Proposed Interchange at Moniya, for Oyo State Government, Ibadan.

(Achieving Ease of Movement Through Circulation Definition in an Interchange)

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Certification

This is to certify that Sakirat A. Afolabi with matriculation number LCU/PG/001902 carried out this research work titled Proposed Interchange at Moniya for Oyo State Government (Achieving Ease of Movement through Circulation Definition in an Interchange) in the Department of Architecture, Faculty of Environmental Design and Management, Lead City University, Ibadan, Oyo State, for the award of Master Degree (MSc) in Architecture and has not been previously submitted.

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Dedication

I dedicate this project to God Almighty for His continuous favour which has enabled me to attain this height of my academic career and to the memory of my late father, Surv. (Alhaji) Abdul Fatai Adebimpe Adelekan.

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Abstract

This study focused on the need to improve passenger movement in a bid to enhance the transportation sector while assessing the challenges faced with the current situation at the Moniya train station in Ibadan. Integration of a bus terminal with the existing rail transit will provide comfortable and safe travel experience for passengers especially the disabled, aged and young children. This is to be achieved through intermodal transfer of passengers by creating a synergy between the two modes of transportation as a strategy to improve passengers travel pattern. Qualitative research method was adopted for the study using case study approach as the instrument. Five related case studies to include two local (Modern Bus Terminal, Ojoo, Ibadan and Oshodi Interchange, Lagos) and three internationals (Metro Station, Beijing, China; Manukau Bus Interchange, New Zealand and Christ Church Bus Station, Auckland) were analysed using physical observation and photographs to record findings. Journals, books and previous research works related to the study were also upheld and concerned Government offices were visited for data collection. This provided detailed information on the historical background of the project, main spaces provided, materials used and peculiar features about the projects. Findings from the case studies shows that ease of movement is achieved based on factors to include accessibility, space zoning / Facilities provided, shelter, security, operating system, visibility, adequate ventilation and daylighting. However, direction of movement and space allocation have been found to be the most important factors that determines easy movement along the circulation flow. In conclusion, an effective interchange will ensure efficient circulation and seamless movement within and around the interchange, serve as protection from weather effect with the provision of adequate ventilation and efficient daylighting. This study therefore, recommends that the above findings be included in all proposed interchange designs.

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IGC	International Growth Centre	11
CCTV	Closed Circuit Television	19
IITA	International Institute of Tropical Agriculture	57
L.G	Local Government	57
ATM	Automated Teller Machine	67
IT	Information Technology	71
HVAC	Heating Ventilating Air – Conditioner	77

Chapter One

Introduction

1.1 Background to the Study

The persistent rise in urban population coupled with the rapid sprawl of the geographical extent of cities and towns in most part of Nigeria has resulted into a paradigm where people now engage in more than one means of transportation to get to their final destination (Chauhan, Gupta & Parida, 2021; Rodrigue, 2020; Soteropoulos, *et al.,* 2019; Hernandez *et al.,* 2016). In order to reduce the inconveniences encountered through this complex transport facility, interchanges were established as an alternative means to ease movement (Afolabi *et al.*, 2017).

Over the years, the policy sector of Nigeria, in a bid to enhance the transportation sector, launched the public mass transit in 1989 (Eboreime & Ohiorenoya, 2017; Efobi & Anierobi, 2014) which unfortunately yielded minimal contribution to mobility problems due to inadequacy and inefficiency in the management of the corporation (Nwaogbe *et al.,* 2020; Adeke *et al.,* 2018; Aderamo, 2010). On the other hand, the adoption of private sector based-service-delivery, to overrun the transport facilities (Omotayo, 2020; Igwe *et al.*, 2013) as a sort of intervention failed to live up to expectations thereby causing more problems (Abdulkarim, 2020; Adedotun, 2015). This according to Hernandez & Monsoon (2016) resulted in long distance travel, increase in travel time and high level of traffic congestion.

Today, efficient transportation plays a critical role in a city's social and economic advancement (Ikenwa, 2019). For example, it fosters community cohesion, improves safety, increase mobility and access to market, employment and enhances the visual quality of the urban scape (Eboreime & Ohiorenoya, 2017; Adedotun, 2015; del Olmo, 2015). Similarly, investment in transportation enhances economic activities needed to sustain life and well-being (Okotie, 2020) thereby bringing about expansion in a country's manufacturing,

industrial, tourism and distribution sector (Afolabi *et al.*, 2017). Interestingly, the situation of Obafemi Awolowo Train Staion, Moniya in Ibadan according to Osuntokun (2022), does not live up to expectation. He highlighted the fact that despite being constructed in a non-visible location, the project seems not completed because the road leading to the station is along the bush, untarred and with few parking spaces.

In practice, a public transport interchange is a location where facilities are provided for specified types of interconnected public transport services for the transfer of passengers between those services (Solecka *et al.,* 2020; Lamiquiz Dauden *et al.*, 2014). However, a clear definition was given by the Madrid Regional Transport Authority in 1985 as ‘’Area whose purpose is to minimize the inevitable sensation of having to change from one mode of transportation to another and efficiently using the inevitable waiting time’’ (Heddebaut & Di Ciommo, 2018). Notwithstanding, the main purpose of an Interchange is for easy transfer from one mode of transportation to another.

In essence, interchange is more than mere conventional bus network (Yang *et al.* 2020) and therefore requires effective circulation for ease of movement (del Olmo, 2015). Planned allocation of space as explained in the SG Architects' report (2015), helps to reduce delay and improve level of service for passengers. Also, del Olmo (2015) further highlighted seven functional factors of an interchange as travel information, accessibility, co-ordination between operator and transport services, safety and security condition, shelter and waiting areas, facilities, way-findings and sign posting. Circulation definition is therefore, influential in efficiently integrating these factors so as to achieve the goals of a public interchange (SG Architect, 2015).

This will partly address the creation of safe and efficient spaces to accommodate the movement of goods (Francis *et al.*, 2020); on one hand and further ensures effective mobility of passengers between transit modes, proper signage that is visual enough for the users,

access and egress to station, effective pedestrian route as well as a safe and secured environment (Khattak, & Hussain, 2021; Qamhieh, 2012).

Based on the fore mentioned and considering the fact that built environment professionals are beginning to recognize the importance of efficient interchange in improving urban transportation, this study is aimed at designing a befitting bus terminal at the existing train station environment at Moniya, Ibadan to establish an interchange in order to mitigate crowding and circulation problems at the existing train station environment.

1.2 Statement of the Problem

Today, cities are complex systems that serves as a major hub for various economic, social and infrastructural activities (Zhang, *et al.,* 2017; Hernandez & Monzon, 2016). This concept of urban growth has led to a constant increase in traffic congestion, noise and air pollution; a creating more complex travel pattern (Gonzalez & Karakayacı, 2020; Hernandez *et al.*, 2015). In most cities in Nigeria, efforts have been made to ease these urban problems. For example, Federal Government launched a mass transit program in 1989 with the objective of moving many passengers in one vehicle at a time from one place to another (Eboreime & Ohiorenoya, 2017; Efobi & Anierobi, 2014). Similarly In 2002, a 25year strategic plan was approved for the modernization of the transport sector to include the construction of about 8,000km standard rail line which was amended in 2006 and ratified again in 2012 (Chen, 2018) and ₦276 billion budgeted for transport infrastructure in 2017 towards a smooth running of the on-going rehabilitation and construction of rail lines and airports (Eboreime & Ohiorenoya, 2017).

Unfortunately, these transportation systems are not connected, as they are run as separate entities and do not share synergies. This has created even more challenges (Chauhan, Gupta & Parida, 2021; Hernandez *et al.* 2016) and crowding around station. However, mobility is more than mere access and dispersal of goods and passengers; it considers connectivity

among other forms of land use within the environment and the transport station together with the spatial network in relation to street configuration (Butler, *et al.,* 2020; Holden, *et al.,* 2019; Lamiquiz Dauden *et al.*, 2014). While the main purpose of an Interchange is for easy connectivity from one mode of transportation to another (Moyo *et al.*, 2021); it also promotes effective circulation that brings about harmony and improved accessibility between private cars, rail to urban public transport and other facilities in order to ease movement with the proper planning and management of accessibility features like station layout, shelter, ticketing, proper signage within the interchange.

This research therefore, focuses on the development of a suitable Bus – Train Interchange that will meet the urgent need of solving the crowding and traffic congestion problems in Ibadan.

1.3 Aim and Objectives of the Study

1.3.1 Aim

The aim of the study is to design a public interchange by the integration of spaces and design consideration for a Bus-Train interchange at the existing Train Station site, Moniya in Ibadan for Oyo State Government to achieve ease of movement through circulation definition.

1.3.2 Objectives

The specific objectives set out to achieve the aim of the study are to:

i. assess the current situation of the Moniya public rail facility in Ibadan
ii. carry out case studies of existing interchanges in order to identify the functional spaces required in a public interchange facility
iii. determine the mobility standards in a public interchange facility
iv. develop an aesthetically pleasing and cost-effective design to improve circulation by integrating the identified functional spaces and mobility standards established in the design of a bus – train interchange.

1.4 Research Questions

i. What is the current situation of the Moniya public interchange?

ii. What are the functional spaces required in a public interchange?

iii. What are the mobility standards required in a public interchange?

iv. How can effective circulation be achieved in a public interchange?

1.5 Significance of the Study

The study is expected to improve users' experience during waiting time as it will enhance the beauty of the environment and improves the journey by providing ease of mobility and movement especially for people with disability. It will therefore, boost the economic development of the immediate surrounding by providing opportunities for various forms of economic activity around the interchange. It will also benefit the built environment by encouraging the use of public transportation which improves the effect of road congestion as the number of vehicles plying the road would be reduced. This would invariably lead to improved indoor air quality as the gaseous emission produced by motorist would be minimal.

1.6 Scope of the Study

The scope of the proposed project would be based on the functional spaces required in a bus - train station with the integration of car park facilities focusing on analysing the service quality. This would include spaces like passenger waiting platform area, loading platform, signages, ticketing, toilet facilities, car park, motorcycle stand, kiosks, guest house etc.

1.6.1 Target Groups

a) People embarking on long distance journey

b) People working in remote places

c) People with limited walking abilities

d) People with disability

1.7 Limitation of the Study

As there is no Bus – Train interchange facility existing in the country, it was tasking for the researcher to source information from concerned Government Ministries and challenging, capturing the full situation in photographs at the existing related facilities due to the level of insecurity in the country. Also, accessing information online requires data subscription which is not cost effective.

1.8 Operational Definition of Terms

1. **Public Transportation:** a means of movement used in common by all citizens.
2. **Mode of Transportation:** type of transportation service used in conveying people.
3. **Interchange:** a location where facilities are provided for the transfer of passengers within same or different modes of service.
4. **Mobility:** moving freely and easily from one location to another
5. **Accessibility:** ease of reaching or linking the facilities.
6. **Circulation:** safe and efficient spaces to accommodate the movement of goods and people.
7. **Travel time:** the time it takes to accomplish the journey.
8. **Waiting time:** the time it will take to transfer people from one mode of transportation to another.
9. **Terminal Building:** a building within the interchange with facilities for passengers' use.
10. **Passenger:** people transferring from one mode of transportation to another.
11. **Multimodal:** having different transportation modes.
12. **Integration:** uniting different modes of transportation.
13. **Travel Pattern:** the way people travel over a period of time.

Chapter Two

Review of Related Literature

This session covers the review of related literature, theories and concepts on ease of movement through circulation in a public interchange facility.

2.1 Conceptual Review

2.1.1 Urban Mobility

Urban Mobility is the movement of people from one location to another location within or between urban areas (Holland, 2021; Rodrigue, 2020). In furtherance, it has become a key function of the society as people need to access housing, job, education, and other urban services. The growing population of the city due to urbanization has resulted to higher demand for urban services and public transport which has brought about the challenges of traffic congestion, pollution, waste of time, noise among other things (Ceder, 2020; Rodrigue, 2020; Gonzalez & Karakayacı, 2020; Hernandez *et al.*, 2016). This change has caused a revolution in mobility as people tend to engage in more than one mode of transportation in preference of motorised mobility due to its cost efficiency (Soteropoulos, *et al.,* 2019; Reddy & Balachandra, 2012).

Federal Government in its efforts towards easing the urban transport problem, launched a mass transit program in 1989 with the objective of moving many passengers in one vehicle at a time from one place to another (Eboreime & Ohiorenoya, 2017; Efobi & Anierobi, 2014) as well as the adoption of Public Private Partnership (Omotayo, 2020). In 2002, a 25year strategic plan was approved for the modernization of the transport sector to include the construction of about 8,000km standard rail line which was amended in 2006 and ratified again in 2012 (Chen, 2018) and ₦276 billion budgeted for transport infrastructure in 2017 towards a smooth running of the on-going rehabilitation and construction of rail lines and airports (Eboreime & Ohiorenoya, 2017).

Nevertheless, deductions from past literatures (Vandana, 2022; Prasanna, 2020; Ajibola, 2019; Plamadeala & Slobodeaniuc, 2019; Lucas *et al.*, 2017;) shows that railway systems are suitable for long distance and heavy loads. In furtherance, it is said to be at a disadvantage due to its inflexible activities, lack of rural service as well as the difficulties in its construction on high terrain and curved areas among others. However, mobility is more than mere access and dispersal of goods and passengers; it sustains cities' growth and services available to users on demand (Holland, 2021). It also creates connectivity among other forms of land use within the environment and the transport station together with the spatial network in relation to street configuration (Dauden *et al.*, 2014).

2.1.2 Types of Urban Mobility

Urban Mobility encompasses all aspects of movement linked to designated activities and land use in urban centres which facilitates the establishment and realization of various movements (Rodrigue, 2020). He maintained that this could either be obligatory or voluntary where the major types are highlighted below;

Pendulum Movement – these are expected movements embarked upon on a daily basis and thus are predictable. Example is the movement from home to work places.

Professional Movement – are mainly observed during work hours in connection to one's professional activities. Example are attending meetings, marketing and carrying out repair works.

Personal Movement – these are optional movements that are carried out deliberately either for commercial activities of relaxation purposes. Examples are going for shopping or to picnics.

Tourist Movement – these are seasonal movements done at specific periods to celebrate a landmark. Example is the Olympic World Cup.

Distribution Movement – these movements are concerned with load delivery for manufacturing and consumption purposes. They are mostly linked to terminals, retail outlets and distribution centres.

2.1.3 Sustainable Urban Mobility

Sustainability is a broad discipline which has been defined differently by different researchers (Page & Gordon, 2017). In furtherance, some use it as a measure for quality while others take it to mean the process of keeping something in a particular state. It is defined by the Centre for Sustainable Urban Development as "a process by which present and future communities flourish harmoniously" (Ortuzar, 2019). Further explanation shows that sustainable cities' exhibit high performance in the social, economic and environmental aspects which is strong enough to withstand challenges. However, the universal definition of sustainability is given as *the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs.* (Kayal, *et al.* 2014).

Sustainable Urban Mobility as explained by Lam & Head (2012); Nikitas *et al.,* (2021), ensures a sense of relief, comfort, reduced cost and openness in the process of transferring to ones' proposed location with little environmental effect among others. This is supported quoting the definition of sustainable urban mobility by World Bank Council for Sustainable Development 2001 as

"The ability to meet the needs of society to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values today or in the future" (Herrmann-Lunecke, 2020). Deductions from Kayal *et al.* (2014) review work shows that sustainable urban mobility is a system which embodies a feasible economy in a secure environment exhibiting social justice to effectively meet up with the transportation and land use requirements of today and future situations.

This has thus corroborated the explanation on urban mobility where governments, as policy makers, attach importance to the need of formulating strategies and programs relating to infrastructure, traffic management, road safety and investment (Hernandez *et al.,* 2013).

This according to Ahmad & Oliveira (2016) can best be achieved with a vivid understanding of customers expectation (Lang *et al.* 2020) through a physical based mobility pattern to harness situations pertaining to urban forms, socio-economic and socio-cultural characteristics of urban residents. The mobility pattern helps to ascertain and differentiate both individual and collective requirements of users based on five major factors to include income, employment, gender, age and type of transport mode (Costa *et al* 2017). Effectiveness of the urban mobility process therefore seeks to regulate the city's productivity and sustainability (IGC 2018).

2.1.4 Public Buildings

Public buildings are buildings that are funded by the government which is generally accessible and used by the citizens for different purposes (Van Baren, 2019; Rajeev, *et al.,* 2018; Ubale, 2016). As opined by Adedayo *et al.* (2013), the design of a public building is expected to be all inclusive; where everybody's need considering their satisfaction in relation to circulation flow within and outside the building is equally guaranteed (Boisjoly & El-Geneidy, 2017). Moving easily within buildings enables neighborhood access through different but related spaces and exposure to the built environment (Vroman & Lagrange, 2017). This according to Adedayo *et al.* (2013), is determined by the size and location of spaces within the building and with careful arrangement for efficient usage.

2.1.5 Transport Interchange

Transport interchanges have become a fundamental component of a day–to–day experience of many people in a bid to reduce the challenges arising from urban mobility and to increase users 'perception. Rodrigue (2020), highlighted that people interchange for two main reasons;

either because there is no direct route from their present places to their final destination or because they choose to change services in order to take advantage of a more convenient, faster and cost-effective mode of travel. Different transport modes complementing each other are connected to transfer people from their one destination to another (Garcia-Martinez *et al.,* 2018; Hernandez *et al.*, 2016). This tends to support the population growth with increasing access to services in an efficient and timely manner (Ceder, 2021).

Ferreira da Silva, in his thesis submitted to the University of Porto explained that there is no specific definition for Interchange as it has been defined by various scholars to mean different but related terms depending on the point of reference. Ibifuro & Pepple (2021) defined interchange as a purpose-built facility that allows for flexible and possible transfer of passengers and goods from one mode of transportation to another. Del Olmo (2015) in his own definition highlighted that transport interchange does not only serve as link to cities, but it also serves as a place from where people come and go on foot or by other means to get to and from the station. According to Yap *et al.* (2019) and van Hagen (2011), it is a multi-modal facility that allows passengers to transfer and efficiently use the inevitable waiting time (Heddebaut & Di Ciommo, 2018; Tsami, Adamos & Nathanail, 2018) which further allows access to facilities within or close to the interchange (Turnbull, 2013) enabling a sort of socialization where people meet, shop and do business (Aongusa, 2019, Hernandez *et al.*, 2016).

Deductions from literature defined interchange to be (i) a location where passenger transfer from one mode of transportation to another or between two services of the same mode; (ii) a place where passengers join or leave the public transport system on foot, bicycle, or motorcycle and (iii) a convenient location for a journey to be broken to allow access to facilities within or close to the interchange. Further explanation shows that interchanges can either be the physical action of passengers transferring between different modes or services

through a journey or the physical location that provides access to the transport system (Lamiquiz Dauden *et al.*, 2014).

2.1.6 Categories of Interchange

According to Conticelli *et al.* (2021), interchanges are classified differently considering the modes of transportation involved or by focusing on the major characteristics of the particular mode of transport like its location, catchment area, passenger flow and the type of services provided. In furtherance other classifications are Regional, Sub-regional and Suburban based on the land use planning of the area. However, Turnbull (2013) highlighted that interchanges are internationally classified as:

International Interchange: usually found at the city hub serving as a converging point for different or all types of transport modes. It comprises of airports, intercity bus terminals and train station covering international or long-distance services. Example is the Britomart Interchange in Auckland that combines a railway station with a bus interchange. It is located in the central business district of Auckland at the foot of Queen Street; the main commercial centre with the main ferry terminal.

Figure 2.1: Britomart Interchange, Auckland
Source: (www.myguideauckland.com).

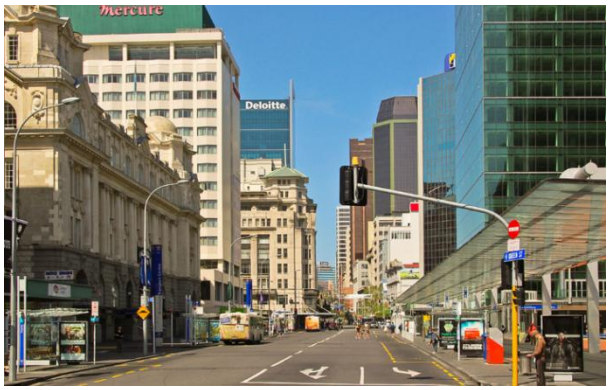


Figure 2.2: View along Queen Street
Source: (www.wikiwand.com).

Figure 2.3: Underground train terminal
Source: (www.wikiwand.com).

Major / Specialized Interchange: this category of interchange comprises of multiple modes of transportation that service an exceptional destination. It is normally located at the Central Business District off the residential areas where major access is by public transport, bicycle or walking and so does not have provision for commuter parking. Example is the New Lynn Station in Auckland.

Figure 2.4: New Lynn Station, Auckland, New Zealand
Source: (www.simondevitt.com).

Figure 2.5: Way-finding to Buses Point.
Source: (www.simondevitt.com).

Figure 2.6: Way-finding to Train Point.
Source: (www.simondevitt.com).

Local Interchange: are built to serve the local community. It is usually the first point of contact passengers have with the public transport system to get to their final destination. Main access mode may be by walking, cycling, buses or by transfer between local and high frequency bus routes. Example is the Otara Bus Interchange in Auckland, New Zealand.

Figure 2.7: Shelter for passengers' waiting.
Source: (www.pensar.com.au).

Figure 2.8: Covered walkway.
Source: (www.wsp.com).

2.1.7 Modes of Public Interchange

The complexity of urban area makes it a system of many divisions with different forms of interaction (Macharis & Kin, 2017; Behrends, 2012). The major factor that determines the decision making for users to shift to public transport is the travel time (Ivan, 2016) which encompasses varying phases like preparation time for a journey, walking and waiting time, transfer time between modes and the time spent through the journey. Overcoming these challenges of urban transport system necessitated the creation of a comfortable, safe, convenient and dignified atmosphere (Nathanail *et al.*, 2018) to reduce the imbalance of the various divisions and to enhance users' perception. Deduction made from the objective shows that interchanges may be classified differently according to the mode of transport system it exhibits.

However, Ibifuro & Pepple (2021) maintained that for passengers to be clearly and consistently identified through a specified journey, different modes of interchanges (Kumar, 2022) were highlighted viz;

Road – Road Interchange: a movement within and outside the city where passengers transfer between same or different bus services to get to their proposed destination. This is usually refererred to as Bus Terminal.

Figure 2.9: Road – Road Interchange
Source: (www.reddit.com).

Road – Rail Interchange: this is also an intra-city and inter-city transfer of passengers between train and buses. Being an intermodal station, it allows movement between different modes of transport for a seamless journey.

Figure 2.10: Road – Rail Interchange.

Source: (www.smmr.asia.com).

Road – Air Interchange: this is mainly an inter-city transfer of passengers with movements between buses and aeroplanes. It is otherwise referred to as Airport Terminal.

Figure 2.11: Road – Air Interchange Mode.
Source: (www.dsl-ua.com).

Road – Water Interchange: where people transfer between buses and boats within city, between cities and internationally.

Figure 2.12: Road – Water Interchange.
Source: (www.dsl-au.com).

Road – Rail – Air Interchange: this is an integration of different modes of transport to include buses, train and aeroplanes for transfer of passengers. It is mainly for international travel pattern.

Figure 2.13: Road – Rail - Air Interchange.
Source: (www.joc.com).

Interchange Over Space: is also an integration of multi-modal transport modes. It has two categories which are: -

a). where different terminals are located within the same building to reduce the transfer time and create a more comfortable feeling for passengers.

Figure 2.14: Interchange located within the same building
Source: (www.dsl-ua.com).

b). where different terminals are located within appreciable distance to one another. It usually takes more time and cost to transfer with less comfort for passengers.

Figure 2.15: Interchange located at considerable distance to one another. Source: (www.dsl-au.com).

2.1.8 Bus – Train Interchange

This is defined by Sdoukopoulos *et al.,* (2020) *and* Behrens (2012) as the transfer of passengers in a combined mode of two (bus and train) services to reduce the cost of the journey, improve the quality of the service and invariably enhance the overall efficiency of the transport system. Deductions from the definition reveals that this type of interchange combines both the short-haul service and long distant journey to get to and from the final destination. The scope of work for this study is however limited to a Bus – Train Interchange where people and goods are transferred between buses and train services to and from various points to their final destination.

2.2 Empirical Review

2.2.1 Components of a Bus - Train Interchange

Interchanges are established with the objectives to transfer passengers easily between modes, improve the travel time, engage passenger through the waiting time (Heddebaut & Di Ciommo, 2018) and also serve as a meeting point for safety, comfort, dignity and

convenience businesses (Afolabi *et al.*, 2017). In order to achieve the set objectives as explained by previous researchers (Budd & Ison, 2021; Naude *et al.*, 2005), the following components are required to be in place for a proper operation in an interchange:

Vehicular Layout – this encompasses accessibility and circulation of buses within and outside the interchange; interchange operations (designated routes and direction for buses) within and around the interchange and the civil infrastructure of the interchange.

Pedestrian Space, Circulation and Facilities – this includes pedestrian circulation areas and spaces (walkways, bicycle stands and waiting areas); passenger loading area (boarding and alighting from vehicles); shelters to shield passengers from the effect of weather and rain; building structures and accommodation (terminals, lounge); hard & soft landscape; street furniture and lighting.

Trading Space – composed of formal (dedicated sheltered and lock-up space with flexibility in layout e.g., ticketing booth and retail outlets); informal trading (in relation to main pedestrian flow and public spaces); refuse storage (to keep the surrounding neat) and information trading accommodated in relation to main pedestrian flow (for making enquiries) and public spaces.

Signage – this comprises of information and communication facilities like travel information (arrival / departure time, locations of terminals, fares) zebra crossing (for the less privileged, old people and kids).

Management – this entails the management of the interchange to reduce running cost (installation of solar powered station); CCTV camera, surveillance point (to monitor operations within and around the interchange); rank marshal / disaster control; maintenance of service modes to enhance quality of journey and refuse storage and collection.

2.2.2 Circulation in Bus –Train Interchange

Circulation has been defined on a different note by different disciplines but from the Architecture point of view, it is defined as the safe and comfortable movement of goods and people of all ages and abilities within and around a building (Dima & Lawson, 2021) which include various infrastructure that supports the operation of different modes of transport system. Yang (2017) explains circulation to mean the way spaces and buildings are arranged to ensure that people can move easily in and around the building throughout the period of time. Achieving effective circulation as stated in Richmond General Plan 2030 involves supporting infrastructure for various modes of travel to connect people to their places of interest in a safe and efficient manner.

In a general view for better understanding, it was further stated (Yang, 2017) that circulation is divided into different components that has inter-related functions depending on the type of project. This according to him might include (i) the direction of movement which could be horizontal or vertical (ii) the type of use of the space which can be either public, private or location oriented (iii) frequency of use that could either be for emergency or common use and finally (iv) time of use which may be in the morning, daytime, evening etc. Deductions made from past literature (Dima & Lawson, 2021; Yang, 2017) shows that direction of movement and use of space are crucial and can be achieved with the use of elements like lobbies, corridors, passage ways, stairs, ramps, elevators and of course internal doors.

Ibifuro & Pepple (2021) in their study reveals that circulation within a public interchange can be zoned under different factors depending on the type of user and their personal interest.

Access / Egress Zone -: provides for facilities and services for users boarding and alighting at the interchanges e.g., shelters, motorised transport, pedestrians, rails, cyclist, crosswalk,

traffic control measures, technologies for assistive movement, wayfinding, information and security for all parked vehicles.

