighting controls to modulate daylight admittance and to reduce electric lighting, while meeting the users' lighting quality and quantity requirements (Aderonmu et al., 2019; Shafavi *et al.*, 2020). Arriving at an appropriate daylighting solution requires contribution from different design teams (Kang and Kim, 2021). Hence, the next sections discuss processes involved in the design of daylighting solution for a commercial Hub.

2.3.1 The Feasibility of Daylighting

The objective of carrying out feasibility is to check that daylighting makes sense for a specific site and program; and therefore, determine how much daylight you can use in various areas of the hub (Reinhart et al, 2013). According to Robinson and Selkowitz (2013) and Liu *et al*. (2021), the key ideas in measuring the feasibility of daylighting are: (i) windows must see the light of day; (ii) glazing must transmit light; (iii) install daylight-activated automated lighting controls; (iv) design daylight for the task; and (v) assess daylight feasibility for each different portion of the building.

There are further steps involved in calculating the feasibility of daylighting as listed below:

Step 1: Calculate the planned window-to-wall ratio (WWR) for a typical office space or bay.

Net glazing area (window area minus mullions and framing, or ~80% of rough opening) divided by gross exterior wall area (e.g., multiply width of the bay by floor-to-ceiling height) equals window-to-wall ratio (WWR). The equation is represented as: Feasibility of daylighting $= \frac{NGA}{GEWA}$; where NGA= net glazing area, and GEWA= gross exterior wall area WWR.

Step 2: *Make a preliminary glazing selection and note the visible transmittance (VT).*

Step 3: Estimate the obstruction factor (OF).

These is done by visualizing a typical task location, and then sketch the window elevation and shade in anticipated objects seen from this viewpoint; this can include objects such as trees that might be near to the window or buildings that might be a little further away but still impede the view of the sky. Select the obstruction factor, as shown in Figure 2.10.

Step 4: *Calculate the daylight feasibility factor.*

The daylight feasibility factor is calculated by; Window-to-wall ratio **X** visible transmittance **X** obstruction factor = feasibility factor.

Therefore, Rapid Feasibility Study to Estimate Potential Lighting Energy Savings is calculated by: (Feasibility = "how much glass" x "how transparent" x "obstructions blocking light") Complete this analysis for each major type of space in the building.

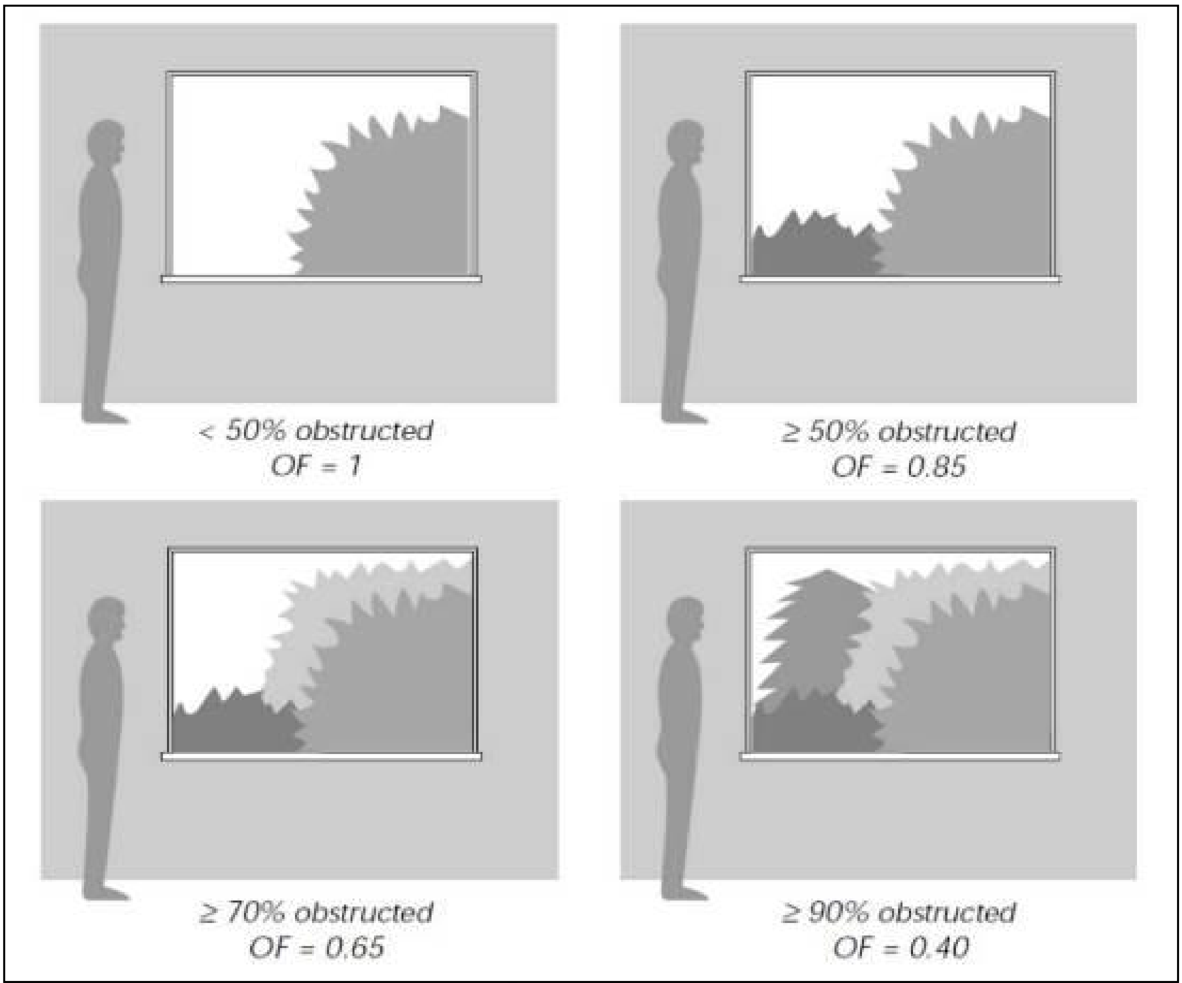

Figure 2.10: Estimating the obstruction factor Step
Source: Robinson and Selkowitz, 2013

2.3.2 Envelope and Room Decisions

The objective carrying out an envelope and room decision in the pre-design stage is to design siting, massing, façade, windows, and interior to maximize daylight effectiveness, provide occupant comfort, and minimize glare (Özdemir and Çakmak, 2022). These decisions determine the potential for useful daylight and energy savings (Hammad *et al.*, 2021). Hence, architectural decisions of this nature can influence the building's lifetime energy use more than mechanical and lighting decisions. The key idea is to use the building form and skin to increase exposure to daylight; shape the building for self-shading; capitalize on other building elements to integrate shading; and incorporate envelope features that improve daylighting

(Freewan and Dalala, 2019). Figure 2.11 shows a section drawing illustrating a deep wall section providing some self-shading. This allows easy integration of a light shelf, creates surfaces that mitigate glare, and reduces noise transmission. Sloped surfaces also help soften glare (Khidmat *et al*., 2022). A blind or shade can be added in the clerestory to manage glare from a low sun angle.

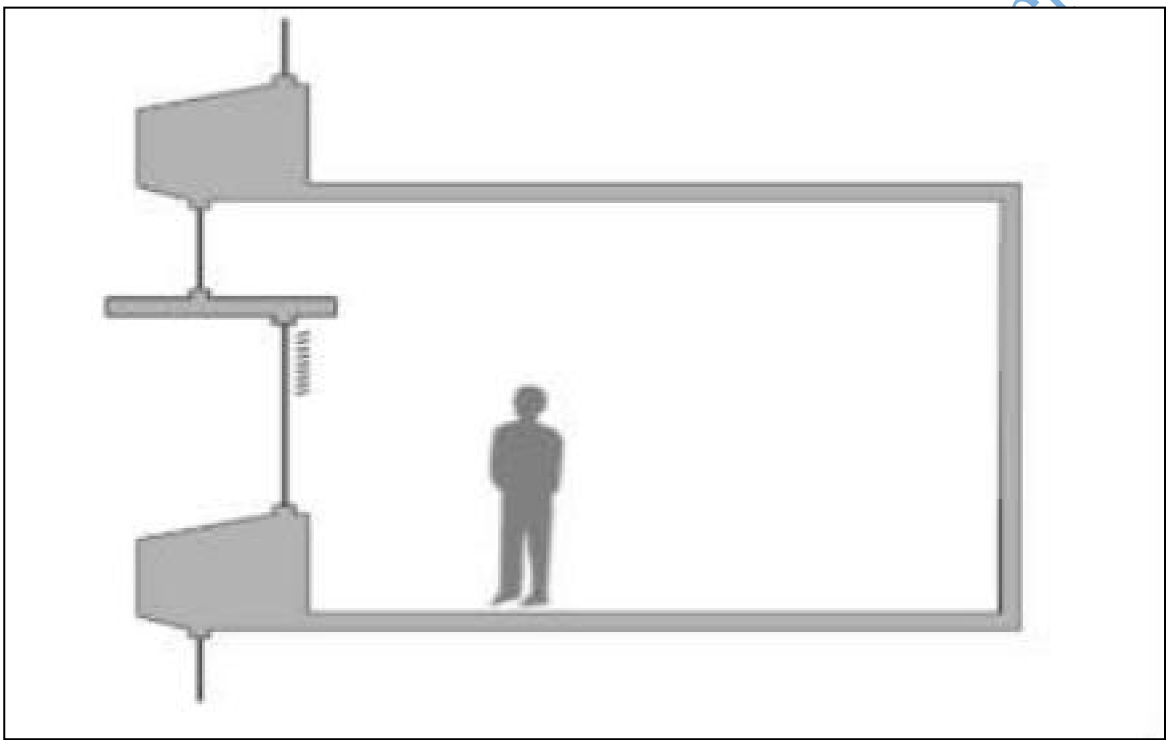

Figure 2.11: Section drawing illustrating a deep wall section providing some self-shading.
Source: Robinson and Selkowitz, 2013

Another approach to optimize envelope and room decisions is by the effective use of windows is to allow adequate amounts of daylight as deep into the space as possible, with a distribution within the space that is visually comfortable and does not create glare. This is typically done by controlling the window area, location type, glazing properties, shading systems, ceiling parameters, and interior design features to achieve these goals (Aydinli, 2000; Bas, 2020). For example, the higher the window, the deeper the daylighting zone; strip windows provide more uniform daylight in comparison with punched windows which have to be paired to be effective when possible (Figure 2.12). Also, clerestories (any window with its sill above eye level) are good options for getting the light source out of a direct sightline (Chi, 2021).

Furthermore, space planning can be used to optimize envelope and room decisions by locating activities according to light requirements and according to comfort requirements, maintaining daylight access and using light-transmitting materials for partitions where possible, and using west zones for service spaces and integrating personal shading / glare control systems into personal workspaces (Hammad *et al*., 2021).

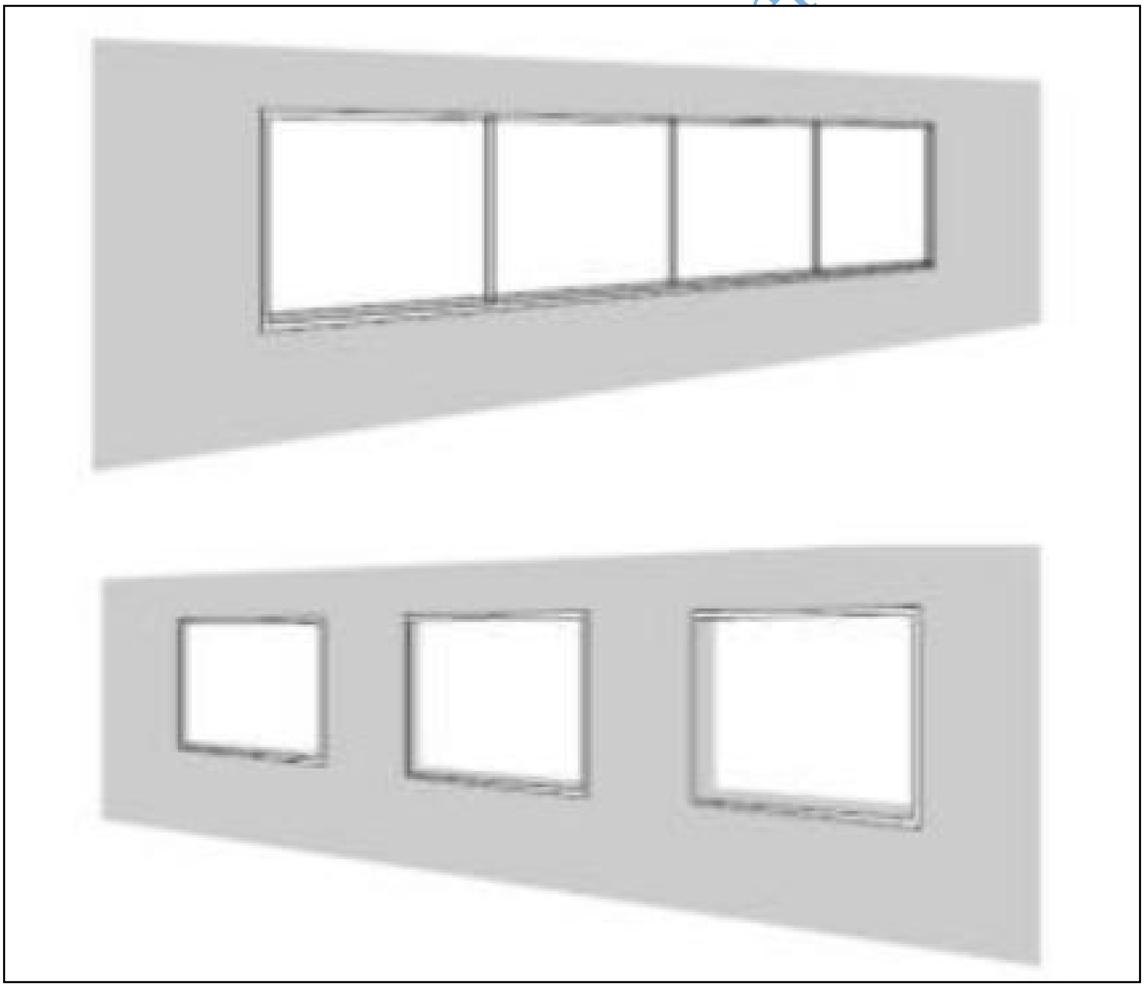

Figure 2.12: Strip windows and Punched windows
Source: Robinson and Selkowitz, 2013

Interior design can help improve daylighting solutions within a public building. For instance, avoid using large areas of dark colours. It is important that the wall facing the window be light-coloured (Bahdad, 2020; Pilechiha et al., 2020). Mullions or other solid objects next to windows should be light-coloured to avoid silhouette contrasts. Keep sills and other reveal surfaces light to improve daylight distribution and soften contrast. Dark artwork can reduce daylight effectiveness. Similarly, aim for recommended surface reflectances. Desirable reflectances (Illuminating Engineering Society recommendations) are: ceilings >80%; walls 50%–70% (higher if wall contains window); floors 20%–40%; and furniture 25%–45%. Also, choose matte over specular surface finishes, and use light-transmitting materials. Lastly, it is ideal to supply window coverings that allow individual control to accommodate different glare tolerances, while choosing colours under the right light (Robinson and Selkowitz, 2013).

2.4 Lighting Control Strategies in Commercial Buildings

Today, lighting takes a significant percentage of the energy used in commercial buildings. For instance, lighting consumes approximately 20-50% of the energy used in specialised retail buildings (Wuppertal Institut-Gokarakonda *et al.*, 2017). The savings incurred by using efficient lighting can be further optimized by the use of different kinds of lighting controls available. Lighting control ensures the light is provided where and when it is needed in the right amount while maximizing the use of daylight and minimizing the lighting energy wastage (EMOS, 2022). Lighting controls typically include occupancy sensors, daylight sensors, dimmers etc. and save approximately 20-50% of total lighting energy consumption. In typical office buildings the pay-back period for wireless lighting controls is approximately 2.3 years (Alliance E, 2011).

Lighting control systems consists of hardware such as sensors and, relay switches controllers which work using various communication protocols like DALI, ENOCEAN etc. DALI is an acronym for Digital Addressable Lighting Interface and is targeted to suit commercial architectural requirements. DALI is specifically developed for ballasts and relay switches. Lighting communication protocols can be used as a stand-alone lighting control system or integrated with other building automation systems using protocol translation with systems like BACnet, LonWorks etc. (Bhatt *et al*, 2015)

2.4.1 Daylight Sensors

Commercial buildings should be appropriately designed to facilitate the efficient utilization of natural daylight. Daylight sensors are employed to gauge the available natural light in a space and subsequently regulate artificial lighting by either switching it off or adjusting its brightness using dimming mechanisms (Samadi et al., 2020). Contemporary lighting sensors commonly utilize silicon photodiodes, which are semiconductor-based photodetectors that generate a current or voltage when exposed to light (EMOS, 2022).

