Ain-Shams University
Faculty of Engineering
Department of Architecture

Influence of the Architecture Design Performance of Multi-modal Hub Passenger Transport in Egypt

By

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DEDICATION

I dedicate this thesis to…

"وَقُل رَّبِّ زِدْنِي عِلْمًا"

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Author's Declaration

I the undersigned, hereby declare that this dissertation submitted to Ain Shams University, Faculty of Engineering, Department of Architecture; is my original work and no part of it was submitted to any other institution or university to achieve any degree and that all the references to the work of other authors have been duly acknowledged.

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Esraa Hany

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List of acronyms

- **SDG:** Sustainable Development Goals
- **RRTS**: Regional Rapid Transit System.
- **ISBT:** Interstate Bus Terminus.
- **DMRC**: Delhi Metro Rail Corporation
- **The Berlin U-Bahn:** The Berlin Underground Bahn (The Berlin underground railway)
- **S-Bahn:** Schnell Bahn or Stadt Schnell Bahn (city rapid rail)
- **Hauptbahnhof**: The main or central station of a town or city.

Abstract

Transportation plays an increasingly important role in the economic and social life worldwide. The demand for mobility has become a daily activity, leading countries to adopt various types of transportation systems and adhere to their principles. These principles are then applied to the transportation system, especially in passenger transport stations. This is necessary because current conditions in passenger transport stations are plagued by social, economic, and health problems for both passengers and operators. Therefore, the study is to deduce the design guidelines for multi-modal hub stations and Propose improvements for the Egyptian case studies in Egypt, to do that the theses consist two parts , **part one** at first ,literature review and knowledge This could be done through careful surveying, analyzing, and evaluating the recently published works, papers, and books related to the major research field ,Secondly, review the importance of multi-modal hub stations and components of station areas. Thirdly analysis for three successful international case studies (Indian -Germany - British) were selected to identify the design requirements. **Part two**, analysis Egyptian case studies (Adly Mansour Transport Center hub – Badr station - Arts and culture station) and access design requirements used in Egyptian stations and existing problems and suggest design guideline for the design aspects of multi- model hub stations and assessing the Egyptian case studies. The study recommends applying the design guidelines that the study suggests developing the efficiency of the Egyptian stations and using the Internet of Things (IoT) at multi- modal hub stations. The scientific addition aimed to offer comprehensive guidelines for architectural design within the public transportation system, focusing on evaluating and proposing design guidelines for current multimodal stations (Adly Mansour Station, Badr Station, and the Arts and Culture Station in the New Administrative Capital). The goal is to enhance the design, quality, and efficiency of the current stations, as well as to provide a comfortable and safe environment for passengers. The study covers various design requirements for the architectural aspects of the public transportation system, including functional, pedestrian movement, security, safety, environmental, social, and economic requirements. It also presents a detailed evaluation of the current multimedia stations, including a comprehensive analysis, identification of strengths and weaknesses, and proposing appropriate design guidelines to improve the mentioned stations.

Keywords: Multi-Modal hub stations; Requirements for public transportation stations in Egypt; Design guidelines for multi-modal hub stations: performance efficiency for public transport stations.

Introduction

Transportation plays an increasingly important role in economic and social life worldwide, leading to a growing demand for daily mobility. As a result, countries have been seeking to implement various types of transportation systems and adhere to their principles, particularly in passenger transport stations. This is due to the existing social, economic, and health issues faced by both passengers and operators in the current conditions of these stations. Therefore, the study focused on global experiences aimed at creating a built environment that meets the needs and behaviors of its users to achieve necessary efficiency. These experiences may not be directly applicable in some countries or in Egypt due to different social, economic, and cultural dimensions, as well as humanitarian factors versus the main services provided by the state. Consequently, countries are developing their own system model to achieve efficiency in performance that is compatible with social and economic requirements, leading to a sense of satisfaction in meeting diverse needs and dealing with the multiple functions of the system. The multi-modal transit system has proven to be an effective way to accommodate diverse forms of travel demands, as it integrates all urban transportation elements into a single coordinated planning and management system for effective utilization (Christopher Blow, 2005). It provides seamless mobility and an atmosphere that allows for easy flow between public transportation and public space, boosting the city's economic situation while also establishing a social identity. The multi-modal transit hub is more than just a beginning or ending place for a journey; it also functions as a node for the community that surrounds or lives near the transit hub system. (Fatma Ibrahim, 2015) .Hubs for public transportation emerge in locations convenient for residents. To become an integrated public transportation hub, the place must be connected to other key regional hubs by the same or a different mode of transportation. (Juliane Stark, 2009) - (Deyas & Woldeamanuel, 2020). .This will reduce the fare the traveler must pay to transfer to their next form of transportation. (Bolkovska & Petuhova, 2016). The location and design of the hub are crucial to enhance passenger convenience and simplicity of travel. Additionally, the hub idea provides the nation with a valuable source of income and economic growth. Many other developing nations, such as the United Kingdom, China, and Japan, have adopted the hub model. (Dawda et al., 2019). Due to economic changes and the demand for public transportation, many public transportation hubs are currently facing challenges. As the population grows, so do the city's transportation requirements. People should plan to avoid traffic jams by switching to public transportation during rush hour, which requires reconfiguring the public transport network's transport modes and linkages. (Staley & Moore, 2012)

Problem Definition

Public transportation stations face a variety of challenges in Egypt, like in many other countries, and the common problems associated with public transportation stations in Egypt are.

1. **Overcrowding:** Public transportation stations in Egypt, particularly in major cities like Cairo and Alexandria, often face issues of overcrowding. This can lead to discomfort for passengers, longer wait times, and difficulties in boarding vehicles : Some public transportation stations in Egypt may lack proper infrastructure, such as shelters, seating areas, or designated platforms.(*Overcrowding = Accidents - Hindustan Times*, n.d.)
2. **Lack of maintenance**: Public transportation stations may sometimes suffer from a lack of maintenance, leading to broken facilities, insufficient lighting, and unsanitary conditions. These issues can have a negative impact on the overall passenger experience.(Wijaya, 2009)
3. **Limited accessibility**: Accessibility can be a significant issue for individuals with disabilities or mobility challenges. Many public transportation stations in Egypt may not have adequate provisions for wheelchair access or other accommodations, making it difficult for certain individuals to use public transportation.(*For Persons with Disabilities, Accessible Transport Provides Pathways to Opportunity*, n.d.)
4. **Safety concerns**: Certain public transportation stations in Egypt may experience safety issues, including inadequate lighting, shortage of security personnel, or occurrences of theft or harassment. These problems can affect the general feeling of security for passengers.(*SAFETY AND SECURITY IMPROVEMENT IN PUBLIC.Pdf*, n.d.)

Efforts are being made by the government and transportation authorities in Egypt to address these challenges. Initiatives include infrastructure improvements, the introduction of new transportation modes, and enhanced security measures. However, it's important to note that the specific situation can vary across different regions and cities within Egypt.

From that, the research problem was identified in several axes, which focus on the most lacking aspects of international studies and applied experiences .

- Difference and diversity in the aspects presented in the previous studies on the one hand and the applied experiences on the other hand, and the focus of most of them on specific design aspects.

- The lack of local studies of multi-modal passenger transport stations and their design requirements in general, and social and economic requirements in particular

The research problem has been identified.

The lack of previous knowledge in creating a comprehensive vision that shows the design patterns of the newly developed passenger transport stations in general and the social and economic patterns in particular, and the impact of these patterns on their local applications.

Research Questions:

As we research at multi-modal hub stations in different countries, we also need to focus on design methodology and design concepts, as evidenced by the following questions:

- What are the requirements that must be considered when designing public transportation stations?
- What are the most and least design requirements in literature review study?
- What are the guidelines for social and economic requirements?
- What is the concept of multi-modal hub stations, and what are their components?
- What are the most international case studies of multi-modal stations and what are the selection criteria?
- What are the main design requirements considered in the international case studies؟
- What are the Egyptian case studies of multi-modal stations and what is the selection criteria?
- What are the main design requirements considered in the Egyptian case studies?
- What are the expected results of the study and how were they achieved and evaluated?
- What is the expected efficiency of Egyptian stations (Egyptian case studies)?

Research Methodology

The research aims to provide a comprehensive guideline for architectural design aspects in the context of public transportation systems. The methodology of the research is based on a theoretical framework and its application in practice.

Theoretical framework: It uses the inductive method and is represented in.

Literature review and knowledge are to explore what others have found, stated, or argued about the research topic and its subject and to gain background knowledge of the research

topic. This could be done through careful surveying, analyzing, and evaluating the recently published works, papers, and books related to the major research field. However, its structure will follow a general to a specific approach. It will consist of three chapters. Firstly, careful surveying of all the published papers, books, theses, and reports will be illustrated. This published research will cover the main wide topic, the subtopic, and the specific subject of this thesis. Secondly, review the importance of multi-modal hub stations and components of station areas. Thirdly, studying and analyzing some international case studies, and successful systems, and their requirements

Practical framework It will consist of two chapters. Firstly, studying and analyzing new multi-modal hub stations in Egypt and constituent elements and their requirements to achieve efficient performance. Secondly, finding the final guidelines after being validated and analytically evaluated according to expert opinions giving weight to each main and secondary requirement of the design guidelines and assessing and propose improvements for the Egyptian case studies in Egypt.

Research Aim

Sustainable development depends on sustainable transportation since it has effects on many Sustainable Development Goals (SDGs). A full transition to sustainable transport still faces substantial obstacles, even though many conventional transport systems are evolving.(Pinheiro Rizerio Carmo et al., 2020)

For example, Sustainable travel is addressed in SDG targets 3.6 on traffic safety, 9.1 on infrastructure, and 11.2 on expanding public transport and ensuring everyone has access to safe, affordable, and dependable transportation options. Thanks to sustainable transportation's function as an enabler, several other SDGs are indirectly related and will affect up to 92% of all SDG targets being met. Figure 0

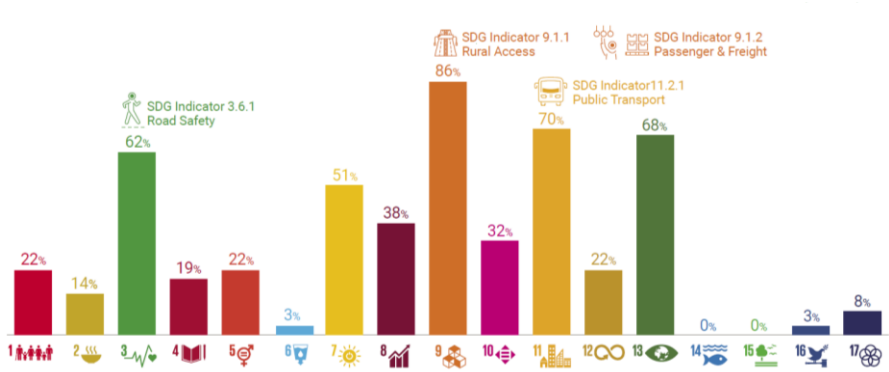


Figure 0: SDG target, **Source**:(Yatskiv & Budilovich, 2017a).

Designing a public transportation station with consideration for the sustainable development goals (SDGs) involves incorporating principles of sustainability, inclusivity, and environmental responsibility. Here are some key points to consider when designing a public transportation station aligned with the SDGs (using Sustainable Materials- Energy Efficiency- Universal Accessibility- Low-Emission Transport- Green Spaces and Biodiversity- Waste Management - Water Conservation- Digital Integration- Community Engagement- Economic Viability)

By incorporating these principles into the design of a public transportation station, you can contribute to the achievement of the SDGs by promoting sustainable and inclusive transportation.

From that, the study aim is to determine the guidelines for the design aspects of multi-model hub stations in Egypt and the extent to which these aspects can be applied, evaluating, and proposing improvements to the Egyptian stations.

Objectives

- Discussing the different researchers' opinions on design requirements of multi-modal hub stations and studying socio-economic- requirements in public buildings & public spaces and define the socio-economic requirements in multi-modal hub stations.
- Discussing background knowledge of the multi-modal hub stations, typical components of station areas, and design principles.
- Analysis Ing and determine the design requirements which used in international cases studies (India -Germany - British)

- Analyze Egyptian stations (Adly Mansour Transport Center hub – Badr station - Arts and culture station) to identify design requirements and existing problems through personal interviews with officials.
- Deduce design guidelines to enhance performance efficiency for the newly established public transport stations.
- Deduce the final design guidelines after validation, analytical testing based on expert opinions, giving weight to each main and secondary requirement, and proposing improvements for the Egyptian case studies.

The scientific addition aimed to offer comprehensive guidelines for architectural design within the public transportation system, focusing on evaluating and proposing design guidelines for current multimodal stations (Adly Mansour Station, Badr Station, and the Arts and Culture Station in the New Administrative Capital). The goal is to enhance the design, quality, and efficiency of the current stations, as well as to provide a comfortable and safe environment for passengers. The study covers various design requirements for the architectural aspects of the public transportation system, including functional, pedestrian movement, security, safety, environmental, social, and economic requirements. It also presents a detailed evaluation of the current multimedia stations, including a comprehensive analysis, identification of strengths and weaknesses, and proposing appropriate design guidelines to improve the mentioned stations.

Structure of the Research

The research consists of two units, five chapters as follows:

PART ONE: Literature Review and Knowledge

The objectives of the literature review and knowledge are to explore what others have found, stated, or argued about the research topic and its subject and to gain background knowledge of the research topic. This could be done through careful surveying, analyzing, and evaluating the recently published works, papers, and books related to the major research field. However, its structure will follow a general to a specific approach. It consists of three chapters. **First**, careful surveying of all the published papers, books, theses, and reports will be illustrated, which cover the main wide topic, the subtopic, and the specific subject of this thesis. **Second**, review the importance of multi-modal hub stations and components of station areas. **Third**, analysis

international case studies stations (Indian -Germany -British) were selected to identify the design requirements.

Chapter 1: The Concept of Intermodal Stations

The objective of this chapter is to examine what other people have discovered, said, or contended regarding the research topic and its subject. In the first chapter, the published articles, books, theses, and reports will be surveyed and reviewed. The literature review will have a broad-to-narrow stance. Within each orientation, the papers will be arranged chronologically and according to their orientations. To put it another way, papers with the same orientation will be collected and arranged in chronological order. However, the literature review will be divided into two themes. Theme one will cover literature on the Architectural Requirements of multi-modal hub stations. Theme two will cover the literature of the subtopic which is socio-economic requirements in a public building& public spaces.

Chapter 2: An Approach to Design Transportation Hub stations

The objective of this chapter is to gain background knowledge of the research topic. This chapter consists of a revision of the concept of the multi-modal transit hub, typical components of station areas, central station hubs user priorities, and design principles of multi-modal hub stations.

Chapter 3: Examples of Existing Best Practices Multi-Modal Hub Stations

Transportation is an important Infrastructure enabling Urban Mobility at both micro & macro levels. Transport is a medium that allows people to access what they want, whether for education, jobs, goods, or any other purposes. Transport promotes development in a global sense.

The final objective of this chapter is access to design requirements used at international cases studies stations. this chapter, consist of three sections of three successful international case studies (India -Germany -British) that were selected to identify the design requirements. The selection was according to several criteria; Indian public transport stations are the main mode of transport and the fourth largest and busiest transport network in the world, while the public transport network in Germany is among the best and most efficient in Europe, it is made up of several modes of transport, and best public buses and trains. The history and success of the first railways in the world in the British experience, as Britain has approximately 15,754 kilometers of railway tracks and more than 2,500 stations distributed along with the network.

PART TWO: Empirical Study

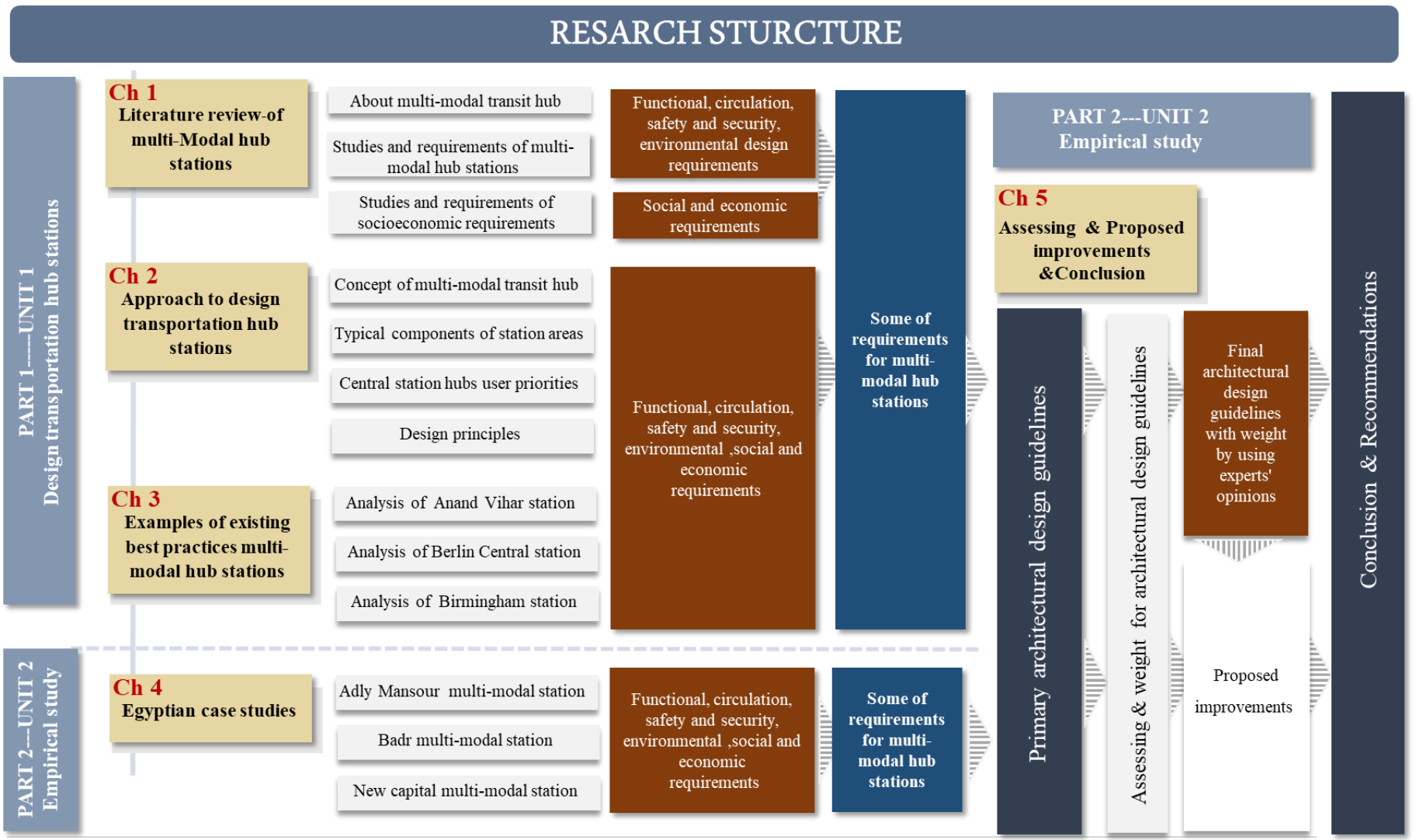
The objective of the Empirical study is to deduce a guideline for the design aspects of multi-model hub stations. This part consists of two chapters. Chapter Four are the Egyptian case studies; the objective of this chapter is access to design requirements used in Egyptian stations and existing problems through personal interviews with officials and analysis stations. Chapter Five are (Assessing & Proposed improvements & Conclusion), The objective of this chapter is to deduce a guideline for the design aspects of multi model hub stations, assessing the Egyptian case studies, and proposed improvements.

Chapter 4: Egyptian Case Studies.

The final objective of this chapter is access to design requirements used in Egyptian stations and existing problems through personal interviews with officials and analysis of stations. This chapter consists of three sections. In these sections concern identifying the design requirements in (Adly Mansour Transport Center hub – Badr station - Arts and culture station). through two steps process: a detailed qualitative and quantitative analysis of a selected local natural setting case study. This chapter includes an overview and the analysis of all aspects related to the design requirements.

Chapter 5: Assessing and Proposed Improvements.

The final objective of this chapter is to deduce and conclude the final version of the guidelines after being validated and analytically tested according to expert opinions and giving weight to each main and secondary requirement and assess and propose improvements for the Egyptian case studies in Egypt.


RESARCH STURCTURE
PART 1----UNIT 1
Design transportation hub stations
Ch 1
Literature review-of multi-Modal hub stations
About multi-modal transit hub
Studies and requirements of multi-modal hub stations
Studies and requirements of socioeconomic requirements
Functional, circulation, safety and security, environmental design requirements
Social and economic requirements
Ch 2
Approach to design transportation hub stations
Concept of multi-modal transit hub
Typical components of station areas
Central station hubs user priorities
Design principles
Functional, circulation, safety and security, environmental ,social and economic requirements
Ch 3
Examples of existing best practices multi-modal hub stations
Analysis of Anand Vihar station
Analysis of Berlin Central station
Analysis of Birmingham station
Some of requirements for multi-modal hub stations
PART 2---UNIT 2
Empirical study
Ch 4
Egyptian case studies
Adly Mansour multi-modal station
Badr multi-modal station
New capital multi-modal station
Functional, circulation, safety and security, environmental ,social and economic requirements
Some of requirements for multi-modal hub stations
PART 2---UNIT 2
Empirical study
Ch 5
Assessing & Proposed improvements &Conclusion
Primary architectural design guidelines
Assessing & weight for architectural design guidelines
Final architectural design guidelines with weight by using experts' opinions
Proposed improvements
Conclusion & Recommendations

PART ONE: Literature Review and Knowledge

The objectives of the literature review and knowledge are to explore what others have found, stated, or argued about the research topic and its subject and to gain background knowledge of the research topic. This could be done through careful surveying, analyzing, and evaluating the recently published works, papers, and books related to the major research field. However, its structure will follow a general to a specific approach. It consists of three chapters. **First**, careful surveying of all the published papers, books, theses, and reports will be illustrated, which cover the main wide topic, the subtopic, and the specific subject of this thesis. **Second**, knowledge about the importance of multi-modal hub stations and components of station areas.

Third, analysis international case studies stations (India -Germany -British) were selected to identify the design requirements. Figure 0-1

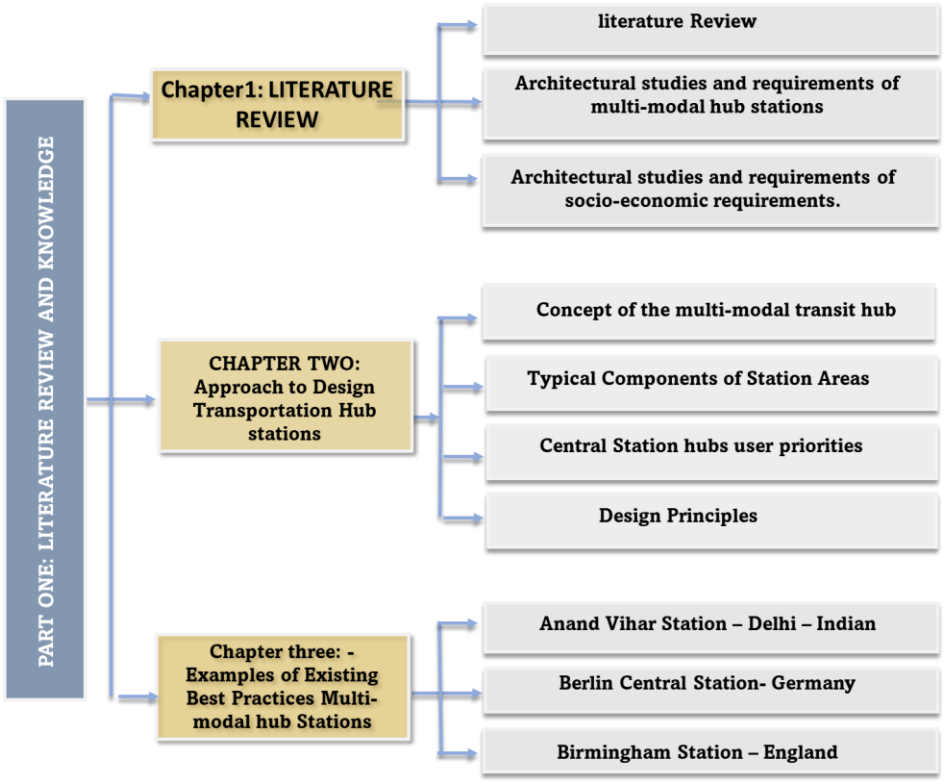


Figure 0-1: Part two structure, **Source**: Authors.

1- Chapter one: Literature Review

1-1. Introduction

This chapter's goal is to examine what other people have discovered, said, or contended regarding the research topic and its subject. The first chapter, the published articles, books, theses, and reports will be surveyed and reviewed. The literature review will have a broad-to-narrow stance. Within each orientation, the papers will be arranged chronologically and according to their orientations. To put it another way, papers with the same orientation will be collected and arranged in chronological order.

However, the literature review will be divided into two themes. Theme one will cover literature on the architectural requirements of multi-modal hub stations. Theme two will cover the literature of the subtopic which is socio-economic requirements in a public building& public spaces.

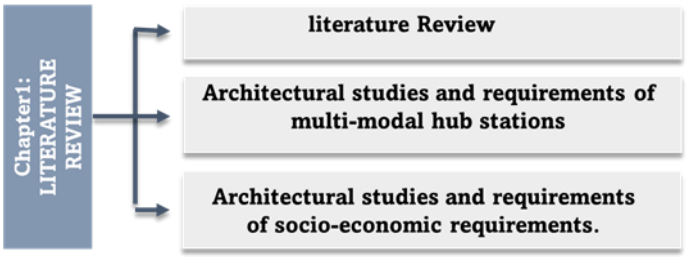


Figure 1-1: Chapter one structure, **Source**: Authors.

Finally, literature review of relevant studies related to the requirements of multi-modal hub stations. The chapter is divided into several axes,

- Identifying research database (SCOPUS database). Where the SCOPUS database is the widest and most comprehensive base in covering research papers. **Table 1-1**
- Finding keywords.
- Setting criteria to select collect and exclude papers that are out of the criteria.
- Analyzing and discussing results.
- Finding research gaps.
- Collecting papers for the gaps that have been found and analyzing it.
- Defining the conclusion of this chapter.

Table 1-1: Criteria of selection.

Filter Category	Criteria
Keyword	Multi-modal - hub stations- social economic requirements.
Language	English and Arabic
Document Type	Article and review.
Subject Area	Architecture Engineering.
Date range	Article published between 2012 and 2021
Journal categories	Scopes
Content	Full articles, Clarity of abstract, Articles that are a relevant topic

Source- Authors based on extant literature sources.

1-2. literature Review

The literature study provides an overall summary of some literature studies based on numerous research publications in the areas of multi-modal hub station design requirements and socio-economic requirements. This chapter defines multi-modal transit hubs, the requirements multi-modal hub stations, and socio-economic requirements in public buildings & public spaces.

1-2.1. Multi-modal Transit Hub

A multi-modal transportation system can be described as a system that combines more than one mode of transportation in one place, it also allows passengers to go from one point to another using several modes based on time, cost, and desired level of comfort. (Mishra & Abdul, 2018b) . Figure 1-2. Such a location that manages multiple types of transportation is referred to as a transportation hub. There are many different types of transportation, including trams, buses, cars, ships, pedestrian lanes, trains, rapid transit systems, buses, trucks, and ferries. As a result, both passenger and cargo transportation operations can be referred to as transportation hubs. Transportation hubs are anticipated to provide many benefits. They may provide services with a high frequency. The spectacular creation of an effective distribution system because of the transportation hubs' increased capacity is the second benefit. Most transportation hubs use shared transshipment facilities, allowing the public to benefit from higher-quality infrastructure at reduced prices. (simens, 2017). Because it is necessary to handle the growing flow of people and goods both inside and between metropolitan centers, transportation hubs are crucial to ensure that people and commodities are carried in a secure, effective, and ecologically responsible. (Khalifa & Fayoumi, 2012)

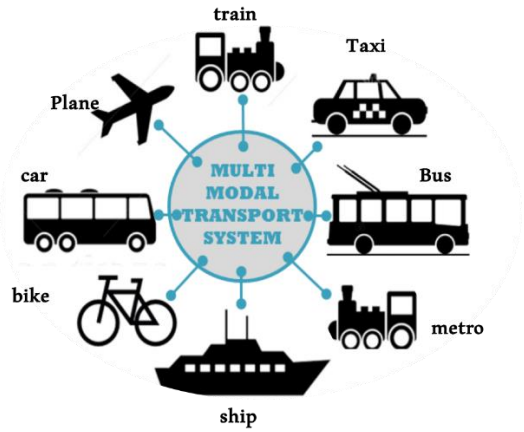


Figure 1-2: About multi-modal transit hub, **Source:** Architectural studies and requirements of multi-modal hub stations,

In this part of the chapter studies 45 articles from peer-reviewed journals about the specifications for multi-modal hub stations of multi-modal hub stations from 2010 to 2021. Figure 1-3.

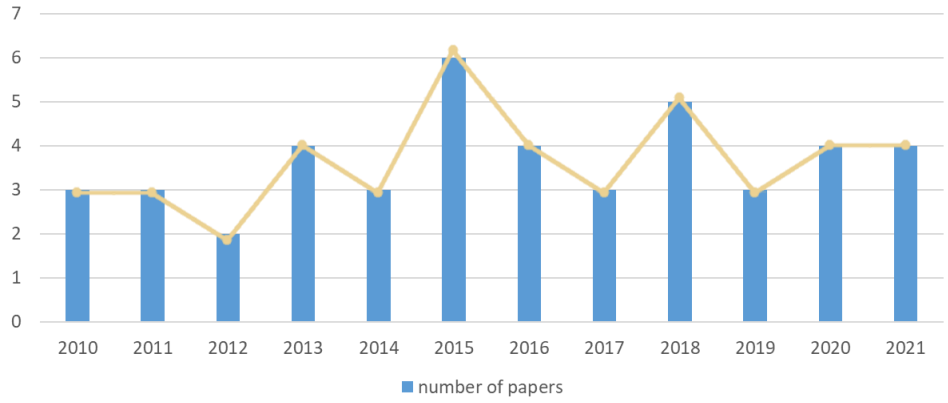


Figure 1-3: Number of articles by year of publication from 2010 to 2021, **Source**: Authors.

1-2.2. Architectural Studies of Multi-Modal Hub Stations

Multi-modal hub stations are very important parts of modern urban history where diverse modes of transportation are connected, and it serves as a gathering area for people, as well as a commercial, recreational, and cultural hub. Therefore, the design requirements for multi-modal hub stations were divided into basic groups of design requirements, each of which contains groups of peer-reviewed journal papers.

1-2.2.1. Functional Requirements Group

The research relied on different literature resources and previous studies in functional requirements in multi-modal hub station**.** Table 1-2.

Table 1-2: Literature sources discussing functional requirements in multi-modal hub stations.

	NO	Title	Authors	Year
functional requirements	1	Developing a Multimodal Transport Hub and Bus Service Improvements for Battaramulla	network rail	2022
	2	Station Design Guidance	N. Rail	2021
	3	Architecture of Train Stations: Analysis of Governing Design Components-Kenitra Station, Morocco	Tork et al	2020
	4	Requirements for Functional Integration in the Design of Train Stations	Ammar et al	2019
	5	Developing a Multimodal Transport Hub and Bus Service Improvements for Battaramulla	Waruni Jayawardane	2017
	6	Design Standards for Accessible Railway Stations	transport scotland comhdhail alba	2015
	7	Multi-modal Transport and Application Requirements in Lattakia Port	Hermez et al.	2014
	8	Model complexities and requirements for multimodal transport network design: Assessment of classical, state-of-the-practice, and state-of-the-research models	an Eck, Brands, Wismans, Pel	2014
	9	Amtrak Station Program and Planning Guidelines	Amtrak	2013
	10	Gathering Requirements for Multimodal Mobile	Baillie	2005

Source- Authors based on extant literature sources.

Literature studies examined the functional requirements of multi-modal hub stations, which focus on.

- The deterioration of local stations, particularly in terms of functional requirements such as providing necessary amenities, movement, and waiting area, as well as a lack of sustainability in the design of these stations. (Ammar et al., 2019)
- Developing the requirements of functional integration in local stations design. (Tork et al., 2020) , and incorporate user's needs and context-specific requirements into the development process. (Baillie, 2005)

- Achieving the requirements to promote good design. (Hermez et al., 2014b)-(transport scotland comhdhail alba, 2015)
- Achieving the spatial organization, the physical and visual interconnection of the station's spaces. (Rail, 2021)-(network rail, 2022)
- Providing service and recreational spaces, information areas, and ticket sales areas. (Hermez et al., 2014b)-(Waruni Jayawardane, 2017)
- Customizing service spaces for operators.
- Determining the capacity in the different spaces. (Amtrak, 2013)
- The theoretical conventional and state-of-the-art approaches do lead to unreasonable predictions of multi-modal travel behavior. On the other hand, the flexibility of the requirement of the hub station is ideally suited to explaining the projected impact of changes on travel behavior in the majority of circumstances. (an Eck, Brands, Wismans, Pel, 2014)

1-2.2.2. Circulation Requirements Group

The research relied on different literature resources and previous studies in circulation requirements in multi-modal hub station**.** Table 1-3.

Table 1-3: Literature sources discussing circulation requirements in multi-modal hub stations.

	NO	Title	Authors	Year
circulation requirements	1	Accessible Train Station Design for Disabled People	fastcoo	2022
	2	Design requirements for contextual integration for train stations (Iraqi stations as a model)	Saadoon & Com	2019
	3	Train platforming problem in busy and complex railway stations.	Bai	2016
	4	A Study towards the Efficiency of Public Transportation Hub Characteristics: A Case Study of Northern Region, Peninsular Malaysia,	Ustadi & Shopi	2016
	5	Policies to Develop Transportation Systems: Alawi Region in Baghdad City	Nsma.maan	2013
	6	Intermodal Passengers Terminals: Design Standards for Better Level of Service	Pitsiava-Latinopoulou & Iordanopoulos	2012

	7	Planning and designing for pedestrians: guidelines - public transport	Department of Transport & Department of Planning & Public Transport Authority	2012
	8	Accessible Train Station Design for Disabled People.	Great Britain. Department for Transport	2011
	9	Design of multimodal transport networks: A hierarchical approach,	Nes	2002

Source- Authors based on extant literature sources.

The literature studies of circulation requirements in multi-modal hubs outlined the primary factors that should be considered when designing the stations, which are:

- Creating methods and regulations to alleviate traffic congestion, as well as addressing how people and vehicles interact with one another.(Great Britain. Department for Transport, 2011)- (Nsma.maan, 2013)
- The need for separation circulation of people and vehicles (Department of Transport & Department of Planning & Public Transport Authority, 2012), as well as the creation of alternative solutions including the building of automobiles and pedestrian-friendly bridges and tunnels, as well as the availability of extra paths.(Bai, 2016)- (Saadoon & Com, 2019)
- Studying economic, and social dimensions and services. (fastcoo, 2022)
- Usage of technology will reduce the amount of time people have to wait in lines to buy tickets and the hub requires cutting-edge technology to support its operations because it will make users more accessible. (Ustadi & Shopi, 2016)
- Poor planning, design, location selection, and operational management practices can result in significant travel delays and malfunctions, each terminal should adhere to specified design criteria appropriate to its nature. (Pitsiava-Latinopoulou & Iordanopoulos, 2012)
- Line spacing should be 750 to 800 meters and stops should be spaced 600 to 800 meters apart, while the speed scale factor of the passenger is 1.5 to 1.67. Ideal scale factors for private transport networks should be about 3 km for access and road spacing and about 1.67 km for speed. (Nes, 2002)

1-2.2.3. Contextual Integration, Functional, and Circulation Requirements Group.

The research relied on different literature resources and previous studies in contextual integration, functional, and circulation requirements in multi-modal hub stations**.** Table 1-4.

Table 1-4: Literature sources discussing contextual integration, functional, and circulation requirements in multi-modal hub stations.

	NO	Title	Authors	Year
contextual integration, functional, and circulation requirements	1	Improved guidance on pedestrian planning and design	Austroads	2020
	2	The impact of spatial configuration on street vendors distribution at terminals	Farouk	2019
	3	The 'Foundations and Criteria's' the Integration of Transportation Systems in Large Cities' Centre's	Mohessen & Shahin	2019
	4	Key considerations for integrated multimodal transport planning Global Future Cities Program	International & Centre,	2017
	5	multimodal assess design guidelines	M Lee Corporation	2017
	6	Service performance evaluation in large railway station in Indonesia.	Caroline Sutandi & Olzon Paladan	2016
	7	Design requirements of Sustainable passengers' Land-transportation stations	Ibrahim Ali Mohammed Saad Al-Jorani Khalilali	2015
	8	From Typology Concept to Smart Transportation Hub.	Elshater & Ibraheem	2014
	9	Guidelines for preparation of integrated transport plans.	western asutralian planning connission	2012
	10	Intermodal Passengers Terminals: Design Standards for Better Level of Service.	Pitsiava-Latinopoulou & Iordanopoulos	2012
	11	Role of Hubs in Resolving the Conflict between Transportation and Urban Dynamics in GCR	Khalifa & Fayoumi	2012

Source- Authors based on extant literature sources.

Hub stations are important in addition to serving as vital economic and cultural hubs in addition to their principal role in the transportation of people and commodities, hub stations are among the significant structures that differentiate cities and give them their identity and distinctive character. In order to properly integrate its many activities, serve the community on multiple levels, and promote the use of public transit, it must be protected and developed. (Austroads, 2020)- (western asutralian planning connission, 2012)-(Caroline Sutandi & Olzon Paladan, 2016)

As the studies indicated the main elements that should be considered when designing the stations, which are:

- Intermodal terminals are a crucial component in the intermodal passenger transport chain, and their effective design may enhance the proportion of commuters who use urban public transportation while also consolidating the system in metropolitan areas. (Pitsiava-Latinopoulou & Iordanopoulos, 2012)
- The necessity of developing a thorough theoretical framework for the idea of contextual integration at multi-modal hub stations. (International & Centre, 2017)
- The requirement for integrating multi-modal transport systems in busy urban areas with a variety of purposes and activities. (Khalifa & Fayoumi, 2012)
- Relying on achieving the requirements of integration with the surrounding environment mainly. (Mohessen & Shahin, 2019a)
- Focusing on the requirements of the stations' accessibility. (Farouk, 2019). The multi-modal station's access design guidelines include simple instructions as well as minimum/maximum and suggested criteria for arranging access for vehicles, bicycles, transit, and pedestrians. (M Lee Corporation, 2017)
- Hub station designs that are environmentally friendly. There is widespread agreement among all stakeholders regarding the critical importance of safety and security, information to passengers, car parking facilities, ticket purchasing, and waiting for modes in a reasonably comfortable manner. Multi-modal stations dress the ecological, social, and economic issues in the context of their surroundings.(Ibrahim Ali Mohammed Saad Al-Jorani Khalilali, 2015)-(Elshater & Ibraheem, 2014)

1-2.2.4. Environmental Design Requirements Group.

This chapter relied on different literature resources and previous studies in environmental design requirements in multi-modal hub station**.** Table 1-5 .

Table 1-5: Literature sources discussing environmental design requirements in multi-modal hub stations.

	NO	Title	Authors	Year
Environmental design requirements	1	Multi-modal transport in the context of sustainable development of a city	Kramarz & Przybylska,	2021
	2	Design requirements of Sustainable Passengers' Land-transportation stations	Alfatlawi & Almaamouri	2019
	3	Influence of microscale environmental factors on perceived walk accessibility to metro stations	Bivina, G. R. Gupta, Akshay Parida, Manoranjan	2019
	4	A comprehensive analysis of the planned multimodal public transportation HUB	Yatskiv & Budilovich,	2017
	5	Directorate general for internal policies.	european parliment	2016
	6	An Approach to Sustainable Design of Intermodal Stations in Greater Cairo Region.	O,Emad & Din Bakry	2008

Source- Authors based on extant literature sources.

Public transportation stations are regarded as necessary for society's development, (Kramarz & Przybylska, 2021) which necessitates the integration of diverse means of transportation into a single location that allows passengers and facilities to interact. (Alfatlawi & Almaamouri, 2019) . The literature studies indicate the main elements that should be considered when designing the stations, which are:

- Achieving functional requirements mainly, in addition to focusing on the requirements of sustainable environmental design. (Kramarz & Przybylska, 2021)
- Planning the rehabilitation of all current stations with the design requirements of sustainable passenger transport stations, considering the specificity of the local aspect in these projects in terms of cultural identity. (Emad & Din Bakry, 2008)
- Reducing the operating cost and saving energy by achieving natural ventilation - natural lighting. (european parliment, 2016)
- Using recycled materials, and collection of rainwater, recycling, and increase green spaces.
- Maintaining the internal environment of the station.
- Changes in the transportation network affect accessibility difficulties, the environment around the network, and, of course, sustainable development. (Yatskiv & Budilovich, 2017b)

- The psychological and environmental factors that affect pedestrian accessibility to stations, as well as an understanding of the various aspects of users' satisfaction with pedestrian facilities, which encourages planners to support various design philosophies that will lead to a more acceptable and satisfying pedestrian environment around the stations. (Bivina et al., 2019)

1-2.2.5. Safety and Security Requirements Group.

The research relied on different literature resources and previous studies in safety and security requirements in multi-modal hub stations**.** **Table 1-6**.

Table 1-6 : Literature sources discussing safety and security requirements in multi-modal hub stations.

	NO	Title	Authors	Year
Safety and security requirements	1	Basic parameters for the design of intermodal public	Lida Margarita & María Durán Bernal,	2016
	2	Public Transport Infrastructure Manual (PTIM)	TransLink Division Public Transport Infrastructure Manual.	2015
	3	Station Design Principles for Network Rail	Rail	2015
	4	Fairfax Multimodal Transit Hub Niehoff Urban Studio Wasson Way Planning Capstone Spring 2014	Charles & Meng	2014
	5	Rail passenger perceptions of risk and safety and priorities for improvement	Thomas et al	2005
	6	Inclusive Design Guidance-Ticket Sales	Rail	------

Source- Authors based on extant literature sources.