Transfer / Transport Zone -: involves the integration of good design and technology for easy accessibility and communication for transfer between different available modes. This includes signage and posters placed at strategic areas, up-to-date travel information, waiting rooms as well as lock-up shelters with cctv for security purposes.

Facilities and Retail Zones -: are leisure areas within the interchange where users engage in different activities to enjoy the quality of their time while waiting to transfer. It consists of places like commercial areas, food courts, toileting, ticketing facilities and public spaces.

2.2.3 Ease of Movement in Public Buildings

Deduction from previous research works (Al – Taesh & Ujma – Wasowicz, 2021; Byahut *et al.* 2005) shows that when there is a barrier in building, there is limitation in mobility as spaces get obstructed and therefore becomes unsafe and uncomfortable to use. Keenthirathna *et al.* (2010), maintained that easy movement requires set of dignified and independent services that will be accessible by all users while revealing barriers that debars easy movement in public buildings. He further highlighted major barriers to include building elements like thresholds, stairs, doors and openings, curbs, narrow passages, entrance and exit ways. Others are toilets and sanitary accesses, car parking, lifts, ramps, sidewalk gratings, signs and traffic signals.

However, while expatiating the discussion on challenges experienced by users in the process of moving within and outside of public buildings, Voce (2017) mentioned the fact that it is not only persons with disabilities that faces barriers in building, everybody does; and it depend on one's age, gender and physical status. This, as explained by Byahut *et al.* (2005) includes the children, aged people, pregnant women and people on wheelchairs. Also

included are people with limited walking ability, those that are temporary disable as well as people with visual or hearing impairment (Littlefield, 2011).

2.2.4 Design Strategies for Achieving Ease of Movement in Public Buildings

Keerthirathna *et al.* (2010); Lontsi & Wandjie (2022), opined that public buildings will remain safe and comfortable if every user can easily locate their ways and are able to understand the use of different types of facilities provided. Adedayo, *et al.* (2013), carried out a survey on five (5) major types of public buildings [Banks, Government Secretariat, Hotels, Commercial and Institutions] in Abuja, Minna, Kaduna and Calabar to analyze users' perception in relation to ease of movement. In all, only 17% of users rated ease of movement in buildings to be good. The bank rating was good because the open plan design allows for free movement of both staff and visitors. Contrary to that, ratings at the commercial and Government buildings were poor because the size of lobbies and corridors provided were not adequate to sustain the number of users of the building.

In the survey carried out by Al-Bathali *et al*., (2019), ease of movement in public buildings was measured by five parameters given as ramps, entrances, elevators, parking and routes with Avenue Cinema as the most accessible (78.12%) and Dickson's House the least accessible (12.5%). Entrances were obstructed with barriers like steps, ramps with inadequate slopes, high thresholds and uneven floor surfaces. Only Avenue cinema had fully accessible elevators while the ones provided at Hawalli Park and Al – Babtain Library were small and cannot allow for the full turning of wheel chair users. The public centres that provided parking for the disabled were not up to standard regarding the cut, curb and clear signs while others did not make provision for it at all. In Nigeria, the level of compliance with accessibility requirements for w/c routes were observed to be 40% for hospitals, 22% for educational institution, 18.2% for social recreation facilities and 14% for government agencies.

Abu Tariah *et al.,* (2018) carried out a survey on fifteen (15) different mosques with forty-eight (48) male wheelchair users in participation. Result from the survey shows that majority of the wheelchair users avoided praying in the mosque as 84% of them needed assistance to get to and inside the mosque due to distance of the mosque to their various locations and the presence of steps at the entrances while 59% confirmed that they can move freely inside the mosque. 67% of people said wheelchair users were not considered in the design of bathrooms, 69%, 70%, 42%, 31% and 27% of people strongly disagree on accessibility to the ablution area, sinks, exit and entrance areas, door handles and shoe racks respectively while 42% said accessible parking provided did not accommodate the disabled as they were being crowded.

Hamzat & Dada (2005), carried out survey on thirty-eight (38) public buildings in Ibadan where observation shows that out of all the buildings, only 20% (6.7% of the educational buildings, 14.3% of government buildings and 0% of recreational buildings) were accessible by people on wheel chair. The educational and recreational buildings had several entrances to cater for the number of users but the path or routes leading to these entrances were not accessible by wheelchair user regarding the width of route, threshold, grade of ramp and door width. The ground floor of majority of the educational buildings were accessible but other floors were not, as only one of the buildings had escalator to connect to other level.

Keerthirathna *et al.* (2010) in their own survey carried out in Colombo Metropolitan area where analysis shows that sufficient facilities were provided for easy movement in hospitals. 20% out of the 40% that provided for ramp in banks do not install hand rails according to requirement while only 20% out of the 90% that provided for lift installed the correct type required in terms of internal space dimension; only 20% had their doors opened outwards while 60% of the school buildings have threshold at entrance higher than 15mm.

Deductions from all the survey carried out shows that ease of movement is achieved using various parameter like signage for space identification, height of threshold, height of step, width of door, width of route, height of ramp its gradient and slope. Others are direction of door opening, size of lift, length of route, design concept, available access points and grab handrails.

2.3 Design Consideration for a Bus - Train Interchange

Having analysed the components and circulation within a public interchange from previous literatures (Ibifuro & Pepple 2021; Dima & Lawson 2021; Heddebaut & Di Ciommo, 2018; Tsami, *et al.*, 2018), and ease of movement in public buildings, it has become a necessity to refer to the primary attributes required for effective planning of an interchange which goes beyond the provision of requisite facilities. These attributes as highlighted in previous literature, aid in enhancing users 'experience, efficiency and attractiveness to the interchange. Turnbull (2013) in his study, highlighted eight key features to include visibility, way-finding, shelter, security and accessibility. Others are service information, facilities and operation.

As observed by Gandhi, Ganguly, Varma, Khandelwal, Kalsi & Bansal (2015), effective quality may not be achieved in interchanges if all the key attributes discussed below are not exhibited and followed up with good maintenance culture.

Visibility – treating the interchange and its surrounding land uses as a single public space requires efficient sighting for both the users and the buses (Lamiquiz Dauden *et al.*, 2014). This according to Turnbull (2013), can be achieved with the use of transparent materials, good lighting and appropriate siting of facilities. In furtherance, this will ensure easy access, provide safety and make the interchange easier to use.

Figure 2.16: Proper vision for bus and users
Source: (www.tandfonline.com).

Figure 2.17: See-through Building Components.
Source: (www.tandfonline.com).

Wayfinding – ensures users move efficiently to / from and within the interchange without encountering any difficulty. It helps visitors find local attractions within the interchange, directs vehicular route through-traffic onto appropriate roadways and from hazardous obstacles (Jacobs, 2012). It is considered by Turnbull (2013) to affect passengers decision making and also guarantees safety and security of the journey. This is achievable with the use of paint markings on footpath, clearly shown directional information with visible maps and sign posts.

Figure 2.18: Zebra crossing for traffic direction.
Source: (www.at.govt.nz).

Figure 2.19: Map pasted for customers use
Source: (www.at.govt.nz).

Shelter – protects passenger from wind, rain and weather, ensures safety of passenger by phasing off isolated areas and serves as a noise barrier. It was further highlighted with the goal of improving comfort and providing vital information for most passenger. It can

significantly improve the perception of wait-time and riders' satisfaction by giving the interchange a physical presence and by calling attention to the quality of service available.

Figure 2.20: Covered Passenger Loading users

Source: (www.alamy.com).

Figure 2.21: Facade Element as shade for

Source: (www.nacto.org).

Security – the interchange services provide physical security for users, drivers, staff, vehicles, all transport modes and the public in general. Consideration for security is initiated in the design in relation to the type of maintenance required of the interchange physical assets. Potentially hazardous situations are being monitored and control with the layout of the interchange by avoiding isolated spaces, proper lighting of the spaces and use of surveillance equipment like CCTV cameras.

Figure 2.22: CCTV Camera Installed at the Loading-bay

Source: (www.at.govt.nz).

Figure 2.23: Security Personnel Monitoring passengers

Source: (www.nature.com/article).

Accessibility – this does not only describe the ease of movement to preferred destination of interest (Litman, 2022) but also the connectivity within the interchange and to other forms of

land use. It also refers to people's ability to use services and opportunities. It has to do with the layout of the interchange, need for unobstructed clear routes, provision of pedestrian desire lines and integration with surrounding land uses.

Figure 2.24: Defined Pedestrian Access
Source: (www.google.com).

Figure 2.25: Easy use of Services and links spaces.
Source: (www.at.govt.nz).

Service Information – it is similar to wayfinding but is concerned mainly about the type, place, time and quality of information that a customer might need to complete the journey. This involves uninterrupted network, travel schedule and fare information.

2.26: Provision of Quality Service Information for Customers Need
Source: www.google.com. / www.at.govt.ng.

Facilities – provision of facilities surrounding the interchange add value to its environment by engaging users through their waiting time. These facilities are sometimes required by the building codes where the type, number and location for its provision are specified. It includes seating, toilets, commercial places, ticketing booths, café room etc.

Figure 2.27: Information Point.
Source: (www.tandfonline.com).

Figure 2.28: Toilet Facilities for customer's comfort.
Source: (www.at.govt.ng).

Figure 2.29: Sitting Facilities for Customers.
Source: ((www.myguideauckland.com).

Operations – focuses on the safe, efficient and future working condition of both the bus driver and the physical requirements of the bus. Consists of good length platforms on either side of the interchange with numbers and clearly demarcated from edge and roadways. Pedestrian crossing points are also marked out clearly to ensure easy movement of buses.

Figure 2.30: Covered Bus-bay
Source: (www.google.com).

Figure 2.31: Clearly defined roadways and platform
Source: (www.alamy.com).

Chapter Three

Methodology

Case study approach was adopted as the methodology used to acquire detailed information and description about the project in a bid to achieve the set objectives of the study. With regards to this, five existing similar cases comprising of two local and three international interchanges were studied and analyzed looking into the historical background of the project, material used, the conceptual formation, peculiar features and the main spaces provided for in the designs. Physical observation and photographs were used to capture and record findings using descriptive approach.

3.1 Case Study 1: Modern Bus Terminal, Ojoo, Ibadan

3.1.1 Brief History

Ojoo Terminal known as Terminal 4 is one of the two modern bus terminals in Ibadan city that the construction had been completed by Planet Projects Limited and was commissioned on the 27th April, 2022 while the remaining two are still under construction. The project was

established on 15th may, 2020 with the mindset to effect changes in the transport sector. This is expected to ease the pressure of transportation system on residents of the city and also to generate income.

3.1.2 General Layout of the Building

The bus terminal which is located along Moniya – Ojoo axes of Ibadan in Akinyele Local Government area, is mainly run for inter- state transport service connecting the city to the Northern parts of the country. The layout plan of the site is strategically sectioned to compose of the Loading Bay, Terminal building, Parking area, other Ancillary buildings and landscaped areas all bounded with perimeter fence. The terminal building is a structure of five floors with the surveillance tower at the last floor.

3.1.3 Circulation Pattern

Circulation in the ultra-modern bus terminal is through two major roads; Iwo Road – Oyo new express road and Ojoo – Moniya Road (old Oyo Road). Separate access is provided for the two accesses to allow both vehicles and pedestrians. The site challenge experienced at the site is the existing central canal that runs along the south-eastern part of the site to the south-west area.

Figure 3.1: Site layout plan of the Modern Bus Terminal at Ojoo in Ibadan.

Source: www.twitter.com/FeedbackOYSG/status.

3.1.4 Zoning / Facilities

The master plan of the Terminal is divided into three zones composing of (i) Access / Egress zone where facilities and services were provided to accommodate different users arriving and departing the bus terminal. It includes the canteen, shelter, buses, lift, pedestrian walkways and perimeter fence; (ii) Transport / Transfer zone which has to do with the integration of good design and technology to ensure seamless transfer of users between the different available buses. It comprises of the waiting hall, parking spaces, loading bay, watch tower, landscaped areas, signages as well as travel information desk and (iii) Facilities and Retail services which serves as a leisure area within the terminal where users have more time to spend while waiting. It consists of the automated teller machine gallery, ticketing area, passenger relaxation area, bar, restaurant, clinic, public toilet, auto workshop and water treatment tank.

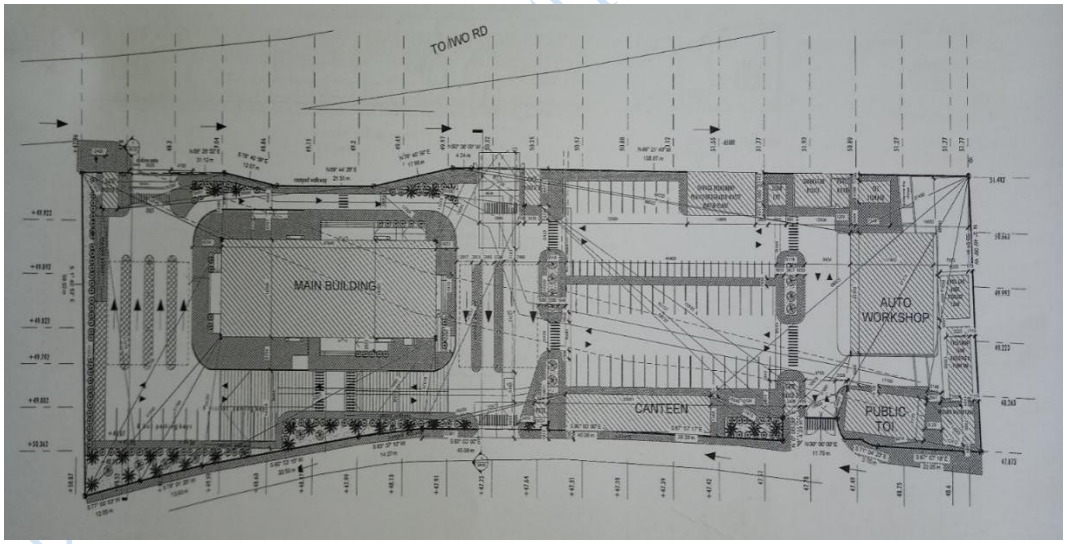


Figure 3.2: Site plan of the Modern Bus Terminal at Ojoo in Ibadan.
Source: Oyo State Ministry of Public Works & Transport, Ibadan

3.1.5 Conceptual formation

The building is ultimately a box with a longer length portraying the physical view of a transit bus. The roof is curved towards the end of both front and back view and adorned with aluco-

bond material supported with steel poles at both sides which runs through from the ground to the last floor.

Figure 3.3: View of the Modern Bus Terminal at Ojoo in Ibadan.
Source: www.pmnewsnigeria.com.

3.1.6 Peculiar Element / Feature

As mentioned above the peculiar element is the watchtower at the top of the building from where the whole surrounding of the terminal can be viewed for security purposes.

3.1.7 Material Used

The major building materials used for the construction of the bus terminal are sandcrete blocks, reinforced concrete, steel, glass, aluminum and aluco-board.

3.1.8 Merits

- The terminal is easily accessible to users through two major roads.
- There is adequate provision for circulation, both within the structure and around the building
- There is provision for watchtower as surveillance for security reasons.
- There is adequate natural lighting and ventilation within the bus terminal.

- The provision of lifts, staircases and walkways facilitates efficient movement within and outside the terminal.
- There is provision for water treatment tank and public toilet for users.
- There is provision for good drainage system

3.1.9 Demerits

- The parking spaces provided is not enough considering the number of buses using the terminal as buses still park along the road to carry passengers.
- There is no way signages outside the terminal building to direct traffic flow.

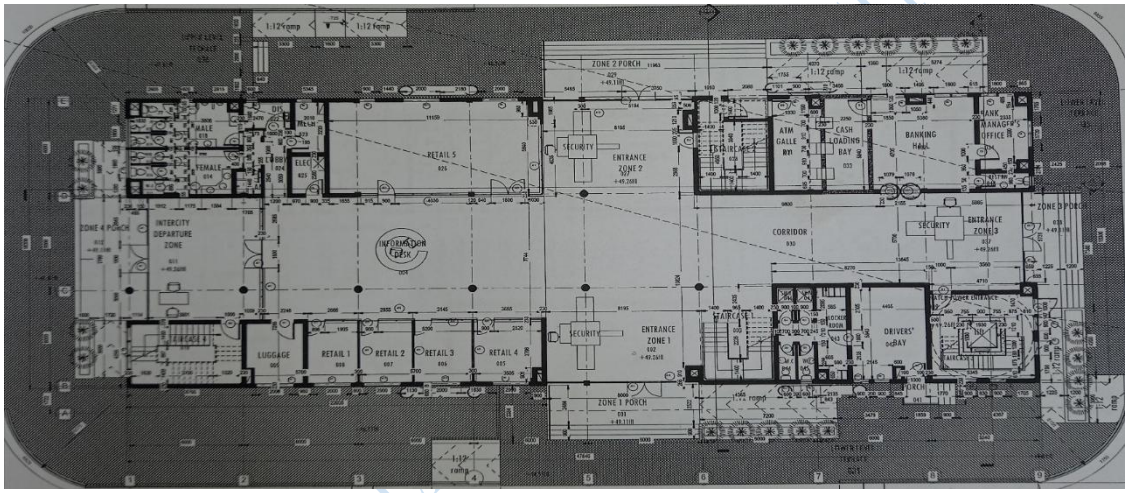


Figure 3.4: Ground Floor plan of the Modern Bus Terminal at Ojoo in Ibadan.
Source: Oyo State Ministry of Public Work & Transport, Ibadan.

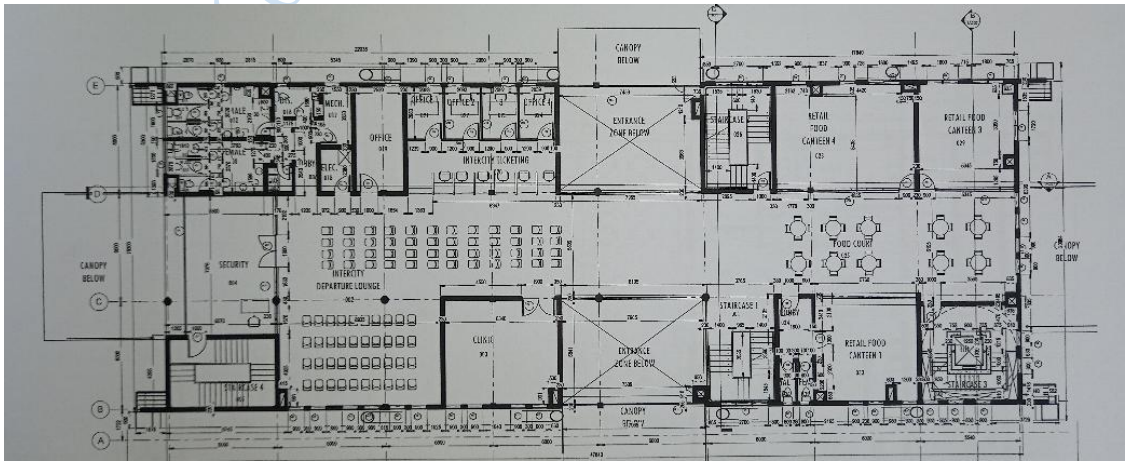


Figure 3.5: First Floor plan of the Modern Bus Terminal at Ojoo in Ibadan.
Source: Oyo State Ministry of Public Works & Transport.

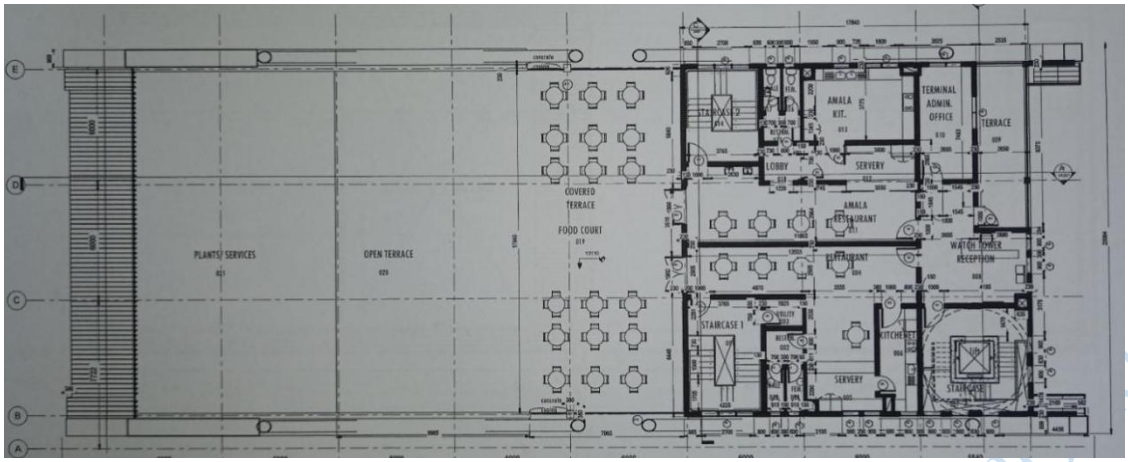


Figure 3.6: Second Floor plan of the Modern Bus Terminal at Ojoo in Ibadan.
Source: Oyo State Ministry of Public Works & Transport.

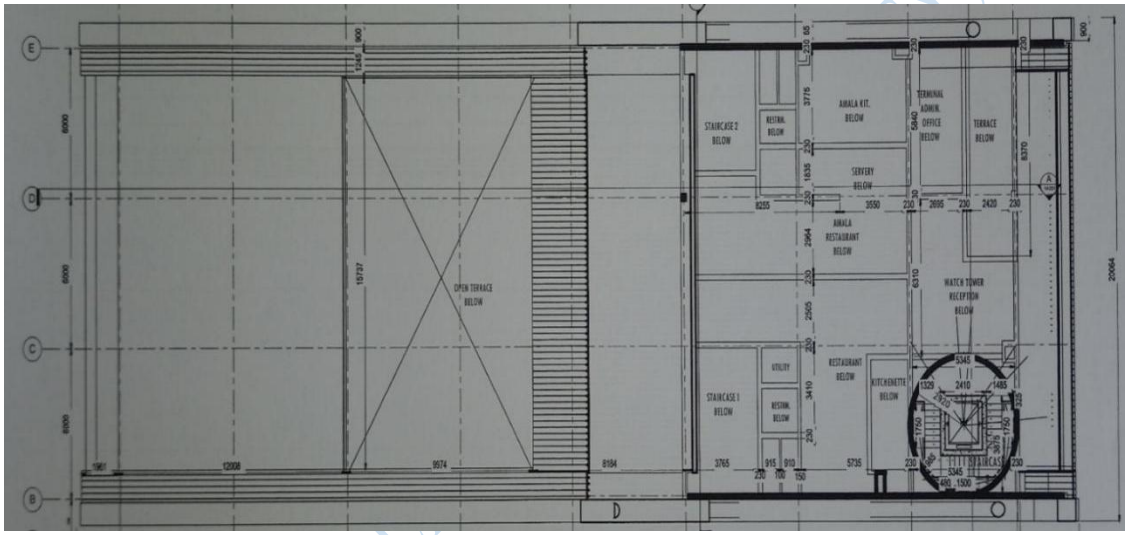


Figure 3.7: Third Floor plan of the Modern Bus Terminal at Ojoo in Ibadan.
Source: Oyo State Ministry of Public Works & Transport.

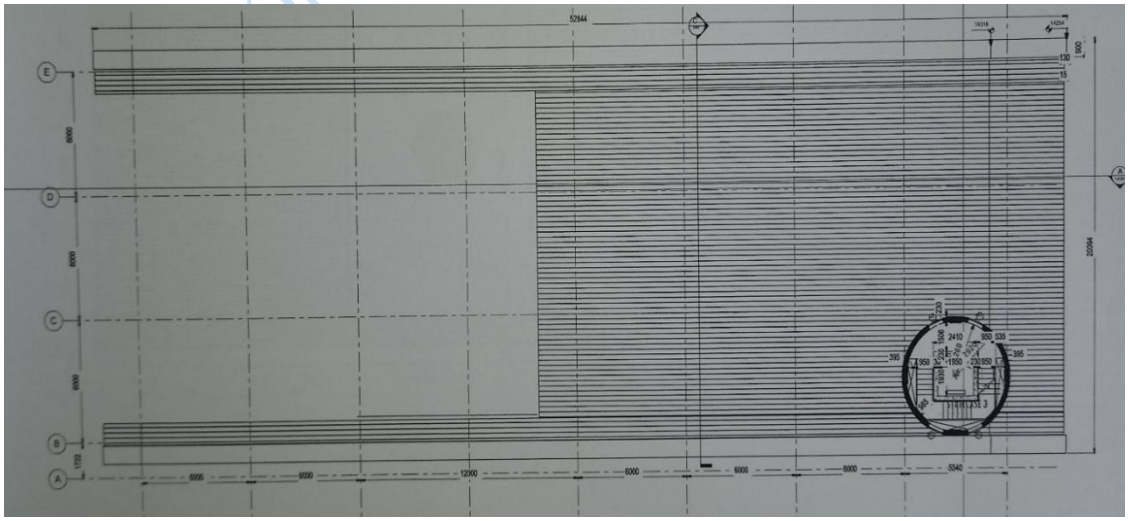


Figure 3.8: Fourth Floor plan of the Modern Bus Terminal at Ojoo in Ibadan.
Source: Oyo State Ministry of Public Works & Transport.

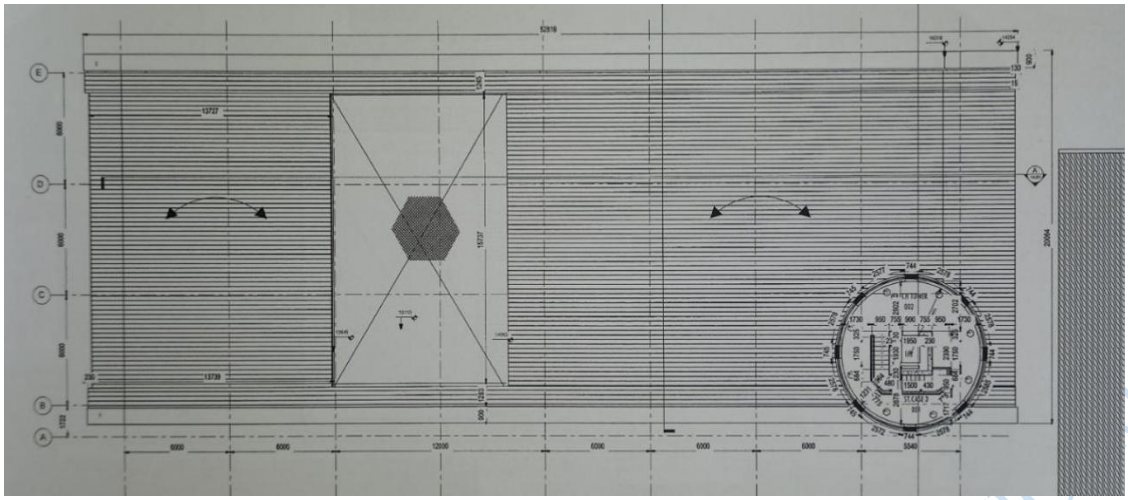


Figure 3.9: Fifth Floor plan of the Modern Bus Terminal at Ojoo in Ibadan.
Source: Oyo State Ministry of Public Works & Transport.

