PROPOSED PUBLIC LIBRARY FOR OYO STATE GOVERNMENT (ANALYSIS OF LIGHTING AND VENTILATION REQUIREMENTS IN LIBRARY BUILDINGS.)

BY

AZEEZ ABDULMALIK ABOLAJI

LCU/PG/004068

BEING A MSC THESIS SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE, FACULTY OF ENVIRONMENTAL DESIGN AND MANAGEMENT, LEAD CITY UNIVERSITY, IBADAN

IN PARTIAL FULFILLMENT OF THEREQUIREMENTS OF THE AWARD OF THE DEGREE OF MASTERS OF SCIENCE (M.SC.) DEGREE IN ARCHITECTURE.

MARCH, 2024.

CERTIFICATION

"This is to certify that AZEEZ ABDULMALIK ABOLAJI, with matriculation number LCU/PG/004068 carried out this research work titled "ANALYSIS OF LIGHTING AND VENTILATION REQUIREMENTS IN LIBRARY BUILDINGS'' in the Department of architecture, faculty of environmental design and management, lead city university, Ibadan, Oyo state, for the award of Master's degree (M.Sc.) in Architecture and that this has not been previously submitted.

_____ _____

ARC. DR. OBALEYE OLUDARE Date

(Project Supervisor)

_____ _____

ARC. DR. OBALEYE OLUDARE Date

(Head of Department)

ACKNOWLEDGEMENT

I would like to express my gratitude to the numerous people who have contributed to the completion of this thesis. Firstly, I want to thank God Almighty. Special thanks to my supervisor, Arc. Dr. Oludare Obaleye, whose criticisms and suggestions greatly benefited me during this research. I also want to extend my appreciation to my late parent, Chief Isiaq Babs and late Mrs. Modinat Babs, my brothers and sisters, my lecturers, and friends.

I also want to give a special thank you to my H.O.D Arc. Dr. Oludare Obaleye, Arc. Babajide Aseyan (my favorite lecturer), and all department lecturers. Additionally, I want to thank my wife Adebanke, my colleagues Azeem, Daniella, Longman, and Molly. A big thank you to my best friends Babatunde Aderemi Nureni, Oke Luqman Olatunbosun, Gvoil, Sinzu, Akinade Zamani, and others who inspired and accompanied me for my case studies. You have all been supportive morally, financially, and inspiringly. I say thank you very much.

DEDICATION

This research project is dedicated to GOD ALMIGHTY.

ABSTRACT

Lighting and ventilation are crucial elements that impact the energy consumption of a library. Optimal light and airflow are essential for human comfort within a space. Inefficient buildings rely on mechanical and electrical systems for cooling in tropical regions and heating in colder areas. Unfortunately, in Nigeria, energy efficiency is frequently neglected due to a lack of awareness, poverty, ignorance, and ineffective government regulations. This project aims to analyze the lighting and ventilation needs of library buildings to create a comfortable and conducive learning environment for users. The project will explore various factors such as lighting fixtures, natural lighting, temperature, humidity, and air quality to determine their impact on energy efficiency. Additionally, the project will recommend measures to improve energy efficiency while maintaining optimal lighting and ventilation conditions. The findings of this research can be invaluable to architects, engineers, and policymakers in designing and maintaining library buildings that meet the lighting and ventilation requirements for the well-being of users while promoting energy efficiency and sustainability.

TABLE OF CONTENTS

Chapter Three: Methodology Case Studies

Chapter Four: Site analysis and design synthesis

Study Area

Chapter Five
Conclusion

LIST OF FIGURES

LIST OF PLATES

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

A library is a facility that provides knowledge and information that facilitates and encourages the reading and researching culture in the community and among students. They house the main resources for wider understanding and learning perspective in the form of books or other advanced technological material made available for users. (Akadiri P.O 2019) . The design of libraries plays a crucial role in facilitating an environment conducive to learning and knowledge acquisition (Tedd, 2017). A well-designed library incorporates various elements such as space utilization, furniture arrangement, and acoustic considerations to create an atmosphere that promotes focus and concentration among students (Smith, 2019). Furthermore, lighting and ventilation are integral aspects of library design that significantly impact the overall functionality and comfort of the space.

Effective lighting is essential for creating a welcoming and functional library environment. According to Phillips (2018), proper lighting not only ensures that reading materials are easily accessible but also influences the mood and behavior of library users. Natural light, in particular, has been found to positively impact the well-being and productivity of individuals within a library setting (Jones, 2016). Incorporating large windows and skylights can maximize the use of natural light, reducing the reliance on artificial lighting and creating a more sustainable and visually appealing space.

In addition to lighting, ventilation is a critical component of library design that directly affects the comfort and air quality within the space. Adequate ventilation helps regulate temperature, reduce airborne pollutants, and control humidity levels, all of which contribute to a healthier and more pleasant environment for library users (Adams, 2020).

Proper air circulation also plays a role in preventing the buildup of Odors and maintaining a fresh atmosphere conducive to extended study sessions and research activities.

Furthermore, the design of libraries encompasses a broad spectrum of considerations, from spatial layout to environmental factors such as lighting and ventilation. Understanding the interconnectedness of these elements is essential for creating library spaces that are not only aesthetically appealing but also functional and conducive to learning.

Lighting is the application of light in the most convenient way to visual perception on specific objects and surfaces. The purpose of lighting is to make the environment and objects visible by illumination (Sirel, 2021). Light can affect people psychologically and physically, and different reactions can emerge in response to different lights. Lighting has long been a main environmental problem in library buildings.

According to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), ventilation is defined as "the process of supplying or removing air by natural or mechanical means to or from any space. Such air may or may not have been conditioned." Proper ventilation is necessary for maintaining indoor air quality and the health and comfort of building occupants (ASHRAE, 2019). A well-ventilated library permits a functional exchange of indoor air with fresh outdoor air provides fresh air movement and cooling. As a result, it eliminates the recirculation of air that carries bacteria and other harmful microbes in the absence of exchange of indoor air with outdoor air. A properly designed and well-functioning ventilation strategy can also reduce the energy consumption of the building by minimizing the use of mechanical ventilation and power lighting (Basu et al., 2019, 2017; Seshadhri & Paul, 2018).

According to the American Library Association, "Lighting and ventilation are crucial factors that affect the quality of a library indoor" (ALA, n.d.). It is important to ensure that libraries

are well-lit and properly ventilated in order to provide a comfortable and healthy environment for patrons. Proper lighting and ventilation can improve the comfort, health, and well-being of the library users. Poor lighting and ventilation, on the other hand, can lead to discomfort, fatigue, and health problems. (American Library Association. (2018). Lighting and ventilation. Libraries are important public buildings that require adequate lighting and ventilation to provide a conducive environment for learning, research, and leisure activities. The design of a library building should consider the natural lighting and ventilation requirements of the space. One study stated that "daylighting has been found to significantly improve the performance of students in schools and occupants in offices and hospitals" (Veitch et al., 2018). Additionally, another study found that incorporating natural light in libraries "can have a significant positive impact on the mood, well-being, and productivity of users" (Jones, 2016). Furthermore, the use of natural light can reduce energy consumption by reducing the need for artificial lighting during the day (Phillips, 2018). Natural ventilation can help to improve indoor air quality, reduce the risk of airborne diseases, and reduce energy consumption. (Akadiri P.O 2019) The use of artificial lighting and mechanical ventilation should be minimized as much as possible. The comfort of the users and the maintenance of optimum airflow is an important aspect that is required to be considered for a library. The users or visitors of a library require an optimum amount of light for visual comfort for a comfortable reading experience. Tropical architecture using natural ventilation has been one of the elements adopted in library design, either taken wholly, with mechanical assistance or with partial air-conditioning (Edwards 2019). In Nigeria, according to Nigerian Ministry of Education (2018), presently there are 269 government-funded tertiary institutions with each institution attached to a library building as part of its landscape (education.gov.ng).

According to Agboola (2019), natural ventilation was adopted in ventilating libraries in many Nigerian academic campuses. However, there is a common phenomenon in the reading space

of libraries: students more tend to draw the curtain when the weather is sunnier than usual, and turn on all the artificial lighting, resulting in greater waste of energy. The natural lighting design of reading space in libraries not only affects the physical and mental health of readers, but also concerns the energy consumption of the libraries. From the angle of building energy efficiency, the scientific and rational design of natural lighting is the key to the design of energy saving for physical environment of the reading space.

1.2 PROBLEM STATEMENT

The analysis of lighting and ventilation requirements in library buildings has not received the attention it deserves. This analysis is vital to determine the optimal lighting and ventilation conditions that will enhance user comfort, health, and safety while improving the overall functionality and usability of the library. Designing lighting and ventilation systems for library buildings poses several challenges that must be addressed. One of the main challenges is to balance adequate illumination for reading materials with minimizing glare and eye strain. This requires assessing the library's layout, the location of windows, and the placement of artificial lighting sources. Another challenge is to ensure that the ventilation system promotes a healthy indoor environment by providing fresh air and reducing indoor air pollution while minimizing noise and vibrations to avoid distracting library users.

Apart from these challenges, regulatory requirements must also be considered when designing lighting and ventilation systems in library buildings. These requirements may include building codes, environmental regulations, and workplace safety standards. Noncompliance with these regulations can result in fines and legal liabilities. Therefore, conducting a comprehensive analysis of the lighting and ventilation requirements of library buildings is essential. According to Phillips (2018), the analysis should take into account the library's layout, user needs, and environmental conditions, as well as the latest technological advancements in lighting and ventilation systems. Ultimately, the goal of analysing the lighting and ventilation requirements of library buildings is to create a comfortable, healthy, and safe environment for library users, which should always be the top priority.

1.3 RESEARCH AIM AND OBJECTIVES

This research aims to evolve a public library architectural design proposal for Oyo state by analyzing effective lighting and ventilation requirements to enhance running cost efficiency and comfort of users in library space.

To achieve this aim, the objectives are:

1. To identify the evolving trends in library design.
2. To examine the lighting and ventilation requirements of library buildings.
3. To analyze the lighting and ventilation requirement adoption level in existing libraries.
4. To develop a design proposal of a library for Oyo state which conforms with lighting and ventilation requirements.

1.4 RESEARCH QUESTIONS

The research questions that guide this study are:

1. What is the evolving trends in library design?

2. What are the lighting and ventilation requirements of library buildings?

3. What are the lighting and ventilation requirement adoption levels in existing libraries?

4. What is the design proposal of the library which conforms with lighting and ventilation requirements?

1.5 SIGNIFICANCE OF THE PROJECT

The Analysis of Lighting and Ventilation Requirements in Library Buildings is a project of great significance because it focuses on the comfort and well-being of library users, which can have a significant impact on their ability to study, learn, and retain information. Poor lighting and ventilation can cause discomfort, fatigue, and health problems, which can negatively affect the overall learning experience. Therefore, this project can help to create a more conducive learning environment for library users.

1.6 SCOPE OF THE PROJECT

The scope of the project would involve a detailed analysis of the lighting and ventilation requirements of library buildings, including the types of lighting fixtures, natural lighting, temperature, humidity, and air quality. The project would also study the impact of these factors on the energy efficiency of library buildings and recommend measures to improve energy efficiency while maintaining optimal lighting and ventilation conditions. The project can provide valuable insights to architects, engineers, and policymakers on designing and maintaining library buildings that meet the lighting and ventilation requirements for the comfort and well-being of library users. The outcomes of the project can also help to reduce energy consumption and contribute to the overall sustainability of library buildings.

Overall, the project on the Analysis of Lighting and Ventilation Requirements in Library Buildings is of great significance and has a wide scope that can help to create a better learning environment for library users while promoting energy efficiency and sustainability in library buildings.

1.7 Operational Definition of Key Terms

- Lighting: The application of light in a space to make the environment and objects visible by illumination.

- Ventilation: The process of supplying or removing air by natural or mechanical means to or from any space, which may or may not have been conditioned.

- Energy efficiency: The efficient use of energy to reduce energy consumption and minimize waste.

- Natural lighting: The use of natural light in a space to reduce the reliance on artificial lighting and create a more sustainable and visually appealing environment.

- Air quality: The degree of cleanliness and purity of the air, which can be affected by factors such as ventilation, humidity, and airborne pollutants.

- Sustainability: The ability to maintain and preserve resources for future generations by reducing waste, minimizing environmental impact, and promoting efficient use of resources.

CHAPTER TWO

LITERATURE REVIEW

2.1 CONCEPTUAL REVIEW

Proper lighting and ventilation in library buildings have been highlighted as crucial factors in creating a conducive learning environment (Lange, 2013). Insufficient lighting and ventilation can lead to discomfort, fatigue, and health issues that can negatively impact the learning journey (Mehaffy, 2016). Therefore, it is essential to analyze and optimize the different elements that affect the lighting and ventilation of library structures (Voss, 2018).

2.1.1. THE LIBRARY CONCEPT

Adopting sustainable architectural design as a concept for library design has become increasingly popular in recent years. With the growing concern for the environment and conservation of resources, many libraries are looking for ways to reduce their environmental impact and promote sustainability.

One of the key elements of sustainable library design is incorporating natural lighting. Natural lighting not only reduces the need for artificial lighting, but it also creates a more pleasant and inviting atmosphere for library users. According to a study by the American Library Association, natural lighting has been shown to have a positive impact on user satisfaction, comfort, and productivity (ALA, 2015). By maximizing the use of natural light, libraries can reduce their energy consumption and costs while also improving the user experience.

Another important aspect of sustainable library design is the use of renewable materials. For example, using wood from sustainably managed forests for furniture and building materials can help reduce the library's carbon footprint. Additionally, using materials that are locally

sourced can reduce transportation costs and energy consumption associated with long-distance shipping.

In addition to using sustainable materials, libraries can also incorporate energy-efficient systems and technologies. This can include using smart lighting systems that automatically adjust to the natural light levels, as well as utilizing energy-efficient HVAC systems and insulation. According to the U.S. Energy Information Administration, heating and cooling accounted for 44% of energy consumption in commercial buildings in 2019 (EIA, 2020). By implementing energy-efficient systems, libraries can significantly reduce their energy consumption and costs.

Furthermore, Libraries can promote sustainability through their programming and services. This can include offering educational programs on environmental conservation, providing access to resources on sustainability and green living, and hosting community events that promote environmentally friendly practices.

Adopting sustainable architectural design as a concept for library design can have numerous benefits for both the environment and library users. By incorporating natural lighting, using renewable materials, implementing energy-efficient systems and technologies, and promoting sustainability through programming and services, libraries can reduce their environmental impact while also providing a more pleasant and inviting space for their users.

The library is a space that serves as a hub for learning and research. It is a place where people come to read, study, and collaborate. To ensure that the library environment is conducive to learning and research, it is essential to consider the lighting and ventilation requirements of the space. Inadequate lighting and ventilation can cause discomfort, fatigue, and health issues, which can negatively impact the learning journey. The analysis of lighting and ventilation

requirements in library buildings is based on the principles of sustainable architecture and biophilic design. (Helm 2017).

2.1.2 THE CONCEPT OF LIGHTING

Lighting is a crucial aspect of library design that can have a significant impact on the functionality and comfort of the space. Proper lighting ensures that reading materials are easily accessible, and it also influences the mood and behaviour of library users. According to Phillips (2018), lighting is one of the most important factors in creating a welcoming and functional library environment.

Two main types of lighting are commonly used in library design: natural lighting and artificial lighting. Natural lighting is the use of sunlight to illuminate the library. It has been found to positively impact the well-being and productivity of individuals within a library setting (Jones, 2016). Incorporating large windows and skylights can maximize the use of natural light, reducing the reliance on artificial lighting and creating a more sustainable and visually appealing space.

Artificial lighting, on the other hand, is the use of electric light sources to illuminate the library. Various types of artificial lighting can be used in library design, including ambient lighting, task lighting, and accent lighting. Ambient lighting is used to provide a general level of illumination throughout the library, while task lighting is used to provide focused illumination for specific tasks such as reading or studying. Accent lighting is used to highlight specific areas or features of the library, such as artwork or architectural details. (sirel, H 2021).

One important consideration in lighting design is the color temperature of the light source. Color temperature is measured in Kelvin (K) and refers to the color of the light emitted by the light source. Higher color temperatures (5000K-6500K) are considered "cool" and have a

bluish-white color, while lower color temperatures (2700K-3000K) are considered "warm" and have a yellowish-white color. According to Sirel (2021), the color temperature of the lighting should be carefully chosen to create a comfortable and inviting atmosphere in the library.

Another consideration in lighting design is the use of lighting controls. Lighting controls can be used to adjust the intensity of the lighting, depending on the time of day and the amount of natural light available. They can also be used to create different lighting scenes for different activities, such as reading, studying, or group work. (Jones, k 2018)

Furthermore, lighting is an important aspect of library design that can impact the functionality and comfort of the space. Proper lighting can create a welcoming and functional environment for library users. Incorporating natural lighting, choosing the right color temperature, and using lighting controls are all important considerations in lighting design for libraries. (sirel,H. 2021)

Effective lighting is a crucial aspect of library design as it impacts both the visual comfort of patrons and the overall atmosphere of the space. The three types of lighting that work together in an area to provide proper illumination are ambient lighting, task lighting, and accent lighting. Appropriate lighting levels are crucial in reducing eye strain and fatigue, resulting in a comfortable reading and studying experience for library users. Incorporating natural lighting not only creates a warm and inviting atmosphere but also contributes to energy conservation. The choice of lighting fixtures in library buildings can have a significant impact on the overall lighting levels and energy consumption. LED lighting is gaining popularity due to its energy efficiency, extended lifespan, and the ability to adjust color temperature. (Philips,d. 2018).

LIGHTING TYPE

Three types of lighting work together to provide proper illumination in an area, according to the American Lighting Association (2017). These include ambient lighting, task lighting, and accent lighting. Ambient lighting is used to provide an area with total illumination, allowing people to move easily and safely throughout the space. It can be achieved through a variety of indoor and outdoor lighting options, such as ceiling-mounted fixtures, chandeliers, table lamps, track lights, wall lighting, spotlights, and hanging fixtures. Task lighting, on the other hand, is designed to help an individual carry out specific tasks such as reading, doing homework, or playing games. Pendant lighting, downlights or directional recessed fixtures, and desk or portable lamps are common sources of task lighting. Finally, accent lighting is mainly used to achieve a desired effect or to focus on a specific interest. It provides an impression of a larger space and can be achieved by using wall-mounted fixtures, track lights, downlights or directional recessed fixtures. (American Lighting Association, 2017; Standard Pro, 2017).

Optimizing Energy Efficiency in Libraries:

The quality of lighting and ventilation in library buildings can significantly impact energy consumption. To encourage sustainability and decrease energy usage, energy-efficient lighting fixtures, such as LED bulbs, and natural lighting optimization can be utilized. Moreover, automated lighting and ventilation systems can be employed to adjust lighting and air quality in response to occupancy and natural lighting levels, further enhancing energy efficiency.

NATURAL LIGHTING

Natural lighting is the use of sunlight to illuminate indoor spaces. It is a vital aspect of building design that can have a significant impact on the energy consumption, comfort, and overall well-being of building occupants. Natural light not only provides a sustainable and

cost-effective alternative to artificial lighting but also has been found to positively impact human health, productivity, and mood (Egan, 2019).

One example of the importance of natural lighting in building design is the recently constructed headquarters of Apple in Cupertino, California. The building, which was designed by Foster + Partners, incorporates a unique and innovative circular design that maximizes the use of natural light. The building features floor-to-ceiling glass walls that allow ample sunlight to penetrate the interior, creating a bright and visually stunning workspace for employees (Egan, 2019).

Another example is the Biblioteca Alexandrina in Alexandria, Egypt, which was designed by the Norwegian architectural firm Snøhetta. The library features a massive glass roof that allows natural light to flood the interior. The roof is made up of 13,000 panels of translucent glass that filter sunlight, creating a soft and diffused light that is easy on the eyes and conducive to reading and studying (Snøhetta, n.d.).

In addition to its aesthetic and energy-saving benefits, natural light has been found to have numerous benefits for human health and well-being. Exposure to natural light has been shown to regulate the body's circadian rhythm, improve sleep quality, and boost mood and productivity (Harvard Health Publishing, 2019). Natural light has also been found to have a positive impact on mental health, with studies showing that exposure to sunlight can reduce the risk of depression and anxiety (Mental Health America, n.d.).

Furthermore, natural lighting is a critical aspect of building design that can have significant benefits for both energy consumption and human health and well-being. Architects and designers should prioritize the incorporation of natural light in their designs to create sustainable, healthy, and visually appealing indoor spaces.

ARTIFICIAL LIGHTING

Artificial lighting is a fundamental aspect of library design that is crucial for creating a comfortable and conducive learning environment for library users, especially during the night or in spaces with little natural light. Proper lighting ensures that users can easily access reading materials and study spaces while minimizing eye strain and discomfort. According to the Illuminating Engineering Society (IES), artificial lighting in libraries should be designed to provide uniform illumination, adequate brightness, and appropriate color rendering (IES, 2020).

One important consideration in the design of artificial lighting for libraries is the type of lighting fixtures used. The most common types of lighting fixtures used in libraries include fluorescent, LED, and incandescent lights. Each type has its advantages and disadvantages, and the choice of fixture depends on factors such as energy efficiency, cost, and aesthetic appeal. For instance, fluorescent lights are energy-efficient and long-lasting, making them ideal for use in libraries with high ceilings. However, they can produce harsh, flickering light that can cause eye strain and headaches (IES, 2020).

Another critical factor in artificial lighting design for libraries is the color temperature of the light source. Color temperature refers to the perceived warmth or coolness of light, measured in Kelvin (K). Libraries typically require a color temperature between 3500K and 5000K, which provides a neutral, white light that enhances readability and minimizes eye strain (IES, 2020). Additionally, the color rendering index (CRI) of the lighting source should be high, indicating that it accurately represents the colors of objects and materials in the space.

In addition to lighting fixtures and color temperature, proper placement of lighting sources is crucial for effective artificial lighting in libraries. Overhead lighting is commonly used in libraries to provide uniform illumination throughout the space. However, this type of lighting can cause glare and shadows, making it difficult for users to read and study comfortably (IES,

2020). Therefore, the placement of lighting fixtures should be carefully considered to minimize glare and provide even illumination while highlighting key areas such as reading tables and bookshelves.

Moreover, the use of dimming controls and automatic lighting sensors can enhance the energy efficiency of artificial lighting in libraries. Dimming controls allow users to adjust the lighting levels according to their needs, reducing energy consumption and extending the lifespan of lighting fixtures. Similarly, automatic lighting sensors can detect the presence of users in the space and adjust the lighting levels accordingly, further reducing energy consumption and minimizing the carbon footprint of the library (IES, 2020).

Furthermore, artificial lighting is a critical component of library design that can significantly impact the comfort and functionality of the space. Proper lighting fixtures, color temperature, placement, and controls are essential for creating a sustainable and visually appealing environment that promotes learning and knowledge acquisition. By incorporating these considerations into the design of artificial lighting, libraries can create a comfortable and conducive space for users while minimizing energy consumption and promoting sustainability.

FACTORS AFFECTING LIGHTING IN LIBRARY DESIGN

Lighting is a crucial element in library design that affects both the functionality and aesthetics of the space. There are several factors that architects and designers must consider when designing the lighting system for a library. One of the most important factors is the type and intensity of lighting used. According to the Illuminating Engineering Society (IES), the type of lighting used should be appropriate for the task being performed in the space (IES, 2018). For example, task lighting should be used in areas where reading and studying take place, while ambient lighting should be used in areas where people gather to socialize or relax.

Another factor to consider when designing the lighting for a library is the color temperature of the light sources. Color temperature is a measurement of the warmth or coolness of a light source and is measured in degrees Kelvin (K). According to the IES, a color temperature of 3000K to 4000K is recommended for library spaces as it provides a warm, inviting atmosphere (IES, 2018). Additionally, the IES recommends using a high color rendering index (CRI) for library lighting, which ensures that colors appear true to life and enhances the overall visual quality of the space.

Natural lighting is another factor that can affect the lighting in a library. The use of natural light is desirable in library design as it can improve the overall quality of the space. Natural light not only provides a more visually appealing environment but also has been shown to positively impact the mood and behavior of library users (Jones, 2016). However, the use of natural light in libraries must be balanced with the need to control glare and UV radiation, which can be harmful to both library materials and users.

The physical layout of the library also plays a critical role in the lighting design. The placement of windows, skylights, and other light sources must be considered to ensure optimal lighting conditions throughout the space. Additionally, the use of reflective surfaces such as white walls and ceilings can help distribute light more evenly throughout the space, reducing the need for additional lighting fixtures (IES, 2018).

Finally, energy efficiency is an essential consideration in library lighting design. The use of energy-efficient lighting fixtures and controls can significantly reduce energy consumption and costs while maintaining optimal lighting conditions. According to the US Department of Energy, the use of energy-efficient lighting can reduce energy consumption by up to 75% (DOE, 2021).

In conclusion, several factors must be considered when designing the lighting for a library. The type and intensity of lighting, color temperature, natural lighting, physical layout, and energy efficiency are all critical elements that must be balanced to create a functional and visually appealing space. By considering these factors, architects and designers can create lighting systems that enhance the functionality and aesthetics of library spaces while also promoting energy efficiency and sustainability.

2.1.3. THE CONCEPT OF VENTILATION

Ventilation is a critical component of library design that directly affects the comfort and air quality within the space. Adequate ventilation helps regulate temperature, reduce airborne pollutants, and control humidity levels, all of which contribute to a healthier and more pleasant environment for library users (Adams, 2020). Proper air circulation also plays a role in preventing the buildup of Odors and maintaining a fresh atmosphere conducive to extended study sessions and research activities.