Commercial sensors are typically composed of Photo ICs, which are responsible for detecting fluctuations in illumination levels within a space. These sensors transmit a signal to a control unit, which, in turn, manages the intensity of the lighting fixtures (Skorka et al., 2011). Daylight sensors are strategically positioned within the perimeter zone of a building, ensuring that they capture daylight penetration effectively. The placement of these sensors requires careful consideration, as their effectiveness hinges on factors such as the location of the task being illuminated, the control algorithm governing daylight adjustments, the lighting system in use, and the sensor's field of view (Doulos et al., 2014; LBNL, 2011).

2.4.2 Occupancy Sensor

Occupancy sensors are designed to identify the presence of individuals in a space and subsequently activate or deactivate the lighting as needed (Gunputh et al., 2007). This not only enhances occupant satisfaction by providing individuals with direct control over their environment but also ensures that lights are automatically switched off when the area is unoccupied, thereby minimizing energy wastage due to negligence. Common types of presence sensors include passive infrared sensors, referred to as PIR, and active ultrasonic or microwave sensors (Keller, 2000).

Occupancy sensors serve a multifaceted purpose by not only facilitating lighting control but also enabling integration with HVAC (heating, ventilation, and air conditioning) and security systems (Wuppertal Institut-Gokarakonda et al., 2017). Selecting the appropriate sensor type and strategically positioning sensors are critical considerations to maximize the detectable area while minimizing the likelihood of false alarms (Flynn et al., 2010). These controls can be customized to align with user behaviour and can be overridden when necessary. Additionally, automatic window blind control devices can be employed to regulate the amount of incoming light, preventing glare and ensuring optimal lighting conditions (Dubois et al., 2011).

2.4.3 Shading Control Devices

Shading devices like fixed shades, internal and external blinds, louvers etc. are necessary in passive building design for controlling seasonal heat gain and amount of daylight in the space (Palarino and Piderit, 2020; Sorooshnia et al., 2021). Automatic window blinds/louver control devices can be used to allow desirable amount of light into the space and also avoid glare. They can be automatically regulated by fixed schedules depending on the Sun path of the place and prevailing ambient light conditions on the outside and can also be manually overridden (O'Brien *et al*, 2013).

2.4.4 Switches

A simple switch operates on the binary function on/off. A switch can be used to control the lighting using occupancy detectors (Labeodan *et al*, 2015). It also can be operated based on the schedules of building occupancy and connected to the central BMS system or can operate locally on the basis of manual on and auto off principle. Turning off the lights when not required is the most simple and effective way of conserving energy (Lundberg *et al,* 2019).

2.4.5 Dimmers

Dimmers are utilized to regulate the brightness of a lamp through the use of dimmable ballasts. In contrast to older dimmable ballasts that employed resistance, reactors, and transformers, dissipating energy as heat, contemporary dimmers rely on thyristors, transistors, or silicon-controlled rectifiers (SCR), as stated by Wang (2010). The choice of control devices depends on the spatial layout and the availability of natural daylight. Prior to opting for a specific technology or a combination thereof, a thorough assessment of energy savings and cost considerations is necessary (Sztubecka et al., 2020). It's worth noting that dimming remains a relatively expensive option compared to simple switching technology and is most suitable for well-daylit areas. Nevertheless, in areas with abundant natural light, dimming offers an advantage, as occupants tend to perceive minimal disruptions in lighting levels when dimmers are employed, making them less intrusive (LBNL, 2011).

2.5 Energy Consumption and Lighting Consideration in Commercial Buildings

Buildings exert a significant influence on global energy consumption and climate considerations (Allouhi et al., 2015). They are responsible for consuming approximately 40% of the world's energy (Yang et al., 2014), with nearly 16% of this energy usage dedicated to the operation of commercial buildings (Berardi, 2017). When it comes to electricity consumption, buildings account for more than 55% of the world's total electricity usage (IEA - International Energy Agency, 2019). Given that the building sector ranks among the largest energy consumers within a nation (IEA - International Energy Agency, 2019), it is imperative to implement measures at the individual level first to collectively achieve significant reductions within the building industry (Hammad, 2021; Andersen et al., 2020).

Energy consumption in commercial buildings arises from a combination of thermal loads and lighting requirements (Sadeghifam et al., 2015; Cao et al., 2016; Kharvari, 2020). Thermal loads are linked to the flow of heat into and out of a building, serving as a critical factor in determining thermal comfort for occupants (Elghamry and Hassan, 2020). Several design aspects of a building, such as the thermal transmittance of its exterior walls, significantly impact heat flow (Latha et al., 2015). Additionally, design choices related to the building's exterior envelope, fenestration systems, and lighting can influence heat flow. Lighting fixtures, in particular, emit heat that often becomes trapped within the building structure, increasing cooling requirements and overall energy consumption (Hammad et al., 2021).

Current efforts to enhance the energy efficiency of buildings draw from past design experiences to determine suitable design parameters (Mirrahimi et al., 2016). However, this approach may yield suboptimal solutions due to the intricate interplay of various design parameters, resulting in a complex and combinatorial decision-making challenge. Despite the existence of advanced energy simulation software for evaluating building energy efficiency, simulations remain time-consuming and are prone to iterative workflows that may not yield optimal design solutions (Delgarm et al., 2016; Samadi et al., 2020).

It is crucial to consider how a building's energy performance can be enhanced from the early stages of the design process (Crawley et al., 2008). Achieving this goal requires the integration of various design considerations that extend beyond thermal loads and heat gains. Other factors that directly influence a building's operational energy performance include window size and the choice of lighting systems. Windows, for example, can significantly impact a building's heating and cooling demands, with up to 40% of heating energy lost and up to 87% of heat gained through windows (Cuce, 2017; Gutiérrez et al., 2019). Improving the thermal performance of windows leads to reduced energy costs and lower greenhouse gas emissions (Lolli and Andresen, 2016). Daylight is also a critical aspect of building design as it directly affects visual comfort, reduces the reliance on artificial lighting, and enhances the well-being of occupants (Hafiz and Mhatre, 2020; Turan et al., 2020).

Chapter Three

Research Methodology

3.1 Research Design

Research design can be defined as the structuring of investigation aimed at identifying variables and their relationship with one another (Bloomfield *et al*, 2019). The research design adopted for the work is cross-sectional adopting a survey research method. The survey research design aims at collecting data on a phenomenon and describing it in a systematic manner, the characteristics, features or facts about a phenomenon. For this study, the case study research approach was adopted.

A graphical outline of the research design is illustrated in Figure 3.1 below:

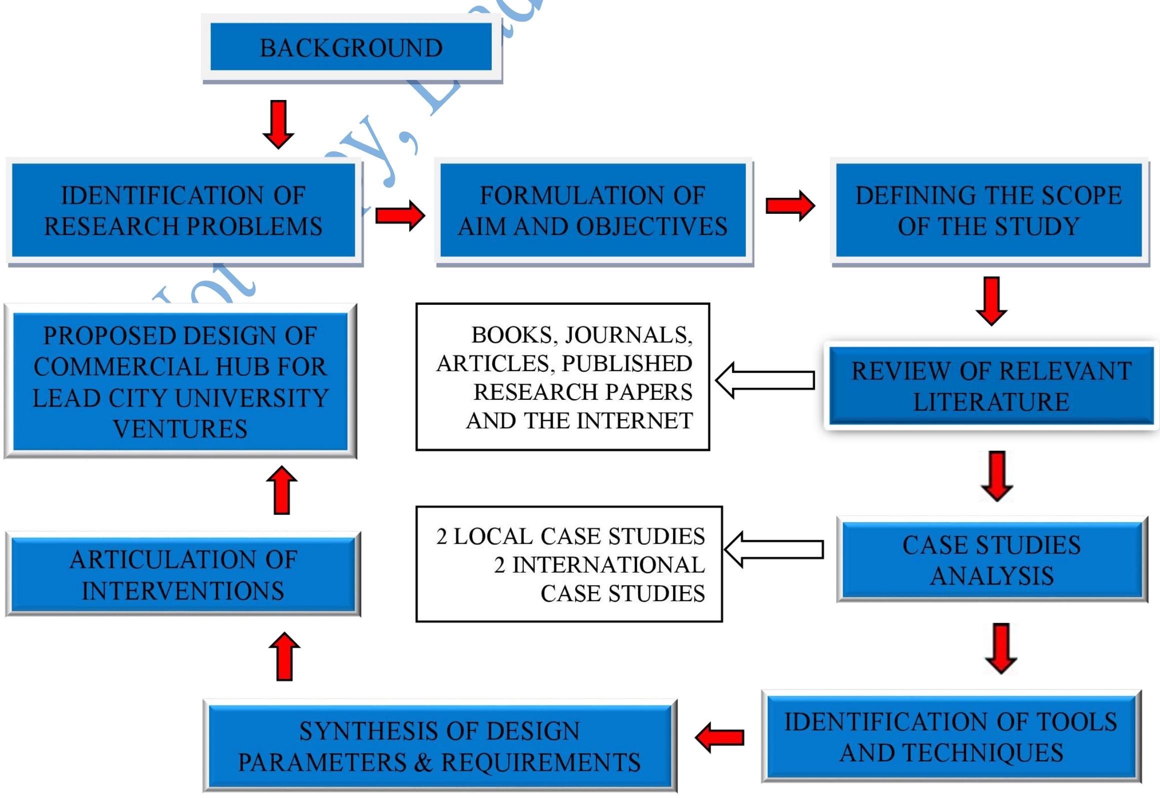

Figure 3.1: Research Design
Source: Fieldwork, 2023

3.2 Case Study Approach

Case study research is commonly categorized as a form of qualitative research. Qualitative case study research stands in contrast to quantitative research, which centres on numerical data and employs statistics to address research inquiries (Antwi et al., 2015). In qualitative research, investigators rely on non-numerical data, such as responses to interview questions, to address research queries. Case study research also distinguishes itself from research carried out through experiments. In case study research, the conditions and context of the setting are integral to the research, and the researcher does not exclude or control for these factors, as is done in experimental research (Gabble, 1994).

The case study research method serves various purposes, including describing and analysing the structure, variables, forms, and interactions among participants in a situation (theoretical purpose) or assessing the performance of work or progress in development (practical purpose) (Williams, 2007). It also involves an in-depth exploration from multiple perspectives of the complexity and uniqueness of a specific project, policy, institution, program, or system. A case study is a suitable tool for examining situations where it is analytically challenging to separate the phenomenon from its context (Yazan, 2015). It can serve as the foundation for any project or act as a reference point to facilitate the clear explanation of the project.

A case study can focus on an individual, a group, an organization, or an event (Yates and Leggett, 2016). Case study research can be employed to develop new theories, extend existing ones, challenge conventional theories, and conduct pilot research. It is particularly useful for comprehending complex issues in their real-life settings and often aims to grasp the perspectives of participants in those settings. In this particular instance, the primary motivation for adopting the case study approach is to investigate and understand the architectural concepts employed in the design of a specific project and how they performed, with the objective of learning from both its successes and shortcomings to provide a comprehensive body of knowledge for informing future design projects.

The fundamental purpose of a case study is to address a research question through thorough investigation and analysis, relying on detailed descriptions rather than statistical data (Darke et al., 1998). An essential element of qualitative research involves conducting observations that yield insights into reality. In applying the case study method, two major approaches are often used to collect data: document review and fieldwork. For this study, document review (including plans, sections, elevations, details, and other drawings, along with photographs) was conducted for international case studies, complemented by fieldwork involving physical observations for the local case studies.

3.3 Existing Facilities in Lead City University

Lead City University is a private tertiary institution situated in the southern fringe of the city of Ibadan which is the capital of Oyo State. It is located in Oluyole Local Government Area and is an important hub of educational and commercial activities. The locational image of Lead City University is depicted in Figure 3.2. The main entrance gate of the university is captured in Figure 3.3.

Figure 3.2: The locational image of Lead City University
Source: Fieldwork, 2023

Figure 3.1: Lead City University Main Entrance
Source: Fieldwork, 2023

There is an existing building used by the Lead City bakery, which also houses a cafeteria, ATM machine, and other shopping activities (Figures 3.4 and 3.5). The building is adjoined by the Adeline Hall (a multi-purpose hall); a female hostel, central car park, and the sports complex. The approach and rear views of the building are captured in Figure 3.6 -3.9).

Figure 3.3: Lead Bakery
Source: Fieldwork, 2023

Figure 3.4 Interior of Lead Bakery
Source: Fieldwork, 2023

Figure 3.5: Front view
Source: Fieldwork, 2023

Figure 3.6: Front/right side view
Source: Fieldwork, 2023

Figure 3.7: Rear view
Source: Fieldwork, 2023

Figure 3.8: Rear view
Source: Fieldwork, 2023

The building was originally designed as a student cafeteria but was later converted to accommodate other uses. The building comprises a fashion design training centre (Figure 3.10), lock-up shops (Figure 3.11), ATM points, cafeteria (Figure 3.12), and a bakery (Figure 3.13).

Figure 3.9: Fashion Training Unit
Source: Fieldwork, 2023

Figure 3.10: Lock-up shop
Source: Fieldwork, 2023

Figure 3.11: Cafeteria
Source: Fieldwork, 2023

Figure 3.12: Bakery
Source: Fieldwork, 2023

3.4 Case Study Analysis

Case study analysis is an appropriate tool to observe situation where the phenomenon and its context are hard to separate analytically (Yazan, 2015). For instance, a building cannot be separated from its site and the environment where it is situated. Therefore, case study analysis forms the starting point of any project as it provides background knowledge of the design context through the examination of similar existing projects and contexts.

For this study, two international case studies and two local studies were examined. the cases were selected purposively in order to provide baseline knowledge for the proposed design based on similar existing projects. The case studies selected for this study are listed below.

i. U.I. Ventures, University of Ibadan, Ibadan, Nigeria
ii. Ventures Building, Landmark University, Omuaran, Nigeria
iii. The Teras Park Mall, Turkey
iv. Rancho Cielo Vocational Center, San Diego, United States

3.4.1 U.I. Ventures, University of Ibadan, Ibadan, Nigeria

3.4.1.1 Physiographic Description

The University of Ibadan (UI) Ventures is situated in the main campus of the University of Ibadan located in the Ibadan North Local Government Area of Ibadan, Oyo State, Nigeria. The UI ventures comprises a water production factory (Figure 3.14) and a printery (Figure 3.15).

Figure 3.13: UI Water Enterprises
Source: Fieldwork, 2023

Figure 3.14: Ibadan University Printery
Source: Fieldwork, 2023

The water enterprises consist of a factory building (Figure 3.16), and a sales and administration building (Figure 3.17) with different architectural design features and elements.

Figure 3.15: UI Water Factory
Source: Fieldwork, 2023

Figure 3.16: UI Water Sales / Administration Building
Source: Fieldwork, 2023

3.4.1.2 Design Characteristics

The UI Ventures buildings are very easy to locate and are situated directly off the entrance road from the second gate of the university. Good ventilation was observed through good plan widths and adequate openings on the building envelope. Good lighting was observed in the buildings as a result of the orientation of the buildings and the provision of adequate openings to take advantage of daylighting.

The combination of soft and hard landscape (Figure 3.18) enhanced the visual appeal of the site and contributed to reducing the glare from solar radiation. The site boasts of efficient access and exit to the printery and the sales and distribution points for water. High quality finishes were observed on the walls and floors. Ample consideration for circulation was observed for vehicular and human traffic (Figure 3.19).

Figure 3.17: UI Ventures (Bakery) showing soft and hard landscape
Source: Fieldwork, 2023

Figure 3.18: UI Water Factory Sales Outlet and Distribution Trucks
Source: Fieldwork, 2023

3.4.2 Ventures Building, Landmark University, Omuaran, Nigeria

3.4.2.1 Physio graphic Description

The ventures building of Landmark University, Omuaran, Kwara State, Nigeria consists of a water production factory and a university bakery. The water production factory buildings were designed with a combination of vaulted and pitched roofs with aluminium fascia cladding characteristics of industrial buildings (Figure 3.20). The bakery was designed with pitched roofs with less emphasis upon the aluminium fascia cladding of the water production factory (Figure 3.21).

Figure 3.19: Landmark Water Production Factory
Source: Fieldwork, 2023

Figure 3.20: Landmark Bakery
Source: Fieldwork, 2023

3.4.2.2 Design Characteristics

The plans, sections and elevations of the Landmark University water production factory (Figures 3.22 to 3.24) indicated that the building was purposely designed and built as a factory building. This is evident in terms of the site layout, spatial configuration, floor-to-ceiling-height, choice of steel roofing trusses and long span aluminium roofing.