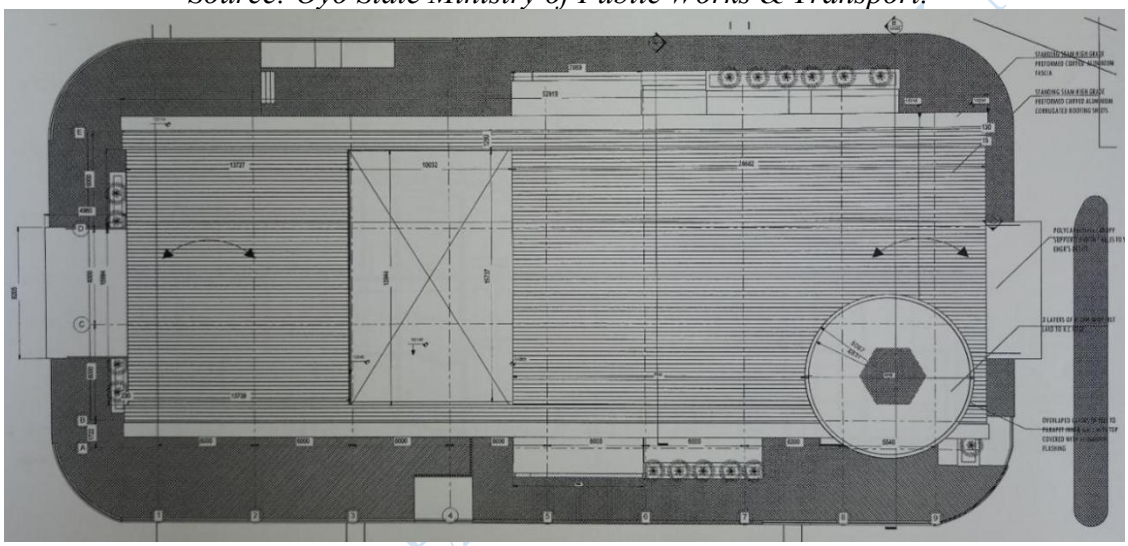


Figure 3.10: Roof plan of the Modern Bus Terminal at Ojoo in Ibadan.
Source: Oyo State Ministry of Public Works & Transport.

Figure 3.11: Customers' waiting Area
Source: www.feedbackoyosg.com.

Figure 3.12: Ticketing booth
Source: www.feedbackoyosg.com.

Figure 3.13: Natural lighting with good vision
Source: www.feedbackoyosg.com.

Figure 3.14: Passengers' Lounge.
Source: www.feedbackoyosg.com.

3.2 Case Study 2: Oshodi Transport Interchange, Lagos.

3.2.1 Brief History

Oshodi is arguably the busiest transport hub in Nigeria with over 5,600 buses loading per day, spreading across13 different motor parks. It attracts over 200,000 passengers boarding per day, about 1 million pedestrians, and 76 percent of its area dedicated to transport and related activities.

The Oshodi transport interchange is a world-class bus terminal, the biggest in Nigeria and West Africa. The multi-storey facility featuring three separate terminals linked by skywalk bridge was constructed by Planet Projects Limited and was commissioned on the 24th of April, 2019. The interchange seeks to create a world-class central business district for road transportation in Lagos State.

3.2.2 General Layout of the Building

The interchange is located in between the Lagos Apapa expressway on one side and the Agege motor park road on the other side. in Oshodi, Lagos State. The interchange involves three number prototype of bus terminal of three floors with a multi-level bus park which can conveniently accommodate over 820 mass transit buses. Terminal 1 which runs an interstate transportation covers twenty-one different routes to include all the south-west states, southern

states, northern states and the federal capital territory Abuja. Terminal 2 is for intercity transportation (Ikeja, Abule – Egba, Egbeda) while the Terminal 3 is meant to run intracity transportation (Mile 2 / Festac, Iyana Isolo / Jakande, Ojodu / Berger, Ojota / Ketu / Mile 12, Tincan, Apapa Wharf etc).

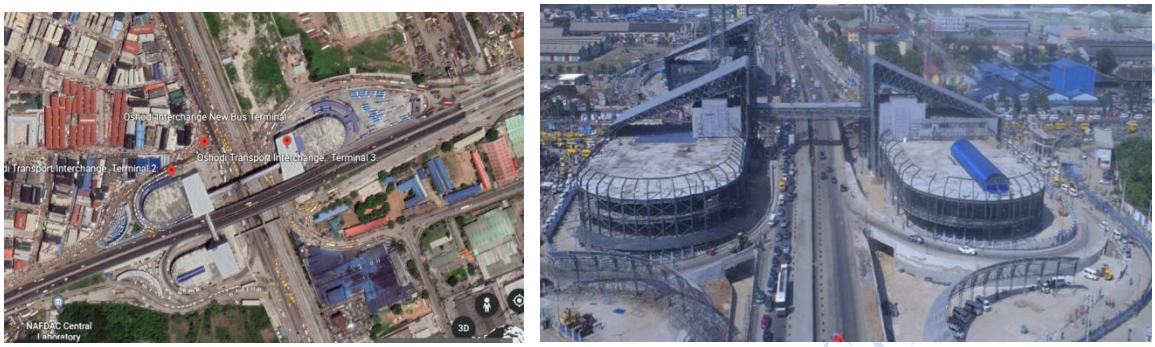


Figure 3.15: Layout of Oshodi Transport Interchange, Lagos.
Source: www.theguardian.ng.

3.2.3 Conceptual formation

The concept of the Oshodi regeneration plan is centred on factors of tourism and transport district with focus on transformation, security, environmental regeneration and urban renewal. The intention is to make Lagos function like other megacities in the developed world.

3.2.4 Facilities

There quite a number of facilities provided at the interchange include waiting halls, ticketing booths, retail outlets, loading bays, automated teller machine points, multi-level car parks, restaurants, conveniences, lifts, escalators, drivers' lounge, offices and skywalk bridges.

3.2.5 Peculiar Element / Feature

The peculiar element is the Pedestrian bridges or skywalks; the longest free-standing bridge in Nigeria which link the three terminals. The triangular steel trusses suspended over the terminal buildings also serves as protection for the reinforced concrete roof slab.

Figure 3.16: Terminals at Oshodi Interchange, Lagos
Source: www.theguardian.ng.

3.2.6 Material Used and Construction Technology

The main construction material used are majorly steel and glass, with some use of reinforced concrete for columns and cladding finishes. The walls were covered with glass cladding.

Steel is used for the construction of the roof while glazing was extensively used on the building especially at the approach to the terminal. Connectivity of the interchange includes twenty (20) lifts and escalators.

Figure 3.17: Skywalk bridge at Oshodi Interchange
Source: www.travelwaka.com.

3.2.7 Merits

- The facade is appreciably pleasing

- Spaces within the site is properly managed with the introduction of multi-level car park.
- The design is well harmonized with the topography of the site
- Stairs, lifts and escalators are properly located to facilitate easy access and circulation within and around the building.
- The use of transparent materials ensures adequate natural lighting and ventilation.
- Adequate information is provided to cater for customers' needs.
- The interchange is equipped with security personnel with cctv cameras installed in strategic areas.

3.2.8 Demerits

- The parks were overcrowded leading to scattered intra and inter-city bus parking which has led to on-street loading and offloading of passengers.

Figure 3.18: Ticketing booth
Source: www.planetprojectltd.com.

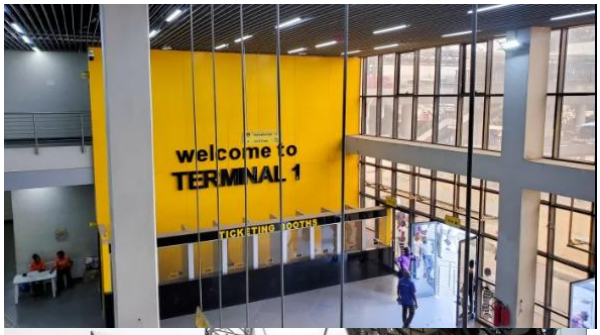


Figure 3.19: Glass material used to enhance visibility *Figure 3.20: Bus loading*
Source: www.planetprojectltd.com. *Source: www.travelwaka.com*

Figure 3.21: Exterior view of the interchange
Source: www.autoreportng.com.

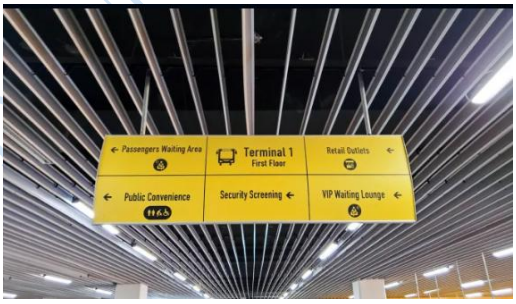
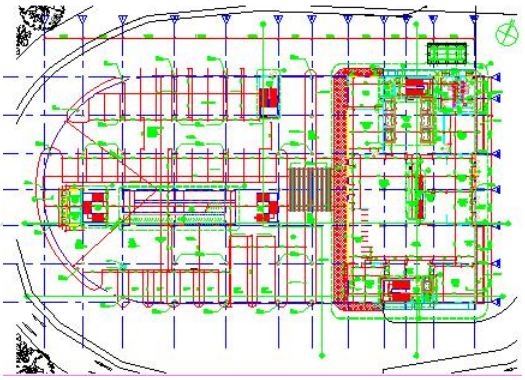
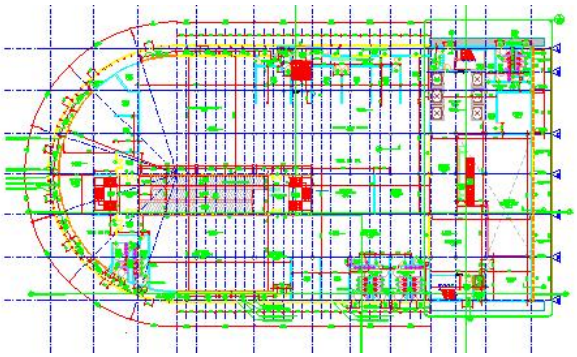


Figure 3.22: Signage for customers' information
Source: www.planetprojectltd.com.





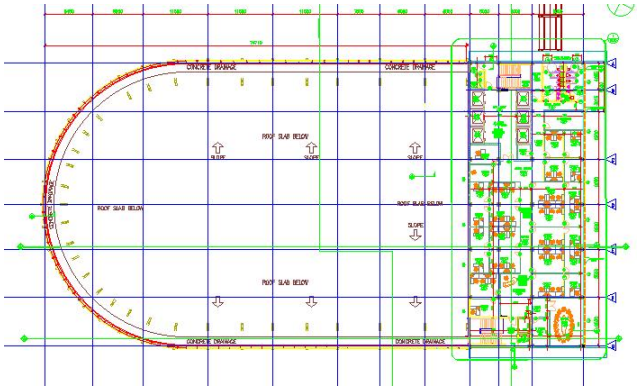


Figure 3.23: Floor Plans of Oshodi Interchange
Source: Lagos State Ministry of Works

3.3 Case Study 3: Metro Station, Beijing, China.

3.3.1 Brief History

The multi-modal facility is one of the new high-speed rails implemented within China as an upgrading and extension project of Beijing South Railway Station. It was designed by TFP Farrell Architects and completed in 2008 with the view to create an urban link with the surrounding cityscape and also acts as a Gateway to the City. The metro station is located about half a kilometre away from the city's old station in Fengtai district between the second and third ring roads. Integrated in the design is a vertical separation strategy to allow for direct flow of passengers in a convenient and efficient manner. The Metro Station connects the Yangtze River Delta cities of Tianjin and Shanghai with a catchment area of two hundred and seventy million people.

3.3.2 Design Concept and Form

The station takes a simple ellipse form in the shape of a saucer. It comprises of three principal floor levels with mezzanine floors for car parking with two ancillary office buildings. The arrival and departure areas were separated to allow passengers board and alight at the shortest distance and time possible.

Figure 3.24: Arial view of Metro Station, Beijing
Source: www.pinterest.com.

Figure 3.25: Design concept of Metro Station, Beijing
Source: www.archydaily.com.

3.3.3 Zoning / Facilities

The station is divided into separate zones to cater for seamless integration and transition to different types of vehicular traffic. This includes (i) nine hundred and nine underground basement carpark (ii) twenty-eight taxi drop off bays (iii) twenty-four taxi pick up bays with one hundred and thirty-eight queuing spaces and (iv) thirty-eight bus spaces. The new metro station comprises of 450 metres long High-speed trains with a total number of eleven (11) island platforms, two (2) side platforms with twenty-four (24) edges; 500 metres long Express train; 450 metres long intercity trains and 120 metres long Metro trains of two (2) platforms with four (4) platform edges.

3.3.4 Material Used and Construction Technology

The major material used for the construction of the metro station is mainly steel and aluminum which was designed to incorporate separate zones for different types of vehicular traffic. Its location on the existing railway station with overhead road network and landscaped pedestrian spine maximizes the sense of approach and creates enhanced public space. The overhead road network decongests the surrounding urban arterial roads by adjusting to traffic flows coming from all directions into and from the station.

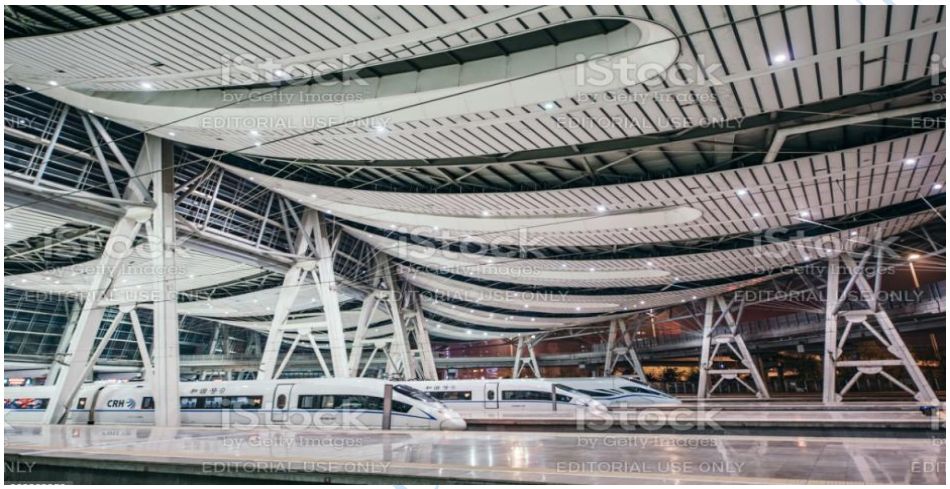


Figure 3.26: Interior of the station showing the type of ceiling material
Source: www.archydaily.com.

3.3.5 Merits

- The transparent roof material allows for efficient lighting at the waiting hall.
- The headroom within the facility is appreciable enough to give a clear sight of services and operations.
- The separated arrival and departure allow for easy and efficient movement within and around the metro station.
- Provision of different vehicular zones and vertical separation of modes allows for safe and effective operation and management within and around the facility.

3.3.6 Demerits

- Requires extra efforts to lower the building temperature at the basement area.

Figure 3.27: Road network around Metro station, Beijing, China
Source: www.archydaily.com.

Figure 3.28: Waiting area for customers
Source: www.modlar.com.

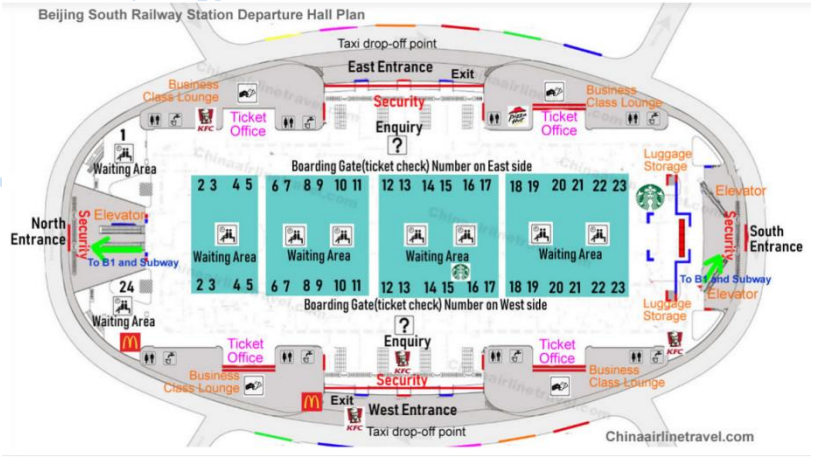


Figure 3.29: Departure Hall Plan of Metro Station, Beijing, China
Source: www.chinaailinetravel.com.

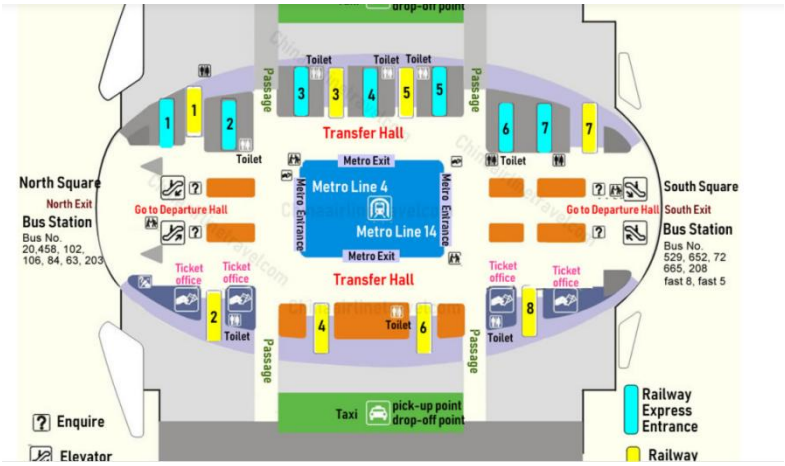


Figure 3.30: Transfer Hall Plan of Metro Station, Beijing, China
Source: www.chinaailinetravel.com.

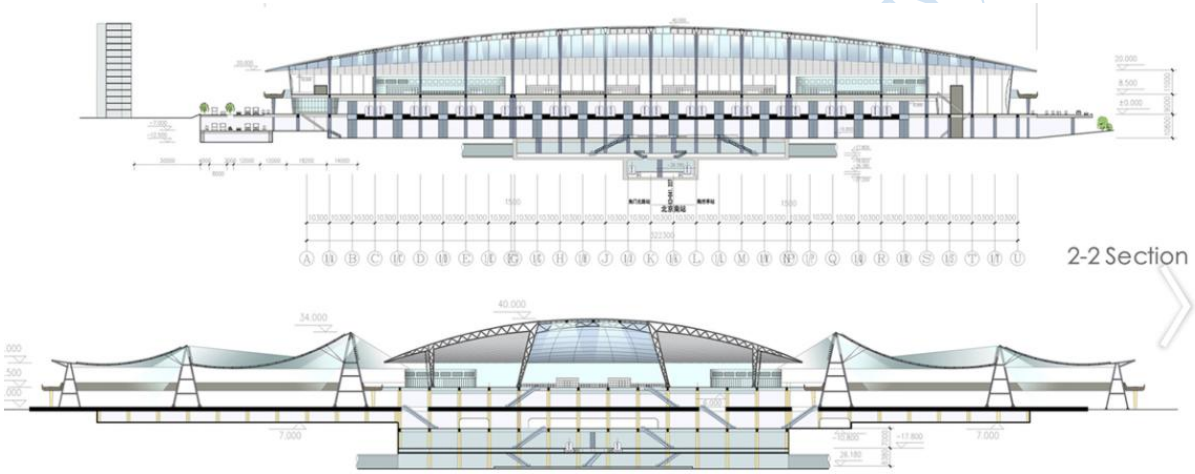


Figure 3.31: Sections through the metro station, Beijing, China
Source: www.archydaily.com.

Figure 3.32: View of the Metro Station, Beijing
Source: www.archydaily.com.

3.4 Case Study 4: Manukau Bus Interchange, Auckland, New Zealand

3.4.1 Brief History

The bus interchange is one of the newest transit stations that runs between bus and train services. It was proposed in 2015 as part of the implementation of the new bus network for South Auckland as a transport hub with the adjacent railway station. Designed by Beca and Cox Architects, its construction commenced in February 2016, completed in 2017 and commissioned on 7th April, 2018. The objective is to allow easy transfer of bus passengers to train services with a refreshing change for public transport attracting users to embark on public transport to the city. The local and regional bus station can accommodate up to fifteen different bus routes and is connected to other adjoining and nearby spaces like the retail, commercial and civic areas (www.nzstrong.co.nz).

Figure 3.33: Layout plan of Manukau Bus Interchange
Source: www.archydaily.com.

3.4.2 General Layout of the Building

The bright and airy bus – train interchange is located across the road opposite Manukau train station with twenty-three bus bays of which twenty-one are sheltered with 12m cantilever sawtooth roof that allows for future changes and extra capacity in bus types. The repeating 'kite' roof encloses a large and open central concourse area that relates effectively with the bus operation area both visually and physically.

3.4.3 Design Concept and Form

The building form is that of a cultural instinct that reflects a "tukutuku manu" otherwise termed as flying kite representation of the roof which is gotten from the heritage of the area. The design concept is based on sustainability as it embraces the environmental, social, cultural and economic value of the area (www.coxarchitecture.com.au).

Figure 3.34: Kite like roof structure of Manukau Bus Interchange
Source: www.coxarchitecture.com.au.

3.4.4 Material Used and Construction Technology

The major materials used for the construction of the interchange are timber, steel and glass. The tapered sheet roof system which allows water to flow efficiently, has clearstory glazing that helps to maximize the natural lighting and fresh air within the main concourse while the high central zone drives the natural ventilation system. The sawtooth bays were used to maximise space by avoiding additional layover facilities for buses. It also creates a sort of shelter around the building for users. The use of automated louvre with the front view of the building facing north-eastwards helps to capture direct sunlight. Energy saving fixtures and fittings were also used in the building to reduce the amount of energy expended while water from sinks were collected using grey water system and recycled back into the building for toilet flushing (www.greaterauckland.org.nz).

Figure 3.35: Automated louvre used to capture direct sunlight
Source: www.greaterauckland.org.nz.

Figure 3.36: Clearstory glazing for natural lighting and fresh air
Source: www.greaterauckland.org.nz

3.4.5 Facilities

The major spaces provided in the facility are Atrium, Entrance concourse, Café, Retail, Ticketing, Theatre, Bicycle Parking, Rail Trench, Lifts, Escalators, Service yard, Medical Centre, Offices, Staff Room, Flexible office spaces and amenities.

Figure 3.37: Escalator for transfer of people
Source: www.archydaily.com.

3.4.6 Merits

- Effective use of space in the interchange design.
- The building is sustainable considering the materials used and technology adopted.
- There is adequate lighting and natural ventilation.
- There is flexibility in space arrangement within the building.
- The sloping nature of the site is well 'manipulated to properly suit building design structure and function.

3.4.7 Demerits

- The sawtooth design though, allows inflow of many buses as it can possibly take it tends to create a complex maneuvering of buses coming in and going out of the interchange.
- The two bus bays located outside of the interchange design does not integrate well with other facilities as they seem isolated.
- The non-provision of layover within the interchange causes quick turnaround of buses thereby reducing their waiting time. This will not allow passengers have a feel of the facility as they just pass through on their journey.

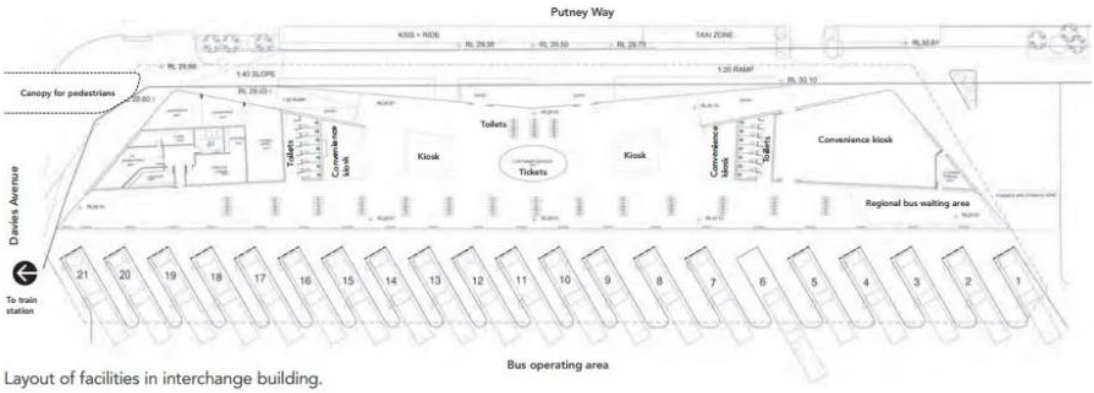


Figure 3.38: Bus parking layout of Manukau Bus Interchange
Source: www.greaterauckland.org.nz

Figure 3.39: Pedestrian and vehicular access at Manukau Bus Interchange
Source: www.greaterauckland.org.nz

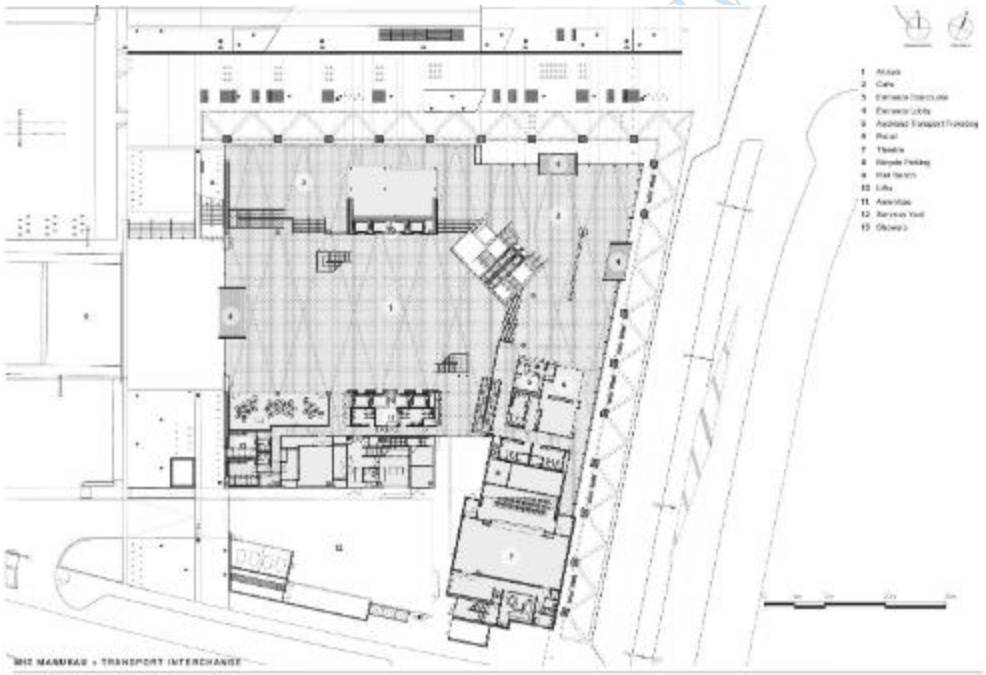


Figure 3.40: Plan of Manukau Bus interchange
Source: www.archydaily.com.