The stations must be designed to accommodate peak passenger movement, as well as to permit safe and efficient entry and exit, in addition to the methodical, safe, and efficient collecting of passengers at the station (Rail, n.d.). From that, the studies emphasized the need to apply safety and security requirements in the designs of passenger transport stations through the following: (TransLink Division Public Transport Infrastructure Manual., 2015)-(Charles & Meng, 2014)

- Stations' design should promote passengers' security.
- Accident risk should be reduced by station design.(Rail, 2015)

- The security and safety of stations should not rely on technology.
- When changing modes of transportation, a passenger's experience may be impacted by a number of variables, including the availability of amenities, travel and waiting times, accurate and readable information, and a sense of safety and security. (Thomas et al., 2005)

Additional factors need to be considered , such as prioritizing foot flows, making extensive use of travelators, and sustainability-related factors.(Lida Margarita & María Durán Bernal, 2016)

1-2.3. Architectural Requirements of Multi-Modal Hub Stations

The requirements of a multi-modal hub are formed from five main requirements, these requirements included (functional requirements, circulation requirements, security and safety requirements, environmental design requirements, and social and economic requirements). **Table 1-7**

Table 1-7: Classification requirements of multi-modal hub stations

Basic Requirements	Secondary requirements
Functional requirements	• Connecting different types of transportation in one place
	• Passenger flow from arrival to departure should be considered when designing the station, and make sure that each phase of the passenger's journey is as seamless as possible.
	• Each function needs its own space, which should be distributed based on the importance of each function. The most space must be dedicated to free circulation.
	• Functional integration according to social and environmental changes, and providing service and commercial spaces
	• Optimal use of space
	• Design spaces, and platforms according to the number of passengers at peak hours
	• Provide usability requirements
	• Considering the individual's share in the different spaces.
	• Provide special spaces for operators
	• Physical, visual interconnection, and aesthetic form.
	• Maintain visual/aesthetic continuity with the rest of the system while incorporating site-specific aspects.
	• Provide sufficient space for movement and waiting.
	• Providing horizontal and vertical movement.

Circulation requirements	• Considering people with special needs.
	• Separation of automobile and pedestrian traffic.
	• Reducing walking distances.
	• paths should be as straightforward as feasible.
	• Station's design must allow for free-flowing passenger to avoid severe congestion within the station, particularly on platforms and escalators.
	• Passenger movement should be unimpeded from the moment they enter the station until they leave.
	• Using technology will reduce the amount of time people have to wait in lines to buy tickets
	• Create a clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation (entry-tickets-waiting-departure).
Environmental design requirements	• Using biophilic design to achieve a comfortable healthy environment inside the station.
	• Using local materials that are resistant to weather conditions and recyclable.
	• Rainwater collection and reuse.
	• Reducing the operating cost and saving energy.
	• Increasing green spaces inside and around the station.
	• Respect the privacy of the site.
Safety and security requirements	• Station design should promote security for the passenger.
	• Accident risk should be reduced by station design.
	• The security and safety of stations should not rely on technology.
	• Pedestrian paths shall be direct, and well-lit.
	• Slip-resistant walking surfaces.
	• Controlling entrances and exits.
	• Protection of personal property.
	• maintenance requirements.
	• Provide emergency requirements.
	• Providing a safe for users and protection from weather conditions.
Socio-economic requirements	• Providing investment and rental spaces.
	• The link between production and consumption areas.

Source- Authors based on extant literature sources.

The results of previous studies showed that there is a discrepancy in achieving design requirements, as (functional requirements) were the most fulfilled criterion out of all the others, followed by the (circulation requirements), followed by (environmental design requirements)

and then (safety and security requirements), while each of (social and economic requirements) achieved the least of design requirements.

1-3. Architectural Studies and Requirements of Socio-Economic Requirements.

Socio-economic requirements in multi-modal hub stations achieved the least of design requirements while socio-economic requirements have taken interest in public buildings & public spaces. (Equality and Human Rights Commission, 2018) from that, an analysis of 15 peer-reviewed journal papers on socio-economic requirements from 2000 to 2021. Figure 1-4

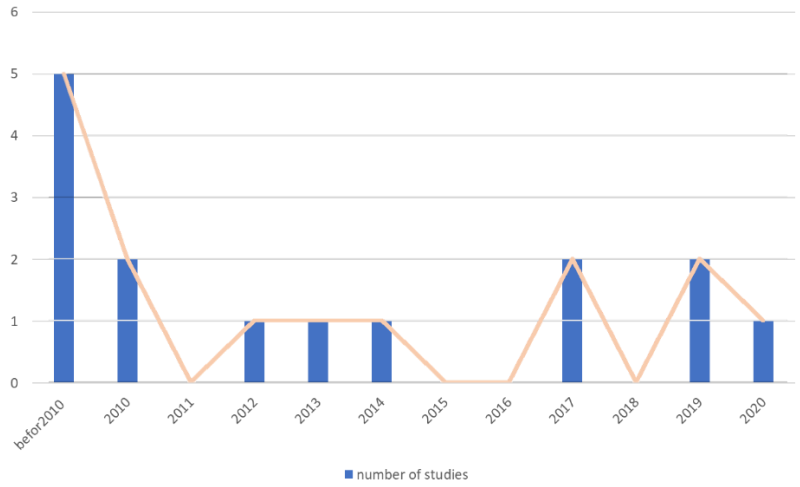


Figure 1-4: Number of articles by year of publication from 2010 to 2020, **Source**: Authors.

1-3.1. Architectural Studies of Socio-Economic Requirements in Public Buildings & Public Spaces.

This chapter relied on different literature resources and previous studies in socio-economic requirements in public buildings & public spaces. Table 1-8

Table 1-8 : Literature sources discussing Socio-economic requirements in public buildings & public spaces.

	NO	Title	Authors	Year
contextual integration	**1**	Social Sustainability Concepts and Benchmarks STUDY Requested by the EMPL committee	McGUINN	2020
	2	Economic, environmental, and social aspects of buildings' refurbishment - A case study	Zygmunt & Piczulski	2019

	3	The Mutual Effect between Design of Space Building and Escape Paths	Adel abass	2017
	4	Mutual influence between urban planning and human behavior in urban communities.	Yousri A. Azzam	2017
	5	Socio Economic Benefits of Commercial Plazas in Faisalabad City.	Kamboh et al	2014
	6	The resource for the evaluation of Socio-Economic Development	G. to the evaluation of S. Development	2013
	7	Socio-economic Development and Empowerment of Disadvantaged Groups	national institute of open schooling	2012
	8	Socio environmental impact in eco-architecture	I. Ibrahim	2010
	9	Socio Economics aspects of Architecture and Planning	Archi-fied,	2010
	10	Building-centred community development as a method to promote social, environmental, and economic sustainability	Floras Phelps et al	2007
	11	A literature review of the social, economic, and environmental impact of architecture and design	McIntyre & Scotland. Social Research	2006
	12	Economic Principles of Sustainable Construction Link to publication record in Manchester Research Explorer Citation for published version (APA)	The University of Manchester Research	2003
	13	A Guide to Socioeconomic Assessments for Ecoregion Conservation two primary goals of socioeconomic assessments.	wwf	2000
	14	Economic, social, and environmental sustainability in development theory and urban planning practice	A. D. Basiago	2000
	15	Human rights requirements to social and economic development,	A.Eide	1996

Source- Authors based on extant literature sources.

The primary factors that should be considered are, according to literature reviews, socio-economic requirements in public buildings and public spaces.

- Studying social-economic and human development ideas, increasing people's choices, and raising levels of well-being. (national institute of open schooling, 2012)-(The University of Manchester Research, 2003)
- Focuses on the economics of sustainable architectural design by clarifying the role that architectural design can play in contributing to the many cost-effective solutions that connect the building to the environment (Development, 2013). Ensuring the application of the concepts of sustainable design, and achieving economic, social, and environmental efficiency. (wwf, 2000)- (McIntyre & Scotland. Social Research., 2006)-(Zygmunt & Piczulski, 2019)
- Study human behavior (Ibrahim, 2010). and, investigating how behavioral changes brought about by urban and architectural changes. (Yousri A. Azzam, 2017)-(Adel abass, 2017)
- The promotion of human rights and development, two objectives that are closely interwoven in the United Nations Charter, are currently being worked on. This is particularly clear in the United Nations general assembly's 1986 adoption of the declaration on the right to development.(Eide, 1996)
- By adopting more all-encompassing tactics, community development may encourage growth that is healthier and more sustainable. Buildings, which are an integral component of a community, offer a possibility to positively impact the development of that community. (Floras Phelps et al., 2007)
- Social sustainability planning must encourage people's cooperative as opposed to competitive impulses. (Basiago, 2000)
- Social and economic factors have an impact on people's behaviors. Among the many social components are:
    - Population density will affect quality of life.
    - Age group - different age groups have different habits.
    - Degree in literacy
    - Various civilizations and customs

These determine societal culture which have an impact on planning and architecture, either directly or indirectly. (Archi-fied, 2010)

The best way to make money and gain several social and economic advantages for the advancement of a nation is through shopping malls. People improve their quality of life by being inspired by the appealing shopping malls, which should be created by investors to make money. (Kamboh et al., 2014)

1-3.2. Socio-Economic Requirements in Public Building& Public Spaces.

literature studies of socio-economic requirements in public buildings & public spaces focus on some basic and secondary requirements (McGUINN, 2020) . Figure 1-5

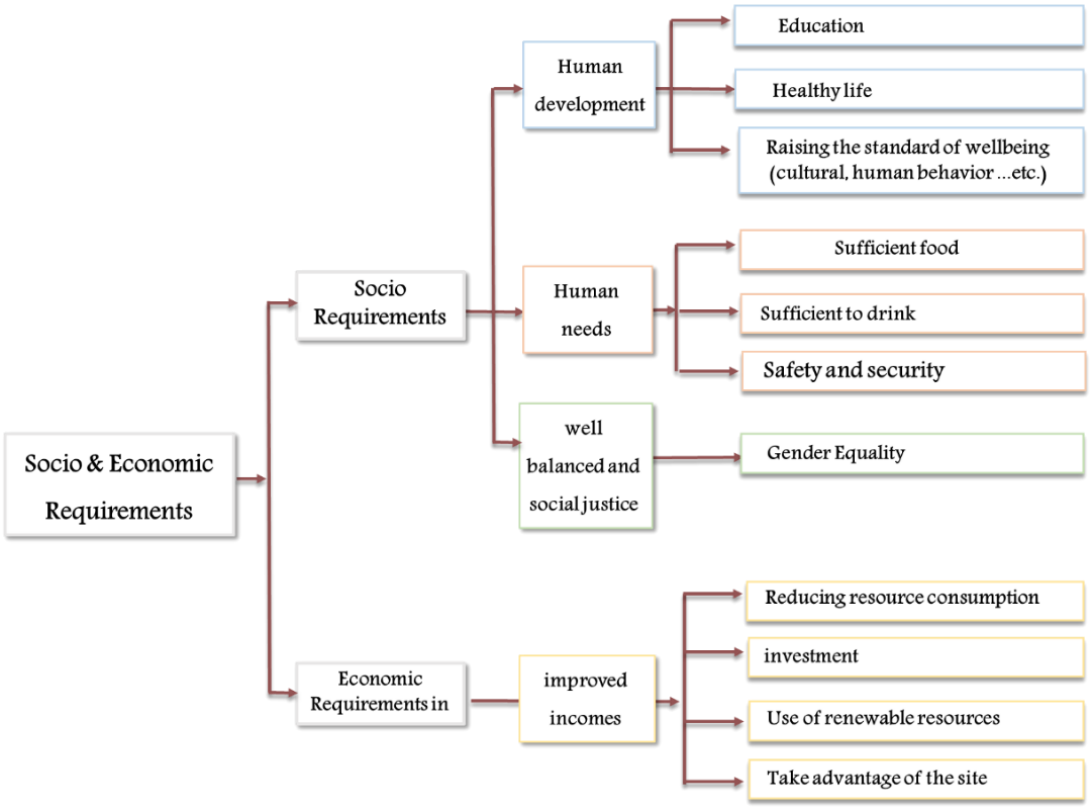


Figure 1-5 : Socio-economic requirements, **Source**: Authors based on extant literature sources.

The results of previous studies on socio-economic requirements showed that many requirements must be considered.

- Socio requirement (human development- well balanced and social justice- humanitarian needs)
- Economic requirement (improved incomes – upgrade what is available)

1-4. Conclusion

In this chapter, an effort was made to identify the aspects of socio-economic requirements in multi-modal hub stations.

The literature studies produced some of the design requirements of multi-modal hub stations, the following were reached:

- The chapter consists of requirements that were drawn from a Literature review of multi-modal hub stations. These requirements included (functional requirements, circulation requirements, safety and security requirements, environmental design requirements, and social and economic requirements). Figure 1-6

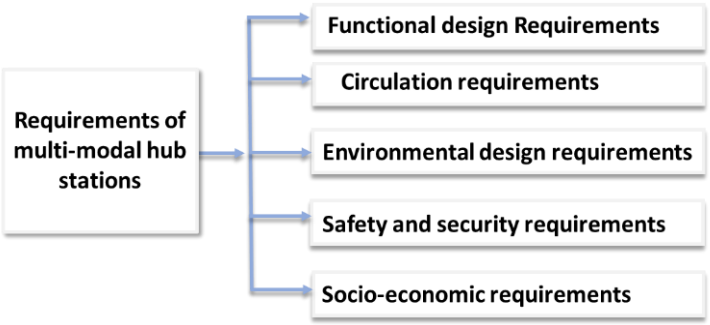


Figure 1-6 : Main requirements for multi-modal hub stations, **Source;** Authors based on extant literature sources.

- Despite the diversity and multiplicity of design requirements for multi-modal hub stations, and deficiency in previous knowledge in creating a theoretical vision that explains the social and economic requirements of multi-model hub stations. Therefore, the designs of multi-modal hub stations consider the following requirements: **Table 1-9**

Table 1-9 : Socio-economic requirements in multi-modal hub stations.

Main socio-economic requirements		**Secondary socio-economic requirements**	**Basic requirements in multi-modal hub stations**
Socio requi	**Human development**	Education	Awareness and education
		Healthy life	
		Raising the standard of well-being (cultural, human behavior ...etc.)	Providing the people with multiple choices.

	Well-balanced and social justice	Gender Equality	N/B
	umanitarian needs	Availability of food	providing service (cafes and restaurants).
		Availability of drinks	
		Safety and security	Achieve safety and security requirements.
Economic requirement	**improved incomes**	Take advantage of the site	Achieve environmental design requirements.
		Reducing resource consumption	
		Use of renewable resources	
		investment	providing service and commercial spaces
	Upgrade	Reconsidering available resources	Reconsider the resources and capabilities available

Source- Authors based on extant literature sources.

- The results of previous studies of socio-economic requirements in multi-modal hub stations outline the primary factors that should be considered when designing the stations, which are:
    - Achieve environmental design requirements (take advantage of the site- reduce resource consumption- use renewable resources- use local materials and recyclables- rainwater collection and reuse- reduce the operating cost and save energy- increase green spaces inside and around the station…. etc.).
    - Achieve safety and security requirements (promote security for the passenger- minimize the possibility of accidents- safe and secure without depending on technology- slip-resistant walking surfaces -provide emergency requirements…. etc.).
    - Increase investments by providing service and commercial spaces.
    - Awareness and education of people
    - Achieve social justice.
    - Raising the standard of well-being (cultural, human behavior ...etc.)
    - Providing the people with multiple choices.

2- CHAPTER TWO: An Approach to Design Transportation Hub Stations

2-1. Introduction

The station planning and design guidelines aim to provide a process that facilitates station planning while also providing comprehensive design guidelines to ensure consistency and clarity in station design. Determine the guidelines for designing practical, efficient, and well-coordinated station areas. The guidelines give the reader a complete grasp of the methodologies and requirements by guiding them from the more basic goals and objectives down to the specific building blocks that help in fulfilling the common system demands.

Stations nowadays must combine the demands of their patronage with continuous operation and maintenance expenses. A specific revenue stream is also essential. Integration into a comprehensive multi-modal connectivity framework and connections to other types of connectors, such as sidewalks and designated bicycle lanes, interstate highways, trolley, and bus station systems, are just a few of the important elements that contribute to a station system's success.

The objective of this chapter is to gain background knowledge of the research topic. The chapter consists of a revision of the concept of the multi-modal transit hub, typical components of station areas, Central Station hubs user priorities, and design principles of multi-modal hub stations. **Figure 2-1**

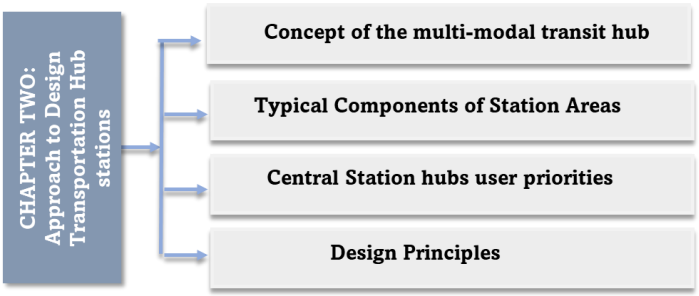


Figure 2-2: Chapter two structure, **Source**: Authors.

2-2. Concept of Multi-Modal Transit Hub

Multi-modal transit hubs are defined as efforts aimed at increasing the general level of commuter services and encouraging utilization of public transportation. Integration refers to the operation of all modes and types of transportation as a single 'Seamless' entity for commuters'

sake and the system in its entirety. (Emad & Din Bakry, 2008) Effective service planning and design may make this happen so that when a change of mode is required, passengers can benefit from convenient interchange facilities that are safe, comfortable, and well-maintained in addition to decreased wait times. (Pinheiro Rizerio Carmo et al., 2020)

Travel time and cost, the distance from house to public transport, and the distance from home to work are some of the elements that affect users' decisions to convert from private automobiles to public transport. In order to accommodate passenger demand, modern transportation must be effective, sustainable, and functionally integrated. (Kandee, 2004). The hub transit system needs to improve the calibers of its offerings in order to persuade more people to switch to public transport. (Crozier, 2005) Nodes, terminals, and locations are possible components of a transportation system. These three components can be optimized, integrated functionally, and controlled more effectively by design and reorganizing the basic relationship components. (Kaveh et al., 2021)

2-2.1. Advantages of Multi-Modal Transit Hub

Multi-modal transportation has several advantages that make it one of the most widely used systems in the world. These benefits include: (fastcoo, 2022)

- Address existing and future needs.
- Moving from one transportation to another.
- Unified fare collection system.
- Effortless switching between modes.
- Reducing spillover of passengers to adjacent areas and preventing unofficial transportation activity.

2-2.2. Disadvantages of Multi-Modal Transit Hub

Despite the numerous advantages provided by the multi-modal transportation system, it does have some disadvantages, such (Shakil, S. M. Mostafa, 2018)

- Certain legal and operational limits due to variances in international standards.
- High security needs are due to regular inspections by authorities at stations or other roads.
- In the transportation sector, there may be a lack of technological advancements.

2-3. Typical Components of a Station.

The arrival area and the transit area from the entrance onto the station platforms are shown in this section. All access/arrival modes lead to the station and platform area. In the "arrival

zone," the user joins the station experience and dons the hat of a traveler. The goal is to reach the selected place, which is accessible from the station platform, even though there are other methods to get there. The station and platform are consequently included as the second element of the "travel zone" sequence. The station system's multiple "arrival zone" and "transit zone" elements work together to provide users with a logical, clear-cut, and smooth movement.((*3.4.1.2)Station Design Guidelines Final 122309*, n.d.) **Figure 2-3**

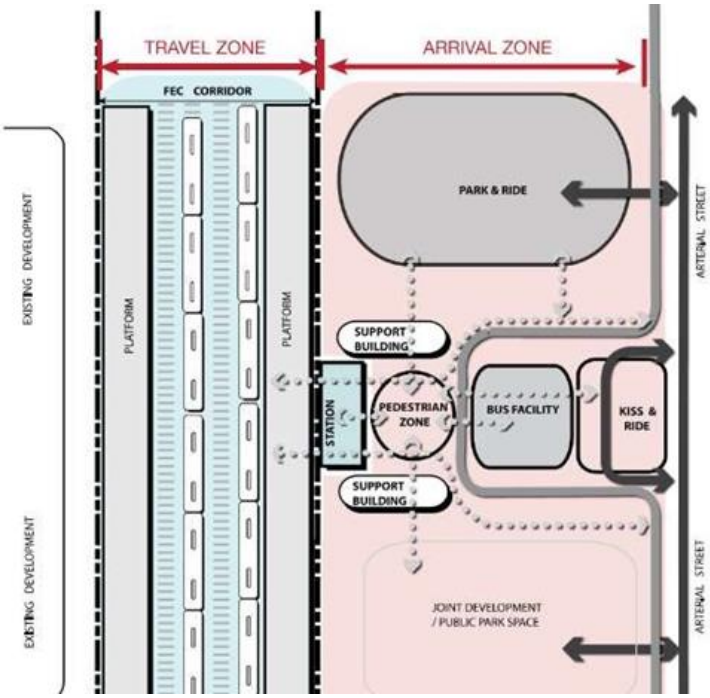


Figure 2-3 : The functional diagram for the arrival zone and departure zone, Source**:** Station Design Guidelines by Gannett Fleming, Inc,2012

2-3.1. Arrival Zone

Stations frequently host "thousands of individual departure and arrival ceremonies." Most of the station experience takes place in the "arrival," or entry, and the "exit," or "travel zone." The arrival zone is the initial part of the station experience, and as various user types will use different modes of transportation to get there, each person's entrance into the station area will be different. The following components make up the arrival zone; pedestrian access is given first priority, followed by bus/station circulation, park and ride access, and then pedestrian access. (Mohessen & Shahin, 2019b)

2-3.1.1. The Pedestrian Zone: Nodes and Circulation Network

Since all users must reach the station and platform area on foot, pedestrians are the most crucial element of the arrival zone. Additionally, the pedestrian zone must convey a feeling of place and blend in with its surroundings. A network of street-level walkways connected with gathering points and places makes up pedestrian zones.

A pedestrian node, also known as a plaza, is the area of a station where people who are coming by various modes, such as buses, bikes, and walkers on foot, congregate and can engage in common activities like dining and people-watching before transferring to the platform for their train. It is imperative to provide protection for commuters who are waiting on sidewalks and in other waiting areas whenever possible. The station area might be enhanced by supporting retail and other commercial uses that boost foot traffic and offer station users services. Outdoor dining areas and cafés spur more activity, which enhances the station area's appearance and usability.(*(3.4.1.2)Station Design Guidelines Final 122309 - [PDF Document]*, n.d.)

A focal point, like a water feature or a piece of art, aids in drawing attention to both the plaza and the station entrance. The design of the pedestrian node may also include shade trees and other landscape features, but they must not obstruct the main circulation path that passengers take to reach the station.

In addition to framing the space by establishing a sense of enclosure, trees and garden beds can offer shaded spaces for meeting and seating. This will help to create an ambiance that is more intimate and reminiscent of a cozy courtyard. Figure 2-4

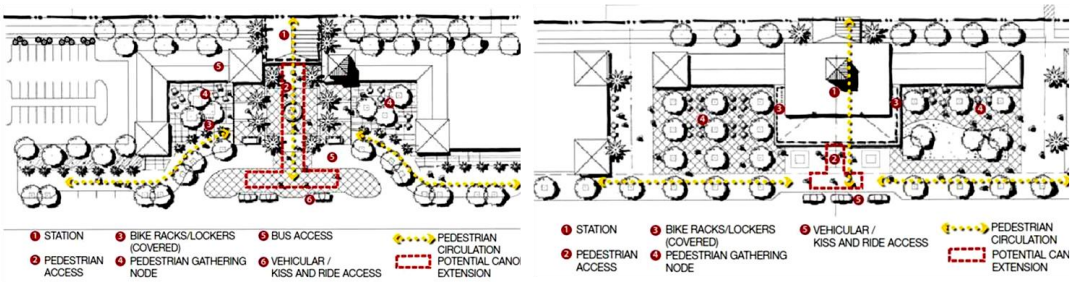


Figure 2-4 ; The gathering space's typical functional diagram in the pedestrian zone, Source: Station Design Guidelines by Gannett Fleming, Inc,2012

2-3.1.2. The Bus Drop-off

After pedestrian circulation, bus/station circulation is given precedence in terms of accessibility. Bus Drop-Offs, which are found at significant job centers, act as key entry points because they transport more people at predetermined times**.**

The bus drop-off point should be located closer to the station entrance. In order to prevent bus waiting from impeding pedestrian movement at station entrances, it should be big enough to hold at least one to two bus lengths (perhaps more depending on the specific station and site factors). When it's feasible, pedestrian waiting areas and the walkways that connect bus drop-off platforms to the station should be covered to protect passengers from the elements (rain, sun, etc.). The following elements should also be considered when planning bus entry and circulation into station areas.

- The circulation of the bus lane should be in one direction, anticlockwise. Avoid two-way circulation whenever possible.
- To allow layover buses to move to their designated positions, bus storage lanes need to be placed close to and visible from the bus bays.
- It's best to avoid using the bus lane as a pedestrian crossing. Crossings ought to be put at the end of the bus staging zones if they can't be avoided. In order to lessen conflicts between buses and passengers, vertical circulation components like pedestrian bridges can also be implemented.*((3.4.1.2)Station Design Guidelines Final 122309 - [PDF Document]*, n.d.)
- Use of appropriate signs, lighting, and landscaping enhances the transfer process's smoothness, safety, and enjoyment. Figure 2-5

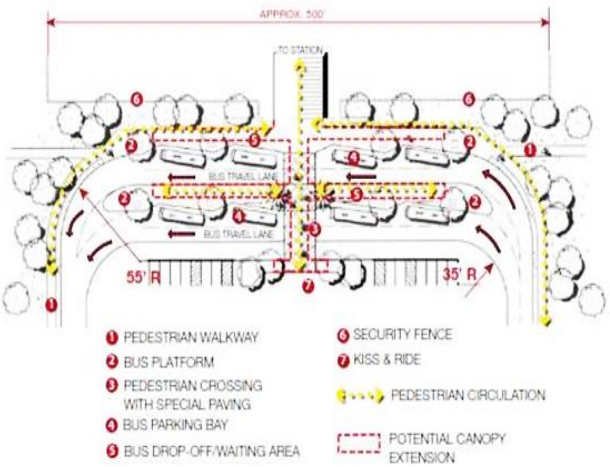


Figure 2-5 : Diagram of a typical bus drop-off, Source: Station Design Guidelines by Gannett Fleming, Inc,2012

2-3.1.3. The Vehicular Drop-off: Kiss and Ride

Like bus drop-offs, vehicle drop-offs serve smaller-capacity vehicles like cars, vans, taxis, shuttles, and other similar vehicles. Therefore, the distance between Kiss and Ride areas and the station and platform area shall not exceed 600 feet. Streets can be added vehicle drop-off zones as simple pull-in places or as loop roads with temporary parking.

Taxicab and shuttle waiting spaces are frequently found in kiss and ride facilities when people are being picked up or dropped off. Two to three cars should be able to be stacked at the car drop-off area; however, cars should not be allowed to form a line that prevents pedestrians from moving towards the station platform door. In stations with higher traffic volumes, there may additionally be facilities for taxi lines and shuttle drop-offs close to the platform and the station entrance. In higher-traffic stations, taxi stands should be set apart from places for vehicle drop-offs to allow for smooth passenger transfers.

Drop-off zones and pedestrian circulation should be kept apart or designed to minimize problems between vehicles and/or pedestrians. Special paving can be used to draw attention to pedestrian crossings and the connections between short-term parking spaces and stations. Additionally separating the pedestrian and vehicular zones with evenly placed bollards or a security barrier will increase passenger safety and point them in the direction of the station entrance.

2-3.1.4. Park and Ride

station patrons can park and have direct walking access to the station entrance within a limit of 1500. Without any dead ends, the surface lot or structured parking facility should efficiently and logically move vehicles throughout.

Since there isn't much space for huge surface parking lots in the corridor, structured parking is more likely to be there. These parking structures can serve as standalone buildings or as multistory complexes with several uses.

Elevated pedestrian crosswalks, sometimes known as catwalks, can be used from parking structures directly into station areas to reduce conflicts between walkers and automobiles. There should be distinct locations designated for crosswalks, and collisions between people and moving cars should be minimized.

The visibility of pedestrian crosswalk locations can be further improved by varying unique pavement materials and treatments. Every pedestrian waiting and using the connecting walkways to the station should be protected, if at all practicable.

2-3.2. Travel Zone

The "Arrival Zone" and access modes, which lead to the station and platform area, guide the user into the station experience. Here, the user assumes the position of a passenger who is waiting to board a station system. Although there may be a variety of ways to arrive, the main goal is for a passenger to reach their destination, which is accessible from the station platform. As a result, the platform and station are now the key elements of the travel zone. It is crucial to recognize how the arrival and journey zones interact to offer a smooth route to the users' ultimate destination once the components of each have been understood.

2-3.2.1. The Station

Since the station is the first of two components in the travel zone, foot traffic has priority there. The word "Station" is frequently used to describe the overall station experience at a specific stop that makes it easier for people to access and use the station system. A station building that serves as a link between the arrival area and the travel zone may be present in the station area. It may also be a concentrated station space, depending on density and volume.

2-3.2.2. Station Main Building

The primary purpose of the station building area is to physically direct traffic onto the platform from nearby pedestrian gathering places and access routes via a security checkpoint with a ticket desk or machine. If at all possible, bathrooms ought to be located in a structure that is directly connected to the station and platform area or that is connected by a semi-covered hallway.(Filipe & Ramos, 2015)

Architecturally, the station has the potential to become a focal point for the surrounding urban landscape as well as the station area. Facade articulation and variation in architecture can improve the public realm experience and point people in the direction of the platform entry. The station building frequently embodies prominent architectural aspects that provide not just the station, but also its surrounding neighborhood and environment, character, and identity. This is especially true in large urban and community centers. In less congested areas and stations with lower traffic numbers, station functions, such as ticket sales and amenities (snack vending machines), are frequently integrated into the platform space itself, negating the need for additional building structures.

2-3.2.3. Restrooms

In most stations, staff members and station visitors will have access to restrooms (smaller Neighborhood Stations may offer restrooms based on demand or as a joint facility with

nearby development). Fully accessible restrooms that adhere to all size and fixture specifications will be provided. Bathrooms for one person require roughly 36 square feet.(*Home - Gannett Fleming*, n.d.)

2-3.2.4. Ticketing Booth

Must adhere to the following specifications, maybe in cooperation with ticket offices, as necessary:

- Area of approximately 300 square feet
- Counters that are accessible to those with disabilities.
- Storm shutters and secure windows
- Speakers impervious to bullets
- Access is restricted to staff only and all doors, frames, and hardware are bulletproof.
- Tools for video surveillance

2-3.2.5. Waiting Spaces

If necessary, future stations might provide indoor waiting areas. Per passenger, these spaces need 14–15 square feet. Also necessary are public bathrooms.

2-3.2.6. Concessions

Future stations might find it useful to have concession buildings as a convenience for travelers and as a potential source of money. One or more concession operators will rent the anticipated space, and they will supply whatever finishing touches and equipment they consider necessary. To promote better use, ticketing services and concession stands may be combined. Concession areas often have the following features:

- A space of around 400 square feet.
- Counters that are handicap accessible.
- Storm and security shutters on windows with vandal-proof glass.
- A ceiling that is impervious to vandalism.
- Employee access is safe.
- Toilet access for employees.

2-3.2.7. The Platform

Travelers typically wait on the platform to board the station system before entering the area once they have it. Depending on the mode selected, changing system requirements

(track configurations, service requirements, etc.), and site-specific limitations, the platform can be set up as either a side platform or a central platform. Platforms for commuter railroads should typically be 500' long (616' for A central meeting space with the station's main amenities should be included in both center and side platform arrangements. For instance, if space restrictions prevent the development of a distinct station structure that incorporates the arrival regions into the trip zone, the central platform can feature ticket booths so that passengers can buy tickets and obtain information about the system, schedule, and destinations. Depending on the size of the station and the surrounding area, the central platform may additionally have other public amenities like restrooms, vending machines, newspaper kiosks, customer information desks, etc. To make the central amenities the focal point, different architectural, signage, and paving elements can be used to bring attention to the center space and make it simpler for people to recognize.

The final crucial element of the platform area is the rail crossing, which allows a passenger to go from one platform to another at a grade and is based on setbacks and mode of technology. In most stations, grade crossings for pedestrians are available outside of the platform area. Additionally, the group with mobility and sensory impairments needs to be given special consideration.(*Information Technology Policy and Planning | Office of Human Resources*, n.d.) Figure 2-6

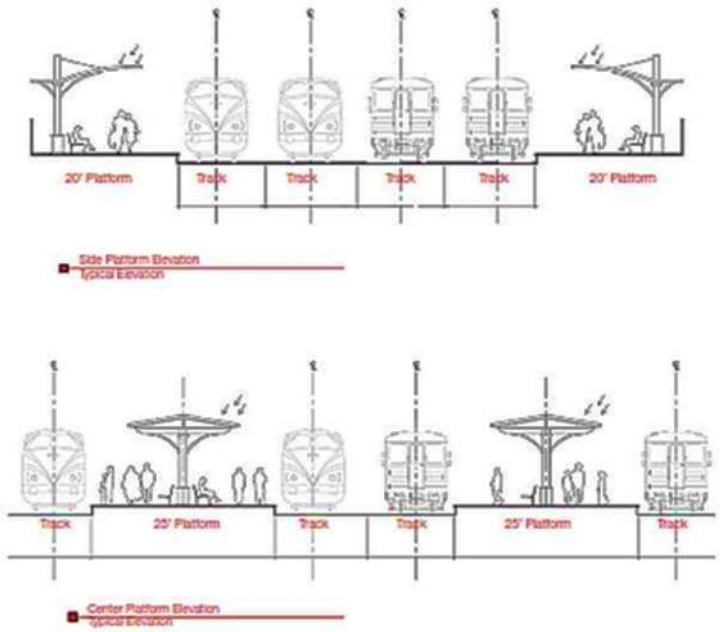


Figure 2-6 : Elevation of the typical side and Centre platforms, Source: Station Design Guidelines by Gannett Fleming, Inc,2012

2-4. Central Station Hubs User Priorities

Designs for stations must be flexible enough to allow a variety of activities and be weather-adaptive both throughout the working day and throughout the year. Depending on the circumstance, station design may also need to take into consideration several operational possibilities, such as big events, service changes, or terrible weather. The design of a station must consider the various stakeholder and user groups' various aims and ambitions. All users should anticipate a facility that is clean, effective, accessible, dependable, safe, and readable as a baseline need, but beyond this, specific user groups may have different needs or expectations. Here are a few of the most important.

Daily use helps commuters become comfortable with a station. The main goal is to reduce travel time with short station dwell periods. They demand:

- Dependable services backed by real-time data on delays and service interruptions.
- A smooth transition.
- Direct access to parking lots and places where taxis can be picked up and dropped off, as well as to and from station thresholds.
- Accurate and speedy ticket collection.
- Accessible choices for shopping.
- Real-time information is displayed for future trips.

Travelers on business are seasoned adventurers who are used to fine accommodations and high levels of comfort. Station wait times can change frequently according on the connected services or modes. They need:

- Premium, welcoming waiting areas.
- Facilities that are tidy, effective, and practical.
- Easy access to parking and locations for taxi pickup and drop-off, as well as direct access to and from station thresholds.
- Convenient retail and beverage establishments.
- Displays of real-time information for further travel.

2-5. Design Principles

The Station's overall aesthetic identity and visual harmony are to be strengthened by the design concepts. Each new project will contribute to achieving this aim by employing an integrated design strategy that reflects the appropriate scale, image, functionality, and integration of buildings and open space. These design guidelines demonstrate the station's

commitment to creating a more cohesive ambiance. This rule will apply to both significant renewal or maintenance projects as well as new or upgraded projects, helping to fulfil the needs of all stakeholders. It can be used in all stages of design, including the development of the design brief, evaluation of an existing design, and assessment of recommended design alternatives.

2-5.1. Design Framework and Themes

A framework plays a specific role in how an application operates. Some of these responsibilities include menu management, form management, security management, communication management, and data access management. The process of creating a framework is not simple. The design must take a lot of factors into account. A development project's success or failure may depend on the use of an efficient design. The Central Station will be located on the subject site according to the design Framework.

- A place that allows people to arrive and depart on foot, by bicycle, automobile, bus, or rail while acknowledging the importance of the transit function.
- A location providing a variety of land use options, including places for dwellings, offices, retail stores, community services, and guest lodging, among others.
- A location that is a landmark in the city and the surrounding area. It is clearly recognized as a major addition to an architectural style that still blends in with the local heritage.
- A location that makes use of green and sustainable building and site design options regarding energy, water, and air quality considerations, making it accessible to all users, including those arriving at the location via various modes of transportation, arriving from various directions, as well as those with various special mobility needs.
- A location that welcomes people entering and makes an enduring impression.
- A location with a network of interconnected, lively areas that are alive with activity at all hours of the day and that are clearly connected to one another and to various forms of transit.

2-6. Station Usability

Stations and the area around them serve a variety of purposes. They provide waiting places, shopping and catering options, ticketing services, public transportation that arrives and departs from various locations, and options for continuing foot, by bus, by bicycle, or by taxi.

It can be difficult to maneuver people, cars, and outsiders via a station. It is crucial to plan and design surroundings that are safe, readable, and accessible to make it easy, pleasant, and accessible for all users to use our stations. The prevailing viewpoint in design theory is that it is critical to comprehend consumer wants and characteristics to create good, useful, and user-friendly products. However, the technologies that are currently in use mold and alter human wants and behavioral patterns. To increase usability, attention must also be paid to how technology affects people, in addition to user demands and characteristics. It can be challenging to navigate a station with passengers, public transportation vehicles, and outsiders.

Four design principles address the usability design theme:

- Movement
- Comfort and Attractiveness
- Wayfinding and Passenger Information
- Access and Inclusivity

2-6.1. Station Movement

A station is a moving, perhaps violent setting where a variety of station users interact. To reduce conflict today and in the future, It should be safe, comfortable, and optimized to move around the station surroundings.(Saelens et al., 2003)

2-6.1.1. Plan spatial capacity.

Commonly the responsibility of building owners, administrators, interior designers, engineers, site designers, and architects. Environmental information specialists should always be a part of the design team, especially.

setting complexity and wayfinding design. Buildings that function and the success or failure of future building users are defined by informed spatial planning. Determine the capacity, configuration, and spatial arrangement required to accommodate anticipated movement volumes up to a certain future year.

- Decide on the capacity, arrangement, and spatial arrangement required to accommodate anticipated movement volumes up to a specified future year.
- Determine anticipated levels of demand for travelers and non-travelers by identifying current and projected internal and external origins and destinations.
- Examine possible patterns of upcoming demand through stakeholder input, industry-known statistics, and regional plans.

- Offer enough space to accommodate the mobility between the station's principal locations and the levels of activity that are currently and subsequently anticipated.
- Design for development integration to maintain or improve station capacity, operations, and internal circulation needs.
- Design decision, entrance, and exit locations to reduce cross flows.
- Provide ample space where movement spaces congregate, such as at entrances, exits, decision spaces, or gate lines, and eliminate unnecessary obstacles when designing spaces.
- Locate information, TVs, and ticket booths away from locations where users might restrict access to the area or interfere with essential station operations.
- When it is important to confirm station users' movements and capacity, consider the use of analytical techniques or computer-aided modelling tools, particularly at passenger decision points, queuing locations, and cross flows.

2-6.1.2. Design legible spaces

Space legibility refers to how easily visual information in space may be arranged to form a coherent basis for action. However, it is obvious that finding one's way into and out of a facility is a requirement for achieving goals, an environment that is easy for consumers to read has a straightforward design, and Legible places improve the user's happiness and experience by reducing the stress brought on by a complicated or foreign setting.

- Establish the station's internal mobility organization by identifying the major destinations. Direct, secure, and appealing linkages between major facilities contribute to the creation of more practical and comfortable spaces.
- Design to create an environment that is intuitive and reduces potential conflicts between various flows. Make sure to account for people who are going against the flow.
- Offer clear sightlines between the main points of interest, clear areas with a unified environmental design, and effective use of lighting and color.
- By adhering to natural desire lines, pedestrian routes can be designed to enhance spatial efficiency and reduce the transfer penalty (the path that users are most likely to use to go between major destinations).

2-6.1.3. Permeability in Access and Movement

People can move around more easily and with more options in a permeable environment. To distinguish between the term’s "connectivity" and "permeability,". First, "permeability"

relates to the ability of a link to convey people or vehicles, second, “connectivity" just refers to the number of connections to and from a specific location. Where possible, integrity stations should have several points of access for both vehicles and pedestrians.(Marshall, 2005)

- To give users the most route alternatives and to improve the likelihood of mixed-use areas both within and outside the station, design a station that maximizes the number of direct links to adjacent streets, "transport hubs," and destinations.
- Make sure that clever and best-practice design solves or at least significantly reduces issues with severance from the local context and impediments from transit services. Determine the volume of travel to and from neighboring present-day and future communities (such as populated areas, businesses, or recreational areas).
- Expand current throughways and build new ones to increase access to the entire station and enable direct movement rather than detoured paths.
- Pedestrian pathways can be created to increase spatial efficiency and lower the transfer penalty (the route that users are most likely to take to travel from one major destination to another).

2-6.1.4. High Quality Lighting for Passenger Movement

For customers, employees, and other station users to feel safe and at ease, lighting is crucial. Increased safety, legibility, accessibility, security, ambiance, and public satisfaction are all outcomes of lighting that is appropriate for site and function.