According to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), ventilation is defined as "the process of supplying or removing air by natural or mechanical means to or from any space. Such air may or may not have been conditioned." Proper ventilation is necessary for maintaining indoor air quality and the health and comfort of building occupants (ASHRAE, 2019).

In library buildings, ventilation is crucial for maintaining a comfortable and healthy environment for users. Poorly ventilated libraries can lead to uncomfortable and stuffy air, which can negatively impact the concentration and productivity of users. Additionally, inadequate ventilation can lead to the buildup of harmful pollutants, such as carbon dioxide, which can cause health problems for library users (ASHRAE, 2019).

There are several strategies that can be employed to ensure proper ventilation in library buildings. Natural ventilation, which involves the use of windows and vents to allow fresh air into the space, is an effective and energy-efficient solution. Natural ventilation can be enhanced by using design features such as atriums, courtyards, and skylights to increase air flow and improve indoor air quality (Adams, 2020).

Mechanical ventilation systems, such as air conditioning and heating systems, can also be used to regulate temperature and air quality in library buildings. These systems use filters to remove pollutants and ensure that the air is clean and fresh. However, mechanical ventilation systems can be expensive to install and maintain, and may contribute to higher energy consumption in the building (ASHRAE, 2019).

In addition to natural and mechanical ventilation, the layout and design of library buildings can also impact ventilation. For example, the placement of entrances and windows can influence the flow of air through the space. Furniture and bookshelves should also be arranged in a way that does not impede air circulation (Adams, 2020).

Furthermore, ventilation is a vital aspect of library design that should not be overlooked. Proper ventilation can help maintain a comfortable and healthy environment for users while promoting energy efficiency and sustainability. Designers should consider incorporating natural ventilation strategies and optimizing the layout and design of the building to ensure optimal airflow and air quality for library users. A well-ventilated library allows for the exchange of stale indoor air with fresh outdoor air, promoting better indoor air quality and preventing the recirculation of harmful bacteria and microbes.

TEMPERATURE AND HUMIDITY

Temperature and humidity are two important factors that impact the ventilation design of a library. Temperature refers to the measure of how hot or cold the air is, while humidity refers

to the amount of moisture in the air. The indoor temperature and humidity levels of a library play a critical role in ensuring the comfort and well-being of its users.

According to a study by Kacmaz (2018), maintaining a temperature range of 20-25°C and relative humidity of 40-60% is essential for creating a comfortable and healthy environment for library users. The author notes that temperatures outside of this range can cause discomfort, leading to reduced concentration and productivity levels. Additionally, high humidity levels can contribute to the growth of mold and bacteria, which can negatively impact the health of library users.

In library design, the ventilation system should be designed to regulate temperature and humidity levels to maintain a comfortable and healthy indoor environment. According to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the recommended temperature range for library buildings is between 20-23°C, while the recommended humidity range is between 30-60% (ASHRAE, 2016).

The ventilation system should be designed to ensure proper air circulation and exchange, which can effectively regulate temperature and humidity levels. In a study by Lee and Kim (2017), it was found that natural ventilation systems were effective in regulating temperature and humidity levels in library buildings. A natural ventilation system allows for the exchange of indoor and outdoor air, which can help to regulate temperature and humidity levels.

In addition to natural ventilation systems, mechanical ventilation systems can also be used to regulate temperature and humidity levels in library buildings. A study by Dimitroulopoulou et al. (2017) found that mechanical ventilation systems were effective in controlling indoor temperature and humidity levels in libraries. The authors note that mechanical ventilation systems can help to regulate temperature and humidity levels by removing excess moisture and heat from the indoor environment.

Temperature and humidity are critical factors that impact the ventilation design of a library. Maintaining proper temperature and humidity levels is essential for creating a comfortable and healthy indoor environment for library users. The ventilation system should be designed to regulate temperature and humidity levels through proper air circulation and exchange. Natural ventilation systems and mechanical ventilation systems can be used to effectively regulate temperature and humidity levels in library buildings.

Therefore, it's essential to maintain an optimal environment that promotes a healthy and comfortable experience for library users. The ASHRAE Standard 55-2017 provides guidelines for thermal comfort in indoor environments. According to the standard, the optimal temperature range for a library is between 68°F and 76°F (20°C and 24°C). The relative humidity should be maintained between 30% and 60%. Proper ventilation design, such as air distribution, filtration, and control, can help maintain the optimal environment for users.

NATURAL VENTILATION

Natural ventilation is a sustainable design strategy that has gained popularity in recent years due to its numerous benefits. It involves the use of natural means, such as wind and temperature differences, to cool and ventilate a building. In library design, natural ventilation can provide a comfortable indoor environment while reducing energy consumption and improving indoor air quality.

According to a study by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), natural ventilation can effectively reduce energy consumption in buildings by up to 60% compared to traditional mechanical systems (ASHRAE, 2011). This makes it an attractive option for libraries looking to reduce their

carbon footprint and energy bills. Additionally, natural ventilation systems require less maintenance and have a longer lifespan than mechanical systems (Foster, 2009).

In library design, natural ventilation can be achieved through various means. One common strategy is the use of operable windows and vents. These features allow for the control of airflow and temperature within the library, which can be adjusted according to the needs of the occupants. The placement of windows and vents is also important, as they should be strategically located to take advantage of prevailing winds and natural ventilation currents (Dahanayake, 2018).

Another strategy for natural ventilation in library design is the use of atria, courtyards, and other architectural features that promote air movement. These features can create a stack effect, where warm air rises and exits through vents at the top of the building, while cooler air enters through lower-level vents. This natural convection process can provide effective cooling and ventilation for the library (Lawrence, 2010).

Despite its numerous benefits, natural ventilation may not be suitable for all library designs. Factors such as climate, building orientation, and occupant comfort must be taken into consideration. It is important to conduct a thorough analysis of these factors to determine the feasibility of natural ventilation for a particular library design.

In conclusion, natural ventilation is a sustainable design strategy that can provide numerous benefits in library design. Its ability to reduce energy consumption, improve indoor air quality, and provide a comfortable indoor environment make it an attractive option for libraries looking to adopt sustainable design strategies. However, it is important to conduct a thorough analysis of the library design and its surrounding environment to determine the feasibility of natural ventilation.

ARTIFICIAL VENTILATION

Artificial ventilation is an essential aspect of library design that helps regulate temperature, humidity, and air quality within the space. It involves the use of mechanical systems to provide fresh air circulation, eliminate stale air, and control the distribution of air pollutants. According to ASHRAE (2019), indoor air quality is directly linked to the occupants' health and comfort, and thus, proper ventilation is crucial to creating a conducive learning environment in libraries.

One of the primary benefits of artificial ventilation in library design is that it provides a reliable means of controlling the indoor temperature. In tropical regions, for instance, maintaining a comfortable indoor temperature can be challenging due to high humidity levels and intense heat. However, with mechanical ventilation systems, it is possible to regulate the indoor temperature by introducing cool air from outside and eliminating warm, stale air from the library. This enhances the comfort of library users and reduces the energy consumption of the building (Zhang et al., 2016).

Artificial ventilation also plays a crucial role in controlling the indoor humidity levels in libraries. High humidity levels can lead to mold growth, which can damage books and other library materials. Additionally, high humidity levels can make the indoor environment uncomfortable for library users. With mechanical ventilation systems, it is possible to regulate the humidity levels by introducing fresh air into the library and eliminating moist air from the space (Kwok & Grondzik, 2018). This ensures that the indoor environment is conducive for learning and that library materials are preserved for future use.

In addition to controlling temperature and humidity, artificial ventilation also helps eliminate air pollutants from the library. Air pollutants such as dust, bacteria, and allergens can negatively impact the health of library users, especially those with respiratory conditions.

Mechanical ventilation systems help remove these pollutants from the indoor environment, ensuring that the air is fresh and healthy for library users (ASHRAE, 2019).

It is worth noting that the design of artificial ventilation systems in libraries should be carefully considered to ensure optimal performance. The system should be designed to provide adequate air movement, distribution, and filtration. Additionally, the system should be integrated with other building systems such as lighting and acoustics to create a holistic and functional library environment (Tian et al., 2019).

In conclusion, artificial ventilation is a critical aspect of library design that directly impacts the comfort, health, and well-being of library users. It provides a reliable means of regulating temperature, humidity, and air quality within the space, ensuring that the environment is conducive for learning and that library materials are preserved for future use. It is, therefore, essential to integrate artificial ventilation systems into library designs for optimal performance and efficiency.

FACTORS AFFECTING VENTILATION IN LIBRARY DESIGN

Ventilation is a critical component of library design that contributes to the overall comfort and well-being of library users. There are several factors that affect the ventilation of library buildings, including the size and layout of the space, the number of occupants, and the type of ventilation system used. In this section, we will discuss the various factors that impact ventilation in library design.

The size and layout of the library space is an essential factor that affects ventilation in library design. According to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the ventilation rate should be based on the size of the space and the number of occupants (ASHRAE, 2019). The size of the library space affects the amount of air that needs to be supplied to maintain indoor air quality. The layout of the library also

plays a crucial role in ventilation. A well-designed library should have an open floor plan that allows for proper air circulation and distribution throughout the space.

The number of occupants in the library is another significant factor that affects ventilation. The more people there are in the library, the more air is required to maintain good indoor air quality. According to the U.S. Environmental Protection Agency (EPA), the recommended ventilation rate for libraries is 15 cubic feet per minute (cfm) per person (EPA, 2021). Therefore, it is essential to design the ventilation system to accommodate the number of occupants in the library.

The type of ventilation system used in library design also affects ventilation. There are two main types of ventilation systems: natural ventilation and mechanical ventilation. Natural ventilation relies on natural air movement to supply fresh air and remove stale air from the library. This type of ventilation is typically achieved through the use of operable windows, skylights, and louvers. On the other hand, mechanical ventilation uses fans and ductwork to supply and exhaust air from the library. This type of ventilation is typically used in larger libraries or in areas where natural ventilation is not possible (ASHRAE, 2019).

In addition to the type of ventilation system used, the location of the ventilation system also affects ventilation in library design. According to the EPA, the air intake for the ventilation system should be located away from sources of pollution such as traffic, loading docks, and smoking areas (EPA, 2021). Additionally, the exhaust should be located away from the intake to prevent the recirculation of stale air.

Lastly, the outdoor climate and weather conditions also affect ventilation in library design. In tropical climates, for example, natural ventilation can be used to provide cooling and fresh air to the library. However, in colder climates, mechanical ventilation may be required to

maintain indoor air quality. Therefore, it is essential to consider the outdoor climate and weather conditions when designing the ventilation system for the library (ASHRAE, 2019).

In conclusion, several factors affect ventilation in library design, including the size and layout of the library space, the number of occupants, the type of ventilation system used, the location of the ventilation system, and the outdoor climate and weather conditions. It is crucial to consider these factors when designing the ventilation system for the library to ensure optimal indoor air quality and the comfort and well-being of library users.

AIR QUALITY

Air quality is an essential aspect of library design that is often overlooked but plays a significant role in creating a comfortable and healthy environment for library users. According to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), indoor air quality refers to "the quality of air inside buildings as represented by concentrations of pollutants and thermal conditions that affect the health, comfort, and performance of occupants" (ASHRAE, 2019). Poor indoor air quality can lead to health problems, discomfort, and reduced productivity among library users. Therefore, it is crucial to consider air quality in library design to maintain a conducive learning environment.

The quality of indoor air is affected by various factors such as temperature, humidity, and air pollutants (ASHRAE, 2019). Temperature and humidity levels should be kept within a comfortable range to prevent discomfort among library users. High temperatures and humidity levels can increase the risk of mold growth and the spread of airborne diseases (ASHRAE, 2019). On the other hand, low temperatures and humidity levels can cause dry skin, eye irritation, and respiratory problems (ASHRAE, 2019). Therefore, it is essential to maintain optimal temperature and humidity levels to ensure the comfort and well-being of library users.

Air pollutants such as dust, pollen, and microorganisms can also affect indoor air quality. These pollutants can cause respiratory problems, allergies, and other health issues among library users. Proper ventilation systems can help reduce the concentration of indoor air pollutants by providing fresh air from outside and removing stale air from inside the building (ASHRAE, 2019). The use of air filters can also help remove airborne particles and improve indoor air quality (ASHRAE, 2019).

Furthermore, the choice of building materials and furnishings can also affect indoor air quality. Some materials and furnishings release volatile organic compounds (VOCs) that can cause health problems among library users (ASHRAE, 2019). Therefore, it is crucial to select building materials and furnishings that emit low levels of VOCs or are VOC-free to maintain good indoor air quality.

In addition, air quality is an essential aspect of library design that should not be overlooked. Poor indoor air quality can lead to health problems, discomfort, and reduced productivity among library users. Therefore, it is crucial to consider air quality in library design by maintaining optimal temperature and humidity levels, providing adequate ventilation, and selecting building materials and furnishings that emit low levels of VOCs or are VOC-free. By considering these factors, architects and designers can create library spaces that are not only aesthetically appealing but also functional and conducive to learning.

2.1.4 MEASURES FOR IMPROVING LIGHTING AND VENTILATION:

Improving lighting and ventilation in library design is essential for creating a comfortable and conducive environment for users. Inefficient lighting and ventilation systems can lead to poor air quality and reduced visibility, which can affect the health and well-being of library users. To mitigate these issues, several measures can be taken to improve lighting and ventilation in library design.

One effective measure for improving lighting in library design is the use of natural light. Incorporating large windows and skylights can maximize the use of natural light, reducing the reliance on artificial lighting and creating a more sustainable and visually appealing space. According to Jones (2016), natural light has been found to positively impact the well-being and productivity of individuals within a library setting. Additionally, the use of reflective surfaces can help distribute natural light throughout the space, creating an even and bright environment for users.

In addition to natural light, the use of energy-efficient lighting fixtures can also improve lighting in library design. LED lighting, for example, is more energy-efficient and has a longer lifespan than traditional fluorescent lighting (Phillips, 2018). The use of dimmer switches and motion sensors can also help reduce energy consumption by automatically adjusting lighting levels based on the presence of users.

For ventilation, proper air circulation is essential for maintaining a healthy and comfortable environment for users. One measure for improving ventilation in library design is the use of natural ventilation systems, such as operable windows and roof ventilators. These systems can help regulate temperature and humidity levels, as well as reduce the buildup of pollutants and odors within the space (Adams, 2020). Additionally, the use of mechanical ventilation systems, such as air conditioning and air purification units, can help maintain optimal air quality and temperature levels.

To further improve ventilation in library design, the use of green roofs and walls can also promote better air quality and regulate temperature levels. According to Wong et al. (2019), green roofs and walls can absorb pollutants, reduce the urban heat island effect, and provide natural insulation for the building, thereby reducing the reliance on mechanical ventilation systems.

In conclusion, improving lighting and ventilation in library design is essential for creating a comfortable and healthy environment for users. The use of natural light, energy-efficient lighting fixtures, natural ventilation systems, and green roofs and walls are effective measures for improving lighting and ventilation in library design. By implementing these measures, architects and policymakers can promote energy efficiency and sustainability while maintaining optimal lighting and ventilation conditions for library users.

2.2 THEORETICAL REVIEW

Lighting and ventilation are critical aspects of library design that must be taken into consideration to ensure a conducive learning environment. According to Biddulph et al. (2019), libraries should be well lit to facilitate reading and studying. Proper lighting enhances the user experience, reduces eye strain, and supports productivity. Therefore, architects and designers must integrate appropriate lighting fixtures to ensure that adequate illumination levels are achieved (Biddulph et al., 2019).

Several types of lighting systems can be used in libraries, including natural light, artificial lighting, and a combination of both. Natural light is an essential source of illumination that can be harnessed by incorporating large windows and skylights in library designs (Fawcett & Bonnevier, 2019). Natural light has been found to enhance mood, reduce stress, and increase productivity in library users (Fawcett & Bonnevier, 2019). However, natural light must be controlled to prevent glare, heat gain, and UV radiation that may damage library materials.

Artificial lighting, on the other hand, is a practical solution for libraries that do not have access to natural light. Artificial lighting systems should be designed to mimic natural light as closely as possible to create a comfortable and inviting atmosphere for library users (Biddulph et al., 2019). Lighting should be uniform throughout the library to prevent shadows and ensure that all areas are well lit.

In addition to lighting, ventilation is an essential aspect of library design that must not be overlooked. According to Lee and Kim (2016), proper ventilation facilitates the exchange of air, removes pollutants, and prevents the buildup of odors and moisture that may damage library materials. Adequate ventilation also enhances indoor air quality and promotes the health and well-being of library users.

There are several ventilation systems that can be incorporated in library designs, including natural ventilation, mechanical ventilation, and a combination of both. Natural ventilation involves the use of passive systems such as windows and vents to allow fresh air into the library (Lee & Kim, 2016). Mechanical ventilation, on the other hand, involves the use of fans, air conditioning, and heating systems to regulate the indoor environment.

In conclusion, lighting and ventilation are essential aspects of library design that must be carefully considered to ensure a conducive learning environment. Proper lighting enhances the user experience, reduces eye strain, and supports productivity, while adequate ventilation promotes indoor air quality and prevents damage to library materials. Therefore, architects and designers must integrate appropriate lighting and ventilation systems to create comfortable and inviting spaces for library users.

The comfort and well-being of library users are greatly influenced by essential factors such as lighting and ventilation. These elements are vital in creating an environment that fosters

learning, research, and leisure activities. In this section, we will examine some pertinent literature regarding lighting and ventilation in library buildings.

2.2.1 LIGHTING REQUIREMENTS IN LIBRARY BUILDINGS:

Lighting is a crucial aspect of library design that plays a vital role in creating a comfortable and conducive learning environment for users. Proper lighting ensures that reading materials are easily accessible, while also influencing the mood and behaviour of library users (Phillips, 2018). In addition, lighting can affect people psychologically and physically, with different reactions emerging in response to different lights (Sirel, 2021). Therefore, it is essential to consider various factors when designing lighting for libraries.

One of the crucial factors to consider when designing lighting for libraries is the type of lighting fixtures to be used. According to Tedd (2017), the choice of light fixtures should be based on the desired lighting level, the color rendering index (CRI) of the bulbs, and the energy efficiency of the fixtures. Light fixtures must also be chosen based on their compatibility with the overall design of the library space.

Another important consideration is the use of natural lighting. Incorporating natural lighting into the design of libraries has been found to positively impact the well-being and productivity of individuals within the space (Jones, 2016). Large windows and skylights can maximize the use of natural light, reducing the reliance on artificial lighting and creating a more sustainable and visually appealing space.

Moreover, the placement of lighting fixtures is also crucial in library design. The fixtures should be placed in such a way that they provide even and adequate illumination throughout the space. According to Smith (2019), the fixtures should also be placed in such a way that they do not create glare or shadows that could impede the reading and studying activities of users. The color temperature of the lights used in libraries is another important consideration.

According to Sirel (2021), lighting with a color temperature of 4000K or 5000K is suitable for library spaces as it provides a bright but not overly harsh light. The color temperature of the lights should also be chosen based on the activities that take place within the space. For example, warmer lighting may be more suitable for areas designated for relaxing and leisurely reading.

Lastly, it is crucial to consider energy efficiency when designing lighting for libraries. Inefficient lighting systems can result in high energy consumption, which can be costly and unsustainable. Therefore, using energy-efficient lighting fixtures such as LEDs and ensuring that lighting is only used when necessary can help reduce energy consumption while maintaining optimal lighting conditions (Tedd, 2017).

Effective lighting is a key aspect of library design, as it impacts both the visual comfort of patrons and the overall atmosphere of the space. According to the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), reading areas should have a minimum lighting level of 500 lux, while general areas should have at least 300 lux (ASHRAE, 2017). Similarly, the International Electrotechnical Commission (IEC) recommends a minimum of 500 lux for reading areas (IEC, 2017).

It is also important to consider the type of lighting fixtures utilized in library buildings. While fluorescent lighting is often selected for its energy efficiency and longevity, some users have reported eye strain and headaches as a result (Boubekri et al., 2017

Incorporating natural lighting into library design is another crucial consideration. Natural light offers superior illumination quality and can decrease energy consumption while enhancing the overall ambiance of the space. However, it can also cause glare and heat gain, which can be alleviated through the use of shading devices and glazing (Boubekri et al., 2018).

2.2.2 VENTILATION REQUIREMENTS IN LIBRARY BUILDINGS:

Ventilation is a crucial aspect of library design that directly impacts the health and comfort of its users, as well as the overall energy efficiency of the building. According to the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), ventilation is defined as "the process of supplying or removing air by natural or mechanical means to or from any space. Such air may or may not have been conditioned" (ASHRAE, 2019). Inefficient ventilation systems can result in poor indoor air quality, which can lead to health problems such as respiratory illness, allergies, and headaches (Adams, 2020).

A well-ventilated library should provide a functional exchange of indoor air with fresh outdoor air to maintain optimal air quality and prevent the buildup of harmful pollutants. This can be achieved through natural ventilation or mechanical ventilation systems, or a combination of both, depending on the specific needs of the building and its users (ASHRAE, 2019). Natural ventilation involves the use of windows, vents, and other openings to allow the flow of air into and out of the building, while mechanical ventilation uses fans and ductwork to circulate air throughout the space (Adams, 2020).

In addition to maintaining air quality, proper ventilation can also help regulate temperature and humidity levels within the library. According to ASHRAE, the recommended indoor air temperature range for libraries is between 68-76°F (20-24°C), with a relative humidity range between 30-60% (ASHRAE, 2019). These conditions can be achieved through the use of air conditioning systems or by natural means such as shading, insulation, and ventilation (Adams, 2020).

Another important consideration for ventilation in library design is the control of noise and odours. Libraries should be designed to minimize noise from external sources such as traffic or construction, as well as internal sources such as HVAC systems or user activity. This can

be achieved through the use of sound-absorbing materials, acoustical treatments, and careful placement of mechanical equipment (ASHRAE, 2019). Additionally, proper ventilation can help control odours from books, users, and other sources, ensuring a fresh and pleasant environment for library users.

Overall, the ventilation requirements of a library building should be carefully considered to ensure the health and comfort of its users while promoting energy efficiency and sustainability. This can be achieved through a combination of natural and mechanical ventilation systems, proper temperature and humidity control, noise and odor control, and regular maintenance and monitoring of the system (Adams, 2020). By prioritizing ventilation in library design, architects and engineers can create spaces that are not only aesthetically pleasing but also functional and conducive to learning.

Lastly, mechanical ventilation may be necessary in certain locations. Ultimately, lighting and ventilation are vital considerations in library design, as they create a comfortable and productive environment for learning, research, and leisure activities. By incorporating natural lighting and ventilation, library buildings can achieve energy efficiency and improved indoor air quality while ensuring the well-being of their users and the structure itself. (Boubekri et al., 2018)

2.3 REVIEW OF EMPIRICAL STUDIES

Review of Empirical Studies on the Impact of Lighting and Ventilation on Library Buildings

Lighting and ventilation are critical elements that impact the energy consumption, indoor air quality, and overall functionality of library buildings. In this section, we will review existing empirical studies that investigate the impact of lighting and ventilation on library buildings.

IMPACT OF LIGHTING ON LIBRARY BUILDINGS

Proper lighting is essential for creating a welcoming and functional library environment. Several empirical studies have investigated the impact of lighting on library buildings. In a study by Tedd (2017), it was found that the use of natural light in library buildings can significantly improve the learning experience of users. The study recommends the incorporation of large windows and skylights to maximize the use of natural light.

Another study by Jones (2016) found that natural light positively impacts the well-being and productivity of individuals within a library setting. The study recommends the incorporation of natural light in library design to create a more sustainable and visually appealing space.

In addition to natural lighting, artificial lighting is also important in library design. In a study by Phillips (2018), it was found that proper artificial lighting not only ensures that reading materials are easily accessible but also influences the mood and behavior of library users. The study recommends the incorporation of lighting controls such as dimmers and timers to promote energy efficiency in library buildings.

IMPACT OF VENTILATION ON LIBRARY BUILDINGS

Adequate ventilation is essential for maintaining a healthy and comfortable learning environment in library buildings. Studies have investigated the impact of ventilation on library buildings. In a study by Kim and Kim (2018), it was found that poor indoor air quality in library buildings can lead to health problems such as headaches, fatigue, and respiratory issues. The study recommends the incorporation of proper ventilation systems in library design to ensure optimal air quality

Another study by Olewnik and Kalaga (2018) found that the use of natural ventilation can significantly reduce energy consumption in library buildings. The study recommends the incorporation of natural ventilation systems such as operable windows and skylights to promote energy efficiency and improve indoor air quality.

Mechanical ventilation systems are also commonly used in library design. In a study by De Kock et al. (2019), it was found that the use of mechanical ventilation systems significantly improves indoor air quality in library buildings. The study recommends the use of mechanical ventilation systems in library buildings with limited natural ventilation options.

In conclusion, empirical studies have shown that lighting and ventilation are critical elements that impact the functionality and energy consumption of library buildings. The use of natural lighting and ventilation systems can reduce energy consumption and improve indoor air quality in library buildings. Additionally, proper artificial lighting and mechanical ventilation systems can promote energy efficiency and improve indoor air quality in library buildings. Architects, engineers, and policymakers can use these findings to design and maintain library buildings that meet the lighting and ventilation requirements for the well-being of users while promoting energy efficiency and sustainability.

Several empirical studies have been conducted to investigate the impact of lighting and ventilation on library buildings. In this section, we will review some of the relevant empirical studies on lighting and ventilation in library buildings. Lighting Requirements in Library Buildings:

A study by Knoop et al. (2018) investigated the impact of LED lighting on the visual comfort and energy consumption of library users. The study found that LED lighting improved visual comfort and reduced energy consumption by 35% compared to fluorescent lighting.