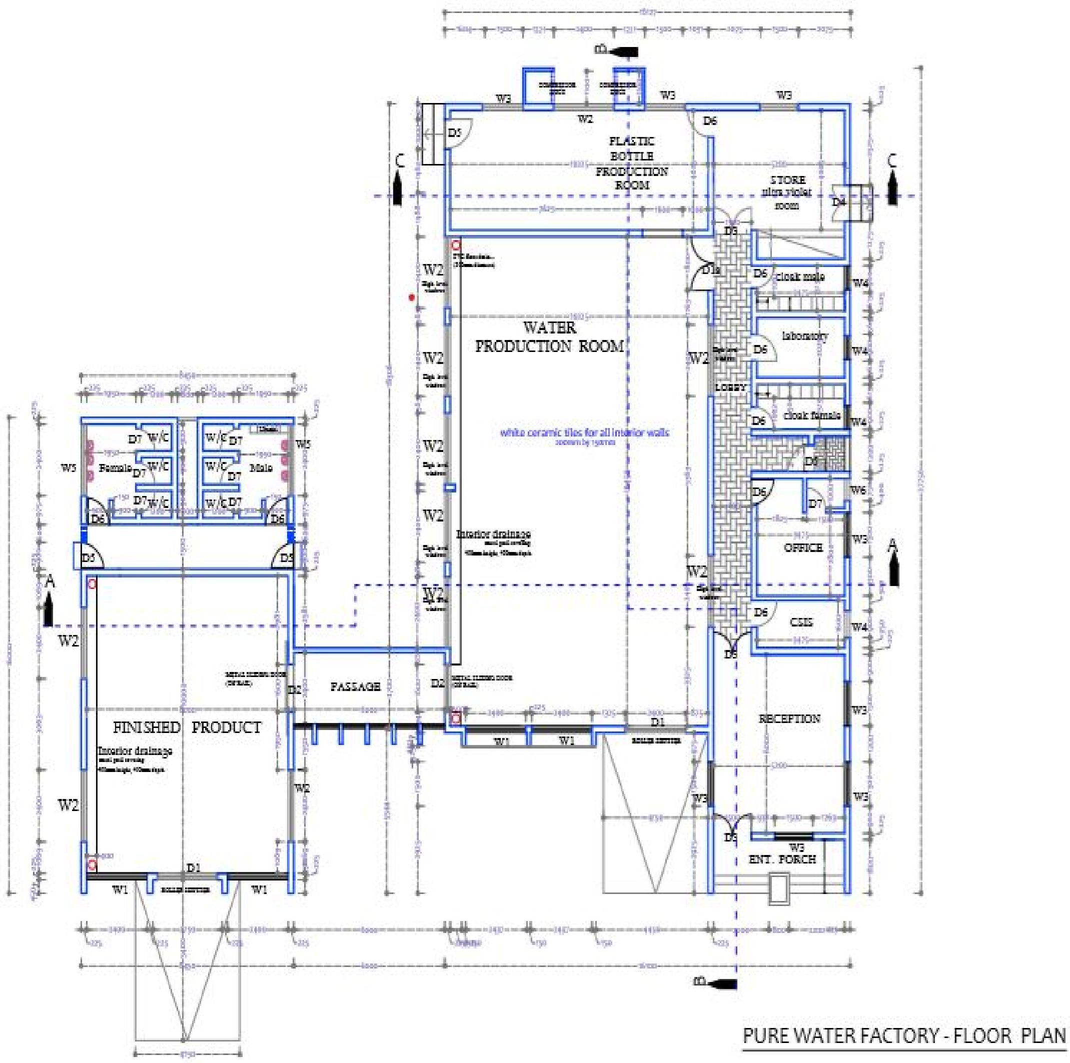

Figure 3.21: Floor Plan of Landmark water factory
Source: Fieldwork, 2023

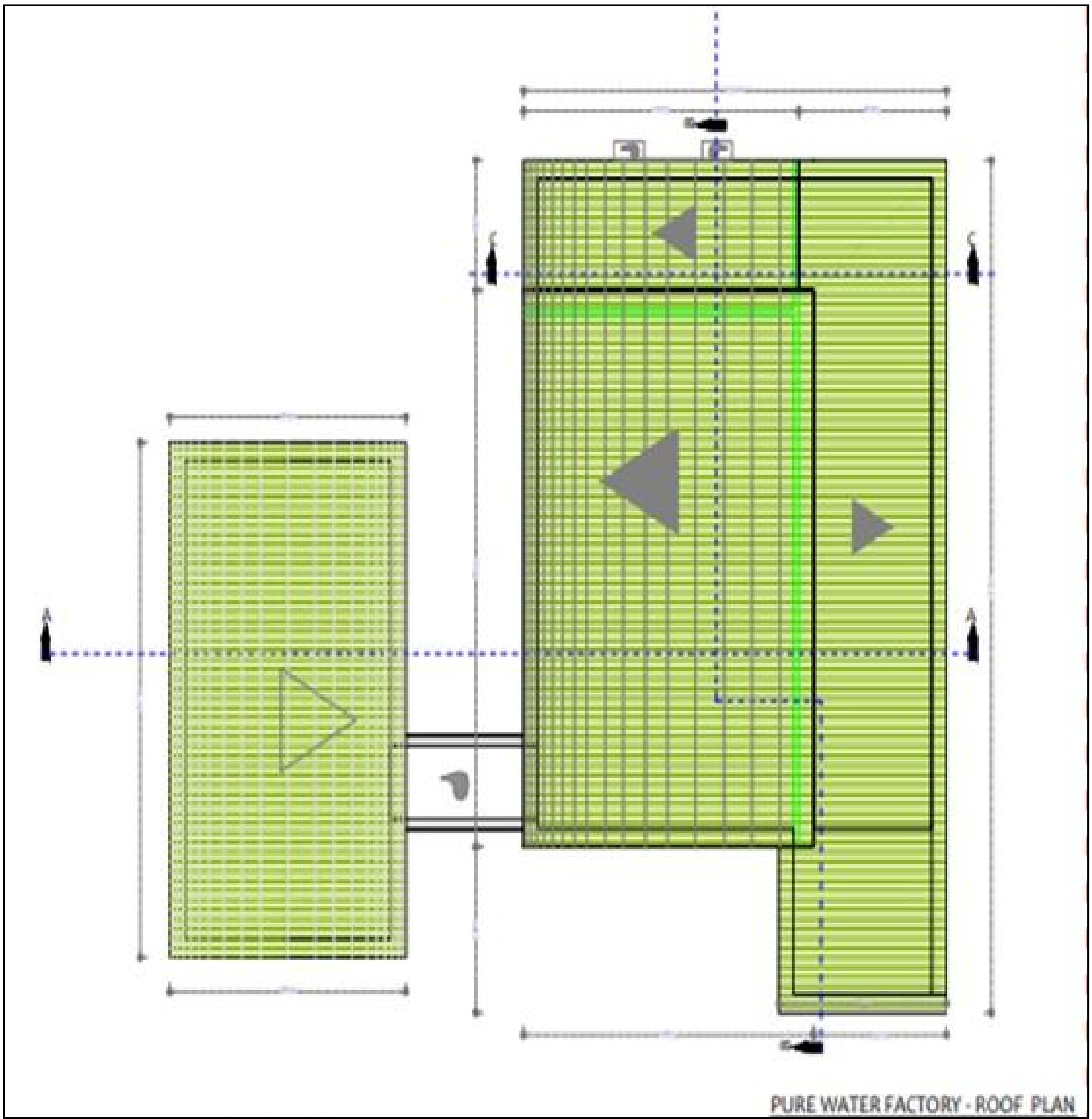

Figure 3.22: Roof Plan of Landmark water factory
Source: Fieldwork, 2023

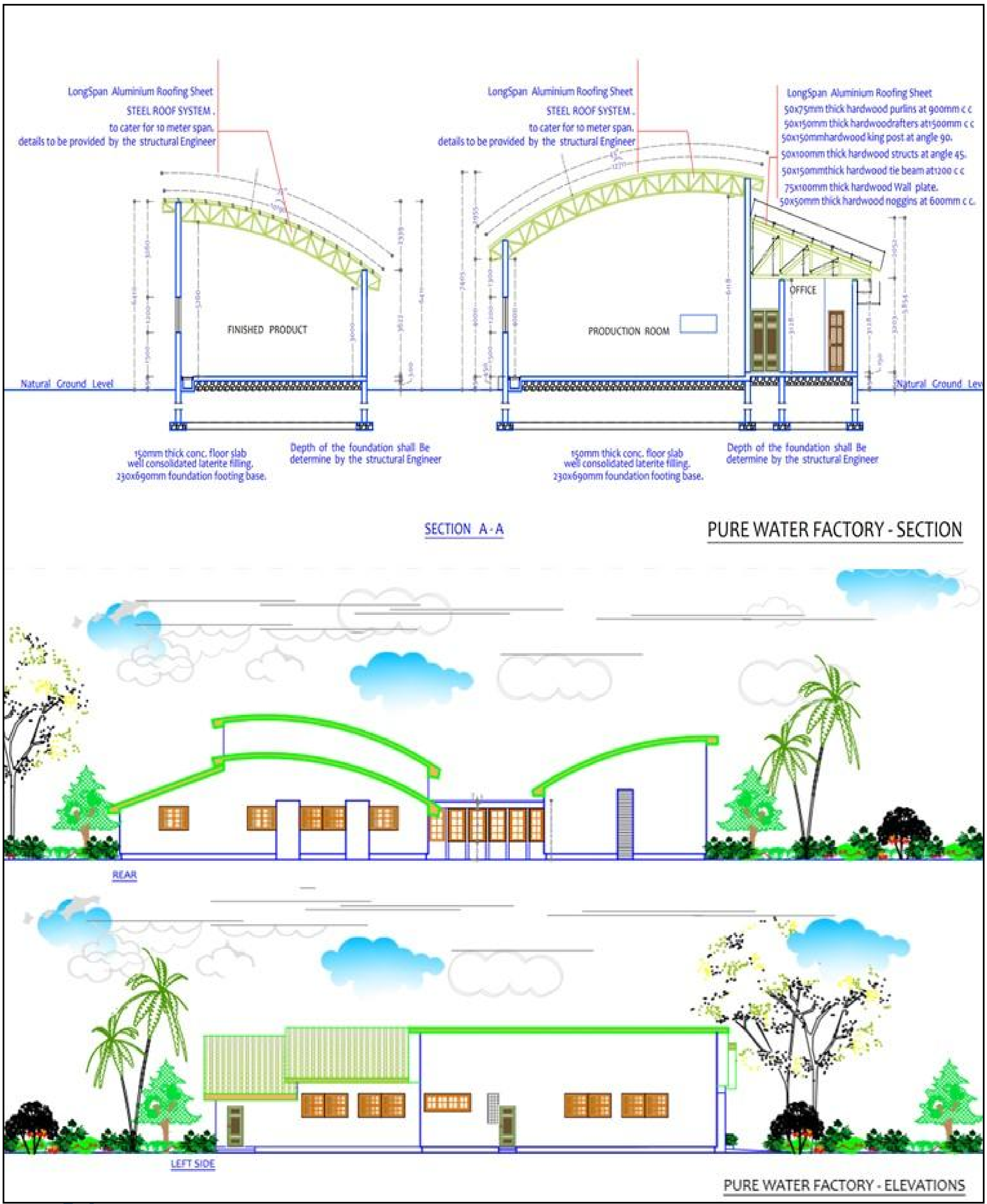

Figure 3.23: Sections and elevations of Landmark water factory
Source: Fieldwork, 2023

Adequate consideration was given to natural lighting and ventilation based on the fenestration on the buildings which consisted of several well designed and sized openings in the water factory building (Figure 3.25) and the university bakery (Figure 3.26).

Figure 3.24: Adequate openings of Landmark water factory
Source: Fieldwork, 2023

Figure 3.25: Adequate Openings of Landmark Bakery
Source: Fieldwork, 2023

3.4.3 Rancho Cielo Vocational Center, San Diego, United States

3.4.3.1 Physiographic Description

The Rancho Cielo Vocational Center is situated in Santa Fe County, San Diego, California, United States of America. It is also known as the Ted Taylor Center. The site character of the vocational centre is visually appealing (Figure 3.27) and the building form combines an intricate combination of geometrical forms (Figure 3.28).

Figure 3.26: Perspective Site View of Rancho Cielo Vocational Center
Source: Fieldwork, 2023

Figure 3.27: Aerial View of Rancho Cielo Vocational Center
Source: Fieldwork, 2023

3.4.3.2 Design Characteristics

The Rancho Cielo Vocational Center was observed to have effective natural ventilation and lighting as a result of a number of design elements and features. The vocational center was designed with an expansive floor layout to take advantage of natural lighting and ventilation and also provide for efficient circulation (Figure 3.29).

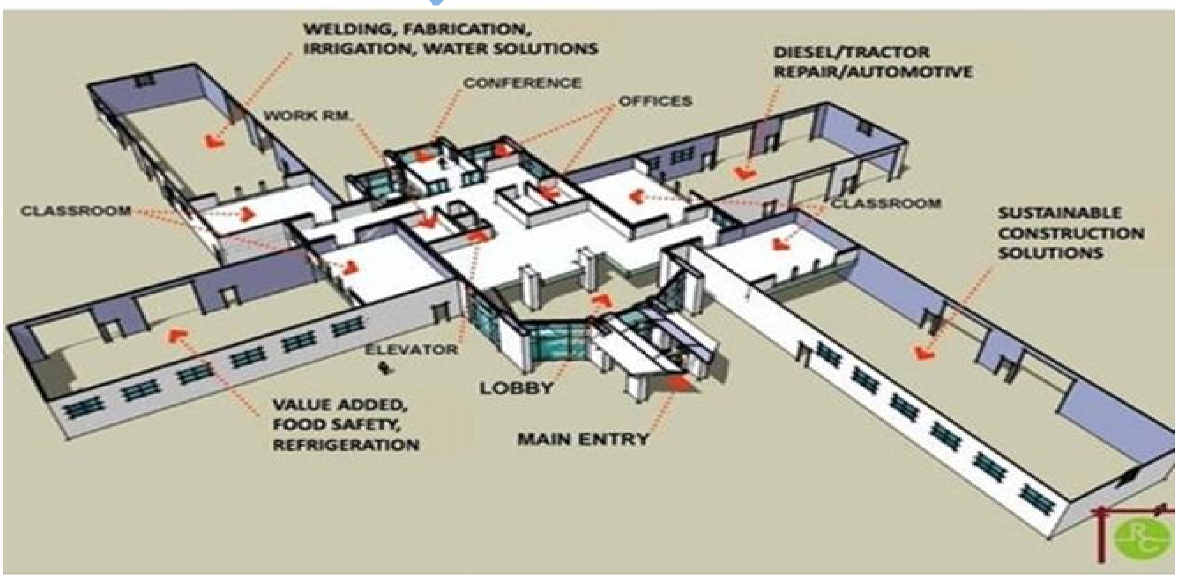

Figure 3.28: Layout of Rancho Cielo Vocational Center
Source: Fieldwork, 2023

The construction of the vocational centre adopted a combination of timber and steel fabrication techniques (Figure 3.30). The pitched roof was designed to maximize natural lighting and ventilation through the introduction of roof monitors standing above the traditional roof at the centre and angled to take advantage of solar radiation (Figure 3.31). The site was well landscaped with a combination of both man-made and natural landscape elements.