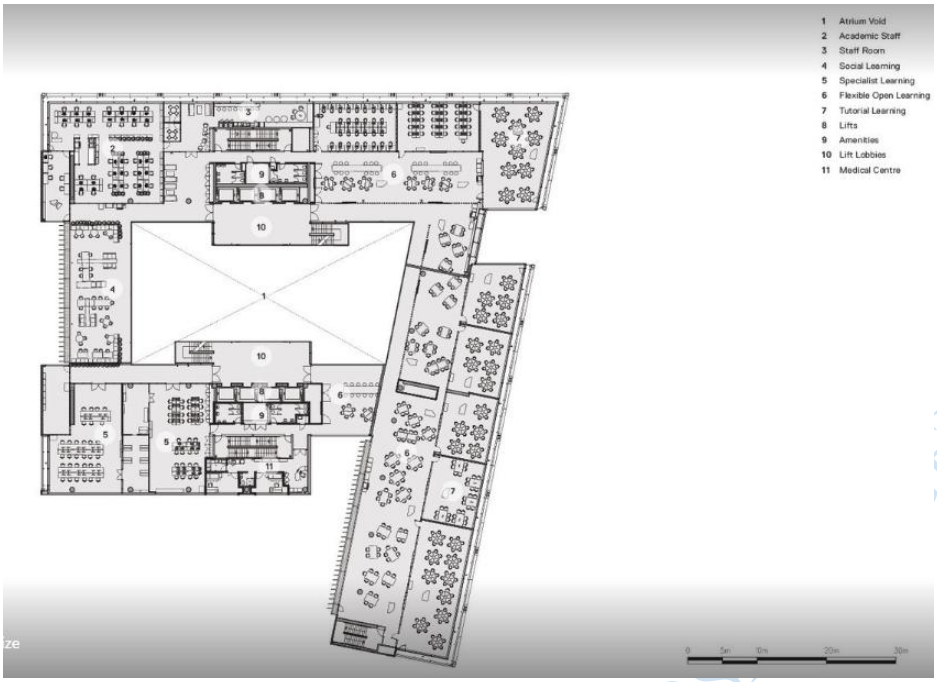


Figure 3.41: Upper floor plan of Manukau Bus interchange
Source: www.archydaily.com.

Figure 3.42: Arial view of Manukau Bus Interchange
Source: www.kingspan.com.

3.5 Case Study 5: Christ Church Bus Station / Interchange, New Zealand.

3.5.1 Brief History

The earthquake incident that happened in Christchurch in the year 2011 damaged the bus exchange facility and led to its demolition. A bus interchange was then proposed as one of the seventeen anchor projects for the central city's earthquake recovery plan to help define

the rebuilt the city's identity and public space. In order to bring the recovery plan to realization, Miller's Departmental Store – the head office of Christchurch city council and a notable building was demolished. The diesel fuel type interchange which integrates buses, intercity coaches, taxis and cyclist in anticipation for future light rail was designed by Architectus and constructed in 2015 by Southbase Thiess JV (https://.architecturenow.co.nz).

3.5.2 General Layout of the Building

The interchange is an L- shaped facility of one floor for possible development. The concourse faces both the Colombo and Lichfield Streets with sixteen bus bays arranged in a crescent shape on the interior of the site and an open space at the opposite direction for future development.

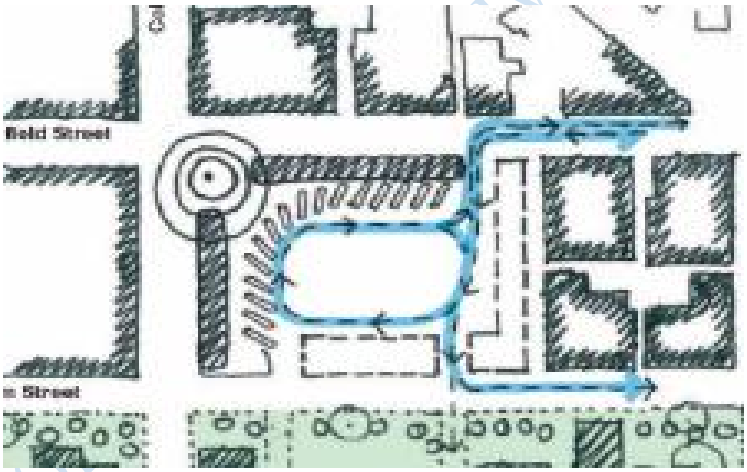


Figure 3.43: Layout of Christ Church Bus Station
Source: www.architectus.co.nz.

3.5.3 Design Concept and Form

The interchange is endowed with four timber pods underneath the main roof and this directs passenger flow, amenity, retail and food outlets. Integrated into the building fabric is the cultural expression based on themes of early Maori navigation which was influenced by the Neo-gothic Architecture and brick buildings. This has created a local urban and cultural

comfort zone for passengers and effective bus operations by upgrading the transportation sector to a modern one (www.archydaily.com).

3.5.4 Material Used and Construction Technology

The major materials used for the construction of the interchange are solid timer, concrete and glass. The folded roof geometry with its gables and large skylights creates an internal volume and also brings daylight into the space. The glazing provides seamless transition between the streets and allows view from the public realm through the concourse to the apron. The automatic sliding doors at the bus bays serves as a barrier to limit passengers 'movement to the apron. The localized air curtains also prevent the ingress of toxic fumes into the interior space. A ground water heat pump is used to moderate the temperature and moisture level within the interior of the interchange (https://en.m.wikipedia.org).

3.5.5 Major Spaces

Ticket booths, locker rooms, food shops, bike rooms, public toilets, storage spaces, waiting hall, Concourse and Information counter.

3.5.6 Merits

- Use of local and cultural materials create a natural and welcoming environment for users.
- Public areas are properly located to facilitate easy access and circulation.
- There is adequate natural lighting and ventilation.
- The temperature of the interior spaces of the interchange is being regulated to harness passengers' comfort.

3.5.7 Demerits

- Buses gets out of the bays in a reversing direction which is not ideal.

Figure 3.44: Floor Plan of Christ Church Bus Station
Source: www.archydaily.com.

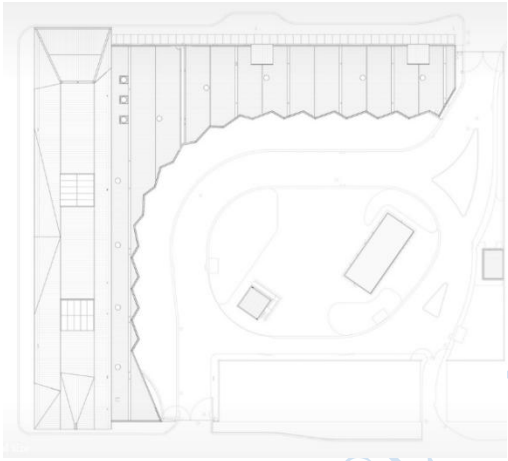


Figure 3.45: Roof plan of Christ Church Bus Station
Source: www.archydaily.com.

Figure 3.46: Front view of Christ Church Bus Station
Source: www.architectus.co.nz.

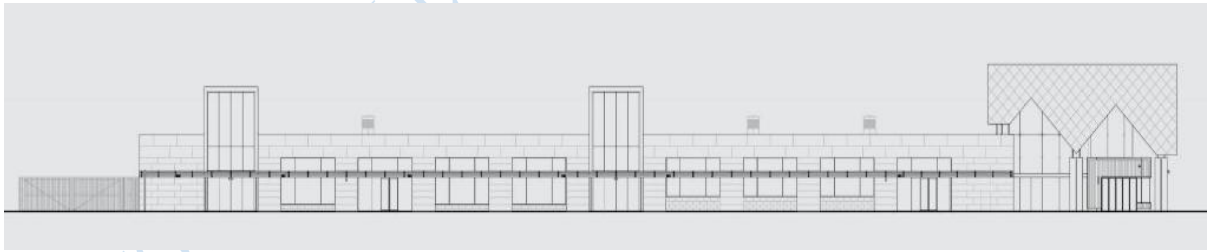


Figure 3.47: Side view of Christ Church Bus Station
Source: www.architectus.co.nz.

Figure 3.48: Sky light in roof
Source: www.archydaily.com

Figure 3.49: Ticketing booth
Source: www.archydaily.com

Figure 3.50: Sectional view of Christ Church Bus Station
Source: www.architectus.co.nz.

3.6 Case Study Appraisal

The case studies carried out created an avenue for a detailed analysis of the project by helping the researcher have an in-depth and better understanding of various aspects particular to the project. It provided a broader knowledge from different perspectives in the reality sense. Information on the planning of an interchange, the spaces and other facilities to be provided, the methodology and materials to be used and what factors to consider in the design of an interchange were all captured from the case studies. This explains why the situation at the Train Station, Moniya remains as it is and what needs to be done to harness the situation to achieve customers' satisfaction through their journey time.

Deduction from the case studies shows that interchanges are used by the general public irrespective of their status and age while the type of mode of travel depends on the purpose

and preferred destination. Glass is adopted as one of the major materials commonly used in all the selected case studies for visuality purposes with the provision of spaces like ticketing booth, waiting area, office spaces, retail outlets, restaurants. The use of multiple access allows for seamless flow with the provision of lifts and escalators to ensure vertical movement of people. At the information desk point, passengers locate their direction and get necessary information about the travel pattern. Other ancillary facilities like toilets, security and service information were also provided to enhance the operation of the interchanges.

However, each of the selected case studies have unique features that are peculiar to their construction. The Modern Bus Terminal at Ojoo, Ibadan has a watch tower at the last floor of the building from where the whole surrounding can be viewed in 360^0 angular directions as part of the security measures. The Oshodi Interchange, has two separate pedestrian skywalk bridge that link-up the three terminals which is meant to take passengers off the vehicular route. The underground basement car park at the Metro Station; Beijing in China was used to achieve a seamless transfer of passengers by zoning the spaces for easy circulation flow. The sawtooth bays at the Manukau Interchange were used to maximize space while adopting a sustainable operational approach where water from the sink was being collected and recycled back into the building for toilet flushing. The folded roof geometry and the large skylights were used to create an internal volume with the provision of maximum daylight into the space at Christ Church Bus Interchange.

Chapter Four

Site Analysis and Design Synthesis

4.1 Study Area

Ibadan, the capital and centre of administration of Oyo state is located approximately between latitude 7º 10' and 7º 30' north of the Equator and 3º 45' and 4º 05' east of the Greenwich Meridian with the record of being the largest city in Africa (Adelekan, 2016; Jolayemi, 2012). It comprises of thirty-three (33) Local Governments with a population of over 6million in the metropolis (Bruce, 2019). It is the most prominent transit point with trading routes between the coastal regions and the neighbouring states and contains major transport arteries linking Lagos with the Federal capital, Abuja, the northern metropolis of Kano and other important cities (Ibadan City Master Plan, 2017).

Akinyele is one of the eleven (11) Local Government areas in Ibadan metropolis with a land mass of 464, 892 km^2 (Adetunji & Oyeleye, 2018). Having its headquarters at Moniya, it is bounded in the north by Afijio L.G., to the east by Lagelu L.G., to the west by Ido L.G., and to the south by Ibadan North L.G. Agriculture being the major occupation of the people has increased the economic activities of the community which has been sustainable through the

transportation sector because the local government area serves as the central access to Ibadan city. Akinyele local government is home to notable places like the Nigerian Institute of Social and Economic Research, International Institute of Tropical Agriculture (IITA), Federal School of Statistics, Second Mechanised Division (Odogbo Cantonment) among others.

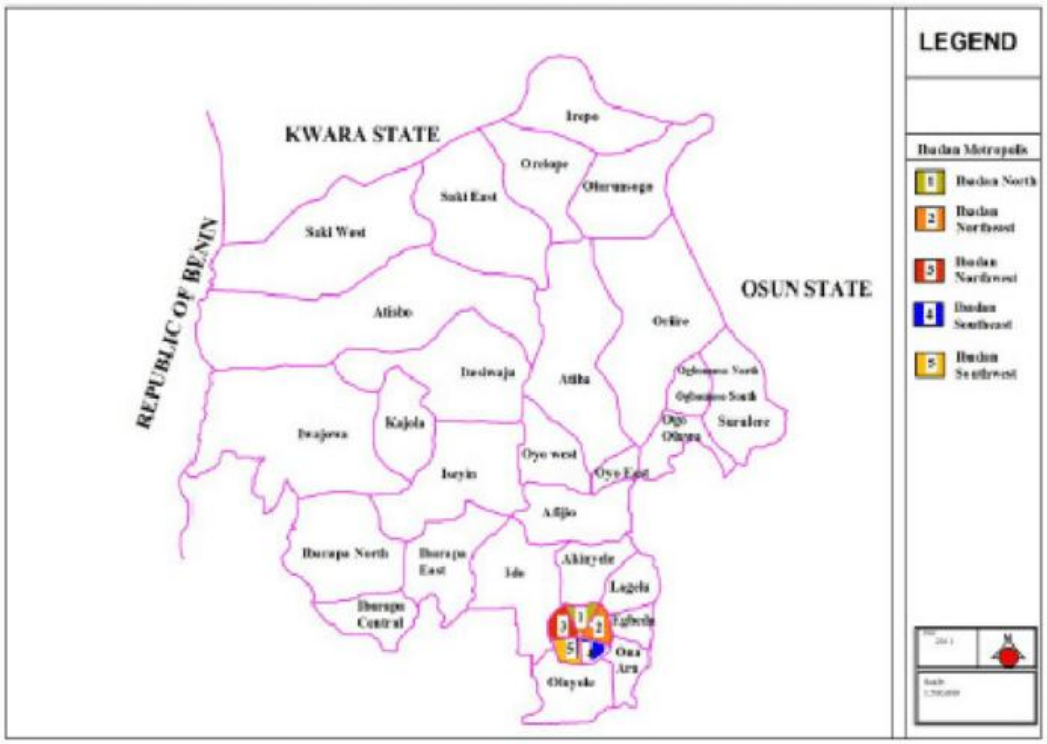


Figure 4.1: Map of Oyo State showing Ibadan Metropolis
Source: www.researchgate.net.

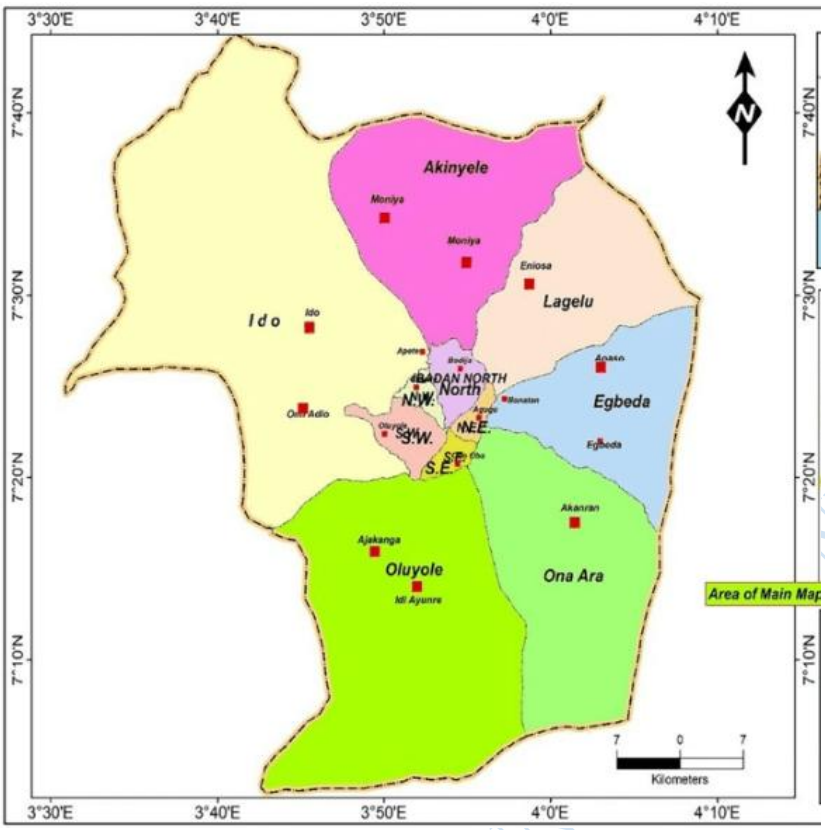


Figure 4.2: Map of Ibadan Metropolis showing Akinyele L.G.
Source: www.researchgate.net.

4.1.1 Site Location

The success and effectiveness of the project depend not only on the functionality of the design, but also on the careful choice of site. The proposed site is located around the existing Obafemi Awolowo train station site on latitude 7° 33'34" north and longitude 3° 53'48" east along Moniya – Iseyin road towards north of Elebu forest, Moniya in Ibadan.

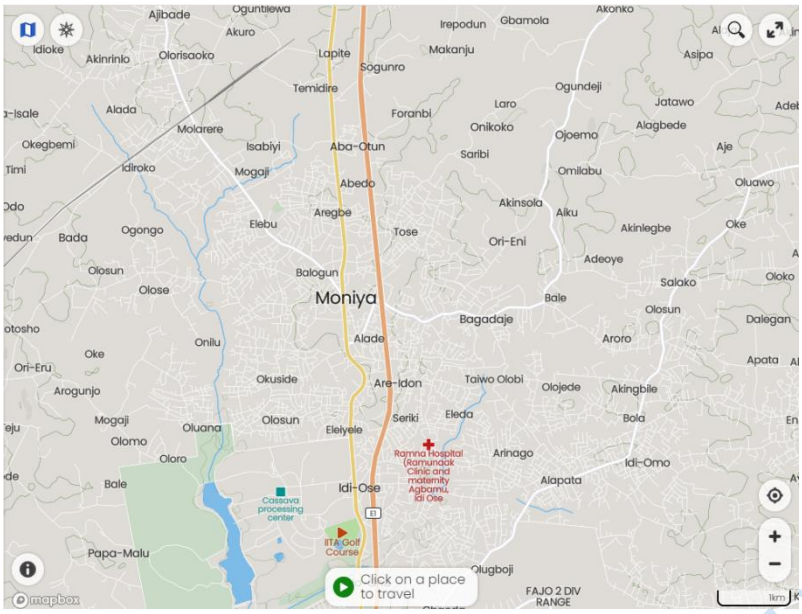


Figure 4.3: Location Map of Moniya in Akinyele L.G.
Source: www.mapcarta.com.

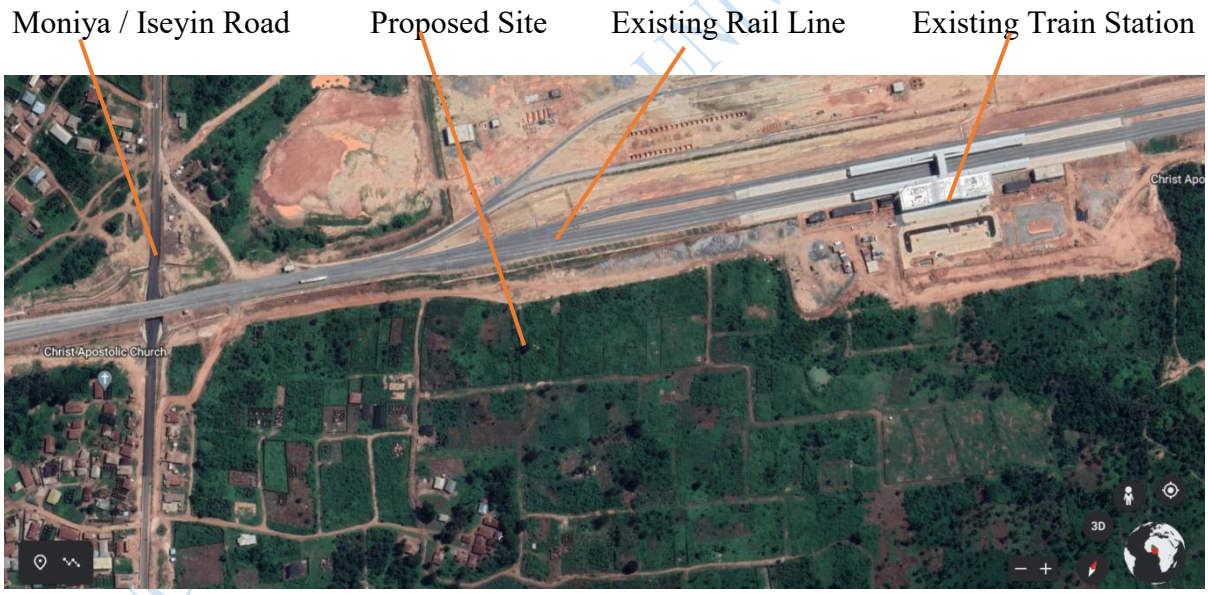


Figure 4.4: Location of the existing Train Station at Moniya in Ibadan.
Source: www.earth.google.com.

4.1.2 Site Selection Criteria

The choice of the site in this context is based on the requirement for effective mobility at the designated area of the existing Obafemi Awolowo Train Station, Moniya, Ibadan. However, some other factors also taken into consideration are:

i. Mobility Need: there is potential for movement and ability to get from one place to another using transport as an instrument for its realization.

ii. Resettlement Issues: people are experiencing stress due to unplanned transfer of passengers.

iii. Availability of Basic Services: there is provision for water, electricity, staff accommodation,

iv. Proximity of Site: the proposed site is about 8,594km from the city centre and serves as the central access to Ibadan city.

v. Environmental Impact Assessment: the site is not exposed to smoke or noise in any form because the trains have non-locomotive engines that runs noiselessly. This reduces environmental and carbon pollution.

vi. Potential for an Integrated Transport Network, Land use Plan and Zoning Restrictions: the site is located very close to the existing train station and away from the built-up environment and in a landed area allocated for sustainable development purposes to avoid displacement of people.

4.1.2.1 Site Analysis / Inventory

Having a better understanding of the site is a prerequisite for good design which is revealed by a thorough site analysis. All information gathered about the site assets and liabilities during the feasibility studies needs to be analyzed to address all issues that may affect the proposed design. Features that are beneficial to the site would be harnessed while those that are not would be improved on or eliminated totally to ensure a good relationship between the building and the site in particular. Sunlight radiation will have impact on the site and is one of the factors that determine the orientation of the building. Therefore, the purpose of the analysis is to gather information about the site prior to starting a project by identifying the existing conditions considering the natural and manmade factors like accessibility, soil,

climate, topography, orientation, vegetation, presence or absence of water and zoning regulation.

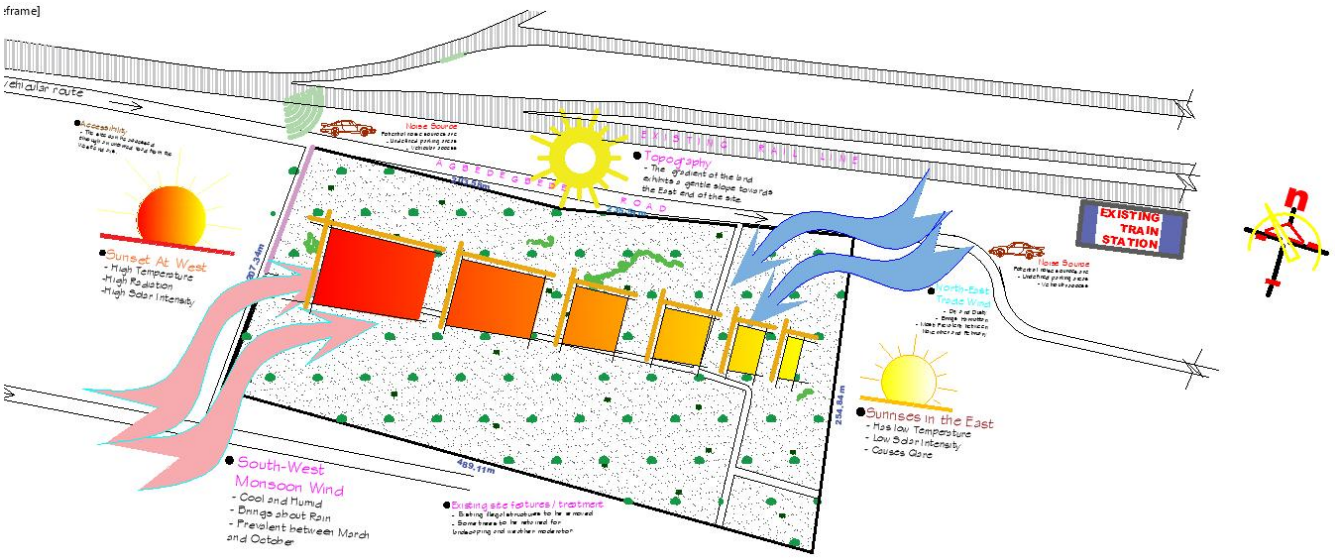


Figure 4.5: Site Analysis.
Source: Researcher's field study, 2022.

Information about the Site

The sit e is about ….m2 with a perimeter of …m. The rail line runs through North end of the site while to the east of the site is the existing train. The Moniya – Iseyin road is to the far West of the site and growing forest to the south.

Access Road

The site is accessible through an untar road that branch off the Moniya – Iseyin road which connects the community to the city centre.

Figure 4.6: Site Inventory.
Source: Researcher's field study, 2022.

Vegetation

Growing on the site are tall trees with thick grasses and shrubs. The soil is a mixture of laterite, fine grained loamy and humus material which is light in nature having a strong bearing capacity to hold and support the proposed terminal design to be constructed. Some vegetations and shrubs would be removed while some would be retained to serve as landscape elements.

Drainage / Topography

The site has a moderate and gentle slope towards the North – east. This will be better utilized in the drainage of surface water and for the achievement of the proposed road leading outwards the site to avoid traffic conflict.

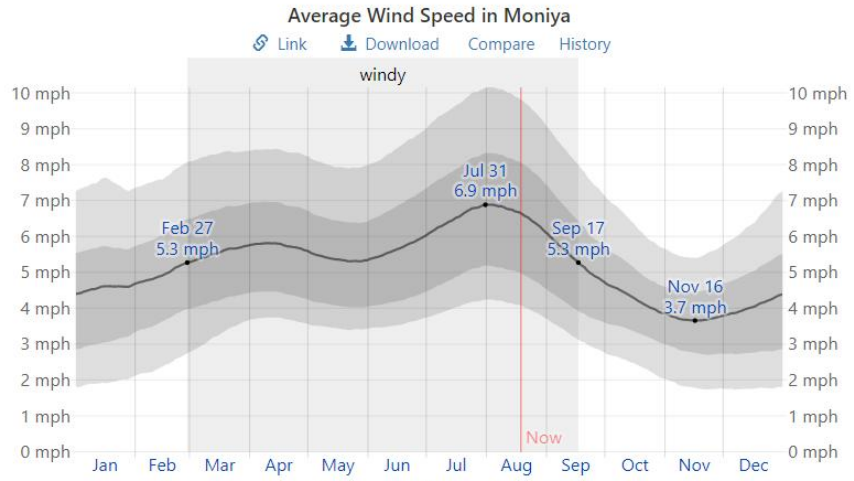
4.1.2.2 Geographic / Climatic Data of the Study Area

Akinyele falls within the forest – grassland within the tropical wet and dry climatic boundary of south – western Nigeria (Adetunji & Oyewale, 2018). It experiences both the wet season

(which lasts from April to October with a high rainfall in June and September) with a break in August and dry season that lasts between November and March. The monthly temperature varies between 24.6^{0}C and 29.9^{0}C with mean monthly temperature of 27^{0}C and annual temperature of about 320C while the relative humidity can be as high as 95%. Approximately, rainfalls for about 109 days totaling about 1,250mm annually.