- Offer station lighting of the highest caliber to accommodate capacity and passenger demand.(Rail, 2021)
- Even provide illumination on all surfaces (walls, ceilings, and floors) using indirect lighting or lighting.
- When designing lighting, try to avoid highly reflecting gloss finishes and reduce reflected glare.
- Without the need for additional infrastructure, use illumination to delineate paths between locations and highlight significant features and destinations. These beneficial effects shouldn't be diminished by the lighting from retail and other commercial establishments. Unexpected shifts in illumination, glare, dark areas, or pooling that can confuse people who are visually impaired should be avoided on illuminated roads.
- When possible, include controlled natural illumination to reduce energy consumption.

- Create a task-based lighting strategy to distribute light as needed, according to location and function, when and where it is needed.

2-6.2. Station Accessible and Inclusive

Making spaces simple to use for all passengers and station users is the goal of accessible station design. Users include those in wheelchairs, seniors, those carrying large or bulky luggage, young children, and those pursuing vocations, as well as those riding bicycles. The station's amenities, the surrounding environment, and the information systems that assist movement, usage, and understanding are all included in the accessible design.(*NZS 4121:1985 Code of Practice for Design for Access and Use of Buildings and Facilities by Disabled Persons | Building CodeHub*, n.d.)

The three components that make up the accessible and inclusive design guidelines include the following subjects:

- Spaces without steps or obstacles.
- Improving the capacity and location of escalators and lifts.
- The provision of buggies for mobility support.

2-6.2.1. Obstacle and step-free spaces

Making an environment accessible entail providing the same movement paths for all users and without asking passengers with mobility or other disabilities to take detours from the main passenger flows.(*Inclusive Mobility: Making Transport Accessible for Passengers and Pedestrians - GOV.UK*, n.d.)

- Make sure the space is clutter-free and that the tones of the floor and the walls contrast appropriately.
- Identify step-free paths and highlight their suitability with lengthy sightlines in places that are logical and not cut off from the main pedestrian flows.
- Locate broad at-grade crossings at intermodal connections that are situated on desire lines and stay away from footbridges and underpasses that have level alterations.
- Identify all hazards, such as platform edges, changes in slope at stairs and ramps, and uniform illumination, to lessen the possibility of accidents.

2-6.2.2. Optimize lift and escalator locations and capacities.

Escalators and elevators should be placed next to current lanes of traffic and other lines that are desired. All users' travel or connection times will be optimized, crashing passenger flows will be less likely, and by avoiding isolated places, the user will feel safer and more at

ease.(*Inclusive Mobility: Making Transport Accessible for Passengers and Pedestrians - GOV.UK*, n.d.)

- Place escalators and lifts immediately on passenger want lines rather than in places that may prolong travel times or cause people to worry about their personal safety.
- Assess the capacity of the waiting areas at lift doors to prevent conflicts with nearby pedestrian traffic.
- Place lifts in areas with good natural lighting for waiting rooms and entry/exit pathways and think about using transparent or glass buildings.
- If elevator or escalator maintenance is necessary, either proactively or reactively, think about providing alternate accessible paths.

2-6.2.3. Provision of Mobility Assistance Buggies

The transportation of people with limited mobility is assisted with mobility buggies. At important stations, mobility assistance buggies are available to help passengers with limited mobility get to and from train services and facilities.

- Determine the best places for mobility aid buggies to prevent affecting station operations.
- Consider auxiliary measures like aid locations and signage where assistance can be obtained.

2-6.3. Wayfinding and Passenger Information

A place will be simple to use, require little signs, and be effectively integrated with its surroundings if it incorporates understandable and accessible design principles from the start for passenger information and navigation.(Weisman, 1981)

The idea of driving station signage and passenger information should be one of clarity, consistency, and coherence to ensure station users enjoy a positive, stress-free experience. This will assist people move through the stations steadily, conveniently, and safely. This idea is essential to the design of a well-thought-out station and supports it. For a positive passenger experience, information is a necessity. Information can be used for a variety of purposes, including providing details about rail services, station and facility opening times, local maps, and interchange mode information. To address the demands of all users of the interchange facility, information should be distributed throughout the complete spectrum of media, including aural, visual, and tactile.

The four sections that make up the design criteria for wayfinding and passenger information address the following subjects: (Arthur & Passini, 1992)

- Provide service information.
- Integrating consistent wayfinding and signage into the constructed design.
- Including directions outside of the station's footprint.
- Information that is available.

2-6.3.1. Provide Service Information.

depending on the type of passenger and where in the voyage they are. Regular commuters, for instance, might prefer timely disruption or delay warnings over complex itineraries, whilst visitors profit from straightforward service, ticket, and location information that helps them comprehend their travel options.(Mishra & Abdul, 2018a)

- Provide passenger information and announcements throughout the station environment, including within concourse, platforms, retail, food & beverage, and waiting areas electronically, through staff, and through static signage, to ensure that customers are aware of general information and information on service disruptions.
- Consider employing audio and visual displays, mobile phones, audio loops, portable sound, and near field technology to provide passengers with the timely information they need, wherever they are.
- Keep traditional communication channels, such as the use of printed information, tactile information, and station staff, consistent with static information, such as service departure information, interchange facility identification and accessible routes to those facilities, safety information and instructions, and warning, prohibition, and mandatory actions.

2-6.3.2. Consistent Wayfinding and Signing, Integrated with the Built Design.

Signs must be placed in areas where people will need them most. These places are typically where routes make decisions, like crossroads, entrances, and exits. Decision point signs typically give directions to exit routes, links for intermodal transportation, platforms, and important facilities. By reducing physical barriers to movement, integrated wayfinding aids station visitors in understanding how the station and its surroundings function as a single, integrated system.(Adel abass, 2017)

- Refrain from using excessive signage, which could be ineffective and add to clutter.
- Create seamless navigation so that passengers can travel from one site to another while utilizing all available forms of transportation.

- By integrating spatial layout, lighting, and surface finishes with other architectural components like public art and planting, routes can be made to be straightforward and legible with no need for signage.
- Wayfinding signs must always take precedence over other information in terms of visual priority and must always be visible from important reading directions.
- Place dependable and straightforward navigation signage at station entrances.
- Exits to confirm route choice and decision points.
- Clearly indicate and post main routes, including diverse modes of transport, leading from the station to significant outside locations.

2-6.3.3. Inclusion of wayfinding information beyond the station footprint

Stations are simply one stop on a passenger's route; further destinations that are not in the local vicinity of the station should also offer navigational assistance. Travel times are so optimized, and potential conflicts in pedestrian movement are controlled. This encourages travel between stations and places close by, such as streets, walkways, bike lanes, and public areas.(Adel abass, 2017)

- Create a seamless information delivery system so that visitors can experience the station as a part of the larger urban landscape. accentuate bicycle and pedestrian paths and destinations.
- When integrating with adjacent third-party navigation systems, use their vocabulary and names consistently.
- Whenever possible, make it simpler to show information about nearby facilities inside the station, such as city or town maps, directions, and directional signs that adhere to third-party local wayfinding practices.

2-6.3.4. Provide Accessible Information Throughout the Station.

All users will benefit from the availability of information that is accessible and considers passengers with disabilities and/or cultural and/or linguistic differences since signs and information will be simpler to use and understand.(Caroline Sutandi & Olzon Paladan, 2016)

- Use high contrast color within a clear hierarchy to provide the best legibility and distinction between various design elements.
- Information for users who are blind or visually impaired is provided using near-field, mobile, and loop technologies.

- For the advantage of all users, identify and clearly mark the locations of passenger assistance support stations.
- Design the typeface to be legible at a variety of distances for users with various visual abilities.
- Most users should be catered for, even though not all varieties can be made large enough for everyone due to practical considerations.
- Create material that is easily understandable for people who struggle with language, whether it be due to learning challenges or the fact that English is not their first language.
- Consider using icons, naming things consistently, using color coding, and other non-textual elements of intuitive design.

2-6.4. Comfort and Attractiveness

Comfortable, spotless, and well-maintained stations offer a pleasant environment that protects customers from unfavorable weather and unpleasant sensory sensations like filthy air, dirt, or noise. Additionally, these settings give users a sense of security and protection. Where appropriate, amenities should be offered to meet the needs of travelers and improve their experiences.

The three sections that make up the Comfort and Attractiveness design guidelines include the following subjects: (*The Rail Vehicle Accessibility Regulations (Northern Ireland) 2014*, n.d.)

- Providing places, conveniences, and facilities
- Advice for preserving the environment and preventing unpleasant sensory experiences.
- Developing waiting areas.

2-6.4.1. The Provision of Facilities, Amenities, and Spaces

Depending on their size, location, and levels of train service, stations serve a variety of purposes. The station environment and its surroundings should be considered while designing facilities, amenities, and activity spaces.

- Consider the variety of users, daily foot traffic, station location, and context.
- Create public amenities and facilities that feature a variety of stores and retail kiosks. - Retailers of food and beverages - Cash machines and telephones - seating areas, luggage drop-off locations, public art, safe, clean, and easily accessible restrooms, waiting areas, and restrooms.

2-6.4.2. Guidance for Climate Protection and Control Against Unpleasant Sensory Experiences

Through the implementation of noise mitigation techniques and the construction of effective climatic protection through platform canopies and covered pedestrian paths, users of stations will be shielded from unpleasant experiences, resulting in a pleasant environment and travel for everyone.

- Passengers should be shielded from adverse weather (severe heat and cold, as well as the wind, rain, snow, and sun) by the way stations are built.
- To maintain constant lighting levels and save energy consumption, managing to please routinely frequented spaces should be taken into consideration.
- Think about using air conditioning and sun blinds.
- Provide effective and visually acceptable lighting settings and fixtures for increased security and visibility.
- Make sure to perform thorough cleaning on a regular basis to get rid of odors and stains, especially in lifts.
- For the sake of convenience and safety, reduce dangers brought on by environmental factors.
- Reduce background noise in particular consumer situations.

2-6.4.3. Developing Space for Waiting Areas

Formal waiting areas, station concourses, shops, and other facilities are examples of waiting areas. There are places to sit, stand, and recline in these areas. This enables station visitors to stay there for extended periods of time in reasonable comfort.

- Create and place waiting areas that are appropriate for the station's size and purpose.
- Choose waiting areas that are close to station amenities and traffic routes. Include the proper levels of seating based on the station's size and purpose, accounting for user needs.
- Permit routine sustaining and providing inspections and offer a quick response.

2-6.5. Station Operability

The layout of station buildings and the area around them should encourage effective operations and upkeep in a functional, cozy, and secure setting. Over the course of a station's existence, an effective station design reduces delays and disruptions, supports modal integration, enhances the passenger experience, and saves money for asset managers and

station operators. The continuous operational needs of a running rail network should be considered when planning station renovation projects in order to protect operational integrity and passenger safety throughout the project's duration. When determining operability, factors like integrated ticketing, maintenance, safety, and servicing are considered Four design principles address the operational design theme:(Hermez et al., 2014a)

- Station Operations
- Administration and Maintenance
- Safety
- Design for Security

2-6.5.1. Station Operations

To provide convenient access to transportation services, seamless switching between modes of transportation, and efficient maintenance, The fleet, infrastructure, and amenities must all be operated optimally during station operations. Effective stations guarantee cost savings for owners and operators. The four sections that make up the design criteria for station operations address the following subjects:(Hermez et al., 2014a)

- Offering sufficient space for all station functions.
- Pointers for organizing modal integration.
- Ensuring easy access to and storage for servicing and delivery vehicles.
- Providing station staff with suitable and practical amenities.

2-6.5.2. Management and Maintenance

Effective station management and maintenance procedures aid in preserving the environment's quality. This preserves the station's longevity while simultaneously improving its usability and gaining the advantages of whole-life cost analyses. The four sections that make up the Management and Maintenance design guidelines address the following subjects: (Hermez et al., 2014a)

- Enabling effective station upkeep and cleaning.
- Determining the obligations and rights of stakeholders.
- Using materials that are durable and resilient.
- Process of Heritage Asset Management.

2-6.5.3. Safety

Infrastructure that has been thoughtfully designed and maintained can reduce the likelihood of mishaps and conflicts. Additionally, it can improve passenger happiness and enjoyment while addressing safety perceptions. All users' fear of crime or accidents is reduced when the

environment is perceived as safe, controlled, managed, and cared for thanks to clean, well-maintained infrastructure and locations. The two elements that make up the design standards for safety encompass the following topics: (Hermez et al., 2014a)

- Techniques for designing buildings and areas to reduce the likelihood of mishaps, disputes, and collisions.
- Advice on how to guarantee that all legislative emergency obligations are fully complied with.

2-6.5.4. Ensure Security by Design

Public safety must be considered when designing stations against a variety of hazards, both man-made and natural. All stations are at some danger from numerous hazards, whether they come from malevolent activity or natural occurrences like flooding and accidents. The four sections that make up the be Secure by Design guidelines address the following subjects: (Hermez et al., 2014a)

- Using secure and thoughtful design to evaluate and reduce the risk of hazards, whether they are man-made or natural.
- Methods for adhering to the principles of crime prevention through environmental design.
- Creating functional, lively, and secure environments and amenities for usage during both day and night.

2-6.6. Quality

The experience of a station user will be enhanced in all respects by providing high quality station environments. Performance, accessibility, and function are all combined into the design of high-quality facilities since they are all crucial components of the user experience. Designing stations to blend in with their surroundings can result in dynamic, vibrant public places and can affect how passengers, operators, and others view these areas. Rail stations may become destinations if mixed-use developments are concentrated in and around them. This would increase value for users, promote investment, and promote socioeconomic and physical revitalization in the neighborhood.. (Hermez et al., 2014a)

three design tenets apply to the quality design theme:

- Contextual integration
- Encourage quality design.
- Sense of location

2-6.6.1. Contextual Integration

Stations that are effectively incorporated into the surrounding urban landscape contribute to the development of thriving communities that are inclusive, secure, well-connected, and ecologically conscious. Context-sensitive station design can consciously mold and energize the public areas around it, resulting in structures that are active, integral parts of their local communities. The three sections that make up the design standards for integration with context address the following subjects:

- Integrating station amenities with the surrounding open space.
- The creation of a connected network of public areas, bike lanes, and platforms.
- Supporting the creation of lively public places in the neighborhood.

2-6.6.2. Promote Good Design.

Global experience demonstrates that user-friendly, high-quality public transport systems that "put the passenger first" can generate significantly more economic advantages and profits than less well-focused or integrated systems. This benefits everyone involved—operators, travelers, adjacent communities, developments, and the environment. The three parts of Promote Good Design's design principles include the following topics:

- Creating buildings and spaces with the proper scale, massing, and orientation.
- Creating warm station settings that encourage people to travel, work, and shop.
- Instructions on how to use premium components and finishes that fit the setting and purpose of the station.

2-6.6.3. Sense of Place

In addition to referring to a feeling or perception that people hold via attachment or belonging, the phrase "sense of place" also describes a characteristic that some geographical areas possess while others do not. For a wide variety of users, stations, and the urban setting in which they are located have many distinct meanings. It is crucial that good design takes advantage of these impressions to preserve and, in the end, improve the region and give everyone a sense of place. The three sections that make up the design criteria for Sense of Place address the following subjects:

- Selecting and creating stations that advance a positive identity and image.
- Considering landmark design where demand or status justifies it.
- Increasing value through public art and gardening.

2-7. Conclusion

- The goal of this chapter was to provide a summary of the pertinent research and studies on multi-modal hub stations.
- The infrastructure that connects commuter and regional train service, as well as intercity bus, taxi, and a local station, is known as an intermodal transportation hub. Its goal is to reduce obstacles and bridge these gaps by making them straightforward and practical.
- By offering facilities, allowing customers to buy tickets, and allowing customers to wait for models in respectable comfort, the Hub station project effectively addresses ecological, social, and economic difficulties in the context of its surroundings. The sustainable approach includes a focus on effective connectivity in the intermediate area, assurance of pedestrian and vehicular safety, assessment of the environmental design requirements for the intermediate project, assurance of equitable passenger services, and revitalization of economically sound downtowns and suburban centers.
- There are many guidelines for multi-modal hub stations represented in Table 2-1

Table 2-1: design guidelines.

	Secondary requirements		
Function and circulation requirement	Station Movement	Plan spatial capacity.	Determine anticipated levels of demand for travelers and non-travelers.
			Examine possible patterns of upcoming demand through stakeholder input and regional plans.
			Offer enough space to accommodate mobility between the station's principal locations
			Design for development integration to maintain or improve station capacity, operations, and internal circulation needs.
			Design decision, entrance, and exit locations to reduce cross flows.
			Offer enough spaces where movement spaces converge, and design spaces to be free of pointless barriers.
			Place information, TVs, and ticket booths in areas where users won't hinder other people's access to the space or interfere with crucial station functions.
			To verify station users' movements and capacity, take into account the use of analytical techniques or computer-aided modelling software as needed, particularly at passenger decision points, queuing locations, and cross flows.
			Establish the station's internal mobility organization by identifying the major destinations.

		Design legible spaces	Design to create an environment that is intuitive and reduces potential conflicts between various flows.
			Offer clear sightlines between the main points of interest, clear areas with a unified environmental design, and effective use of lighting and color.
		Permeability in access and movement	Create a station design that maximizes the number of direct links to nearby streets and “transport hubs"
			Ensure that problems with severance from the local context and obstacles from transit functions are either eliminated or reduced by smart design.
			Determine the volume of travel to and from neighboring present-day and future communities (such as populated areas, businesses, or recreational areas).
			Expand current throughways and build new ones to increase access to the entire station and enable direct movement.
		High-quality lighting for passenger movement	Offer station illumination of the highest caliber to accommodate demand and capacity.
			Ensure uniform illumination of all surfaces (walls, ceilings, and floor) using indirect lighting or lighting.
			Lighting should be planned to reduce reflected glare and to avoid extremely reflecting gloss surfaces.
			Integrate managed, natural lighting where possible to minimize energy consumption.
	Station Accessible and Inclusive	Obstacle and step-free spaces	Make sure the space is clutter-free
			Identify step-free paths and highlight their suitability with lengthy sightlines in places that are logical.
			Locate broad at-grade crossings at intermodal connections that are situated on desired lines and stay away from footbridges.
			Make sure to identify all hazards, including platform edges, changes in slope at stairs and ramps, and uneven lighting, to lessen the possibility of accidents.
		Optimize lift and escalator locations and capacities.	Place escalators and lifts immediately on passenger want lines
			Assess the capacity of the waiting areas at lift doors to prevent conflicts with nearby pedestrian paths.
			Place lifts in areas with good natural lighting
			If elevator or escalator maintenance is necessary, either proactively or reactively, think about providing alternate accessible paths.
		Provision of mobility assistance buggies	Determine the best places for mobility aid buggies to prevent affecting station operations.
			Consider auxiliary measures like aid locations and signage where assistance can be obtained.

	Wayfinding and Passenger Information	Provide service information.	information on service disruptions, provide passenger information and announcements throughout the station environment
			utilizing near-field technologies, mobile phones, audio loops, portable sound, and visual displays.
			Maintain consistency between traditional communication channels, such as the use of printed information, tactile information, and station staff, and static information, such as service departure information, interchange facility identification and accessible routes to those facilities, safety information and instructions, and warning, prohibition, and mandatory actions.
		Consistent wayfinding and signing, integrated with the built design.	Refrain from using excessive signage, which could be ineffective and add to the clutter.
			Create seamless navigation so that passengers can travel from one site to another while utilizing all available forms of transportation.
			By integrating spatial layout, lighting, and surface finishes with other architectural components can be made to be straightforward and legible with no need for signage.
			Place dependable and straightforward navigation signage at station entrances.
			Exits and decision points to confirm route choice.
			Main routes leading from the station to significant outside destinations should be well marked and include all modes of transport.
		Inclusion of wayfinding information beyond the station footprint	Create a seamless information delivery system so that visitors can experience the station as a part of the larger urban landscape.
			make it simpler for town/city maps, directions, and directional signs that adhere to third-party local wayfinding strategies to be shown about external facilities inside the station.
		Provide accessible information throughout the station.	Use high contrast color within a clear hierarchy to provide the best legibility and distinction between various design elements.
			Information for users who are blind or visually impaired is provided using near-field, mobile, and loop technologies.
			identify and clearly mark the locations of passenger assistance support stations.
			Design the typeface to be legible at a variety of distances for users with various visual abilities.
			Most users should be catered for, even though not all varieties can be made large enough for everyone due to practical considerations.

			Consider using icons, naming things consistently, using color coding, and other non-textual elements of intuitive design.
	Comfort and Attractiveness	The provision of facilities, amenities, and spaces	Consider the variety of users, daily foot traffic, station location, and context.
			Create public amenities and facilities that feature a variety of stores and retail kiosks.
		Guidance for climate protection and control against unpleasant sensory experiences	Passengers should be shielded from adverse weather
			To maintain constant lighting levels and save energy consumption, managing to please routinely frequented spaces should be taken into consideration.
			Provide effective and visually acceptable lighting settings and fixtures for increased security and visibility.
		Developing space for waiting areas	Create and place waiting areas that are appropriate for the station's size and purpose.
			Choose waiting areas that are close to station amenities and traffic routes.
			Permit routine maintenance and servicing inspections and offer a quick response.
safety and security	Station Operability	Station Operations	Offering sufficient space for all station functions.
			Pointers for organizing modal integration.
			Ensuring easy access to and storage for servicing and delivery vehicles.
			Providing station staff with suitable and practical amenities.
		Management and Maintenance	Enabling effective station upkeep and cleaning.
			Determining the obligations and rights of stakeholders.
			Using materials that are durable and resilient.
			Process of Heritage Asset Management.
		Safety	Techniques for designing buildings and areas to reduce the likelihood of mishaps, disputes, and collisions.
			Advice on how to guarantee that all legislative emergency obligations are fully complied with.
		Be Secure by Design	Using secure and thoughtful design to evaluate and reduce the risk of hazards, whether they are man-made or natural.
			Methods for adhering to the principles of crime prevention through environmental design.
			Creating functional, lively, and secure environments and amenities for usage during both day and night.
environmental	Quality	Contextual integration	Integrating station amenities with the surrounding open space.
			The creation of a connected network of public areas, bike lanes, and platforms.

			Supporting the creation of lively public places in the neighborhood.
		Promote good design.	Creating buildings and spaces with the proper scale, massing, and orientation.
			Creating warm station settings that encourage people to travel, work, and shop.
			Instructions on how to use premium components and finishes that fit the setting and purpose of the station.
		Sense of Place	Selecting and creating stations that advance a positive identity and image.
			Considering landmark design where demand or status justifies it.
			Increasing value through public art and gardening.

Source- Authors based on extant literature sources.

3- Chapter three: - Examples of Existing Best Practices Multi-modal hub Stations

3-1. Introduction

Transportation is an important Infrastructure enabling urban mobility at both micro & macro levels. Transport is a medium that allows people to access what they want, whether for education, jobs, goods, or any other purposes. Transport promotes development in a global sense.

The final objective of this chapter is access to design requirements used in international cases studies stations, to do that, chapter three consist of three sections of three successful international case studies (India -Germany -British) that were selected to identify the design requirements. The selection was according to several criteria; Indian public transport stations are the main mode of transport and the fourth largest and busiest transport network in the world, while the public transport network in Germany is among the best and most efficient in Europe, it is made up of several modes of transport, and best public buses and trains. The history and success of the first railways in the world in the British experience, as Britain has approximately 15,754 kilometers of railway tracks and more than 2,500 stations distributed along with the network. **Figure 3-1**

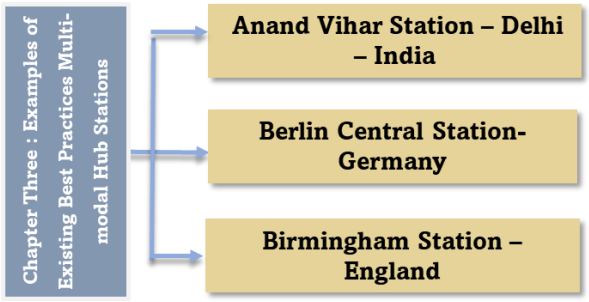


Figure 3-2: Chapter three structure, **Source**: Authors.

3-2. Anand Vihar Station – Delhi – India

The objective of this section is to define the design requirement in international case studies through two steps process: a detailed qualitative and quantitative analysis of selected international case studies. This chapter include an overview of Anand Vihar Station – Delhi – India, the analysis of all aspects related to design requirements in multi-modal hub stations. Figure 3-3

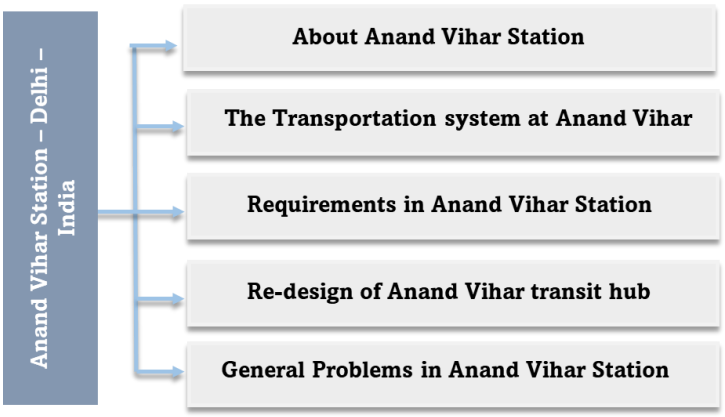


Figure 3-3: Chapter three section one structure, **Source**: Authors.

3-2.1. About Anand Vihar Station – Delhi – India

Delhi is the most populated state in India. where reach the density of population per sq. Km about 11000 which is considerably higher than any other state .

Anand Vihar Terminal is under the administrative control of Delhi, while the terminal is one of the largest railway stations in Delhi, which serves as a key junction joining the whole of the eastern region. This station was officially inaugurated on 19 December 2009 (*Indian Railway Stations Development Corporation Ltd. (IRSDC)*, n.d.) , the station continued operate below capacity till a stampede at New Delhi station on 16 May 2010 made it clear that the New Delhi station handling 300,000 to around 500,000 passengers each day was saturated and thus the Northern Railways decided to transfer more trains to Anand Vihar and utilize it effectively. (*Bhagalpur–Anand Vihar Terminal Garib Rath Express - Wikipedia*, n.d.) Table 3-1.

Table 3-1: About Anand Vihar Station.

Location	eastern quadrant of Delhi
OPENED	19 DECEMBER 2009
Modes Integrated	Railway terminal RRTS (Regional Rapid Transit System) ISBT (INTER STATE BUS TERMINUS) DMRC (Delhi Metro Rail Corporation)
Area	Railway 12,000 sqm RRTS ---------- ISBT 46,500 sqm Metro 6500 sqm
Daily Passengers	Railway 30109

	RRTS	72169
	ISBT	125524
	Metro	13971&29950
	Total	**262723 In 2021**
Peak Hour Passengers	Railway	3011
	RRTS	7217
	ISBT	12552
	Metro	1397&2095
	Total	**26272 in 2021**
Parking Availability	Railway	4-Wheeler, Taxi, Rickshaw
	RRTS	yes
	ISBT	4 wheelers
	Metro	2 & 4 Wheelers
Per capita	To 1,5 m^2 from 5 m^2	
Amenities	Staff Offices, Ticket & Enquiry Counters, ATM, Security Cabin, Waiting Halls High-Speed Wi-Fi, Reservation Halls, Toilets, Parcel and Luggage Office, ATMs, Screen Enquiry through Touch Exchange currency Offices for business and maintenance, food courts	
No of Platforms	Railway	7
	RRTS	2
	ISBT	140 bus stands
	Metro	2
Platform Height from Ground	Railway	ground
	RRTS	-20m
	ISBT	ground
	Metro	15m
Escalators/ Lifts/ Staircases	Railway	2 Staircases, 6 Lifts subway
	RRTS	4 Staircases, 2 Escalators
	ISBT	-----
	Metro	8 Staircases, 2 Escalators

Source- Anand Vihar Railway Station's Redevelopment on the Delhi Integrated Multi-Modal Transit System Limited.(DIMTS, 2015)

It is estimated that about 42 % of traffic from ISBT, 38 % from the rail, 58 % from the metro, and 66 % from RRTS will interchange at the station.

3-2.1.1. Project Description

- The Project Site is in the eastern quadrant of Delhi, as per the Delhi Development Authority. It is close to one of the city's most important bus terminals.

- The Anand Vihar Railway station is located adjacent to the Anand Vihar Metro Station and Anand Vihar ISBT, making this area the hub of inter-modal transport in East Delhi; the passengers can easily travel to any part of Delhi alighting from the Anand Vihar Railway Station and availing the city bus services or metro. Figure 3-4

Figure 3-4: Anand Vihar Station Building, Source: Anand Vihar Terminal railway station ("Anand Vihar Railway Terminal Opens," 2009)

3-2.2. The Transportation System at Anand Vihar Station

The station consists of four modes of public transportation station which represented in (ISBT (Inter State Bus Terminus)- railway terminal - metro station- Regional Rapid Transit System), In the following, we will discuss each of them in detail and study the general location of them.

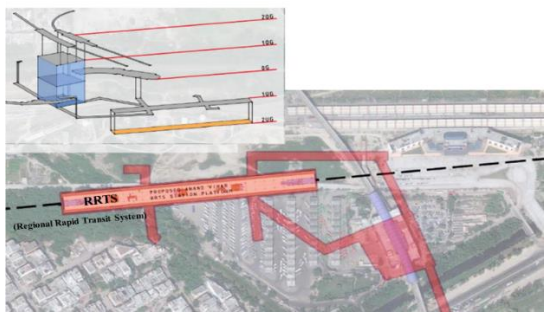
3-2.2.1. zoning in Anand Vihar Station

zoning in the different plans, it becomes clear that

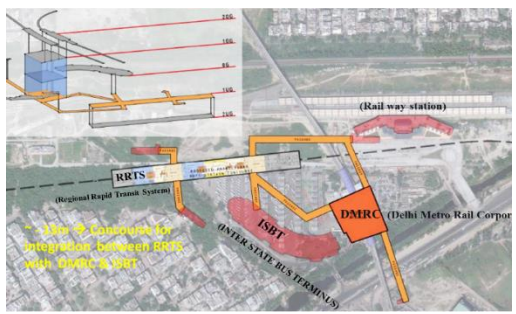
- At 1UG (underground) Level Integration:- Concourse for integration between RRTS with DMRC & ISBT.
- At UG (underground) Level Integration:- Concourse for integration between RRTS, DMRC, ISBT with Railways.
- At 1OG (over ground) Level Integration:- Concourse for integration between DMRC and rest of system. Figure 3-7

Figure 3-5:- zoning in Anand Vihar Station

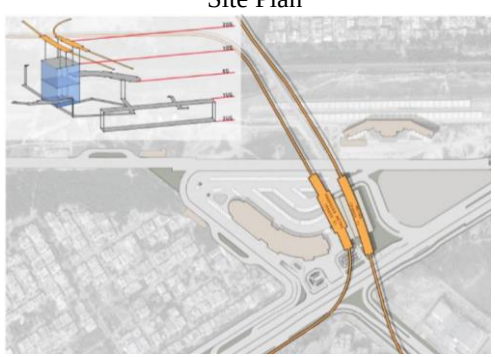
Site Plan



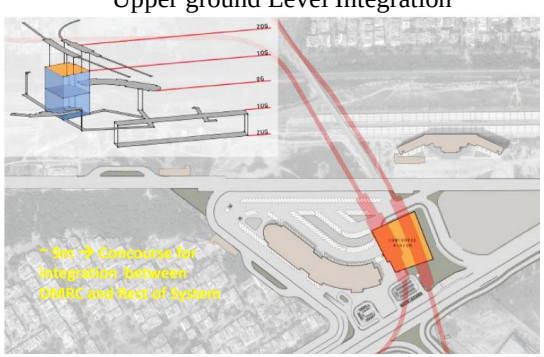
Upper ground Level Integration



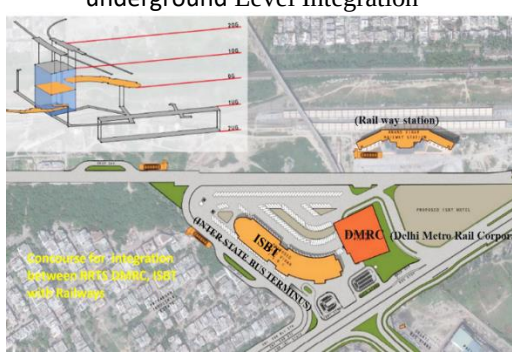
underground Level Integration



2 over ground Level Integration



1 over ground Level Integration



Over ground Level Integration

,Source: Anand Vihar transit Hub (*Anand Vihar Transit Hub*, n.d.)

3-2.2.2. ISBT (Inter State Bus Terminus)

- ISBT Operates bus services between Delhi, Uttar Pradesh, and Uttarakhand.
- There are Four Platforms: Figure 3-6
  - Platform A: It has 36 bus bays for Local Buses.
  - Platform B: It has 36 bus bays for Interstate & Local Buses .
  - Platform C & D: Both have 46 buses.

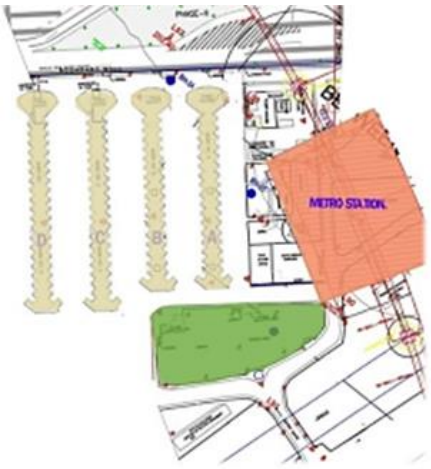


Figure 3-6: - ISBT plan , Source: Anand Vihar transit Hub (*Anand Vihar Transit Hub*, n.d.)

3-2.2.3. Railway Terminal

- The station was formally opened on December 19, 2009, after the first phase of construction was completed.
- The first phase, which took more than five years to build, of the two-story train station began with just three platforms and a coach maintenance yard.
- It is one of the most contemporary stations in Delhi, with a total area of 42 hectares. When the second phase of the station is completed, It will be one of the largest railway stations in the world, catering to all East–bound trains from Delhi.
- Anand Vihar ISBT and Anand Vihar Metro station are both conveniently accessible from the station. the area of the station.
- **Design principles**
  - Planning has been done symmetrically.
  - A two-story building with a dedicated parcel loading area, two escalators, six lifts, a unique heritage gallery, and specially designed subways that are accessible to those with physical disabilities.

3-2.2.4. Metro Station

- On the Blue Line of the Delhi Metro branch line, there is an elevated metro stop called Anand Vihar.
- The station connected to the Anand Vihar ISBT and Anand Vihar Railway Terminal
- **Design principles**

- Main Concept of Planning the Anand Metro station is to cater to the passengers coming for the Railway terminal and the ISBT.
- The metro 2 entrances, Gate No. 1 – on the Railway station side, and Gate no. 2 – the on ISBT side.
- Five levels make up the Anand Metro station: the basement, ground floor, first floor, concourse, and platform. These levels are connected by four escalators—two from the ground floor to concourse and two from concourse to platform—and three lifts.

3-2.2.5. Regional Rapid Transit System

The National Capital Region Transport Corporation is in charge of the Regional Rapid Transit System (RRTS) project (NCRTC). The travel time from Delhi to Meerut will be less than an hour at a top speed of 180 km/h.

- **Design principles**

- A double-storied building with four stairs and stairs, the upper floor contains waiting halls, services, ticket halls and shops, while the lower floor contains the platforms.

3-2.3. Requrments in Anand Vihar Station

The requirements in Anand Vihar Station are formed from five main requirements, these requirements included (functional requirements, circulation requirements, security and safety requirements, environmental design requirements, and social and economic requirements).

Therefore, the requirements in Anand Vihar Station indicated the main and secondary requirements that should be taken into consideration, which are: Table 3-2

Table 3-2:- The requirements in Anand Vihar Station.

		Requirements
functional design Requirements	**functional design**	• The stations should be integrated with other modes of transportation.
		• The station should be designed to accommodate the flow of people from arrival to departure.
		• Space should be assigned based on the importance of each function, with each function having its own area. The most room must be dedicated to free circulation.

		• Considering the individual's share in the different spaces.
		• Functional integration according to social and environmental changes, and providing service and commercial spaces
		• Optimal use of space
		• Provide special spaces for operators
		• Station entrances serve as a connection between the station and the surrounding streets. All passengers must have easy access to the entrances.
		• Must be clear and direct access from the station entrance to the nearby pedestrian network.
		• Arrival and departure concourses should be strategically positioned below and/or above the platforms.
		• The departure concourse and platforms should each have a shared ceiling with unobstructed broad span structural systems
		• Station interiors must include partition walls that allow for flexible area
		• The use of electronic tickets to reduce the need for ticket halls inside the stations
	Quality Design	• System integration (structure, space, materials, lighting, communications, and mechanical)
		• Maintain visual/aesthetic continuity with the rest of the system while incorporating site-specific aspects.
circulation requirements		• To prevent severe congestion inside the station, particularly on platforms and escalators, the design of the Station must allow a free-flowing passenger.
		• Reducing walking distances should be kept to a minimum.
		• Paths should be clear and straightforward as feasible.
		• A passenger's movement must be unhindered from the time he enters the Station until he leaves.
		• All platforms should be parallel and of the same length.
		• Segregation of arriving and departing passengers.
		• provided waiting space to reduce passenger interference in the circulation area.
		• Create a clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation.
		• Assisting with motility (elevators, escalators, moving walkways and assistive devices like wheelchairs for the physically disabled)
		• Providing consistent and obvious directional signage
	Interchanges with Other	• To build a seamless local and regional inter-modal network, station designs should make it simple to change to other Transit System lines and forms of public transport.
		• passengers must be given sufficient options to depart the station campus, such as regional buses, taxis, or the Mass Rapid Transit System.
En vir on		• Energy conservation

	• Resource and material conservation
	• The quality of the indoor environment
	• The most effective operation and maintenance
	• Site management and water conservation
	• Facades must let in as much natural light as possible.
	• Passengers should have access to fresh air and acceptable temperatures at all times of the year.
Requirements of Safety and security	• Accident risk should be reduced by station design.
	• The more accident-prone sections, like the platform and vertical circulation components, require special care.
	• Stations should be built in such a way that they are safe and secure without relying on technology or equipment.
	• The path must be direct, well-lit.
	• Safety and Health - Plans should be made to reduce the likelihood of accidents and health risks. The following strategies are to be used, but are not restricted to them: - Appropriate and sufficient illumination - Slip-resistant surfaces for walking - Proper use of safety rails and guards
Economy, Efficie And Effectiveness	• Station designs must show efficient use of material, structure, and space, as well as integrated lighting, communications, ventilation, electrical, and mechanical systems.
	• The Station's design must achieve the Project's functional goals.
	• provide shops, cafes and restaurants that provide a financial return for the station
Architectura l Heritage and Preservation	• The design of the Station shall consider their maintenance and aesthetic reflection in the neighborhood.

Source- Authors based on extant literature sources.

The results of analysis Anand Vihar Station on design requirements showed that there is a discrepancy in achieving design requirements, between (functional requirements, circulation requirements, security and safety requirements, environmental design requirements, and social and economic requirements) and secondary requirements.

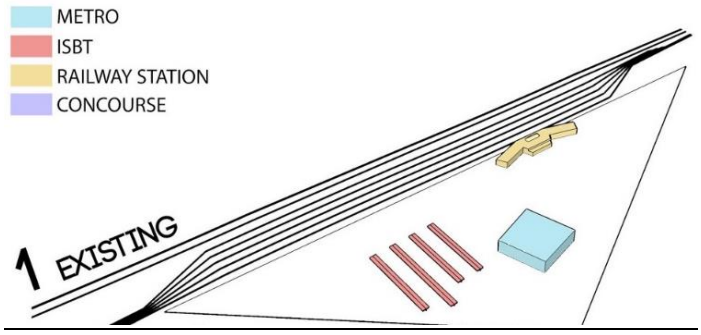
3-2.4. Re-design of Anand Vihar Transit Hub

Re-design of Anand Vihar Transport Hub, New Delhi includes a railway terminal, bus terminal, and two metro stations.(DIMTS, 2015)

The Anand Vihar transport terminal is situated in the recently developed East Delhi. There is no significant historical context around the site, and the hub is still not fully developed, the primary functions are scattered and disconnected.

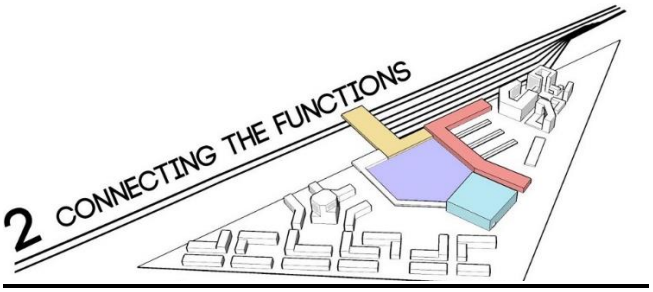
- **The resolution**
  - As the functions were brought together, a common concourse was formed. This space has huge potential and becomes the driving force for the way ahead.
  - The concourse was raised up to a different level, and shaped as a public space, where people could come together, through the medium of common activities.
  - An uninterrupted pedestrian network in and around the site was created.
  - The common concourse is the first image of the city to travelers, a platform for public interaction, and a space which generates collective memory amongst people. **Figure 3-7**

▪ **Redevelopment of Anand Vihar station (February 2015)**



EXISTING

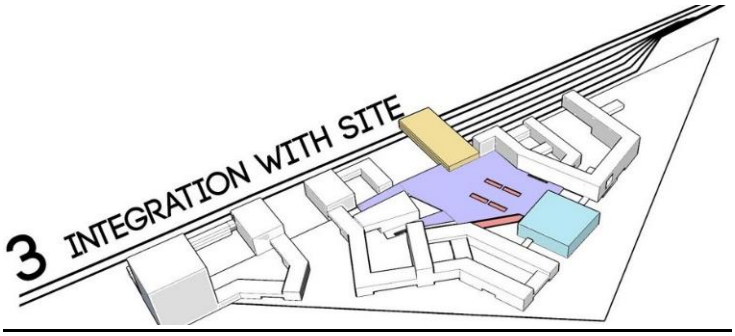
- Disconnected and scattered functions
- Lack of public spaces for interaction



CONNECTING THE FUNCTIONS

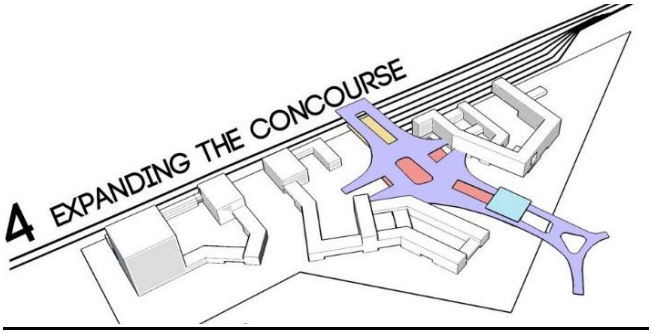
- The railway building acts as a terminating station.