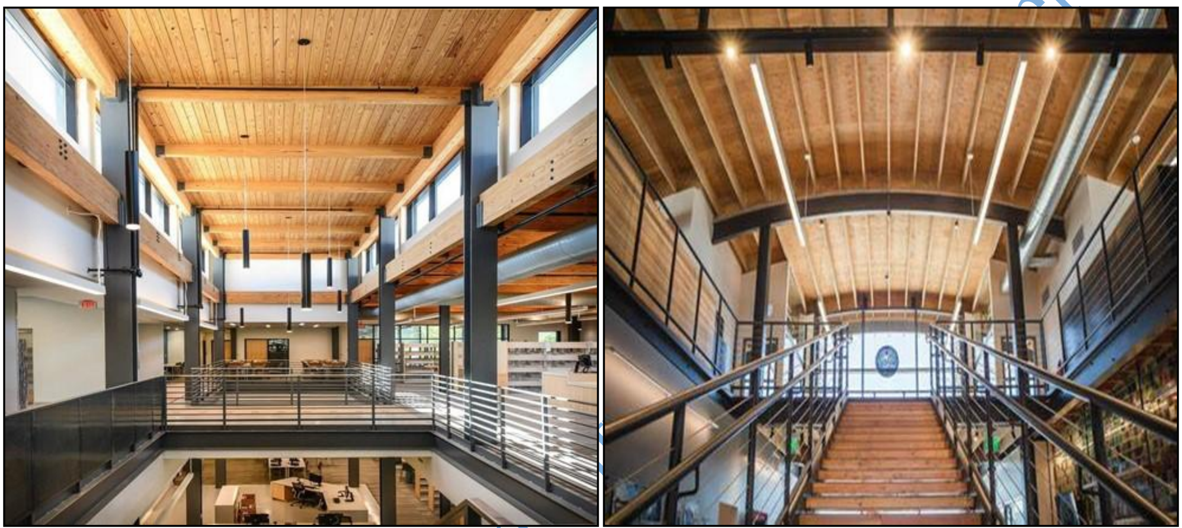

Figure 3.29: Timber and Steel Construction of Rancho Cielo Vocational Center
Source: Fieldwork, 2023

Figure 3.30: Roof Lighting of Rancho Cielo Vocational Center

Source: Fieldwork, 2023

3.4.4 The Teras Park Mall, Turkey

3.4.4.1 Physiographic Description

The Teras Park Shopping Mall is situated in Denizili, Turkey. It is an enclosed shopping mall located in Denizili which is a growing industrial city in the Southwestern part of Turkey. The city of Denizili is notable for textile manufacturing and exports and attracts thousands of visitors all year round. The Teras Park Shopping Mall has a total indoor space of 95,310 square metres and a leasable floor space area of 46,500 square metres with a total vehicular parking space that can accommodate 1,500 vehicles.

The Teras Park Shopping Mall is a very large shopping mall as can be observed in its floor layouts (Figure 3.32). The shopping mall has 150 shops, 15 fast food restaurants, coffee houses, spa and fitness centres and several office accommodation spaces. It is an enticing piece of architecture as revealed in its façade (Figure 3.33).

Figure 3.31: Floor Layout of Teras Park Shopping Mall
Source: Fieldwork, 2023

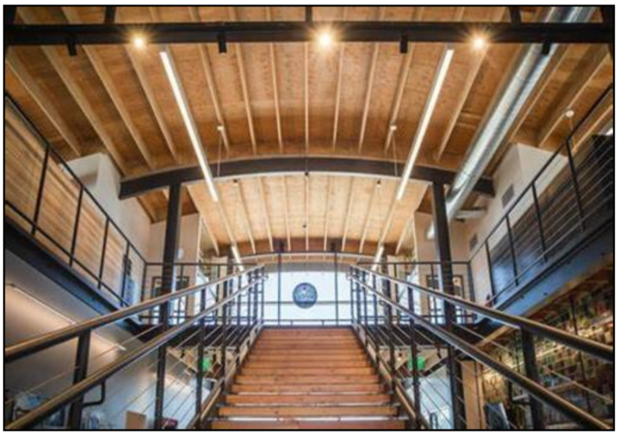

Figure 3.32: Exterior view of Teras Park Shopping Mall
Source: Fieldwork, 2023

3.4.4.2 Design Characteristics

The design of the shopping mall eschews a combination of contemporary concrete and glass construction technology and materials. The shopping mall attracts about 12,000 visitors daily and this volume of users have to have effective means of circulation which is evident in the escalators and lifts in the shopping mall (Figure 3.34).

Figure 3.33: Interior view of Teras Park Shopping Mall
Source: Fieldwork, 2023

3.5 Deductions from the Case Studies

The word "ventures" is generally used for the business arm of Nigerian universities. It was observed that more than 90% of Nigerian universities commence their ventures with a water production factory. Only a few of the university ventures are designed to encompass all the business activities of the university even though they are all designed to accrue internal generated revenue. Most of the ventures have their business arms sited differently based on their functions (Agboli *et al*, 2006).

In Nigerian universities, ventures are quite separated from the academic affairs with its independent administrative control. The immediate university environment tends to benefit from most of these ventures in term of employment, businesses and services. Ventures tend to ease unwanted stress off the shoulders of the students, lecturers and the other university staff by bringing necessary shopping goods and services closer to them. Ventures also serve as a publicity medium for the university to its immediate environment as the goods and services provided tend to go beyond the university boundaries into its immediate environment (Bartell, 2003).

The analysis of the design considerations highlights areas that may affect the requirement, design, or operational concept of a building, they are articulated to broaden the architect's applications of the basic principles and requirements which enable a building or facility to serve its anticipated functions. They can also be used to identify barriers to functionality in existing buildings. These considerations are intended as a design guideline and planning tool (Bunz *et al*, 2006). It is recommended that buildings and communal facilities, especially those frequently accessed by the public or intended for commercial/business purposes should take into account the content of these considerations from the inception design stage where they can be easily implemented.

Based on the case study analysis, some factors to be considered while designing a commercial hub for a university include the following:

- Detailed spatial provision guided by Literature Review and Case Study Analysis.
- Promotion of new trends and innovations with emphasis on technology.
- Analysis of site constraints to promote horizontal or vertical distribution of spaces and maximization.
- Efficient zoning of spaces and activities to facilitate construction in phases.
- Appropriate compartmentalization and the adoption of modular coordination principles.
- Adequate consideration for fire safety and COVID-19 protocols.

Chapter Four

Site Analysis and Design Synthesis

4.1 The Study Area

The proposed design project is situated in Lead City University, Ibadan, Nigeria. Nigeria is a country situated on the African continent on the west coast as illustrated in Figure 4.1. The country shares boundaries with Niger Republic to the north, Chad and Cameroun to the East, the Republic of Benin to the west, and the Gulf of Guinea – the Atlantic Ocean – to the south.

Figure 4.1: Location of Nigeria in Africa
Source: Ministry of Lands, Ibadan

The city of Ibadan where the project site is situated lies on Latitude $7^{o}3^{1}$ North to $7^{o}4^{1}$ and Longitude $3^{o}8^{1}$ East to $3^{o}9^{1}$ at the fringe between the rain forest and savannah region of

Nigeria which falls within the warm humid zone. Ibadan is the capital city of Oyo State in southwest Nigeria which shares boundaries with Lagos, Ogun, Osun and Kwara States in Nigeria and Benin Republic to the west as shown in Figure 4.2.

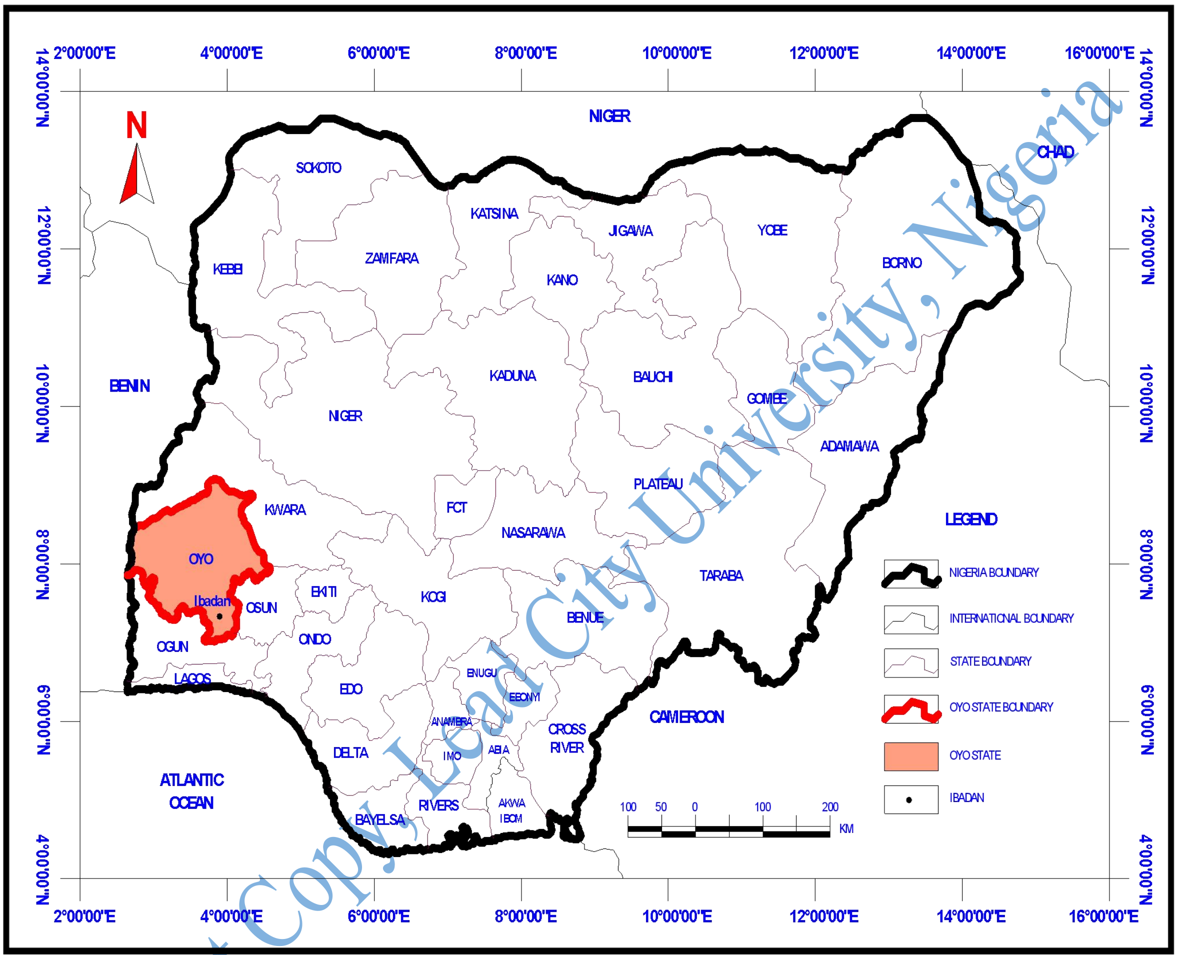

Figure 4.2: Location of Ibadan and Oyo State within Nigeria
Source: Ministry of Lands, Ibadan

Ibadan is surrounded by seven hills with elevations from 150 metres in the valley area, to 275 metres above sea level on the major north-south ridge which crosses the central part of the city. Ibadan consists of eleven local government areas (LGAs) with five in the inner-city/metropolis and six in the outer-city (Figure 3.3). Ibadan metropolis (the core of the city comprising five LGAs) covers an area of 250 square kilometres while the Ibadan Region's total area is 3,080 square kilometres. It is a prominent transit point between the coast and the hinterland. Its population is estimated to be about 3,800,000. Ibadan was the centre of administration of the old Western Region of Nigeria since British colonial rule. The principal inhabitants of the city are the Yoruba.

The city is home to several academic and research institutions. The first university to be set up in Nigeria is the University of Ibadan founded in 1948. It has the distinction of being one of the premier educational institutions in Africa. Other noteworthy institutions in the city include the University College Hospital; the first teaching hospital in Nigeria, Cocoa Research Institute of Nigeria and the internationally acclaimed International Institute of Tropical Agriculture (IITA).

4.1.1 Site Location

The project site is located along the Oba Otudeko Avenue, adjacent to the Lead City University Campus, off the Lagos-Ibadan dual carriage expressway at the old Lagos toll gate, Ibadan. Lead City University which is the pivot of this study is situated in the southern part of Ibadan in Oluyole Local Government Area as illustrated in Figure 4.3.

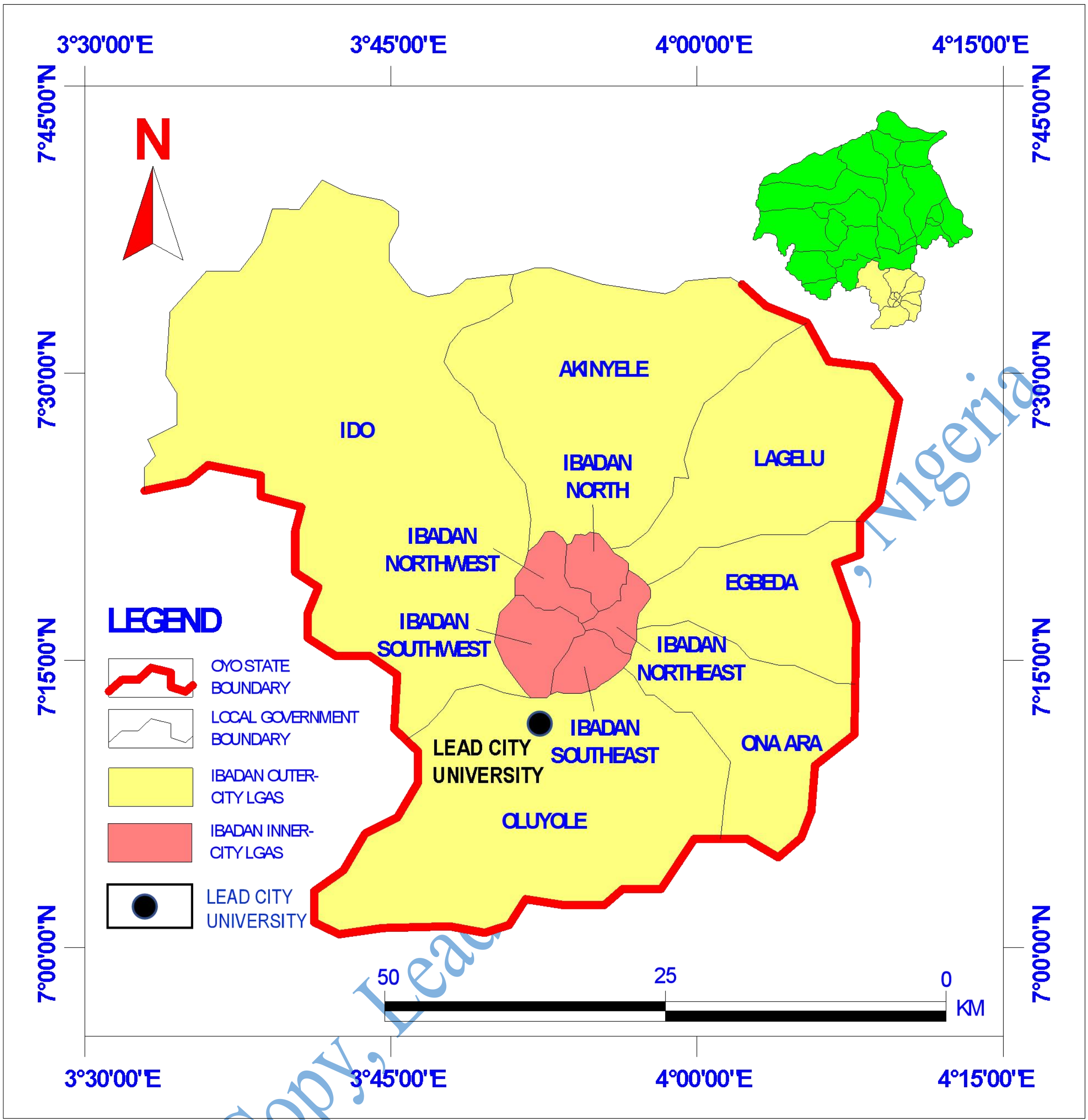

Figure 4.3: Local Government Map of Ibadan showing the location of Lead City University

Source: Ministry of Lands, Ibadan

4.1.2 Site Selection Criteria

A number of criteria were identified to analyze the suitability of the selection of the proposed site for the Commercial Hub for Lead City University, Ibadan, Nigeria. Some of the important criteria analysed include the following criteria discussed below.

Availability of Land

The choice land selected has commercial activities presently taking place. Though some unplanned shops will be demolished and cleared off site to accommodate the proposed ventures.

Site Location

The site is located directly opposite the school main entrance gate which will make good patronage possible and also helps to create a serene environment for both members of the university and the immediate university environment.

Site Accessibility

The site has easy and convenient access for both vehicular and pedestrian. The proposed site for Ibadan shopping mall has four roads around it.

Possibility of Expansion

The site is suitable to conveniently accommodate the commercial venture. This is as a result of the size of the site which will allow for the creation of adequate vehicular parking spaces and other facilities needed for the smooth running of the ventures. Possible expansion and extension of the proposed ventures made possible by the availability of ample area of land at the back of the site which can serve as spaces for future expansion.

Site Topography

The site has a relatively flat topography but slopes gently from the centre of the site to the eastern and western ends of the site.

Vegetation

The site is characterized with a very few green vegetation and shrubs. No serious green area, as ample commercial activities are presently taking place.

Nearness to Utilities

The site has adequate access to basic infrastructure, for example, good road connectivity and access, drainage, electricity power transmission lines and installations, telecommunication facilities, security, and others.

4.1.3 Site Analysis

An understanding of the site and its potential is an analytical process before the business of designing can get under way. There are obvious physical characteristics like contour and climate, for example, which may stimulate creative imagination but first it is imperative to comprehend the 'sense of place' which the site itself communicates. It is necessary therefore, to have some understanding of the locality, its history, its social structure and physical patterns or 'grain', so that the form and density of the proposed interventions are appropriate.