Prevailing Wind

The prevailing winds blows across the proposed site and the design was tailored in a way that both winds are efficiently utilized. The South – west wind blows for about 7months in a year from February to September and most prevailing in the month of August with an average hourly speed of 6.6 miles per hour while the North – east wind blows for about 6months from September to February and most calm in November with an average hourly speed of 3.7 miles per hour.



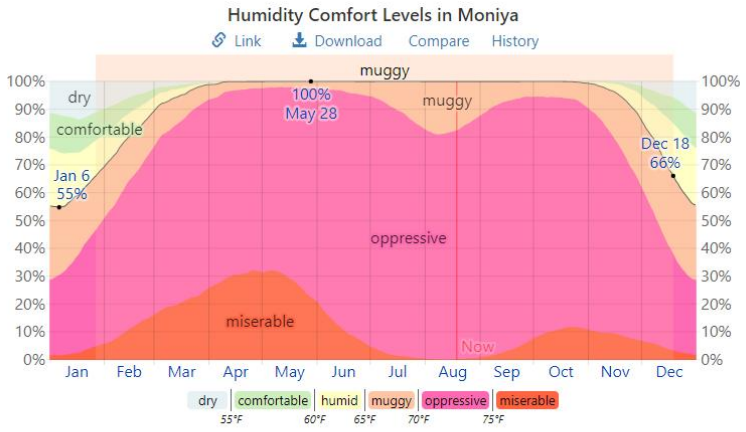
The average of mean hourly wind speeds (dark gray line), with 25th to 75th and 10th to 90th percentile bands.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wind Speed (mph)	4.6	5.0	5.6	5.7	5.4	5.7	6.5	6.6	5.3	4.2	3.7	4.1

Figure 4.7: Wind Speed in Moniya.
Source: https://weatherspark.com.

Relative Humidity

In January, there is a general reduction in the relative humidity whereas the relative humidity rises in the raining season mostly around May with a drop in temperature.

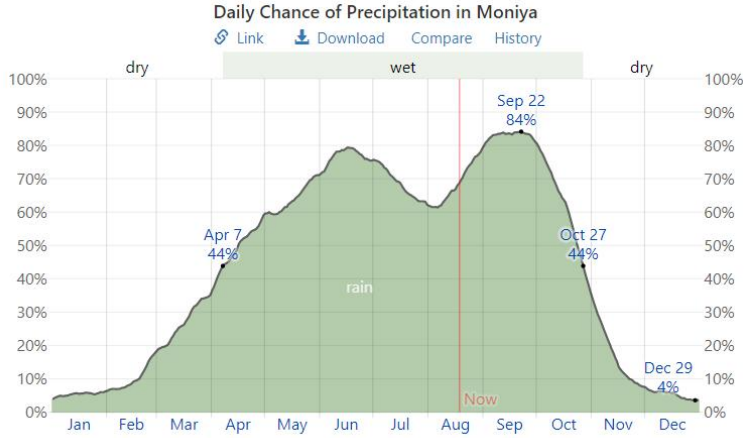


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Muggy days	18.6d	22.4d	29.5d	29.9d	31.0d	30.0d	31.0d	31.0d	30.0d	30.9d	28.3d	21.2d

Figure 4.8: Relative Humidity Level in Moniya..
Source: https://weatherspark.com.

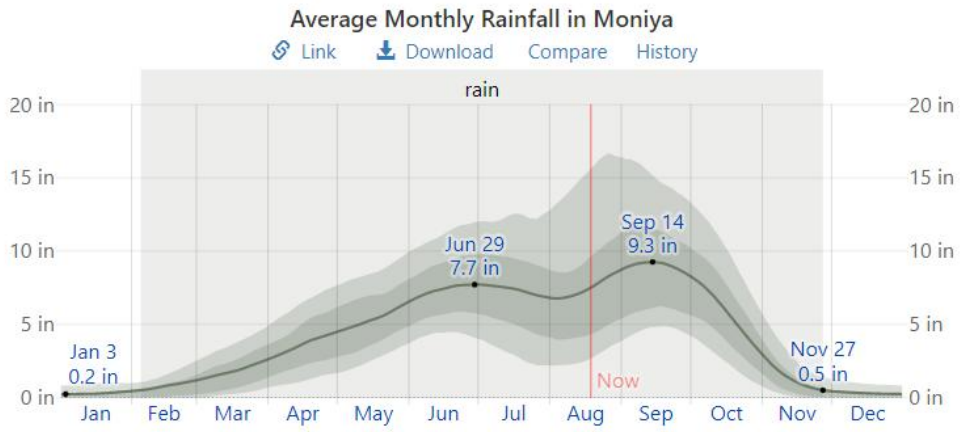
Precipitation / Rainfall

Throughout the year, the most common form of precipitation is experienced in September with a peak probability of 845% while the dry season last for about 5months (October to April).



Days of	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rain	1.7d	2.9d	8.5d	14.9d	20.0d	23.1d	21.1d	21.4d	24.9d	18.5d	4.9d	1.6d

Figure 4.9: Chance of Precipitation in Moniya..
Source: https://weatherspark.com



The average rainfall (solid line) accumulated over the course of a sliding 31-day period centered on the day in question, with 25th to 75th and 10th to 90th percentile bands. The thin dotted line is the corresponding average snowfall.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	0.3"	0.8"	1.8"	3.6"	5.3"	7.4"	7.4"	7.3"	9.2"	5.9"	1.1"	0.3"

Figure 4.10: Average Monthly Rainfall in Moniya.
Source: https://weatherspark.com.

4.2 Project Analysis and Design Synthesis

Why People Interchange

Mobility and movement are basic to human condition and major contributing factors to life activities. In the past, people embark on seamless journey from home to work place by public transport but as more people disperse outwards the city area in search for job, entertainment, business and others, a more complex travel pattern that requires passengers to interchange along a single trip was established. Pressure on spaces for home and work became high, creating the need for more roads and alternative means of transportation. Therefore, interchange is very crucial in the operation of public transport network. Through proper organization and use of space, the comfort of the users and functionality of the environment in meeting the mobility standards would be achieved.

Assessing the Demand for an Interchange

Over half of cities in the world experience challenges in providing adequate and appropriate transportation service as there will always be new problems in the system. Although, the

Moniya train station was established in a bid to reduce transportation problem encountered by people in the course of their journey, ease of movement still remains an issue registering the fact that buses are one of the main options among the modes of public transport. Effective integration of transport modes will achieve harmony and increased functional efficiency. The quality of the building and users' comfort is the impact of the design, arrangement, orientation and materials used.

4.2.1 Brief Analysis

The Obafemi Awolowo Train Station at Moniya is a double track standard gauge rail of 156.65km distance. It is the first part of the new 2,773km Lagos – Kano standard gauge line with full air-condition services and first of its kind in West Africa. It provides coaches for the economy, business and first-class passengers. The project has been an important contributor to the economic development of the state. Its operation reduces the pressure on Lagos – Ibadan expressway with an influx of movement of goods from the Apapa port and other major connecting routes. However, considering passengers' comfort and efficiency in operation, the design of a bus terminal building is required to be provided around the train station building to make it an interchange to achieve effectiveness and efficient movement of passengers.

4.2.1.1 Client Information

Oyo state government, the client on the project, has been saddled with the management of the state affairs having the vision of making Oyo State a better place to live in and ensuring that no one is left behind. This is set to be achieved with the mission of committing Local Governments and communities to reduce poverty, improve health and education, promote peace, human rights and environmental sustainability.

4.2.2 Brief Development

The integration of a bus terminal with the existing train station will make an interchange hub for easy transfer of passengers. It will create an enabling environment where people can transact business, meet to share ideas and also enjoy their waiting time using require mobility standards. The functional spaces needed to achieve the set standards includes;

a) Entrance Porch
b) Reception / Waiting Area
c) Ticketing Booth
d) Information Desk
e) Luggage Holding
f) Drivers' Lounge
g) Luggage Claim
h) Departure Hall
i) Sick-bay
j) Offices
k) Store
l) Tuck Shop
m) Staff Lounge
n) Retail Outlets
o) ATM Gallery
p) Restaurant
q) Kitchen
r) Travelers' Lodge
s) Travelers' Lounge
t) Conveniences

u) Police Station

v) Parking

w) Maintenance Yard

x) Fuel Station

4.2.3 Design Criteria

To design an effective and functional terminal building, it is important to put into consideration the environment in which the terminal is to be located, the users and the building's sustainability. These involves;

i. Provision of public spaces and other amenities
ii. Pedestrian access
iii. Green areas
iv. Signage and Way finding standards
v. All-inclusive pathway
vi. Effective parking
vii. Open plan design

However, the general design consideration with respect to their overall impact on the building includes;

- Site layout – this has to do with the organization and arrangement within the building and the site to enhance safety by controlling access while location of building and its form address the effect of climate.
- Rhythm – involves access into and out of the building and site, zoning of spaces for specific functions, connectivity among different inter-related spaces and circulation flow (both vehicular and pedestrian) in a barrier free movement.

- Lighting – both natural and artificial lighting creates a sense of feeling and mood for safety purposes and functionality of spaces.
- Sustainability – this considers use of appropriate building materials to maximize natural lighting and ventilation with good maintenance strategy.
- Aesthetics – view of the building serves as an attraction to users and a place where users derive comfort.

4.2.4 Conceptual Development

This is the most important part of the project development as it not only describes the details and intricacies of the idea behind the project but also the motive behind the design. The approach to the design follows an idea that manages the incentives of both form and function simultaneously by looking at and beyond the function as well as abstraction and other things to solve architectural problems while having a good form from the solution to the problem.

4.2.4.1 Site Concept

The drive behind the conceptualization of the site borders on an effort to create an environment capable of enhancing an efficient transportation network in an effective way. This is evident in the planning of the site activities in relation to the situation of the existing physical structure which is likened to the 'Circulatory System'. The terminal building, which acts as the heart where blood is pumped to other parts of the body, is the centre point of passenger transfer where people reach other places for different activities.

Figure 4.11: Site Concept Formation; 'The Circulatory System'.
Source: Author's Survey, 2022 (https://world.dan.org.)

4.2.4.2 Design Concept

The trend of formation that leads to the final design concept as graphically illustrated is derived from the combination of spaces of the key mobility function of an interchange as a social, economic and environmental system. These spaces are classified into zones that are denoted by four a (4) bladed fan. The interdependent zones work together like the rotation action of a fan to bring comfort and satisfaction to users.

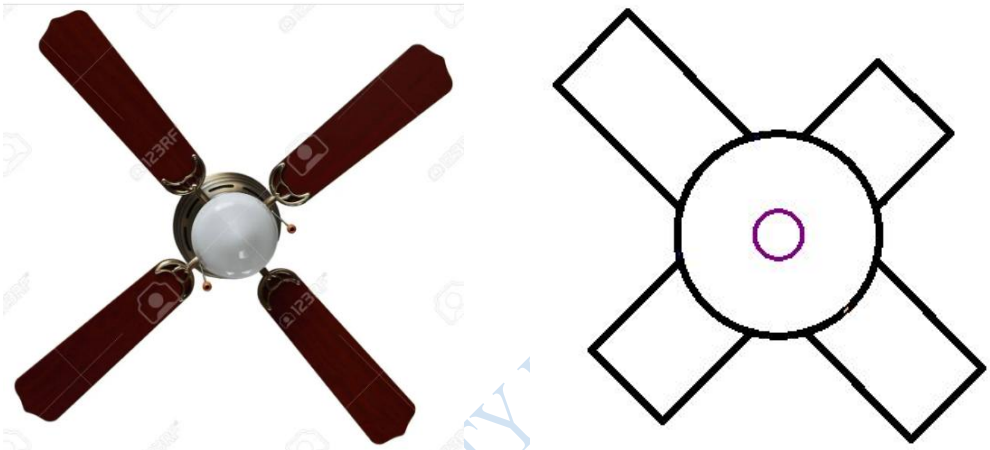


Figure 4.12: Design Concept; 'Four Bladed Ceiling Fan.
Source: Author's Survey, 2022 (https://www.123rf.com).

4.2.5 Functional Relationship

The functional relationship shows the connection and circulation flow among various spaces in the facility. This involves separating the pedestrian and vehicular access, different spaces within the building and other ancillary structures within the site in relation to the existing structure. The three zones which are achieved through vertical and horizontal circulation comprise of -:

1. Public zone – these are areas within and outside the project site that are freely accessible to every user. It includes the Waiting area / Information desk, Restaurant, Tuck shop, Service banking, Retail outlets, Lettable office space, ATM gallery, Stair Hall, Lift, Departure Hall, Luggage claim, Fare complain room, Parking area, Drivers' waiting room, Travelers' checking, Ticketing booth and Conveniences.

2. Semi-Private zone – access to these areas involves people that have reason or mission to carry out at that point like the Drivers' waiting, Travelers' lounge, Sick – bay, Drivers' lounge, Kitchen, Station Manager's office, Supervisor's office, Staff lounge, Training / Conference room, Freight lift and Conveniences.
3. Private zone – includes areas that are out of bound to non – staff member of the terminal building like the Cash office, Strong room, System room, Technical room, Fire control room, Central Control room, I.T room, Store and the Watch tower.

4.2.6 Space Allocation / Schedule of Accommodation

4.2.6.1 Space Allocation

Spaces within the building are allocated based on the functional activity required. This will reduce traffic build-up, improve service operation and enhance users' satisfaction. The classification led to the zoning of services within the building to comprise of the Administrative, Commercial, Utility and Departure zone.

Administrative zone	**Facility zone**
Waiting area / Information desk	Fare complains room
Training / Conference room	Luggage claim
Sick – bay	Cash office
Travelers' lounge	Strong room
Drivers' lounge	System room
Staff lounge	Technical room
Watch tower	Fire control room
Conveniences	Central Control room
Stair hall	Store
Lift	Conveniences

Commercial zone	Departure zone
Tuck shop	Fare complains room
ATM gallery	Luggage claim
Service banking	Travelers' checking
Restaurant	Record Office
Retail outlets	Secretary's Office
Lettable office space	Departure Hall
Kitchen	Drivers' waiting
Storage	I.T room
Freight lift	Supervisor's office
Conveniences	Conveniences
Stair hall	Store

4.2.6.2 Schedule of Accommodation

Table 1: Schedule of Accommodation for Administrative zone

S/n	Space	Area (m^2)	Unit
1.	Waiting area / Information desk	267.95m^2	1
2.	Ablution	57.58m^2	1
3.	Sick – bay	137.09m^2	1
4.	Travelers' lounge	78.53m^2	1
5.	Drivers' lounge	94.51m^2	1
6.	Staff lounge	104.20m^2	1
7.	Conveniences	7.67m^2	2

Table 2: Schedule of Accommodation for Commercial zone

S/n	Space	Area (m^2)	Unit
1.	Tuck shop	12.81m^2	2
2.	ATM gallery	15.98m^2	1
3.	Service banking	33.94m^2	1
4.	Restaurant	166.88m^2	1
5.	Retail outlets	72.26m^2	1
6.	Lettable office space	72.29m^2	4
7.	Kitchen	59.72m^2	1
8.	Storage	18.05m^2	3
9.	Freight lift	11.82m^2	1
10.	Conveniences	7.67m^2	2
11.	Stair hall	32.94m^2	1

Table 3: Schedule of Accommodation for Departure zone

S/n	Space	Area (m^2)	Unit
1.	Fare complains room	148.54m^2	1
2.	Luggage claim	37.136m^2	1
3.	Travelers' checking	37.136m^2	1
4.	Departure Hall	228.00m^2	1
5.	Drivers' waiting	37.136m^2	1
6.	I.T room	36.92m^2	1
7.	Supervisor's office	22.54m^2	1
8.	Conveniences	7.67m^2	2

Table 4: Schedule of Accommodation for Facility Zone

S/n	Space	Area (m^2)	Unit
1.	Central Waiting / Ticketing booth	1134.57m^2	1
2.	Station Manager's office	36.78m^2	1
3.	Cash office	36.64m^2	1
4.	Strong room	11.35m^2	1
5.	System room	36.89m^2	1
6.	Technical room	13.00m^2	1
7.	Fire control room	36.87m^2	1
8.	Central Control room	68.48m^2	1
9.	Store	12.92m^2	2
10.	Conveniences	7.67m^2	2

4.2.7 Construction Methods and Materials

Visitation to the site gives thorough information about the condition of the site and the full extent of the works to be executed, storage space, the conditions affecting the supply of labour and materials. This will assist the Contractor at all phases of the construction (substructure, superstructure and the roof stage). The soil type found in the site is a combination of loamy (which is the top soil) and laterite as the underlayer soil that has a good load bearing capacity. Pad foundation would be employed for the construction of the terminal building. This type of foundation is favourable as it spreads the load to support the weight of building and the roof structure. The different stages involved in the construction activities are:

-

a. Site clearing – this is the removal of all unwanted facility or barrier on the proposed site to accommodate the construction exercise. All makeshift containers, temporary structures put up for commercial activities would be dismantled and cart away from site. All plants and shrubs existing on the site will be excavated and some trees retained to serve as landscape elements.

b. Site hoarding - this is the perimeter fencing round the site boundary to form the site compound. Material to be used for hoarding the site is galvanized corrugated iron roofing sheets nailed to 50x75mm timber frames. This is used to secure and monitor the site.

c. Removal of top soil – areas earmarked for the building construction would have their top soils removed while other parts would be retained for landscape purposes and future development. The depth of the soil to be removed would be determined on site.

d. Setting out – centre walls and columns of the building are established on site using the site layout. The building dimensions would be transferred on site according to the architectural drawings in relation to the survey of the proposed site as earmarked by the Ministry of Lands.

e. Excavation to trenches – trenches are to be done by excavators to depth approved and certified by the structural engineer.

f. Blinding, foundation footing and column bases – concrete mix required is a combination of cement, coarse and soft aggregates with adequate water. The mix ration would be 1:2:4 with reinforcement to structural engineer's specification for different locations.

g. Foundation block wall – blocks to be laid on foundation footing will be cement sand-crete hollowed blocks of 230mm filled with concrete for additional strength.

h. Hardcore filling – after filling the internal part of the blocks with laterite to the level of the last block, hardcore is placed. Hardcore materials for the building would be larger parts of granite, boulders which would be levelled with ramming machine and well compacted with a vibrator to get rid of voids which may exist within the soil. This will help strengthen the stability of the foundation and create a strong base for the german concrete.

i. Damp proof – to prevent damage to surface finishes and decay of building fabrics, a membrane material is applied to prevent moisture in buildings. Polyethylene material with uniform thickness of 40mm would be laid as damp proof membrane to prevent the transmission of moisture into the building.

j. Casting of oversite concrete - wire mesh and iron rods would be placed over the damp proof membrane to act as reinforcement. Concrete mixture would be poured to make a ground floor slab with the specified thickness of the engineer.

k. Walls – these are major building elements that define the shape and look of the building. They are used to define and enclose spaces within the building. Walls for terminal buildings are to be good sound insulators, fire resistant and rigid enough to withstand both live and imposed loads. The walls will be of 225mm thick sand-crete hollowed blocks while all conveniences will be of 150mm thick walls. The curtain walling will be of 6mm thick glass insulating glass shielded with aluminum plate wall facing used as shading device.

l. Floors – floors should be constructed to provide comfort, safety, less noisy and easy to maintain. The terminal building floors will be of reinforced concrete slab finished with polished terrazzo, vitrified tiles, cement screed for walkways and parking areas.

m. Doors and Windows – these are used to provide ventilation and physical access into a place. All external doors will be double leaf swing glass door of 5mm thickness,

2100mm high with fixed glass of 600mm height. Some internal doors will be double swing glass doors of 2100mm high while some will be 50mm thick high density fibre door of same height.

n. Ceiling – suspended ceiling materials of 600x600mm cellulose ceiling boards installed to architect's specification will be used for acoustic purposes and to conceal the light fittings.

o. Roof – roofing system in building is usually determined by the span and nature of its construction. Gauge of 0.75mm thick long span aluminum roof cover will be laid over the steel roof trusses.

p. Painting – building surfaces are painted to give colour, provide texture and also protect the building. The internal and external walls of the building will be painted with product of Portland Paints Nigeria and colour to architect's specification.

4.2.8 Building Services

Installation of service systems in a building makes it to be comfortable, functional and efficient to use. It includes the mechanical, electrical and plumbing systems in a building otherwise known as MEP services.

Mechanical services

Firefighting systems, elevators & escalators, HVAC systems, gas supply system, sprinklers, security systems and management systems.

Electrical services

Power supply, back-up power (such as diesel generators), emergency power (such as battery-based uninterrupted power supply) public address systems and data networks.

Plumbing systems

Water supply, drainage of wastes, water recycling systems (these allow you to recover the water for low-grade applications such as flushing), rain harvesting, storm water drainage.

Chapter Five

Conclusion

5.1 Project Appraisal

Various parameters are used to check the viability of a project in order to make a decision whether to proceed with the project or not. The interchange design is appraised on the basis of the following:

5.1.1 Accessibility

The site is accessible through multiple entrances to avoid congestion and delay in movement. The pedestrian movement shall be clearly separated from the vehicular movement with the incorporation of paved walkways and the introduction of ramp as an inclusive design. The drive way at the main entrance shall serve as drop off area to cater for people on the wheel chair and the aged for effectiveness and during emergency period. Speed breakers are introduced along the road to avoid risk of accident while negotiating turning to other link roads. The introduction of staircases and lifts will ease movement within the building regardless of one's status. The provision for handicapped toilet is an advantage in creating a sense of satisfaction in every user of the facility.

5.1.2 Lighting

The lighting system of this project is very vital as it plays an intrinsic role in all the functioning of the building. The lighting scope extends to all spaces in the building as well as some furtive aspects of behavioral coordination especially when it comes to pedestrian movement, which is achieved through the provision of barrier free and large passage ways, transparent wall materials (glass) and high-level window openings. The central waiting area provides day lighting to the interior of the building through the atrium dampalon sheet covering. Also, void provided at the middle of the structure provides inner garden which serves as boundary to different spaces at the interior.

5.1.3 Ventilation

The natural system of ventilation is adopted in the design of the building with the use of casement windows for utmost air inlet. Coolness in the building will be achieved naturally with the introduction of laser cut exterior façade which is used as sun-breaker or shading device to shield the building from reflection from the sun. also, high level windows were also adopted to allow the displaced hot air escape outwards of the building. This natural method of ventilation is not only cost effective but energy saving. However, artificial ventilation is employed only at offices and travelers' lodging which is to be powered by Electricity Distribution Company.

5.1.4 Electrical Services

The electrical system of the building is conceived to be powered from the Electricity Distribution Company using energy saving bulbs. Tracking and signaling devices are considered to be important equipment in the station as they require to be on constant operation. Careful thought has then been made to provide a hitch free source of electrical Generator to power these devices. All power cables on the buildings have been artistically and functionally worked into the design where the panels are being concealed as much as possible.

5.1.5 Energy and Cost Saving Techniques

The electrical light fixtures designed to dim or turn off in the presence of extreme sunlight are installed along the pedestrian walkways and parking areas. Sensor doors are installed at areas with low traffic flow for easy access.

5.1.6 Safety and Fire Services

High pressure fire extinguishers are to be mounted at various strategic areas. Underground high-pressure pipes are to be linked to all external water points along the external lobby platform which make it easy for fire fighters to use in case of a fire incident.

5.1.7 Drainage

Surface storm water within the premises shall be collected and directed through covered drainage of 600mm width by 900mm depth according to the topography of the site. The green areas will also be effective in reducing the run off of surface water within the premises and will as well assist in the plant growth to create an appealing environment.

5.1.8 Parking

All parking areas shall be of interlocking paving stones and marked accordingly for way finding and easy circulation. There shall be provision for both natural and artificial shelter over the vehicles with the use of trees and steel cover.

5.1.9 Security

The issue of security is very important in any public building especially one that manages high human activities and at a constant twenty-four basis. CCTV camera are installed in strategic locations to monitor the movement of people and bus operations. Security personnel are also in place to monitor easy flow during peak periods which makes it difficult for unfortunate scenarios like purse snatching or pick-pocketing.

5.1.10 Plumbing and Water Services

The plumbing system employed in the building is conduit with accessible wall ducts at various hidden areas for ease of maintenance. Hot and cold water is also available with the heating system to be controlled from the facility department.

5.1.11 Sewage Disposal

There shall be provision for waste basket on every floor with adequate signage to direct user accordingly. There shall be appointed cleaners to sweep, mob floors and dispose waste collected to appropriate places. There shall be provision for incinerator within the site premises which would be carried on a regular basis.

5.1.12 Future Expansion

Since the train station is meant to cover for future transportation to the norther parts of the country, this design provided for future expansion as the number of passengers increase.

5.2 Conclusion

This study has carried out research and observed the current situation at the Obafemi Awolowo Train Station, Moniya in Ibadan and confirmed that passengers are being subjected to stress as there is no provision for public transit to transfer passengers along the travel pattern considering the location of the train station to the city centre. This reveals that the existing train station is not living up to expectation and has thus become challenging for passengers to convergence and disperse from the train station.

Deduction from the case studies shows that the design of an interchange comprises of spaces to include the waiting area, ticketing booth, information desk, luggage claim, restaurant, departure hall, loading bay, parking area, retail outlets, lounge, utility zones and conveniences. Also, the pedestrian routes were clearly defined from the vehicular access with the provision of facilities including security and safety measures, alternative lighting system, water treatment plant and open spaces for passengers' use. Transparent materials were used in the construction of the building for visual aid with the provision of adequate ventilation and daylighting.

An in-depth assessment and analysis of the five selected case studies within the real-life context shows that an effective interchange comprises of various parameters like multi-access for easy circulation flow with adequate parking spaces and well-defined pedestrian route. It also includes provision for shelter to protect users from the effect of weather through a seamless movement. Another factor is effective space zoning for seamless movement in

around the interchange. However, it was identified that direction of movement and use of space has been the most crucial factor to ease of movement in public buildings.

Therefore, the design and integration of a bus terminal into the existing train station environment to make it an interchange will guide and manage circulation flow for easy movement of people at the train station in Moniya, Ibadan. This will bring about users' comfort and satisfaction as well as efficiency in operation of the two modes of transportation system while encouraging the use of public transportation.

5.3 Recommendation

The realization of this project will significantly enhance the transportation system of Ibadan and the nearby communities with overall productivity among the workers in the area, as unnecessary delays associated with avoidable increased travel time would be overcome. It will also boost the economic gains of the nation. It is therefore recommended that government formulate regulatory policy to ensure the above stated parameters be included in the design of any interchange for efficiency and effectiveness.