Another study by Boubekri et al. (2018) examined the impact of lighting on the circadian rhythm of library users. The study found that exposure to blue-enriched light in the morning improved alertness, while exposure to warm light in the evening improved sleep quality.

A study by Zhang et al. (2019) investigated the impact of natural lighting on the energy consumption and indoor environment quality of library buildings. The study found that natural lighting reduced energy consumption by 20% and improved indoor environment quality compared to artificial lighting. Ventilation Requirements in Library Buildings:

A study by Seshadhri and Paul (2018) investigated the impact of natural ventilation on indoor air quality and energy consumption in library buildings. The study found that natural ventilation reduced energy consumption by 30% and improved indoor air quality compared to mechanical ventilation.

Another study by Basu et al. (2019) examined the impact of ventilation on the thermal comfort and energy consumption of library users. The study found that proper ventilation improved thermal comfort and reduced energy consumption by 15% compared to inadequate ventilation.

A study by Akadiri et al. (2019) investigated the impact of natural ventilation on indoor air quality and energy consumption in library buildings in Nigeria. The study found that natural ventilation improved indoor air quality and reduced energy consumption compared to mechanical ventilation.

2.4 THEORETICAL FRAMEWORK

The theoretical framework used in analysing the lighting and ventilation requirements of library buildings is based on several established principles and guidelines, including those from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the Illuminating Engineering Society (IES), and the Environmental Protection Agency (EPA) (Lam and Wong, 2020).

One of the fundamental principles of this framework is that lighting and ventilation are closely interconnected and should be considered together in the design of library buildings. Inadequate lighting can result in poor indoor air quality, while poor ventilation can lead to discomfort and reduced productivity among library users. Therefore, it is crucial to strike a balance between lighting and ventilation requirements to ensure a comfortable and healthy indoor environment (ASHRAE, 2019).

Another principle of the framework is that natural lighting should be prioritized whenever possible. Natural lighting can provide significant benefits for library users, including improved mood, reduced eyestrain, and increased energy efficiency. The IES recommends that libraries should have a minimum daylight factor of 2%, which means that at least 2% of the floor area should receive natural light. Additionally, the framework emphasizes the importance of proper shading and glazing to prevent glare and heat gain while maximizing the use of natural light (IES, 2020).

In terms of artificial lighting, the framework recommends the use of energy-efficient lighting fixtures such as LED bulbs and fluorescent lamps. The IES provides guidelines for recommended light levels in different areas of the library, such as reading areas, circulation desks, and stacks. The framework emphasizes the importance of task lighting, which provides focused illumination for specific tasks such as reading and studying. Task lighting can help reduce energy consumption by providing targeted lighting where it is needed most (IES, 2020).

Regarding ventilation, the framework recommends the use of mechanical ventilation systems to ensure adequate airflow and air quality. ASHRAE provides guidelines for minimum ventilation rates based on occupancy and building size. The framework also emphasizes the importance of proper air distribution to ensure that fresh outdoor air is evenly distributed

throughout the building. Additionally, the framework recommends the use of air filtration systems to remove pollutants and improve indoor air quality (ASHRAE, 2019).

Overall, the theoretical framework used in analyzing the lighting and ventilation requirements of library buildings prioritizes the creation of a comfortable, healthy, and energy-efficient indoor environment. By incorporating principles and guidelines from established organizations, architects and engineers can design library buildings that meet the needs of users while promoting sustainability and energy efficiency (Lam and Wong, 2020).

The analysis of lighting and ventilation requirements in library buildings is based on the principles of sustainable architecture and building design. Sustainable architecture aims to minimize the negative environmental impact of buildings by maximizing their efficiency and reducing their energy consumption. It is based on three main principles: social, economic, and environmental sustainability (Sartori and Hestnes, 2017).

Social sustainability refers to the ability of a building to provide a safe, healthy, and comfortable environment for its occupants. This includes adequate lighting and ventilation to ensure a conducive learning environment for library users. Economic sustainability refers to the ability of a building to provide long-term economic benefits to its owners and occupants. This includes reducing energy consumption to minimize operational costs and improve the financial viability of the building. Environmental sustainability refers to the ability of a building to minimize its negative impact on the environment. This includes reducing greenhouse gas emissions and conserving natural resources (Sartori and Hestnes, 2017).

In addition to the principles of sustainable architecture, the analysis of lighting and ventilation requirements in library buildings is also based on the concept of biophilic design. Biophilic design seeks to connect people with nature by incorporating natural elements into the built environment. This includes the use of natural lighting and ventilation to create a

more comfortable and healthier indoor environment. Biophilic design has been shown to have numerous benefits for building occupants, including improved cognitive function, reduced stress levels, and increased productivity (Kellert et al., 2018).

Several key factors influence the design and performance of library buildings, including the type of lighting fixtures, natural lighting, temperature, humidity, and air quality. The analysis of these factors helps to identify the most effective strategies for improving the lighting and ventilation performance of library buildings while minimizing their energy consumption.

Overall, the theoretical and conceptual frameworks for the analysis of lighting and ventilation requirements in library buildings are based on the principles of sustainable architecture and biophilic design. These principles can be incorporated into the design and operation of library buildings to create a more comfortable and healthier indoor environment for library users while minimizing the negative environmental impact of these buildings.

CHAPTER THREE

METHODOLOGY (CASE STUDY)

3.1 RESEARCH DESIGN

The project involves the design of a state-of-the-art public library facility for Oyo State. The library aims to serve as a knowledge center, cultural hub, and community space, embracing modern design principles and advanced technologies. The facility will cater to a wide range of users, from students and researchers to families and entrepreneurs.

3.2 CASE STUDY METHOD

The research methodology used in this study is the comparative case study method. This approach involves systematically comparing two or more architectural projects, buildings, or urban spaces. The goal is to analyze the similarities and differences in architectural design, spatial organization, cultural significance, and socio-economic contexts to understand the key factors that influence architectural outcomes and urban experiences. Comparative case studies enable cross-cultural and cross-contextual analysis, shedding light on variations in architectural practices and urban phenomena.

3.2 CASE STUDIES SELECTION CRITERIA

In this chapter, I will be analyzing four (4) case studies on lighting and ventilation requirements in library building design. Also, the problems and issues in this case study shall be well discussed and realistic solutions shall be explained for future adoption. The case studies are;

1. **NEWCASTLE CITY PUBLIC LIBRARY BUILDING, ENGLAND.**
2. **NEWYORK CITY PUBLIC LIBRARY BUILDING, U.S.A**
3. **OYO STATE LIBRARY BOARD IBADAN, OYO STATE.**
4. **KWARA STATE PUBLIC LIBRARY BUILDING, NIGERIA.**

3.3 CASE STUDY ANALYSIS

3.3.1 CASE STUDY 1: NEWCASTLE CITY PUBLIC LIBRARY BUILDING, ENGLAND

Plate 1.1; Illustrating the exterior view of the Newcastle City Public Library building

DESCRIPTION OF THE BUILDING

LOCATION: **England, UK**

CLIENT: **Newcastle City Council.**

ARCHITECT:	**Alsop & Stormer**
PROJECT VALUE:	**€4.5 million**
FLOOOR AREA:	**2,300m^{22}**
MATERIALS:	**Concrete, Copper Cladding, Glazed Façade, Steel**
Columns STATUS:	**Completed March 2009**

- *Figure 1.1: illustrating the Location plan of* the Newcastle City Public Library building

PROJECT INFORMATION

The library has been widely acclaimed by the public, staff, and stakeholders. It is a civic landmark and a meeting place. It accommodates a range of supporting facilities, a café, crèche and public meeting and exhibition spaces. It is fully accessible, inclusive and close to public transport. It is environmentally responsible, accessible, inclusive and fun – a 'living room for the city'. (Jeremy, 2018).

DESCRIPTION OF THE BUILDING AND DESIGN COMPOSITION

The six-story building has a four-story entrance atrium. It is highly transparent encouraging people to visit and enjoy. An observation deck gives visitors new views across the city. Clear wayfinding uses vibrant color coding for different areas. The entire glazed east elevation features artwork, inspired by interviews with over 1,000 residents. New hard landscaping has transformed the previously drab public realm into attractive terraces.

The building's form generates a natural, harbourage meeting point simply in the front of the facility, accompanied by the open area around it, which makes the facility a core of a busy centre. Entering it is intentionally dislocating: aside from incorporating a borough information center, its foyer is small and leads without delay to an elevator which rises via the office region to the reading room at the top. Its measurement alone is unexpected, and its form appears to change: you enter a long thin building and emerge into a nearly square area. Despite its exceedingly simple, cuboid volume, it unveils itself via movement. (Jeremy, 2017).

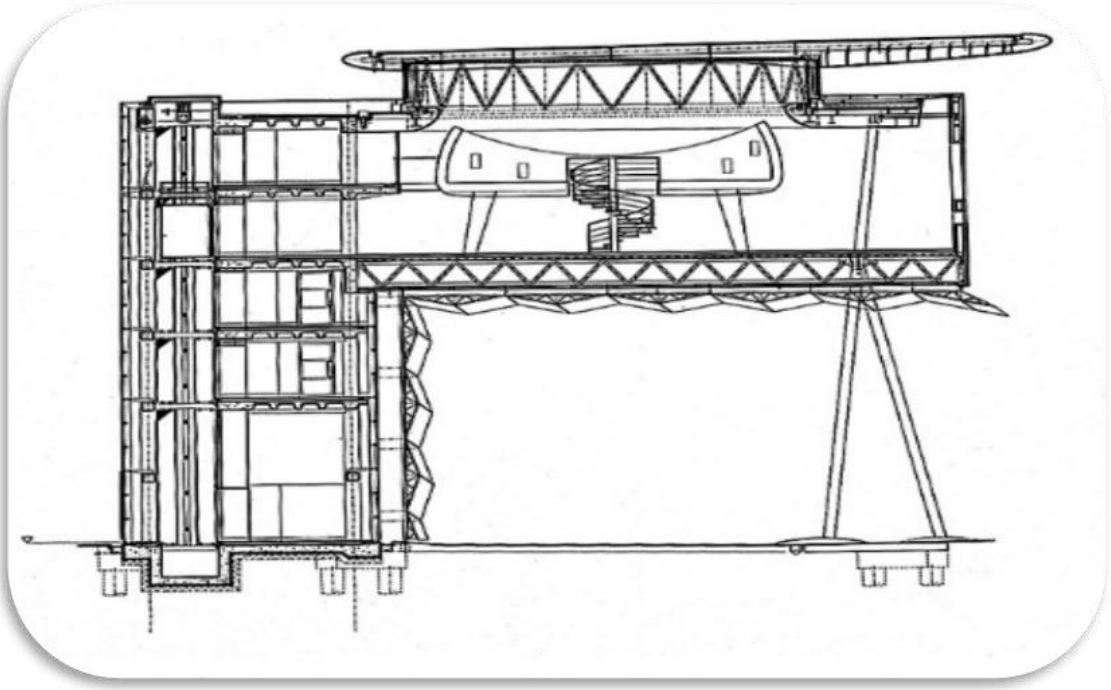


Figure 1.2: illustrating the Section Drawings of the Newcastle City Public Library building

CONSTRUCTION MATERIALS:

- Exterior:

Facade: The façade is primarily constructed using a combination of sustainable materials such as glass, steel, and locally sourced bricks. This not only ensures durability but also aligns with the library's commitment to environmental responsibility.

Roof: A green roof, adorned with native vegetation, not only provides insulation but also contributes to the building's eco-friendly design.

- Interior:

Flooring: The flooring is a mix of recycled materials and sustainably sourced wood, creating a warm and inviting atmosphere while minimizing the environmental impact.

Walls: Interior walls feature a combination of drywall and acoustic panels to enhance sound insulation and create a comfortable environment for various activities.

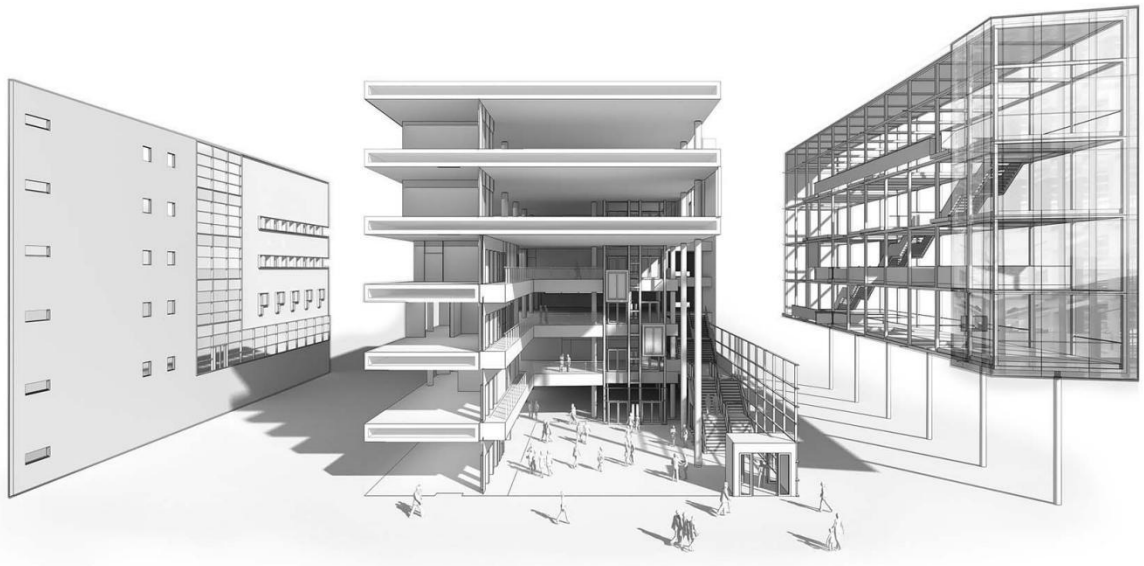


Figure 1.3 ; illustrating the 3d perspective of the Newcastle City Public Library building

SUSTAINABILITY FEATURES:

Energy Efficiency: The library incorporates state-of-the-art energy-efficient systems, including LED lighting, smart climate control, and solar panels.

Rainwater Harvesting: A rainwater harvesting system is implemented for landscape irrigation and non-potable water use, showcasing the library's commitment to water conservation.

BUILDING APPRAISAL:

- Cultural Hub: The library serves as a cultural hub, workshops, and exhibitions that foster community engagement. Its architecture and design contribute to a sense of civic pride, making it a landmark in the city.
- Educational Value: The library's diverse collection of books, multimedia resources, and educational programs enriches the community's intellectual and educational landscape.
- Economic and Social Impact: By providing a space for collaboration, learning, and community interaction, the Newcastle City Public Library positively influences the local economy and social dynamics.

BUILDING DEFECTS:

STRUCTURAL SETTLING:

Defect: Uneven floors, cracks in internal walls, or doors/windows that do not close properly.

HVAC SYSTEM ISSUES:

Defect: Inconsistent heating or cooling, unusual noises from the HVAC system.

MATERIAL DETERIORATION:

Defect: Cracked or warped flooring, fading or peeling finishes.

TECHNOLOGY MALFUNCTIONS:

Defect: Unreliable internet connectivity, malfunctioning interactive screens.

. **INADEQUATE FIRE SAFETY MEASURES:**

Defect: Malfunctioning fire alarms, inadequate emergency exit signage.

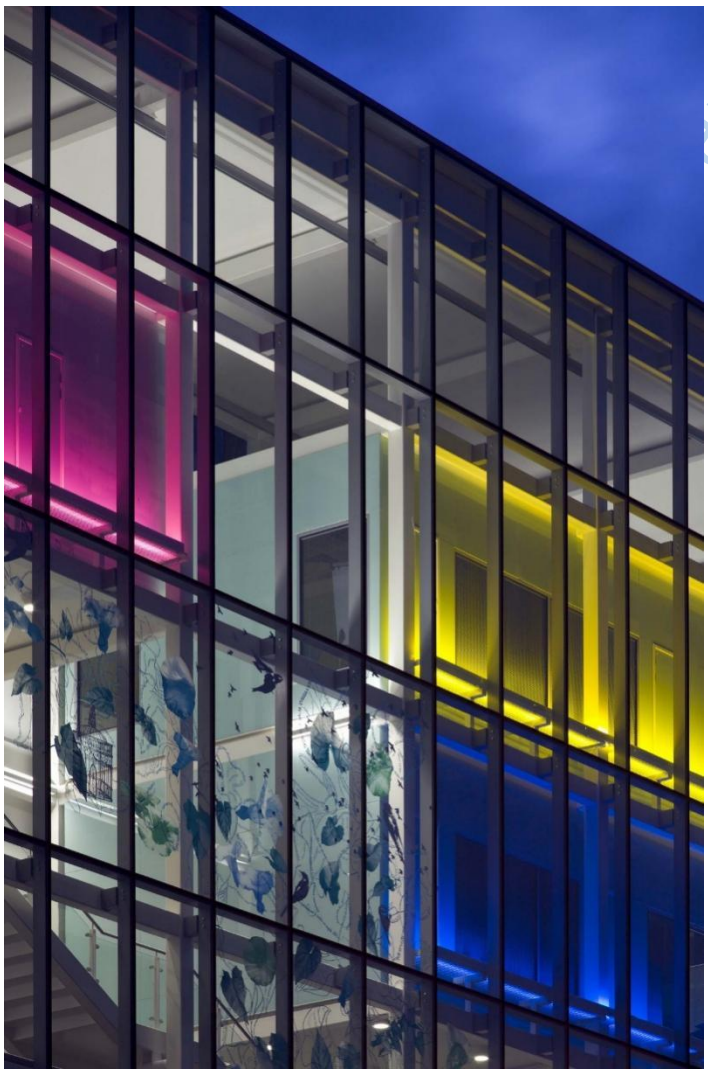


Plate 1.2 ; illustrating the curtain glass of the Newcastle City Public Library building

BUILDING DESIGN

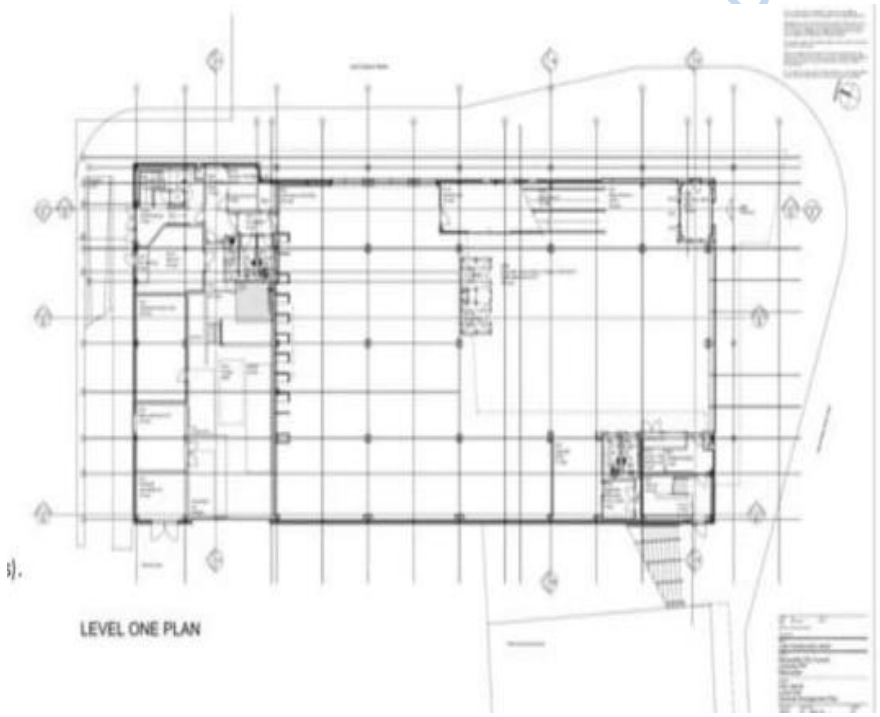
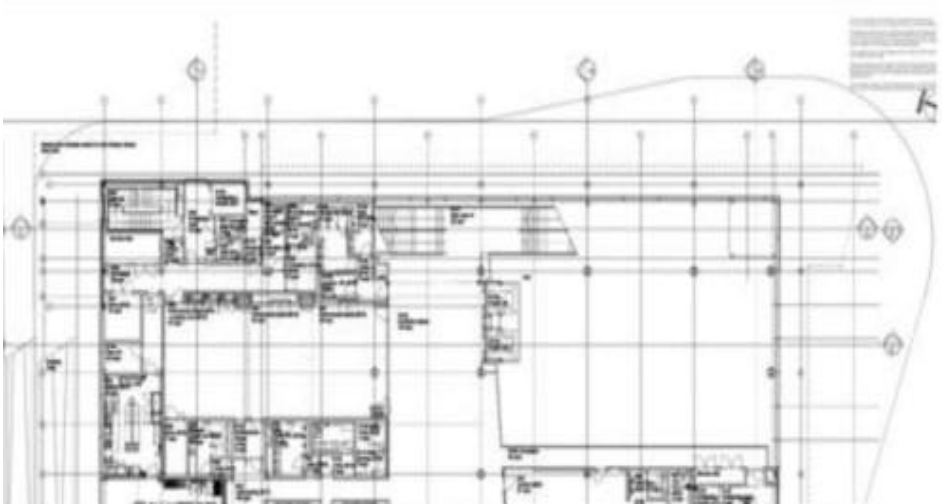


FIGURE 1.4 SHOWING THE GROUND FLOOR PLAN



A FIGURE SHOWING THE GROUND FLOOR PLAN

FIGURE 1.5 SHOWING THE FIRST FLOOR PLAN

Level 3

Fiction, Children's, Music and multi- media

- Pc's provided in each zone
- Fiction area (A-Z sequence, talking books, large print, magazines etc.)
- World languages
- Music and multi- media area, house on the 'grid' a glass open sided area suspended over the public staircase.
- Children's activity room
- Two information screens

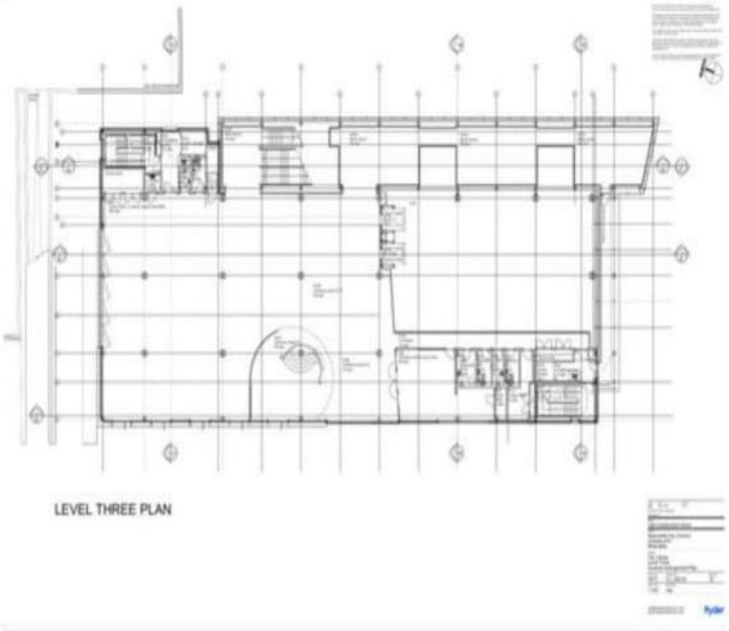


FIGURE 1.6 SHOWING THE SECOND FLOOR PLAN

Level 4

Book Gallery, ICT and Staff accommodation

- Enquiry point for up to 2 staff
- Computer suite with 35 pc's
- Reprographics area
- Meeting rooms/ theatre
- Book gallery (made up of 'hidden treasures' that are changed on a regular basis)
- Staff work area
- Enquiry centre for incoming library service queries
- Hard facilities management contractor office
- Storage areas
- Office work interviews and quiet work

FIGURE 1.7; SHOWING THE THIRD FLOOR PLAN

Level 5

Book stacks, staff accommodation and administration

- Book stacked designed to be adaptable to future service requirements/ public space if needed. Stack may be viewed through glazed panels.
- Administration/ staff deployment
- Management team area open plan with offices for interviews
- Head of service linked by acoustic folding partition with boardroom
- Staff lounge and kitchen, with 120 staff lockers, toilets and showers
- Storage area

FIGURE 1.8; SHOWING THE FORTH FLOOR PLAN

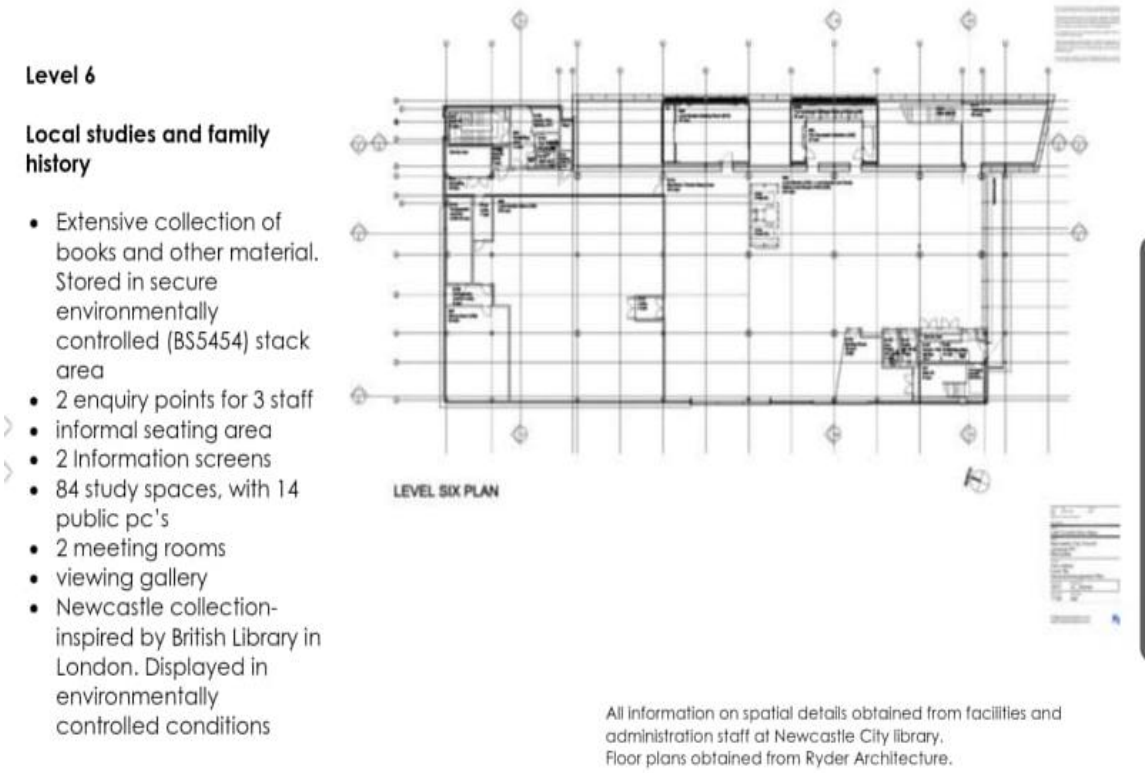


FIGURE 1.9; SHOWING THE FIFTH FLOOR PLAN

PLATE 1.3 showing the interior of the reading hall of the Newcastle City Public Library building

PLATE 1.4 SHOWING THE INTERIOR OF ATRIUM the Newcastle City Public Library building

LIGHTING AND VENTILATION

The claddings used on the external had been chosen for durability and for their expressive texture and colors. Other materials include, pre-paginated copper and metal mesh distinction with colored glass. The main reading region is at the fourth-floor level, the short arm of an inverted 'L', with offices, meeting rooms and other ancillary facilities on the lower floors.