The following questions will generate ideas from the analysis of the site that will influence the proposed design:

- How for instance will the site's topography suggest patterns of use?
- Is the utility of concentrating activity on the level areas of the site overridden by concerns for maintaining mature planting or avoiding overshadowing?
- Are gradients to be utilized in generating the sectional organization of the building?
- How will the building's physical form respond to and moderate the climate?
- Is it important to maintain existing views from the site or will the building construct its own inward-looking prospect?
- How do site access points respond to an existing infrastructure of vehicular and pedestrian routes?
- How will access to the site be effected and how can the placing of buildings reduce roads and site works to a minimum whilst allowing for easy circulation of people and vehicles?

- Where are existing services to the site located?

4.1.3.1 Site Inventory and Characteristics

At the design stage, there are a set of parameters which should guide the selection of a site for any development. These parameters ensure that the choice of the site is appropriate for the proposed project through a detailed site analysis. Some of the parameters analyzed include:

- Climatic Factors;
- Topography and Drainage;
- Locational Attributes;

The illustration of the site analysis that examined the trajectory of the sun, the directions of predominant winds, the orientation, adjoining buildings and facilities as well as access is depicted in Figure 4.4.

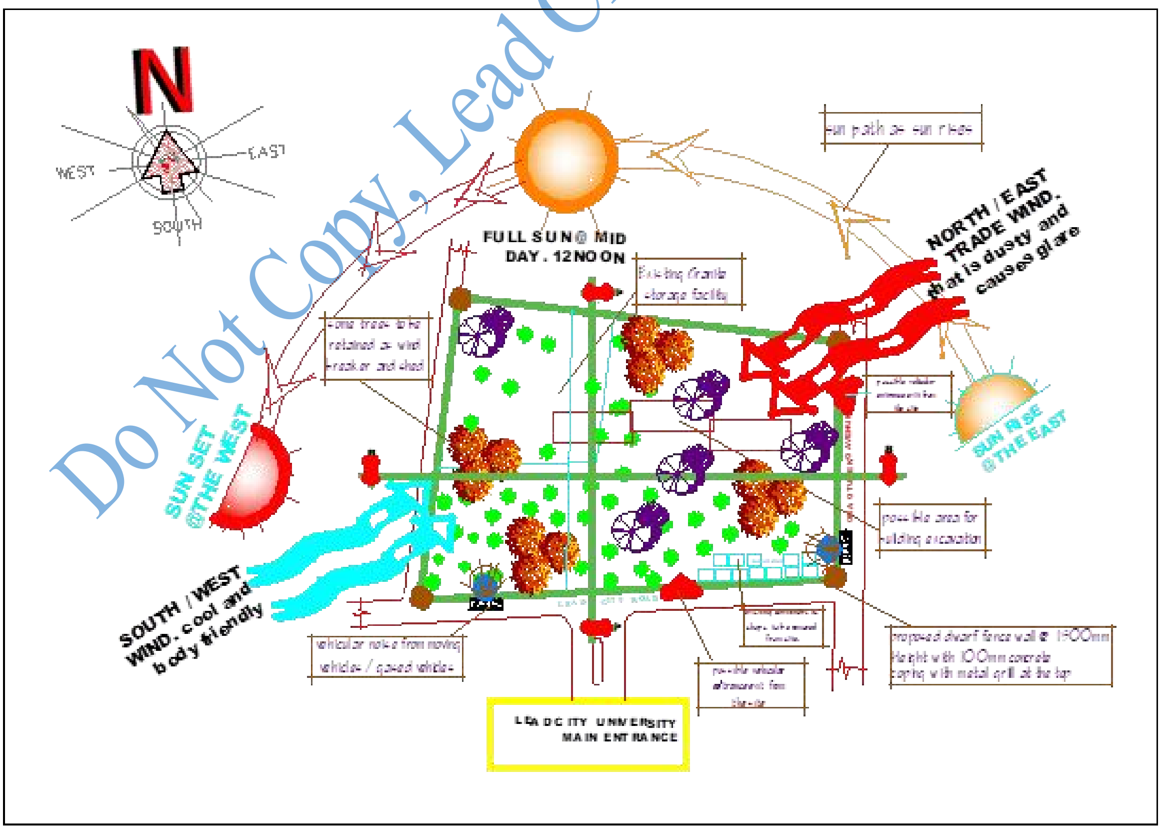

Figure 4.4: Site Analysis

Source: Field work, 2023

Climatic Factors

The Southwest trade wind with dominance for approximately eight months in a year and the North-East trade winds which is relatively influential for approximately four months in a year are the two predominant driving factors influencing the seasonal changes. As such, there are two distinct seasons; the wet or rainy season from March to October (eight months) and the dry or harmattan season from November to February four months). The wet season occurs in two spells with the heaviest rains falling from April to July and a weaker rainy season in October and November with a brief dry spell in August. The peak rainfall period is between June/July and December/October.

There is presence of heavy rainfall during the wet season and a mean temperature all year round of over 29°C with average daily temperature reaching 31°C during the hot season. In order to combat the effect of solar radiation, shady trees, shrubs and grasses are proposed to be planted to convert the hot breeze to cool breeze. Adequate opening sizes that are appropriately positioned will enhance adequate air movement in the interior spaces to keep the inhabitants of the spaces thermally comfortable. Building will also be orientated such that shorter area of the building is affected by solar radiation.

Wind speeds in the area are generally low but may reach 16.1km/h. There is cold dusty harmattan wind from the North-East which brings about discomfort. On the other hand, the South-West trade wind brings cold humid wind. To maximize these prevailing winds to the advantage of the building, adequate ventilation through the use of appropriate sizes of opening is of essence. Also, orientation of the building such that the harsh effect of weather on the structure is minimized while taking advantage of the south west trade wind.

Topography and Drainage

The topography of the site is relatively flat, however, there is a gentle slope observable from the centre of the site to the eastern and western ends of the site. The site sections captured in Figure 4.5 further indicate that the site enjoys a relatively gentle slope. The soil condition is relatively stable with good bearing capacity. This will make it suitable for the three-floor proposed building. Isolated pad foundation is a suitable foundation type for this project.

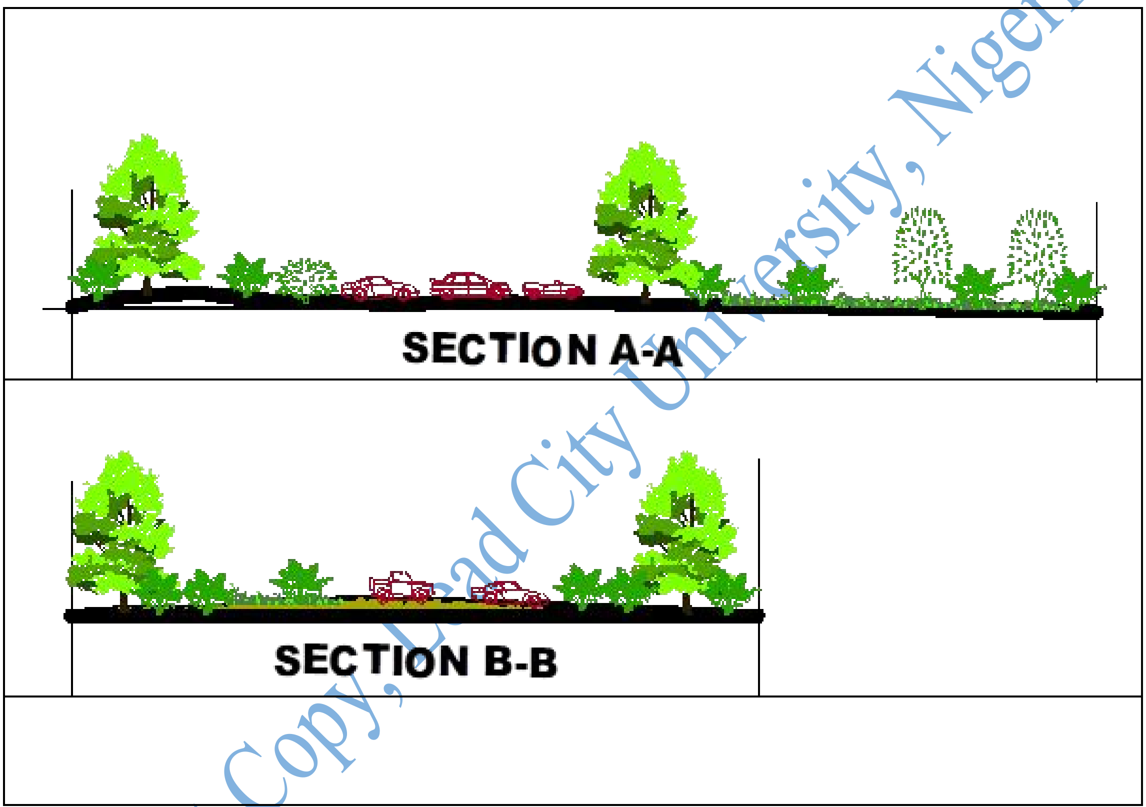

Figure 4.5: Site Sections
Source: Fieldwork, 2023

Drainage channels will be designed such as to take advantage of the gentle slope and drainage will be constructed in the same direction as the slope of the site. The relatively negligible slope of the site is an advantage because a relatively flat terrain is preferable for this proposal as it reduces the overall cost of the project and eliminates some of the constraints associated with sharp gradients.

Locational Attributes

The site is bounded by Oba Otudeko Avenue and the setback between the Lagos – Ibadan dual carriage federal highway and Oba Otudeko Avenue to the East, the Lead City University Campus to the North and the TSPC College to the west of the site as illustrated in Figure 4.6.

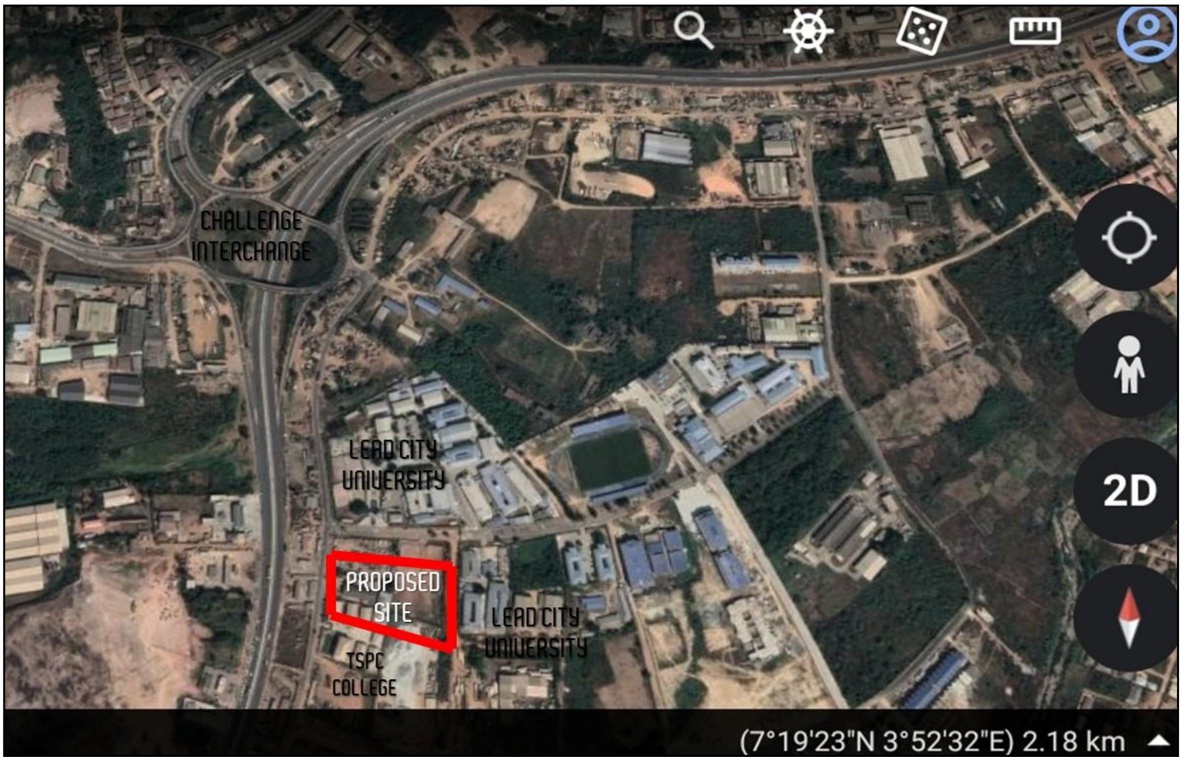

Figure 4.6: Satellite Image of Site Location
Source: Google Earth, 2023

The site therefore enjoys easy accessibility and flow of vehicular traffic as the project site can be accessed through its northern and eastern boundaries that are situated off the Oba Otudeko Avenue and the Lead City University dual carriage access road respectively.

Some of the identified adjoining facilities the proposed site enjoys within a 1-km radius includes a number of vehicle service and filling stations, industrial complexes, electricity power transmission lines and installations, health facilities (Lead City University Teaching Hospital), Police station, offices of government agencies and parastatals, and other public institutions.

4.2 Project Analysis and Design Synthesis

According to the Economist Journal (2017) commercial hub or simply mall is one or more buildings forming a complex of shops representing merchandisers, with interconnecting walkways enabling visitors to walk from unit to unit. Other establishments including movie theatres and restaurants. Commercial as an activity, process and system has improved considerably in recent times with new forms, styles and formats responding to demands for convenience and easy access physically and online. There has been the rise and dominance of shopping malls and ensembles with distinct brands and sophistication. It has been affirmed that over one-thirds of the energy used in buildings are utilized for lighting. Energy consumption in commercial hub which have huge volumes and great number of users can be decreased by using day lighting. Considering the volume, function and user amount of the public spaces of shopping malls, considerations for the use of daylight becomes imperative.

Over the years there has been a high dependence on artificial lighting in Nigeria which has not been reliable due to poor power supply and large expenses incurred on generator sets in the long run. Admitting daylight into areas of commercial malls help to reduce possible occurrence of accidents as a result of power outages especially areas of circulation and savings are made on a project when daylight is admitted into critical areas of the shopping mall. As such, asides the functional and aesthetic considerations which guide the project and design synthesis, the application and utilization of daylighting is a significant parameter accorded importance in the design synthesis.

The proposed project design of a commercial hub is expected to increase the school internal generated income by the artful integration, concentration and agglomeration of a number of focal activities articulated in Figure 4.7. The design proposal is conceptualized to be spread on not more than three floors on a 36,191 square metres land directly opposite the Lead City University main entrance gate.

Figure 4.7: Design Synthesis
Source: Fieldwork, 2023

4.2.1 Brief Analysis

From the series of case studies that were carried out at various case studies on ventures both locally and foreign, appraisal of these case studies is improved upon for the proposed design. The proposed ventures that will also serves as commercial center will be a hub of activities for the people of Lead City University and the immediate university community and Ibadan at large. The proposed design is set to be purpose-built adopting existing national and international standards to effectively reflect an approach directed towards the achievement of sustainability, flexibility and originality.

Over the years there has been a high dependence on artificial lighting in Nigeria which has not been reliable due to poor power supply and large expenses incurred on generator sets in the long run. Admitting daylight into areas of commercial malls help to reduce possible occurrence of accidents as a result of power outages especially areas of circulation and savings are made on a project when daylight is admitted into critical areas of the shopping mall.

The design is pivoted upon some guiding principles that convey a welcoming atmosphere with easy access and circulation. It will strengthen the community, respect the history, heritage and culture of the people, and evolve with needs and changes. The guiding principles is further conceptualized upon the tenets of purpose, function and contributions to society as reflected in Figure 4.8. The aim of this project is to design a commercial hub for Lead City University, Ibadan with a view to enhance the efficient and effective use of Daylight through the adoption of innovative passive design strategies.