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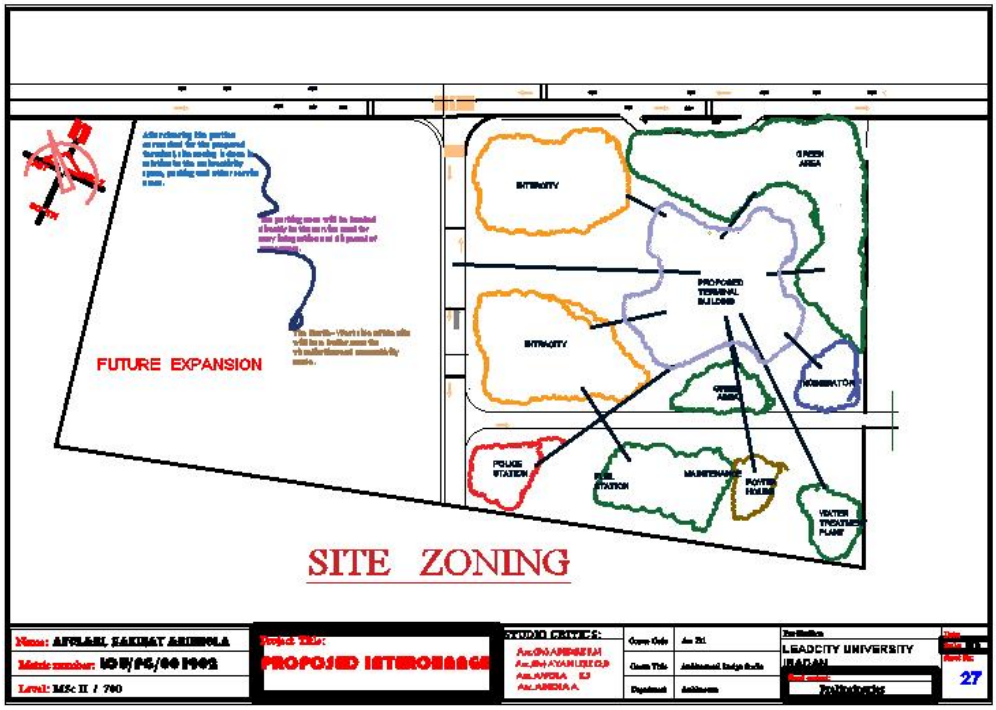
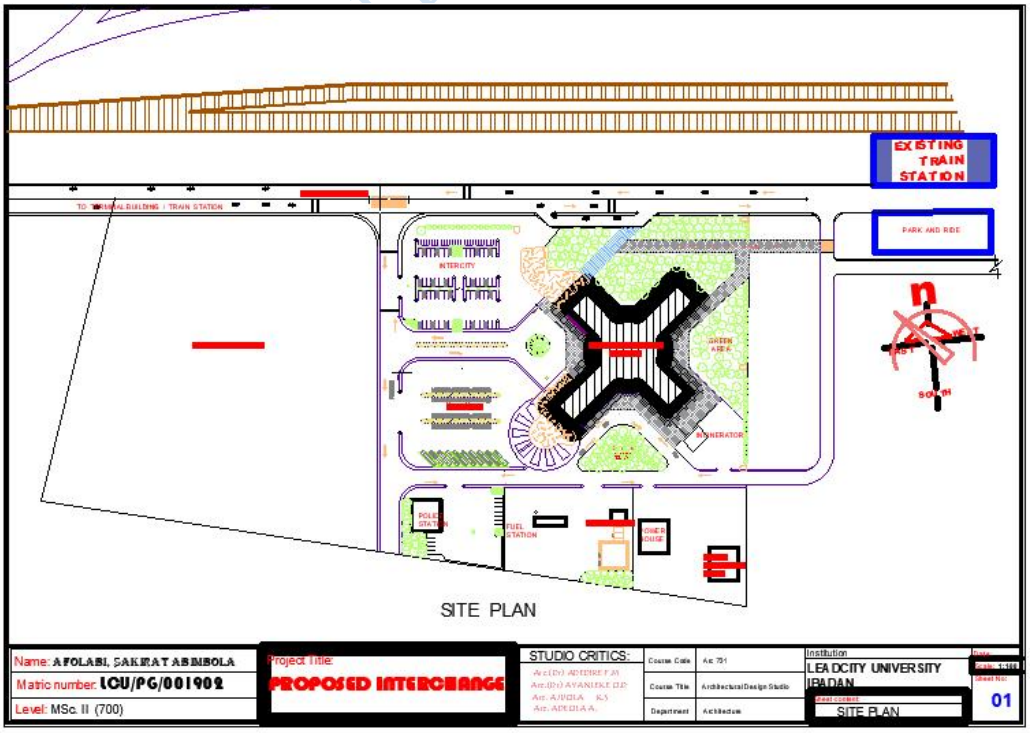
Appendixes