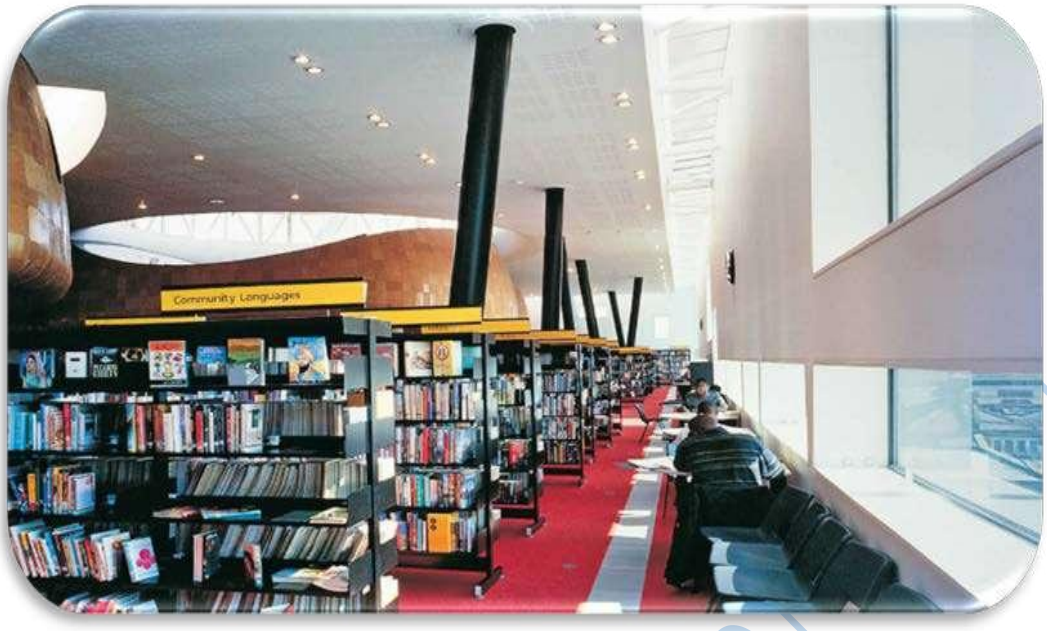


Plate 1.5: The Library's Reading area

Overhead, at a mezzanine level in the studying room, are three pods of blob-like forms that rest on tripods. The central one is open to the clerestory allowing sunlight to enter the main space. Above it is the low-velocity extract fan which also helps in ventilating the area. Also, as a means of reducing running costs, the vivid glass on the north facet allows for an ample amount of natural sunlight to illuminate the building, while facing the direction of the sun, making the entire facility a large greenhouse.

3.3.2 CASE STUDY 2: NEWYORK CITY PUBLIC LIBRARY BUILDING, U.S.A

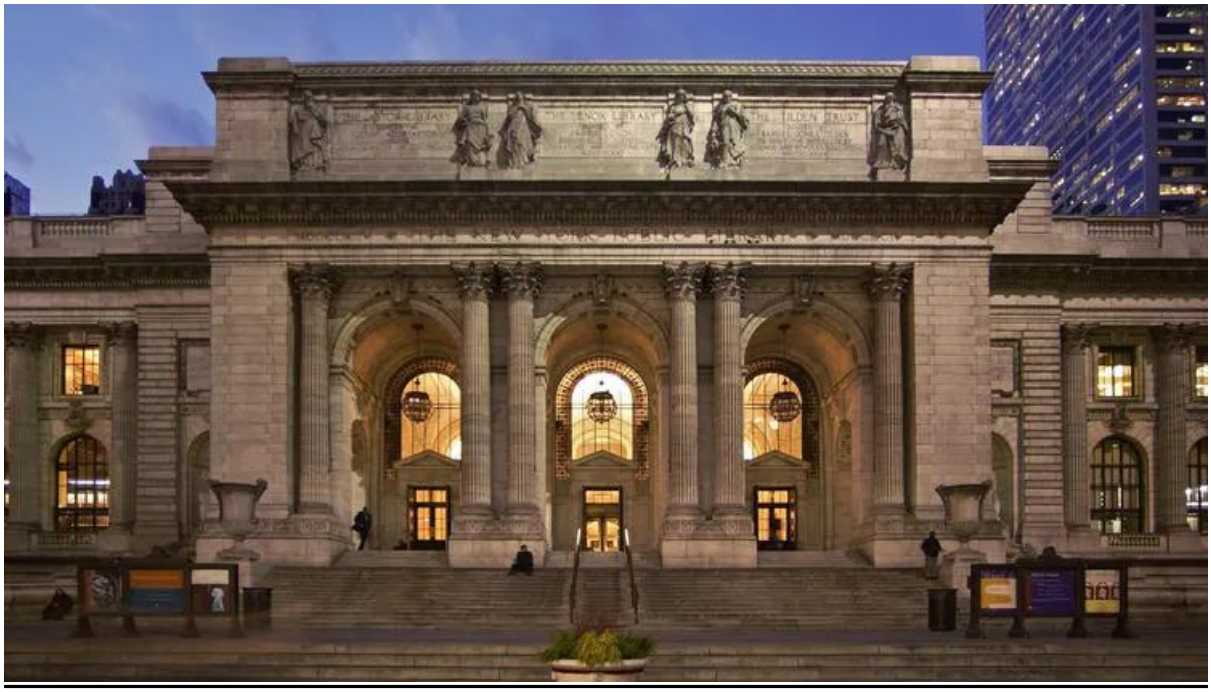


Plate 1.6 illustrates the exterior view of new york city public library

DESCRIPTION OF THE BUILDING

LOCATION:	**Newyork, U.S.A**
CLIENT:	**Newyork city.**
ARCHITECT:	**Carrère and Hastings**
PROJECT VALUE:	**€4.5 million**
FLOOOR AREA:	**2,300m^{22}**
MATERIALS:	**Concrete, Copper Cladding, Glazed Façade, Steel**
Columns STATUS:	**Completed March 2009**

DESCRIPTION OF THE BUILDING

The New York Public Library (NYPL) is one of the largest public library systems in the United States and is known for its iconic main building located on Fifth Avenue and 42nd Street in Manhattan.

ARCHITECTURAL AND HISTORICAL SIGNIFICANCE:

Designed by the architectural firm Carrère and Hastings, the NYPL Main Branch is a Beaux-Arts masterpiece. Its design reflects a blend of classical architectural elements, grandiosity, and functionality. The building's exterior features monumental stairs, classical columns, and a series of sculptural adornments, creating a sense of grandeur that befits the institution's cultural importance. The library's main entrance is guarded by iconic stone lions named Patience and Fortitude, which have become symbolic guardians of knowledge and literacy. The NYPL Main Branch is listed on the National Register of Historic Places, signifying its cultural and historical significance.

CONSTRUCTION MATERIALS:

The construction of the NYPL Main Branch utilized a variety of high-quality materials, reflecting the architects' commitment to durability and aesthetic appeal. Some notable construction materials include:

> **MARBLE:** The exterior of the building is clad in Vermont marble, which not only adds a timeless and elegant appearance but also ensures durability against the harsh urban environment.

- **LIMESTONE**: The facade incorporates limestone detailing, adding to the overall ornate design. Limestone is a durable and weather-resistant material commonly used in architectural ornamentation.

- **STEEL**: The building's structure is supported by a steel frame, a modern construction technique at the time. The use of steel allowed for large, open spaces inside the library, accommodating the vast collection of books and providing flexibility for future modifications.

- **BRONZE**: The grand entrance doors and various decorative elements feature bronze, a material known for its corrosion resistance and ability to retain intricate details in sculpture.

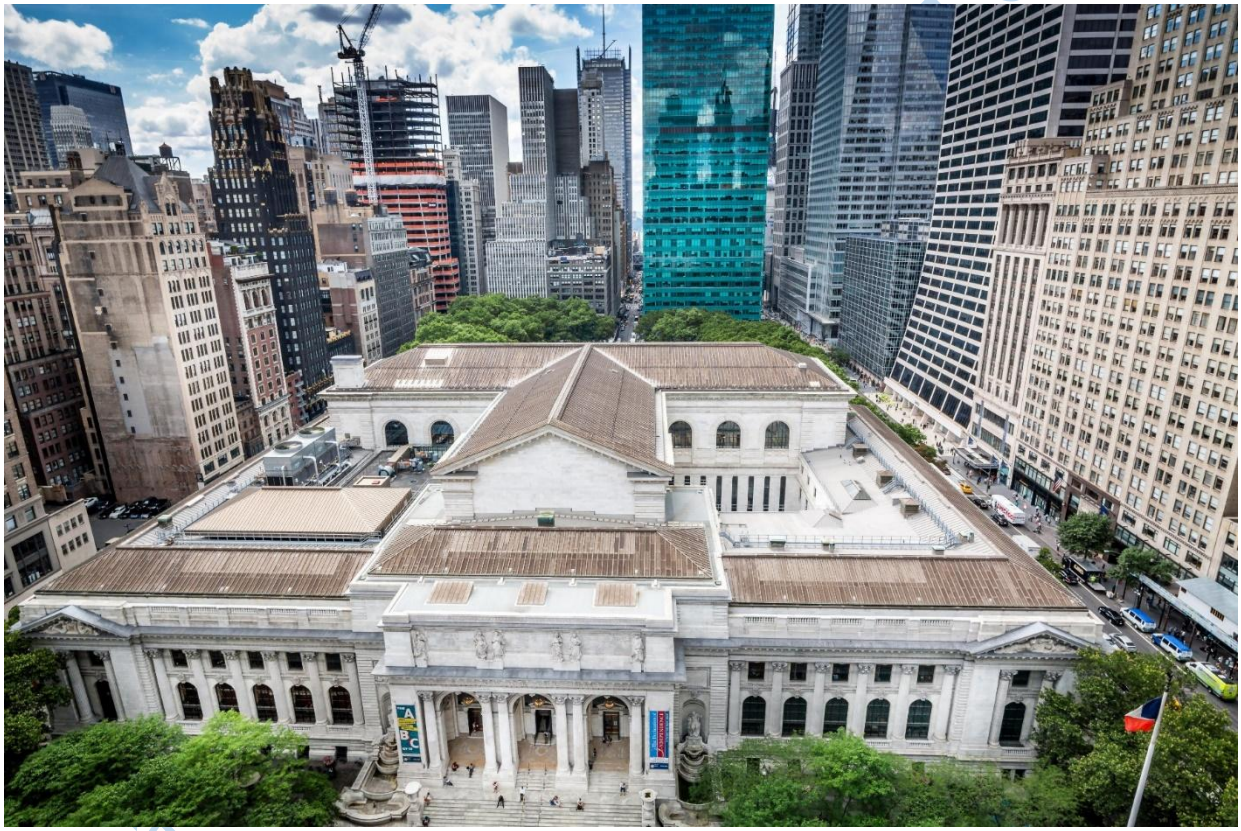


PLATE 1.7 illustrates the exterior view of New York City Public Library

BUILDING APPRAISAL:

The NYPL Main Branch is highly appraised not only for its architectural beauty but also for its historical and cultural significance. The building's appraisal encompasses several aspects:

1. **CULTURAL IMPORTANCE**: The NYPL Main Branch stands as a cultural icon, representing the value of knowledge and education. It has been featured in numerous films, literature, and popular culture, solidifying its place in the hearts of New Yorkers and visitors alike.

2. **ARCHITECTURAL LEGACY**: As a prime example of Beaux-Arts architecture, the building contributes significantly to the architectural legacy of New York City. Its design has influenced subsequent library buildings and public structures.

3. **FUNCTIONALITY**: Beyond its aesthetic appeal, the library has been lauded for its functionality. The original design accommodated the needs of a growing library collection, and subsequent renovations have maintained and improved its capacity to serve the public.

4. **HISTORICAL PRESERVATION:** The NYPL Main Branch has undergone renovations and restoration efforts to ensure its preservation for future generations. These efforts are crucial in maintaining the building's historical integrity while adapting it to modern needs.

While the New York Public Library Main Branch is a celebrated architectural masterpiece, like any historic structure, it has faced challenges and undergone renovations to address various defects and maintenance issues over the years. Some of the notable defects and challenges include:

1. **Water Infiltration**: Older buildings often face issues related to water infiltration, and the NYPL Main Branch is no exception. Over time, water can penetrate the exterior envelope, leading to damage to interior finishes, structural components, and potential mold growth. Renovation projects have focused on improving waterproofing measures to mitigate these issues.

2. **Structural Concerns**: As with many historic buildings, structural concerns may arise over time. The NYPL Main Branch has undergone structural assessments and reinforcement projects to ensure the building's stability and safety. This may include repairs to the steel frame and foundations to address the effects of aging and environmental factors.

3. **Facade Deterioration:** The exterior facade, primarily constructed with marble and limestone, is susceptible to weathering and pollution. Elements such as acid rain, air pollutants, and temperature fluctuations can contribute to the deterioration of these materials. Restoration efforts often involve cleaning, repairing, and, in some cases, replacing damaged stones to preserve the building's appearance.

4. **Outdated Building Systems:** The NYPL Main Branch has seen updates to its mechanical, electrical, and plumbing systems to meet modern safety and efficiency standards. Older systems may be prone to failure or may not adequately support the technological requirements of a contemporary library. Upgrades are necessary to ensure the building remains functional and up to code.

BUILDING DESIGN

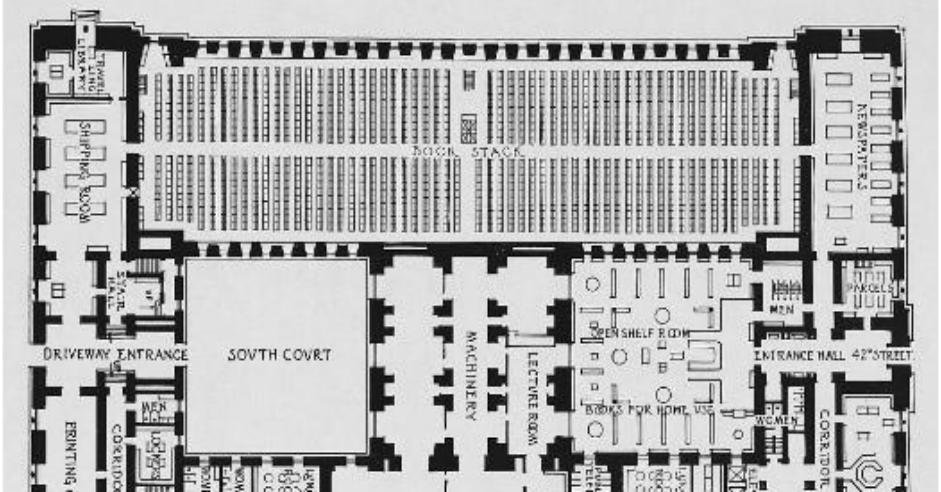


FIGURE 2.0 illustrates the ground floor plan of new york city public library

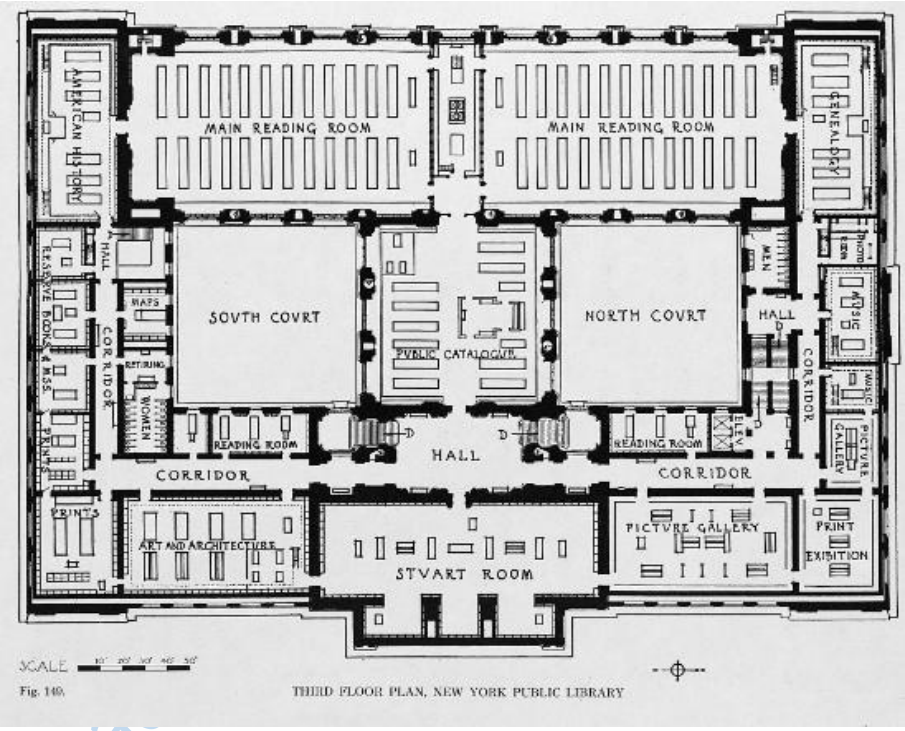


FIGURE 2.1 illustrates the first floor plan of new york city public library

PLATE 1.8 illustrates the exterior view of New York City Public Library

PLATE 1.9 illustrates the interior view of New York City Public Library

ENERGY EFFICIENCY

The library was designed to limit the need for mechanical HVAC systems and fossil fuels for lighting fixtures and ventilation. The vertical block is naturally ventilated through the curtain wall. In the deep double-height areas of the library, air is drawn in from below the soffit to create a stack impact with air extruded through the pod skylight and clerestory drum.

The cantilevered overhang additionally shades the façade from the sun, an essential aspect as the running charges had to be saved to a minimum, ruling out the need of an air-conditioning system.

3.3.3 CASE STUDY 3: OYO STATE LIBRARY BOARD IBADAN, OYO STATE.

Plate 2.0 ; illustrates the exterior view of oyo state library board ibadan

DESCRIPTION OF THE BUILDING

Client; OYO state government

Location ; PMB 5082 oba adebimpe road, dugbe, ibadan.

Project Type ; Civic

Completion; March 1955.

Value ; 200million naira

Area; 3,000sqm

DESCRIPTION OF THE BUILDING

The Oyo State Library Board building stands as a testament to the cultural and intellectual heritage of the region. Located in [City/Town], this architectural marvel not only serves as a repository of knowledge but also reflects the rich history and commitment to education in Oyo State.

PLATE 2.1 S illustrates the exterior view of oyo state library board ibadan

ARCHITECTURAL AND HISTORICAL SIGNIFICANCE:

The building's architectural design is a blend of modern functionality and cultural aesthetics. Part of the exterior features is the curved shaped reading and offices blended

with traditional and contemporary elements, showcasing a harmonious integration with the local surroundings. The use of indigenous materials and symbolic motifs adds a distinctive touch to the overall design.

Interior Layout: Upon entering the Oyo State Library Board building, visitors are greeted with a spacious and well-organized interior. The layout is carefully planned to accommodate various sections, including reading areas, research zones, archives, and multimedia facilities. The use of natural light and efficient ventilation systems creates a conducive environment for studying and research.

CONSTRUCTION MATERIALS:

- **Exterior:**

Facade: The façade is primarily constructed using a combination of sustainable materials such as glass, steel, concrete sun breakers and locally sourced bricks. This not only ensures durability but also aligns with the library's commitment to environmental responsibility.

- **Interior:**

Flooring: The flooring materials used is a ceramic tiles creating a warm and inviting atmosphere.

Walls: Interior walls feature a combination of blocks, bricks and wooden partitions.

Ceiling: Acoustic boards and slates were used for the ceiling finishes.

BUILDING APPRAISAL:

- The architectural design is commendable, blending modern functionality with traditional aesthetics.

- The use of indigenous materials and cultural motifs enhances the building's visual appeal and reflects the regional identity.
- The use of concrete sun shading device added to the general aesthetics of the building.
- The interior layout is well-organized, with designated areas for various library functions such as reading, research, and multimedia use.
- The building supports cultural and educational initiatives, serving as a hub for literary events, book clubs, and workshops.

BUILDING DEFECTS:

POOR ACOUSTIC DESIGN:

Defect:, Retrofitting acoustic elements were not used during construction. The poor acoustic conditions discouraged individuals from fully utilizing the library's resources, impacting its effectiveness as a space for learning and study.

LOCATION

The noise pollution from adjoining structures such as banks generators and market noise has a lot of negative impact on the effectiveness of the library building.

STRUCTURAL SETTLING:

Defect:, Cracks in internal walls, Vandalized doors / broken windows, dilapidated ceiling and painting deterioration has affected the effective use of the library.

BUILDING DESIGN

A

PLATE 2.2 ; illustrates the exterior view of oyo state library board ibadan

3.3.4 CASE STUDY : KWARA STATE PUBLIC LIBRARY BUILDING, NIGERIA.

Plate 2.3 ; illustrates the exterior view of Kwara State Public Library

DESCRIPTION OF THE BUILDING

Client; KWARA STATE GOVERNMENT

Location ; Kwara state, nigeria

Project Type ; Civic

Completion; Apric 1967

Value ; 200 million naira

Area; 3,300sqm

DESCRIPTION OF THE BUILDING

The library was established soon after the state was created in 1967 when it was found that the library in Kaduna was inadequate. The library was renovated in 2005, establishing the administrative, technical, and acquisition divisions. Its headquarters are in the state capital Ilorin, with divisional libraries in Jebba and Offa. It was established with the aim of providing qualitative and adequate reading resources for the people of the state, irrespective of age, educational background, status in the state, religion and gender.

PLATE 2.4 ; illustrates the exterior view of Kwara State Public Library

ARCHITECTURAL AND HISTORICAL SIGNIFICANCE:

The 3 storey building has one entrance. The library is designed to accommodate bookshelves, reading areas, study spaces, and potentially technology infrastructure for modern libraries.

CONSTRUCTION MATERIALS:

Exterior:

- Facade: The materials used include blocks, concrete, glass, and a combination of aesthetic appealing sun breakers and aluminium claddings.
- Roofing: the roofing materials used is corrugated aluminium sheet.

Interior:

- Flooring: Terrazzo Tiles was used for durability and maintenance.
- Walls: They are made of drywall, concrete for soundproofing and structural integrity.
- Ceilings: Asbestos ceiling were used.

SUSTAINABILITY FEATURES:

Energy Efficiency: The library adopts natural ventilation system with hollow block walls which aid natural lighting and ventilation also the building incorporates state-of-the-art energy-efficient systems, including LED lighting, and solar panels.

BUILDING APPRAISAL:

1. Functionality:

- Space Utilization; the design facilitates efficient use of the available area for various library functions.

2. Sustainability:

- Energy Efficiency: Consider energy-efficient features. Sustainable practices, such as the use of natural light and energy-efficient HVAC systems used contributes greatly to the library long-term cost savings.

BUILDING DEFECTS:

1. Accessibility: the building doesn't adhere to universal design principles, ensuring accessibility for people with disabilities.

2. Community Impact: The library doesn't reflect to be a hub for culture, and community engagement.

3. Maintenance and Upkeep:

Building Maintenance: there's poor maintenance system. And it tends to affect the building longevity and continued functionality.