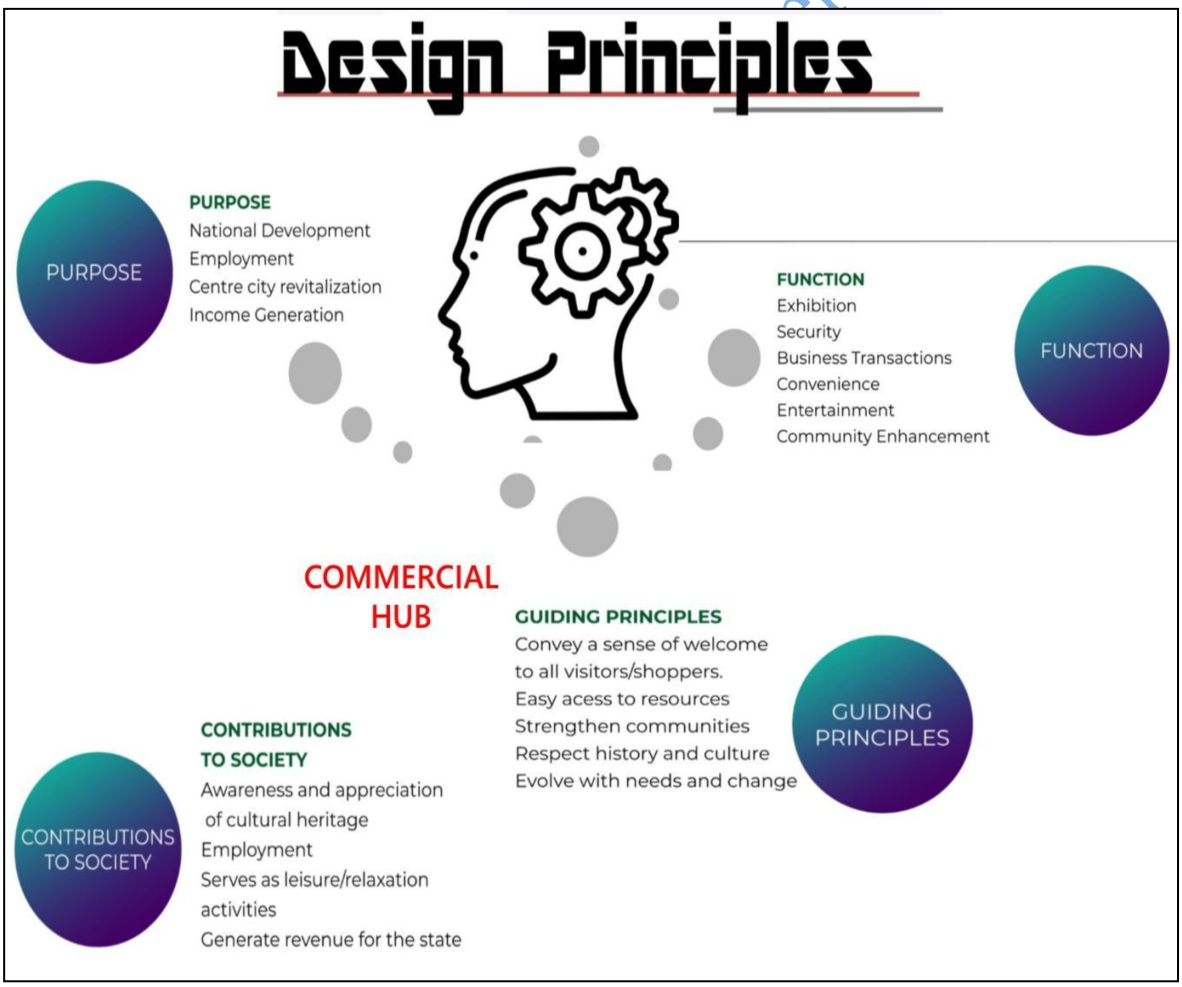

Figure 4.8: Design Principles
Source: Fieldwork, 2023

4.2.2 Brief Development

The design shall make provision for fully functional facilities for a commercial center that will generate fund for the school. It shall provide sufficient activity spaces and good zoning for common functions. A suitable location has being selected for the project directly opposite the main entrance gate of Lead City University, Ibadan. The parcel of land selected is approximately 56,191 square metres in acreage and has been adjudged suitable due to the direct link the adjoining roads around the site afford to the major highway and the Challenge interchange that links other arterial roads in the area. Below listed is a description of the different parts that makes up the design.

Production

- Water Production
- Printing Press
- Bakery/ Confectionaries

Sales and Services

- Retail Stores
- Anchor Store
- Restaurants
- Lock Up Offices

Entertainment and Hospitality

- Cinema
- Gymnasium
- Games Arcade
- Wine And Drink

- Specialized Retail Outlet
- Laundry Services
- Warehouses
- Delivery Bay

Vocational Training

- Fashion Design
- Make Up
- Leather Works /Bead Work
- Computer Repairs
- Hair Dressing and Barbing

Administrative Services

- C.E.O
- Offices
- Accounts

4.2.3 Design Criteria and Considerations

The major design criteria and considerations for the proposed design of a Commercial Hub for Lead City University include the below-listed further delineated in Figure 4.9.

- Functionality
- Landscape
- Parking
- Circulation and Connectivity
- Lighting and Acoustics
- Security
- Aesthetics

Figure 4.9: Design Considerations
Source: Fieldwork, 2023

4.2.4 Conceptual Development

The act of designing clearly embraces at its extremes logical analysis on the one hand and profound creative thought on the other, both of which contribute crucially to the central ground of "form-making". It is axiomatic that all good buildings depend upon sound and imaginative decisions at the early stages and how such decision-making informs that creative "leap" towards establishing an appropriate "three-dimensional outcome". This three-dimensional outcome is influenced by the articulation of a central concept or idea that is vital to the conceptualization of the design. The proposed commercial hub for Lead City University is conceptualized to integrate the different arms of production (water ventures); vocational enterprises (fashion design, metal works, wood work, ICT; shopping; and social interactions as illustrated in Figure 4.10.

Figure 4.10: Different Arms of the Commercial Hub for Lead City University
Source: Fieldwork, 2023

The pivotal concept upon which the proposed design of the commercial hub was fluidity which was epitomized through dynamism and movement as captured in Figure 4.11.

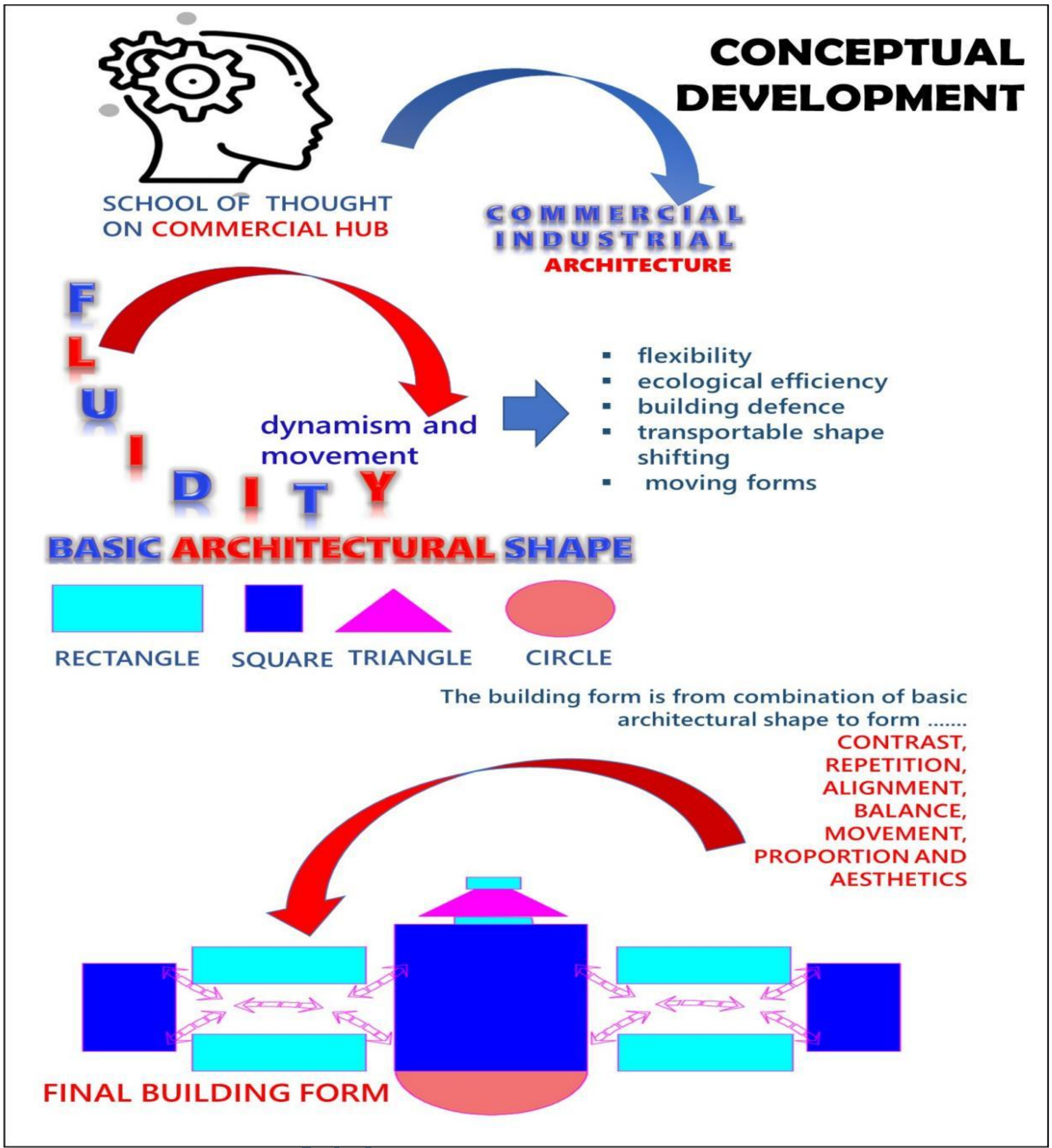

Figure 4.11: Conceptual Development
Source: Fieldwork, 2023

4.2.5 Space Allocation

Space allocation is an important aspect of design as it is directly related to the functional requirements of spaces. The allocation of spaces and the schedule of accommodation is also determined by the hierarchical characteristics of spaces as well as the inter-relationship of spaces and activities. Space allocation should also reflect the zoning of activities into conflicting and contemporary as well as the principles of functional zoning. A commercial hub as a public building should therefore be devoid of obstructions to movement and circulation as well as designed with the capabilities to incorporate the free flow of users, equipment's, materials as well as services. This will aid ease of circulation, prevent accidents, and increase efficiency of services and ultimately user satisfaction.

4.2.5.1 Spatial Requirements

The functional configuration and spatial articulation of the spaces in the proposed commercial hub for Lead City University is articulated through six tangential yet interrelated arms elaborated in Figure 4.12. The activity arms delineated are listed below:

- Administrative / Control
- Production
- Sales and Services
- Training / Vocation
- Entertainment / Hospitality
- Ancillary / Support

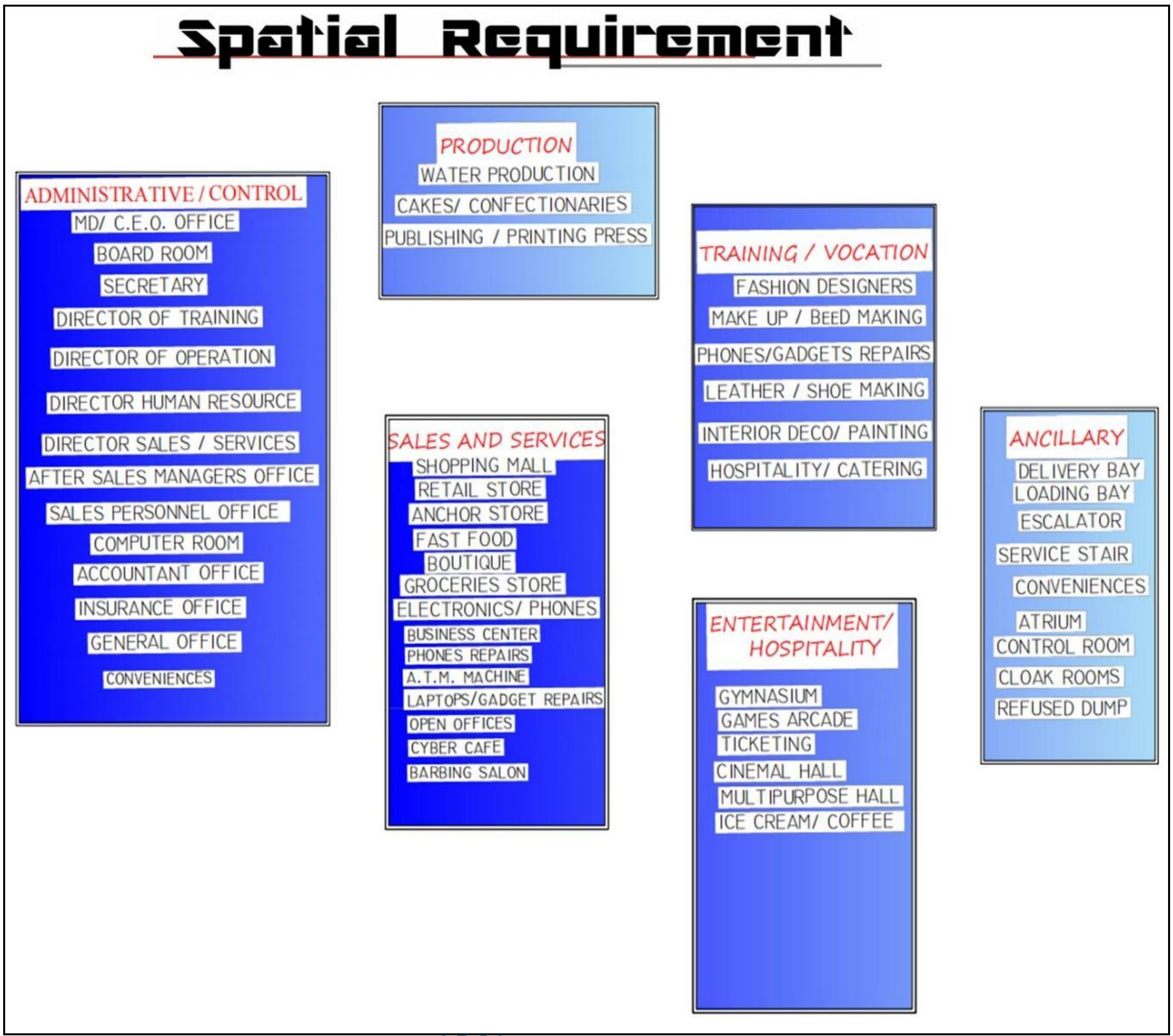

Figure 4.12: Spatial Requirements
Source: Fieldwork, 2023

4.2.5.2 Spatial Programming

The design of the proposed commercial hub for Lead City University is encapsulated within three floors. The activities and spaces programmed for each floor and the area of spaces dedicated to these activities are captured in Figure 4.13.

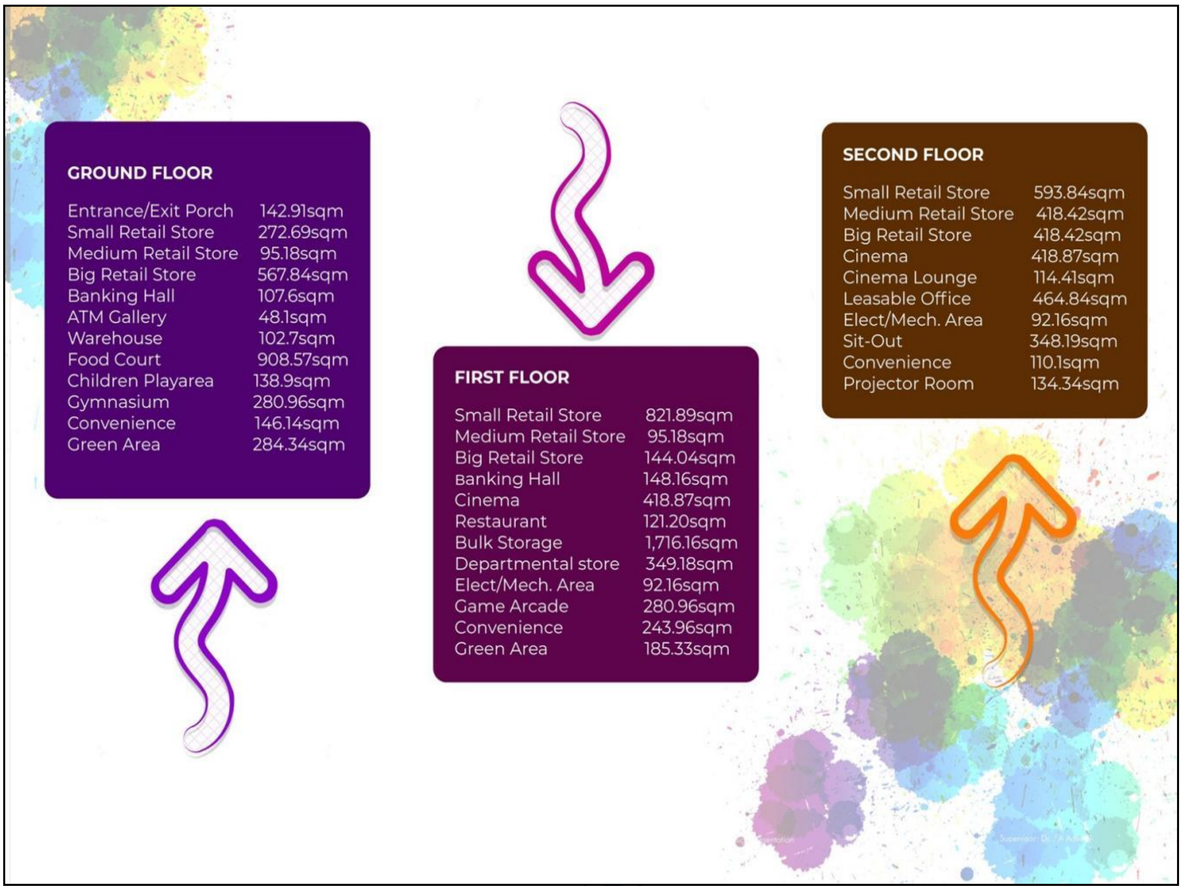

Figure 4.13: Spatial Programming
Source: Fieldwork, 2023

4.2.6 Functional Relationships

Although, patterns of circulation and the ordering of 'routes' through a building allow us to 'read' and to build up a three-dimensional picture, there remains the equally important question of how we communicate the essential differences between the spaces which these systems connect. This suggests a hierarchical system where spaces, for example, of deep symbolic significance, are clearly identified from run-of-the-mill elements which merely service the architectural programme so that an organizational hierarchy is articulated via the building.