- a common concourse provided.



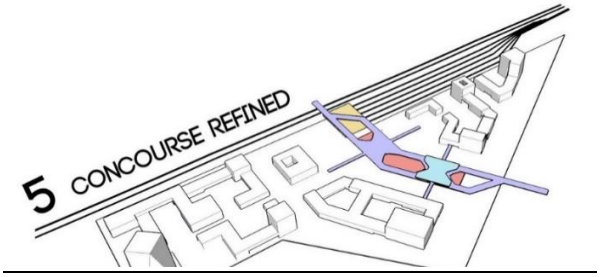
INTEGRATION WITH SITE

- Concourse was raised, thus enhancing connectivity to the rest of site.
- ISBT placed below the concourse.



EXPANDING THE CONCOURSE

- Metro station integrated to the concourse.
- The shape of plaza derived from circulation patterns.



Concourses fined.

- plaza refined into a more balanced shape.
- axes accentuated, thus enhancing aesthetics.

Figure 3-7: Redevelopment of Anand Vihar Station, **Source**-(DIMTS, 2015)

3-2.5. Problems in Anand Vihar Station

By studying zoning and different modes we found some of the Problems represented in

- The ISBT is not connected to any of the other structures.
- The road that enters the ISBT is where you reach the Metro station. This causes a collision between vehicles and pedestrians. The Main Road does not directly link to the Metro, either.
- The Metro station is connected by a footbridge to access the platforms, passengers must cross the road.
- The lack of natural lighting and ventilation in the RRTS station.
- Unavailability of a service building for the ISPT station.

The station faces many problems that affect efficiency, but in the proposal to develop the station, most of these problems have been resolved.

3-3. Berlin Central Station- Germany

The objective of this section is to define the design requirement in international case studies through two steps process: a detailed qualitative and quantitative analysis of selected international case studies. This chapter include an overview of Berlin Central Station- Germany, the analysis of all aspects related to design requirements in multi-modal hub stations. Figure 3-8

Figure 3-8: Chapter three section two structure, **Source**: Authors.

3-3.1. About Berlin Central Station- Germany

Public transport is the backbone of the passenger transportation system around Berlin ,70% of all trips in Berlin are already taken by public transport**.**

Berlin station has five different public transport modes with interconnected routes and timetables, so that passengers only must buy one ticket even if their journey involves different modes. This ensures a service that is easy to understand for tourists and other users.

Table 3-3

Table 3-3: About Berlin central station

Location	- Berlin, Germany
Opened	- Year: 1996 - 2006
Modes Integrated	- U-bahn - S-bahn - Tram - Bus - Ferries
Area	- Total area 175000 m2
Area of spaces	- Shops and Gastronomy - 50,000 m² - Office - 15,000 m² - Railway Operations - 15,000 m² - Circulation - 21,000 m² - Platforms - 32,000 m² - Parking - 25,000 m²
Daily passenger	- 3,00,000 passengers
Per capita	- To 1,5 m^2 from 10 m^2
Amenities	- Shopping Mall, International Booking Counters, Plazas, Waiting Area, Staff Offices, Control Rooms, Service Rooms, ATMs, Information Centre, Ticket Counters, Security Room, Platforms, **Basement** Parking
Parking Availability	Yes 2 -wheeler, 4- wheeler, cycling, bus
Parking Area	- 2-wheeler & cycle 1000 sqm - buses 1250 sqm - taxi 2500 sqm - 4 -wheeler 20,000 sqm (including basement)
No of Platforms	**7**
Platform Height from Ground	NMT & IPT at ground level east-west lines ground +2, north-south ground -2
Escalators/ Lifts/ Staircases	28 Scalators,4 lifts

Source- Hauptbahnhof (Berlin Central Station).(*Hauptbahnhof (Berlin Central Station) – Berlin.De*, n.d.)

3-3.1.1. Project Description

- Berlin Central Station is Europe's largest train station, located close to the government district in the heart of Berlin, Located along the Spree River north of the Tier Garten, in historic Lehrer Bohnhoff. Figure 3-9

- Berlin Central Station is a vital transportation hub and a vibrant building complex that has evolved into the capital's urban heart and Europe's largest railway crossroads, thanks to its mixed-use design.
- Central node for tracks in all four cardinal directions
- At the main station there are connections to the local transport lines
- There are two service points of the Deutsche Bahn located inside Berlin-Hauptman station, one of which is open around the clock.

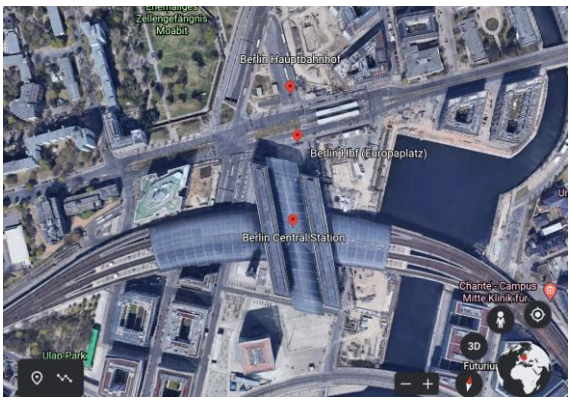


Figure 3-9: Berlin Central Station, **Source**: Berlin Central Station in Berlin, Germany (Google Maps).

- **Concept**

- Two curved structures that are 46 feet tall surround the station's lobby to emphasis the size of the building and the significance of the station as a hub connecting the east and west and a crossing point for Europe.
- The two structures that make up the station bridge are split into two separate functional sections. Nine of the 10 floors of these buildings are occupied by areas for commercial uses, restaurants, and services for rail users, as well as areas with 50 000 m2 of office space. By connecting the various sections by stairs, they are practical and versatile offices.
- The station is supported on a cruciform base that also incorporates the main diagonal building blocks. The rectangular hole offers sizable public spaces that are visible separated from the areas of traffic and extend up to 4.43 meters above street level. The stairways connect the hole's four sides.

3-3.2. Building Specifics

The new Berlin Hauptman's building is a logistical marvel. The construction of a metal bridge that crosses the station was a feat of engineering in this project. Due to the danger involved in installing it when the station was crowded with people, it was decided to run for a weekend during which the station was closed to the public for 54 hours. Then, the building was built in two vertical, 1,200-ton portions that were eventually connected to make a drawbridge.

- The intersection of the east-west and north-south railroads produced the cruciform configuration.
- A vast, curved glass hall that encloses the East-West rails.
- The main hall, which has a barrel vault roof and five stories stretching from north to south.
- The sides of the main hall are flanked by two 12-story office structures.
- The east-west hall's office buildings are connected by two bridges.
- The use of glass permits natural light to enter the building.
- North-South rails in the tunnel are 15 meters below ground.
- East-West tracks that are 10 meters above earth.
- Easy access to individual, public, and tourist transportation.

3-3.2.1. Spaces

The U-Bahn, S-Bahn, and tram networks all converge at Berlin Central Station. As a shopping and office complex, it also benefits from the mixed-use design philosophy.

Of its 175,000 square meters, 21,000 are utilized for rail transportation, taking up two stories and having fourteen platforms, 15,000 are used for shops and restaurants, 50,000 are used for offices and 5,500 are used as bridges for railway functions. A total of 32,000 square meters of space is taken up by the platforms, while roughly 25,000 square meters are used for the garage. Figure 3-10

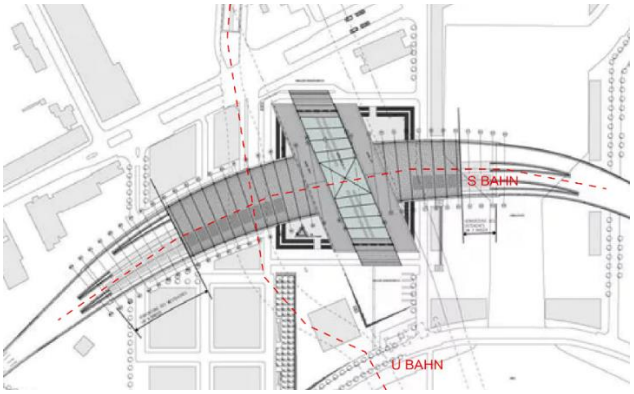


Figure 3-10: S-Bahn, U-Bahn Network and Berlin Central Station , **Source:** https://en.wikiarquitectura.com/building/berlin-central-station/)

3-3.2.2. Entrance

The entrance hall has a glass roof that connects to the bridge and has buildings on either side. These buildings serve as the outer supporting structure, like support beams in the shape of a fish's belly, and are 4,70 meters high, on which the glass dome of the roof rests. Figure 3-11

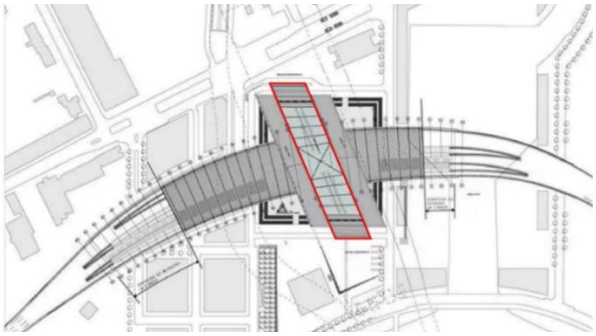


Figure 3-11: Entrance and lobby in Berlin Central Station , **Source:** **https://en.wikiarquitectura.com/building/berlin-central-station/**)

3-3.2.3. Central Nave

- A massive glass dome with light that stretches over 321 meters covers the 430-meter-long central nave, which houses the station platforms and is oriented east-west, between two frames.
- Between the two blocks of buildings is a 45 m wide by 159 m long building with a north-south orientation that is covered in a barrel vault, filigree, and glass.
- These structures, sometimes referred to as building bridges from an architectural and urban planning standpoint, connect the glass containers in the train station.
- The long-distance intersection of the two railway lines is made better by the cruise ships of the two windows. Figure 3-12

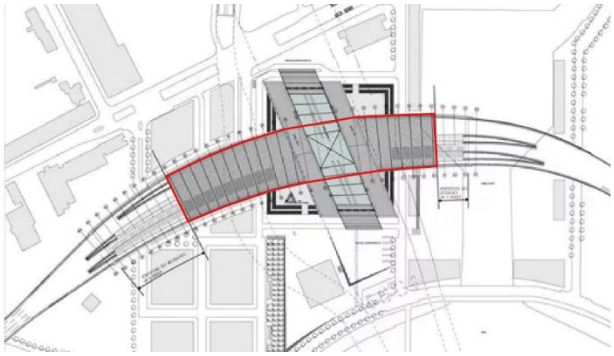


Figure 3-12: Central Nave in Berlin Central Station , **Source:** **https://en.wikiarquitectura.com/building/berlin-central-station/)**

"Between two frames is the central nave that houses the station platforms, 430 meters long, oriented in the direction east-west, covered by a huge glass dome and light that extends over 321 meters." Figure 3-13 , Figure 3-14

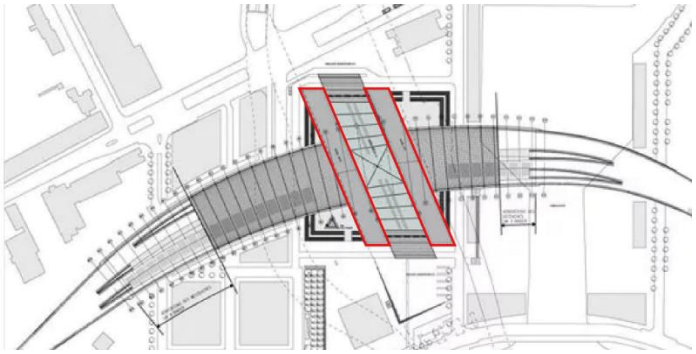


Figure 3-13 : Bridge building at Berlin Central Station , **Source:** **https://en.wikiarquitectura.com/building/berlin-central-station/)**

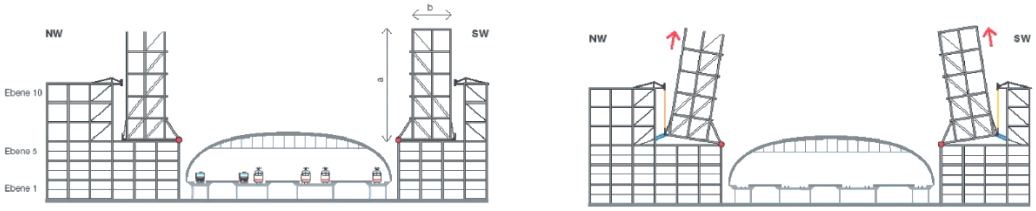


Figure 3-14 : section in Bridge building in Berlin Central Station , **Source:** **https://en.wikiarquitectura.com/building/berlin-central-station/)**

The two structures that make up the station bridge are split into two separate functional sections. The lower levels house the areas used for businesses, restaurants, and services for rail users. Nine of the ten floors of these structures are taken up by areas of 50 000 m2 offices. By connecting the various sections by stairs, they are practical and versatile offices.

3-3.2.4. Shopping Center

The station also developed into the future commercial and business Center of the neighborhood with its substantially sized vacant three floors of shops and restaurants situated between the two levels of terraces.

- Total area: 175,000 m²
- Total retail area: 15,000 m²
- Parking spaces: 900
- Length hall station, north south: 160 meters

Longitude * hall station, east-west: 321 meters

3-3.3. Structure of Berlin Central Station

- A space grid supported by cable networks was used to build the roomy, well-lit area. Whether the glazing support and the underlying structure are the same or not, these grids offer free surfaces and are as clear as glass when utilized directly.
- Six railway tracks are located on one, which spans the width of a cellblock, and flat elliptical arches are supported by a tensioned cable construction. Spatial grids that are 13 meters apart between each arch are used instead of the customary clear straps.
- With a weight of 330 tons each and a 15-degree incline, the cross trusses that make up the bridge superstructure were hoisted into position by lift after being positioned vertically on the towers and weighing an average of 1,250 tons each. Eight lifts received a comparable location in each horizontal portion. The structure's upper and middle strands could be temporarily screwed together, while the lower strand could be temporarily lowered. The 42-meter-long north-south deck was pre-assembled in a number of the towers' south-side and track-facing locations. Fixed bridge routes to these constructions are therefore necessary.

3-3.4. Environmental Treatments in Berlin Central Station

Utilizing design principles that lessen a built environment's detrimental effects on the environment is known as sustainable architecture. When planning a project, architects consider the site's landscaping, energy use, and stormwater management. During construction, they use environmentally friendly methods and materials.

3-3.4.1. Ventilation Tower

The Hauptbahnh of, New Berlin's tallest building, has four exhaust pipes that are clearly visible for miles. Both are considerably over the roof of the building.

A reinforced concrete tower with a 60-meter-tall steel framework that emerges from its underground portion, which is buried around 20 metres below ground, houses 250 tonnes of gold. Across a large portion of central Berlin, it is possible to view the emblem for Deutsche Bahn on each side of the vent pipe.

3-3.4.2. Materials

Its construction required the use of 85,000 tons of steel and 500 000 m3 of concrete. The ventilation towers for each bay's 27000 glass blocks. When designing and building, special consideration was given to security and fire protection concerns, and components that follow the most recent advancements in safety and prevention were used.

3-3.4.3. Roof

- The roof is a massive 20,000 square meter dome made of 11,800 unique glass panels, none of which are the same. Four months set a new record for the quickest completion of the glass ceiling. A total of 85 miles of steel cable holds the roof in place and protects it from wind and weather. There are around 100 kilograms of these panels.
- **Solar panels.** A total of 1250 solar modules cover 2700 square meters of the glass ceiling with solar panels.
- **Technical**
  - Concrete used in construction: 500,000 m^3
  - Steel used in construction: 85,000 t
  - Stairs: 54
  - Lifts: 43
  - Panoramic Lifts: 6
  - Sunroof Area: 2,700 m^2
  - Number of solar modules ceiling: 1250
  - Bow’s structure height: 46 meters.

3-3.5. The Requirements in Berlin Central Station

The requirements in Berlin Central Station are formed from five main requirements, these requirements included (functional requirements, circulation requirements, security, and safety requirements, environ mental design requirements, Architectural Heritage and Preservation, and social and economic requirements).

The considerations for each Requirement were found from existing guideline documents and research regarding mobility hubs. As such, these considerations are a brief overview of what is found and are meant to guide the development of complete guidelines. Table 3-4

Table 3-4: The requirements at Berlin central station

requirements	Secondary requirements
functional requirements	• Connecting different types of transportation in one place
	• Functional integration according to social and environmental changes, and providing service and commercial spaces
	• Optimal use of space
	• Design spaces, and platforms according to the number of passengers at peak hours
	• Provide usability requirements
	• Considering the individual's share in the different spaces.
	• Provide special spaces for operators
	• Use a unified ticket
	• The use of electronic tickets to reduce the need for ticket halls inside the stations
	• Sufficient parking all around the 4 sides of station/ basement parking as well
	• Physical, visual interconnection, and Aesthetic form
circulation requirements	• Provide sufficient space for movement and waiting
	• Providing horizontal and vertical movement
	• Considering people with special needs.
	• The separation between the movement of people and vehicles
	• Reducing walking distances
	• The station's design must allow free-flowing passenger movement to avoid severe congestion within the Station, particularly on platforms and escalators.
	• A passenger movement must be unhindered from the time he enters the Station until he leaves.
	• Providing consistent and obvious directional signage
	• Cycle tracks & cycle parking
	• Sequence in motion (entry-tickets-waiting-departure)
Environmental design requirements	• Using biophilic design to achieve a comfortable healthy environment inside the station
	• Using local materials that are resistant to weather conditions and recyclable
	• Rainwater collection and reuse
	• Reducing the operating cost and saving energy

	• Increasing green spaces inside and around the station
	• Respect the privacy of the site
	• Good open spaces around the station/ plaza/ creating a fresh environment/pedestrian-friendly atmosphere
	• The use of glass allows natural light
Safety and security requirements	• The Station design should promote security for the passenger.
	• Accident risk should be reduced by station design.
	• Stations should be designed to be safe and secure without depending on technology.
	• Pedestrian path must be direct, and well lit.
	• Slip-resistant walking surfaces
	• Controlling entrances and exits
	• Protection of personal property
	• maintenance requirements
	• Provide emergency requirements
	• Providing a safe for users and protection from weather conditions.
Socio-economic	• Active spaces in & outside the station/ has a shopping mall`
	• The link between production and consumption areas
Architecture	• The design of the Station shall consider their maintenance, aesthetic, and historic reflection

Source- Authors based on extant literature sources.

3-4. Birmingham Station – England

The objective of this section is to define the design requirement in international case studies through two steps process: a detailed qualitative and quantitative analysis of selected international case studies. This chapter includes an overview of Birmingham Station – England, and the analysis of all aspects related to design requirements in multi-modal hub stations. **Figure 3-15**

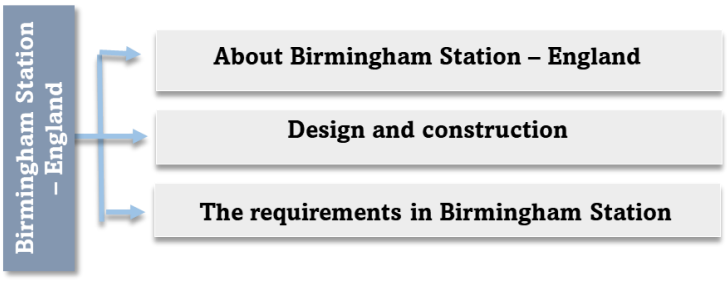


Figure 3-15: Chapter three section three structure, **Source:** Authors.

3-4.1. About Birmingham Station – England

According to Owen Pritchard, Birmingham New Street Station might represent the triumph of function over form as a new icon in a city of icons.

A new station in Birmingham was required to accommodate more passengers both now and in the future. To provide visitors to Britain's second city a good first impression, the project's backers, Birmingham City Council, the Department for Transport, Advantage West Midlands, Centro, and Network Rail, saw the necessity of improving the station's design and atmosphere. In 2000, these parties got together with a plan for New Street Station's renovation that would benefit both Birmingham residents and the areas outside the city, and they pledged the money to make it happen. The current station was constructed in 1967 to replace a Victorian structure that had suffered severe bombing during World War II. The station was designed to accommodate 60,000 passengers daily, but by 2010, it had seen roughly 170,000 visitors. The station has been inadequate for its intended use for many years, and it was not unusual for it to close platforms during rush hour to maintain passenger safety.

In 2000 it was the decision by the clients (Birmingham City Council, the Department for Transport, Advantage West Midlands, Centro, and Network Rail) that this station would not only have to handle the growing number of passengers more effectively but also become a landmark to give visitors a great first impression of Britain’s second city. The refurbished station would improve connections to the rest of the city, acting as a hub for a new metro.

3-4.1.1. Project Description

- Birmingham New Street Station is a vital transportation hub as well as an integral part of the city's public environment. Birmingham's first impression is based on its strategic location in the city and its ability to handle a huge amount of traffic.
- Grand Central, a highly upscale shopping center, now shares space with the train station, making it a perfect place to board a train. Figure 3-16
- There are numerous access points to and from the trains, which is ideal for frequent customers.
- The train station is below street level, so trains travel through tunnels beneath the city Centre to access the station.

Figure 3-16: Location of Birmingham station, **Source:** (Aeroengland | Aerial Photograph of Birmingham New Street Railway Station Birmingham, West Midlands England UK, n.d.)

Table 3-5 : About Birmingham Station – England

Location	- Birmingham, England
OPENED	- YEAR: 2015
Modes Integrated	- Railway station - Bus Stations - Mega Bus
AREA	- Total area 91500 m2 - Gross internal floor area - Lower mezzanine 3,000m² - platforms - 8,000m² - concourse - 20,000m² - upper mezzanine - 4,500m² - grand central - 17,000m² - JLP - 24,000m² - upper retail - 15,000m²
Daily passenger	- 140,000 passengers
Per capita	- To 2,5 m^2 from 6 m^2
amenities	- Shopping central, Waiting Area, Offices, Control Rooms, Service Rooms, ATMs, Information Centre, Ticket Counters, Security Room, Platforms.
No of Platforms	- **7**

Source- Birmingham New Street Station.(AZPML, 2016)

3-4.1.2. Concept Architect's View

- The project's architectural expression was inspired by the geometry of motion and the distortion of vision brought on by movement. The building's design was altered to incorporate the bifurcating, undulating, smooth forms of the tracks to represent the building's historical function as a crossroads where numerous traffic systems—such as the well-known canals and Roman roads—converge and overlap. Figure 3-17
- The new station design includes the cladding and the restructuring of the building; attempted to restore continuity between form and expression. The old building was constructed for a different organizational and aesthetic performance than the current station Because the cladding could not, practically, be tied to the interior of the building, the facade's design has been related to the exterior area instead than aiming to show the building's inner structure. As a result, the structure serves as a tool to improve how Birmingham's inner city is perceived.
- Birmingham New Street Station has been built to reflect the surrounding urban environment in a controlled manner, including the once-dark, now-bright Birmingham sky, the crowds of passengers, the trains coming into and leaving the station, the colors of the sunrise and sunset, and other dynamic regimes at the location. The external rainscreen is converted into a warped, reflecting stainless-steel surface to do this. To highlight the main entrance locations, large media panels resembling eyes have been placed into the facade.

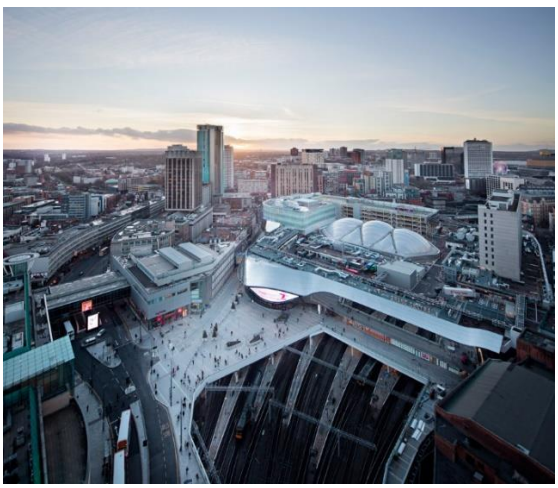


Figure 3-17: designed Birmingham new street station, **Source**: (*Designed Birmingham New Street Station*, n.d.)

"The bifurcating, undulating, smooth forms of the track field have been transferred and embedded into the geometry of the building to ornate the city and to convey its historical character as a transport hub, where various traffic systems -- such as the famous canals and the roman roads -- converge and overlay."

The ‘media eyeballs,' which are big screens that display videos, are located above the three main entry points. The John Lewis store, one of the largest outsides of London, rises above the Southside entrance as a glacial green rotunda from the building's gleaming arm hours. The building's façade rolls up to its entire height, facing east, creating a vast, reflected cliff that curves and morphs around the structure. Figure 3-18

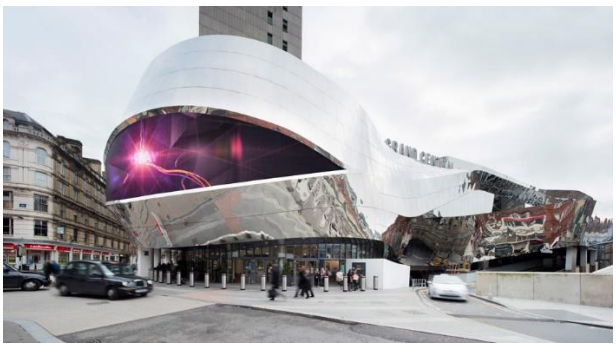


Figure 3-18: Elevation of Birmingham new street station, **Source**: (*Designed Birmingham New Street Station*, n.d.)

3-4.2. Design and Construction

A significant transport hub and an essential component of the city's public domain is Birmingham New Street Station. With its prominent location and capacity for heavy traffic, it gives a considerable influx of tourists to the Midlands their first impression of Birmingham**.**

The Birmingham New Street Station design idea aspires to produce a work of iconic architecture that will be able to communicate to the public the building's mission and the distinctive attributes of its site in the center of Birmingham City. It is suggested that to accomplish this, the dynamic aspect of the railway topic be given expression.

The station's renovation was done in two stages. A new concourse was built in the existing parking lot above the station platforms as part of phase one. The concourse was opened in April 2013 after preparatory work for this phase had started in September 2009**.**

The current concourse, which had been increased in size from its current 10,500m2 to three and a half times that amount, was shut down during phase two. It is surrounded by a massive, well-lit atrium that offers access to platforms that are crisper and brighter. Platforms 8 and 9—the busiest ones—were expanded. Midway through 2015, phase two was finished.

3-4.2.1. Building Specifics and design

- The three-story building, which boasts a massive balustraded entryway and was built in Classical style based on the architect's travels through Italy, held offices for clerks and company secretaries of the L&BR. Figure 3-19
- The building's façade still has a Roman-style design, and above its main doors are the emblems of the London and Birmingham Railway. However, the majority of its roof and all of its windows were replaced as a result of a direct hit during a bombing raid in the Second World War.
- The design approach for the new station, both in terms of cladding and structural restructuring, aims to re-establish consistency between form and expression.

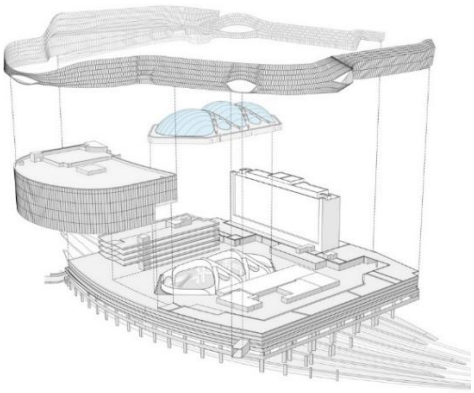


Figure 3-19: Schematic View of Birmingham Station, **Source**: (AZPML, 2016)

3-4.2.2. Services and Station Facilities

- 92 more trains were added to the fleet because of the station's renovation. An additional 106 cars were added to the pentominoes that connect Birmingham, London, and the West Coast Main Line in order to increase their length.
- Arriva added 40 additional coaches, adding 3,000 extra seats per day to the capacity.
- Birmingham New Street Station has a ticket office, restrooms with showers and baby changing stations, a lost and found office, food and drink outlets, Wi-Fi, long- and short-term parking, accessible parking, and bike parking, among other services.
- As part of the station's reconstruction, platform escalators were raised from five to 36, public lifts from two to 15, and pedestrian access from two to eight.(*Birmingham-New-Street-Accessible-Station-Guide.Pdf*, n.d.)

3-4.2.3. Station Design Principles

- The station design will provide:
  - A gateway to Birmingham,
  - Improved rail and other mode of transport connectivity,
  - A potential stimulus for Eastside, Digbeth, and the larger city region's regeneration.
- The Promoter has agreed to the general design principles for Curzon Street station, covering the following problems, as assurances to Birmingham City Council and CENTRO.(Manual, 2020)
  - Simple and unambiguous
  - Secure and safe
  - Inclusive and accessible
  - Warm and user-friendly
  - Operable and operable
  - Maintainable and flexible
  - Sustainable – Economical
  - Integrable and permeable – Buildable
  - Design and material quality
  - Internal organization, local transportation network integration, and active frontage optimization
- principles also include needs for additional stations in addition to requirements for Curzon Street station in terms of optimizing station entrances and exits, minimizing construction impacts, and future regeneration, redevelopment, and public realm.

3-4.2.4. Access To and From the Station

It is anticipated that the bulk of passengers using HS2 Curzon Street Station will arrive at the station on foot, mostly changing trains at other Birmingham stations. It is anticipated that a modest number of individuals would drive to and from the station. This is consistent with the development goal of the Birmingham Eastside Master Plan, which calls for more pedestrianization and public reliance on the bus, rail, and bicycle networks. The majority of visitors will likely arrive through the main entrance on Moor Street Queensway.(*Birmingham-New-Street-Accessible-Station-Guide.Pdf*, n.d.)

3-4.2.5. Operational Requirements

- In addition to providing access and room for passengers to move around the station building, the station will also allow for both pedestrian and automobile access. Platforms, escalators, concourses, and circulation spaces must provide enough space to accommodate peak passenger volumes, including anticipated future growth.
- There will be level access to all public and employee areas, and the station will have lifts in addition to stairs and escalators for access to all levels. It will be possible to go to and from the station via cars, delivery trucks, taxis, buses, bike storage areas, and friendly pedestrian entrances.

3-4.2.6. Environmental Effects

- The "Environmental Minimum Requirements" include the Code of Construction Practice (COCP), which will incorporate a variety of mitigation measures to limit impacts as much as is reasonably practical. These requirements control noise, atmospheric emissions, and other undesirable environmental consequences. Additionally, it provides for the creation of local environmental management plans (LEMPs) that incorporate community and regional environmental protection strategies. Contractors must control exhaust emissions, noise, dust, and air pollution.
- Making use of natural ventilation and lighting in keeping with the curved architectural motif, seven domed skylights made of translucent ethylene tetrafluoroethylene plastic cover a huge atrium above the station concourse within.
- Reduce energy usage and materials waste and minimize impact on the natural environment.
- The station is planned to be net zero carbon in operation.

3-4.3. Requirements in Birmingham Station – England

Considerations for each requirement were found from existing guideline documents and research regarding mobility hubs. As such, these considerations are a brief overview of what is found and are meant to guide the development of complete guidelines. Table 3-6

Table 3-6: Requirements for Birmingham Station – England

requirements	secondary requirements
functional requirements	• Connecting different types of transportation in one place
	• Functional integration according to social and environmental changes, and providing service and commercial spaces
	• Optimal use of space
	• Providing waiting areas and restrooms inside the main halls and ticket halls and places for decision-making and providing services for them
	• Design spaces, platforms according to the number of passengers at peak hours
	• Considering the individual's share in the different spaces.
	• Provide usability requirements
	• The use of electronic tickets to reduce the need for ticket halls inside the stations
	• Provide special spaces for operators
	• Physical visual interconnection, and Aesthetic form
Circulation requirements	• Provide sufficient space for movement and waiting
	• Providing horizontal and vertical movement
	• Considering people with special needs.
	• The separation between the movement of people and vehicles
	• Reducing walking distances
	• The station's design must allow for free-flowing passenger movement to avoid severe congestion within the Station, particularly on platforms and escalators.
	• A passenger movement must be unhindered from the time he enters the Station until he leaves.
	• Define separate areas for the movement of baggage
	• Providing consistent and obvious directional signage
	• The platform is divided into parts, the first of which is at the edge a warning area, then a movement area, followed by a waiting area, and there is a line separating the prohibited area from the waiting area
	• Sequence in motion (entry-tickets-waiting-departure)
Environmental design requirements	• Using local materials that are resistant to weather conditions and recyclable
	• Rainwater collection and reuse
	• Reducing the operating cost and saving energy
	• Increasing green spaces inside and around the station
	• Respect the privacy of the site
Safety and	• The Station design should promote security for the passenger.
	• Accident risk should be reduced by station design.

	• Stations should be designed to be safe and secure without depending on technology.
	• Pedestrian path must be clear and well-lit.
	• Slip-resistant walking surfaces
	• Controlling entrances and exits
	• Protection of personal property
	• maintenance requirements
	• Provide emergency requirements
	• Providing a safe for users and protection from weather conditions.
Socio economic	• Providing investment and rental spaces
	• The link between production and consumption areas
Architectural Heritage and	• The design of the Station shall consider their maintenance, aesthetic, and historic reflection.

Source- Authors based on extant literature sources.

3-5. Conclusion

- The Anand Vihar Station is situated next to the Anand Vihar Metro Station and Anand Vihar ISBT, making this area the center of intermodal transportation in East Delhi. Passengers can easily travel to any part of Delhi after alighting at the Anand Vihar Railway Station and using the city bus services or metro, with an estimated 42% of traffic from ISBT, 38% from the rail, 58% from the metro and 66% from RRTS interchanging at the station.
- The Anand Vihar Station consists of four modes of public transportation station which are represented in (ISBT (Inter State Bus Terminus)- railway terminal - metro station - Regional Rapid Transit System).
- The re-design of Anand Vihar Transport Hub, New Delhi includes a railway terminal Theus terminal, and two metro stations. As the functions were brought together, a common concourse was formed, and the oncourse was raised up to a different level, and shaped as a public space, where people could come together, and an uninterrupted pedestrian network in and around the site was created.
- Berlin has five separate public transport options (U-bahn, S-bahn, Tram, Bus, and Ferries), however even if different operators are involved in each trip, only one ticket needs to be purchased. This guarantees a service that is simple for tourists and other sporadic users to grasp.

- The construction of the new Berlin Hauptman is a masterpiece of logistics. and the main element in the station represented in (Service and administrative spaces -- Entrance and main hall -- Central Nave --Shopping Center).
- Birmingham New Street Station is a vital transportation hub as well as an integral part of the city's public environment. Birmingham's first impression is based on its strategic location in the city and its ability to handle a huge amount of traffic, Birmingham New Street Station has three different public transport modes (Railway station- Bus Stations- Mega Bus)
- The station's renovation was done in two stages, and the building, was built in Classical style based on the architect's travels through Italy, held offices for clerks and company secretaries of the L&BR.
- The case studies produced design requirements for multi-modal hub stations, the following conclusions were reached:

The requirements of multi-modal hub formed from five main requirements that were drawn from three case studies of multi-modal hub stations. These requirements included (functional requirements, circulation requirements, safety and security requirements, environmental design requirements, and social and economic requirements). Table 3-7

Table 3-7: Requirements for case studies

requirements	Secondary requirements	ANAND	Berlin	Birmingham
functional requirements	- Connecting different types of transportation in one place	*	*	*
	- The station should be designed to accommodate the flow of people from arrival to departure.	*		
	- Design spaces, and platforms according to the number of passengers at peak hours		*	*
	- Considering the individual's share in the different spaces.	*	*	*
	- Each function should have its own space, which should be divided up according to the importance of each function. The most room must be dedicated to free circulation.	*		
	- Functional integration according to social and environmental changes, and providing service and commercial spaces	*	*	*
	- Providing waiting areas and restrooms inside the main halls and ticket halls and places for decision-making and providing services for them			*

	- Optimal use of space	*	*	*
	- Provide special spaces for operators	*	*	*
	- Station entrances serve as a connection between the station and the surrounding streets. All passengers must have easy access to the entrances.	*		
	- The station entry must provide clear and direct access to the local footpath system.	*		
	- Arrival and departure concourses should be strategically positioned below and/or above the platforms.	*		
	- The departure concourse and platforms should each have a shared ceiling with unobstructed broad span structural systems	*		
	- Station interiors must include partition walls that allow for flexible area	*		
	- Provide usability requirements		*	*
	- Use a unified ticket		*	
	- The use of electronic tickets to reduce the need for ticket halls inside the stations	*	*	*
	- Sufficient parking all around station.		*	
	- System integration (structure, space, materials, lighting, communications, and mechanical)	*		
	- Maintain visual/aesthetic continuity with the rest of the system while incorporating site-specific aspects. (Physical, visual interconnection, and Aesthetic form)	*	*	*
Circulation requirements	- To prevent severe congestion inside the station, particularly on platforms and escalators, the design of the Station must allow for a free-flowing passenger.	*	*	*
	- Reducing walking distances should be kept to a minimum.	*	*	*
	- Paths should be clear and straightforward as feasible.	*		
	- A passenger's movement must be unhindered from the time he enters the Station until he leaves.	*	*	*
	- All platforms should be parallel and of the same length.	*		
	- Segregation of arriving and departing passengers.	*		
	- provided waiting space to reduce passenger interference in the circulation area.	*		
	- Create a clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation. (Sequence in motion (entry-tickets-waiting-departure)	*	*	*
	- Assisting with motility (elevators, escalators, moving walkways and assistive devices like wheelchairs for the physically disabled)	*	*	*
	- Providing consistent and obvious directional signage	*	*	*
	- To build a seamless local and regional inter-modal network, station designs should make it simple to change to other Transit System lines and forms of public transport.	*		

	- passengers must be given sufficient options to depart the station campus, such as regional buses, taxis, or the Mass Rapid Transit System.	*		
	- Provide sufficient space for movement and waiting		*	*
	- Considering people with special needs.		*	*
	- The separation between the movement of people and vehicles		*	*
	- Define separate areas for the movement of baggage			*
	- The platform is divided into parts, the first of which is at the edge a warning area, then a movement area, followed by a waiting area, and there is a line separating the prohibited area from the waiting area			*
	- Cycle tracks & cycle parking		*	*
Environmental design requirements	- Using biophilic design to achieve a comfortable healthy environment inside the station		*	
	- Using local materials that are resistant to weather conditions and recyclable	*	*	*
	- Rainwater collection and reuse	*	*	*
	- Reducing the operating cost and saving energy	*	*	*
	- Increasing green spaces inside and around the station	*	*	*
	- Respect the privacy of the site		*	*
	- Good open spaces around the station/ plaza/ creating a fresh environment/pedestrian-friendly atmosphere	*	*	
	- The use of glass allows natural light	*	*	
	- The most effective operation and maintenance	*		
	- The material finishes of the Station's structural elements should be extremely long-lasting, low-maintenance, and less frequently cleaned.	*		
Safety and security requirements	- The station design should promote security for the passenger.		*	*
	- Stations should be built with the least amount of potential for accidents.	*	*	*
	- Stations should be designed to be safe and secure without depending on technology.	*	*	*
	- Pedestrian path must be clear and well-lit.	*	*	*
	- Slip-resistant walking surfaces		*	*
	- Controlling entrances and exits		*	*
	- The more accident-prone locations, like the platform and vertical circulation components, require special care.	*		
	- Protection of personal property		*	*
	- maintenance requirements			
	- Provide emergency requirements		*	*
	- Providing a safe for users and protection from weather conditions.		*	*
	• Safety and Health - Plans should be made to reduce the likelihood of accidents and health risks. The following strategies are to be used, but are not restricted to them: - Appropriate and sufficient illumination - Slip-resistant surfaces for walking	*		

	- Proper use of safety rails and guards			
Soci	- Providing investment and rental spaces	*	*	*
	- The link between production and consumption areas	*	*	*
Archite	• The design of the Station shall consider their maintenance, aesthetic, and historic reflection.	*	*	*

Source- Authors based on extant literature sources.

The results of case studies showed that there is a discrepancy in achieving design requirements, as (functional requirements- circulation requirements) were achieved and it was the highest of the design requirements, while (social and economic requirements & Architectural Heritage and Preservation) achieved the least of design requirements.

And there are common requirements in case studies, which are:

- **Functional Requirements**
  - Connecting different types of transportation in one place
  - Design spaces, and platforms according to the number of passengers at peak hours
  - Considering the individual's share in the different spaces.
  - Functional integration according to social and environmental changes and providing service and commercial spaces.
  - Optimal use of space
  - Provide special spaces for operators.
  - Provide usability requirements.
  - The use of electronic tickets to reduce the need for ticket halls inside the stations.
  - Maintain visual/aesthetic continuity with the rest of the system while incorporating site-specific aspects.