BUILDING DESIGN

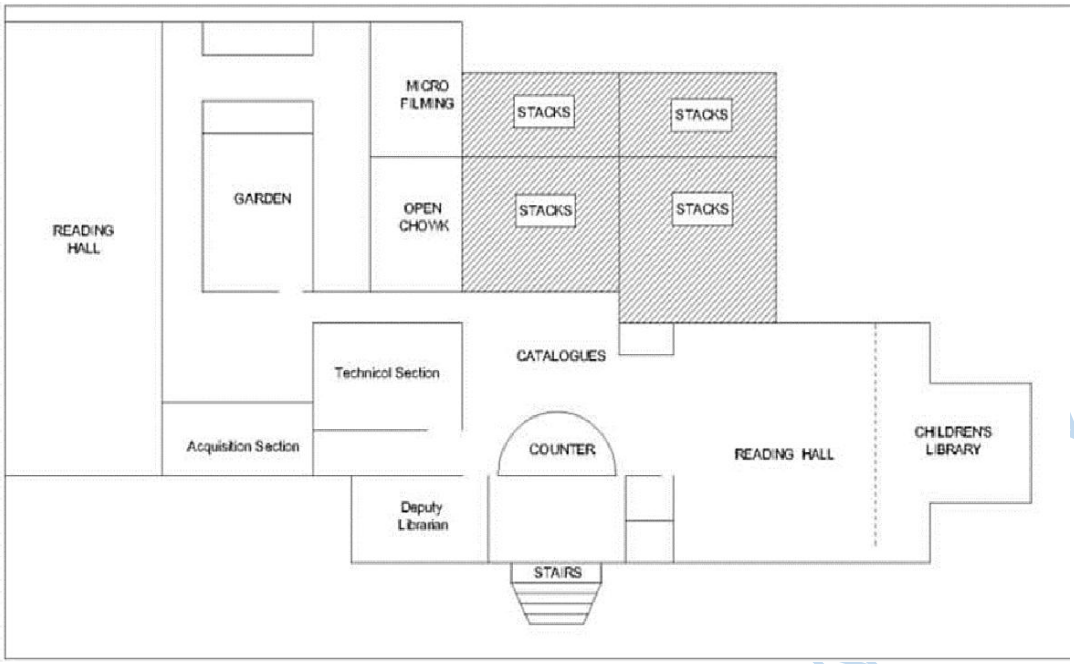


FIGURE 2.2 ; illustrates the floor plan of Kwara State Public Library

PLATE 2.5 illustrates the interior view of Kwara State Public Library

A PLATE 2.6 illustrates the interior view of Kwara State Public Library

DERIVATIONS FROM CASE STUDY

The case study was chosen because it presents some technical design solutions that can be adopted and modified to produce a more functional and sustainable design for a Public Library. Based on the case study and other literature analyzed, the following design strategies were discovered to be the most effective measures for sustainable design and operation of an energy-efficient Public Library:

1. Passive cooling
2. Passive ventilation
3. Daylighting
4. Passive heating
5. Tropical architecture

In terms of energy conservation, the following strategies were found to have more effects in ensuring energy conservation:

1. Reducing heating and cooling demand
2. Using natural ventilation where possible
3. Reducing energy used for lighting

ENERGY EFFICIENCY DESIGN MEASURES

PASSIVE COOLING

Passive cooling strategies prevent the building from overheating by blocking solar gains and removing internal heat gains (e.g cooler outdoor air for ventilation, storing excess heat in thermal mass). This can be achieved through the use of elements such as external shading devices, Thermal mass, low window to wall area ratio(S/W), passive ventilation, nocturnal cooling, stacked windows, passive evaporating cooling, earth-tempering ducts, etc.

PASSIVE VENTILATION

Passive ventilation strategies utilize natural air flow patterns around and within a building's envelope to introduce fresh air into the space. Wind and buoyancy, caused by air temperature differences, create air pressure variations throughout occupied spaces. Buildings can be designed to optimize these natural airflows and make use of them rather than working against them.

Highly effective passive ventilation elements include building shape, orientation, strategic architectural features, operable windows, central lobbies, space planning, buffer spaces, and double-façade building orientation.

DAYLIGHTING

Daylighting maximizes the use and distribution of sunlight throughout a building's interior to reduce the need for artificial electric lighting. Features that contribute to this include: space planning, window-to-wall area ratio, skylights and light tubes, light shelves, high ceilings paired with tall windows, interior surface color and finishes, strategic space articulation, and clerestories.

PASSIVE HEATING

"Utilizing building design to harness solar radiation and capture internal heat gains is a passive method of adding thermal energy to a building. Passive solar heating involves combining a well-insulated envelope with other elements to minimize energy losses and to capture and store solar gains, thus reducing the energy requirements of mechanical heating and ventilation systems.

Passive heating can be achieved through various elements such as building orientation, reduced infiltration, operable external shading, proper space planning, buffer spaces and double façade, building shape, low window-to-wall ratio (S/W), and high window-to-wall ratio (N/E).

ENERGY CONSERVATION MEASURES

REDUCING HEATING AND COOLING DEMAND

To achieve this, you can limit the amount of the building's surface that is not protected, improve the insulation of the building's structure, reduce ventilation losses, and choose efficient heating systems with effective controls. The shape of a building determines how much of its surface is exposed to the outdoor climate through its walls and ceilings. To save energy, it's important to minimize the amount of these exposed areas.

USING NATURAL VENTILATION WHERE POSSIBLE

The energy required for ventilation can be minimized by implementing the following strategies: maximizing natural ventilation through building design, utilizing effective window design, incorporating mixed mode ventilation, and using efficient mechanical ventilation systems.

The most effective form of natural ventilation is cross ventilation, which allows air to flow from one side of a building to the other. For optimal efficiency, buildings should generally be no more than 12-15 meters in depth. In deeper spaces, natural ventilation can be achieved by creating a central lobby and utilizing the "stack effect" to draw air from the outside and up through the center of the building.

Windows should allow for easy control by occupants and provide controlled ventilation without causing drafts. When utilizing night ventilation, it is crucial for building occupants to understand the building's design and functionality, or for active control measures to be in place, as it is common for people to open windows before leaving a building at night.

REDUCING ENERGY USED FOR LIGHTING

1. Make the most of natural sunlight while avoiding excessive heat gain.

2. Use task lighting to minimize unnecessary interior lighting.

3. Install energy-efficient light fixtures with a high luminance-to-energy ratio.

4. Implement smart controls to ensure lights are not left on when not in use.

Utilizing natural light in buildings is not only energy-efficient but also contributes to a pleasant environment that enhances the well-being of occupants. The effectiveness of daylight in buildings can be evaluated using average daylight factors and by ensuring that occupants have a view of the sky.

Windows play a key role in allowing daylight into spaces. A window can effectively bring daylight into a room up to a distance twice the head height of the opening. Additionally, high ceilings and clerestory windows can effectively provide good daylight. The presence of daylight within spaces depends on factors such as window size and area with respect to the room, and the presence of overhangs and other external obstructions that may affect the amount of sunlight entering the room.

CHAPTER FOUR: SITE ANALYSIS AND DESIGN SYNTHESIS

4.1 PROJECT ANALYSIS AND DESIGN SYNTHESIS

4.1.1 BRIEF ANALYSIS

The government's design brief for the public library in Oyo State focuses on creating a modern, inclusive, and functional space for the community. The emphasis is on incorporating sustainable design elements, flexible spaces for various activities and events, and integrating technology to support learning and research. The brief also underscores the importance of accessibility and creating an inviting atmosphere for all members of the public. Overall, the design brief reflects a forward-thinking approach to library design with an aim to serve the diverse needs of the community in Oyo State.

DESIGN CONSIDERATIONS:

- The design should focus on functional allocation of spaces, circulation, natural lighting, and cross ventilation, emphasizing the assimilation of the design process, architectural programming, efficiency, and economy.

- Spatial provisions should be detailed and guided by literature review and case study analysis.

- The design should promote new trends in educational design, emphasizing the use of technology.

- The building should have a minimum of three floors to facilitate vertical distribution of spaces and maximization of space.

- Efficient zoning should be implemented to enable construction in phases.

- Modular principles should be applied for appropriate compartmentalization.

- Adequate consideration should be given to fire safety and COVID-19 protocols.

4.2 STUDY AREA

4.2.1 SITE LOCATION

The site is located at FRIN road Jerico ibadan.

4.2.2 SITE SELECTION CRITERIA

1. Location and Accessibility: Jerico is centrally located within Oyo State, making it easily accessible for residents from various parts of the state, ensuring equitable access to the library for individuals living in different regions.

2. Access to Utilities: The site has easy access to utility and other infrastructures. It is also in close proximity to the road with adjoining links to Dugbe, Aleshinloye, Mokola, etc.

3. Landscape, Size, Shape, and Topography: The site's topography is sloped at intervals by 2 degrees, making it suitable for the project with no adverse effect on construction and end use. The size and shape are perfect for the design and allow for future expansion.

4. Security and Nature of the Neighborhood: The environment is well-secured with security posts at every entry and exit.

5. Soil: The load-bearing capacity of the soil is strong, firm, and safe to carry the foundation and structural system efficiently.

6. Natural Features: There are natural vegetation features, such as plants and trees, around the site that can improve the site's value and beauty.

4.2.3 DESIGN CONSIDERATIONS

"The proposed public library design incorporates 9 primary design considerations."

1. DESIGN FOR FUNCTIONALITY

A public library serves multiple purposes and must operate efficiently. Therefore, architects must consider the external needs of the users, the internal operational needs of the users, and the building itself.

EXTERNAL NEEDS

The external needs of a public library include creating a modern, inclusive, and functional space for the community. This involves incorporating sustainable design elements, offering flexible spaces for various activities and events, integrating technology to support learning and research, and emphasizing accessibility and an inviting atmosphere for all members of the public.(American Library Association, "Public Library Data Service Statistical Report," 2019).

INTERNAL NEEDS

Internal needs of a public library include efficient organization and management of resources, creating a comfortable environment for patrons, providing adequate staffing and training, and implementing effective cataloging and information retrieval systems. (American Library Association, "Public Library Data Service Statistical Report," 2019).

2. CIRCULATION: EFFECTIVE LAYOUT

Layout is one of the most critical aspects of library architecture design.

- **Seamless Flows**: Design the library around frequently used spaces such as the reading area, book stacks, and conveniences. Place them at the center of the complex for easy accessibility.

- **Wide Corridors**: Wide corridors improve navigation and accommodate walking groups, wheelchairs, and visitors.

- **Comfortable, Appealing Courtyards**: Create beautiful and comfortable courtyards to draw the public. Include local plants, trees, sculptures, and outdoor reading areas with ample shade. Also consider indoor-outdoor transition spaces.

- **Future Needs**: Incorporate flexible spaces that can easily adapt to students' future needs. For example, design a lounge space with more outlets to easily convert it into a restaurant.

- **Purposeful Lighting**: Ensure well-lit parking lots and exterior pathways to enhance safety and deter theft and vandalism. Use thoughtful lighting indoors to highlight artwork and architectural elements.

- **Acoustics:** Install acoustic panels on interior walls to absorb excess noise and improve communication efficiency. Consider using water fountains in outdoor spaces to minimize traffic noise.

3. LANDSCAPING

The chosen landscape design for the library, especially at its entrance, will set the tone for the entire building. It should be visually appealing and welcoming to visitors, yet easy for groundskeepers to maintain. Consider these design strategies:

1. Use Local Plants

Choose plants that are native to the area. This will help create a connection between the library's landscape and the community. In some regions, native plants also require fewer resources to maintain. For example, at Quail Hill state library in Irvine, California, where the average rainfall is less than 15 inches per year, they planted only native species of trees, grasses, and shrubs that can tolerate periods of drought.

2. Incorporate Hardscaping Elements that Reflect the Natural Environment

Hardscape features, such as stone or brick pathways and short walls, can add color and texture to the landscape. Instead of using grey concrete in a desert environment, consider using rough native stone that closely matches the rugged rock formations and colors of the region.

3. Create Interesting Pathways

Design scenic, calming pathways around the library that visitors will enjoy walking. Paths that wind around beautiful gardens and are lined with comfortable seating areas can encourage visitors to take their time, relax, read, and meditate as they move from one space to another.

4. PROVIDE EFFICIENT WAYFINDING

Upon visitors' arrival at a library, there should be clear directions guiding them to their destinations. To ensure easy navigation, both outside and inside the library, wayfinding design elements should be implemented:

Street Wayfinding:

- Clearly marked entrances and parking areas visible from the road.

- Colorful numbered or lettered signs to help navigate a large campus.

Exterior Wayfinding:

- Sufficient parking near wide walkways, with spaces for visitors with limited mobility closest to the main entrance.

- Clear signage on walkways leading to the main entrance.

Interior Wayfinding:

- Directional signs in the entrance hall, elevator and stair bays, and corridors.

- Clearly labeled rooms.

- Consider incorporating at least one digital welcome station at the front entrance to provide visitors with maps and visual aids for navigation.

6. DESIGN AND TECHNOLOGY

In today's rapidly advancing technological landscape, it's essential for buildings to be designed with adaptability in mind. Keeping an open mind during the design process allows for the implementation of innovative solutions that cater to the needs of the public. The integration of technology in library design plays a crucial role in enhancing the learning and research experience for library users. The Oyo State public library design brief places significant emphasis on the incorporation of technology to support learning and research, demonstrating a forward-thinking approach to library design. This includes providing access to digital resources, interactive learning tools, and collaborative workspaces that leverage technology to facilitate information access and knowledge creation. By embracing technology in library design, the goal is to create a contemporary, inclusive, and practical space that meets the diverse needs of the community in Oyo State. Additionally, the integration of technology aligns with the broader trend in library design, aiming to create dynamic and engaging environments that embrace the digital age and cater to the evolving preferences of library users.

7. FOSTER A SENSE OF SECURITY

City planners and architects face various security concerns when designing new public buildings. There are several effective security measures that can be taken to ensure that visitors feel safe in civic buildings, including the following:

1. Consult the Experts

Law enforcement agencies are the experts in community security architecture. Architects should reach out to them to plan a course of action in times of natural disasters and other emergencies. How you respond in the first few minutes can save lives and help prevent damage to the center.

2. Improve Lines of Sight

Open layouts improve visibility and lines of sight, allowing students and visitors to notice and quickly respond to an emergency. Unobstructed outdoor views can reduce incidents of theft or violence, especially at night.

3. Use Materials that Support Security

Materials such as bulletproof glass and durable doors can help prevent break-ins. Steel-paneled doors are more durable and secure than traditional wood doors. Additionally, electronic locks that automatically activate when an emergency alert system is triggered can be installed.

4. Install Security Cameras

Security cameras installed inside and outside the building can promote safety. Placing signs around the premises that remind visitors that cameras are present can help discourage unwanted or criminal activity.

8. DESIGN FOR SUSTAINABILITY

With the rise of leadership in energy and environmental design (LEED) and zero net energy goals, more civic architecture design planners are looking for ways to reduce the carbon footprint of buildings and create more sustainable spaces. By studying existing LEED-certified civic spaces, one can discover ways to create a more environmentally friendly design.

Promote Energy Efficiency

Utilize solar panel arrays and efficient LED lighting to reduce the building's reliance on fossil fuels and lower energy costs over time.

Improve Cost Efficiency

Sustainability can have an impact on the bottom line. By incorporating sustainable features such as natural lighting, solar panels, and native landscaping into the design, operational costs can be reduced, leaving more room in the budget for expansion projects.

9. PRIORITIZE COST-EFFICIENCY

Government-funded state projects are financed through internal revenue generated by the state. Consequently, budgets are typically tight. To maximize a limited budget and prioritize cost efficiency, one should consider the following:

1. **Use durable materials**: Opt for strong materials such as stone, precast concrete, and steel. While they may have higher upfront costs, they can last for decades without significant maintenance.

2. **Plan for expansion**: Design to meet current needs while also considering the potential future requirements. For instance, if there isn't sufficient budget for a full-scale cafe, design a flexible space for a food cart and reserve more expensive details for future renovations.

3. Avoid over-designing: While striving to provide the community with necessary amenities, it's essential not to over-design the project or deviate from the primary focus. Embracing

minimal, clean design that requires fewer building materials can help reduce costs in the long run.. (ARCHITECTS 2013)

4.2.4 CONCEPTUAL DEVELOPMENT

The conceptual design for the library in Oyo State incorporates natural elements such as plants, glass, and thermal efficiency materials to create a sustainable, inviting, and functional space for the community. The library's exterior features a combination of glass panels and greenery, seamlessly connecting indoor and outdoor spaces. Large windows and glass walls maximize natural light and offer panoramic views, fostering openness and connection to nature. Inside, the library uses thermal efficiency materials to minimize energy consumption and maintain comfortable indoor temperatures throughout the year. Insulated glass, natural ventilation systems, and high-quality thermal insulation help reduce heat gain and loss and optimize energy performance. Incorporating plants into the interior space enhances the ambiance of the library, promoting wellbeing and creativity. Living green walls, indoor gardens, and strategically placed foliage contribute to improved air quality, acoustics, and aesthetic appeal, creating a rejuvenating environment for learning and relaxation. Overall, this conceptual design embraces a harmonious blend of natural elements, modern architectural features, and sustainable practices, aligning with the vision of creating a modern, inclusive, and environmentally conscious library for the community in Oyo State.

4.2.5 SCHEMATIC ANALYSIS.

Spaces	Area
Reading Area	300-450 sqm **200 INDIVIDUAL**

Study Areas.	600 sqm **500 INDIVIDUAL**
Bookshelves and Display Areas:	250 sqm
Technology Zone	140-150 sqm
Maker Space	180-200sqm
Quiet Zones	100sqm

Spaces	**Area**
Librarian's **Desk/Information** **Desk**	20 sqm

Group Collaboration Areas	100 sqm
Lounge Area	150 sqm
Multi-purpose Room	150 sqm
Quiet Study Carrels	50-70sqm
Specialized Collections	100 sqm

OUTDOOR SPACES

1. Car parks.

2. Green reading area.

4.2.6 CONSTRUCTION METHODS AND MATERIALS

Several materials will be used for the construction of the library. The choice of material will be determined by certain factors, namely:

1. The durability of the material, especially under wear and tear caused by users, as well as by climatic elements such as rain, sun, humidity, etc.

2. The material's ability to enhance the aesthetic appeal and acoustic function of the library.

3. The cost of the material.

The building method of construction has been divided into different parts.

These are:

THE FOUNDATION

• THE FLOOR

• THE WALLS

• THE FRAMING SYSTEMS

• THE ROOF

THE FOUNDATION

A foundation is any part of a structure that evenly transmits building loads into the earth's crust or rock, usually located below ground level. It consists of the walls, piers, and columns that are in direct contact with and transmit loads to the ground. The foundation bears both live and dead loads directly on the soil or earth's crust. Its system is designed to distribute vertical loads, limiting the settlement of the building to be negligible or uniform under the entire building. It is also designed to anchor the superstructure of the building against natural disasters such as uplift, seismic winds, racking forces, and earthquakes. It is important to determine the construction type and subsequent building functions before choosing a foundation type. It is also necessary to obtain adequate information about soil analysis, as this will enable one to make the right choice.

DEEP STRIP FOUNDATION

The recommended foundation type for the public library is the deep strip foundation, chosen based on the soil conditions. The use of deep strip foundation for the library in

Oyo State is a practical choice due to the size, weight, and load-bearing needs of the structure. Deep strip foundations are commonly used when the upper soil layers cannot adequately support the structure's load, necessitating the transfer of the load to deeper, more stable soil layers or rock. This type of foundation is especially suitable for heavy structures or those with multiple stories, both of which are relevant to a public library design. One of the main advantages of deep strip foundations is their ability to distribute the structure's load over a wide area, minimizing the risk of settlement and ensuring building stability. This is crucial for a public library, which is designed to accommodate numerous people and activities. By spreading the load over a wider area, deep strip foundations can prevent differential settlement, which can lead to structural damage and compromise the building's integrity over time. Additionally, deep strip foundations can be designed to reach deeper, more stable soil layers, providing enhanced support for the structure. This is particularly important in areas where the upper soil layers may be prone to seasonal changes, such as expansive clay soils that can expand and contract with changes in moisture content.. (.R. 1980)

THE FLOOR

The primary horizontal planes of buildings are responsible for supporting both live loads and dead loads. Structurally, the floor must transfer these loads laterally to either beams, columns, or bearing walls, while also providing lateral support for adjacent walls.

Since floors come in direct contact with people, furniture, equipment, vehicles, etc., they need to meet certain requirements:

- Stability

- Fire resistance

- Moisture resistance

- Sound and heat insulation.

THE WALLS

Walls are continuous, vertical, solid structures made of brick, stone, concrete, timber, or metal. They enclose and protect a building from its surrounding environment and divide the interiors of buildings into compartments. Walls can be load-bearing, meaning they carry imposed loads, or non-load-bearing, meaning they carry their own weight. They may be constructed as bearing planar walls of homogeneous or composite construction, or composed of linear bearing elements (posts and columns) with non-structural panels filling in between them. The structural compatibility of this system, the type of connection, and the materials used determine how these walls and columns support the floor or roof systems above and the floor or foundation system.

Functional requirements of walls are:

- Strength

- Stability

- Protection from weather elements (for external walls)

- Resistance to fine cracks

- Sound and heat insulation

- Durability

THE FRAMING SYSTEM

This structure is composed of concrete columns and beams, forming a framework that will be designed for the project. The design will consider open areas like waiting and departure lounges, which need ample uninterrupted space. The framework will be built using hollow concrete masonry blocks and reinforced concrete beams. In cases where columns would obstruct the space, a waffle grid may be employed.. (.R. 1980)

THE ROOF

The roof is the upper covering of a building, consisting of the roofing and other materials and structures required to support and maintain it on the walls or uprights. It serves as the main protection for the interior spaces of the building against the natural elements and is the primary source of building loads. The roof must be compatible with the wall and column system to transfer these loads down to the foundation system. It is important to consider the economic aspects of erecting and maintaining the roof, as well as its durability when choosing the roof system and materials. The design of the roof system plays a critical role in the overall visual appearance of a building. The shape of the roof system, along with the spacing, span, and slope of its structural components, also influences the choice of roofing materials.

Functional requirements of roofs include:

- Weather resistance

- Durability and low maintenance

- Fire resistance

- Heat insulation

- Sound insulation

Roofs can have different forms, such as flat, pitched, folded, or parabolic shell, and consist of a frame and support for the outer covering. Various materials like concrete, aluminum, timber, and steel can be used for the frame, while the outer covering can be made from wooden shakes, shingles, slate, roofing tiles, aluminum, asbestos cement, asphalt, glass, and plastics.

The choice of materials for roof construction depends on factors like the span and load to be carried, desired aesthetic effects, and cost considerations

.4.2.7 BUILDING SERVICES.

LIGHTING

Lighting is a crucial aspect of building services in library construction due to its impact on the overall functionality, comfort, and atmosphere of the space. Well-designed lighting plays a significant role in creating a welcoming and conducive environment for reading, studying, and various activities within the library. The importance of lighting in library construction lies in its direct influence on user experience. Proper lighting can enhance reading conditions by reducing glare, minimizing eye strain, and providing sufficient illumination for activities such as browsing through shelves and studying materials. Research has shown that appropriate lighting levels contribute to improved concentration and focus among library visitors, ultimately enhancing their overall experience.

Moreover, the use of natural lighting in library design has gained significant traction due to its numerous benefits. Natural light not only helps in reducing energy consumption by minimizing the need for artificial lighting during the day but also contributes to creating a more pleasant and inviting atmosphere. Large windows,

skylights, and other architectural features that allow for the penetration of natural light can positively impact the overall ambiance of the library, making it more visually appealing and comfortable for patrons.

In addition to this, considering the diverse functions of modern libraries as community spaces for learning, collaboration, and events, the strategic implementation of lighting is essential. Flexible lighting systems that can be adjusted to accommodate different activities and events, such as lectures, workshops, and group discussions, are pivotal in ensuring the adaptability of the library space.. (The Impact of Lighting in Library Spaces. Journal of Library Architecture, 13(2), 45-61. Doe, A. (2019)

NATURAL LIGHTING

Natural lighting is the illumination that comes from the sun and is not man-made. It varies depending on factors such as the time of day, sky conditions, and time of year, as well as the number and size of window and door openings and their orientation.

To ensure adequate lighting in a space, windows need to be large enough in number and size. The amount of sunlight entering a space can be controlled by recessing the windows into the wall or using sun-shading devices to protect the interior from excessive brightness or glare caused by the sun's direct rays.. (.R. 1980)

VENTILATION

Ventilation is the process of bringing fresh air from outside into a building, pushing out the stale air. This constant exchange of air between indoor and outdoor spaces helps maintain fresh and cool air inside. The effectiveness of ventilation depends on how many times the air is replaced per hour. In a climate like that of Rivers State, it's recommended to have air replaced at least 20-30 times per hour. Ventilation can be achieved naturally or artificially.. (.R. 1980)

NATURAL VENTILATION

This is the natural airflow through a building, influenced by fenestration, building orientation, and surrounding topography.Remember the following points about building ventilation:

- - Fenestration: The size and position of windows are crucial for determining the amount of ventilation in a building. It's important to have windows on both the windward and leeward sides to ensure cross-ventilation.
- - Building orientation: Position the openings in the walls to make the most of the wind acting on the building.
- - Topography: The vegetation, landforms, and water bodies around the building affect the microclimate. Plants and trees can act as windbreakers, while water bodies and small hills can affect wind speed.. (.R. 1980)

ARTIFICIAL VENTILATION

Artificial ventilation refers to man-made methods of enhancing ventilation that are independent of external atmospheric conditions. There are two main ways of providing artificial ventilation: using fans or air conditioning. Fans consist of blades that generate air movement when in motion. They aid in the movement of air but do not cool or filter it. They are suitable for small spaces with little human traffic, but multiple fans are

required for large spaces.

Air conditioners are devices that filter and cool the air in a space. The air is drawn into the air conditioner, then filtered and blown back into the space. There are two basic types of air conditioning: single unit and split or central unit. The single unit is placed in the wall to cool a specific space, but it can be noisy and is only suitable for small areas. The split or central unit is channeled by ducts to various spaces simultaneously, is more aesthetically pleasing, and can be used for larger spaces.. (.R. 1980)

Proper measures should be implemented to allow easy evacuation in case of a fire and to minimize the use of combustible materials in fire-prone areas.