Similarly, it is essential that spaces within the public domain are clearly distinguished from those deemed to be intensely private. Between these two extremes there is, of course, a range of spatial events which needs to be placed within this hierarchical order which the building also must communicate.

The building comprises three floors which accommodate all the spaces in order of hierarchy, zoning considerations, functionality and utility. The bubble diagrams in Figure 4.14, Figure 4.15 and Figure 4.16 illustrate the functional relationships on the ground floor, first floor and second floor respectively.

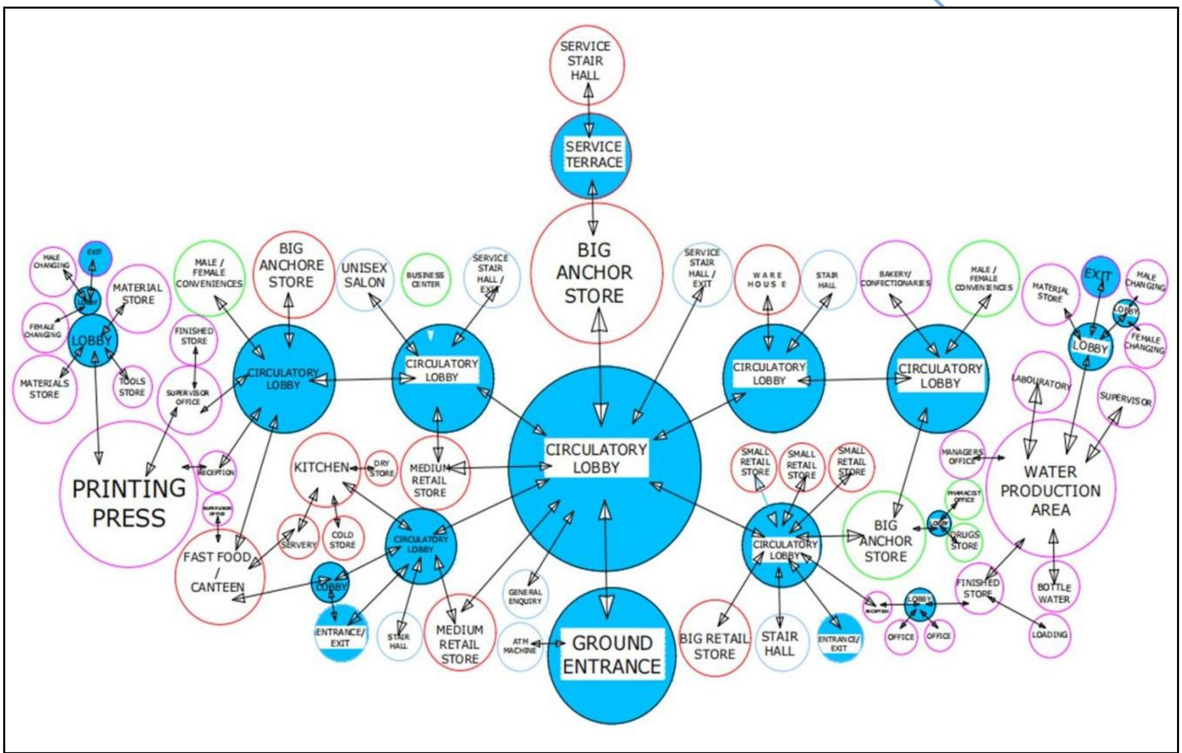

Figure 4.14: Ground Floor Bubble Diagram
Source: Fieldwork, 2023

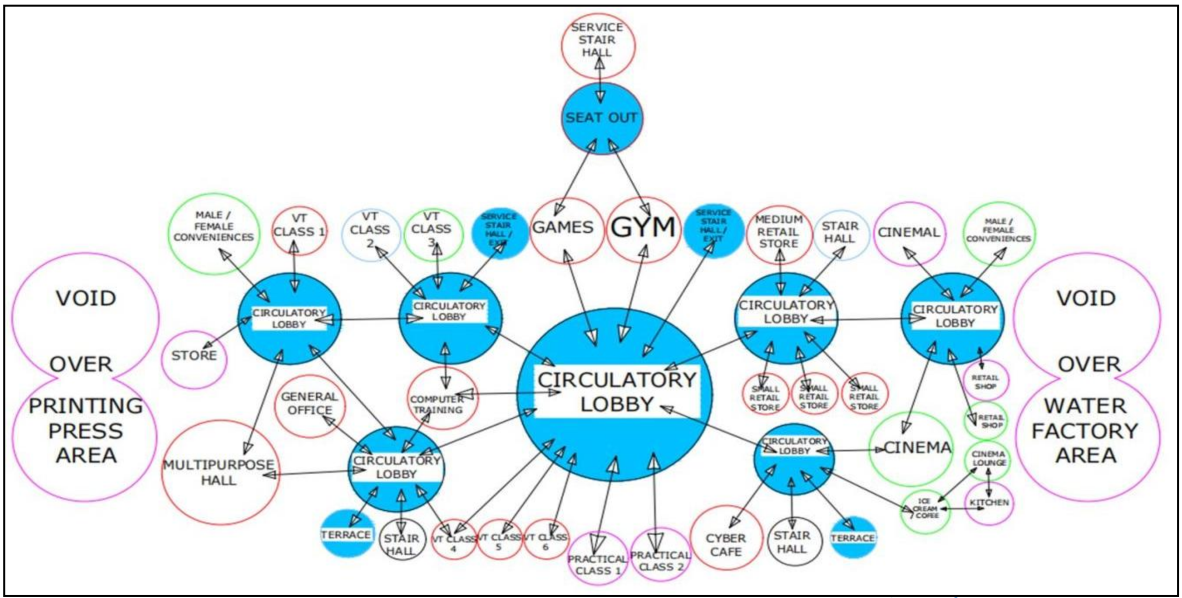

Figure 4.15: First Floor Bubble Diagram
Source: Fieldwork, 2023

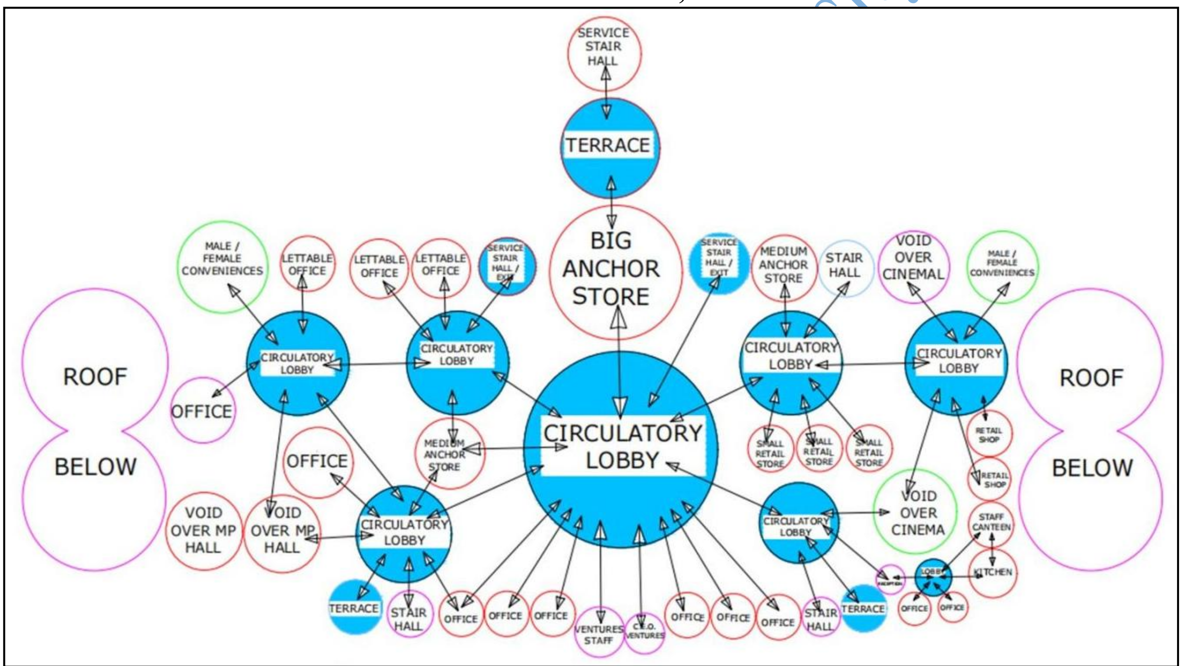

Figure 4.16: Second Floor Bubble Diagram
Source: Fieldwork, 2023

4.2.7 Construction Methods and Materials

The design of a commercial hub requires the designer to take into cognizance the aesthetic appeal, initial cost, and durability when choosing building materials, initial and ongoing costs, durability and availability of the material and must importantly the acoustic implication of the material and how flexible can the material be used for. The construction method should suit the functional and aesthetic requirements of the building, the available professional, technical and available technology as well as maintenance and overall life cycle of the building. These considerations will help the integration of the proposed project into the natural landscape and the peculiarities of the local environment as well as curtail the environmental impact of the proposed development and its ecological footprint.

Given the nature of this design, budgetary considerations necessitated the adoption of cost efficient and effective design solution to achieve the desired functionality and effect within the boundaries of the available limited resources. The design uses a variety of passive climate control techniques and lessens the need for resource-intensive mechanical environmental control measures.

The building is protected from the effect of weather with the use of vertical and horizontal shading devices. The use of perforated metal sheets over the openings reduces glare while daylight is sufficiently admitted into the spaces. The construction materials used are a combination of block, concrete, steel and glass keeping in mind the climatic needs of this region and yet retain the design intent. Energy efficiency is a prime concern with cost effective passive design strategies. This construction of this proposed building will be based on modular coordination and functional efficiency.

4.2.7.1 Structural System

The structural system is designed adopting a mix of structural steel, glass and reinforced concrete. The factors considered in the choice of the structural system include the following:

- Site conditions especially soil type and the bearing capacity;
- Functional requirements;
- Aesthetic requirements;
- Performance specifications and durability;

- Availability of construction materials; and
- Cost of construction, materials and the cost of maintenance

4.2.7.2 Material Selection and Specifications

Concrete

Concrete is a composite stone like material formed by mixing an aggregate (such as stones of irregular shape or crushed rock) with cement (which acts as the binding material) and water, then allowing the mixture to dry and harden. Concrete as a composite material is one of the man-made construction materials that is most frequently utilized. It is a crucial building component that is widely employed in structures including buildings, bridges, highways, and dams. It can be used for structural purposes as well as for pavement, kerbs, pipelines, and drains.

Concrete Boards / Cement Board

Cement and reinforcing fibers/admixtures are employed to create composite boards which can be used for various building elements like wall and floor claddings, compared to backing board, cement board strengthens and provides impact resistance to the wall surface. It is preferrable to other non-metallic cladding materials because of its durability and performance characteristics. Concrete boards also serve as good acoustics absorbers preventing the transmission of noise from the exterior of buildings into the interior space. One other property of cement board is its capability to enable bending for curved surfaces. Cement board can also made in thin sheets using cements that have been treated with polymers.

Glass

Glass is a hard, brittle inorganic substance, ordinarily transparent or translucent, produced by melting a mixture of silicates (such as sand) and a flux (such as lime and soda). Architectural glass is glass that is incorporated into building construction. Most frequently, it serves as a clear glazing material for building envelope components like wall windows. Glass is also employed as an architectural element and for interior dividers. Glass of the safety kind, such as reinforced, toughened, and laminated glasses, is frequently used in structures.

Glass block which is a hollow block of glass, usually translucent with textured faces is used in non-load-bearing walls but suitable for throwing daylighting into interior spaces. Glass blocks are frequently employed in construction as it follows the most recent trends in architectural design for contemporary structures. The glass block can also be utilized in the roof, front and side walls, and for daylighting purposes. Figure 4.18 depicts the placement of glass blocks on walls and roofs. The glass block is made up of two distinct pieces of pressed glass that have been partially vacuumed and heated to a high temperature before being cemented together. Glass blocks that transmit light up to their transmitting limits have good thermal conductivity, are soundproof, moisture-proof, and fireproof. It is enduring and makes cleaning simple. It is offered in a wide range of sizes, shapes, and prices.

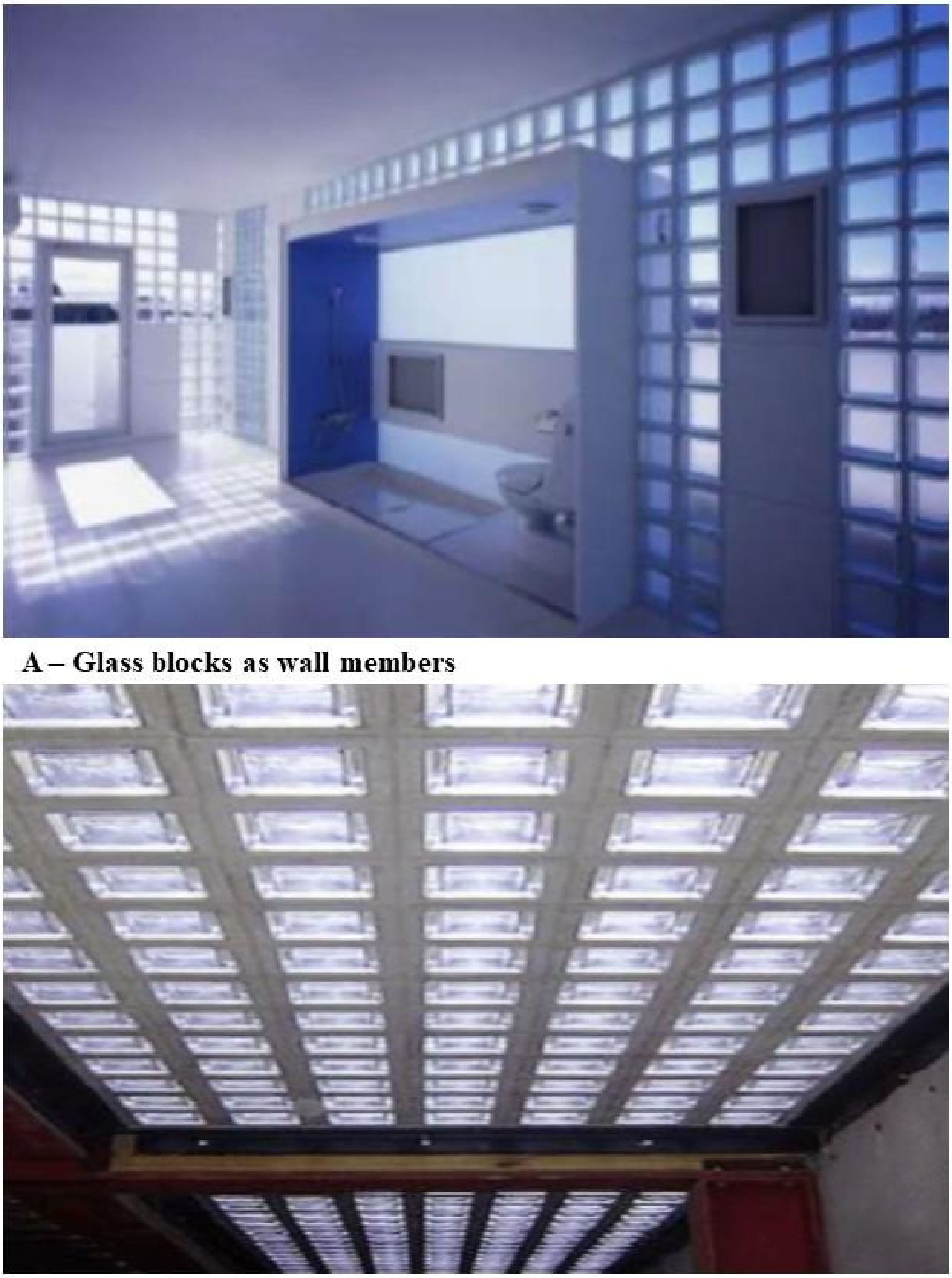

Figure 4.18: Glass blocks application in buildings for daylighting
Source: Fieldwork, 2023

Timber and Wood Products

Timber and wood products can be used as a structural element, as non-load bearing members or as finishing and furnishing materials. These products range from timber planks, timber panels, ply-woods, laminates and boards. Wooden boards are thin boards made from wood used as finish cladding in construction. Wood possesses good acoustic properties and can be structurally efficient to support loads in a longitudinal direction of the grain rather than perpendicular.