- **Circulation Requirements**
  - To prevent severe congestion inside the station, particularly on platforms and escalators, the design of the Station must allow for free-flowing passenger.
  - Reducing Walking distances should be kept to a minimum.
  - A passenger's movement must be unhindered from the time he enters the Station until he leaves.
  - Create a clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation.
  - Sequence in motion (entry-tickets-waiting-departure)

- Assisting with motility (elevators, escalators, moving walkways and assistive devices like wheelchairs for the physically disabled)
- Providing consistent and obvious directional signage
- Provide sufficient space for movement and waiting.
- Considering people with special needs.
- The separation between the movement of people and vehicles

- **Environmental Design Requirements**
  - Using local materials that are resistant to weather conditions and recyclable.
  - Rainwater collection and reuse
  - Reducing the operating cost and saving energy
  - Increasing green spaces inside and around the station
  - Respect the privacy of the site.
  - Good open spaces around the station/ plaza/ creating a fresh environment/pedestrian-friendly atmosphere.
  - The use of glass allows natural light.

- **Safety and Security Requirements**
  - The station design should promote security for the passengers.
  - Stations should be designed to be safe and secure without depending on technology.
  - The pedestrian path must be clear and well-lit.
  - Slip-resistant walking surfaces
  - Controlling entrances and exits.
  - Protection of personal property
  - maintenance requirements
  - Provide emergency requirements.

- **Socio-Economic Requirements**
  - Providing investment and rental spaces
  - The link between production and consumption areas

- **Architectural Heritage and Preservation**
  - The design of the station shall consider their maintenance, aesthetic, and historic reflection.

Summary of part one

Part one attempted to identify the design requirements for multi-modal hub stations by examining literature reviews, knowledge, and examples of current best practices for such stations.

In Chapter One, the literature studies produced design requirements for multi-modal hub stations by study literature review, the following were reached:

The chapter consists of some requirements that were drawn from a literature review of multi-modal hub stations. These requirements included (functional requirements, circulation requirements, safety and security requirements, environmental design requirements, and social and economic requirements).

Despite the diversity and multiplicity of design requirements for multi-modal hub stations, and deficiency in previous knowledge in creating a theoretical vision that explains the social and economic requirements of multi-model hub stations. Hence, there is a gap in the social and economic requirements for multi-model hub stations.

In Chapter Two, provides a summary of the pertinent research and studies on multi-modal hub stations, the result of this chapter is some of the guidelines for multi-modal hub stations.

In Chapter Three, the case studies produced some of the design requirements for multi-modal hub stations, the following conclusions were reached:

The requirements of multi-modal hub formed from five main requirements that were drawn from three case studies of multi-modal hub stations. These requirements included (functional requirements, circulation requirements, safety and security requirements, environmental design requirements, and social and economic requirements).

PART TWO: Empirical Study

The objective of empirical study is to deduce a guideline for the design aspects of multi-model hub stations. This part consists of two chapters. Chapter four are the Egyptian case studies; the objective of this chapter is access to design requirements used in Egyptian stations and existing problems through analysis and personal interviews. Chapter Five is (Assessing & Proposed improvements & Conclusion), The objective of this chapter is to deduce a guideline for the design aspects of multi model hub stations, assessing the Egyptian case studies, and proposed improvements. Figure 0-2

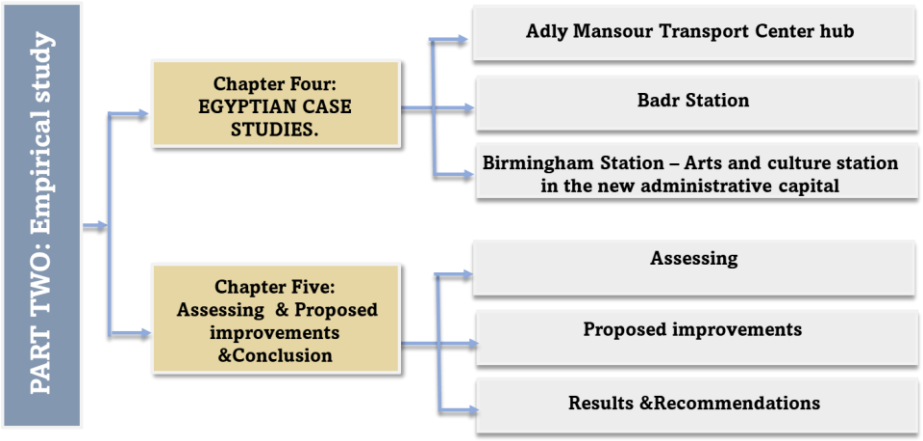


Figure 0-2: part two structure, **Source**: Authors.

4- Chapter Four: Egyptian Case Studies.

The final objective of this chapter is access to design requirements used in the Egyptian stations and existing problems through analysis and personal interviews with officials. This chapter consists of three sections. In these sections concern identifying the design requirements in (Adly Mansour Transport Center hub – Badr station - Arts and culture station) through a two steps process: a detailed qualitative and quantitative analysis of a selected local natural setting case study. This chapter includes an overview and analysis of all aspects related to the design requirements.

Figure 4-1

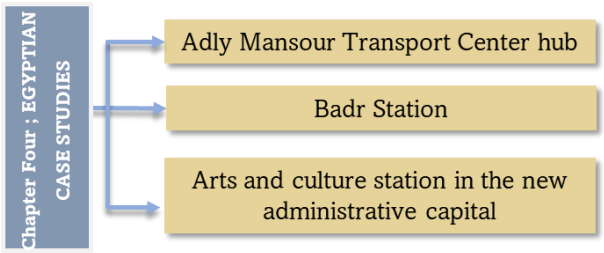


Figure 4-1: Chapter Four structure, **Source**: Authors.

4-1. Adly Mansour Transport Center Hub

Many countries are increasing their research interest in multi-modal passenger transportation design, including hubs, interchange, and other typologies. Multi-modal transportation is the act of connecting and moving people and goods using at least two different modes of transportation. As a result, expanding the country's transportation system is part of its economic reform strategy.(Kramarz & Przybylska, 2021) In order to ease congestion in the Cairo and Alexandria metropolitan regions and spur urban expansion elsewhere, the country's economic reform strategy back then included expanding the transport network and infrastructure a key component.(*Transport Terminals and Modal Interchanges Planning and Design*, 2005) Adly Mansour Terminal will be a sizable transportation hub with a variety of modes of transportation. Passengers can switch modes of transportation at this main central station. The project's goal is to build an integrated transportation complex on 15 acres so that five various modes of transportation can interchange services. To meet the needs of the present and the potential for future growth, the area surrounding the station was intended to have various surface parking lots for taxis and owners' automobiles, together with a commercial investment area and green areas on a surface area of 49170 m2.

The objective of this section is to identify the design requirements in Adly Mansour Transport Center hub through two steps process: a detailed qualitative and quantitative analysis of a

selected local natural setting case study. This chapter will include Adly Mansour Transport Center hub overview and the analysis of all aspects related to the design requirements. Figure 4-2

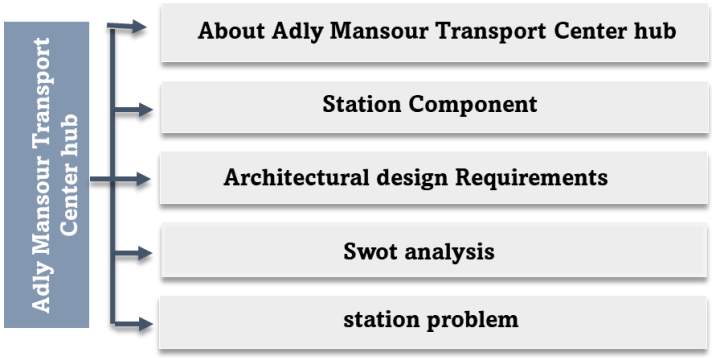


Figure 4-2: Chapter four section one structure, **Source**: Authors.

4-1.1. About Adly Mansour Transport Center Hub

The station is situated on 30 feddans of land. The station's service switches between five different modes of transportation. The station features a private automobile parking facility with 260 car capacity and 4.5 feddans of space. There is a VIP parking area in front of the Adly Mansour train station, with space for 100 vehicles across 1.5 feddans. The station contains green spaces, eight feddans of pathways, 500-meter-long tunnels, and passageways that connect the various parts of the station. On 6.5 feddans of space, including a basement, the station also has a commercial mall that serves the neighborhood around it. (The Arab Contractors (Osman Ahmed Osman & Co.), 2022)

from that, the following factors were consideration when selecting the station: -

- Adly Mansour terminal is a transportation hub with a variety of modes of transportation. At this main central station, travelers can switch to a different mode of transportation.
- Adly Mansour station is one of the main hubs that connect the republic's cities and governorates to the New Administrative Capital.
- The station has a 15-acre site and consists of a full-service transit complex and a commercial investment area.
- Adly Mansour station connects the network of five different means of transportation nationwide, represented by the third metro line, the electric train track, a railway station, and a SuperJet station, in addition to the BRT express bus and the frequency bus.

4-1.1.1. Station location and Access Routes

Adly Mansour station is situated in Huckstep, El Nozha, Cairo Governorate. The station can be accessed through various axes and roads. Additionally, the station is encompassed by metro workshops and verdant areas. Figure 4-3.

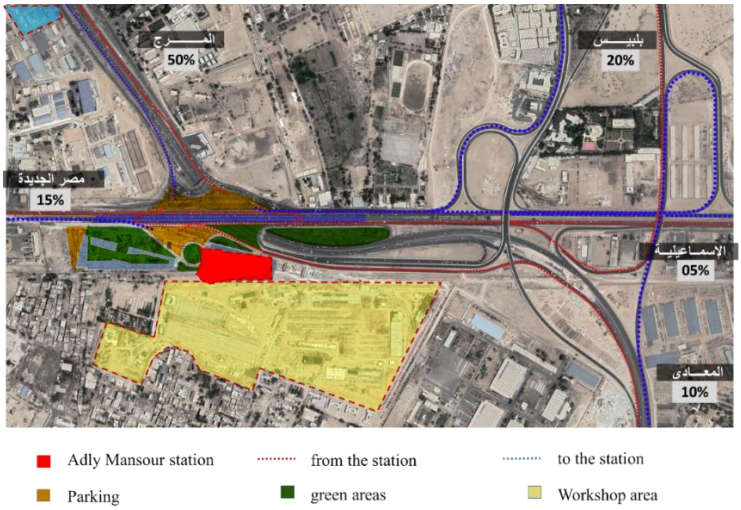


Figure 4-3 : Adly Mansour location and access routes, **Source:** Adly Mansour location google earth pro.(*Google Earth*, n.d.-a)

4-1.1.2. Site Context

- Adly Mansour Transportation Hub in Egypt is a multi-transportation mode hub that connects a variety of different travel types into one central area.
- The different travel types include: an electric train track, a railway station, and a SuperJet station, in addition to the BRT express bus and the frequency bus, and other local modes, as well as mall that features retail stores of different areas, as well as outdoor areas. Figure 4-4 (*ARCONS with Arab Contractors at Greater Cairo Metro, Adly Mansour Hub*, n.d.)
- The station is built on an area of 30 feddans, there is a group of 500m tunnels to connect these modes with each other, 10 feddans of green areas and communication elements, in addition to a commercial mall on 6 feddans: the ground floor of which is a basement garage accommodates 600 cars to serve the mall.
- The inside of the Adly Mansour station is completely covered with a metal structure that rises to a height of 23 m, covering a total area of 6 feddans. The station consists of the main gate and three stations below the coverage: the Cairo-Suez railway station, the LRT station, and the metro station on the third line. A bridge connecting

the electric train station and the metro station, one connecting the electric train station and the Cairo-Suez railway station, a VIP hall with an area of 160 m2, and an upper commercial service area to serve the station covering an area of 1500 m2 are also included. The main square in the middle of the stations also connects them to a 7500 m2 area.

- Other amenities at the station include WIFI, self-propelled stairs, elevators for the disabled, ATMs, Electronic Ticket Machines, a control room, GPS screens, trip coordination and planning screens, monitoring camera screens, screens for electric bus charging systems, and a tunnel connecting it to Adly Mansour station and the parking lot to the north of Al Salam Bridge.

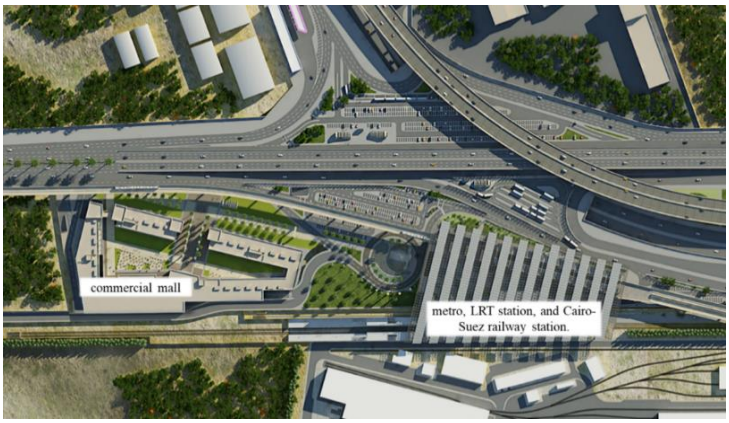


Figure 4-4: Site context of Adly Mansour station**, Source:** (Archplan | Adly Mansour Transportation Hub, n.d.)

4-1.2. Station Component

Adly Mansour station connects the network of five different modes of transportation nationwide, represented by the third metro line, the electric train track, a railway station, and a SuperJet station, in addition to the BRT express bus and the frequency bus. Figure 4-5 Appendix 1

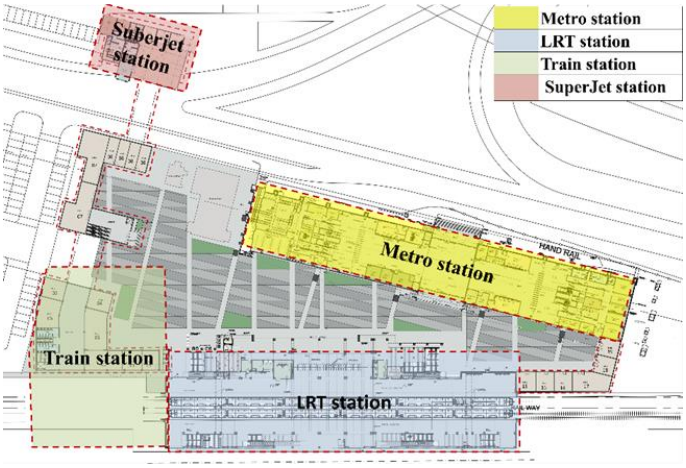


Figure 4-5 : Adly Mansour station layout**, Source:** Arch plan - Adly Mansour Transportation Hub.(*Archplan | Adly Mansour Transportation Hub*, n.d.)

4-1.3. Architectural Design Requirements at Adly Mansour Transport Center Hub

In this section, we will discuss the requirements for the Adly Mansour transport center hub. Multi-modal hub stations play a crucial role in the development of modern cities, as they connect various modes of transportation. These stations serve as gathering areas for people and function as commercial, recreational, and cultural hubs. Based on this, the design requirements for multi-modal hub stations were divided into primary groups of design requirements, each of which contains secondary groups of design requirements.

4-1.3.1. Functional Requirements

The effectiveness of multi-modal stations is a crucial aspect of intermodal success. Information management, a ticketing system, and platform accessibility are all important physical and operational measures at such terminals. The segregation of different modes of transportation in intermodal terminals can greatly enhance system efficiency. These are all equally significant factors that influence the layout of intermodal stations, and they have also enhanced the integration of public transportation by creating station plazas with amenities for multiple modes of transportation and pedestrian-friendly environments. Therefore, Adly Mansour station has a multitude of functional requirements.

- Connecting different types of transportation in one place and Providing spaces for movement between different modes
- Spatial organization of spaces to minimizes intersections for passengers and reduce movement paths and decision points.

- Functional integration according to social and environmental changes and providing service and commercial spaces.
- The separation between entrances and exits in LRT station and metro station, while the separation is not done in other modes.
- The separation between the arrival and departure halls in LRT station, while other modes are not separated.
- Providing private entrances and services for employees and operators in the station
- Providing services and shops at the train station while not provided in the other modes.
- Dividing the platform cross-section at the LRT and metro station, while it is not done at the railway station.
- Optimal use of space
- Provide usability requirements.
- Providing waiting areas and restrooms inside the main halls and ticket halls and places for decision-making and providing services for them.
- Physical, visual interconnection, and Aesthetic form.

4-1.3.2. Circulation Requirements

Transportation and circulation depend on the safe and efficient movement of people and goods. In the past passenger movements between platforms and the waiting halls of the station. while the Present day, big stations serve as hubs for connections between a variety of modes, and a user-friendly information system is required because there are now many flows within the station complex, some of which are running at different levels and using different ways since every journey begins and ends with a walk, it makes sense that walking is one of the most relevant modes of transportation. According to transportation planning, walking is the primary mode of transportation for individuals in their daily lives. How easily a place can be walked through, and the amenities offered to passengers both affect safety. (Filipe & Ramos, 2015)There are various metrics by which we might assess the amenities for pedestrians.

- Flow Rate is calculated as the number of people at a certain time by the area of the spaces.
- Spatial distribution is the number of pedestrians across the different spaces of the stations.

- Rate per capita is calculated by the area of the spaces divided by the number of pedestrians.
- Density is calculated by the number of pedestrians divided by the area of the spaces.
- Delay in time is calculated by (delay time = observation time - Standard Time). While the standard time is calculated by (standard time =distance / standard speed).

Transportation and circulation are key components of safe and effective pedestrian circulation, where the circulation paths are regarded as one of the most influential aspects of Transportation stations, where the paths intersect and form many spaces, which leads to issues in the circulation paths for users, and thus an increase in the time spent in the path, an increase in densities, and a decrease in per capita share. So many countries are interested in pedestrian circulation patterns within stations, successful international studies were chosen and identify their design requirements for pedestrian circulation. (Amtrak, 2013), (for Transport, 2015),(Ministry of Railways, 2009) Within the studies, there were several similar requirements of pedestrian movement paths, which are as follows:(Hany, 2019)

- ***Factors affecting pedestrian circulation efficiency.***

Circulation requirements in multi-modal hubs indicated the main elements that should be considered to achieve pedestrian circulation efficiency.(PDHK, 2019)

- **Flow Rate** is the number of people at a certain time by the area of the spaces.
- **spatial distribution** is the number of pedestrians across the different spaces of the stations based on the types of users, their locations, their pathways, and the area allocated to the main elements.(Sangeeth K., 2019)
- **Rate per capita** is calculated by the area of the spaces divided by the number of pedestrians in peak hours. (Sangeeth K., 2019)
- **Density** is one of the general methods for assessing the efficiency of spaces, which gives indicators that help in the best distribution of areas. Density is calculated through the following (Density = numbers of users/area of spaces).
- **delay** in time is calculated by (delay time = observation time - Expected Time). While the Expected time is calculated by (Expected time =distance / standard speed).(*Author: Mr. Esraa Hani Fadel./ Title: Design Determinants of Pedestrian Traffic Elements at Egypt Railway Stations /*, n.d.)
- **Guidance signs** achieve a kind of communication between people and the architectural environment around them, and their forms differ to help them know their place in the different spaces.(One-Jang Jeng, 2003).

- ***The pedestrian Circulation Requirement***
  - The station's design allows for a free-flowing passenger to avoid severe congestion within the Station, particularly on platforms and escalators**.**
  - Paths clear and straightforward as feasible**.**
  - A passenger's movement unhindered from the time he enters the Station until he leaves**.**
  - All platforms parallel and of the same length **.**
  - Segregation of arriving and departing passengers**.**
  - provided waiting space to reduce passenger interference in the circulation area**.**
  - Create a clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation**.**
  - Sequence in motion (entry-tickets-waiting-departure).
  - Assisting with motility (elevators, escalators, moving walkways and assistive devices like wheelchairs for the physically disabled)
  - Providing consistent and obvious directional signage
  - Passengers are given sufficient options to depart the station campus.
  - The separation between the movement of people and vehicles

- ***Categories and Numbers of Users at Adly Mansour hub station***

The number of users was determined by the average number of passengers at peak hours. (Authority, 2022)(Tunnels, 2022) Table 4-1.

Table 4-1: Categories and numbers of users at Adly Mansour hub station.

Number of users in peak hour at Adly Mansour station			
	Arrivals	Departures	Total in peak hour
Train station	1000	1000	2000
LRT Station	8086	6690	14776
Metro station	12000	12000	24000
Superjet station	500	500	1000
total	21586	20190	41776

Source: National Authority for Tunnels.(Tunnels, 2022).

The number of users at metro station represents about 57 % of the total users, followed by LRT station users represent about 35 %. then the Train station represents about 5%, while the Superjet station achieved the least which represents about 3%. Figure 4-6

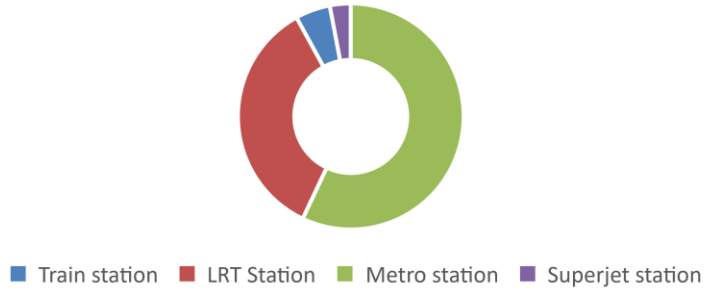


Figure 4-6: Percentage of users, **Source**: Authors.

- ***Area of zones at Adly Mansour Hub Station***

The following table shows the areas of the different zones at Adly Mansour hub station. (Authority, 2022)(Tunnels, 2022). Table 4-2

Table 4-2: Area of zones at Adly Mansour hub station.

Spaces	Area			
	Waiting hall	Ticket area	platform	Services &shops
Train station	250 m^2	260 m^2	3630 m^2	15000m^2
LRT Station	870 m^2	120 m^2	1650 m^2	350 m^2
Metro station	1800 m^2		1760 m^2	410 m^2
Superjet station	305 m^2		----------	230 m^2

Source: National Authority for Tunnels.(Tunnels, 2022).

The area of zones at the **train station** showed that there is a discrepancy in area, with (services &shops) having the largest area among all the other zones followed by the platforms, and then the Ticket area while waiting hall achieved the least. On the other hand, **LRT station** showed that platforms had the largest area among all the other zones followed by the waiting hall, and then the Services &shops while the Ticket area achieved the least. Meanwhile the **metro station** showed that the (waiting hall &Ticket area) had the largest area among all the other zones followed by the platforms area, and the (services &shops)

achieved the least. However **Super jet station** showed that (waiting hall &Ticket area) had the largest area, and the (services &shops) achieved the least. Figure 4-7

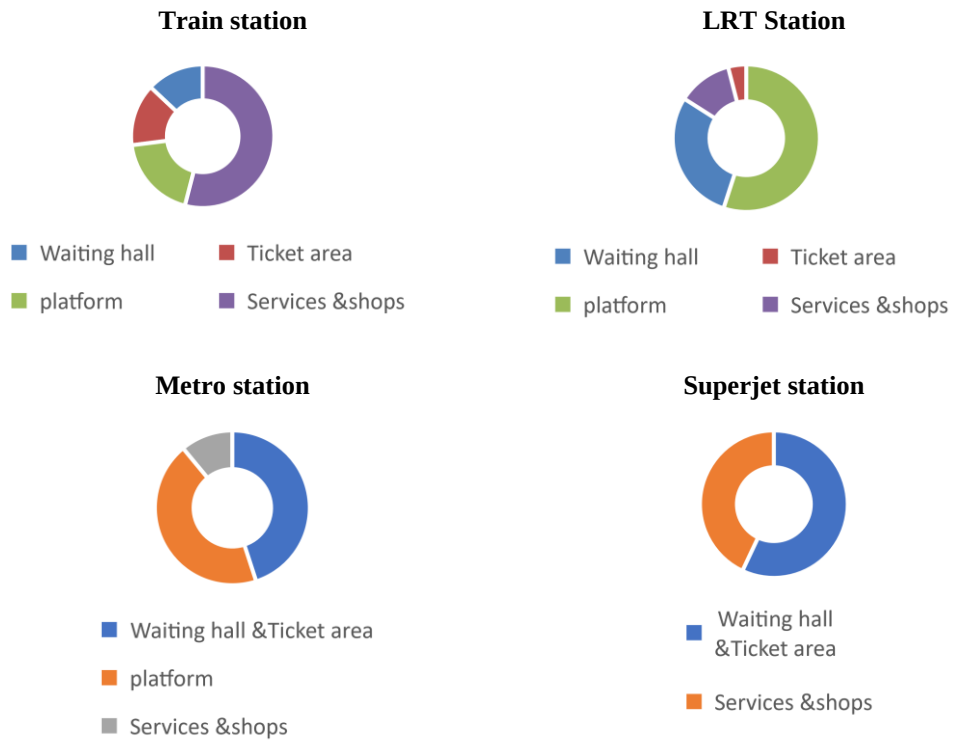


Figure 4-7: Percentage of users at Adly Mansour hub station, **Source**: Authors.

- ***Spatial Distribution of Users at Adly Mansour Hub Station***

The number of users for each category in 2022 can be distributed in the different spaces of the station to estimate the volumes of pedestrians based on the categories of users, their locations, their movement paths, and the areas allocated to the main elements. Table 4-3

Table 4-3: Spatial distribution of users at Adly Mansour hub station.

Main Elements	(Number of users \ hour)			
	Waiting hall	Ticket	platforms	Services& shops
The train station	520	305	1000	175
LRT Station	2420	335	6690	5331
Metro station	5000		12000	7000
Superjet station	375		500	125

Source- Authors based on extant literature sources.

- ***Rate Per Capita at Adly Mansour Hub Station***

With the increase in the number of users at Adly Mansour hub station, the per capita share decreases. From that, the per capita for the different spaces at the **train station** ranges from 0.48 m^2 to 8.57 m^2, and the average per capita inside the train station is 3.39 m^2, while the per capita at the **LRT station** ranges between 0.10 m^2 to 0.36 m^2, and the average per capita in the LRT station is 0.27 m^2, while the per capita at the **metro station** ranges between 0.10 m2 to 0.36 m2, and the average per capita in the metro station is 0.20 m^2, while the per capita at the **Superjet station** ranges between 0.81 m^2 to 1.84 m^2, and the average per capita in the metro station is 1.825 m^2, while the per capita inside Adly Mansour hub station is 1.50 m^2 ¨Table 4-4 . From that, the LRT station and metro station achieved the least rate per capita in Adly Mansour hub station.

Table 4-4: rate per capita in different spaces, **Source**: Authors.

	Main Elements	Waiting hall	Ticket office	platform	**Services & shops**
Train station	Per capita in spaces	0.48 m^2	0.88 m^2	3.63 m^2	8.57 m^2
	Average per capita	**3.39 m2**			
LRT Station	Per capita in spaces	0.36 m^2	0.36 m^2	0.25 m^2	0.10 m^2
	Average per capita	**0.27 m2**			
Metro station	Per capita in spaces	0.36 m^2		0.15 m^2	0.10 m^2
	Average per capita	0.20 m^2			
Superjet station	Per capita in spaces	0.81 m^2		---------	1.84 m^2
	Average per capita	1.825 m2			
Average per capita in station		**1.50 m2**			

Source- Authors based on extant literature sources.

- ***Density at Adly Mansour Hub Station***

The density of different spaces at Adly Mansour hub station increases according to economic and social changes and the population increase from that the density for the different spaces at the **train station** ranges from 1 person\ m to 2 persons\ m, while the density at the **LRT station** ranges between 3 person\ m to 15 persons\ m, while the density at the **metro station** ranges between 3 persons\ m to 17 persons\ m, while the density at the **Superjet station** ranges 1 person\ m. Table 4-5

Table 4-5: Density at different spaces.

Main Elements	Density (person\ m)			
	Waiting hall	Ticket office	platform	Services & shops
Train station	2 persons\ m^2	1 person \ m^2	1 person \ m^2	1 person\ m^2
LRT Station	3 persons\ m^2	3 persons\ m^2	4 persons\ m^2	15 persons\ m^2
Metro station	3 persons\ m^2		7 persons\ m^2	17 persons\ m^2
Superjet station	1 person \ m^2		----------	1 person\ m^2

Source- Authors based on extant literature sources.

- ***Delay in Times at Adly Mansour Hub Station***

It is difficult to calculate delays and the times spent in the different spaces (through monitoring) because the station does not operate at full efficiency, but it works experimentally.

4-1.3.3. Environmental Requirements

As green building continues to gain traction in the construction industry, it is essential to prioritize energy efficiency and water conservation in station building design. It is necessary to enhance energy efficiency in design to different extents, while also incorporating passive solar approaches to reduce energy consumption. Research on design indicates that maximizing the use of natural light and ventilation can lead to substantial energy savings.

- Using local materials that are resistant to weather conditions and recyclable.
- Saving energy
- Increasing green spaces inside and around the station
- Respect the privacy of the site.
- Provide natural lighting.
- Provide natural ventilation.

4-1.3.4. Safety and Security Requirements

The most crucial needs for any system are safety and security. It is essential to design a system's architecture with safety and security in mind from the outset, rather than adding them as an afterthought. However, it is uncommon for system requirements to specify the level of safety and security necessary to effectively protect the system and its connected assets, including people, property, the environment, and services. Too often, requirements fail to identify the accidents and attacks that must be avoided, the types of vulnerabilities that the system must not include, the dangers and threats it must combat, and the measures it must

take to protect against these threats. Therefore, we have safety and security requirements for the Adly Mansour station.

- The pedestrian path is clear and well-lit.
- Slip-resistant walking surfaces
- Controlling entrances and exits.
- Protection of personal property
- Providing maintenance requirements
- Provide emergency requirements.
- Providing safety for users and protection from weather conditions.
- Provide guide signs.

4-1.3.5. Equitable People's Mobility

Since welfare policy and equity are closely connected, it is crucial to align policy advocacy with welfare policy. In the long term, it is important to have barrier-free facilities such as ramps, elevators, restrooms, and other amenities at stations and terminals to provide comfort and assistance to the elderly and disabled. Accessible vehicles can be an additional option.

- ***Economy***

- Advertisements have plenty of surface area to exhibit in busy public transportation terminals and stations.
- Retail concessions in stations and terminals can include small businesses that cater to passengers, such as convenience stores, branch banks, automated teller machines (ATMs), coffee shops and snack restaurants, and vendors of newspapers and magazines. Another possible source of income for mass transport operations is the park and ride concept that is reflected in commuter parking facilities.

- ***Socio***

- process of reconciling competing social equity, economic
- The stock of social capital needed for the development of the economy and the environment is formed through social sustainability.
- Social sustainability as place based.

4-1.4. SWOT Analysis

Table 4-6 : Swot analysis.

STRENGTHS	OPPORTUNITIES
• station has a variety of modes of transportation. • travelers can switch to a different mode of transportation. • connect the Republic's cities and governorates to the New Administrative Capital. • The station has a 15-acre site and consists of a full-service transit complex and a commercial investment area. • connects the network of five different modes of transportation. • Availability of green area • fulfill some functional requirements, circulation requirements, Environmental requirements, and Safety security requirements	• There are many residential and service areas. • Presence of metro workshops • Excellent tourism destination • Can serve as a transportation network hub.
WEAKNESSES	**THREATS**
• The pressure of population growth • The pressure of traffic growth	• Noise and Ecological pollution

Source- Authors based on extant literature sources.

4-1.5. Current Problems at Adly Mansour Transport Center hub

The lack of clear design criteria in the Egyptian experience led to the emergence of many of the problems represented in,

- Not providing separate arrival and departure halls for each means of transportation.
- Not providing information centers to help users.
- There is no separation between the ticket halls and the main waiting halls of the station.
- The intersection of pedestrian and car traffic, and the pedestrian tunnel is far from the metro exit.
- Long distances to move from LRT to any other modes.
- Long distances to get from the train station to any other mode.
- Long distances to move from any mode to the SuperJet station.
- Long walks underground.
- Long distances to move from any mode to shops.
- The waiting room and tickets at the SuperJet station are very small.
- The ticket halls for the LRT are very small.
- The departure halls of LRT are very large.
- The cross-section of some parts of the train platforms does not exceed 2 m.
- The average per capita inside the train station is 3.39 m^2, the LRT station is 0.27 m^2, the metro station is 0.20 m^2, the Superjet station is 1.825 m^2, while the per capita inside the Adly Mansour hub station is 1.50 $m^{2.}$
- Density in train station ranges from 1 person \ m to 2 persons\ m, LRT station ranges between 3 persons\ m to 15 persons\ m, metro station ranges between 3 persons\ m to 17 persons\ m, while Superjet station ranges 1 person\ m.
- Unavailability of ramps, stairs and escape exits from the station in emergency cases.
- Do not use fire-resistant materials.
- Failure to apply the concept of environmental sustainability by not using clean energies to save energy, not treating water, and not using modern technologies in roofs and destinations.

4-2. Badr Station

Public transportation's efficiency depends on network effects and connectivity between different modes of transportation or between the various lines of a single mode. Multi-modal transport hubs play a crucial role in ensuring the smooth operation of public transportation by serving as points of connection and meeting places for different modes. Urban mobility systems rely on interchange hubs to facilitate transitions between cities and transportation networks. These hubs, which offer mobility, accessibility, and attractiveness, can vary significantly from one city or country to another based on the transportation modes and urban development.(Pinheiro Rizerio Carmo et al., 2020)

The objective of this section is to identify the design requirements in Badr station through two steps process: a detailed qualitative and quantitative analysis of a selected local natural setting case study. This chapter includes Badr station overview and the analysis of all aspects related to the design requirements. Figure 4-8

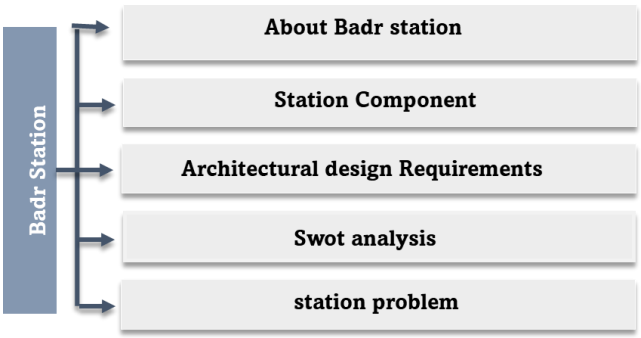


Figure 4-8: Chapter four section two structure, **Source**: Authors.

4-2.1. About Badr Station

Badr station is a Multi-modal hub station, where the passenger can change between the LRT station and the train station, where he takes Adly Mansour station, arrives at Badr Station, and from their heads to the Tenth of Ramadan city.

Badr station is one of the largest stations areas, as the length of the platform is 123 meters and its area is 8,500 square meters, in addition to car parks on the northern and southern sides of the stations. It serves Badr city and its environs due to the density of urban communities that have been inaugurated.

There are other stations such as Al-Shorouk station to serve the residents of Al-Shorouk city, and Al-Rubaiky station to serve the residents of the Al-Rubaiky area.

4-2.1.1. Station location and Access Routes

- Badr Transportation Hub in Egypt is a multi-transportation mode hub that connects a variety of different travel types into one central area, making commuting much easier for those that need to change the method of transportation.
- Badr station location in Badr city, Cairo Egypt
- The station is reached through several different axes and roads. The station is surrounded by LRT workshops and green spaces. Figure 4-9

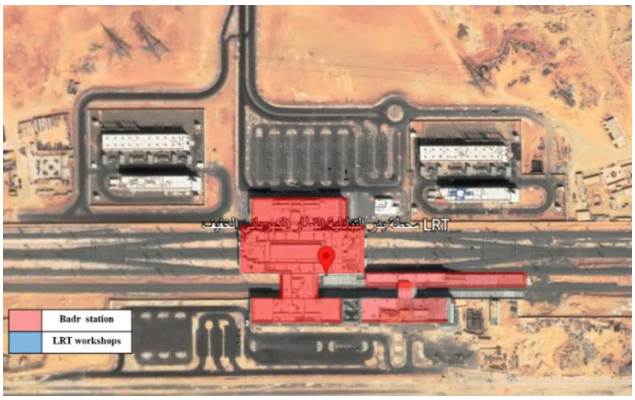


Figure 4-9; Badr location and access routes, **Source:**(ELECTRIC LIGHT RAILWAY TRANSIT (LRT)- BADR DEPOT | Rowad Modern Engineering, n.d.)

4-2.2. Station Component

Badr station connects the network of two different modes of transportation nationwide, represented by the LRT station, and railway station. Figure 4-10 . **Appendix 1**

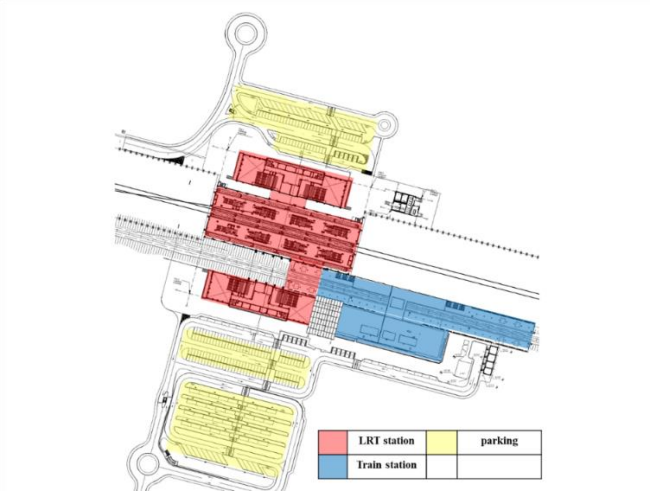


Figure 4-10: layout of Badr station, **Source:** National Authority for Tunnels.(Tunnels, 2022).

4-2.3. Architectural Design Requirements in Badr Station

In This part studies requirements in Badr station, Multi-modal hub stations are very important parts of modern urban history where diverse modes of transportation are connected, and it serves as a gathering area for people, as well as a commercial, recreational, and cultural hub from that, the design requirements for multi-modal hub stations were divided into basic groups of design requirements, each of which contains groups of design requirements.

4-2.3.1. Functional Requirements

Information management, a ticket distribution system, and platform accessibility are all physical and operational actions at such terminals. The separation of different modes of transportation in intermodal terminals can significantly increase system efficiency. They are all equally significant and serve as deciding criteria for the design of intermodal stations. By including station plazas with pedestrian-friendly settings and multimodal amenities, they have also increased public transportation integration. As a result, Badr station has a lot of functional needs.

- Connecting different types of transportation in one place and providing spaces for movement between different modes.
- Spatial organization of spaces to reduce intersections for passengers and reduce movement paths and decision points.
- Functional integration according to social and environmental changes and providing service and commercial spaces.
- The separation between entrances and exits at LRT station and train station.
- Providing services and shops at the train and LRT station
- Dividing the platform cross-section at the LRT and train station.
- Optimal use of space
- Provide usability requirements.
- Providing waiting areas and restrooms inside the main halls and ticket halls and places for decision-making and providing services for them
- Physical, visual interconnection, and Aesthetic form

4-2.3.2. Circulation Requirements

Factors affecting pedestrian circulation efficiency.

- Flow Rate is calculated as the number of people at a certain time by the area of the spaces.
- spatial distribution is the number of pedestrians across the different spaces of the stations.

- Rate per capita is calculated by the area of the spaces divided by the number of pedestrians.
- Density is calculated by the number of pedestrians divided by the area of the spaces.
- delay in time is calculated by (delay time = observation time - Standard Time). While the standard time is calculated by (standard time =distance / standard speed).

- ***The pedestrian Circulation Requirement***
  - The layout of the station makes it possible for passengers to move freely and avoid major crowding, especially on platforms and escalators.
  - Reducing walking distances should be kept to a minimum**.**
  - Paths clear and straightforward as feasible**.**
  - A passenger's movement unhindered from the time he enters the station until he leaves**.**
  - All platforms should be parallel and of the same length **.**
  - Create a clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation**.**
  - Sequence in motion (entry-tickets-waiting-departure)
  - Assisting with motility (elevators, escalators, moving walkways and assistive devices like wheelchairs for the physically disabled)
  - Providing consistent and obvious directional signage
  - To build a seamless local and regional inter-modal network, station designs should make it simple to change to other transit system lines and forms of public transport.
  - passengers given sufficient options to depart the station campus.
  - Provide sufficient space for movement and waiting.
  - Considering people with special needs**.**
  - The separation between the movement of people and vehicles
  - The platform is divided into parts, the first of which is at the edge a warning area, then a movement area, followed by a waiting area, and there is a line separating the prohibited area from the waiting area.

- ***Categories and Numbers of Users at Badr Station***

The number of users was determined by the average number of passengers at peak hours. (Authority, 2022)(Tunnels, 2022) . Table 4-7

Table 4-7 : Categories and numbers of users at Badr station.

	Number of users in peak hour at badr station		
	Arrivals	Departures	Total in peak hour
Train station	600	600	1200
LRT Station	799	999	1798
total	1399	1599	2998

Source: National Authority for Tunnels.(Tunnels, 2022).

The number of users at LRT station represents about 60 %. while the train station represents about 40%. Figure 4-11 .

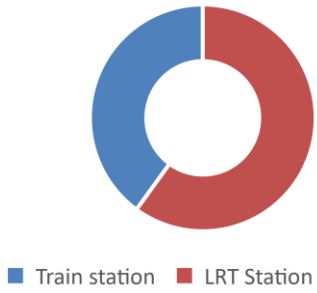


Figure 4-11: Percentage of users, **Source**: Authors.

- ***Area of zones at Badr Station***

The following table shows the areas of the different zones at Badr station. (Authority, 2022)(Tunnels, 2022). Table 4-8

Table 4-8: Area of zones at Badr station.

Spaces	Area			
	Waiting hall	Ticket area	platforms	Services &shops
Train station	1452 m^2		3416 m^2	1024 m^2
LRT Station	1200 m^2		3250 m^2	540 m^2

Source: National Authority for Tunnels.(Tunnels, 2022).

The area of zones at the **train station** showed that there is a discrepancy in area, with platforms having the largest area among all the other zones followed by the (waiting hall & ticket area), while (Services &shops) achieved the least. On the other hand, **LRT station** showed that platforms had the largest area among all the other zones followed by the (waiting hall & ticket area), while the (Services &shops) achieved the least. Figure 4-12 .