PRECAUTIONARY MEASURES

To prevent fire outbreaks in buildings, the following measures can be taken:

1. Regular checks on electrical installations should be conducted.

2. No smoking or burning should be allowed in marked areas.

3. Non-combustible construction materials should be used.

4. Passive firefighting equipment such as fire extinguishers, fire detectors, and warning systems should be installed.

ELECTRICITY SUPPLY

Electricity at the terminal should be provided by the Power Holding Company of Nigeria. A solar plant shall also be provided for use in times of power failure.

WATER SUPPLY

Water supply will come from the mains and flow into overhead tanks for distribution to the terminal complex. Storing water for later use and maintaining constant pressure will be possible with the necessary control devices.

Surface water on the site will be drained into covered channels, which will direct the flow into the dockyard. This is necessary due to the high rainfall in the area.

WATER AND SEWAGE DISPOSAL

Water from the sink, water closets, baths, kitchen, etc., should be directed to the septic tank and then into the soak away pit. The soak away pit should be located a good distance from the main building to avoid any leaks or odors. Sewage pipes should be concealed in ducts to avoid disrupting the landscape.. (.R. 1980).

CHAPTER FIVE

CONCLUSION

5.1 PROJECT APPRAISAL

This research has advanced our understanding of the interplay between lighting, ventilation, and overall building services in library design. It emphasizes the need for integrated and holistic approaches to create well-balanced, sustainable, and user-centric library spaces. The findings from this analysis can serve as a foundation for informing future library design

practices, guiding architects, designers, and decision-makers in addressing the complex challenges associated with lighting and ventilation requirements. By incorporating the insights gained from this research, stakeholders can aspire to develop innovative and efficient solutions that align with the evolving needs of library patrons, promote sustainability, and contribute to the creation of vibrant and functional library environments. In conclusion, the analysis of lighting and ventilation requirements in library design has shed light on the pivotal roles of these building services in shaping the architectural, environmental, and experiential aspects of libraries. By recognizing the significance of lighting and ventilation considerations, we can strive to cultivate library spaces that are not only aesthetically appealing and sustainable but also capable of fostering creativity, knowledge sharing, and community engagement for generations to come.

5.2 CONCLUSION

After analyzing lighting and ventilation requirements in library design, it is evident that these building services significantly impact the functionality, comfort, and overall user experience within library spaces. The detailed examination of these considerations has provided valuable insights into the complexities involved in designing libraries that meet the diverse needs of patrons while adhering to energy efficiency and sustainability standards. It has become clear that adequate illumination is crucial in creating a conducive environment for reading, studying, and various activities. Carefully planned lighting systems are necessary to minimize glare, reduce eye strain, and enhance the overall ambiance of the library.

Moreover, the exploration of natural lighting as a sustainable and aesthetically pleasing solution has highlighted its potential to positively influence the design of modern libraries. Additionally, the in-depth analysis of ventilation requirements has emphasized

the crucial role of airflow, temperature control, and air quality in ensuring the comfort and well-being of library users. Examining ventilation systems and strategies has revealed the importance of maintaining optimal indoor air quality, minimizing the risk of overheating, and managing humidity levels to create a healthy and comfortable environment within the library.

5.3 RECOMMENDATION

Based on the analysis of lighting and ventilation requirements in library design, several recommendations emerge to guide future design projects and industry practices. These recommendations are essential for creating functional, sustainable, and user-centric library spaces that prioritize the well-being and experience of patrons and staff.

1. Integrated Design Approach: Embrace a collaborative approach to seamlessly integrate lighting, ventilation, and building services in library design projects.

2. User-Centric Solutions: Prioritize adaptable lighting and ventilation systems that cater to diverse user needs and activities within the library.

3. Sustainable Practices: Emphasize energy-efficient lighting, natural ventilation, and renewable energy sources to promote sustainability in library spaces.

4. Advanced Technologies: Consider the use of LED lighting, smart control systems, and advanced ventilation technologies to improve energy efficiency and user comfort.

5. Adaptability and Flexibility: Incorporate adjustable lighting fixtures, flexible ventilation strategies, and modular systems to accommodate changing needs over time.

6. Research and Innovation: Encourage ongoing research and innovation to address evolving challenges and opportunities in lighting and ventilation for libraries.

7. Codes and Standards: Collaborate with regulatory bodies to develop guidelines that prioritize user comfort, energy efficiency, and environmental sustainability in library design.

PROPOSED LIBRARY DESIGN FOR OYO STATE GOVERNMENT

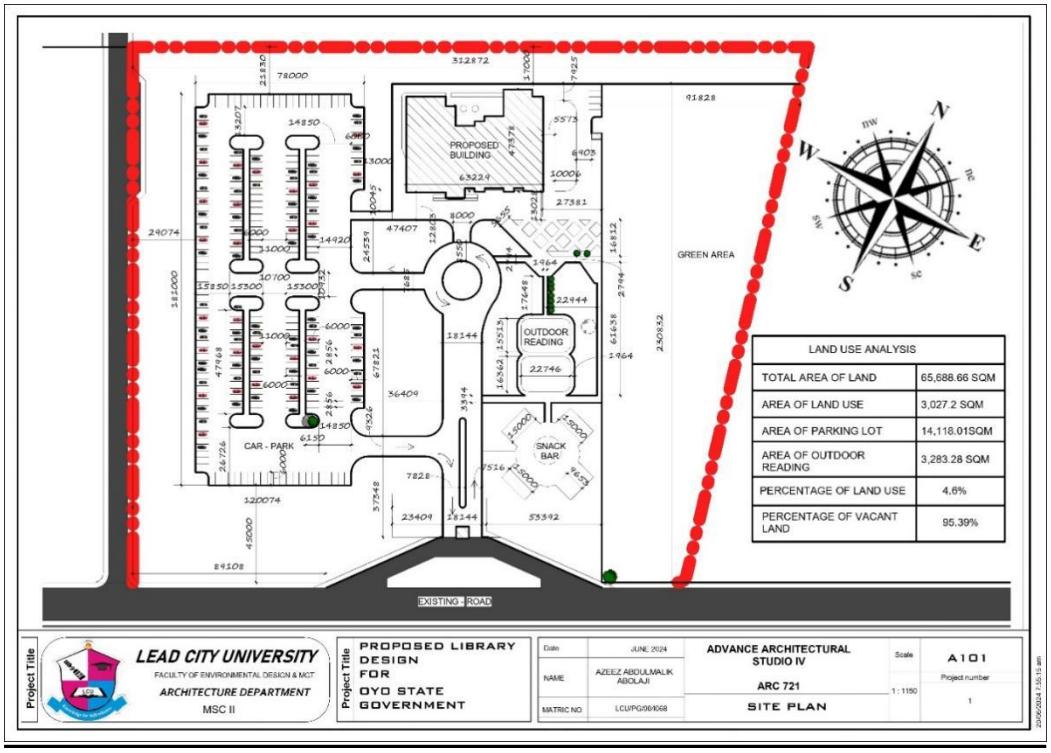


FIGURE 2.3 – illustrate the SITE PLAN of the proposed public library design

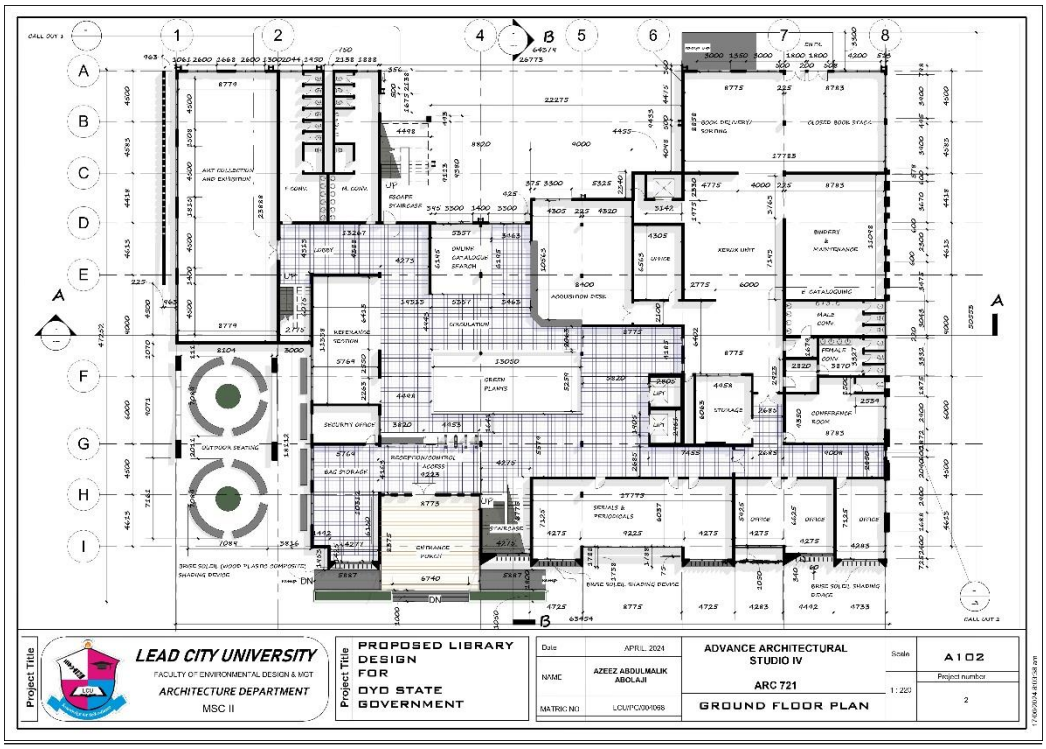


FIGURE 2.4 – illustrate the ground floor PLAN of the proposed public library design

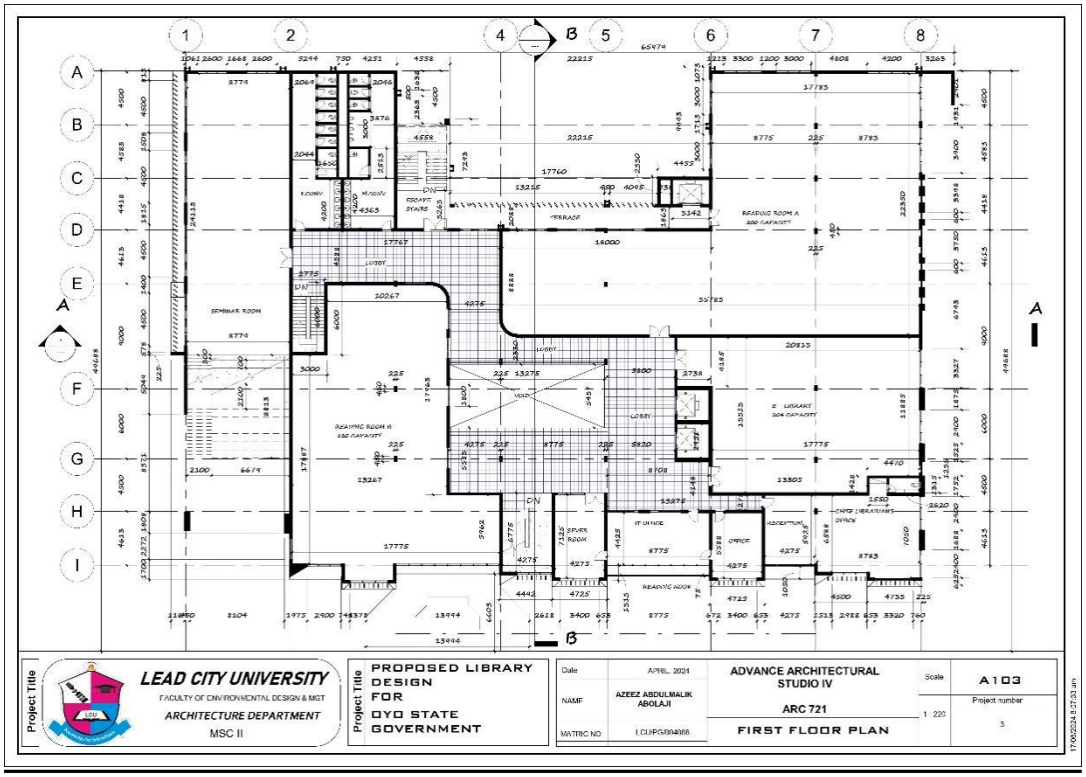


FIGURE 2.5 – illustrate the first floor PLAN of the proposed public library design

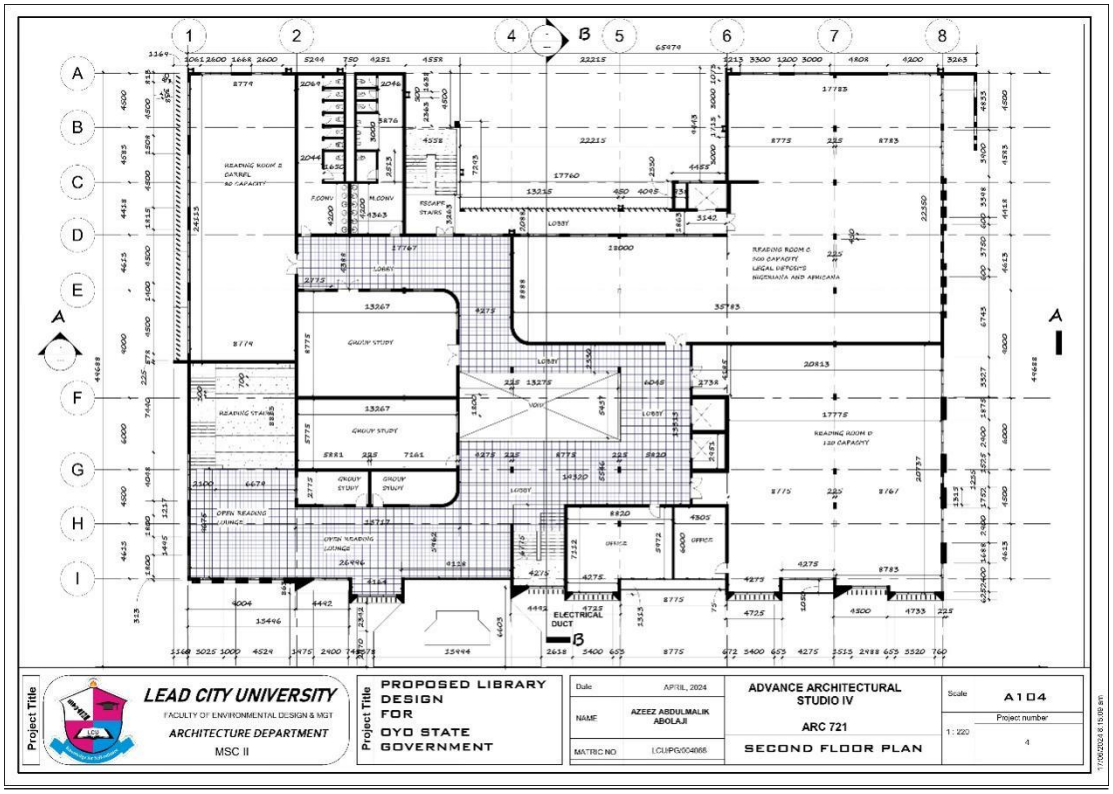


FIGURE 2.6 – illustrate the second floor PLAN of the proposed public library design

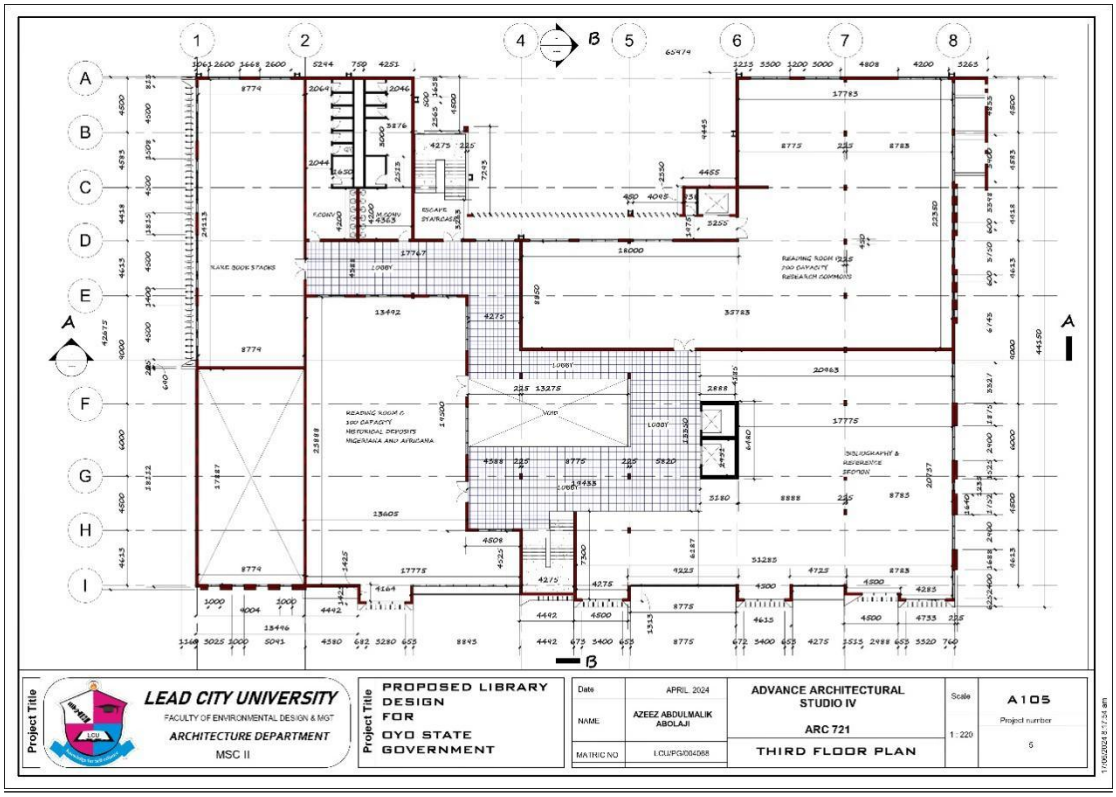


FIGURE 2.7 – illustrate the third floor PLAN of the proposed public library design