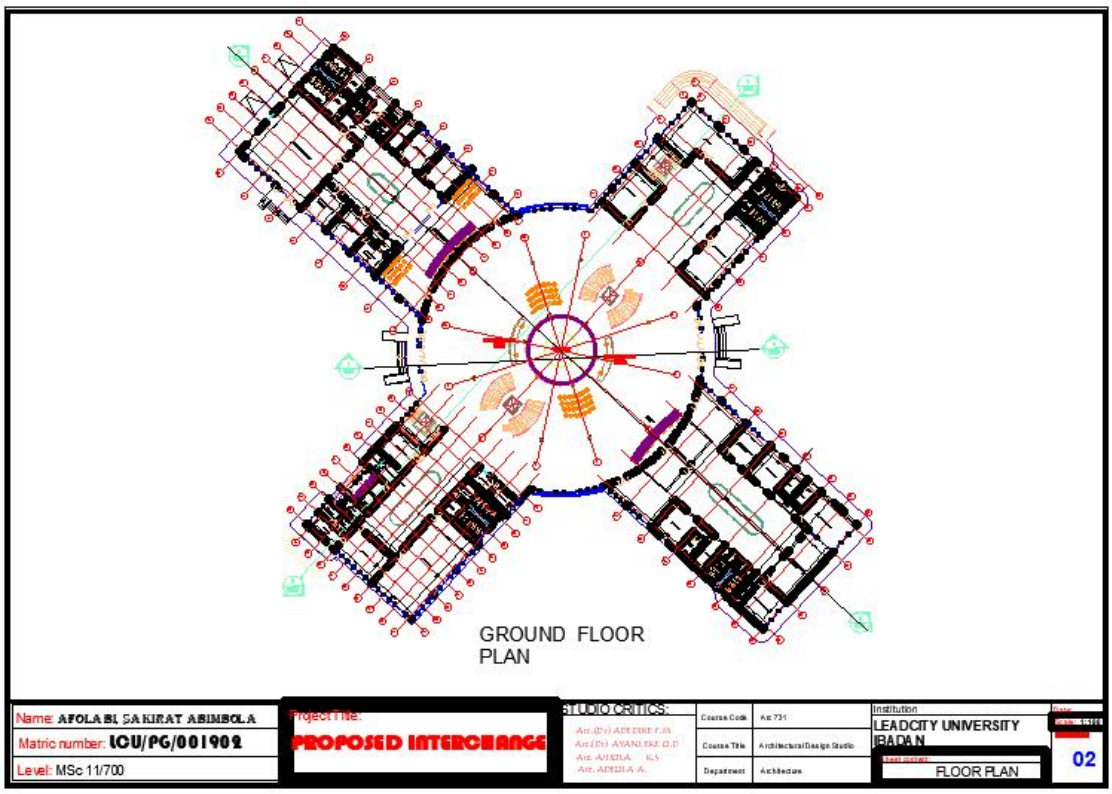
A. Presentation Drawing



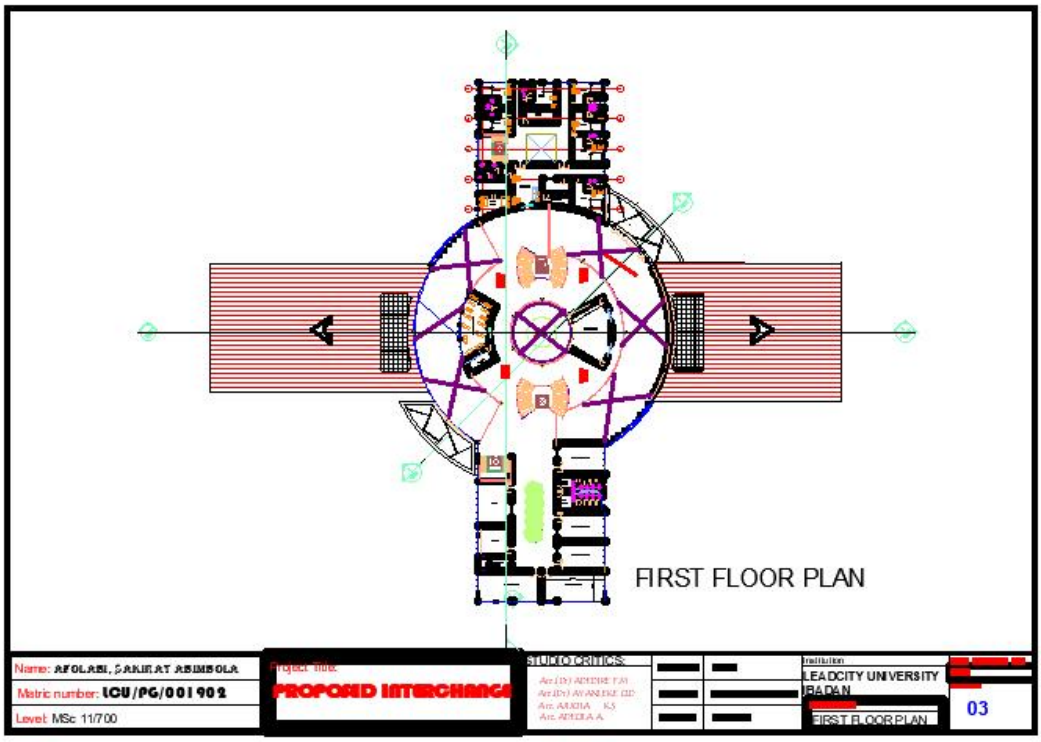
Drawing 1: Site Zoning



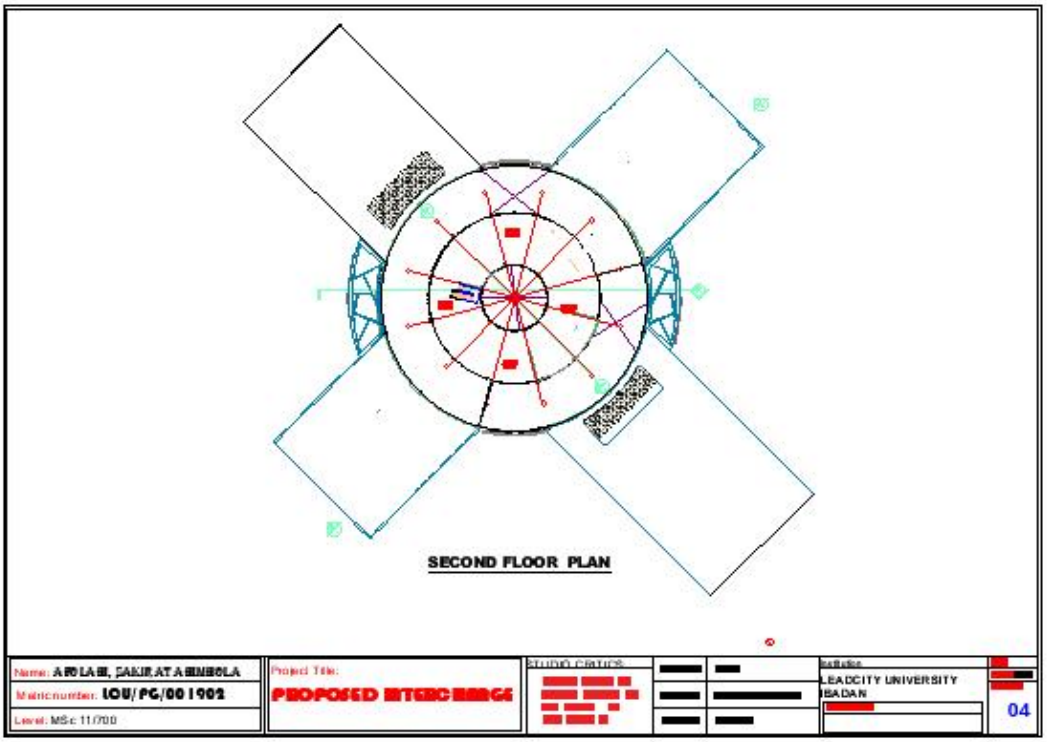
Drawing 2: Site Plan



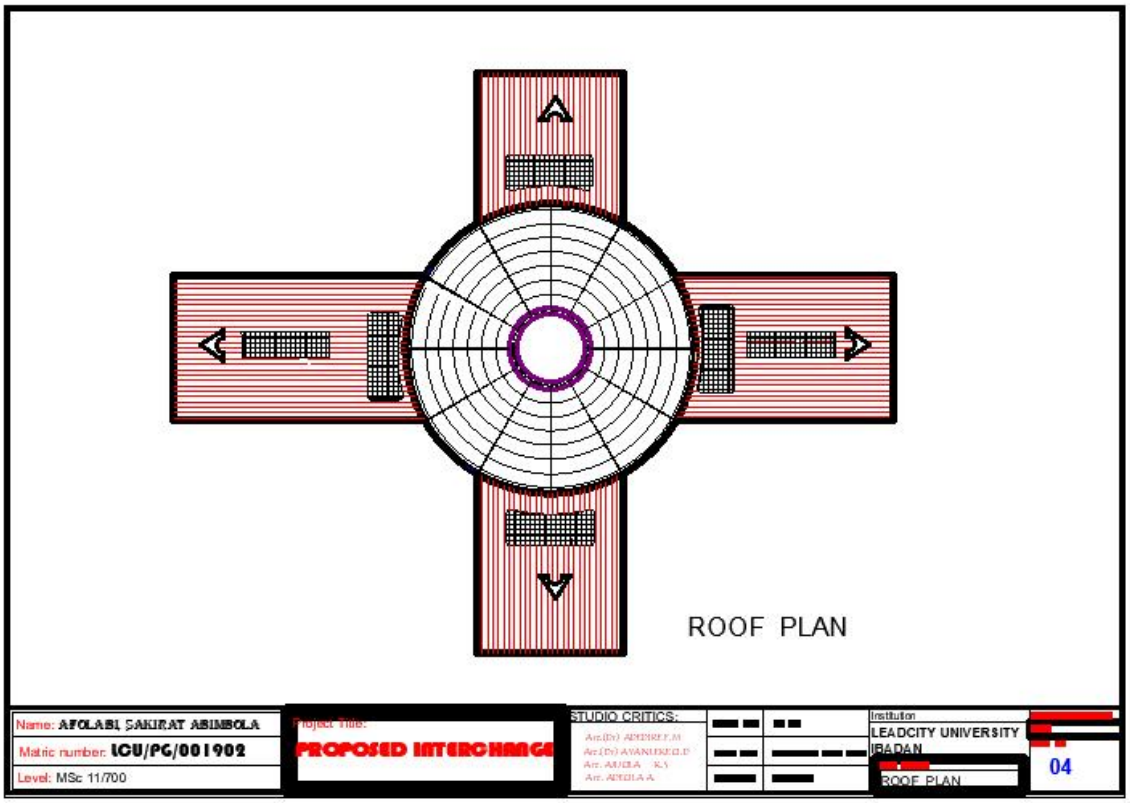
Drawing 3: Ground Floor Plan



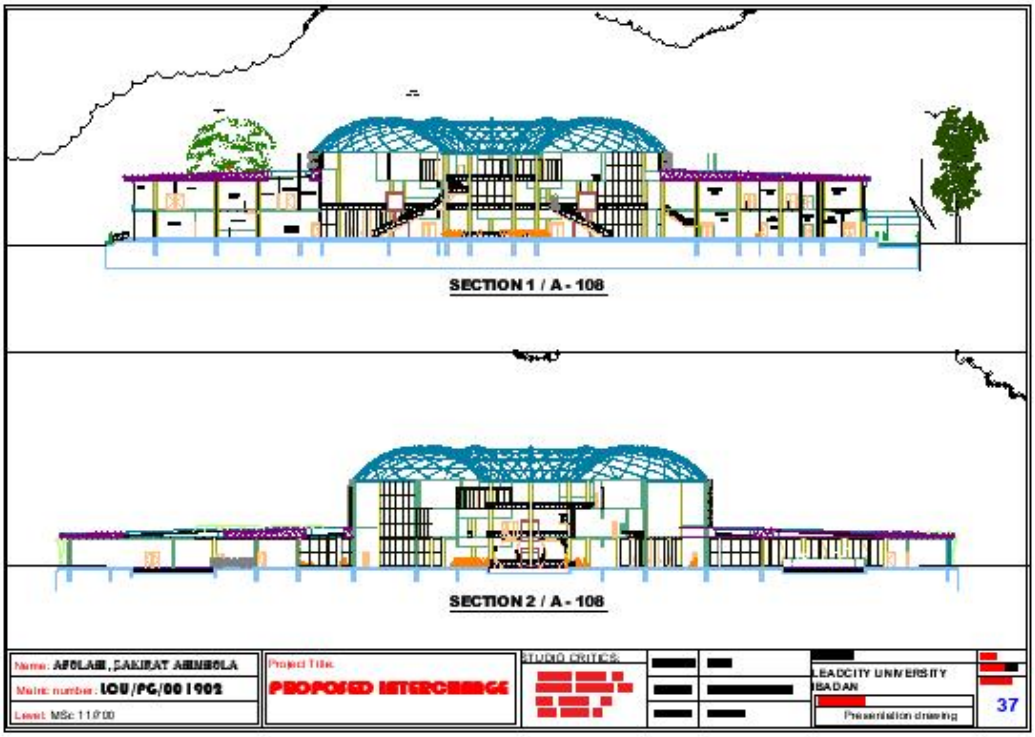
Drawing 4: First Floor Plan



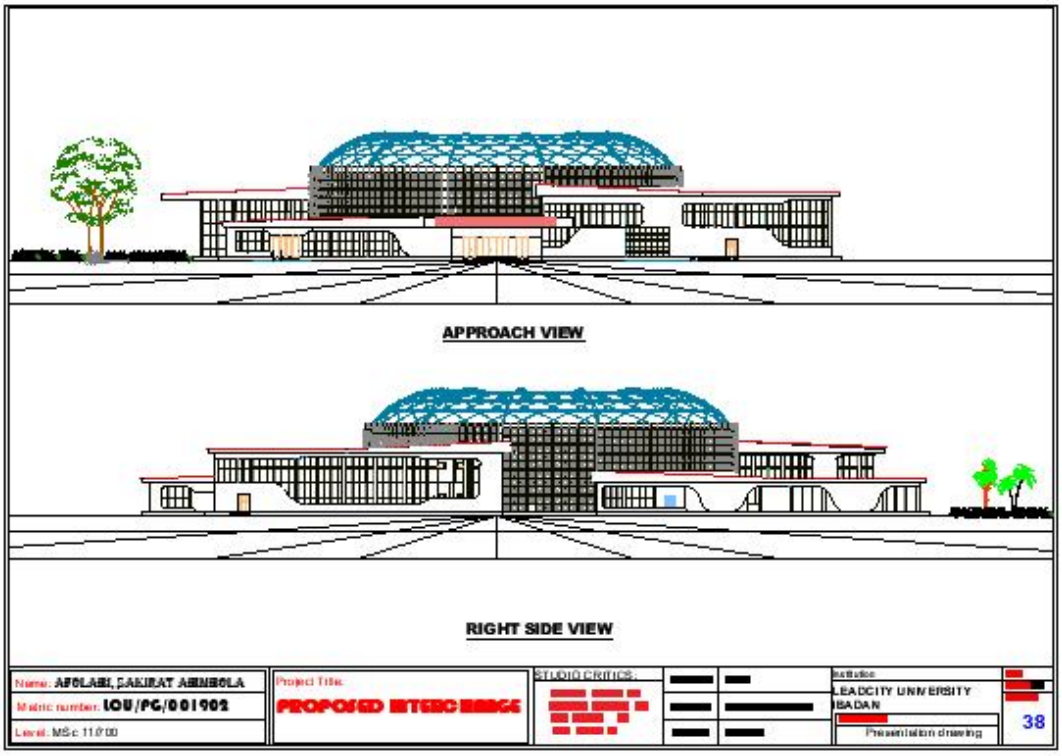
Drawing 5: Second Floor Plan



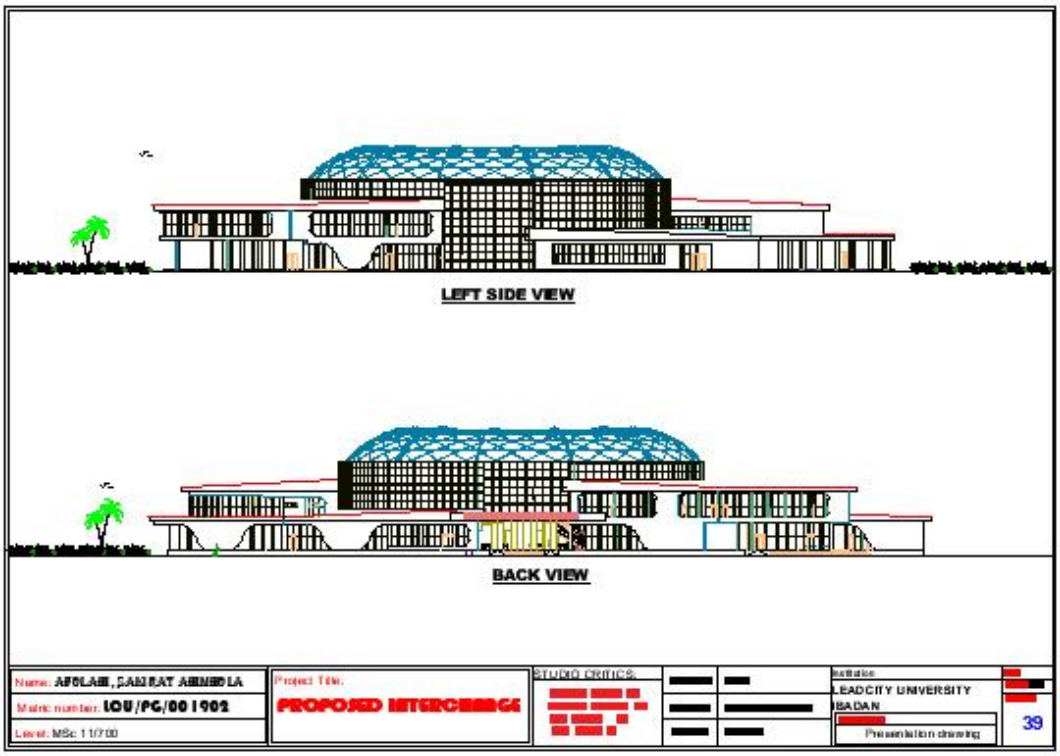
Drawing 6: Roof Plan



Drawing 7: Section

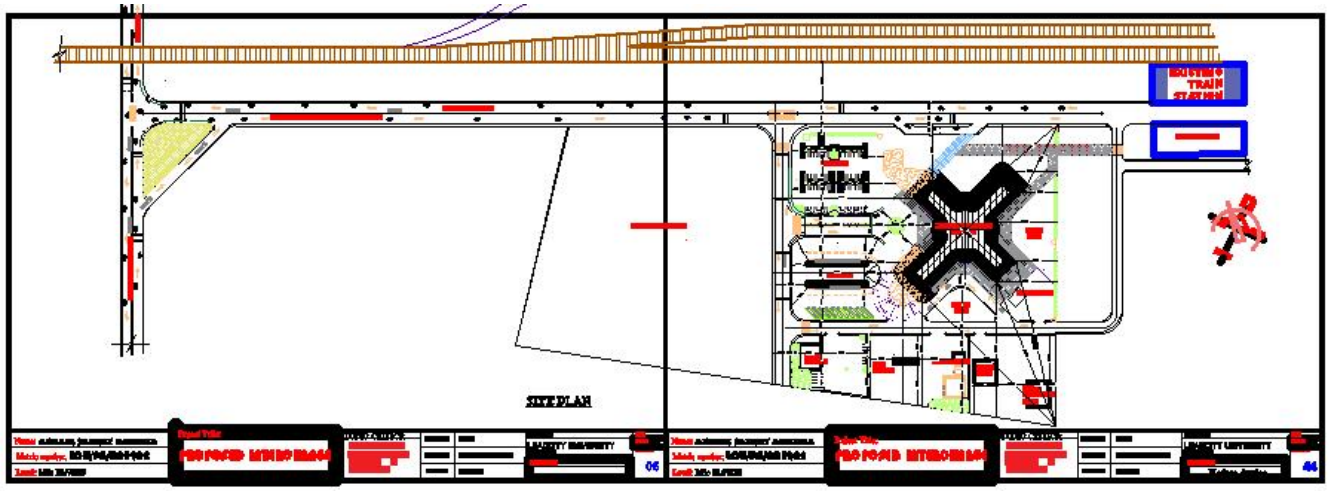


Drawing 8: Elevation

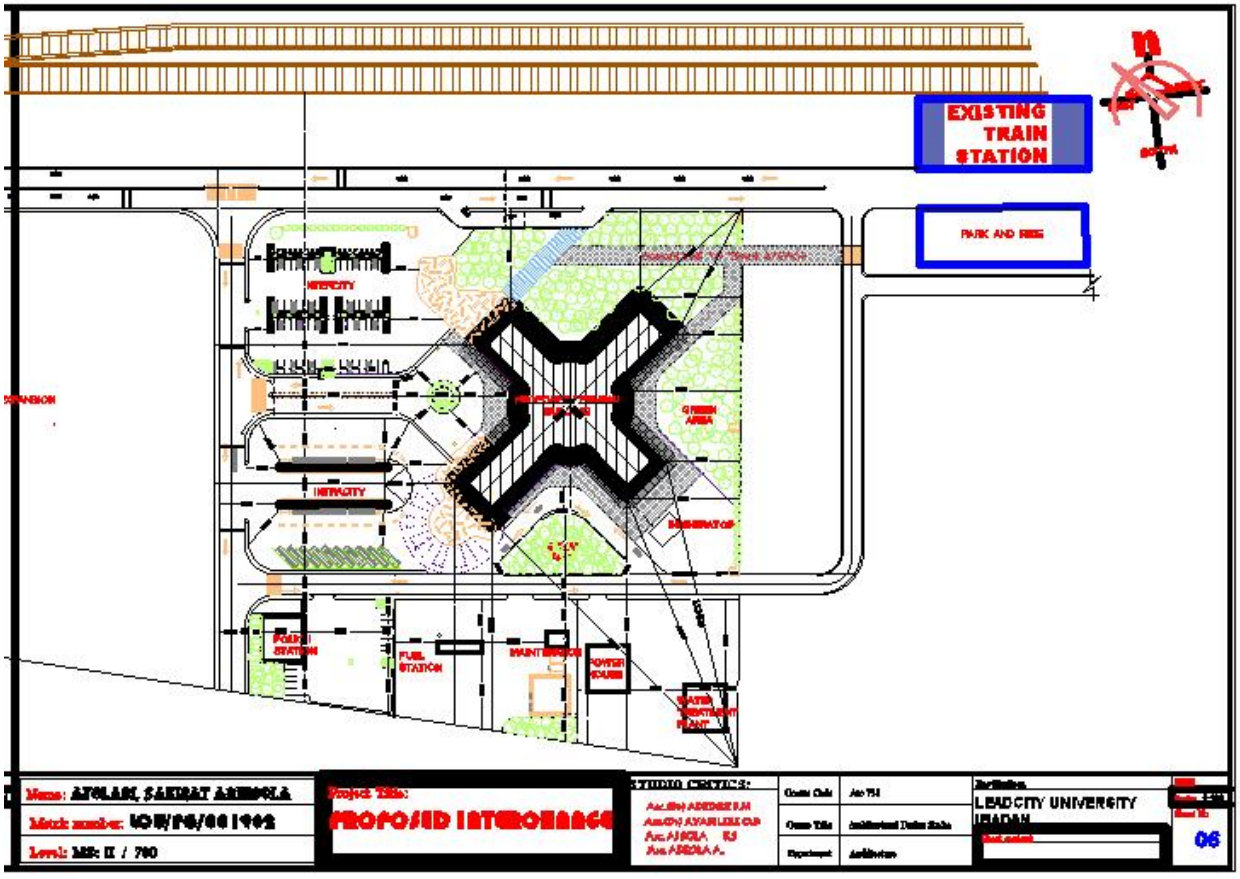


Drawing 9: Elevation

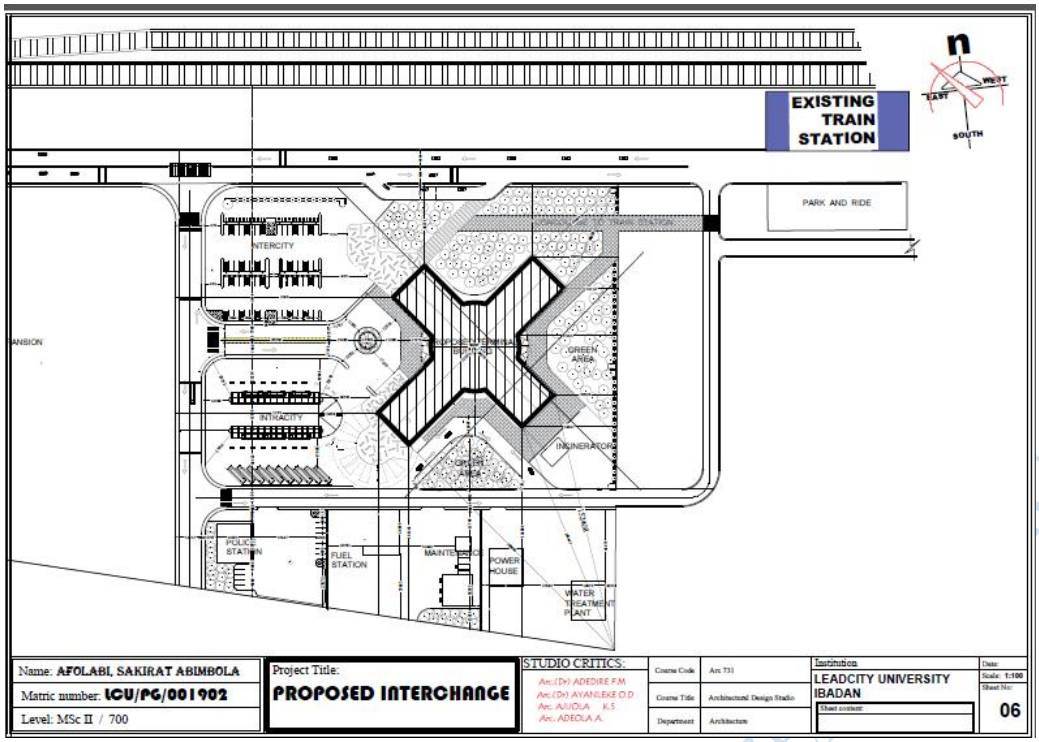
B. Working Drawing



Drawing 10: Site Location Plan

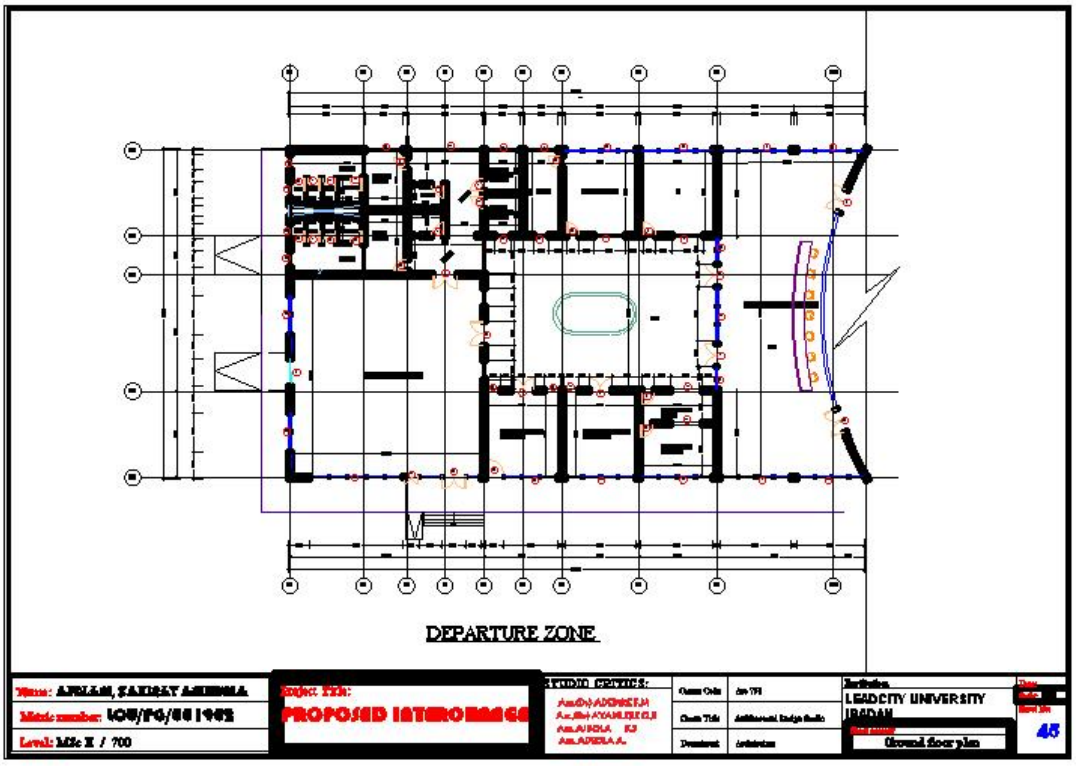


Drawing 11a: Site Plan



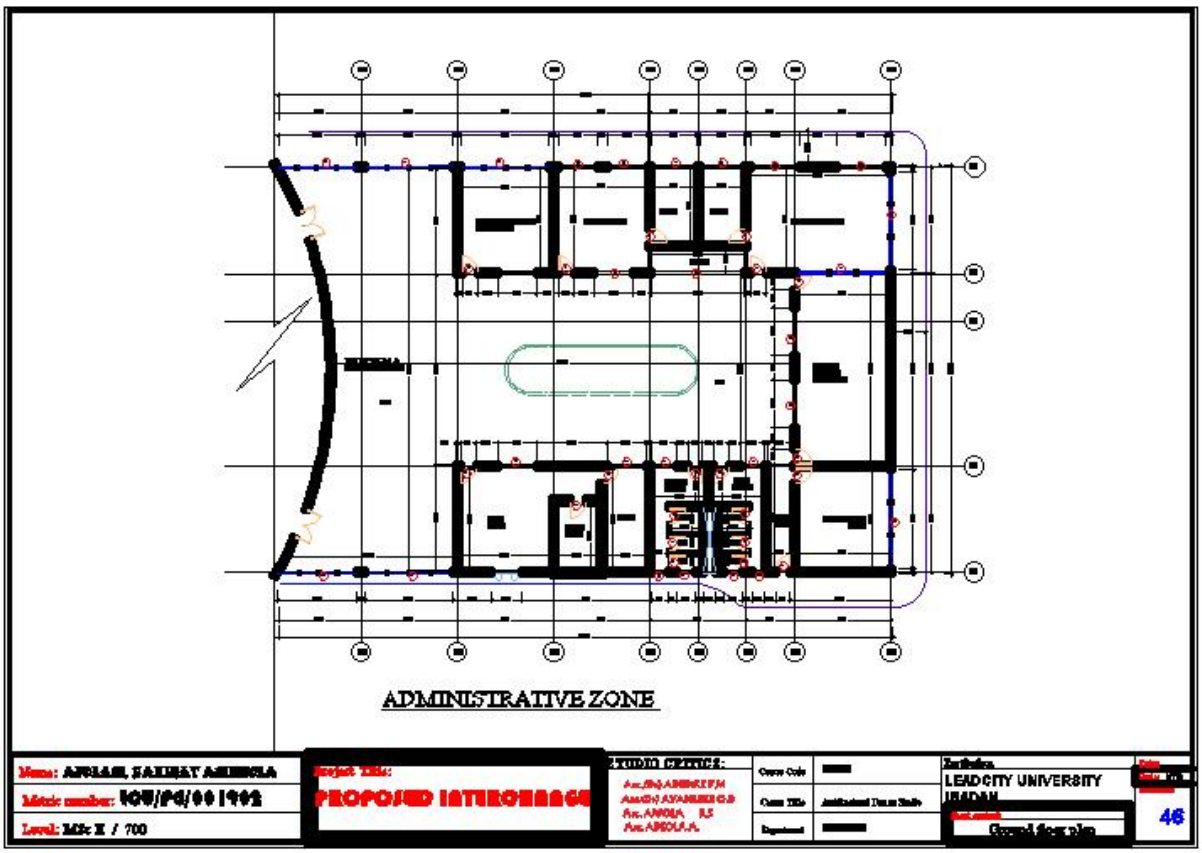
Drawing 11 b: Site Plan

GROUND-

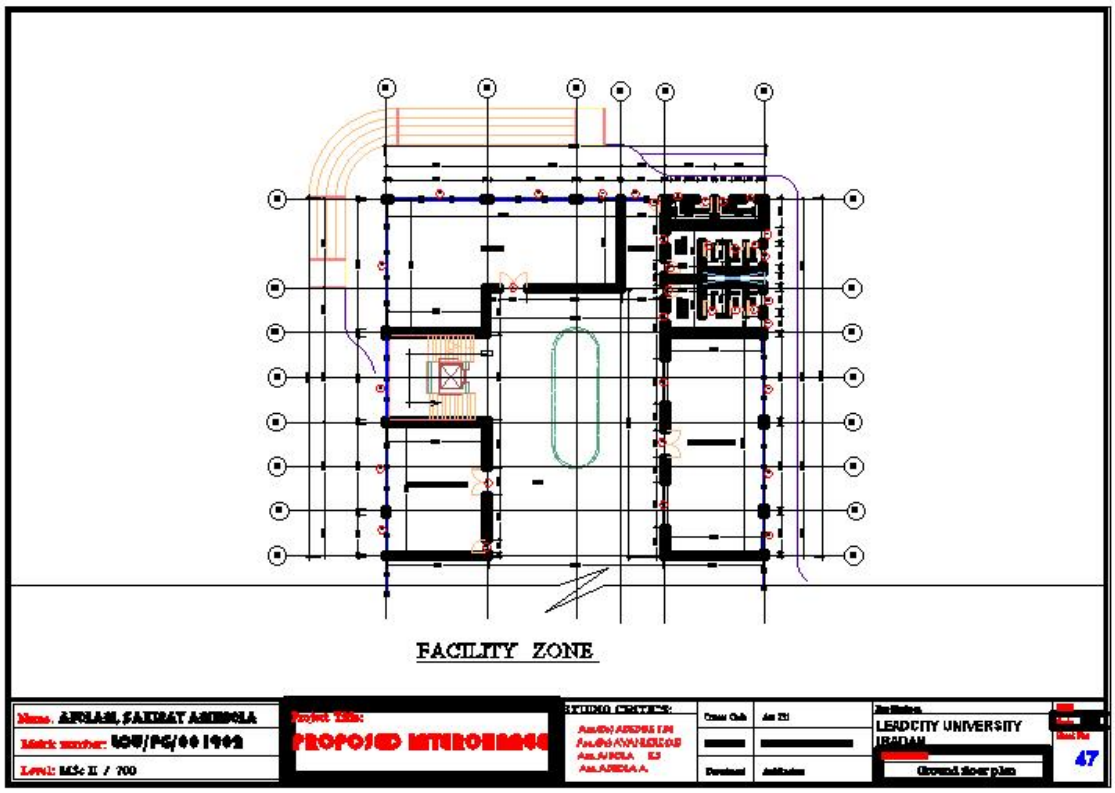


FLOOR

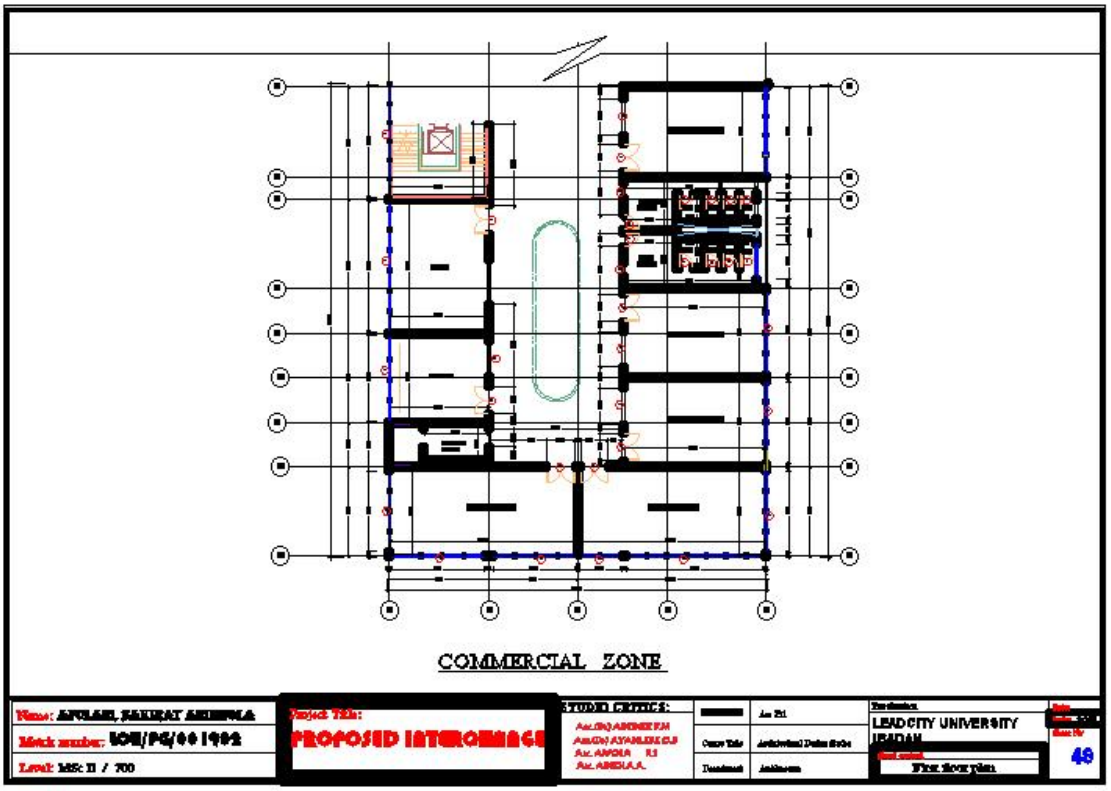
Drawing 12: Ground Floor Plan (Departure Zone)



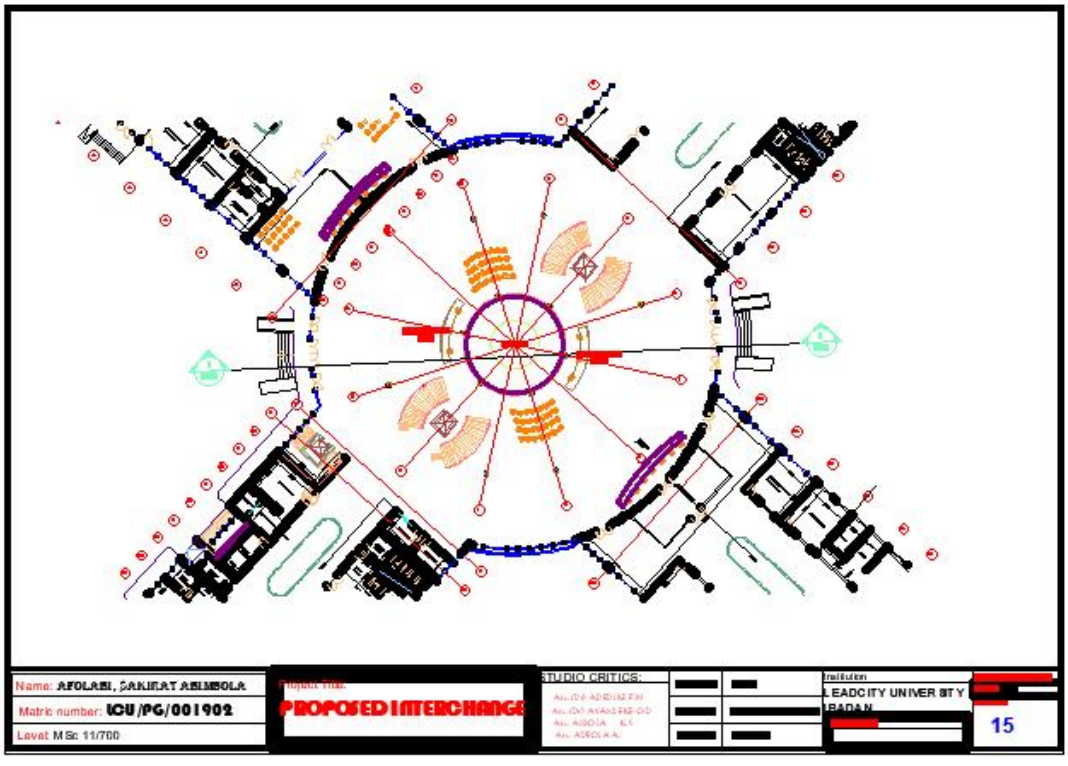
Drawing 13: Ground Floor Plan (Administrative Zone)



Drawing 14: Ground Floor Plan (Facility Zone)

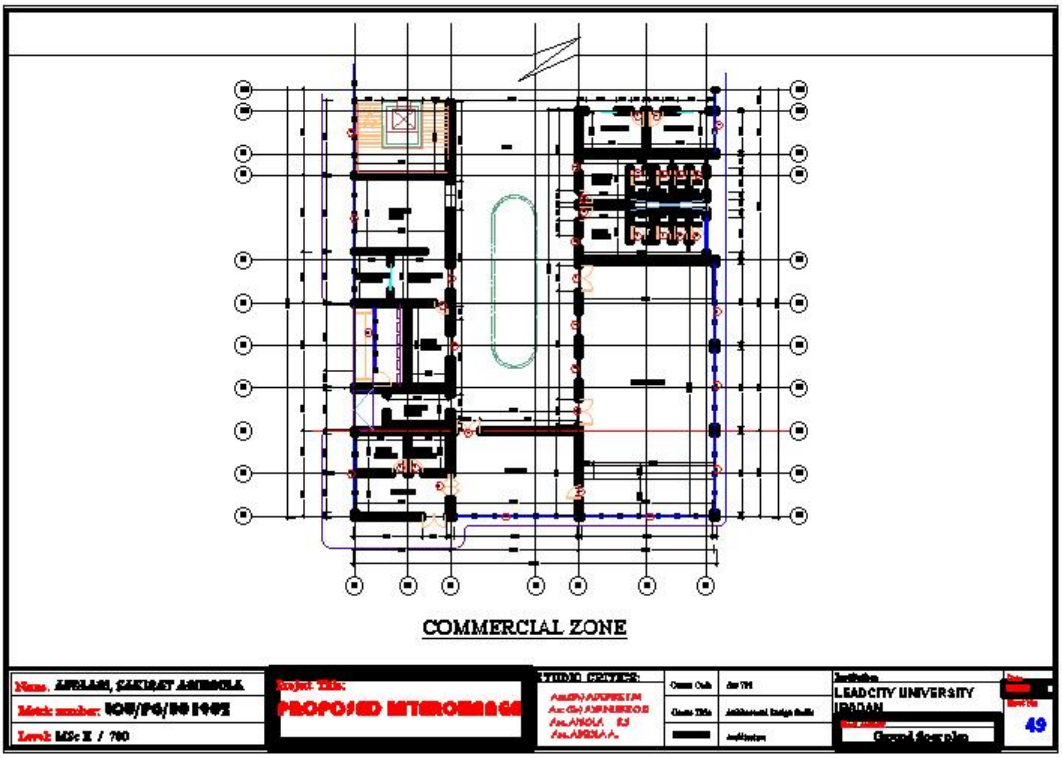


Drawing 15: Ground Floor Plan (Commercial Zone)

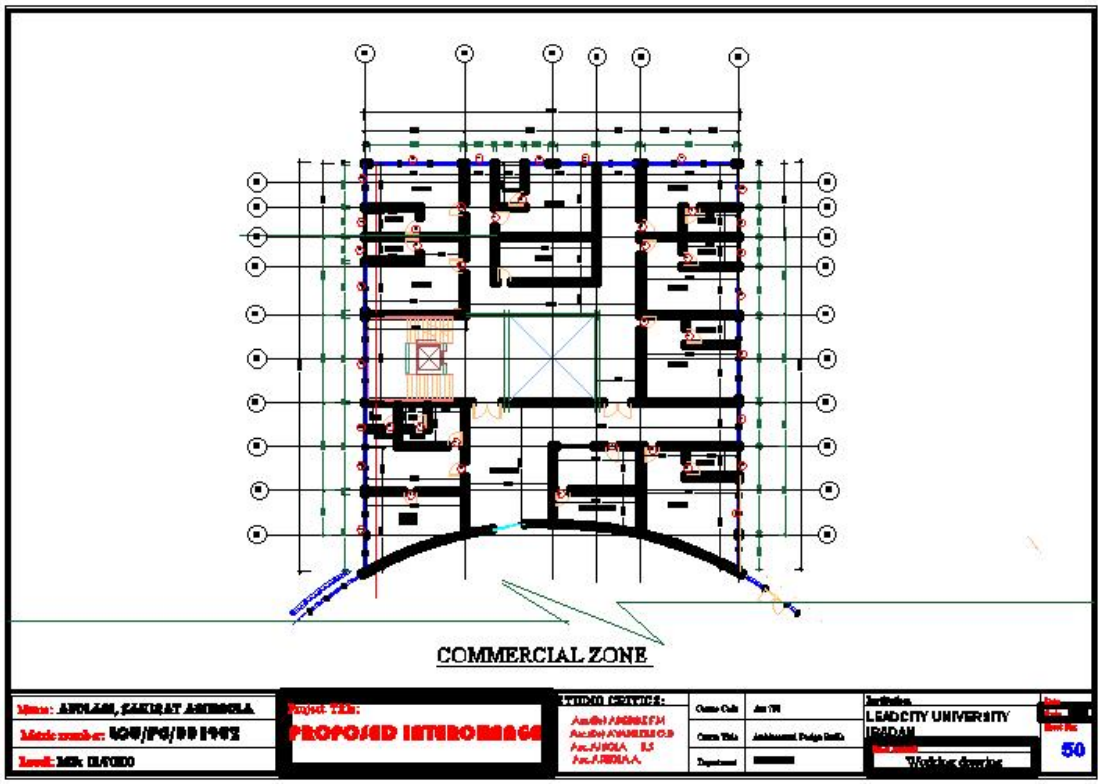


Drawing 16: Ground Floor Plan (Waiting Area)

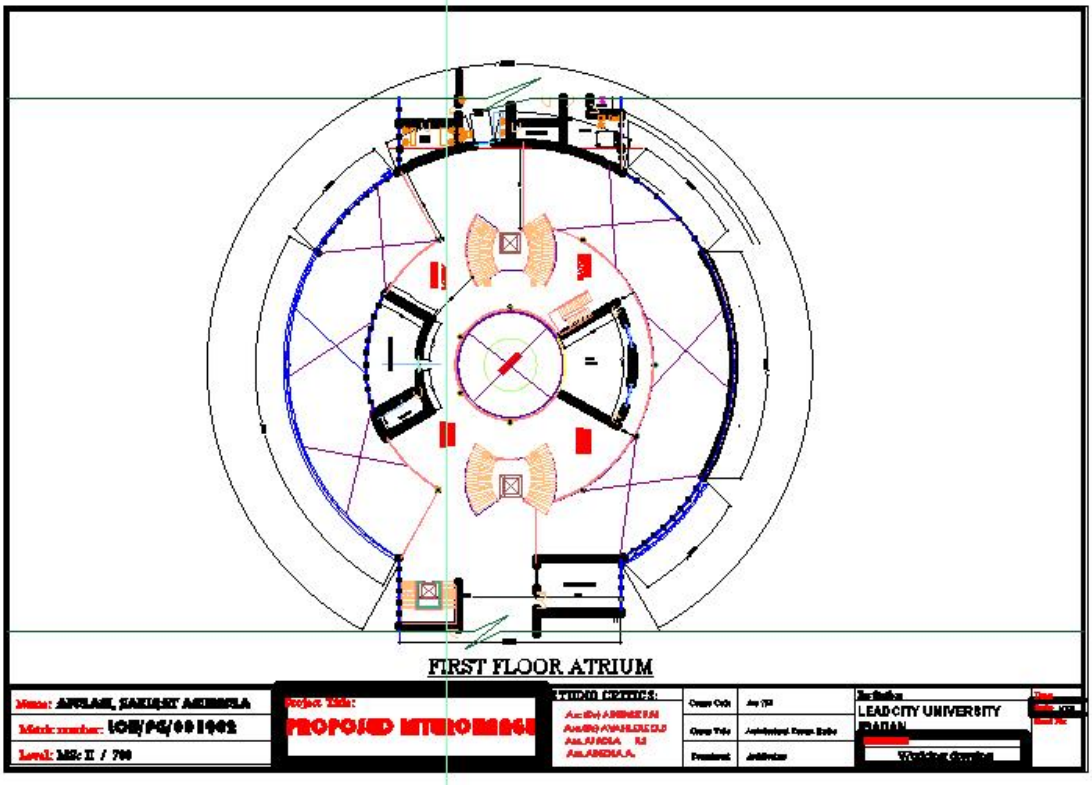
FIRST FLOOR



Drawing 17: First Floor Plan (Commercial Zone)

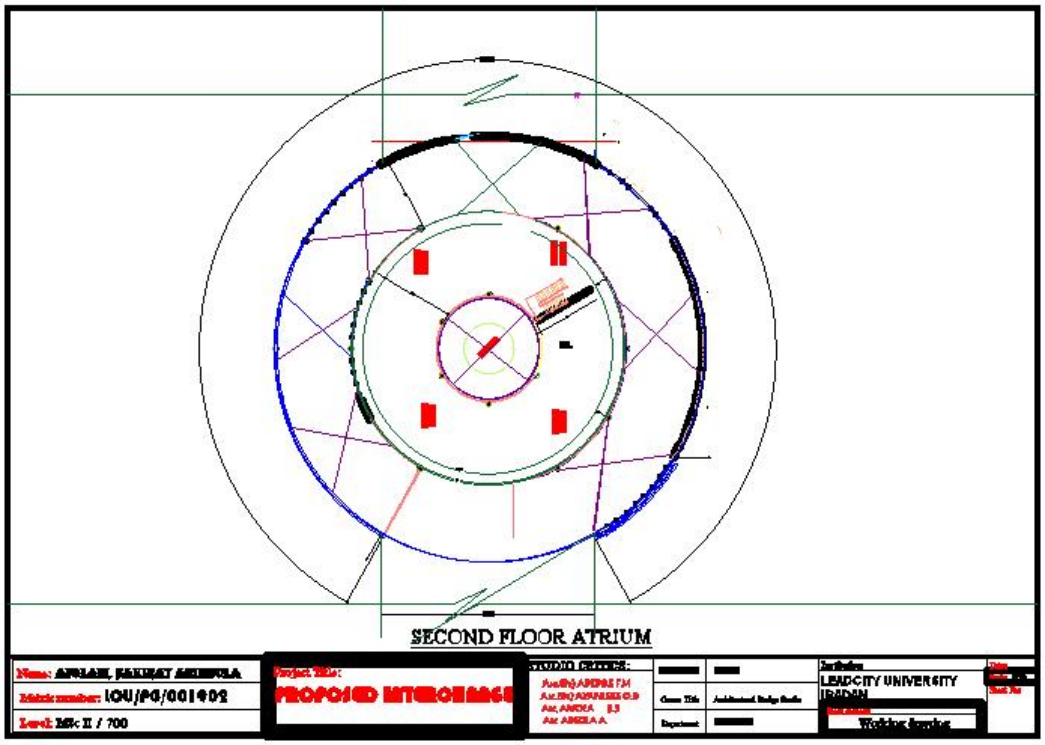


Drawing 18: First Floor Plan (Administrative Zone)