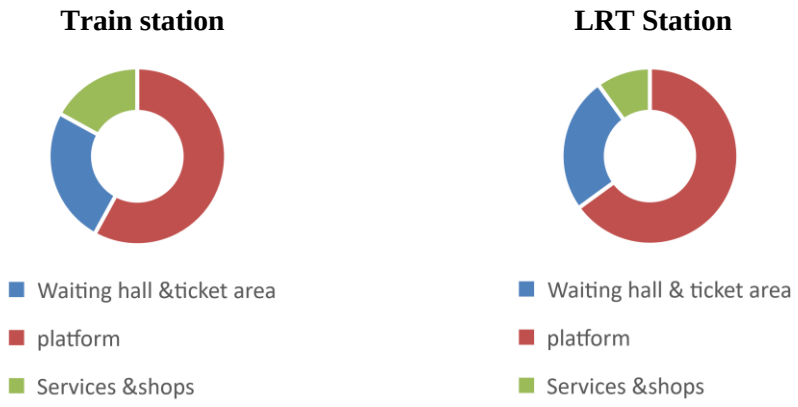


Figure 4-12: Percentage of users in Badr station, Source: Authors.

- ***Spatial Distribution of Users at Badr Station***

The number of users for each category in 2022 can be distributed in the different spaces of the station to estimate the volumes of pedestrians based on the categories of users, their locations, their movement paths, and the areas allocated to the main elements. Table 4-9

Table 4-9: Spatial distribution of users at Badr station.

Main Elements	(Number of users \ hour)			
	Waiting hall	Ticket	platforms	Services& shops
The train station	400		600	200
LRT Station	532		999	267

Source- Authors based on extant literature sources.

- ***Rate per Capita at Badr Station***

With the increase in the number of users at Badr station, the per capita share decreases. From that, the per capita for the different spaces at the **train station** ranges from 3,60 m^2 to 5.70 m^2, and the average per capita in the train station is 4.80 $m^{2,}$ while the per capita at the **LRT station** ranges between 2.00 m^2 to 3.25 m^2, and the average per capita at the LRT station is 2.50 m^2, while the average of rate per capita at Badr station is 3.65m^2. Table 4-10 .From that, the LRT station achieved the least rate per capita at Badr station.

Table 4-10: rate per capita in different spaces.

	Elements Main	Waiting hall	Ticket office	platform	**Services & shops**
Train station	Per capita in spaces	3.60 m^2		5.70 m^2	5.12 m^2
	Average per capita	4.80m2			
LRT Station	Per capita in spaces	2.25 m^2		3.25 m^2	2.00 m^2
	Average per capita	2.50m^2			
Train& LRT station		3.65 m^2			

Source- Authors based on extant literature sources.

- ***Density at Badr Station***

The density of different spaces at Badr station increases according to economic and social changes and the population increases from that the density for the different spaces at the **train station and LRT station** is 1 person\ m^2. Table 4-11

Table 4-11: Density in different spaces.

Main Elements	Density (person\ m)			
	Waiting hall	Ticket office	platform	Services & shops
Train station	1 person\ m^2		1 person\ m^2	1 person\ m^2
LRT Station	1 person\ m^2		1 person\ m^2	1 person\ m^2

Source- Authors based on extant literature sources.

- ***Delay in Times at Badr Station***

It is difficult to calculate delays and the times spent in the different spaces (through monitoring) because the station does not operate at full efficiency, but it works experimentally.

4-2.3.3. Environmental Requirements

Your physical environment must meet certain standards on using renewable energy, intelligent controls, thermal comfort (heating, cooling, and ventilation), the acoustics of rooms, and lighting design from that the Environmental requirements at Badr station represent in

- Using local materials that are resistant to weather conditions and recyclable.
- saving energy
- Respect the privacy of the site.
- Provide natural lighting.
- Provide natural ventilation.

4-2.3.4. Safety and Security Requirements

An architect must determine what needs to be secured and protected in station, system requirements to state how safe and secure a system must be in order to effectively protect itself and the assets it is connected to (including people, property, the environment, and services). Too frequently, requirements do not outline what accidents and attacks must be avoided, what types of vulnerabilities the system must not include, what dangers and threats it must fight against, and what the system must do in order to protect against these threats. From that we need some of safety and security requirements at Badr station which represented in

- The pedestrian path is clear and well-lit.
- Slip-resistant walking surfaces
- Controlling entrances and exits.
- Protection of personal property
- Providing maintenance requirements
- Provide emergency requirements.
- Providing safety for users and protection from weather conditions.
- Provide guide signs.
- Alarm systems

4-2.3.5. Equitable People's Mobility

Since welfare policy and equitability are intimately intertwined, it is essential to coordinate policy persuasion with welfare policy. In the long run, barrier-free facilities including slopes, lifts, toilets, and other amenities should be available to assist the elderly and disabled in finding comfort at stations and terminals. Accessible vehicles would be one of the extra alternatives.

- ***Economy***

- Advertisements have plenty of surface area to exhibit in busy public transportation terminals and stations.
- Retail concessions in stations and terminals can contain small businesses that cater to users, such as convenience stores, branch banks, automated teller machines (ATMs), coffee shops and snack restaurants, newspaper, and magazine dealers.

  Another possible source of income for mass transport operations is the park and ride concept that is reflected in commuter parking facilities.

- ***Socio***

- process of reconciling competing social equity, economic

- The stock of social capital needed for the development of the economy and the environment is formed through social sustainability.
- Social sustainability as place based.

4-2.4. SWOT Analysis

Table 4-12 : Swot analysis

STRENGTHS	**OPPORTUNITIES**
• station has a variety of modes of transportation. • travelers can switch to a different mode of transportation. • connect the Republic's cities and governorates to the New Administrative Capital. • The station has both a commercial investment area and a full-service transit complex. • connects the network of two different modes of transportation. • Availability of green area • fulfill some functional requirements, circulation requirements, Environmental requirements, and Safety security requirements	• There are many residential and service areas. • Presence of LRT workshops • Excellent tourism destination • Can serve as a transportation network hub.
WEAKNESSES	**THREATS**
• The pressure of population growth.	• Noise and Ecological pollution

Source- Authors based on extant literature sources.

4-2.5. Current Problems at Badr station

The lack of clear design criteria in the Egyptian experience led to the emergence of many of the problems represented in,

- Not separation between the arrival and departure halls in LRT station, while the train station is separated.
- Not Providing private entrances and services for employees and operators in the station.
- Not providing information centers to help users.
- There is no separation between the ticket halls and the main waiting halls.
- The intersection of movement between pedestrians and others at different path.
- The intersection of the movement path between pedestrians and vehicles
- The areas of the elements are very large in relation to the number of users, and this was evident through studying the per capita share and density inside the station.
    - The per capita for the different spaces at the **train station** ranges from 3,60 m^2 to 5.70 m^2, and the average per capita at the train station is 4.80 $m^{2,}$ while the per capita at the **LRT station** ranges between 2.00 m^2 to 3.25 m^2, and the average per capita at the LRT station is 2.50 m^2. while the average of rate per capita at Badr station is 3.65m^2
    - The density for the different spaces at the **train station and LRT station** is 1 person\ m^2.
- Do not use fire-resistant materials.
- Failure to apply the concept of environmental sustainability by not using clean energies to save energy, not treating water, and not using modern technologies in roofs.

4-3. Arts and Culture Station at The New Administrative Capital

Buses, light rail, and metro are just a few examples of the transit alternatives available in public transportation networks. These services are open to the public, may have fares, and operate on a set schedule. Increasing access to and use of public transport is the goal of introducing or expanding it to decrease the number of motor vehicle miles travelled and traffic congestion. Public transport systems can be subsidized by the nation and are frequently established at the municipal or regional level.

The Capital Stations, one of the largest stations in the Middle East with a total area of more than 1,100,000 square meters in parking areas and commercial areas, is an interchange station with the LRT and is regarded as a center for various means of transport coming to the Administrative Capital and serving primarily the New Administrative Capital and the Sports City, as well as all new cities in eastern Cairo.

The objective of this section is to identify the design requirements in Arts and culture station through two steps process: a detailed qualitative and quantitative analysis of a selected local natural setting case study. This chapter includes the Arts and culture station overview and the analysis of all aspects related to the design requirements. Figure 4-13

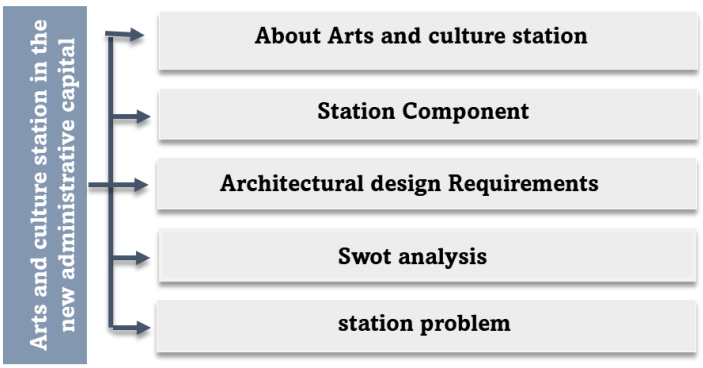


Figure 4-13: Chapter four section three structure, **Source**: Authors.

4-3.4. About the Arts and Culture Station

The LRT is a sustainable mode of green mass transportation since it runs on electricity instead of diesel. The 22 trains of the LRT also include seats allocated for people with special needs, stressing that all the LRT stations are configured to facilitate access and movement for people with disabilities.Figure 4-14

In addition to being linked to various modes of transportation in Adly Mansour Interchange Station, the LRT will also intersect with Egypt's under construction monorail at the Arts and Culture Centre station in the NAC, along with Egypt's first high-speed electric railway at an interchange station on the Cairo-Sokhna Highway.

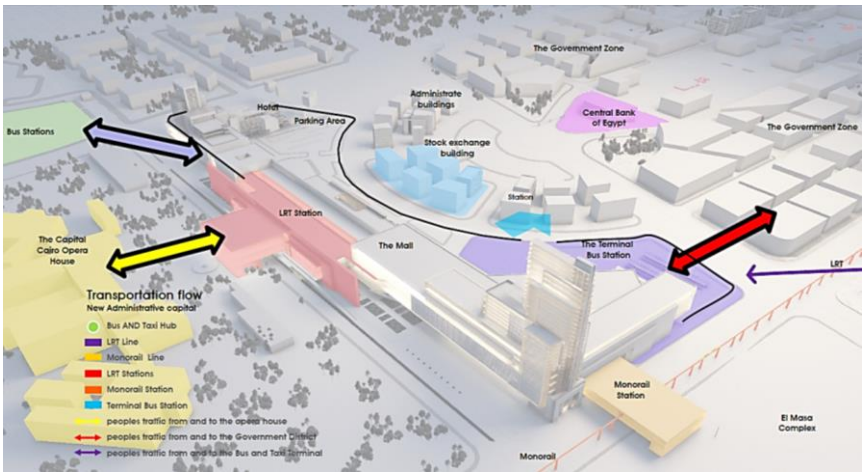


Figure 4-14 : The Arts and culture station at the new administrative capital**, Source:** National Authority for Tunnels.(Tunnels, 2022).

4-3.4.1. Station location and Access Routes

- The Arts and culture station in Egypt is a multi-transportation mode hub that connects a variety of different travel types into one central area, making commuting much easier for those that need to change their method of transportation .
- The station is reached through several different axes and roads. Figure 4-15

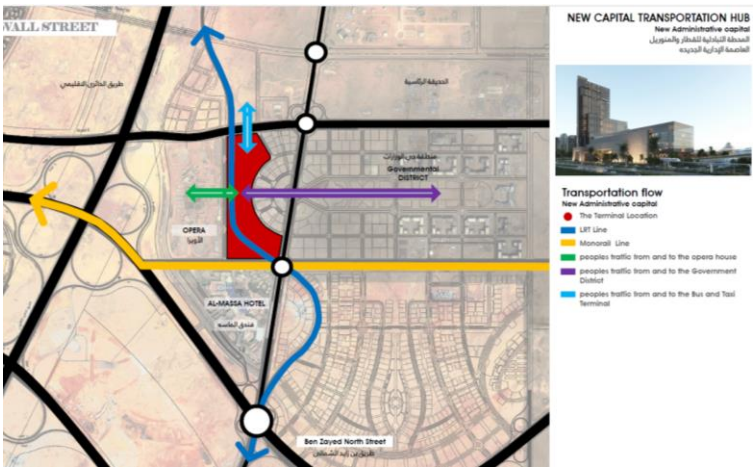


Figure 4-15 : Arts and culture station at the new administrative capital location and access routes**, Source:** (*Google Earth*, n.d.-b)

4-3.5. Stations Component

Arts and culture stations connect the network of two different modes of transportation, represented by five zones (LRT station zone – Monorail station zone – Mall - Business Tower – Hotel Tower) Figure 4-16 . Each zone has a set of entrances and exits. Figure 4-17 , Table 4-13 **Appendix 1**

Table 4-13: Stations Component

	Main	
A	Terminal Mall	footprint: 123,606.00 m2(% 32.70)
		No. floors: G + 3
		Built-Up Area: 347,447,00 m2
		space program (Shopping areas – Hypermarket - Food Court - Cafes & Restaurants - Cinema Complex- Skating hall - LRT axis - Monorail axis)
B	Business Tower	footprint: 8,900.00 m2(% 2.60)
		No. floors: G + 30
		Built-Up Area:100,868,00m2
		space program (Business office building - Conference area - LRT & monorail axis)
C	Hotel Tower	footprint:17,737,00m2(% 4.70)
		No. floors: G + 7
		Built-Up Area: 135,187,00m2
		space program) 800 Rooms 4 Stars hotel - Banquette halls - Restaurants - Pool area & Rooms - Mall axis)
D	LRT Station	No. floors: G + 2
		Built-Up Area: 4500 m^2
		space program) Platforms - Waiting area - Ticket hall - Administrative office - Shopping areas - Restaurants - Mall axis)
E	Monorail Station	No. floors: G + 2
		Built-Up Area:3500 m^2
		space program (Platforms - Waiting area - Ticket hall - Administrative office - Shopping areas - Restaurants - Mall axis)

Source: National Authority for Tunnels.(Tunnels, 2022)

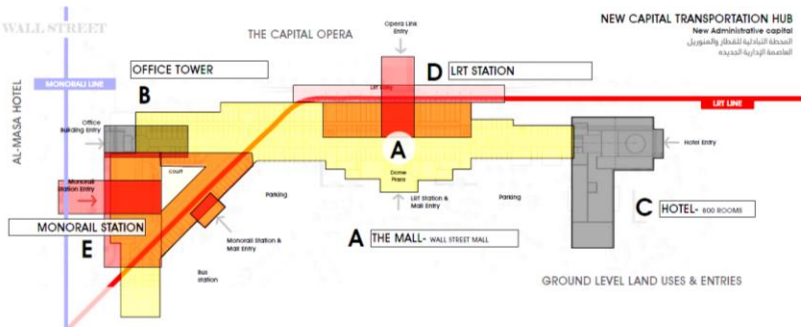


Figure 4-16 : Station Component**, Source:** Authors based on extant literature sources.

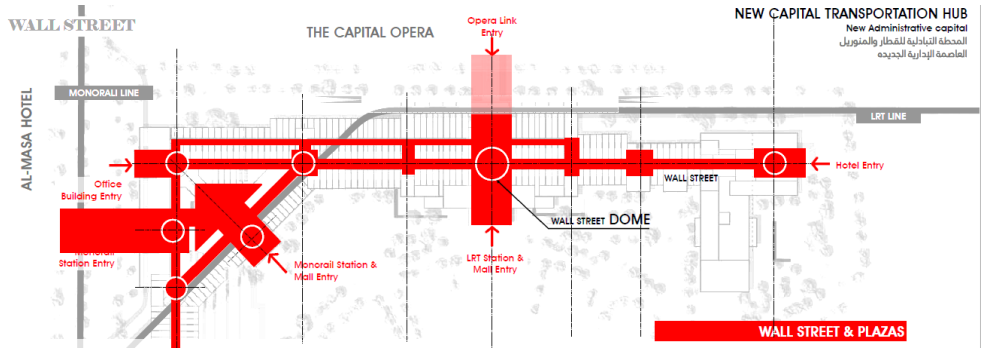


Figure 4-17 : Station entrances and exits**, Source:** Authors based on extant literature sources**.**

4-3.6. Architectural Design Requirements in the Arts and Culture station at the new Administrative Capital

This part studies requirements at the Arts and Culture station at the new administrative capital, Multi-modal hub stations are very important parts of modern urban history where diverse modes of transportation are connected, and it serves as a gathering area for people, as well as a commercial, recreational, and cultural hub from that, the design requirements for multi-modal hub stations were divided into basic groups of design requirements, each of which contains groups of design requirements.

4-3.6.1. Functional Requirements

Information management, a ticketing system, and platform accessibility are all physical and operational actions at such terminals. The separation of various modes of transportation in intermodal terminals can significantly increase system efficiency. As a result, the Arts and Culture station has many functional requirements. All of these are equally significant and act as deciding factors for the layout of intermodal stations. They have also improved public transportation integration by station plazas with pedestrian-friendly surroundings and multimodal amenities.

- Connecting different types of transportation in one place and Providing spaces for movement between different modes, and the distance between the LRT and the monorail is about 850 meters.
- Spatial organization of spaces to reduce intersections for passengers.
- Functional integration according to social and environmental changes and providing service and commercial spaces.
- The separation between entrances and exits in LRT station and Monorail station.

- providing a commercial mall linking the Monorail and LRT station
- Dividing the platform cross-section at the LRT and Monorail station.
- Optimal use of space
- Provide usability requirements.
- Providing waiting areas and restrooms inside the main halls and ticket halls and places for decision-making and providing services for them
- Physical, visual interconnection, and Aesthetic form

4-3.6.2. Circulation Requirements

Factors affecting pedestrian circulation efficiency.

- Flow Rate is calculated as the number of people at a certain time by the area of the spaces.
- spatial distribution is the number of pedestrians across the different spaces of the stations.
- Rate per capita is calculated by the area of the spaces divided by the number of pedestrians.
- Density is calculated by the number of pedestrians divided by the area of the spaces.
- delay in time is calculated by (delay time = observation time - Standard Time). While the standard time is calculated by (standard time =distance / standard speed).

- ***The pedestrian Circulation Requirement***
  - The Station's design allows for a free-flowing passenger to avoid severe congestion within the Station, particularly on platforms and escalators**.**
  - Paths clear and straightforward as feasible**.**
  - A passenger's movement unhindered from the time he enters the Station until he leaves**.**
  - All platforms should be parallel and of the same length **.**
  - provided waiting space to reduce passenger interference in the circulation area**.**
  - Create a clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation**.**
  - Sequence in motion (entry-tickets-waiting-departure)
  - Assisting with motility (elevators, escalators, moving walkways and assistive devices like wheelchairs for the physically disabled)
  - Providing consistent and obvious directional signage
  - To build a seamless local and regional inter-modal network, stations are designed to make it simple to transfer to other Transit System lines and forms of public transportation.

- passengers given sufficient options to depart the station campus.
- Provide sufficient space for movement and waiting.
- The separation between the movement of people and vehicles
- The platform is divided into parts, the first of which is at the edge a warning area, then a movement area, followed by a waiting area, and there is a line separating the prohibited area from the waiting area.

- ***Categories and Numbers of Users at The Arts and Culture Station.***

The number of users was determined by the average number of passengers at peak hours. (Authority, 2022)(Tunnels, 2022) Table 4-14

Table 4-14 : Categories and numbers of users at the Arts and Culture station

	Number of users in peak hour at Arts and Culture station		
	Arrivals	Departures	Total in peak hour
Monorail station	2857	3997	6854
LRT Station	11404	8280	19584
total	14261	12277	26438

Source: National Authority for Tunnels.(Tunnels, 2022).

The number of users at LRT station represents about 74 %. while the Monorail station represents about 26%. Figure 4-18

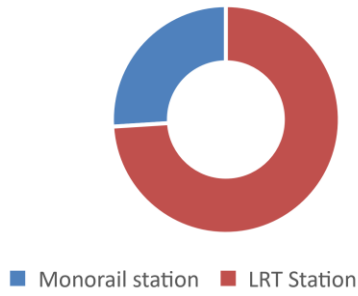


Figure 4-18: Percentage of users, **Source**: Authors.

- ***Area of Zones at Arts and Culture Station***

The following table shows the areas of the different zones at the Arts and Culture station. (Authority, 2022)(Tunnels, 2022). Table 4-15

Table 4-15: Area of zones at the Arts and Culture station.

Spaces	Area			
	Waiting hall	Ticket area	platforms	Services &shops
Monorail station	950 m^2		1300 m^2	3000 m^2
LRT Station	1050 m^2		3000 m^2	3950 m^2

Source: National Authority for Tunnels.(Tunnels, 2022).

The area of zones at the **LRT station** and **Monorail station** showed that there is a discrepancy in area, with services &shops having the largest area among all the other zones followed by the platforms, while (waiting hall & ticket area) achieved the least. Figure 4-19

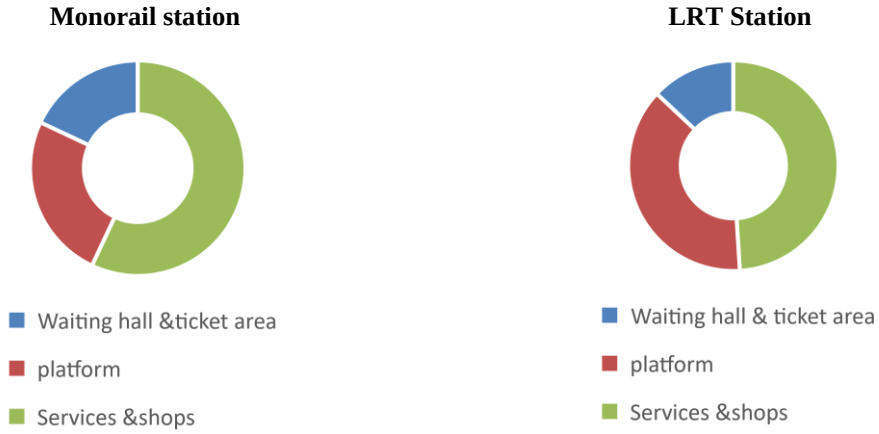


Figure 4-19: Percentage of users at the Arts and Culture station, Source: Authors.

- ***Spatial Distribution of Users at Arts and Culture Station***

The number of users for each category in 2023 can be distributed in the different spaces of the station to estimate the volumes of pedestrians based on the categories of users, their locations, their movement paths, and the areas allocated to the main elements. Table 4-16

Table 4-16 : Spatial distribution of users at the Arts and Culture station

Main Elements	(Number of users \ hour)			
	Waiting hall	Ticket	platforms	Services& shops
The Monorail station	1580		2160	3110
LRT Station	13811		1500	1950

Source: National Authority for Tunnels.(Tunnels, 2022).

- ***Rate per Capita at the Arts and Culture Station***

With the increase in the number of users in the Arts and Culture station at the new administrative capital, the per capita share decreases. From that, the per capita for the different spaces at the Monorail station ranges from 0.60 m^2 to 0.96 m^2, and the average per capita in the Monorail station is 0.72 m^2, while the per capita at the LRT station ranges between 0.07 m^2 to 2.00 m^2, and the average per capita at the LRT station is 1.35 m^2. Table 4-17

From that, the LRT station achieved the least rate per capita at the Arts and Culture station.

Table 4-17: Rate per capita in different spaces.

	Main Elements	Waiting hall	Ticket office	platform	**Services & shops**
Monorail station	Per capita in spaces	0.60 m^2		0.60 m^2	0.96 m^2
	Average per capita	0.72 m^2			
LRT Station	Per capita in spaces	0.07 m^2		2.00 m^2	2.00 m^2
	Average per capita	1.35 m^2			

Source- Authors based on extant literature sources.

- ***Density at The Arts and Culture Station.***

The density of different spaces at the Arts and Culture station at the new administrative capital increases according to economic and social changes and the population increase from that the density for the different spaces at the **train station** ranges from 1 person\ m^2 to **2** person\ m^2 ,while the **LRT station** ranges from 1 person\ m^2 to 13 person\ m^2 . Table 4-18

Table 4-18: Density at different spaces.

Main Elements	Density (person\ m)			
	Waiting hall	Ticket office	platform	Services & shops
Monorail station	2 persons\ m^2		2 person \ m^2	1 person\ m^2
LRT Station	13 persons\ m^2		1 persons\ m^2	1 persons\ m^2

Source- Authors based on extant literature sources.

- ***Delay at Times in the Arts and Culture Station***

It is difficult to calculate delays and the times spent in the different spaces (through monitoring) because the station does not operate at full efficiency, but it works experimentally.

4-3.6.3. Environmental Requirements

Your physical environment must meet certain standards on using renewable energy, intelligent controls, thermal comfort (heating, cooling, and ventilation), the acoustics of rooms, and lighting

design from that the Environmental requirements at Arts and Culture station at the new administrative capital which represent in

- Using local materials that are resistant to weather conditions and recyclable.
- Respect the privacy of the site.

4-3.6.4. Safety and Security Requirements

An architect must determine what needs to be secured and protected in station, system requirements to state how safe and secure a system must be in order to effectively protect itself and the assets it is connected to (including people, property, the environment, and services). Too frequently, requirements do not outline what accidents and attacks must be avoided, what types of vulnerabilities the system must not include, what dangers and threats it must fight against, and what the system must do in order to protect against these threats. From that we need some of safety and security requirements at Arts and Culture station at the new administrative capital which represented in

- The pedestrian path is clear and well-lit.
- Slip-resistant walking surfaces
- Controlling entrances and exits.
- Protection of personal property
- Providing maintenance requirements
- Provide emergency requirements.
- Providing safety for users and protection from weather conditions.
- Provide guide signs.
- Alarm systems

4-3.6.5. Equitable People's Mobility

Since welfare policy and equitability are intimately intertwined, it is essential to coordinate policy persuasion with welfare policy. In the long run, barrier-free facilities including slopes, lifts, toilets, and other amenities should be available to assist the elderly and disabled in finding comfort at stations and terminals. Accessible vehicles would be one of the extra alternatives.

- ***Economy***

- Advertisements have plenty of surface area to exhibit in busy public transportation terminals and stations.

- Retail concessions in stations and terminals can contain small businesses that cater to users, such as convenience stores, branch banks, automated teller machines (ATMs), coffee shops and snack restaurants, newspaper, and magazine dealers.

  Another possible source of income for mass transport operations is the park and ride concept that is reflected in commuter parking facilities.

- ***Socio***

- process of reconciling competing social equity, economic
- The stock of social capital needed for the development of the economy and the environment is formed through social sustainability.
- Social sustainability as place based.

4-3.7. SWOT Analysis

Table 4-19: swot analysis

STRENGTHS	OPPORTUNITIES
• The station has a variety of modes of transportation. • Travelers can switch to a different mode of transportation. • connect the Republic's cities and governorates to the New Administrative Capital. • The station has both a commercial investment area and a full-service transit complex. • connects the network of two different modes of transportation. • Availability of green area • fulfill some functional requirements, circulation requirements, Environmental requirements, and Safety security requirements	• The station is near the City of Arts and Culture • The station is located near the financial and business district. • The station is located near Al-Massa Hotel. • Can serve as a transportation network hub.
WEAKNESSES	**THREATS**
• The pressure of population growth	• Noise and Ecological pollution

Source- Authors based on extant literature sources.

4-3.7. Current Problems at Arts and Culture Station.

The lack of clear design criteria in the Egyptian experience led to the emergence of many of the problems represented in,

- The distance between the LRT and the monorail is about 850 meters.
- Not separation between the arrival and departure halls in LRT station, while other modes are not separated.
- Not Providing private entrances and services for employees and operators in the station.
- Not providing information centers to help users.
- The ticket halls, waiting halls &shops area of LRT are very large.
- Walking distances are very long.
- Do not use fire-resistant materials.
- Failure to apply the concept of environmental sustainability by not using clean energies to save energy, not treating water, and not using modern technologies in roofs and destinations.
- According to the areas of the elements and the number of users, the per capita and density inside the station.
    - The per capita for the different spaces in the Monorail the average per capita in the Monorail station is 0.72 $m^{2,}$ while the per capita in the LRT station average per capita in the LRT station is 1.35 m^2.
    - The density for the different spaces in the **train station** ranges from 1 person\ m^2 to **2** person\ m^2, while the **LRT station** ranges from 1 person\ m^2 to 13 person\ m^2.

4-4. Conclusion

- **Architectural Design Requirements in Egyptian Case Studies.**

  The requirements of Egyptian case studies are formed from main requirements; included (functional requirements, circulation requirements, security and safety requirements, environmental design requirements, and social and economic requirements)

  - The separation of different modes of transportation in intermodal terminals, as well as the physical layout of the terminal, can significantly increase system efficiency. Information management, ticket distribution, and platform accessibility are all physical and operational actions at such terminals.
  - Pedestrian circulation requirements, study the guidelines, Factors affecting pedestrian circulation, and determine the (Rate per capita - Density - delay) of pedestrian circulation requirements.
  - Environmental design requirements study sustainable design, saving energy, and providing natural light and ventilation.
  - Safety and security requirements by providing maintenance requirements and emergency requirements and safety for users and protection from weather conditions and guide signs and Protection of personal property.
  - Socio and Economic requirements small businesses that serve users, such as convenience stores, branch banks, automated teller machines (ATMs), coffee shops and snack restaurants, newspaper and magazine sellers, can be accommodated in retail concessions in stations by providing a process of resolving conflicting social equity.

- The design requirements varied and differed from one case study to another. Some agreed on requirements, and another study was unique in fulfilling other requirements.

Table 4-20: Architectural design Requirements in Egyptian case studies

requirements	secondary requirements	ADIY Mansour	Badr	Art
functional	- Connecting different types of transportation in one place and Providing spaces for movement between different modes	*	*	*
	- Spatial organization of spaces to reduce intersections for passengers and reduce movement paths and decision points.	*	*	*
	- Functional integration according to social and environmental changes and providing service and commercial spaces.	*	*	*

	- The separation between entrances and exits in LRT station and metro station, while the separation is not done in other modes.	*	*	*
	- Separation between the arrival and departure halls	*		
	- Providing private entrances and services for employees and operators in the station	*		
	- Providing services and shops at the train station while not provided in the other modes.	*	*	*
	- Dividing the platform cross-section	*		*
	- Optimal use of space	*	*	*
	- Provide usability requirements.	*	*	*
	- Providing waiting areas and restrooms inside the main halls and ticket halls and places for decision-making and providing services for them.	*		
	- Physical, visual interconnection, and Aesthetic form.	*	*	*
circulation requirements	- Paths clear and straightforward as feasible.	*	*	*
	- A passenger's movement unhindered from the time he enters the Station until he leaves.	*	*	*
	- All platforms should be parallel and of the same length.	*	*	*
	- Segregation of arriving and departing passengers.		*	
	- provided waiting space to reduce passenger interference in the circulation area.	*	*	*
	- Create a clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation. (Sequence in motion (entry-tickets-waiting-departure)	*	*	*
	- Providing consistent and obvious directional signage	*	*	*
	- To build a seamless local and regional inter-modal network, stations are designed to make it simple to transfer to other Transit System lines and forms of public transportation.		*	*
	- passengers given sufficient options to depart the station campus, such as regional buses, taxis, or the Mass Rapid Transit System.	*	*	*
	- Provide sufficient space for movement and waiting	*	*	*
	- The separation between the movement of people and vehicles	*	*	*
	- The platform is divided into parts, the first of which is at the edge a warning area, then a movement area, followed by a waiting area, and there is a line separating the prohibited area from the waiting area		*	*
Environmental design requirements	- Using local materials that are resistant to weather conditions and recyclable.	*	*	*
	- saving energy	*	*	
	- Increasing green spaces inside and around the station	*		*
	- Respect the privacy of the site.	*	*	
	- Provide natural lighting.	*	*	
	- Provide natural ventilation.	*	*	
Safety and security	- The pedestrian path is clear and well-lit.	*	*	*
	- Slip-resistant walking surfaces	*	*	*
	- Controlling entrances and exits.	*	*	*
	- Protection of personal property	*	*	*
	- Providing maintenance requirements	*	*	*
	- Provide emergency requirements.	*	*	*

	- Providing safety for users and protection from weather conditions.	*	*	*
	- Provide guide signs.	*	*	*
	- Alarm systems			
Socio-economic requirements	- Advertisements have plenty of surface area to exhibit in busy public transportation terminals and stations.	*	*	*
	- Retail concessions in stations and terminals can contain small businesses that cater to users, such as convenience stores, branch banks, automated teller machines (ATMs), coffee shops and snack restaurants, newspaper, and magazine dealers. Another possible source of income for mass transport operations is the park and ride concept that is reflected in commuter parking facilities.	*	*	*
	- process of reconciling competing social equity, economic	*	*	*
	- The stock of social capital needed for the development of the economy and the environment is formed through social sustainability.	*	*	*
	- Social sustainability as place based.	*	*	*

Source- Authors based on extant literature sources.

- **Common Architectural Design Requirements at Egyptian Case Studies**
  - **Functional Requirements**
    - Connecting different types of transportation in one place and Providing spaces for movement between different modes
    - Spatial organization of spaces to reduce intersections for passengers and reduce movement paths and decision points.
    - Functional integration according to social and environmental changes and providing service and commercial spaces.
    - The separation between entrances and exits in LRT station and metro station, while the separation is not done in other modes .
    - Providing services and shops at the train station while not provided in the other modes .
    - Dividing the platform cross-section
    - Optimal use of space
    - Provide usability requirements.
    - Physical, visual interconnection, and Aesthetic form.

  - **Circulation Requirements**
    - Paths clear and straightforward as feasible.

- A passenger's movement unhindered from the time he enters the Station until he leaves.
- All platforms should be parallel and of the same length .
- provided waiting space to reduce passenger interference in the circulation area.
- Create a clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation.
- Sequence in motion (entry-tickets-waiting-departure)
- Providing consistent and obvious directional signage
- To build a seamless local and regional inter-modal network, stations are designed to make it simple to transfer to other Transit System lines and forms of public transportation.
- passengers given sufficient options to depart the station campus, such as regional buses, taxis, or the Mass Rapid Transit System.
- Provide sufficient space for movement and waiting.
- The separation between the movement of people and vehicles
- The platform is divided into parts, the first of which is at the edge a warning area, then a movement area, followed by a waiting area, and there is a line separating the prohibited area from the waiting area.

- **Environmental Design Requirements**
  - Using local materials that are resistant to weather conditions and recyclable.
  - saving energy
  - Increasing green spaces inside and around the station
  - Respect the privacy of the site.
  - Provide natural lighting.
  - Provide natural ventilation.

- **Safety and Security Requirements**
  - The pedestrian path is clear and well-lit.
  - Slip-resistant walking surfaces
  - Controlling entrances and exits.
  - Protection of personal property
  - Providing maintenance requirements

- Provide emergency requirements.
- Providing safety for users and protection from weather conditions.
- Provide guide signs .
- Alarm systems

- **Socio-Economic Requirements**
  - Advertisements have plenty of surface area to exhibit in busy public transportation terminals and stations .
  - Retail concessions in stations and terminals can contain small businesses that cater to users, such as convenience stores, branch banks, automated teller machines (ATMs), coffee shops and snack restaurants, newspaper, and magazine dealers. Another possible source of income for mass transport operations is the park and ride concept that is reflected in commuter parking facilities.
  - process of reconciling competing social equity, economic
  - The stock of social capital needed for the development of the economy and the environment is formed through social sustainability.
  - Social sustainability as place based.

- **General Problem in Egyptian Case Studies**

The lack of clear design determinants in the Egyptian experience resulted in the emergence of many of the problems represented in,

- Not providing separate arrival and departure halls for each mode of transportation.
- Not providing information centers to help users.
- Not Providing private entrances and services for employees and operators in the station .
- There is no separation between the ticket halls and the main waiting halls of the station.
- Long distances between mode of transportation in Adly Mansour station, and long distances between mode of transportation and shops in Badr station, and Arts and Culture station.
- The cross-section of some parts of the train platforms does not exceed 2 m. in Adly Mansour station.
- The areas of the elements are very large in relation to the number of users, and this was evident through studying the per capita share and density inside the station.

- Average per capita inside the Adly Mansour hub station is 1.50 $m^{2,,}$ Average per capita inside the Badr station is 3.65 $m^{2,}$ Average per capita inside Arts and Culture station is 1.35 $m^{2.}$
- Unavailability of ramps, stairs and escape exits from the station in emergency cases.
- Do not use fire-resistant materials.
- Failure to apply the concept of environmental sustainability by not using clean energies to save energy, not treating water, and not using modern technologies in roofs and destinations.
- Providing mobility aids (elevators, escalators, moving walkways and assistive devices like wheelchairs for the physically disabled)
- Considering people with special needs.
- Provide separate areas for baggage movement.
- Availability of parking lots for long and short waiting periods

5- Chapter Five: Assessing and Proposed Improvements.

The final objective of this chapter is to deduce and conclude the final version of guidelines after being validated and analytically tested according to expert opinions and giving weight to each main and secondary requirement of the guidelines and assess and propose improvements for the Egyptian case studies in Egypt. Figure 5-1

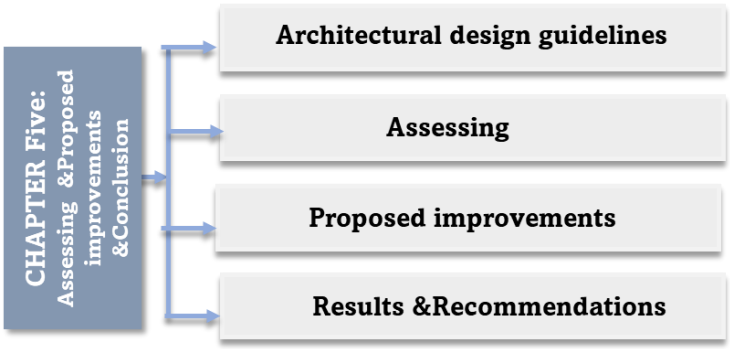


Figure 5-1: Chapter Five structure, **Source:** Authors.

5-1. Architectural Design Guidelines at Multi Modal Hub Stations

By studying literature review, studying literature knowledge, studying, and analyzing international and local case studies, some of the requirements are common standards and others are unique to each study. Table 5-1

Table 5-1:- Architectural design requirements at multi modal hub stations

requirements		secondary requirements	Chapter 1	Chapter 2	Chapter 3	Chapter 4
functional	Quality	- Connecting different types of transportation in one place	*		*	*
		- The station should be designed according to accommodate the flow of people from arrival to departure and ensuring that each point along the way is as seamless as possible.	*		*	*
		- Design spaces, and platforms according to the number of passengers at peak hours	*		*	
		- Determine expected number of demands for both travelers and non-travelers.				*
		- Considering the individual's share in the different spaces.	*		*	

		- Each function should have its own space, which should be divided up according to the importance of each function. The most space must be dedicated to free circulation.	*		*	
		- Spatial organization of spaces to reduce intersections for passengers and reduce movement paths and decision points.				*
		- Functional integration according to social and environmental changes, and providing service and commercial spaces	*		*	*
		- Providing waiting areas and restrooms inside the main halls, ticket halls and places for decision-making and providing services for them			*	
		- Dividing the platform cross-section				*
		- Optimal use of space	*		*	*
		- Provide special spaces for operators			*	*
		- Station entrances provide a connection between the station and the surrounding streets, ensuring that all passengers have easy access to the entrances.			*	
		- The station entrance must have obvious and direct access to the surrounding pedestrian network.			*	
		- Arrival and departure concourses should be strategically positioned below and/or above the platforms.			*	
		- The departure concourse and platforms should each have a shared ceiling with unobstructed broad span structural systems			*	
		- Station interiors must include partition walls that allow for flexible area			*	
		- Provide usability requirements			*	*
		- Use a unified ticket	*		*	
		- The use of electronic tickets reduces the need for ticket halls inside the stations			*	
		- Place information, TVs, and ticket booths in locations that do not obstruct other people's access to the space or interfere with important station functions.				*
		- Consider using analytical techniques or computer-aided modelling tools to confirm the movements and capacity of station users, especially at passenger decision points, queuing locations, and cross flows.				*
		- Integrating spatial layout, lighting, and surface finishes with other architectural components can simplify the need for signage and allow for town/city maps, directions, and directional signs local wayfinding strategies to be displayed around external facilities within the station.				*
		- Information for users who are blind or visually impaired is provided using near-field, mobile, and loop technologies.				*
		- Sufficient parking all around station.			*	
		- System integration (structure, space, materials, lighting, communications, and mechanical)			*	
		- Maintain visual/aesthetic continuity with the rest of the system while incorporating site-specific aspects. (Physical, visual interconnection, and Aesthetic form)	*		*	*
circul		- To avoid excessive crowding in the station, especially on platforms and escalators, the design of the station must allow for a free-flowing passenger.	*		*	

		- Reducing walking distances should be minimized.	*		*	
		- Paths should be clear and direct as much as possible.	*		*	*
		- A passenger's movement should be unimpeded from the moment he enters the station until he departs.	*		*	*
		- All platforms should be parallel and of the same length.			*	*
		- Segregation of arriving and departing passengers.			*	*
		- provided waiting space to reduce passenger interference in the circulation area.			*	*
		- Create a clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation. The sequence should be entry, tickets, waiting, and departure.	*		*	*
		- Assisting with motility (elevators, escalators, moving walkways and assistive devices like wheelchairs for the physically disabled)	*		*	
		- Providing clear and consistent directional signage.			*	*
		- To build a seamless local and regional inter-modal network, station designs should facilitate easy transfers to other transit system lines and modes of public transportation.			*	*
		- passengers must be given sufficient options to depart the station campus, such as regional buses, taxis, or the Mass Rapid Transit System.			*	
		- Provide sufficient space for movement and waiting	*		*	
		- Considering people with special needs.	*		*	
		- The separation between the people movement and vehicles.	*		*	
		- Define separate areas for the movement of baggage			*	
		- Using technology will reduce time for people that have to wait in lines to buy tickets	*			*
		- The platform is divided into parts, the first of which is at the edge a warning area, then a movement area, followed by a waiting area, and there is a line separating the prohibited area from the waiting area			*	*
		- Cycle tracks & cycle parking			*	
Environmental design		- Using biophilic design to achieve a comfortable healthy environment inside the station			*	*
		- Using local, weather-resistant, and recyclable materials	*		*	
		- Rainwater collection and reuse			*	*
		- Reducing the operating cost and saving energy	*		*	*
		- Increasing green spaces inside and around the station	*		*	*
		- Respecting the privacy of the site	*		*	*
		- Good open spaces around the station/ plaza/ creating a fresh environment/pedestrian-friendly atmosphere			*	
		- Using glass which allows natural light	*		*	

		- Provide natural ventilation.				*
		- Integrating station amenities with the surrounding open space to create a cohesive environment.				*
		- Creating a connected network of public areas, bike lanes, and platforms to improve accessibility and convenience.				*
		- Designing warm station settings that encourage people to travel, work, and shop, enhancing the overall experience.				*
		- Selecting and creating stations that promote a positive identity and image, contributing to the community's development.				*
		- The Most Effective Operation and Maintenance			*	
		- In the public areas of the Station, material finishes of elements should be highly durable, low maintenance, and require less frequent cleaning.			*	
Safety and security requirements		- The station design should promote security for the passenger.	*		*	
		- Stations should be constructed to minimize the potential for accidents.	*		*	
		- Stations should be designed to be safe and secure without depending on technology.	*		*	
		- Pedestrian path must be clear and well-lit.	*		*	*
		- Walking surfaces should be slip-resistant.	*		*	*
		- Controlling entrances and exits	*		*	*
		- The more accident-prone locations, like the platform and vertical circulation components, require special care.			*	
		- When elevator or escalator maintenance is required, consider providing alternative accessible paths either proactively or reactively.				*
		- Enabling effective station upkeep and cleaning.				*
		- Using materials that are durable and resilient.				*
		- Implementing the process of Heritage Asset Management.				*
		- Techniques for designing buildings and areas to reduce the likelihood of mishaps, disputes, and collisions.				*
		- Utilizing secure and thoughtful design to assess and mitigate the risk of hazards, whether they are caused by humans or nature.				*
		- Methods for adhering to the principles of crime prevention through environmental design.				*
		- Creating functional, lively, and secure environments and amenities for usage during both day and night.				*
		- Protection of personal property	*		*	*
		- maintenance requirements	*		*	*
		- Provide emergency requirements	*		*	*
		- Providing a safe for users and protection from weather conditions.	*		*	*
		- Provide guide signs.				*
		- Providing alarm systems				*

		• Safety and Health - Plans should be made to reduce the likelihood of accidents and health risks. The following strategies are to be used, but are not restricted to them: - Appropriate and sufficient illumination - Slip-resistant surfaces for walking - Proper use of safety rails and guards			*	
Socio-		- Providing investment and rental spaces			*	*
		- The link between production and consumption areas			*	*
Architect		- Their design should reflect the preservation and beauty of the surrounding area. The new station design must not isolate the existing historic structures.			*	

Source- Authors based on extant literature sources.