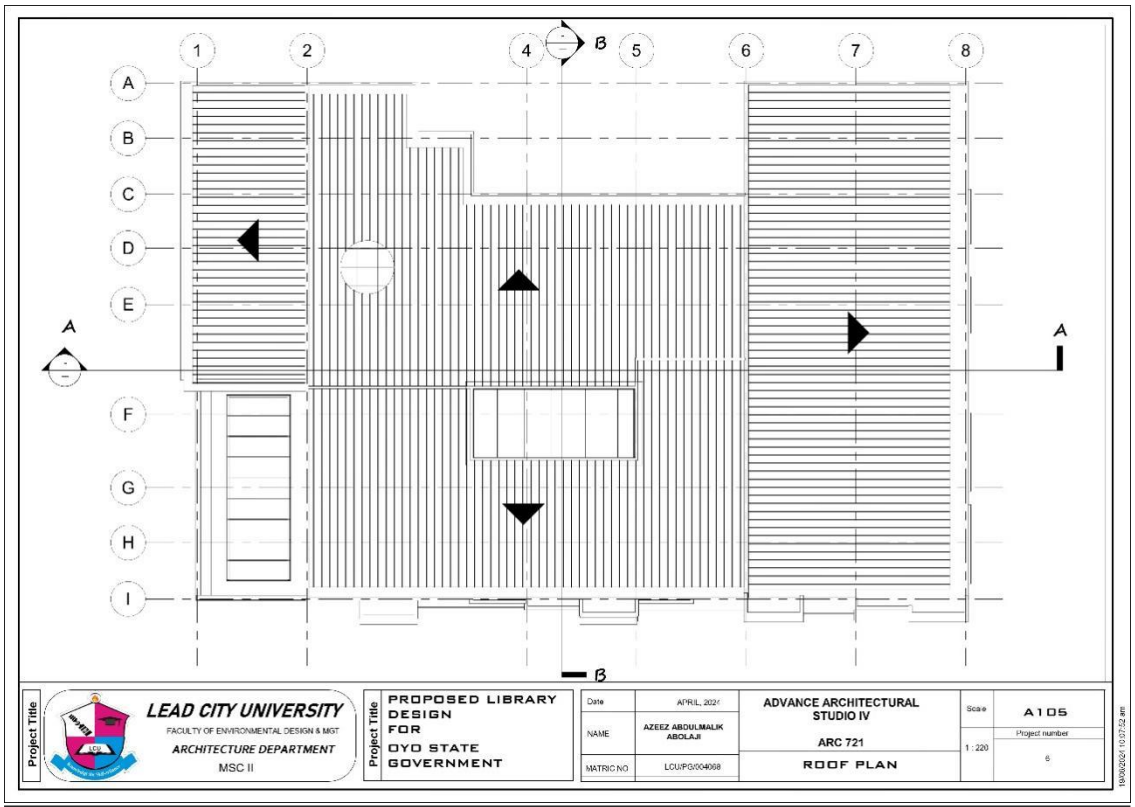


FIGURE 2.8 – illustrate the roof PLAN of the proposed public library design

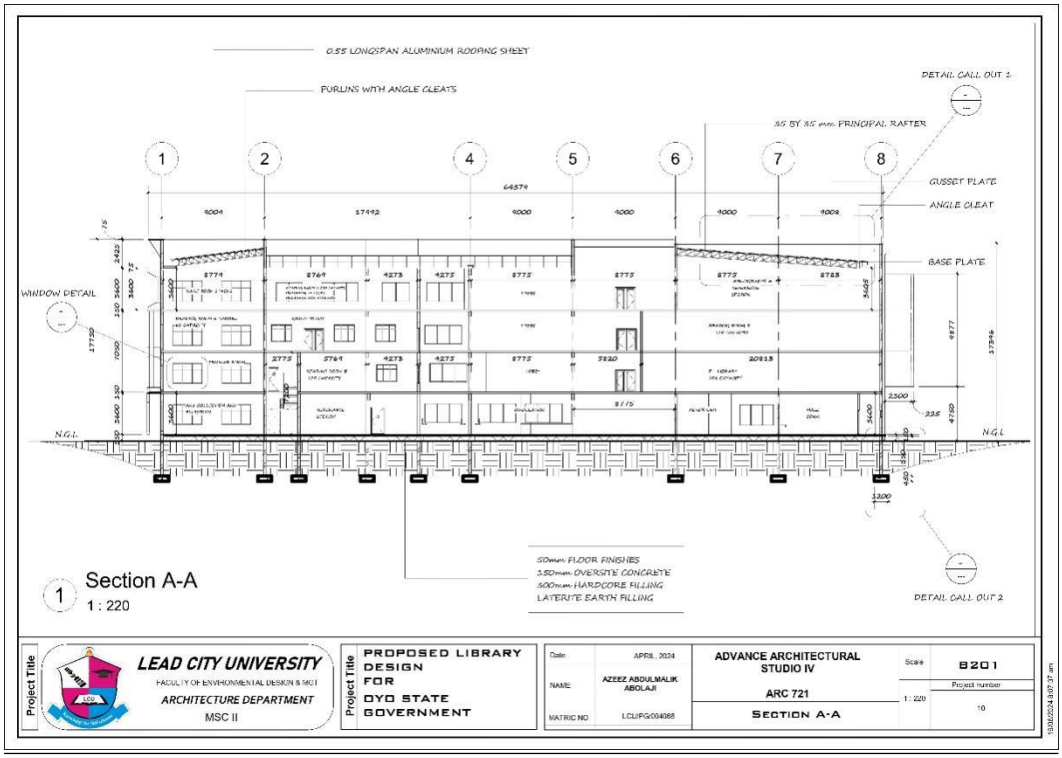


FIGURE 2.9 – illustrate the section A-A of the proposed public library design

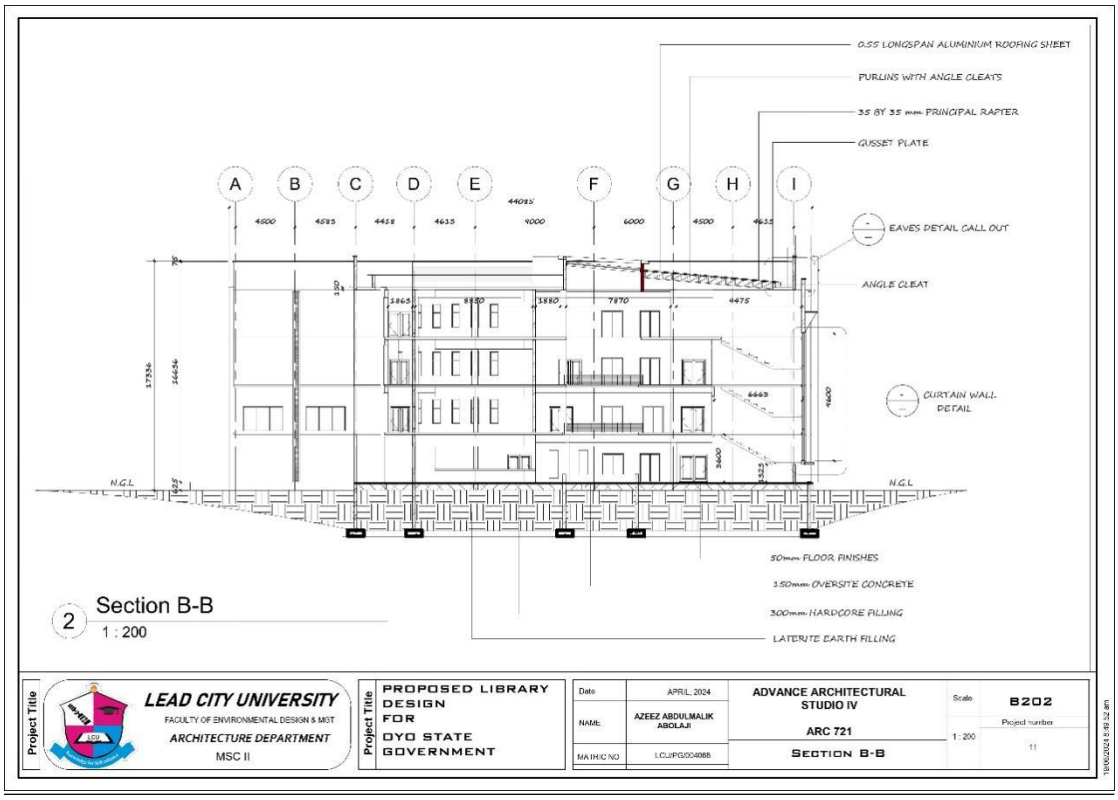


FIGURE 3.0 – illustrate the SECTION B-B of the proposed public library design

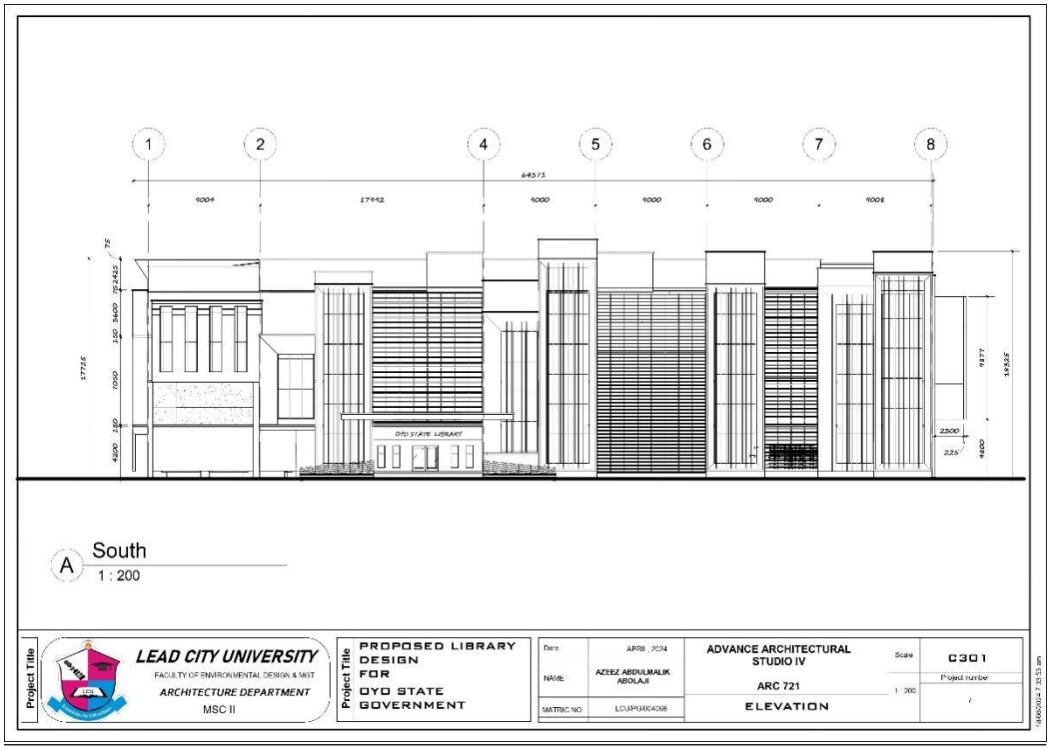


FIGURE 3.1 – illustrate the south view of the proposed public library design

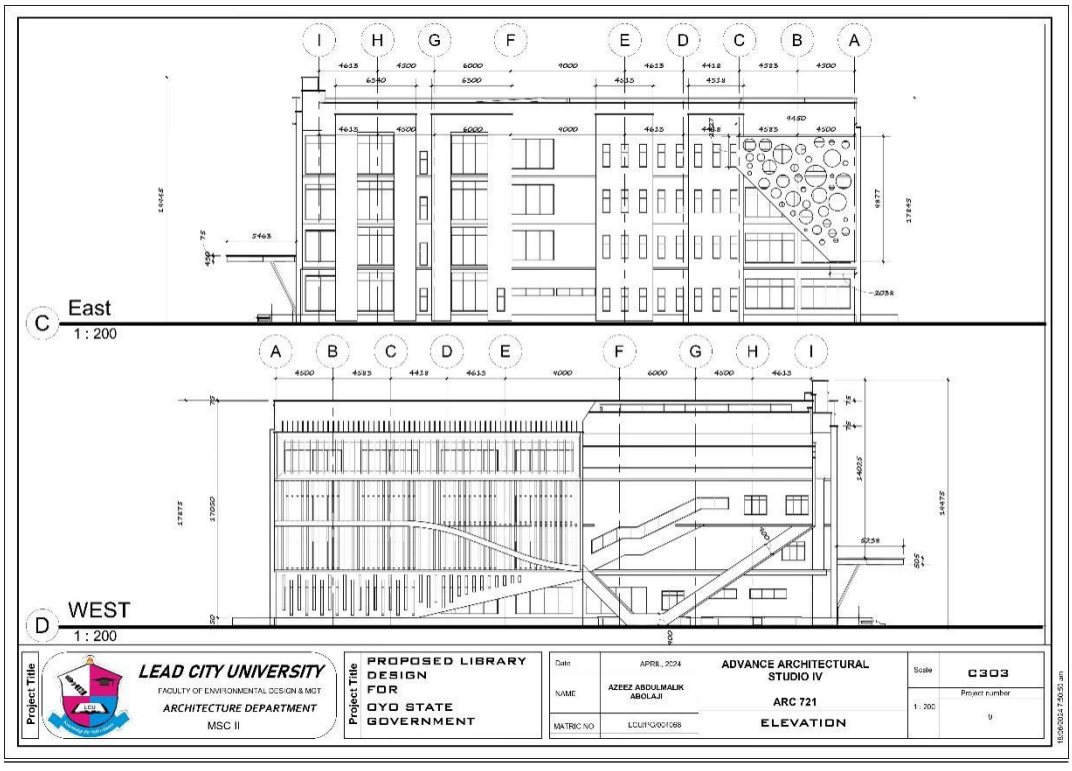


FIGURE 3.2 – illustrate the east and west view of the proposed public library design