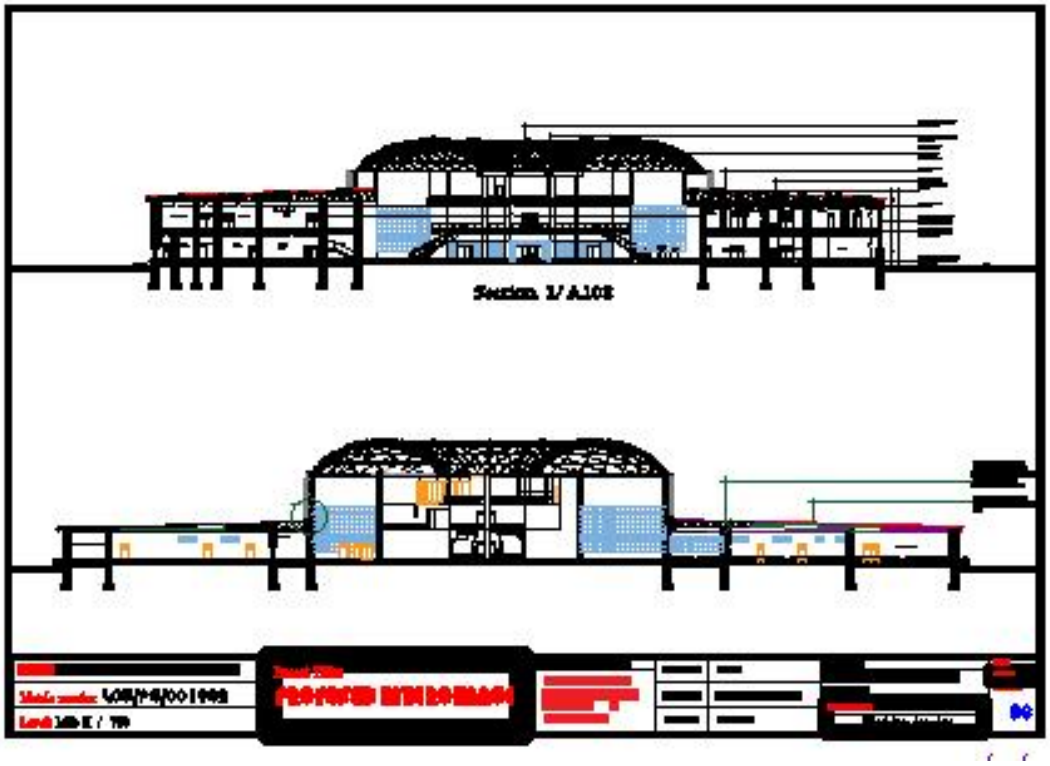


Drawing 1: First Floor Plan (Lounge)

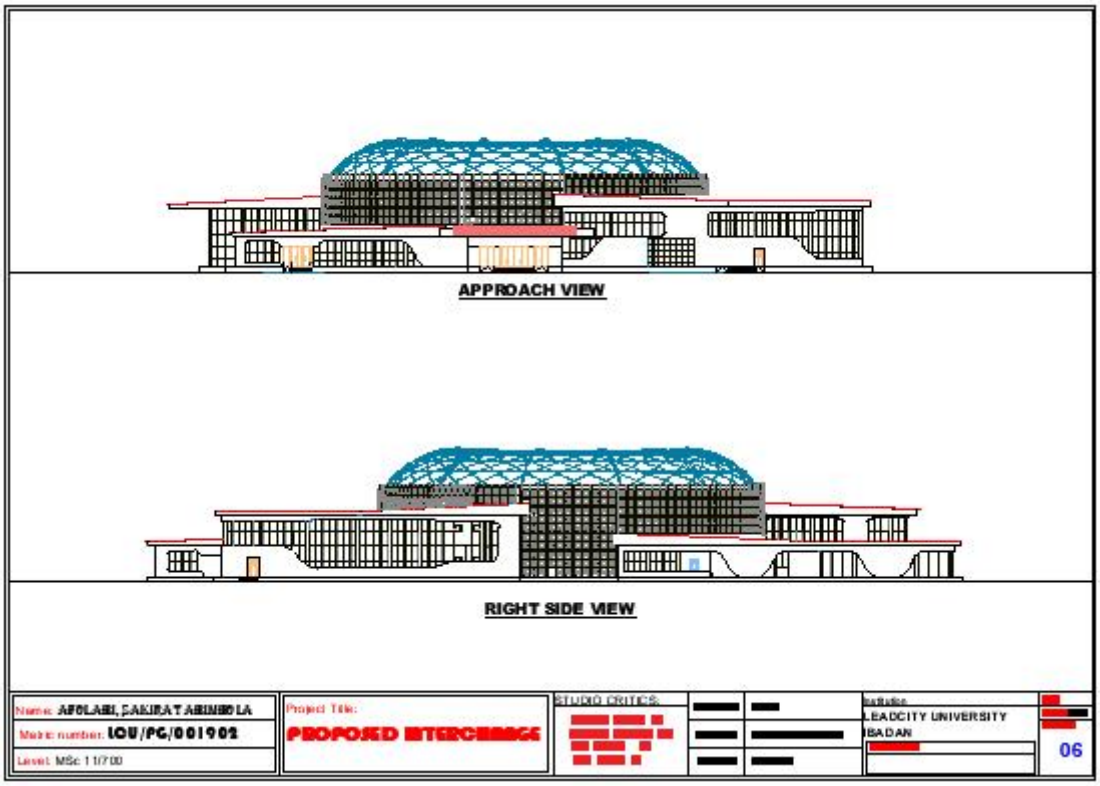
SECOND FLOOR



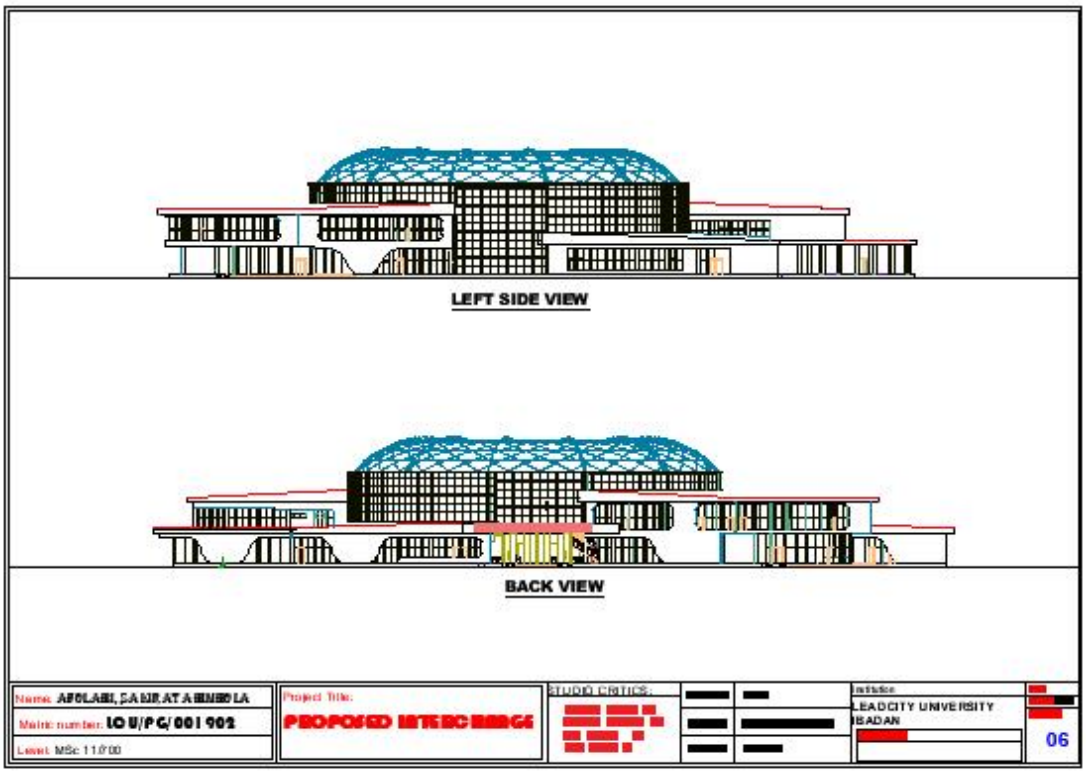
Drawing 19: Second Floor Plan (Watch Tower)



Drawing 20: Section

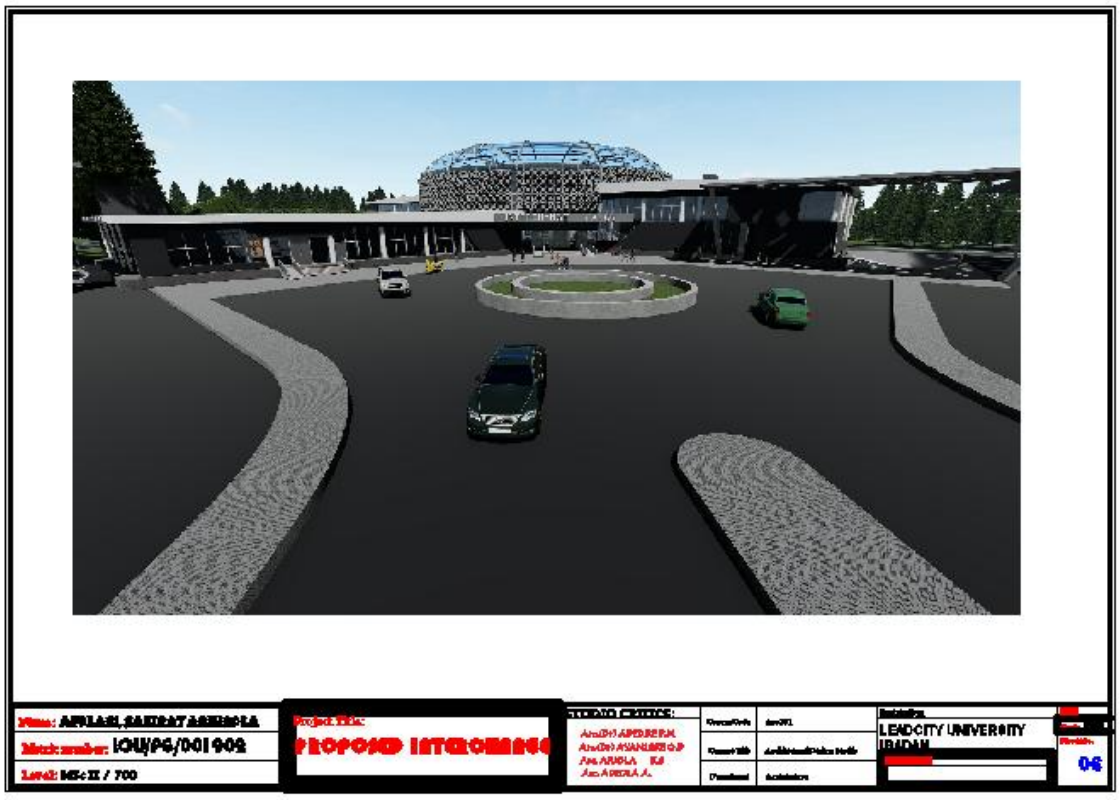


Drawing 21: Elevation



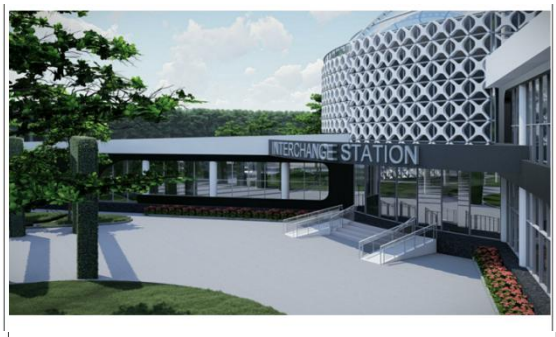
Drawing 22: Elevation

Drawing 23: Perspective



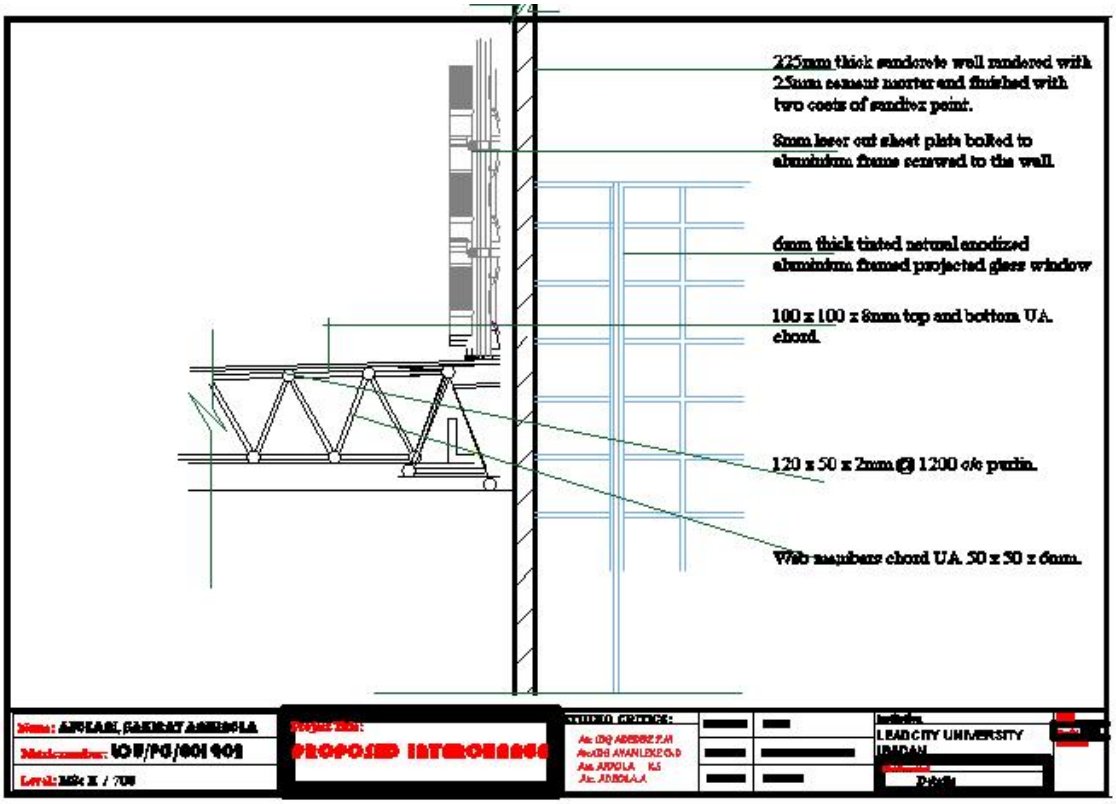
Drawing 23: Perspective

Drawing 24: 3D View

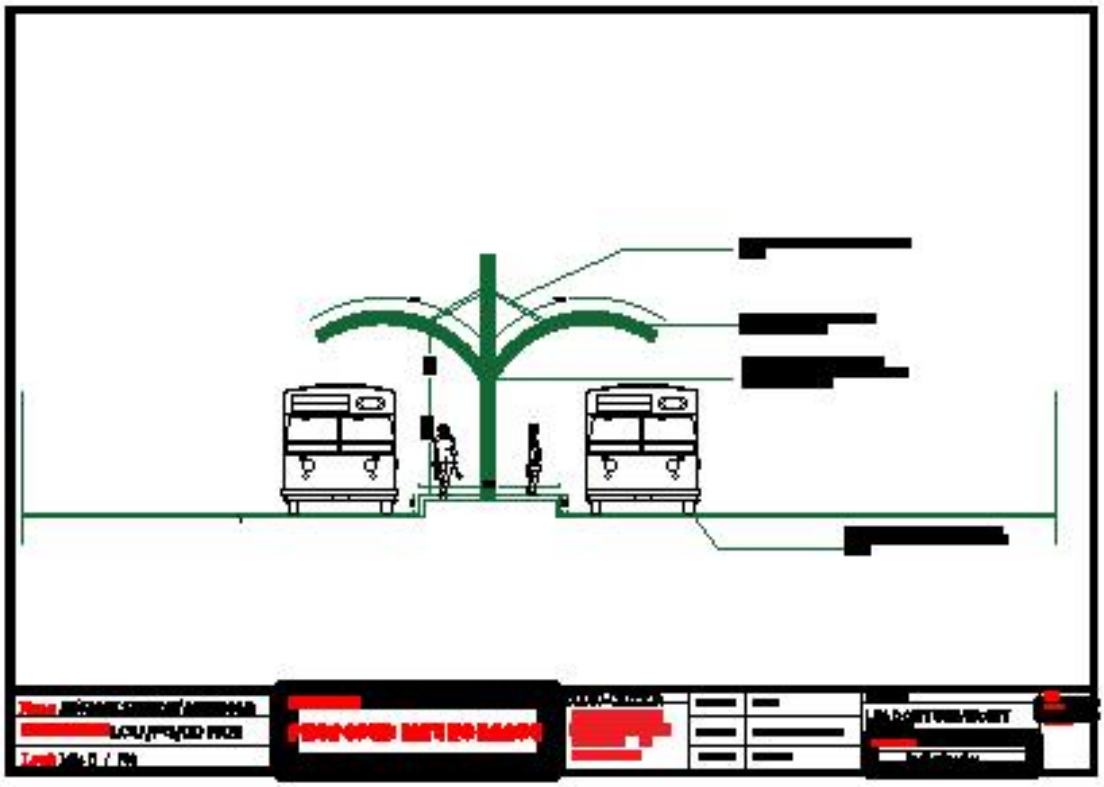


Drawing 25: 3D Views

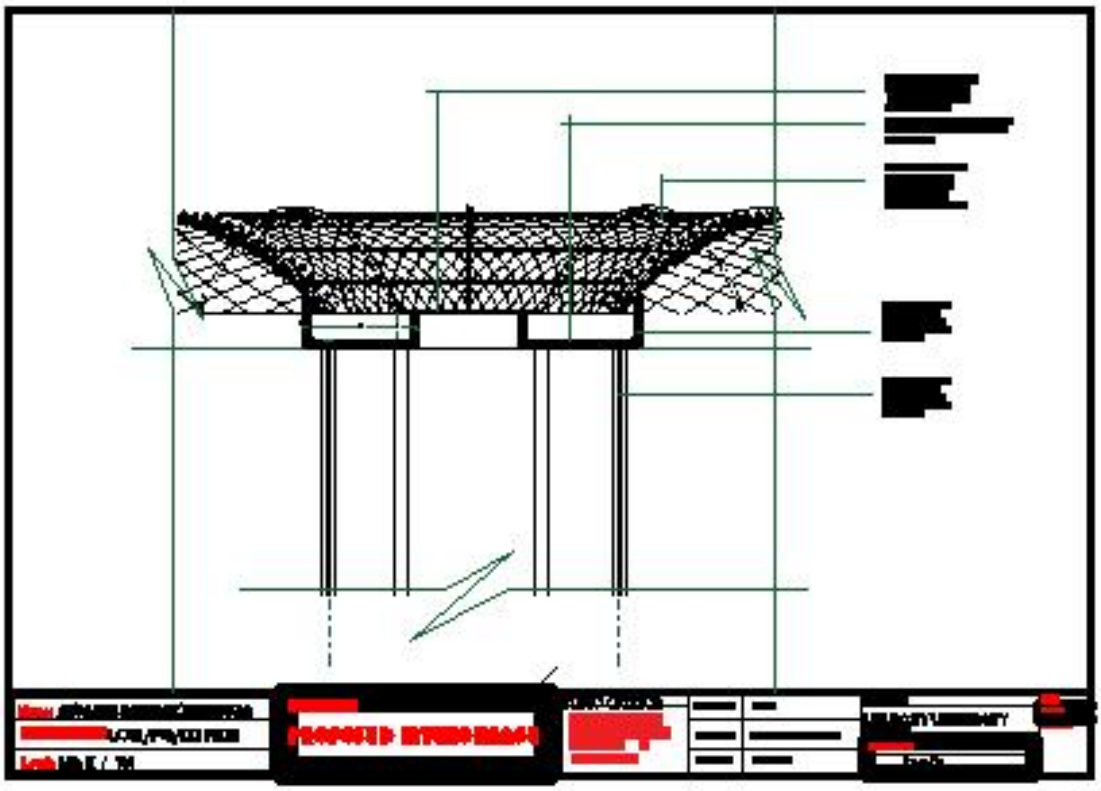
C. Details



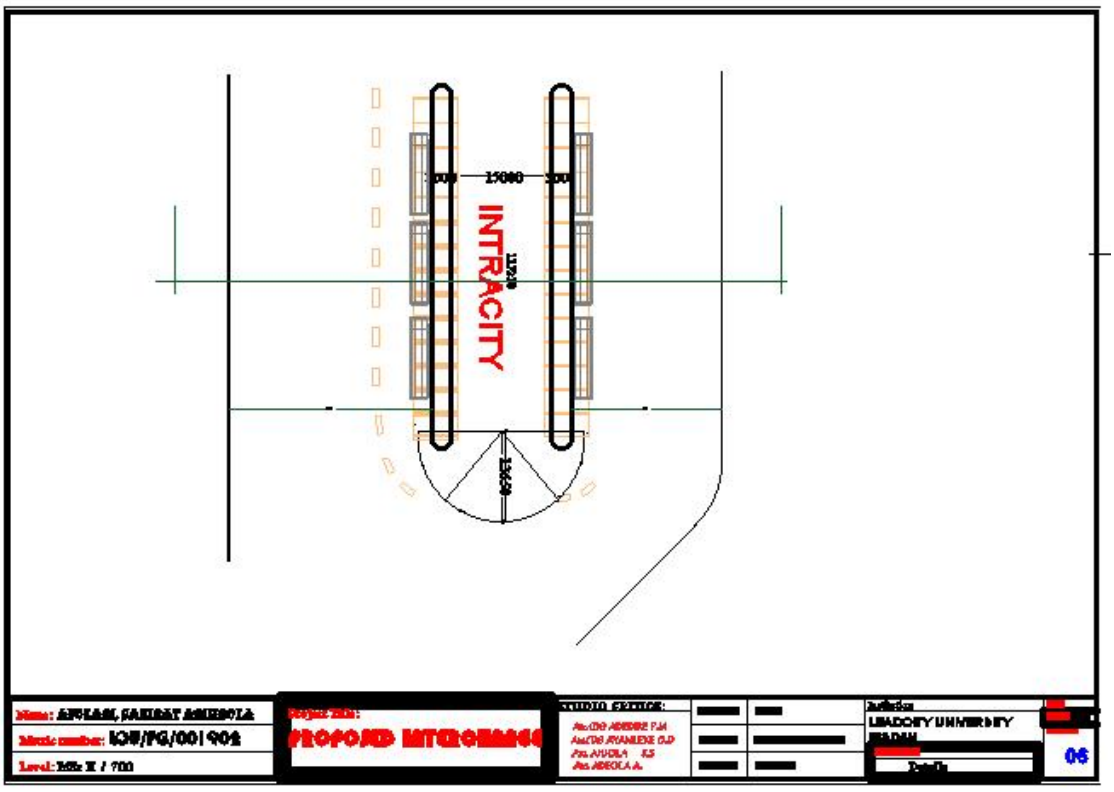
Drawing 26: Roof Detail



Drawing 27: Roof Detail at Loading-bay



Drawing 28: Space-deck Detail



Drawing 29: Turning Radius for Buses

Biodata

A. Personal Data

Name:	Sakirat Abimbola AFOLABI
Personal Home Address:	No 26, Olose Zone 2, Kuola, off Akala Express Apata, Ibadan.
Contact Address:	P. O. Box 3368, Mapo, Ibadan.
Email Address:	afolabis2020@gmail.com
Phone Number:	08055904939; 08137198650
Date of Birth:	1st July, 1974
Place of Birth:	Ibadan, Oyo State
Nationality:	Nigerian
Next of Kin:	Olufemi Sikiru Afolabi
Address:	No 26, Olose Zone 2, Kuola, off Akala Express Apata, Ibadan.

B. Educational Background with Dates

i. Institutions attended with Dates

Lead City university, Toll Gate, Ibadan, Oyo State	2020 till date
Lead City university, Toll Gate, Ibadan, Oyo State	2018 – 2020
University of Ibadan, Oyo State	2010 – 2012
Kwara State Polytechnic, Ilorin, Kwara State	1999 – 2001
Federal Polytechnic, Ede, Osun State	1995 – 1997

Queen's School, Apata, Ibadan, Oyo State	1985 – 1991
Ebire Nursery / Primary School, Felele, Ibadan, Oyo State	1979 – 1985

ii. Qualifications with Dates

Bachelor of Science (BSc) in Architecture	2020
Masters of Science (MSc) in Housing	2012
Higher National Diploma (HND) in Architecture	2001
Ordinary National Diploma (OND) in Architecture	1997
National Examinations Council (NECO)	2006
Secondary School Certificate Examination (SSCE)	1994
Primary School Leaving Certificate	1985

C. Work Experience with Dates

Principal Architect Public Buildings Department, Ministry of Public Works & Transport, Ibadan, Oyo State.	2013 till date
Principal Technical Officer Ibadan South West Local Government Universal Basic Iyaganku, Ibadan, Oyo State.	2004 – 2013
Architect Don. J Design, Oluyole Estate, Ibadan, Oyo State.	2001 – 2004
Trainee Architect (SIWES) Alag Architect, Oluyole, Ibadan, Oyo State.	1996

D. Award and Fellowship

Lead City University ASA Award	2021
Lead City University Scholarship Award	2020
Federal Polytechnic Ede NATAS Award	1996

E. Membership of Academic Professional Bodies

Graduate Member, Architect Registration Council of Nigeria

Associate Member Nigerian Institute of Architect

Graduate Member Institute of Personality Development & Customer Relationship Management

F. Publication

Maintenance Culture in Selected Public Buildings within Ibadan Metropolis

G. Referees

1. **Mr. Olalekan Adelekan**
   Executive Director, Head of Business Development,
   First Bank UK Limited.
   08086631537.
2. **Arc. 'Dayo Jikiemi**
   Director, Don J. Designs,
   Oluyole Estate, Ibadan.
   08034090882
3. **Surv. 'Kunle Ogunbadewa**
   Director, Kunle Ogunbadewa and Co.,
   Ijebu – Ode, Ogun State
   08037183109

…….. …….
Signature Date

University Compliance Form

This is to certify that this thesis by Sakirat Abimbola Afolabi with Matriculation Number LCU/PG/001902 in the Department of Architecture, Faculty of Environmental Design and Management, Lead City University, Ibadan is in full compliance with the approval of the University's format and style.

……. …….

Signature Date