5-2. Guidelines Weight

After reaching design guidelines and presenting them to a group of specialized experts, they were evaluated by the experts and suggested some missing design guidelines that help to raise efficiency. Table 5-2 There were specific factors for selecting the sample of experts, and these factors were: First: The location of the study sample and the scope or field of study, the location of the study sample was represented in Egypt and the scope or field of study is the design of guidelines for multi-modal hub stations .Second, a group of specialized experts was selected, represented by (researchers - consulting engineering offices designed and implemented - station operators - users), but excluded each of users and station operators due to the inaccuracy of their results, while 20 experts were relied upon each of the researchers and engineering offices due to the limited number of experts in this field. The ratio between them was as follows: 50% researchers and 50% engineering offices to link the theoretical and applied study. Then determine the weight of each main and secondary architectural design requirement in the multi-modal hub stations. **Appendix 1**

To determine the specific weight of (functional requirements, circulation requirements, security and safety requirements, environmental design requirements, and social and economic requirements), we use the following equation.

The weight of the sub-requirements is equal to the weight of the main requirements multiplied by the total of the sub-points given by the experts and divided by the total points ,

knowing that one point represents 100.

weight of the sub-requirements = weight of the main requirements * total of the sum points given by the experts / total points ,knowing that one point represents 100.

Table 5-2:- Architectural design requirements weight.

requirements	Percentage%	Secondary requirements		Weight
functional requirements		Quality	- Connecting different types of transportation in one place	1.28
			- Optimal use of areas	1.08
			- Provide special spaces for operators.	1.17
			- Station entrances provide a connection between the station and the surrounding streets, ensuring that all passengers have easy access to the entrances.	1.25
			- The station entry must provide clear and direct access to the local footpath system.	1.34
			- The departure concourse and platforms should each have a shared ceiling with unobstructed broad-span structural systems.	1.11
			- Station interiors must include partition walls that allow for a flexible area.	1.12
			- Provide usability requirements.	1.12
			- Use a unified ticket.	0.88
			- The use of electronic tickets to reduce the need for ticket halls.	1.13
			- Consider using analytical techniques or computer-aided modelling tools to confirm the movements and capacity of station users, especially at passenger decision points, queuing locations, and cross flows.	0.99
			- Make it simpler for town/city maps, directions, and directional signs that adhere to third-party local wayfinding strategies to be presented about exterior facilities inside the station.	1.23
			- Considering people with special needs, and Information for users who are blind or visually impaired is provided using near-field, mobile, and loop technologies.	1.15
			- Sufficient parking all around the station.	0.98
			- System integration (structure, space, materials, lighting, communications, and mechanical)	1.25
			- Maintain visual/aesthetic continuity with the rest of the system while incorporating site-specific aspects. (Physical, visual interconnection, and Aesthetic form)	1.20
			- Their design should reflect the preservation and beauty of the surrounding area. The new station design must not isolate the existing historic structures.	1.19
		Zoning	- Functional integration according to social and environmental changes, and providing service and commercial spaces	1.10
			- Providing waiting areas and restrooms inside the main halls and ticket halls and places for decision-making and providing services for them	1.13
			- Concourses for arrival and departure ought to be placed strategically below and/or above the platforms.	1.28
			- Place information, TVs, and ticket booths in locations that do not obstruct other people's access to the space or interfere with important station functions.	1.25

			- integrating spatial layout, lighting, and surface finishes with other architectural components can be made to be straightforward and legible with no need for signage.	1.07
		Area	- Design spaces, and platforms according to the number of passengers at peak hours	1.22
			- Determine expected number of demands for both travelers and non-travelers.	1.14
			- Considering the individual's share in the different spaces.	1.19
			- Each function should have its own space, which should be divided up according to the importance of each function. The most room must be dedicated to free circulation.	1.15
circulation requirements		Accessibility	- The station's design must allow for a free-flowing passenger to avoid severe congestion within the station, particularly on platforms and escalators.	1.79
			- Reducing walking distances should be kept to a minimum.	1.38
			- Paths should be clear and straightforward as feasible.	1.81
			- A passenger's movement must be unhindered from the time he enters the Station until he leaves.	1.73
			- Segregation of arriving and departing passengers.	1.39
			- The separation between the people movement and vehicles	1.77
			- Define separate areas for the movement of baggage	1.01
			- Using technology will reduce time for people that have to wait in lines to buy tickets	1.39
			- All platforms should be parallel and of the same length.	1.64
			- The platform is divided into parts, the first of which is at the edge a warning area, then a movement area, followed by a waiting area, and there is a line separating the prohibited area from the waiting area	1.83
		providing	- providing Waiting space to reduce passenger interference in the circulation area.	1.62
			- Providing clear and consistent directional signage.	1.89
			- Sufficient space for movement and waiting	1.80
			- clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation. A sequence in motion (entry-tickets-waiting-departure)	1.64
			- motility (elevators, escalators, moving walkways and assistive devices like wheelchairs for the physically disabled)	1.77
			- Cycle tracks & cycle parking	0.51
Environmental design requirements			- Using biophilic design to achieve a comfortable healthy environment inside the station	0.87
			- Using local, weather-resistant, and recyclable materials	0.89
			- Rainwater collection and reuse	0.63
			- Reducing the operating cost and saving energy	0.68
			- Increasing green spaces inside and around the station	1.03
			- Respecting the privacy of the site	1.23
			- Good open spaces around the station/ plaza/ creating a fresh environment/pedestrian-friendly atmosphere	1.25
			- Using glass which allows natural light	1.25
			- Provide natural ventilation.	0.75

			- In the public areas of the Station, material finishes of elements should be highly durable, low maintenance, and require less frequent cleaning.	1.41
Safety and security requirements		Be Safety and Secure by Design	- The Station design should promote security for the passenger.	1.91
			- Created with the least amount of potential for accidents and health risks. The following strategies are to be used, but are not restricted to them: - Appropriate and sufficient illumination - Slip-resistant surfaces for walking - Proper use of safety rails and guards.	1.86
			- Stations ought to be built with safety and security in mind, independent of technology.	1.79
			- Controlling entrances and exits	1.75
			- The more accident-prone locations, like the platform and vertical circulation components, require special care.	1.73
			- Using materials that are durable and resilient.	1.77
			- Utilizing secure and thoughtful design to assess and mitigate the risk of hazards, whether they are caused by humans or nature.	1.52
			- Protection of personal property	0.77
			- Provide emergency requirements	1.57
			- Providing a safe for users and protection from weather conditions.	1.52
			- Provide guide signs.	1.99
			- Alarm systems	2.01
		Manag	- Provide maintenance requirements	1.75
			- When elevator or escalator maintenance is required, consider providing alternative accessible paths either proactively or reactively.	1.70
			- Enabling effective station upkeep and cleaning.	1.37
Socio-economic requirements		Socio	- Integrating station amenities with the surrounding open space.	1.02
			- The creation of a connected network of public areas, bike lanes, and platforms.	0.56
			- Creating warm station settings that encourage people to travel, work, and shop.	0.82
			- Raising the standard of well-being (cultural, human behavior ...etc.)	0.79
			- Awareness and education through information centers and screens	1.10
			- Well-balanced and social justice	0.73
			- Humanitarian needs (Availability of food- Availability of drinks- Safety and Security)	1.17
		Economi	- Providing investment and rental spaces	1.26
			- Take advantage of the site	1.25
			- Reducing resource consumption	0.79
			- Use of renewable resources	0.49

Source- Authors based on extant literature sources and experts' opinions.

5-2.1. Analysis of The Expert Opinions and Weight.

The main requirement in the multi-modal hub station showed a discrepancy in percentage, with (functional requirements) having the highest percentage among all the others equal to 30% followed by the (Circulation requirements - Safety and security requirements) equal to

25%, and then the (Environmental design requirements -Socio-economic requirements) achieved the least, which equal 10%. Figure 5-2

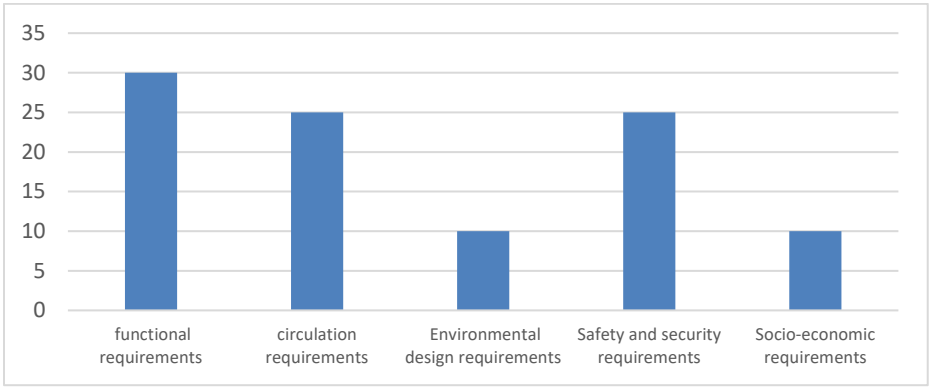


Figure 5-2: The main requirement in the multi-modal hub station, **Source**: Authors.

5-2.1.1. Functional Requirements

The function requirements showed a discrepancy in the number of main elements, with (quality) scoring the highest score 19.47 point followed by (zoning) representing about 5.83 point and then the (Area) achieved the least representing about 4.7 point. Figure 5-3

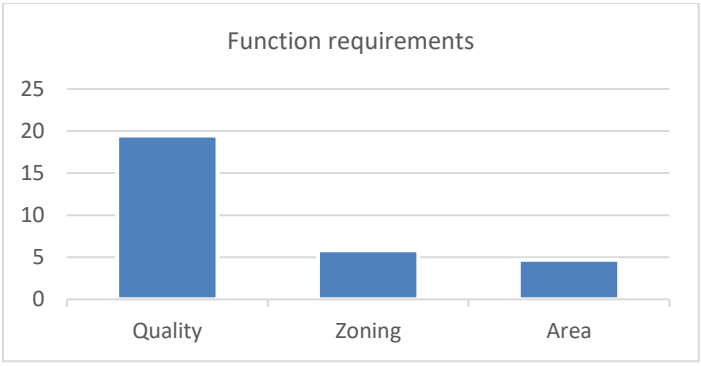


Figure 5-3: Functional requirements, **Source**: Authors.

- ***Quality***

The secondary elements at quality in the function requirements showed a discrepancy in percentage, with "The station entrance must have obvious and direct access to the surrounding pedestrian network" having the highest score 1.34 points, while "Use a unified ticket" achieved the least which equal 0.88 points. Figure 5-4

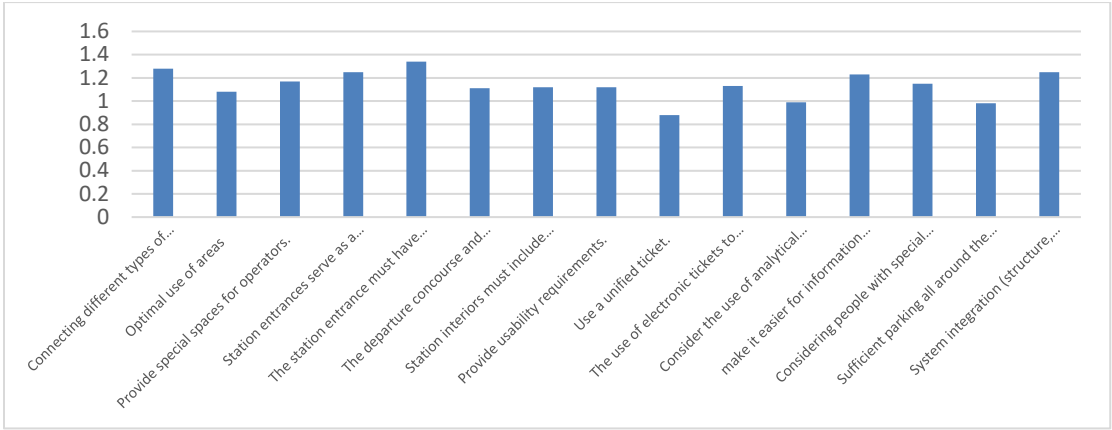


Figure 5-4: Quality requirements, **Source**: Authors.

- ***Zoning***

The secondary elements at zoning in the function requirements showed a discrepancy in percentage, with "Paths should be clear and straightforward as feasible" scoring the highest score 1.28 points, while "integrating spatial layout, lighting, and surface finishes with other architectural components can be made to be straightforward and legible with no need for signage" achieved the least which equal 1.07 points. Figure 5-5

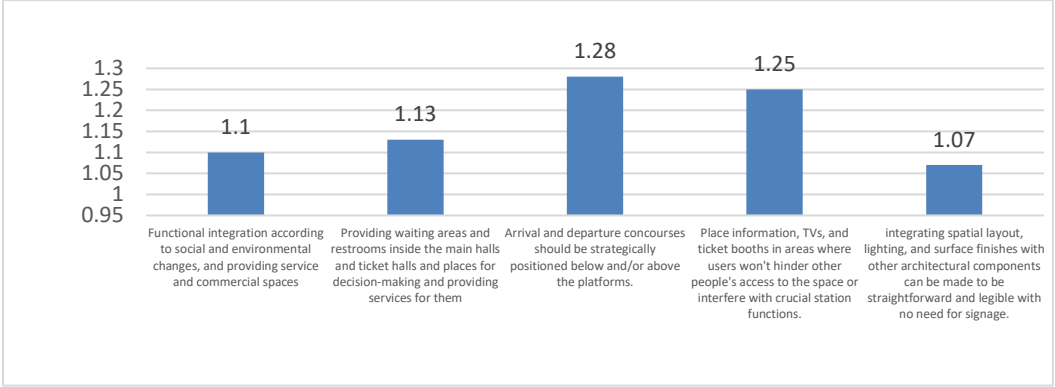


Figure 5-5: zoning requirements, **Source**: Authors.

- ***Area***

The secondary elements at area in the function requirements showed a discrepancy in percentage, with (Design spaces, and platforms according to the number of passengers at peak hours) scoring the highest score 1.22 points, and (Determine anticipated levels of demand for travelers and non-travelers) achieved the least which equal 1.14 points. Figure 5-6

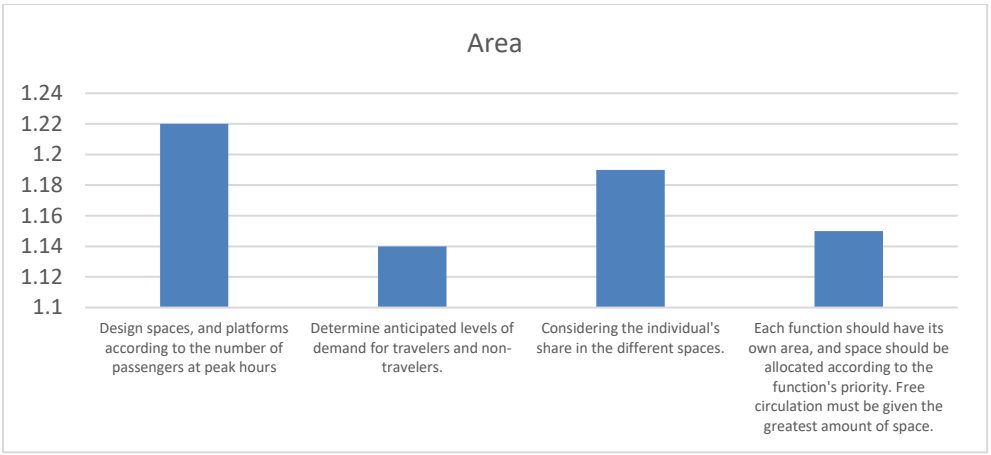


Figure 5-6: Area requirements, **Source**: Authors.

5-2.1.2. Circulation Requirements

The circulations requirements showed a discrepancy in percentage, with (Accessibility) scoring the highest score 15.74 point, and then the (Providing) achieved the least which represented about 9.23 point Figure 5-7

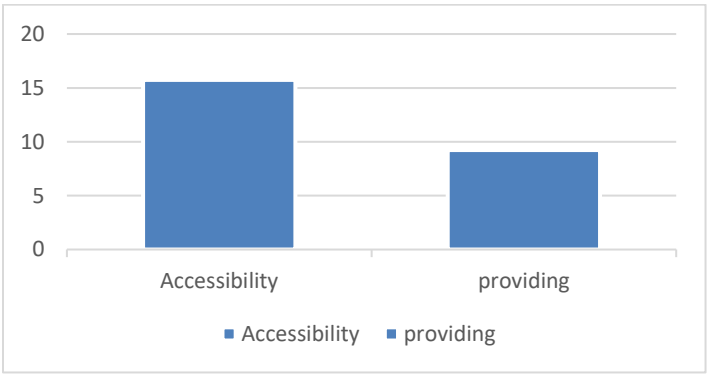


Figure 5-7: Circulation requirements, **Source**: Authors.

- ***Accessibility***

The secondary elements at accessibility in the circulation requirements showed a discrepancy in percentage, with (The platform is divided into parts) scoring the highest score 1.83 points, and (Define separate areas for the movement of baggage) achieved the least which equal 1.01 points. Figure 5-8

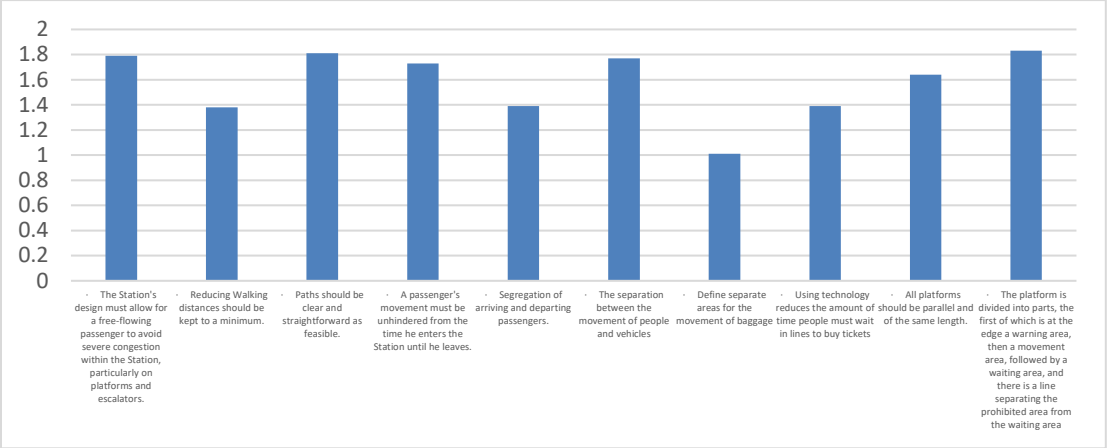


Figure 5-8: Accessibility requirements, **Source**: Authors.

- ***Providing***

The secondary elements at providing in the circulation requirements showed a discrepancy in percentage, with (Consistent and obvious directional signage) scoring the highest score 1.89 points, and (Cycle tracks & cycle parking) achieved the least which equal 0.55 points. Figure 5-9

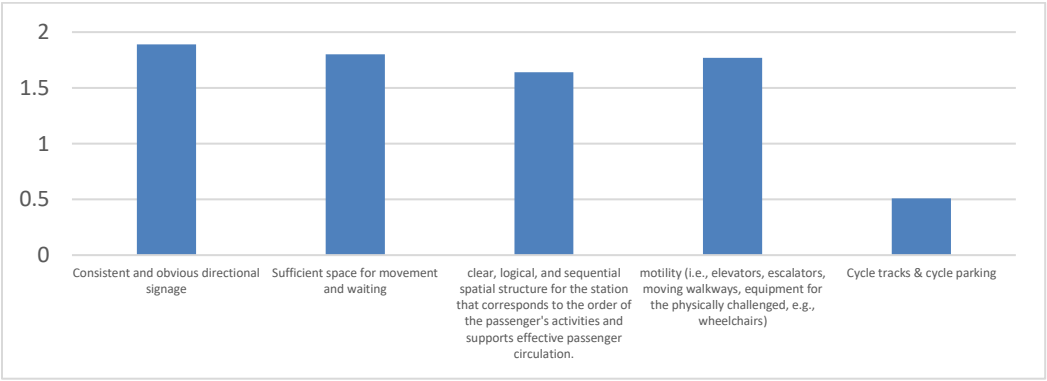


Figure 5-9: Providing requirements, **Source**: Authors.

5-2.1.3. Environmental Design Requirements

The environmental design requirements showed a discrepancy in percentage, with (material finishes of elements should be highly durable, low maintenance, and require less frequent cleaning) scoring the highest score 1.41 points, and (Rainwater collection and reuse) achieved the least which equal 0.63 points. Figure 5-10

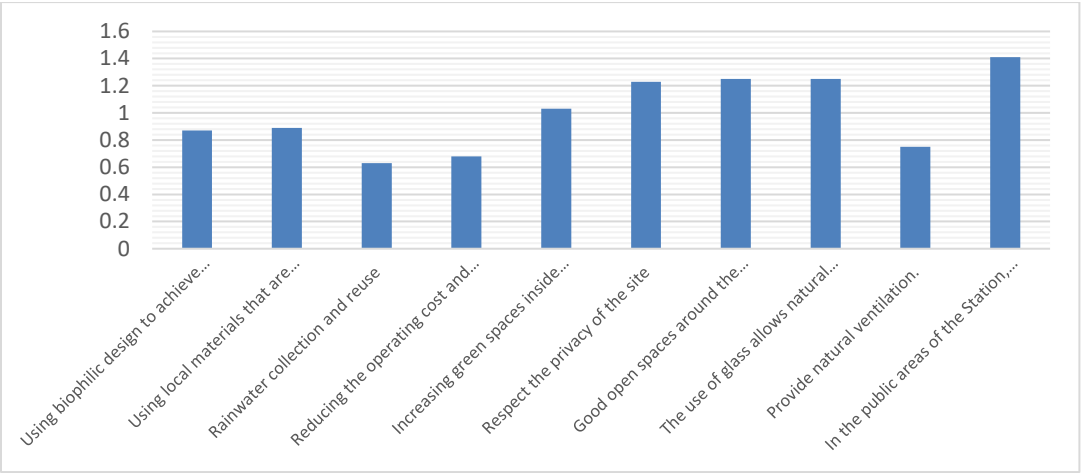


Figure 5-10: Environmental design requirements, **Source**: Authors.

5-2.1.4. Safety and Security Requirements

The safety and security requirements showed a discrepancy in percentage, with (Be safety and security) scoring the highest score 20,19 point and then the (management and maintenance) achieved the least which representing about 4.82 point Figure 5-11

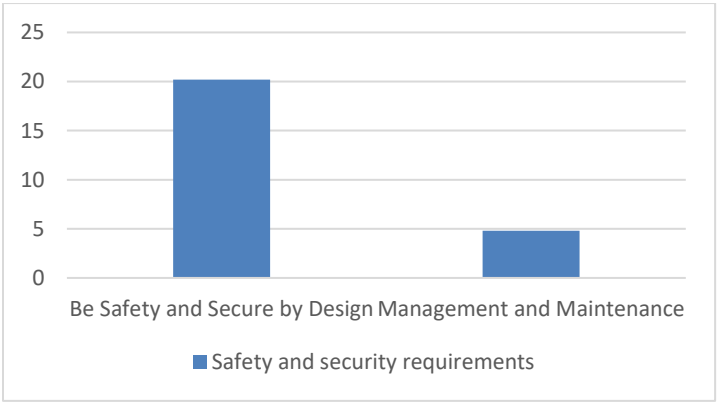


Figure 5-11: Safety and security requirements, **Source**: Authors.

- ***Be safety and secure.***

The secondary elements at Be safety and security in the safety and security requirements showed a discrepancy in percentage, with (Alarm systems) scoring the highest score 2.01 points, and (Protection of personal property) achieved the least which equaled 0.77 points. Figure 5-12

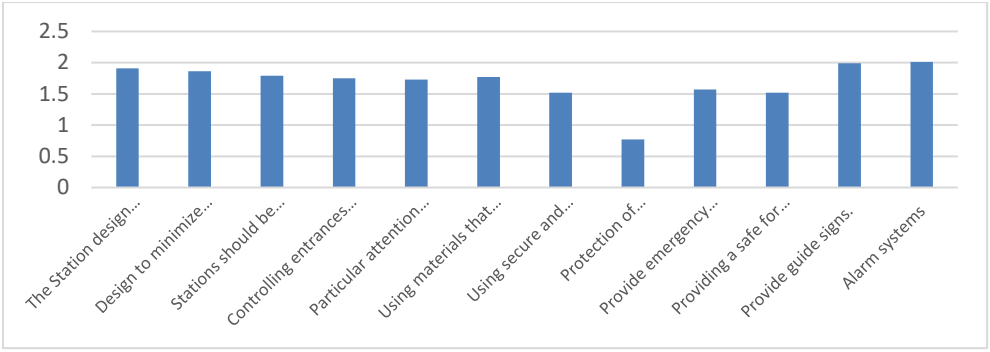


Figure 5-12: Be safety and security requirements, **Source**: Authors.

- ***Management and Maintenance***

The secondary elements at Management and maintenance in the safety and security requirements showed a discrepancy in percentage, with (Provide maintenance requirements) scoring the highest score 1.75 points, and (Enabling effective station upkeep and cleaning) achieved the least which equaled 1.37 points. Figure 5-13

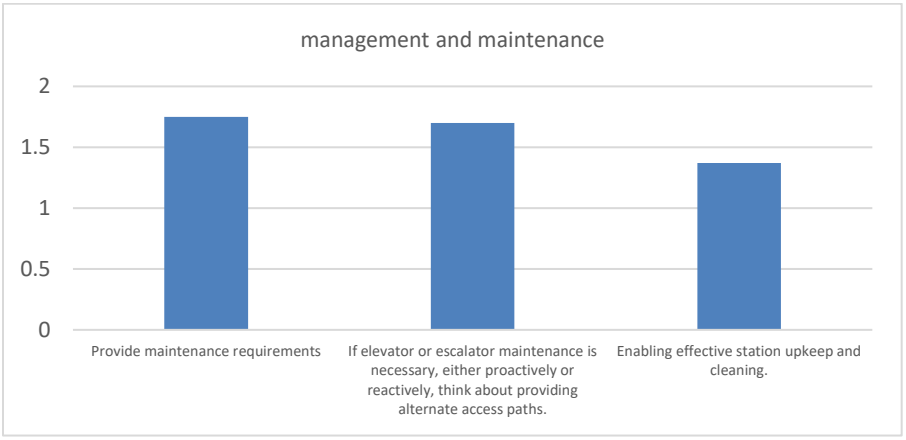


Figure 5-13: management and maintenance requirements, **Source**: Authors.

5-2.1.5. Socio and Economic Requirements

The socio and economic requirements showed a discrepancy in percentage, with (socio) scoring the highest score 6.19 point, and then the (Economic) achieved the least which represented about 3.79 point. Figure 5-14

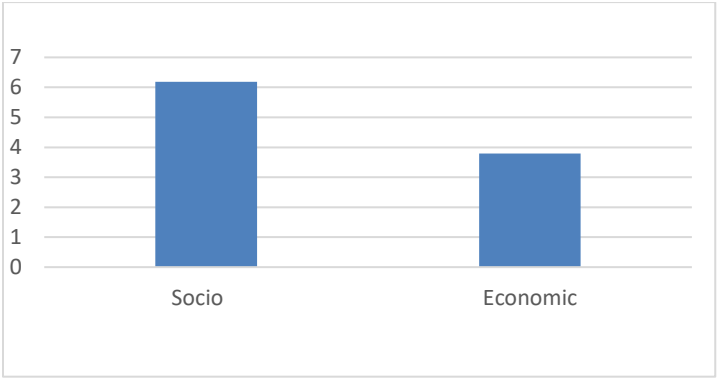


Figure 5-14: Socio and economic requirements, **Source**: Authors.

- ***Socio Requirements***

The secondary elements at socio in the socio and economic requirements showed a discrepancy in percentage, with (Humanitarian needs scoring the highest score 1.17 points, and (The creation of a connected network of public areas, bike lanes, and platforms) achieved the least which equaled 0.56 points. Figure 5-15

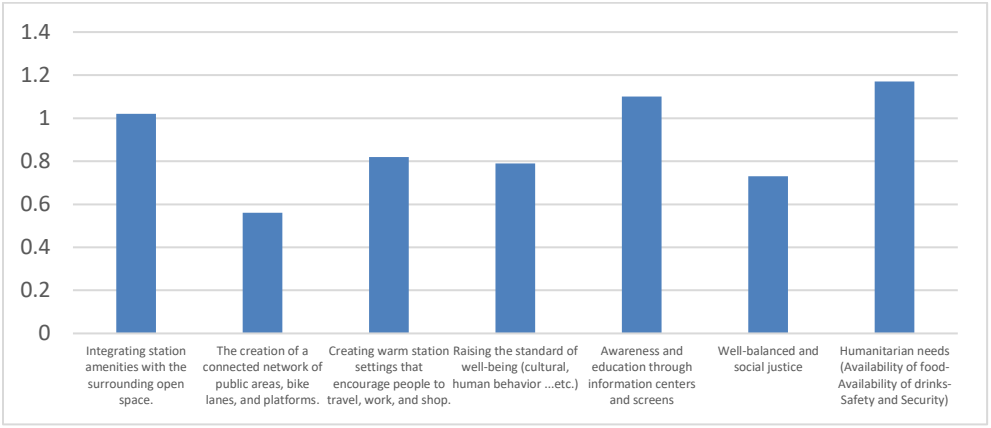


Figure 5-15: Socio requirements, **Source**: Authors.

- ***Economic Requirements***

The secondary elements at economic in the socio and economic requirements showed a discrepancy in percentage, with (Providing investment and rental spaces) scoring the highest score 1.26 points, and (Use of renewable resources) achieved the least which equaled 0.49 points. Figure 5-16

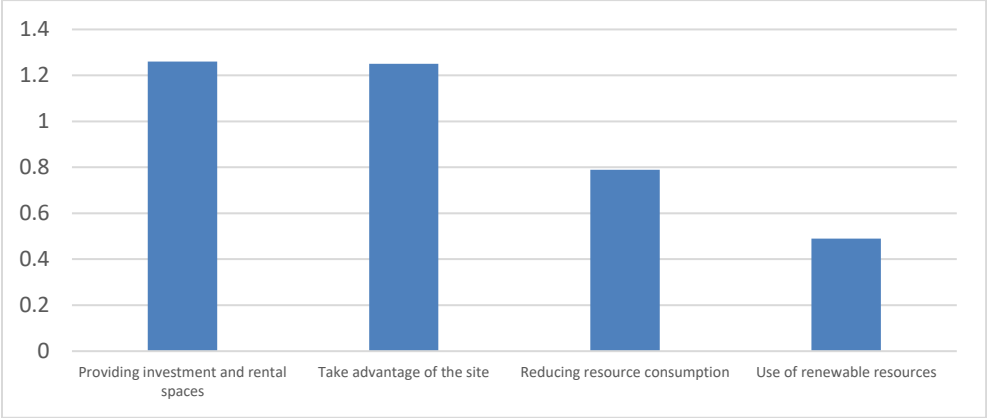


Figure 5-16: Economic requirements, **Source**: Authors.

5-3. Evaluate Egyptian Case Studies.

By evaluating and giving weight to the design guidelines of multi-modal hub stations by specialized experts. From that, the efficiency of the Egyptian case studies is evaluated and determined according to that framework .

5-3.1. Evaluate Adly Mansour Stations.

Adly Mansour station is evaluated according to the design guidelines evaluated by a group of specialized experts. Table 5-3

Table 5-3: Adly Mansour station is evaluated.

requirements	Percentage%	Secondary requirements		Weight		
functional requirements		Quality	- Connecting different types of transportation in one place	1.28	1.28	21.11
			- Optimal use of areas	1.08	1.08	
			- Provide special spaces for operators.	1.17	1.17	
			- Station entrances provide a connection between the station and the surrounding streets, ensuring that all passengers have easy access to the entrances.	1.25	1.25	
			- The station entry must provide clear and direct access to the local footpath system.	1.34	1.34	
			- The departure concourse and platforms should each have a shared ceiling with unobstructed broad-span structural systems.	1.11	0	
			- Station interiors must include partition walls that allow for a flexible area.	1.12	0	
			- Provide usability requirements.	1.12	1.12	

			- Use a unified ticket.	0.88	0	
			- The use of electronic tickets to reduce the need for ticket halls.	1.13	1.13	
			- Consider using analytical techniques or computer-aided modelling tools to confirm the movements and capacity of station users, especially at passenger decision points, queuing locations, and cross flows.	0.99	0	
			- Make it simpler for town/city maps, directions, and directional signs that adhere to third-party local wayfinding strategies to be presented about exterior facilities inside the station.	1.23	0	
			- Considering people with special needs, and Information for users who are blind or visually impaired is provided using near-field, mobile, and loop technologies.	1.15	1.15	
			- Sufficient parking all around the station.	0.98	0.98	
			- System integration (structure, space, materials, lighting, communications, and mechanical)	1.25	1.25	
			- Maintain visual/aesthetic continuity with the rest of the system while incorporating site-specific aspects. (Physical, visual interconnection, and Aesthetic form)	1.20	1.20	
			- Their design should reflect the preservation and beauty of the surrounding area. The new station design must not isolate the existing historic structures.	1.19	1.19	
		Zoning	- Functional integration according to social and environmental changes, and providing service and commercial spaces	1.10	1.10	
			- Providing waiting areas and restrooms inside the main halls and ticket halls and places for decision-making and providing services for them	1.13	1.13	
			- Concourses for arrival and departure ought to be placed strategically below and/or above the platforms.	1.28	1.28	
			- Place information, TVs, and ticket booths in locations that do not obstruct other people's access to the space or interfere with important station functions.	1.25	1.25	
			- integrating spatial layout, lighting, and surface finishes with other architectural components can be made to be straightforward and legible with no need for signage.	1.07	1.07	
		Area	- Design spaces, and platforms according to the number of passengers at peak hours	1.22	0	
			- Determine expected number of demands for both travelers and non-travelers.	1.14	1.14	
			- Considering the individual's share in the different spaces.	1.19	0	
			- Each function should have its own space, which should be divided up according to the importance of each function. The most room must be dedicated to free circulation.	1.15	0	
circulation		Accessibility	- The station's design must allow for a free-flowing passenger to avoid severe congestion within the station, particularly on platforms and escalators.	1.79	0	17.06
			- Reducing walking distances should be kept to a minimum.	1.38	0	
			- Paths should be clear and straightforward as feasible.	1.81	1.81	
			- A passenger's movement must be unhindered from the time he enters the Station until he leaves.	1.73	1.73	
			- Segregation of arriving and departing passengers.	1.39	1.39	

			- The separation between the people movement and vehicles	1.77	1.77	
			- Define separate areas for the movement of baggage	1.01	0	
			- Using technology will reduce time for people that have to wait in lines to buy tickets	1.39	0	
			- All platforms should be parallel and of the same length.	1.64	1.64	
			- The platform is divided into parts, the first of which is at the edge a warning area, then a movement area, followed by a waiting area, and there is a line separating the prohibited area from the waiting area	1.83	0	
		providing	- providing Waiting space to reduce passenger interference in the circulation area.	1.62	1.62	
			- Providing clear and consistent directional signage.	1.89	1.89	
			- Sufficient space for movement and waiting	1.80	1.80	
			- clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation. A sequence in motion (entry-tickets-waiting-departure)	1.64	1.64	
			- motility (elevators, escalators, moving walkways and assistive devices like wheelchairs for the physically disabled)	1.77	1.77	
			- Cycle tracks & cycle parking	0.51	0	
Environmental design requirements			- Using biophilic design to achieve a comfortable healthy environment inside the station	0.87	0	4.28
			- Using local, weather-resistant, and recyclable materials	0.89	0	
			- Rainwater collection and reuse	0.63	0	
			- Reducing the operating cost and saving energy	0.68	0	
			- Increasing green spaces inside and around the station	1.03	1.03	
			- Respecting the privacy of the site	1.23	0	
			- Good open spaces around the station/ plaza/ creating a fresh environment/pedestrian-friendly atmosphere	1.25	1.25	
			- Using glass which allows natural light	1.25	1.25	
			- Provide natural ventilation.	0.75	0.75	
			- In the public areas of the Station, material finishes of elements should be highly durable, low maintenance, and require less frequent cleaning.	1.41	0	
Safety and security requirements		Be Safety and Secure by Design	- The Station design should promote security for the passenger.	1.91	0	11.96
			- Created with the least amount of potential for accidents and health risks. The following strategies are to be used, but are not restricted to them: - Appropriate and sufficient illumination - Slip-resistant surfaces for walking - Proper use of safety rails and guards.	1.86	0	
			- Stations ought to be built with safety and security in mind, independent of technology.	1.79	0	
			- Controlling entrances and exits	1.75	1.75	
			- The more accident-prone locations, like the platform and vertical circulation components, require special care.	1.73	0	
			- Using materials that are durable and resilient.	1.77	0	

			- Utilizing secure and thoughtful design to assess and mitigate the risk of hazards, whether they are caused by humans or nature.	1.52	0	
			- Protection of personal property	0.77	0	
			- Provide emergency requirements	1.57	1.57	
			- Providing a safe for users and protection from weather conditions.	1.52	1.52	
			- Provide guide signs.	1.99	1.99	
			- Alarm systems	2.01	2.01	
		Managem	- Provide maintenance requirements	1.75	1.75	
			- When elevator or escalator maintenance is required, consider providing alternative accessible paths either proactively or reactively.	1.70	0	
			- Enabling effective station upkeep and cleaning.	1.37	1.37	
Socio-economic requirements		Socio	- Integrating station amenities with the surrounding open space.	1.02	1.02	7.97
			- The creation of a connected network of public areas, bike lanes, and platforms.	0.56	0.56	
			- Creating warm station settings that encourage people to travel, work, and shop.	0.82	0.82	
			- Raising the standard of well-being (cultural, human behavior ...etc.)	0.79	0.79	
			- Awareness and education through information centers and screens	1.10	1.10	
			- Well-balanced and social justice	0.73	0	
			- Humanitarian needs (Availability of food- Availability of drinks- Safety and Security)	1.17	1.17	
		Economi	- Providing investment and rental spaces	1.26	1.26	
			- Take advantage of the site	1.25	1.25	
			- Reducing resource consumption	0.79	0	
			- Use of renewable resources	0.49	0	

Source- Authors based on extant literature sources and experts' opinions.