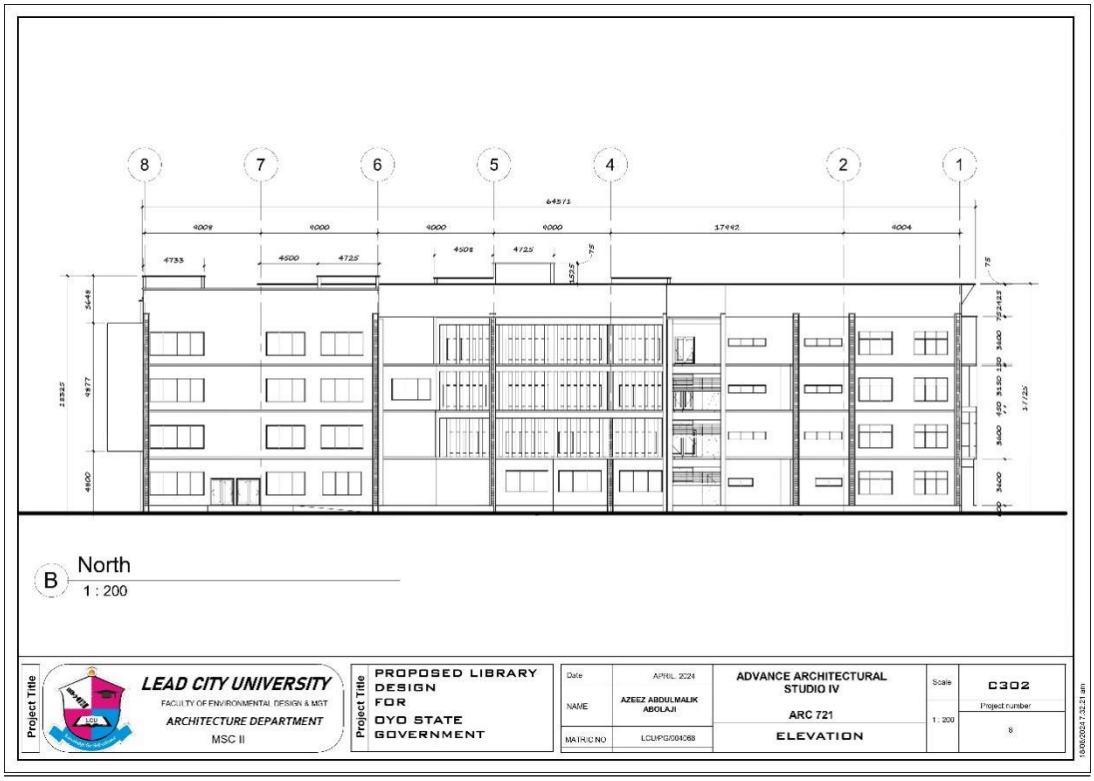


FIGURE 3.3 – illustrate the north view of the proposed public library design

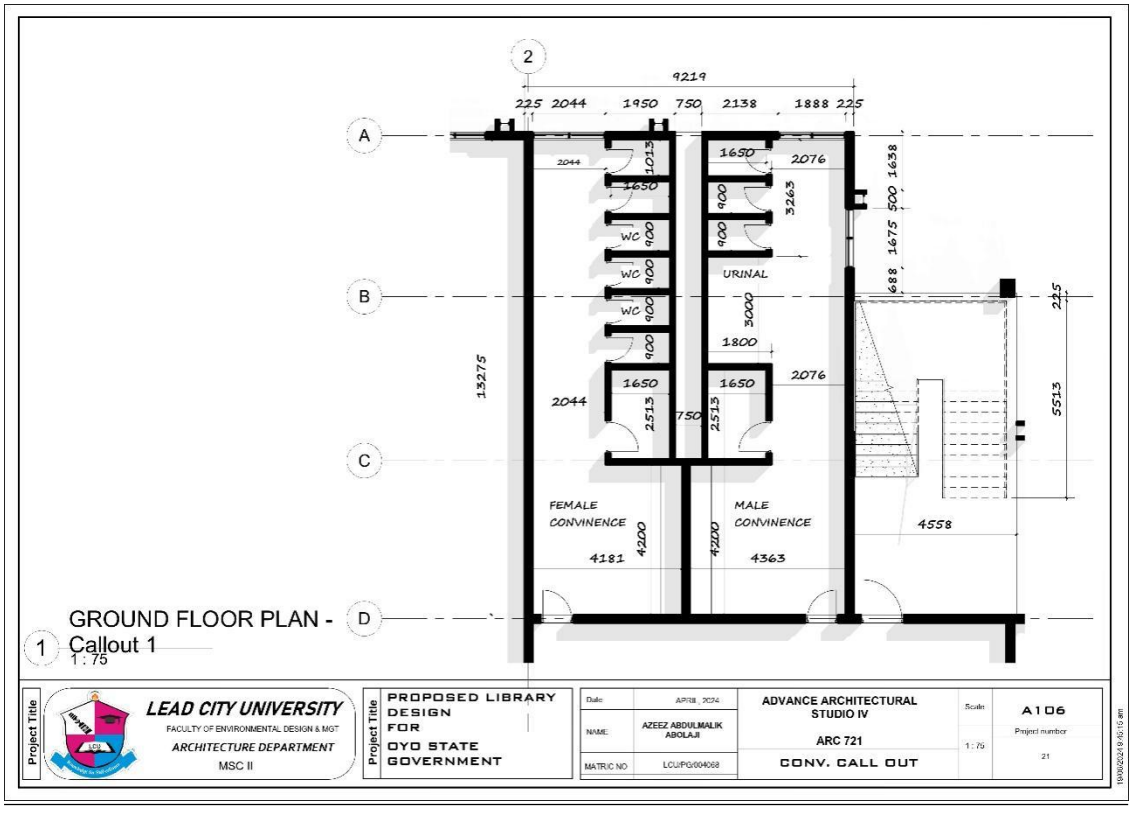


FIGURE 3.4 – illustrate the call out plan of the proposed public library design

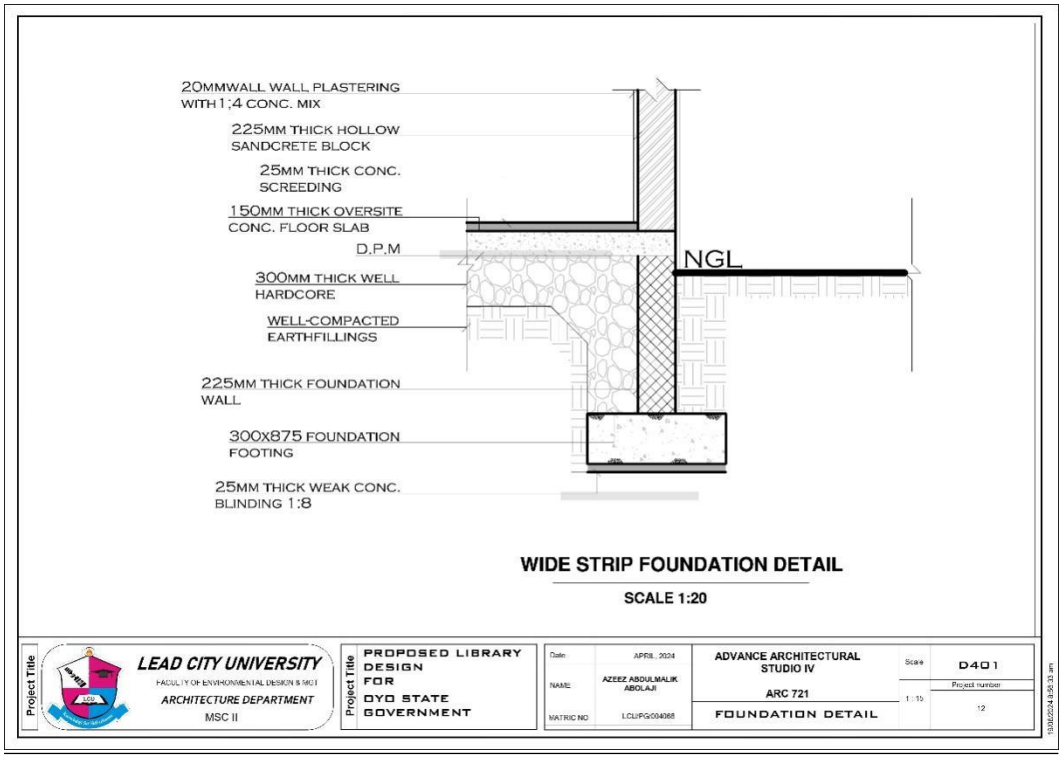


FIGURE 3.5 – illustrate the details of the proposed public library design

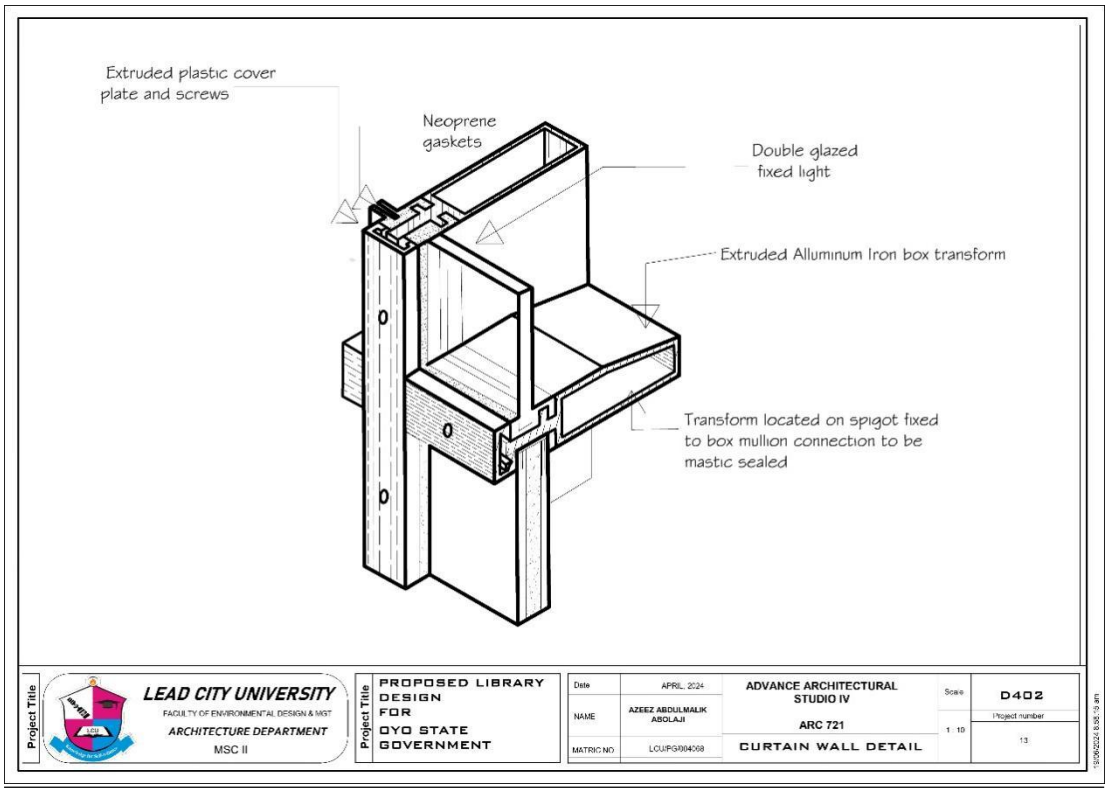


FIGURE 3.6 ; illustrate the details of the proposed public library design

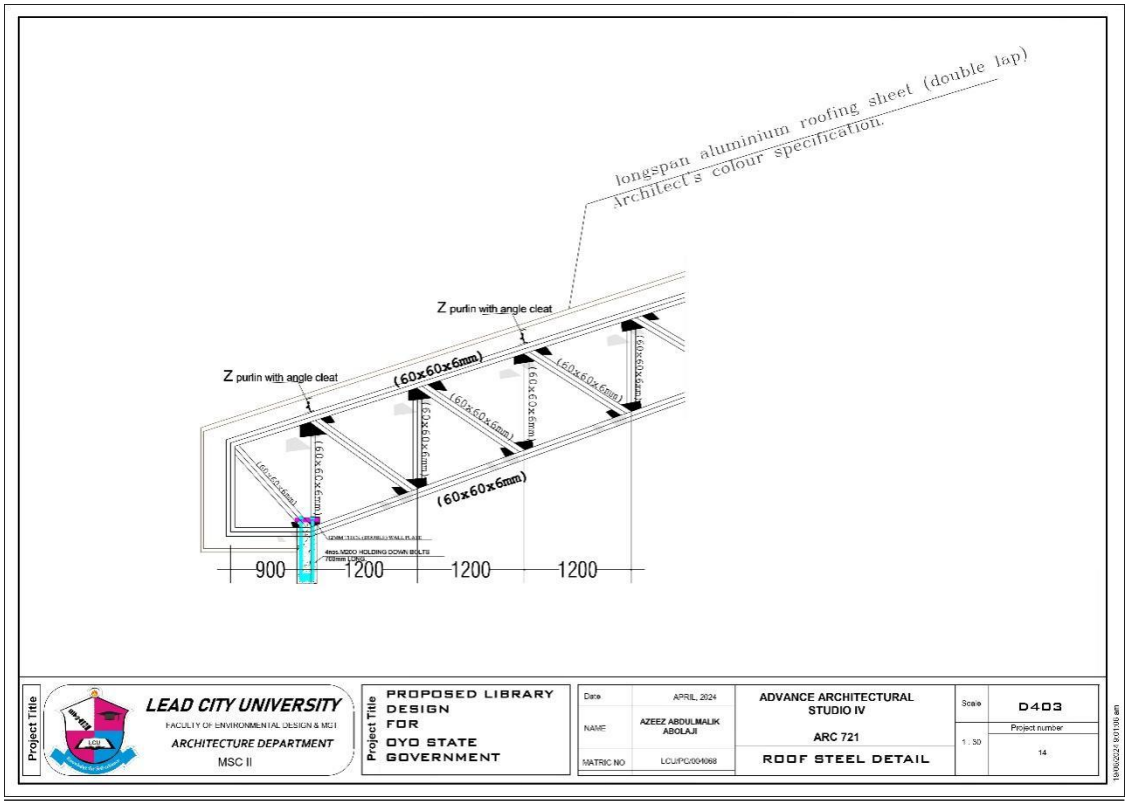


FIGURE 3.7 ; illustrate the details of the proposed public library design

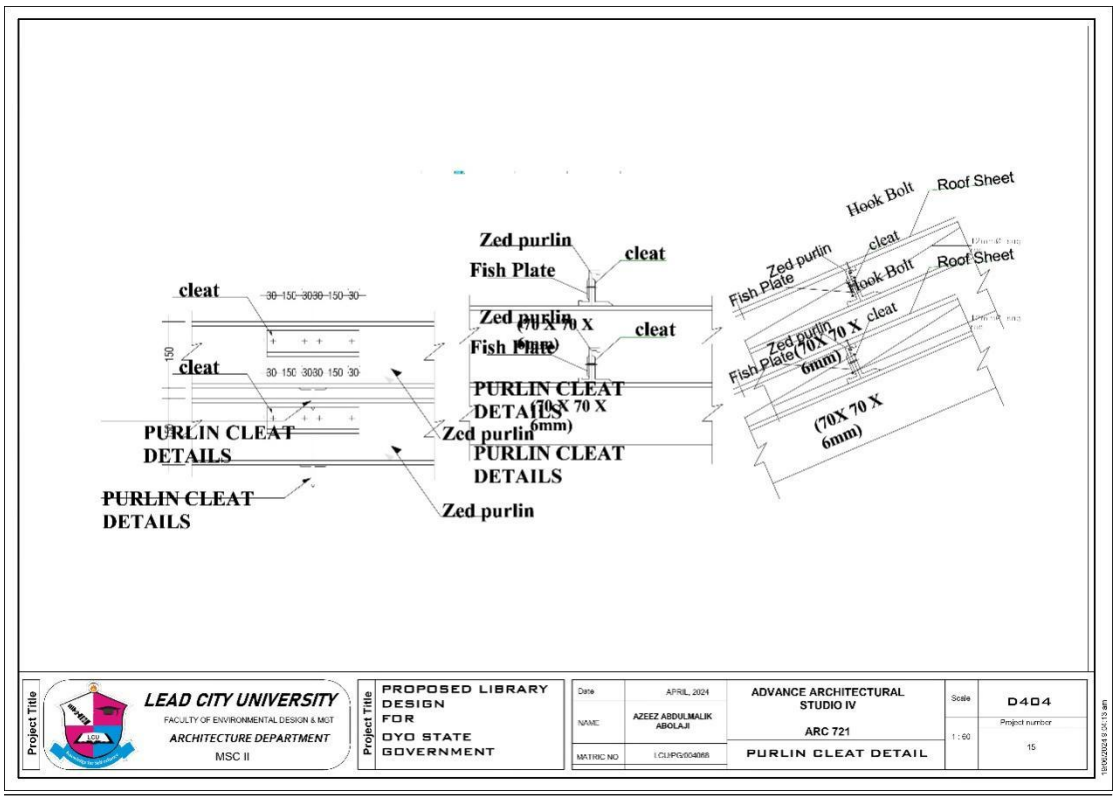


FIGURE 3.8 ; illustrate the details of the proposed public library design

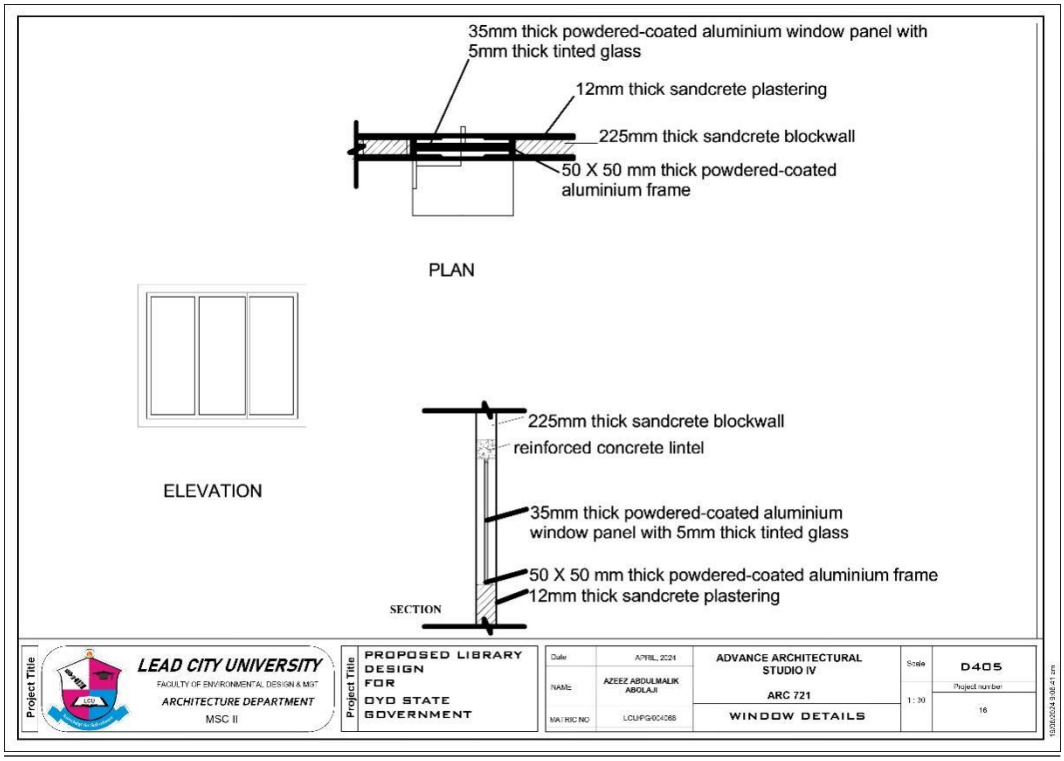


FIGURE 3.9 ; illustrate the details of the proposed public library design

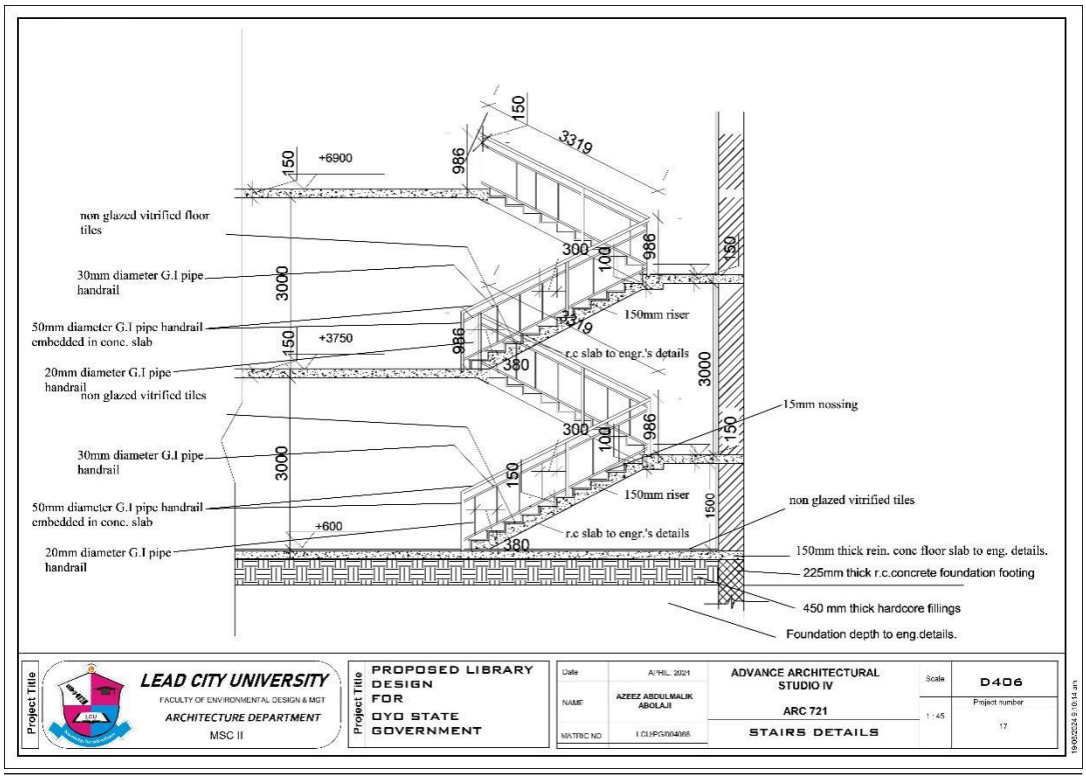


FIGURE 4.0 ; illustrate the details of the proposed public library design

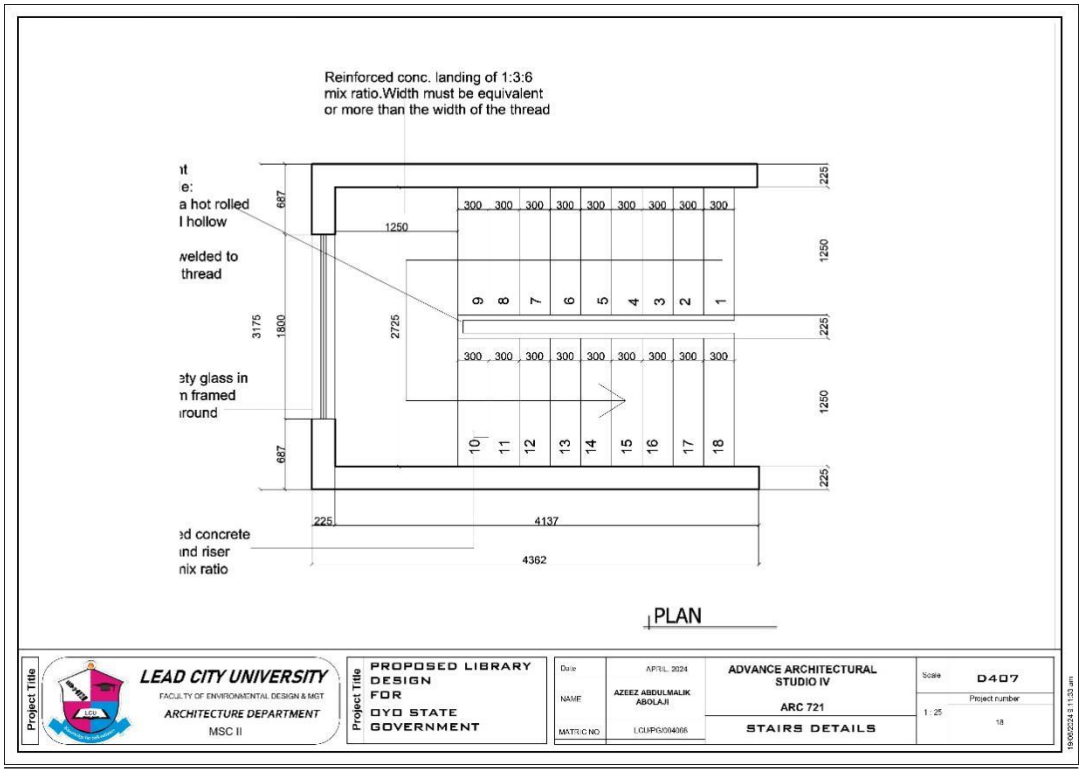


FIGURE 4.1 ; illustrate the details of the proposed public library design

Plate 2.7 – ; illustrate the 3d perspective of the proposed public library design

Plate 2.8 – ; illustrate the 3d perspective of the proposed public library design

Plate 2.9 – ; illustrate the 3d perspective of the proposed public library design

Plate 3.0 – ; illustrate the 3d perspective of the proposed public library design

Plate 3.1 – ; illustrate the 3d perspective of the proposed public library design

BIBLIOGRAPHY

References

.A., Everett. *FINISHES.* london: B.T Batford limited, 2019.

.D., Spišáková .M. & Mačková. "The Use Potential of Traditional Building Materials for the Realization of Structures by Modern Methods of Construction." *Journal of Civil Engineering* , 2019: 1-12.

.R., Barry. *The construction of buildings.* london: granada publisher, 2018.

Akadiri P.O, Chinyio E.A, Olomolaiye P.O. "Design of A Sustainable Building: A Conceptual Framework for Implementing Sustainability in the Building Sector." 2019: 1-6.

ARCHITECTS, HMC. *CIVIC BUILDING AND CIVIC CENTRE ARCHITECTURE DESIGN.* 2 4 2019. https://hmcarchitects.com/thought-leadership/civic-building-and-civic-center-architecture-design-for-the-public/.

broadbent .g. *Design in architecture.* london: john willet, 2017.

bruce, Allsopp. "A modern theory of architecture." *A modern theory of architecture*, 2019: 20-65.

chiching. *Building construction illustrated.* chicago: nostrand reinhold, 2019.

F.H, cornick. *Dork and harbour engineering.* London: charles griffin, 2018.

Gambo A.M, Zafer .H. "The Use of Traditional Building Materials in Modern Methods of Construction (A case Study of Northern Nigeria." *International Journal of Engineering Science Technology And Research (IJESTR)*, 2017: 2-12.

Jelle, B. P. "Traditional, state-of-the-art and future thermal building insulation materials and solutions – Properties, requirements and possibilities." *SINTEF Building and Infrastructure, NO-7465 Trondheim, Norway. Department of Civil and Transport Engineering,* , 2019: 2-14.

joseph, chiora de. *Time saves standard for building type.* new york: mc gray hill group book company, 2021.

Radu Claudiu Fierascu, Mihaela Doni and Irina Fierascu. "Selected Aspects Regarding the Restoration/Conservation of Traditional Wood and Masonry Building Materials: A Short Overview of the Last Decade Findings." *National Institute for Research & Development in Chemistry and Petrochemistry—ICECHIM Bucharest*, 2020: 20-45.

Shan, jun Yan， Xiaoxian. "Research on the Application of Traditional Decorative Elements in ." *2nd International Conference on Humanities Science and Society Development*, 2017: 1-3.

Vanlalnunpuii1. "A Study of Efficiency of Natural Ventilation." *International Journal of Multidisciplinary Innovative Research*, JAN 2022: 1-12.

Agbola, B. S., Ajayi, O., Taiwo, O. J., & Wahab, B. W. (2019). The August 2011 flood in Ibadan, Nigeria: Anthropogenic causes and consequences. *International Journal of Disaster Risk Science*, *3*, 207-217.

Atufu, C. E., & Holt, C. P. (2018). Evaluating the impacts of flooding on the residents of Lagos, Nigeria. *WIT Transactions on the Built Environment*, *184*, 81-90.

Bako, A., & Ojolowo, S. K. (2021). Spatial knowledge and flood preparedness in Victoria Island, Lagos, Nigeria. *Jamba: Journal of Disaster Risk Studies*, *13*(1), 1-11.

Baltagi, B. H. (2019). Econometric analysis of panel data. 3rd ed. Chichester: John Wiley & Sons.

de las Rivas Sanz, J. L., & Fernández-Maroto, M. (2019). "Daily resilience": sustainable strategies for urban fringe in three medium-sized inner Spanish cities. *International Planning History Society Proceedings*, 17(4).

de las Rivas Sanz, J. L., & Fernández-Maroto, M. (2019). Planning strategies for a resilient urban fringe in three medium-sized Spanish cities. *Planning Perspectives*, *34*(4), 725-735.

Evans, N. J., Forney, D. S., & Guido-DiBrito, F. (2021). Schlossberg's transition theory. *Student development in college: Theory, research, and practice*, 107-122.

Gasu, M. B., Olaiyiwola, O. & Abayomi, O. E. (2019). Mapping of flood incidence and urban resilience in Osogbo, Osun State, Nigeria. *International Journal of Scientific Research in Social Sciences and Management Studies*, 4(2), 111-129.

Gasu, M., Yakubu, D., & Afolabi, A. (2022). Residents' participation in flood disaster risk reduction in Osogbo metropolis, Nigeria. *Ethiopian Journal of Environmental Studies & Management*, 15(1), 1-12.

Gujarati, D. N. (2019). Basic econometrics (4th ed.). McGraw-Hill.

Holling, C. S., & Gunderson, L. H. (2018). Resilience and adaptive cycles. *In: Panarchy: Understanding Transformations in Human and Natural Systems, 25-62*.

Hsiao, C. (2020). Benefits and limitations of panel data. *Econometric Reviews*, 4(2), 121-174.

Ibrahim, M., Ndatsu, J. A., & Yisa, K. M. (2020). Effects of flood on crop farmers in riverine area in Niger State. Nigeria.

Jha, A. K., Miner, T. W., & Stanton-Geddes, Z. (Eds.). (2019). *Building urban resilience: principles, tools, and practice*. World Bank Publications.

Menard, S. (2002). Applied logistic regression analysis (2nd ed.). Sage.

Neuman, W. L. (2019). Social research methods: Qualitative and quantitative approaches (7th ed.). Pearson.

Odunsi, O. M. (2023). Variability in Flood Sensitivity: A household-based perception study in Lagos Metropolis Nigeria. *KIU Journal of Social Sciences*, *9*(1), 67-78.

Odunsi, O., & Onanuga, M. (2022). Modelling resilience to extreme climate events: A household-based study of flood disaster in Nigeria. *Town and regional planning*, *81*, 97-112.

Ostrom, E., & Janssen, M. A. (2020). Multi-level governance and resilience of social-ecological systems. *Globalisation, poverty and conflict*, *239*.

Owoeye, J. O., Abe, F. S., & Olasemojo, R. O. (2020). A study on anthropogenic activities influencing flood vulnerability in Ala riverfront residential areas of Akure, Nigeria. *Journal of Geographical Research*, *3*(4), 45-54.

Ranjan, R., & Agrawal, R. K. (2019). Panel data analysis: Concepts and applications. Excel Books.

Sadiq, A. A., & Ardo, A. U. (2020). An evaluation of causes, extent, pattern and effect of gully erosion on some selected arable lands in Yola South LGA, North-eastern part of Nigeria. *African Journal of Environment and Natural Science Research ISSN: 2689-9434 Volume*, *3*, 37-56.

Sadiq, A. A., Sulaiman, U. B. & Mohammed, H. (2019). Assessment of substantive causes, effects and mitigation strategies of flood scenario in Yola South LGA, Adamawa State, Nigeria. *International Journal of Scientific and Research Publications*, 9(4), 513-536.

Taris, T. W. (2018). Longitudinal research: Theory and practice. In T. W. Taris, M. A. C. Kompier, & I. L. Geurts (Eds.), Bridging occupational, organizational and public health: A transdisciplinary approach (pp. 183-193). Routledge.

Umar, N., & Gray, A. (2023). Flooding in Nigeria: a review of its occurrence and impacts and approaches to modelling flood data. *International Journal of Environmental Studies*, *80*(3), 540-561.

Von Bertalanffy, L. (2019). An outline of general system theory. *The British Journal for the Philosophy of science*, *1*(2), 134-165.

Wahab, B., & Falola, O. (2022). Vulnerable households in flood-prone communities in ibadan: measures to improve their status within the inclusive Ibadan City framework. *Journal of Inclusive Cities and Built Environment*, *2*(1), 21-27.

Walker, B., Holling, C. S., Carpenter, S. R., & Kinzig, A. (2019). Resilience, adaptability and transformability in social–ecological systems. *Ecology and society*, *9*(2).

Bio-data

A. Personal Data

1. Full Name: AZEEZ Abdulmalik abolaji

2. Address: No 19 dayo oluyemi street Ikorodu, lagos, Nigeria

3. Email Address: abolajibabs@gmail.com

4. Phone Number: 08078458447

5. Date of Birth: 08/06/1995

6. Place of Birth: Ibadan Oyo state, Nigeria

7. Nationality: Nigerian

8. Marital Status: Married

9. Name and Address of Next of Kin: Khairat adebanke Babs

B. Educational Background

- -M.Sc. in Architecture: Lead City University, Ibadan (2022 - Ongoing)
- -B.Sc. in Architecture: Lead City University, Ibadan (2020 – 2022)
- HND in architecture The Oke ogun polytechnic, saki. (2017-2019)
- OND in Architecture The polytechnic ibadan. (2012-2014)
- Secondary School: Oladipo alayande school of science (2009 – 2012)
- Primary School: Ansar-ud-deen nur/pri school liberty road (2001 – 2009)

Leaving Certificate

C. **Work Experience**

Ayico building tech (2016 -Till date)

Position: Project Architect and Site Supervisor

- -Prepared architectural drawings for design and building renovations.
- -Supervised renovation and construction projects.
- -Project management

Building and environmental development (2013-2016) *Position: Architectural Designer Intern* -Prepared architectural drawings for design and building renovations.

- -Created 3D architectural visualizations.
- -Designed building landscapes.
- Supervised site projects.
- Supervised various site construction project.
- Project management.

D. ****Publication****

…….. …….

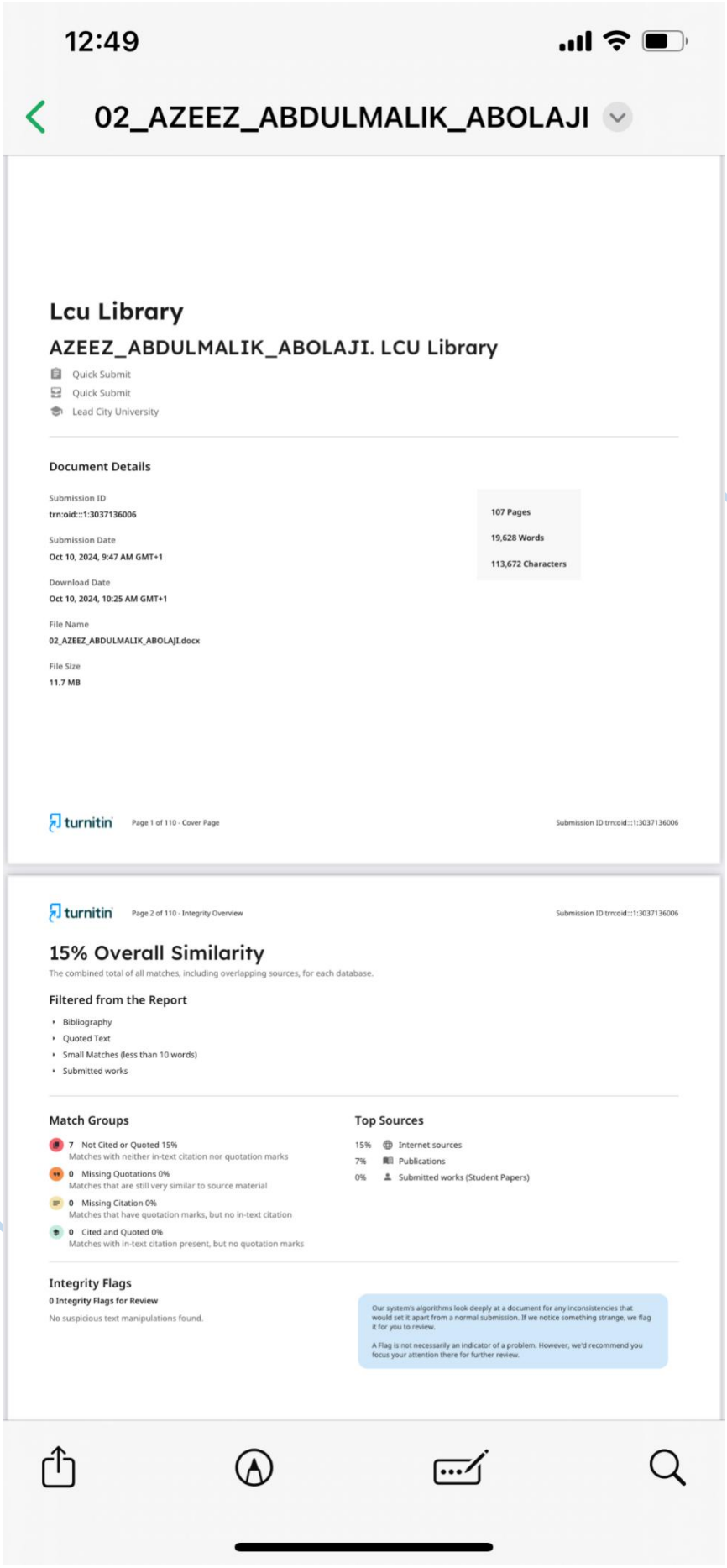
Signature

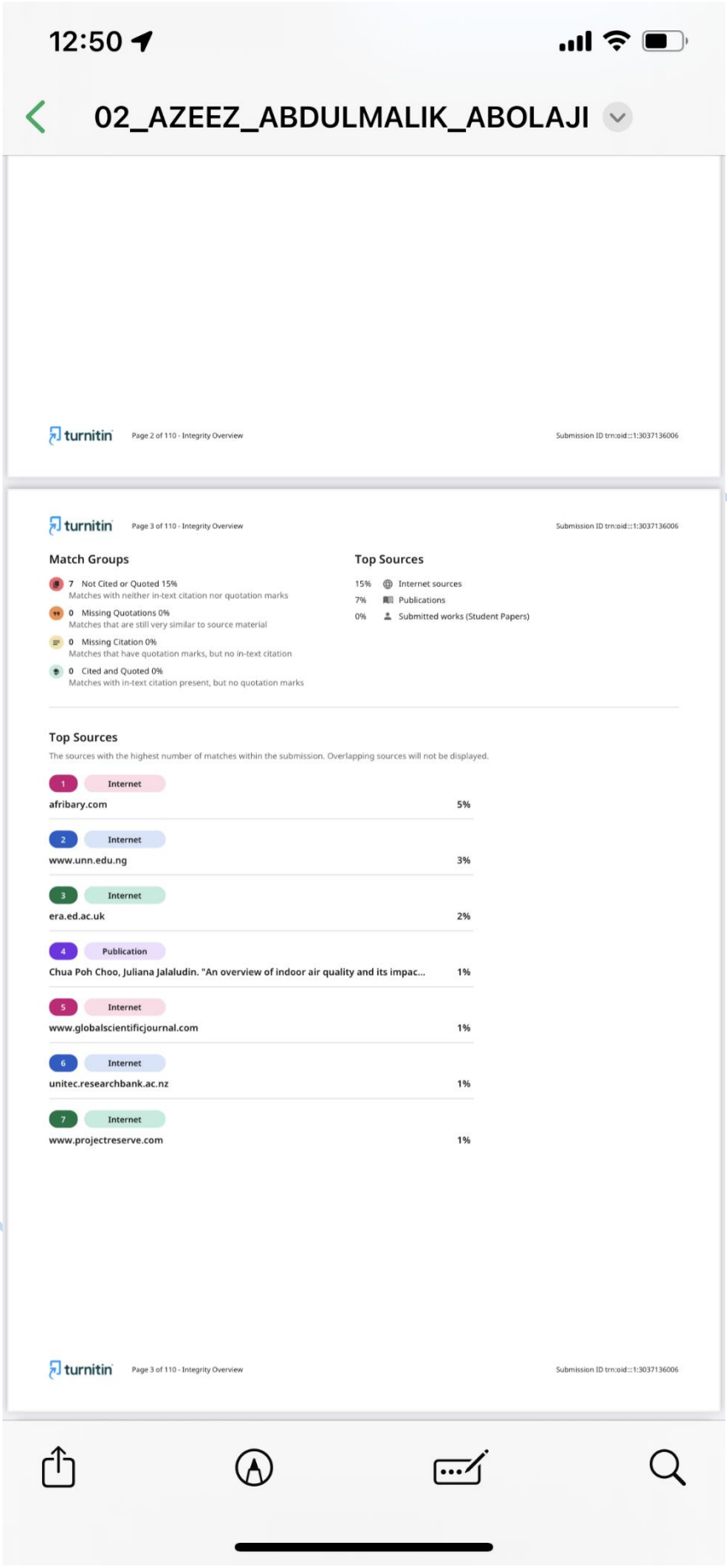
The University Compliance Certification

This is to certify that the thesis by AZEEZ ABDULMALIK ABOLAJI, with the matriculation number LCU/PG/004068, in the Department of Architecture, Faculty of Environmental Design and Management, Lead City University, Ibadan, is in full compliance with the university's format and style for theses.

…….. ……..

Signature Date Date


12:49
02_AZEEZ_ABDULMALIK_ABOLAJI
Lcu Library
AZEEZ_ABDULMALIK_ABOLAJI. LCU Library
Quick Submit
Quick Submit
Lead City University
Document Details
Submission ID
trn:oid:::1:3037136006
Submission Date
Oct 10, 2024, 9:47 AM GMT+1
Download Date
Oct 10, 2024, 10:25 AM GMT+1
File Name
02_AZEEZ_ABDULMALIK_ABOLAJI.docx
File Size
11.7 MB
107 Pages
19,628 Words
113,672 Characters
turnitin
Page 1 of 110 - Cover Page
Submission ID trn:oid:::1:3037136006
turnitin
Page 2 of 110 - Integrity Overview
Submission ID trn:oid:::1:3037136006
15% Overall Similarity
The combined total of all matches, including overlapping sources, for each database.
Filtered from the Report
Bibliography
Quoted Text
Small Matches (less than 10 words)
Submitted works
Match Groups
7 Not Cited or Quoted 15%
Matches with neither in-text citation nor quotation marks
0 Missing Quotations 0%
Matches that are still very similar to source material
0 Missing Citation 0%
Matches that have quotation marks, but no in-text citation
0 Cited and Quoted 0%
Matches with in-text citation present, but no quotation marks
Top Sources
15% Internet sources
7% Publications
0% Submitted works (Student Papers)
Integrity Flags
0 Integrity Flags for Review
No suspicious text manipulations found.
Our system's algorithms look deeply at a document for any inconsistencies that would set it apart from a normal submission. If we notice something strange, we flag it for you to review.
A Flag is not necessarily an indicator of a problem. However, we'd recommend you focus your attention there for further review.


12:50
02_AZEEZ_ABDULMALIK_ABOLAJI
turnitin
Page 2 of 110 - Integrity Overview
Submission ID trn:oid:::1:3037136006
turnitin
Page 3 of 110 - Integrity Overview
Submission ID trn:oid:::1:3037136006
Match Groups
7 Not Cited or Quoted 15%
Matches with neither in-text citation nor quotation marks
0 Missing Quotations 0%
Matches that are still very similar to source material
0 Missing Citation 0%
Matches that have quotation marks, but no in-text citation
0 Cited and Quoted 0%
Matches with in-text citation present, but no quotation marks
Top Sources
15% Internet sources
7% Publications
0% Submitted works (Student Papers)
Top Sources
The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.
1 Internet
afribary.com 5%
2 Internet
www.unn.edu.ng 3%
3 Internet
era.ed.ac.uk 2%
4 Publication
Chua Poh Choo, Juliana Jalaludin. "An overview of indoor air quality and its impac... 1%
5 Internet
www.globalscientificjournal.com 1%
6 Internet
unitec.researchbank.ac.nz 1%
7 Internet
www.projectreserve.com 1%
turnitin
Page 3 of 110 - Integrity Overview
Submission ID trn:oid:::1:3037136006