Steel (Space Frame)Steel is employed as reinforcement for concrete wherein such types of concrete are referred to as reinforced concrete. Structural steel is also used for steel construction ranging from light steel frames structures, steel portal frames, space frames and other sophisticated structural steel systems. Steel is essentially a material that exhibits linear elastic properties; it has a great tensile strength that enables it to be bent into any desired shape, and it also possesses a compressive strength that is roughly equal to that of its tensile strength. It is an important structural construction material for buildings with suspended floors.

4.2.8 Building Services

Building services are essential to the functioning of any building. These services transform the building from a shell into a space that is supports the various activities to be carried out within the building. For a commercial hub, the services to be considered include circulation, ventilation and air-conditioning, lighting, acoustics, electrical systems, fire protection, waste and sewage disposal, and water supply systems.

4.2.8.1 Circulation

Mechanical installations for vertical circulation considered include lifts and escalators. As a commercial hub which provides an environment beyond shopping, panoramic glass lifts will be provided to create platforms to absorb the different views within the commercial hub. Escalators are provided at strategic locations to facilitate movement between floors and intermediate levels.

4.2.8.2 Ventilation and Air-Conditioning (VAC)

The installation of ventilation and air conditioning services shall be based upon considerations regarding the microclimate of the site, the building shape and space orientation, the building's thermal performance characteristics, and occupancy patterns. Pollutant emission regulations will all be considered in the design of the ventilation and air conditioning services.

The VAC loads in different parts of the building at different times and in various locations will vary. Systems will only run as needed to coincide with core business hours if time controls are properly set up. The energy consumption of an VAC system is influenced by five key factors:

- The layout, design and operation of the building have effect on how the external environment impacts internal temperatures and humidity;
- The air quality and indoor temperature that is required – more extreme temperatures, greater precision and more refined air quality consume more energy;
- The heat that is internally generated as a result of people, equipment and lighting have an impact on how the building retains warmth;
- The VAC system's design and efficiency ensure that heat, cool, and moisture are controlled exactly where they are needed in the structure.;
- The VAC system's running hours and controllability only allow for operation at necessary times.

4.2.8.3 Lighting

Lighting is a significant consideration especially in specialised retail building like the commercial hub. The savings incurred by using efficient lighting can be further optimized by the use of different kinds of lighting controls available. Lighting control ensures the light is provided where and when it is needed in the right amount while maximizing the use of daylight and minimizing the lighting energy wastage. Lighting controls typically include occupancy sensors, daylight sensors, and dimmers can save approximately 20-50% of lighting energy consumption.

Lighting control systems comprising hardware such as sensors and, relay switches controllers which work using various communication protocols like DALI, ENOCEAN etc will be adopted. DALI is an acronym for Digital Addressable Lighting Interface and is targeted to suit commercial architectural requirements. DALI is specifically developed for ballasts and relay switches. Lighting communication protocols can be used as a stand-alone lighting control system or integrated with other building automation systems using protocol translation systems.

4.2.8.4 Acoustics

Noisy and quiet areas should be separated, with noises contained within their spaces of origin as much as possible. Acoustic treatment such as acoustic tile or plaster, cork flooring, double glazing and sound insulation should be considered for each area.

4.2.8.5 Electrical Systems

All electrical systems should conform to the applicable codes. The national grid will provide power to the building. The supply arriving must be tunneled underground. The metering tariff shall be the adopted. The Electrical Switch Room shall be located in a dedicated area and in shall have internal access. The room's location shall be such that it does not present difficulties for services distribution from adjoining plant spaces or rooms and provides for economic distribution of services. The primary switchboard will have a metal-clad cubicle design in accordance with established norms and laws. On the incoming mains, electronic surge protection will be provided. Electrical distribution cables will be carried via galvanized trays, trunking, or conduits as necessary. The distribution boards will be contained within built-in fire-stopped construction with the proper door closures, without them projecting into circulation spaces.

Large general lighting areas should be provided with rheostats for economical lighting control. Power supply outlets, switches, and all other electrical connections in high moisture spaces should be located away from wet floor areas and mounted a minimum of 1200mm from the ground. Vapor proof lighting is required in all damp humid areas like dressing rooms, locker rooms, showers and toilets. Planned access to lighting for changing and cleaning fixtures should be some important criteria.

Protective impact resistant lighting should be used in areas that may involve frequent physical contact with play equipment. Exit lighting should be provided indicating the nearest direction to the exterior. Exit light should be placed above exits in rooms that are used for large meetings and gatherings. Recreational activities require that the user be able to see objects clearly with little distortion in all areas generating play. Even light distribution is required in congregational spaces.

4.2.8.6 Fire Safety and Protection

In consideration of the congregation of people and activities in a commercial hub, fire protection and safety considerations become a primary important building service. Fire protection is necessary to stop the spread of smoke, stop the initiation and growth of a fire, and make it easier for people to flee or rescue. In the case of an outbreak, it is pertinent to implement active and passive safety measures to put out fires successfully. One example of an active precaution is installing heat-activated sprinklers, which stop a fire at its source by releasing discrete quantities of water adequate to put out a fire. Operational precautions are devices that are automatically deployed in the case of a fire. Smoke and heat detectors, smoke and fire alarm systems, water spray extinguishers, CO_2 extinguishers, and others should all be easily accessible and well-marked. Sprinkler systems should be provided throughout the complex. Panic bars should be provided for all doors. Doorways and entrances and exits should be wide enough to allow easy egress in case of emergency, Accident prevention should be built into the building, which means safety consciousness in the planning stage.

Construction solutions in the design and layout of the building and its parts that aid in limiting the spread of fire are known as passive precautions. These consist of the structure of supporting floors, installation of fire doors and windows, casings and coatings, and minimal structural sections. Passive measures adopted also include the compartmentalization of spaces to curtail fire spread and easy layout of interconnecting spaces to aid quick egress in the event of a fire outbreak.

4.2.8.7 Waste and Sewage Disposal

Access granted to waste management facilities for regularly handling, storing, and collecting trash. It must be disposed of properly and must make users aware. Both the garbage of how to do so. Additionally, waste is collected separately on each floor and carried to a collection station on the main floor in a big container. Every floor has a garbage chute, and the ground floor serves as the collecting location. There are also incinerators available at the site.

4.2.8.8 Water Supply

Independent water supply is considered for this development through the installation of industrial boreholes to provide site-based water supply. Provisions shall be made to access water supply from the water mains if installed or provided by the public authority. Overhead and underground reservoirs shall be provided. Considerations will be put in place for enhanced rain water harvesting, as well as improved water efficiency through reuse and recycle.

Chapter Five

Conclusion

5.1 Project Appraisal

The The amount of light within indoor spaces can be precisely quantified using various metrics, while its quality is subjective and relates to human preferences and needs. The natural variation of daylight throughout the day and night positively impacts the circadian rhythm of occupants and contributes to their overall well-being. Daylight is recognized as a crucial factor for both the physiological and psychological health of individuals. Multiple sources can provide daylight to the interior of a building, including direct sunlight, diffused light from the sky and clouds, reflections from the surroundings, and even interior spaces themselves. Among these sources, direct solar radiation is highly valued for its abundant quantity, quality, and potential for even distribution.

The utilization of natural light in retail environments enhances occupants' comfort and experience. People tend to spend more time in well-lit commercial spaces, leading to increased sales. Research findings have demonstrated an average 40 percent boost in sales attributed to the use of skylights in shopping malls. Daylight holds particular advantages for commercial hubs due to the alignment of building occupancy hours with daylight availability. Moreover, large commercial structures, such as retail complexes, can harness natural light not only through windows but also predominantly through skylights, which offer higher light intensity and can reach central areas of the building. Maximizing daylight relies on the thoughtful design of glazing surfaces, including their placement, orientation, size, and materials.

The advantages of incorporating daylighting strategies in the design of commercial hubs are numerous. While reducing the need for artificial lighting leads to electricity savings, it also impacts cooling requirements and the overall energy consumption of the building. Importantly, daylighting not only promotes energy efficiency but also ensures a well-lit and thermally comfortable indoor environment. Through a well-balanced approach that considers daylight admission and solar heat management, efficient and innovative daylighting guarantees that building occupants can enjoy a well-illuminated and pleasantly cool indoor atmosphere. This comprehensive integration of energy efficiency and visual comfort underscores the significance of a holistic approach to building design and operation, resulting in substantial benefits in terms of energy conservation and occupant satisfaction.

In summary, this study highlights the significant potential of efficient and innovative daylighting in shopping malls and commercial hubs located in hot and humid climates. The research emphasizes the remarkable energy-saving capabilities of such daylighting techniques, particularly when combined with measures for controlling glare, shading from solar radiation, and optimizing natural light penetration. Furthermore, the study emphasise the pivotal role of visual comfort in enhancing occupants' well-being and emphasizes the synergistic combination of energy efficiency and visual comfort as a fundamental principle in effective building design. Ultimately, the integration of efficient and innovative daylighting holds the promise of significantly advancing energy performance goals while ensuring an optimal visual environment within built spaces.

5.2 Recommendations

Passive design solutions have the potential to significantly reduce a building's energy consumption when compared to active design strategies that rely on mechanical systems for lighting. This can lead to lower energy expenses and a reduced carbon footprint. Even in projects where active design approaches are incorporated, passive design strategies remain essential. This is because they provide cost-effective, reliable, and energy-efficient building design options. Beyond improving indoor comfort and energy efficiency, passive design strategies also contribute to the visual appeal and sustainability of buildings. By harnessing natural daylight and minimizing exposure to direct sunlight, passive design solutions can create a comfortable indoor environment that is both healthy and aesthetically pleasing.

Key considerations for passive design may encompass factors such as location, landscape, building orientation, massing, shading techniques, material selection, thermal mass, insulation, internal spatial configuration, and the placement of openings to facilitate air circulation, natural light, and solar radiation infiltration. Prior to initiating the design of a commercial hub with the aim of enhancing passive daylighting and space conditioning, certain crucial parameters should be taken into account.

Incorporating efficient and effective daylighting in the architectural design of commercial hubs can be facilitated by following these recommendations:

1. Increased Glazing: Opt for larger window areas and reduce internal lighting needs through efficient lighting design and controls.

2. Shading Systems: Implement well-designed shading systems that can lower cooling requirements, reduce heat gain, minimize glare, and enhance occupant comfort by allowing the right amount of daylight as needed.

3. Dynamic Dimming Systems: Maximize energy savings in electric lighting through the use of dynamic dimming systems in conjunction with LED fixtures and efficient ballasts, which can achieve substantial reductions in lighting power consumption compared to filament or fluorescent lamps.

4. Lighting Control: Implement continuous dimming lighting control systems, which can result in a 46 percent annual reduction in electrical lighting consumption, and automatic on/off controls, which can save up to 17 percent of lighting energy in large atrium spaces.

5. Daylight Sensors: Use sensors and controllers to regulate lighting based on daylight levels, potentially eliminating the need for artificial lighting in areas with adequate natural light.

6. Lighting Schedules: Implement lighting schedules that align with natural daylight variations, potentially leading to a 50 percent reduction in electric lighting consumption in office buildings.

5.3 Conclusion

It is essential to recognize that additional research efforts may be required to fine-tune daylighting strategies for various building types and climates, thus advancing the effectiveness of efficient daylighting techniques and technologies. Nevertheless, this current research study marks a significant starting point, providing valuable insights and paving the way for future research and development in the field of daylighting for commercial hubs.

The findings presented in this research have practical implications for architects and building owners, facilitating well-informed decision-making when considering the adoption of daylighting for commercial hubs. Key factors such as energy efficiency and visual comfort are taken into account. Moreover, this study underscores the potential of efficient daylighting methods and technologies to contribute to energy conservation and enhance visual comfort in commercial buildings situated in hot-humid climates.

The results of this research arm professionals in the field with pertinent information required for sound decision-making processes, shedding light on the economic feasibility of implementing efficient daylighting methods and technologies. This study acts as a catalyst for further progress and advancements in efficient daylighting strategies and technologies, propelling the quest for sustainable and energy-efficient building solutions.

Future research should concentrate on the efficiency and performance of diverse daylight sources, lighting controls, and zoning strategies. When it comes to daylight sources, it is important to analyse various types of skylights, such as monitor and saw-tooth designs, in relation to building orientations and the necessity for deflectors. In the case of wall windows, an assessment of the performance of innovative light-diffusing materials is needed. Lastly, variations in internal obstacles, including different shelf layouts, as well as varying quantities and locations of lighting control zones, should be subject to study. Coupled with these variations, an evaluation of energy performance and comparisons with previous cases should also be included. Advancements in future research will make significant contributions to the shift toward sustainable energy and daylight design for new, energy-efficient commercial buildings.

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Biodata

A. Personal Data

1. Full Name:	OJELEYE Olusegun Isaac
2. Address:	House 2 adjacent The Apostolic church, shiloh district Abanla, Ologuneru, Ibadan.
3. Email Adress:	segetyny13@gmail.com, segetyny@yahoo.com
4. Phone Number:	08037284922, 07010556353
5. Date of Birth:	13th August 1981,
6. Place of Birth:	Ibadan, Oyo state.
7. Nationality:	Nigerian
8. Marital Status:	Married

9. Name and Address of Next of Kin: OJELEYE Olufunke Abiodun

House 2 adjacent The Apostolic church, shiloh district Abanla, Ologuneru, Ibadan.

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B. Educational Background

1. Educational Institutions Attended with Dates and Qualification:

Qualifications	Institution	Date
MSc. Architecture	Lead City University, Ibadan, Oyo State.	2021(Inview)
BSc.Architecture (Second Class upper class)	Lead City University, Ibadan, Oyo State.	2019-2021
H.n.d. Architecture (Upper Credit)	Moshood Abiola Polytechnic Abeokuta, Ogun state.	2006-2007
O.n.d. Architecture (Lower credit)	Federal Polytechnic Ede, Osun state.	2002-2004
Secondary school certificate	Eleyele secondary school Ibadan.	1993 -1999
Primary school leaving certificate	Army Children School Mokola	1987-1993

C. **Awards and Fellowships:**

i. Departmental Ambassador 2007 (National Association of Architecture Students'' NAAS Moshood Abiola Polytechnic Chapter)

ii. Most outstanding Honorable (Student union government, Moshood Abiola Polytechnic, Abeokuta)

iii. Mr. designer Best Student in Studio ND (2003/2004 Session). Department of Architecture Federal Polytechnic Ede, Osun State.

D. Work Experience: With Dates

Company	Description	Date
EP-GRAPH KONSULT LIMITED No2 Suite2 fundex house,Beside khalil & dibbo, Ashi-Bodija road Bodija, Ibadan, Oyo State	• Design Student chapel Samuel Adegboyega University Ogwa EdoState. • Design HID Awolowo Anglican Cathedral Shagamu, Ogun-State • Design & Supervision Faculty Of Art Library University of Ibadan • Design & Supervision Large Animal House Vetenary Medicine Department University Of Ibadan	2009 – 2013
REGENT HOMES No 12 Aba Alamu street, Ashi Bodija, Ibadan, Oyo State	• Supervision of Tribunal Court (Osun State Ministry of Justice Okefia Osun State) • Design and supervision of hostel building, Osun state University, Ikire	2009

	osun state	
EP_GRAPH KONSULT. Fundex house ashi bodija way, bodija oju irin Ibadan.	• Design, analyse and Site supervision • Interpretation of Drawings on site • Subcontractors' selection and payment • Procurements of Building Materials • Site meetings coordination and report writings	2014-2018

D. Publications

Safety Considerations in Airport Terminal Design

…………………………………… ……………………………………

Signature Date

The University Compliance Form

This is to certify that the Thesis by Olusegun Isaac OJELEYE, with the matriculation number LG/PG/002827 in the Department of Architecture, Faculty of Environmental Design and Management Lead City University, Ibadan, is in full compliance with the University format and style of Thesis.

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