According to specialized experts' opinions and their evaluation of the design guideline, the Adly Mansour station's efficiency is 62.38%. This efficiency is broken down into 21.11% for functional requirements, 17.06% for circulation requirements, 4.28% for environmental design requirements, 11.96% for safety and security requirements, and 7.97% for social and economic requirements. Figure 5-17

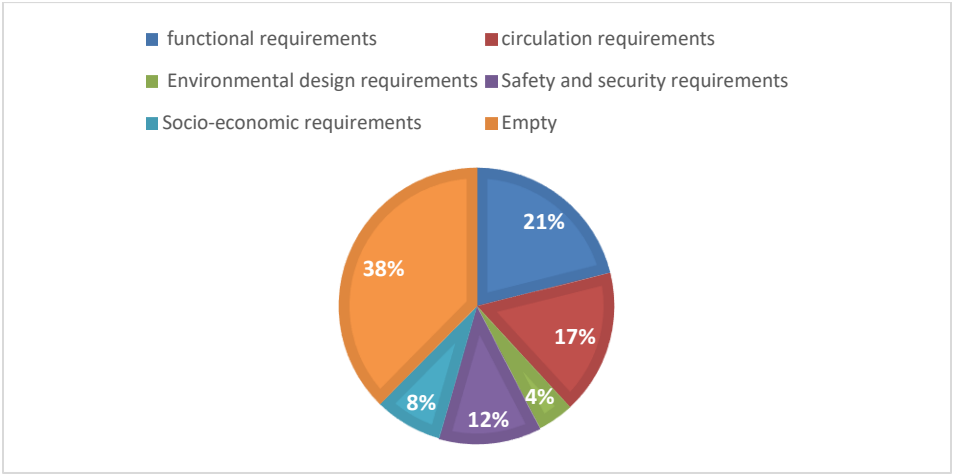


Figure 5-17: Efficiency of the Adly Mansour station, **Source**: Authors.

5-3.2. Evaluate Badr Stations.

Badr station is evaluated according to the design guidelines evaluated by a group of specialized experts. Table 5-4

Table 5-4:- Badr station is evaluated.

requirements	Percentage%	Secondary requirements		Weight		
functional requirements		Quality	- Connecting different types of transportation in one place	1.28	1.28	18.94
			- Optimal use of areas	1.08	1.08	
			- Provide special spaces for operators.	1.17	1.17	
			- Station entrances provide a connection between the station and the surrounding streets, ensuring that all passengers have easy access to the entrances.	1.25	1.25	
			- The station entry must provide clear and direct access to the local footpath system.	1.34	1.34	
			- The departure concourse and platforms should each have a shared ceiling with unobstructed broad-span structural systems.	1.11	0	
			- Station interiors must include partition walls that allow for a flexible area.	1.12	0	
			- Provide usability requirements.	1.12	1.12	
			- Use a unified ticket.	0.88	0	
			- The use of electronic tickets to reduce the need for ticket halls.	1.13	1.13	
			- Consider using analytical techniques or computer-aided modelling tools to confirm the movements and capacity of station users,	0.99	0	

			especially at passenger decision points, queuing locations, and cross flows.			
			- Make it simpler for town/city maps, directions, and directional signs that adhere to third-party local wayfinding strategies to be presented about exterior facilities inside the station.	1.23	0	
			- Considering people with special needs, and Information for users who are blind or visually impaired is provided using near-field, mobile, and loop technologies.	1.15	1.15	
			- Sufficient parking all around the station.	0.98	0.98	
			- System integration (structure, space, materials, lighting, communications, and mechanical)	1.25	1.25	
			- Maintain visual/aesthetic continuity with the rest of the system while incorporating site-specific aspects. (Physical, visual interconnection, and Aesthetic form)	1.20	1.20	
			- Their design should reflect the preservation and beauty of the surrounding area. The new station design must not isolate the existing historic structures.	1.19	1.19	
		Zoning	- Functional integration according to social and environmental changes, and providing service and commercial spaces	1.10	0	
			- Providing waiting areas and restrooms inside the main halls and ticket halls and places for decision-making and providing services for them	1.13	1.13	
			- Concourses for arrival and departure ought to be placed strategically below and/or above the platforms.	1.28	1.28	
			- Place information, TVs, and ticket booths in locations that do not obstruct other people's access to the space or interfere with important station functions.	1.25	1.25	
			- integrating spatial layout, lighting, and surface finishes with other architectural components can be made to be straightforward and legible with no need for signage.	1.07	0	
		Area	- Design spaces, and platforms according to the number of passengers at peak hours	1.22	0	
			- Determine expected number of demands for both travelers and non-travelers.	1.14	1.14	
			- Considering the individual's share in the different spaces.	1.19	0	
			- Each function should have its own space, which should be divided up according to the importance of each function. The most room must be dedicated to free circulation.	1.15	0	
circulation requirements		Accessibility	- The station's design must allow for a free-flowing passenger to avoid severe congestion within the station, particularly on platforms and escalators.	1.79	0	15.43
			- Reducing walking distances should be kept to a minimum.	1.38	1.38	
			- Paths should be clear and straightforward as feasible.	1.81	1.81	
			- A passenger's movement must be unhindered from the time he enters the Station until he leaves.	1.73	1.73	
			- Segregation of arriving and departing passengers.	1.39	0	
			- The separation between the people movement and vehicles	1.77	1.77	
			- Define separate areas for the movement of baggage	1.01	0	
			- Using technology will reduce time for people that have to wait in lines to buy tickets	1.39	0	

			- All platforms should be parallel and of the same length.	1.64	1.64	
			- The platform is divided into parts, the first of which is at the edge a warning area, then a movement area, followed by a waiting area, and there is a line separating the prohibited area from the waiting area	1.83	0	
		providing	- providing Waiting space to reduce passenger interference in the circulation area.	1.62	0	
			- Providing clear and consistent directional signage.	1.89	1.89	
			- Sufficient space for movement and waiting	1.80	1.80	
			- clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation. A sequence in motion (entry-tickets-waiting-departure)	1.64	1.64	
			- motility (elevators, escalators, moving walkways and assistive devices like wheelchairs for the physically disabled)	1.77	1.77	
			- Cycle tracks & cycle parking	0.51	0	
Environmental design requirements			- Using biophilic design to achieve a comfortable healthy environment inside the station	0.87	0	1.25
			- Using local, weather-resistant, and recyclable materials	0.89	0	
			- Rainwater collection and reuse	0.63	0	
			- Reducing the operating cost and saving energy	0.68	0	
			- Increasing green spaces inside and around the station	1.03	0	
			- Respecting the privacy of the site	1.23	0	
			- Good open spaces around the station/ plaza/ creating a fresh environment/pedestrian-friendly atmosphere	1.25	0	
			- Using glass which allows natural light	1.25	1.25	
			- Provide natural ventilation.	0.75	0	
			- In the public areas of the Station, material finishes of elements should be highly durable, low maintenance, and require less frequent cleaning.	1.41	0	
Safety and security requirements		Be Safety and Secure by Design	- The Station design should promote security for the passenger.	1.91	1.91	15.73
			- Created with the least amount of potential for accidents and health risks. The following strategies are to be used, but are not restricted to them: - Appropriate and sufficient illumination - Slip-resistant surfaces for walking - Proper use of safety rails and guards.	1.86	1.86	
			- Stations ought to be built with safety and security in mind, independent of technology.	1.79	0	
			- Controlling entrances and exits	1.75	1.75	
			- The more accident-prone locations, like the platform and vertical circulation components, require special care.	1.73	0	
			- Using materials that are durable and resilient.	1.77	0	
			- Utilizing secure and thoughtful design to assess and mitigate the risk of hazards, whether they are caused by humans or nature.	1.52	0	
			- Protection of personal property	0.77	0	
			- Provide emergency requirements	1.57	1.57	
			- Providing a safe for users and protection from weather conditions.	1.52	1.52	

		Managem	- Provide guide signs.	1.99	1.99	
			- Alarm systems	2.01	2.01	
			- Provide maintenance requirements	1.75	1.75	
			- When elevator or escalator maintenance is required, consider providing alternative accessible paths either proactively or reactively.	1.70	0	
			- Enabling effective station upkeep and cleaning.	1.37	1.37	
Socio-economic requirements		Socio	- Integrating station amenities with the surrounding open space.	1.02	0	2.35
			- The creation of a connected network of public areas, bike lanes, and platforms.	0.56	0	
			- Creating warm station settings that encourage people to travel, work, and shop.	0.82	0	
			- Raising the standard of well-being (cultural, human behavior ...etc.)	0.79	0	
			- Awareness and education through information centers and screens	1.10	1.10	
			- Well-balanced and social justice	0.73	0	
			- Humanitarian needs (Availability of food- Availability of drinks- Safety and Security)	1.17	0	
		Economi	- Providing investment and rental spaces	1.26	0	
			- Take advantage of the site	1.25	1.25	
			- Reducing resource consumption	0.79	0	
			- Use of renewable resources	0.49	0	

Source- Authors based on extant literature sources and experts' opinions.

According to specialized experts' opinions and their evaluation of the design guidelines, the efficiency of the Badr station is 53.7%. This is broken down as follows: 18.94% for functional requirements, 15.43% for circulation requirements, 1.25% for environmental design requirements, 15.73% for safety and security requirements, and 2.35% for social and economic requirements. Figure 5-18

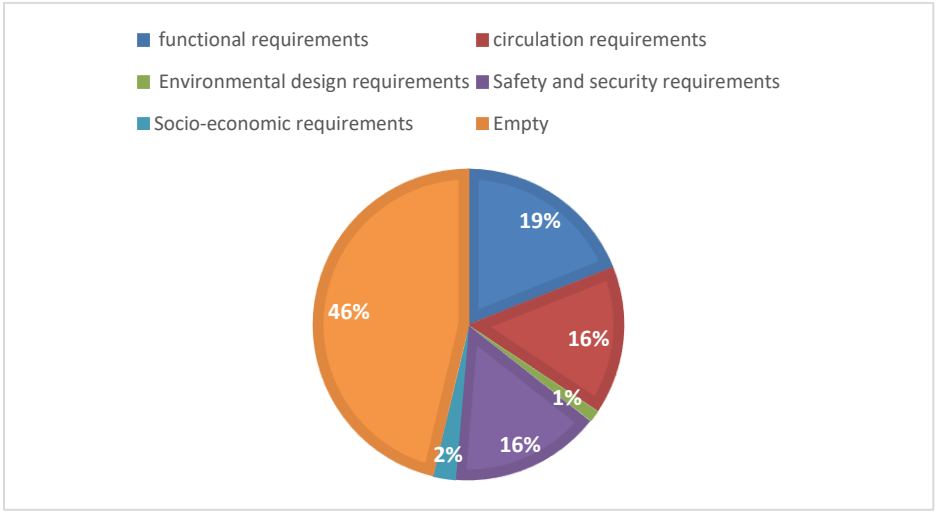


Figure 5-18: Efficiency of the Badr station, Source: Authors.

5-3.3. Evaluate Arts and Culture Station at the New Administrative Capital.

Arts and culture stations are evaluated according to the design guidelines evaluated by a group of specialized experts. Table 5-5

Table 5-5:- Arts and culture station is evaluated.

requirements	Percentage%	Secondary requirements		Weight		
functional requirements		Quality	- Connecting different types of transportation in one place	1.28	1.28	16.41
			- Optimal use of areas	1.08	1.08	
			- Provide special spaces for operators.	1.17	1.17	
			- Station entrances provide a connection between the station and the surrounding streets, ensuring that all passengers have easy access to the entrances.	1.25	1.25	
			- The station entry must provide clear and direct access to the local footpath system.	1.34	0	
			- The departure concourse and platforms should each have a shared ceiling with unobstructed broad-span structural systems.	1.11	0	
			- Station interiors must include partition walls that allow for a flexible area.	1.12	0	
			- Provide usability requirements.	1.12	1.12	
			- Use a unified ticket.	0.88	0	
			- The use of electronic tickets to reduce the need for ticket halls.	1.13	1.13	
			- Consider using analytical techniques or computer-aided modelling tools to confirm the movements and capacity of station users, especially at passenger decision points, queuing locations, and cross flows.	0.99	0	
			- Make it simpler for town/city maps, directions, and directional signs that adhere to third-party local wayfinding strategies to be presented about exterior facilities inside the station.	1.23	0	
			- Considering people with special needs, and Information for users who are blind or visually impaired is provided using near-field, mobile, and loop technologies.	1.15	1.15	
			- Sufficient parking all around the station.	0.98	0.98	
			- System integration (structure, space, materials, lighting, communications, and mechanical)	1.25	1.25	
			- Maintain visual/aesthetic continuity with the rest of the system while incorporating site-specific aspects. (Physical, visual interconnection, and Aesthetic form)	1.20	1.20	

			- Their design should reflect the preservation and beauty of the surrounding area. The new station design must not isolate the existing historic structures.	1.19	0	
		Zoning	- Functional integration according to social and environmental changes, and providing service and commercial spaces	1.10	0	
			- Providing waiting areas and restrooms inside the main halls and ticket halls and places for decision-making and providing services for them	1.13	1.13	
			- Concourses for arrival and departure ought to be placed strategically below and/or above the platforms.	1.28	1.28	
			- Place information, TVs, and ticket booths in locations that do not obstruct other people's access to the space or interfere with important station functions.	1.25	1.25	
			- integrating spatial layout, lighting, and surface finishes with other architectural components can be made to be straightforward and legible with no need for signage.	1.07	0	
		Area	- Design spaces, and platforms according to the number of passengers at peak hours	1.22	0	
			- Determine expected number of demands for both travelers and non-travelers.	1.14	1.14	
			- Considering the individual's share in the different spaces.	1.19	0	
			- Each function should have its own space, which should be divided up according to the importance of each function. The most room must be dedicated to free circulation.	1.15	0	
circulation requirements		Accessibility	- The station's design must allow for a free-flowing passenger to avoid severe congestion within the station, particularly on platforms and escalators.	1.79	0	15.74
			- Reducing walking distances should be kept to a minimum.	1.38	1.38	
			- Paths should be clear and straightforward as feasible.	1.81	1.81	
			- A passenger's movement must be unhindered from the time he enters the Station until he leaves.	1.73	1.73	
			- Segregation of arriving and departing passengers.	1.39	0	
			- The separation between the people movement and vehicles	1.77	1.77	
			- Define separate areas for the movement of baggage	1.01	0	
			- Using technology will reduce time for people that have to wait in lines to buy tickets	1.39	0	
			- All platforms should be parallel and of the same length.	1.64	1.64	
			- The platform is divided into parts, the first of which is at the edge a warning area, then a movement area, followed by a waiting area, and there is a line separating the prohibited area from the waiting area	1.83	0	
		providing	- providing Waiting space to reduce passenger interference in the circulation area.	1.62	0	
			- Providing clear and consistent directional signage.	1.89	1.89	
			- Sufficient space for movement and waiting	1.80	1.80	
			- clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation. A sequence in motion (entry-tickets-waiting-departure)	1.64	1.64	

			- motility (elevators, escalators, moving walkways and assistive devices like wheelchairs for the physically disabled)	1.77	1.77	
			- Cycle tracks & cycle parking	0.51	0	
Environmental design requirements			- Using biophilic design to achieve a comfortable healthy environment inside the station	0.87	0	1.25
			- Using local, weather-resistant, and recyclable materials	0.89	0	
			- Rainwater collection and reuse	0.63	0	
			- Reducing the operating cost and saving energy	0.68	0	
			- Increasing green spaces inside and around the station	1.03	0	
			- Respecting the privacy of the site	1.23	0	
			- Good open spaces around the station/ plaza/ creating a fresh environment/pedestrian-friendly atmosphere	1.25	0	
			- Using glass which allows natural light	1.25	1.25	
			- Provide natural ventilation.	0.75	0	
			- In the public areas of the station, material finishes of elements should be highly durable, low maintenance, and require less frequent cleaning.	1.41	0	
Safety and security requirements		Be Safety and Secure by Design	- The Station design should promote security for the passenger.	1.91	1.91	15.73
			- Created with the least amount of potential for accidents and health risks. The following strategies are to be used, but are not restricted to them: - Appropriate and sufficient illumination - Slip-resistant surfaces for walking - Proper use of safety rails and guards.	1.86	1.86	
			- Stations ought to be built with safety and security in mind, independent of technology.	1.79	0	
			- Controlling entrances and exits	1.75	1.75	
			- The more accident-prone locations, like the platform and vertical circulation components, require special care.	1.73	0	
			- Using materials that are durable and resilient.	1.77	0	
			- Utilizing secure and thoughtful design to assess and mitigate the risk of hazards, whether they are caused by humans or nature.	1.52	0	
			- Protection of personal property	0.77	0	
			- Provide emergency requirements	1.57	1.57	
			- Providing a safe for users and protection from weather conditions.	1.52	1.52	
			- Provide guide signs.	1.99	1.99	
			- Alarm systems	2.01	2.01	
		Managem	- Provide maintenance requirements	1.75	1.75	
			- When elevator or escalator maintenance is required, consider providing alternative accessible paths either proactively or reactively.	1.70	0	
			- Enabling effective station upkeep and cleaning.	1.37	1.37	
Socio-		Socio	- Integrating station amenities with the surrounding open space.	1.02	0	6.39
			- The creation of a connected network of public areas, bike lanes, and platforms.	0.56	0	
			- Creating warm station settings that encourage people to travel, work, and shop.	0.82	0.82	

			-	Raising the standard of well-being (cultural, human behavior ...etc.)	0.79	0.79
			-	Awareness and education through information centers and screens	1.10	1.10
			-	Well-balanced and social justice	0.73	0
			-	Humanitarian needs (Availability of food- Availability of drinks- Safety and Security)	1.17	1.17
		Economi	-	Providing investment and rental spaces	1.26	1.26
			-	Take advantage of the site	1.25	1.25
			-	Reducing resource consumption	0.79	0
			-	Use of renewable resources	0.49	0

Source- Authors based on extant literature sources and experts' opinions.

According to specialized experts' opinions and their evaluation of the design guidelines, the Arts and Culture station's efficiency is 55.52%. This is broken down into 16.41% for functional requirements, 15.74% for circulation requirements, 1.25% for environmental design requirements, 15.73% for safety and security requirements, and 6.39% for social and economic requirements. Figure 5-19

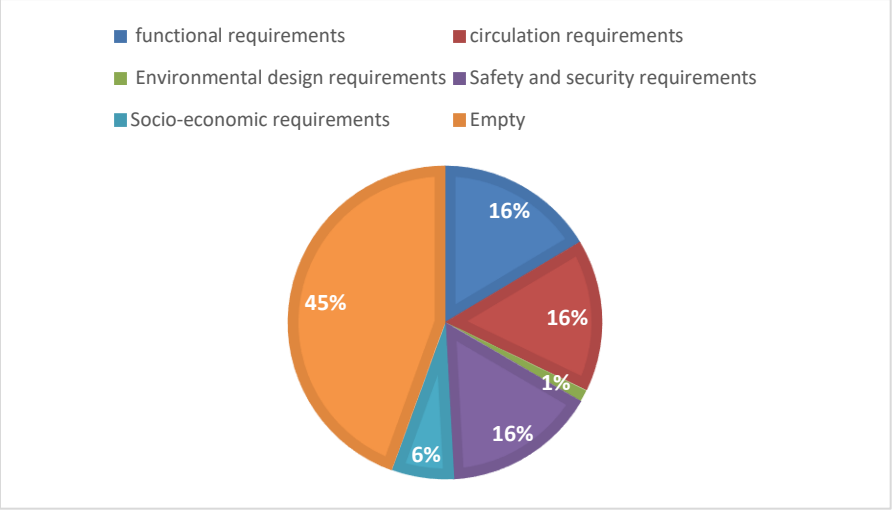


Figure 5-19: Efficiency of the Arts and culture station, **Source**: Authors.

5-4. Improving the Efficiency of the Egyptian Case Studies.

By studying and evaluating the Egyptian case studies and reaching the performance efficiency of each of them, the author proposes some requirements that help to raise the performance efficiency of these stations.

5-4.1. Adly Mansour Station

- **Functional Requirements**
  - The departure concourse and platforms should each have a shared ceiling with unobstructed broad-span structural systems.
  - Station interiors must include partition walls that allow for a flexible area.
  - Use a unified ticket.
  - Consider using analytical techniques or computer-aided modelling tools to confirm the movements and capacity of station users, especially at passenger decision points, queuing locations, and cross flows.
  - make it simpler for town/city maps, directions, and directional signs that adhere to third-party local wayfinding strategies to be presented about exterior facilities inside the station.
  - Design spaces, and platforms according to the number of passengers at peak hours
  - Considering the individual's share in the different spaces.
  - Each function should have its own space, which should be divided up according to the importance of each function. The most room must be dedicated to free circulation.

- **Circulation Requirements**
  - To avoid excessive crowding in the station, especially on platforms and escalators, the design of the station must allow for a free-flowing passenger.
  - Reducing walking distances should be kept to a minimum.
  - Define separate areas for the movement of baggage.
  - Using technology will reduce time for people that have to wait in lines to buy tickets
  - The platform is divided into parts, the first of which is at the edge a warning area, then a movement area, followed by a waiting area, and there is a line separating the prohibited area from the waiting area.
  - Cycle tracks & cycle parking

- **Environmental Design Requirements**
  - Using biophilic design to achieve a comfortable healthy environment inside the station.
  - Using local, weather-resistant, and recyclable materials.
  - Rainwater collection and reuse

- Reducing the operating cost and saving energy
- Respecting the privacy of the site.
- The material finishes of the station's structural elements should be extremely long-lasting, low-maintenance, and less frequently cleaned.

- **Safety and Security Requirements**
  - The station design should promote security for the passengers.
  - Created with the least amount of potential for accidents and health risks. The following strategies are to be used, but are not restricted to them:
    - Appropriate and sufficient illumination
    - Slip-resistant surfaces for walking
    - Proper use of safety rails and guards.
  - Stations ought to be built with safety and security in mind, independent of technology.
  - The more accident-prone locations, like the platform and vertical circulation components, require special care.
  - Using materials that are durable and resilient.
  - Utilizing secure and thoughtful design to assess and mitigate the risk of hazards, whether they are caused by humans or nature.
  - Protection of personal property
  - When elevator or escalator maintenance is required, consider providing alternative accessible paths either proactively or reactively.

- **Socio-Economic Requirements**

  - Well-balanced and social justice
  - Reducing resource consumption
  - Use of renewable resources

5-4.2. Badr Station

- **Functional Requirements**
  - The departure concourse and platforms should each have a shared ceiling with unobstructed broad-span structural systems.
  - Station interiors must include partition walls that allow for a flexible area.
  - Use a unified ticket .

- Consider using analytical techniques or computer-aided modelling tools to confirm the movements and capacity of station users, especially at passenger decision points, queuing locations, and cross flows.
- Make it simpler for town/city maps, directions, and directional signs that adhere to third-party local wayfinding strategies to be presented about exterior facilities inside the station.
- Functional integration according to social and environmental changes and providing service and commercial spaces.
- Integrating spatial layout, lighting, and surface finishes with other architectural elements can be made to be clear and easy to understand without the need for signage.
- Design spaces, and platforms according to the number of passengers at peak hours
- Considering the individual's share in the different spaces.
- Each function should have its own space, which should be divided up according to the importance of each function. The most room must be dedicated to free circulation.

- **Circulation Requirements**
  - The station's design must allow for a free-flowing passenger to avoid severe congestion within the station, particularly on platforms and escalators.
  - Segregation of arriving and departing passengers.
  - Define separate areas for the movement of baggage.
  - Using technology will reduce time for people that have to wait in lines to buy tickets.
  - The platform is divided into parts, the first of which is at the edge a warning area, then a movement area, followed by a waiting area, and there is a line separating the prohibited area from the waiting area.
  - Providing waiting space to reduce passenger interference in the circulation area.
  - Cycle tracks & cycle parking

- **Environmental Design Requirements**
  - Using biophilic design to achieve a comfortable healthy environment inside the station.

- Using local, weather-resistant, and recyclable materials.
- Rainwater collection and reuse
- Reducing the operating cost and saving energy
- Increasing green spaces inside and around the station
- Respecting the privacy of the site.
- Good open spaces around the station/ plaza/ creating a fresh environment/pedestrian-friendly atmosphere.
- Provide natural ventilation.
- The material finishes of the Station's structural elements should be extremely long-lasting, low-maintenance, and less frequently cleaned.

- **Safety and Security Requirements**
  - Stations ought to be built with safety and security in mind, independent of technology.
  - The more accident-prone locations, like the platform and vertical circulation components, require special care.
  - Using materials that are durable and resilient.
  - Utilizing secure and thoughtful design to assess and mitigate the risk of hazards, whether they are caused by humans or nature.
  - Protection of personal property
  - When elevator or escalator maintenance is required, consider providing alternative accessible paths either proactively or reactively.

- **Socio-Economic Requirements**
  - Integrating station amenities with the surrounding open space.
  - The creation of a connected network of public areas, bike lanes, and platforms.
  - Creating warm station settings that encourage people to travel, work, and shop.
  - Raising the standard of well-being (cultural, human behavior ...etc.)
  - Humanitarian needs (Availability of food- Availability of drinks- Safety and Security)
  - Providing investment and rental spaces
  - Well-balanced and social justice
  - Reducing resource consumption
  - Use of renewable resources

5-4.3. Arts and Culture Station

- **Functional Requirements**
  - The station’s entrance must provide clear and direct access to the local footpath system.
  - The departure concourse and platforms should each have a shared ceiling with unobstructed broad-span structural systems.
  - Station interiors must include partition walls that allow for a flexible area.
  - Use a unified ticket.
  - Consider using analytical techniques or computer-aided modelling tools to confirm the movements and capacity of station users, especially at passenger decision points, queuing locations, and cross flows.
  - Make it simpler for town/city maps, directions, and directional signs that adhere to third-party local wayfinding strategies to be presented about exterior facilities inside the station.
  - Their preservation and attractiveness in the surrounding area shall be reflected in the Station's design. The existing historic structures must not be isolated by the new station design.
  - Functional integration according to social and environmental changes and providing service and commercial spaces.
  - Integrating spatial layout, lighting, and surface finishes with other architectural elements can be made to be clear and easy to understand without the need for signage.
  - Design spaces, and platforms according to the number of passengers at peak hours
  - Considering the individual's share in the different spaces.
  - Each function should have its own space, which should be divided up according to the importance of each function. The most room must be dedicated to free circulation.

  - **Circulation Requirements**
  - The station's design must allow for a free-flowing passenger to avoid severe congestion within the station, particularly on platforms and escalators.
  - Segregation of arriving and departing passengers.
  - Define separate areas for the movement of baggage.

- Using technology reduces the amount of time people must wait in lines to buy tickets.
- The platform is divided into parts, the first of which is at the edge a warning area, then a movement area, followed by a waiting area, and there is a line separating the prohibited area from the waiting area.
- Providing waiting space to reduce passenger interference in the circulation area.
- Cycle tracks & cycle parking

- **Environmental Design Requirements**
  - Using biophilic design to achieve a comfortable healthy environment inside the station.
  - Using local, weather-resistant, and recyclable materials.
  - Rainwater collection and reuse
  - Reducing the operating cost and saving energy
  - Increasing green spaces inside and around the station
  - Respecting the privacy of the site.
  - Good open spaces around the station/ plaza/ creating a fresh environment/pedestrian-friendly atmosphere.
  - Provide natural ventilation.
  - The material finishes of the Station's structural elements should be extremely long-lasting, low-maintenance, and less frequently cleaned.

  - **Safety and Security Requirements**
    - Stations ought to be built with safety and security in mind, independent of technology.
    - The more accident-prone locations, like the platform and vertical circulation components, require special care.
    - Using materials that are durable and resilient.
    - Utilizing secure and thoughtful design to assess and mitigate the risk of hazards, whether they are caused by humans or nature.
    - Protection of personal property
    - When elevator or escalator maintenance is required, consider providing alternative accessible paths either proactively or reactively.

- **Socio-Economic Requirements**
  - Integrating station amenities with the surrounding open space.
  - The creation of a connected network of public areas, bike lanes, and platforms.
  - Well-balanced and social justice
  - Reducing resource consumption
  - Use of renewable resources

Summary of Part Two

Part two consists of an empirical study to deduce a guideline for the design aspects of multi-model hub stations .

In Chapter Four are the Egyptian case studies,

The result of this chapter is the design requirements used in Egyptian stations and existing problems through personal interviews with officials and stations analysis.

The requirements of Egyptian case studies are formed from main requirements; included (functional requirements, circulation requirements, security and safety requirements, environmental design requirements, and social and economic requirements)

- The separation of different modes of transportation in intermodal terminals, as well as the physical layout of the terminal, can significantly increase system efficiency. Information management, ticket distribution, and platform accessibility are all physical and operational actions at such terminals .
- At pedestrian circulation requirements, study the guidelines, Factors affecting pedestrian circulation, and determine the (Rate per capita - Density - delay) of pedestrian circulation requirements.
- At environmental design requirements study sustainable design, saving energy, and providing natural light and ventilation.
- At the safety and security requirements by providing maintenance requirements and emergency requirements and safety for users and protection from weather conditions and guide signs and Protection of personal property.
- At socio and economic requirements small businesses that serve users, such as convenience stores, branch banks, automated teller machines (ATMs), coffee shops and snack restaurants, newspaper, and magazine sellers, can be accommodated in retail concessions in stations by providing a process of resolving conflicting social equity.

Chapter Five are (Assessing & Proposed improvements & Conclusion),

The result of this chapter is to deduce a guideline for the design aspects of multi model hub stations, assessing the Egyptian case studies, and proposed improvements.

CONCLUSIONS, RECOMMENDATIONS

Conclusions

At this section, the research's findings are summarized, and the extent to which they met the study's goals and objectives is examined. The study then discusses the importance of the research by demonstrating how the conclusions help determine the standards for a multi-modal hub station in Egypt and suggest improvements for the local stations. The study clarifies what has been realized and what is still impossible. The reflection on the methods used in this research to carry out the various design and development process steps follows.

Reflections on the Research

In order to draw a conclusion from the study, it is important to revisit the primary goals and research questions and examine the degree to which the study was successful in meeting those goals. In the introduction, the study questions, and methodology are laid out. The study findings in this section will be presented in reverse chronological order, with the key research objectives being discussed first, followed by how well they address the research questions.

What are the requirements that must be considered when designing public transportation stations?

The question is fulfilled in part one at chapter (1). The chapter consists of requirements that were drawn from a Literature review of multi-modal hub stations. These requirements included (functional requirements, circulation requirements, safety and security requirements, environmental design requirements, and social and economic requirements).

What are the most and least design requirements in literature review study?

The question is fulfilled in part one at chapter (1). The results of previous studies showed that there is a discrepancy in achieving design requirements, as (functional requirements) were the most fulfilled criterion out of all the others, followed by the (circulation requirements), followed by (environmental design requirements) and then (safety and security requirements), while each of (social and economic requirements) achieved the least of design requirements.

What are the guidelines for social and economic requirements?

The question is fulfilled in part one at chapter (1). The results of previous studies of socio-economic requirements in multi-modal hub stations indicated the main elements that should be taken into consideration when designing the stations, which are:

- Achieve environmental design requirements (take advantage of the site- reduce resource consumption- use renewable resources- use local materials and recyclables- rainwater collection and reuse- reduce the operating cost and save energy- increase green spaces inside and around the station…. etc.).
- Achieve safety and security requirements (promote security for the passenger- minimize the possibility of accidents- safe and secure without depending on technology- slip-resistant walking surfaces -provide emergency requirements…. etc.).
- Increase investments by providing service and commercial spaces.
- Achieve awareness and education of people.
- Achieve social justice.
- Raising the standard of well-being (cultural, human behavior ...etc.)
- Providing the people with multiple choices.

What is the concept of multi-modal hub stations, and what are their components?

The first part of this question is fulfilled in part one chapter (2). A multi-modal transportation system can be described as a system that combines more than one mode of transportation in one place, it also allows passengers to go from one point to another using several modes based on time, cost, weather, and desired level of comfort.

The second part of this question is fulfilled in part one chapter (2). Transportation stations, such as train stations, bus stations, and metro, are key nodes in transportation networks that facilitate the movement of people and goods. While the specific components may vary depending on the type and scale of the station, some common elements found in transportation stations:

- Platforms: Designated areas where passengers can board and alight from vehicles, such as trains, buses, or the metro.

- Ticketing and Information Counters: Centralized areas where passengers can purchase tickets, obtain travel information, and seek assistance from station staff. This includes ticket booths, self-service kiosks, or electronic ticketing systems.
- Waiting Areas: Spaces equipped with seating arrangements for passengers to wait for their respective modes of transportation. These areas may include benches, chairs, or lounges.
- Signage and Wayfinding: Clear and visible signage throughout the station, including directional signs, maps, and information boards that guide passengers to their desired destinations within the station.
- Retail and Commercial Spaces: Shops, cafes, restaurants, and other commercial establishments within the station premises, providing convenience and services to passengers.
- Security Checkpoints: Areas where passengers and their belongings are screened for security purposes, including metal detectors, X-ray scanners, and security personnel.
- Waiting Rooms or Lounges: Exclusive areas within the station, often available for premium or first-class passengers, offering additional amenities such as comfortable seating, Wi-Fi access, charging stations, and refreshments.
- Restrooms: Facilities equipped with toilets, sinks, and other amenities to meet the sanitary needs of passengers.
- Parking Facilities: Dedicated areas for parking private vehicles, including car parks or parking garages, often located near the station for the convenience of commuters.
- Passenger Information Systems: Digital displays, information kiosks, or interactive screens displaying real-time travel information, schedules, maps, and other relevant updates.
- Safety and Security Measures: Adequate lighting, surveillance cameras, emergency response systems, and other security measures to ensure the safety of passengers and their belongings.

These components collectively create a functional and user-friendly transportation station that enhances the travel experience, promotes efficient operations, and accommodates the needs of a diverse range of passengers.

What are the most international case studies of multi-modal stations and what is the selection criteria?

The question is fulfilled in part one at chapter (3). chapter three will consist of three sections of three successful international case studies (India -Germany -British) that were selected to identify the design requirements. The selection was according to several criteria; Indian public transport stations are the main mode of transport and the fourth largest and busiest transport network in the world, while the public transport network in Germany is among the best and most efficient in Europe, it is made up of several modes of transport, and best public buses and trains. The history and success of the first railways in the world in the British experience, as Britain has approximately 15,754 kilometers of railway tracks and more than 2,500 stations distributed along with the network.

What are the main design requirements considered in the international case studies?

The question is fulfilled in part one at chapter (3). The chapter consists of five main requirements of multi-modal hub stations. These requirements included (functional requirements, circulation requirements, safety and security requirements, environmental design requirements, and social and economic requirements).

What are the Egyptian case studies of multi-modal stations and what is the selection criteria?

For the first part of this question is fulfilled in part two at chapter (4). This chapter will include (Adly Mansour Transport Center hub – Badr station - Arts and culture station) overview and the analysis of all aspects related to the design requirements,

For the second part of this question is fulfilled in part two chapter (4). The study selected the new multi-modal hub stations which, can be content more than one mode of transportation in one place.

What are the main design requirements considered in the Egyptian case studies?

The question is fulfilled in part two at chapter (4). The chapter consists of five main requirements of multi-modal hub stations. These requirements included (functional requirements, circulation requirements, safety and security requirements, environmental design requirements, and social and economic requirements).

What are the expected results of the study and how were they achieved and evaluated?

The question is fulfilled in part two at chapter (5). The final objective of this chapter is to deduce and conclude the final version of guidelines after being validated and analytically tested According to expert opinions and giving weight to each main and secondary requirement of the guidelines and assess and Propose improvements for the Egyptian case studies in Egypt.

What is the expected efficiency of Egyptian stations (Egyptian case studies)?

The question is fulfilled in part two at chapter (5). According to the opinions of specialized experts and their evaluation of the framework and the measurement of the efficiency of the Adly Mansour station on this evaluating guideline, the efficiency of the Adly Mansour station is 62.38%, Badr station is 53.7%, while Arts and culture station 55.52%

What is the scientific addition?

The scientific addition aimed to offer comprehensive guidelines for architectural design within the public transportation system, focusing on evaluating and proposing design guidelines for current multimodal stations (Adly Mansour Station, Badr Station, and the Arts and Culture Station in the New Administrative Capital). The goal is to enhance the design, quality, and efficiency of the current stations, as well as to provide a comfortable and safe environment for passengers. The study covers various design requirements for the architectural aspects of the public transportation system, including functional, pedestrian movement, security, safety, environmental, social, and economic requirements. It also presents a detailed evaluation of the current multimedia stations, including a comprehensive analysis, identification of strengths and weaknesses, and proposing appropriate design guidelines to improve the mentioned stations.

RECOMMENDATIONS

- Apply the design guidelines that the study suggests when considering public transportation stations in the new Egyptian stations. The key points of attention are.
    - Functional requirements.
    - Circulation requirements
    - Environmental design requirements

    - Safety and security requirements
    - Socio-economic requirements
- Apply the design guidelines that the study suggests for developing and raising the efficiency of Egyptian stations.
- When designing new public transportation stations in Egypt, it's essential to consider factors such as the local context, climate, cultural considerations, and the needs of the community. Here are some design recommendations to consider:
    - **Accessibility**: Make sure that those with impairments, the elderly, and others with restricted mobility can readily access the stations. To make moving around easier, install ramps, lifts and tactile paving. Create spacious platforms and exits/entrances to handle high passenger volumes.
    - **Integration:** Create a plan for smooth integration with the current transportation infrastructure, including bus stops, metro lines, and tram systems. Establish clear navigation and signs to direct travelers between various types of transportation.
    - **Climate-responsive design:** Because of Egypt's hot, dry climate, it is essential to include climate-responsive design elements. Provide passengers with covered spaces, canopies, or awnings to shield them from the sun. Think about utilizing passive cooling methods or cross-ventilation as natural ventilation and cooling alternatives.
    - **Energy efficiency:** Use energy-saving solutions, such as solar power, rainwater collection systems, and LED lighting. These actions can encourage sustainability and lessen the stations' negative effects on the environment.
    - **Security and safety:** Put a priority on the safety of the passengers by including well-lit spaces, security cameras, emergency call points, and clear visibility throughout the station. Create a layout to eliminate blind spots and make sure security officers are present, especially during busy hours.
    - **Comfortable waiting areas:** Give them access to amenities like drinking water fountains, vending machines, and restrooms as well as comfortable sitting and shade. When planning seating arrangements, consider the local population's cultural conventions and preferences.
    - **Passenger flow and capacity:** Analyze anticipated passenger flows and plan the stations' capacity to meet peak-hour demands. Make sure there is enough room for the ticketing, waiting, and line-up areas. Create platforms that provide easy boarding and disembarking.

- **Aesthetics and cultural context:** The design of the stations should reflect the regional culture, heritage, and architectural design. Think of utilizing regional fabrics, hues, and designs that are popular with the neighborhood. Incorporate cultural or public art components to raise the aesthetic appeal overall.
- **Sustainability and green spaces:** Create green areas, landscaping, and plants near the stations to enhance the surrounding area's visual appeal and air quality. Add bike racks and advocate riding as a different form of transportation.
- **Community engagement:** Include the neighborhood's residents in the design process to get their opinions, fix any issues, and make sure the stations are functional for them. Hold workshops and consultations with the general population to get feedback and instill a sense of ownership among the locals.

To construct transportation stations that are uniquely tailored to the needs of the Egyptian setting, it is necessary to collaborate with local stakeholders, transportation officials, and design experts. Keep in mind that these proposals should only be used as a starting point.

- Transport hubs are becoming smarter and more effective thanks to the Internet of Things (IoT). Transport hubs may improve the passenger experience, boost operational effectiveness, and boost safety and security by integrating IoT technologies. Several important IoT uses for train stations are listed below:
    - **Passenger Information Systems**: IoT makes it possible for passengers to receive real-time information. Up-to-date information on train/bus timetables, delays, platform changes, and anticipated arrival times can be found through interactive displays, digital signage, and mobile applications. IoT sensors can track passenger flow and provide information to improve crowd control.
    - **Smart Ticketing and Fare Management**: IoT makes contactless ticketing systems possible by utilizing wearable tech, smartphone apps, and smart cards. These devices can speed up transactions, reduce wait times, and enhance the ticketing process with the aid of Near Field Communication (NFC) or Bluetooth Low Energy (BLE) technology.
    - **Security and Surveillance**: IoT-based security technologies improve security and safety at transit hubs. IoT sensors and analytics enable video surveillance cameras to track crowd density, look for suspicious activity, and detect potential threats. Systems for managing entry and exit points that are IoT-enabled can guarantee authorized staff access while preventing unauthorized entry.

- **Energy Management**: IoT can reduce how much energy is used in transit hubs. Motion sensor-equipped smart lighting systems may alter lighting levels based on occupancy automatically, saving energy. IoT sensors can monitor and manage HVAC (heating, ventilation, and air conditioning) systems in real-time based on occupancy and ambient data, which can reduce energy use.
- **Facility Maintenance**: IoT sensors can keep an eye on the health of vital infrastructure elements like electrical systems, lifts and escalators. Maintenance personnel may prevent problems, reduce failures, and boost operational effectiveness by gathering real-time data on performance and spotting anomalies.
- **Predictive Analytics and Asset Tracking**: Internet of Things (IoT) devices are able to track and monitor transportation assets, including luggage, trains, and buses. To increase asset utilization, predict breakdowns, and optimize maintenance schedules, real-time data on asset location, condition, and performance can be analyzed.
- **Passenger Safety and Assistance**: Rapid identification and response of urgent situations is a capability of IoT-enabled emergency response systems. The detection of dangers, accidents, or security issues by panic buttons, emergency call stations, and IoT sensors can result in the required alerts and the provision of real-time assistance to passengers in need.

Overall, IoT integration in transit hubs fosters a safer and more secure environment, increases operational efficiency, improves passenger experience, and allows for data-driven decision-making.

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Appendix: Field Survey Study

- Egyptian case studies component
- Survey weight of the framework

Appendix 1

Egyptian Case Studies Component

- Adly Mansour Station Component

- LRT Station

The LRT is a contemporary version of the tram that is quicker, lighter, and more environmentally friendly because it uses electricity rather than gasoline. Even though they are both above ground, the monorail takes a separate path, connecting Greater Cairo, the New Administrative Capital, and the 6th of October City via mass transit.

The LRT can accommodate up to 500,000 passengers per day, with 30,000 passengers per hour in each direction. The trip duration from Adly Mansour, the starting point of the LRT, to the New Administrative Capital station, the final point, will not exceed 45 minutes. Each train carriage can carry 300 passengers, with a total capacity of 1,300 passengers.

The LRT station consists of two floors, the ground floor includes entrance, platforms, ticket offices, and services Figure 0-1, while the first floor includes a waiting hall for arrivals and Transfers to the metro station. Figure 0-2

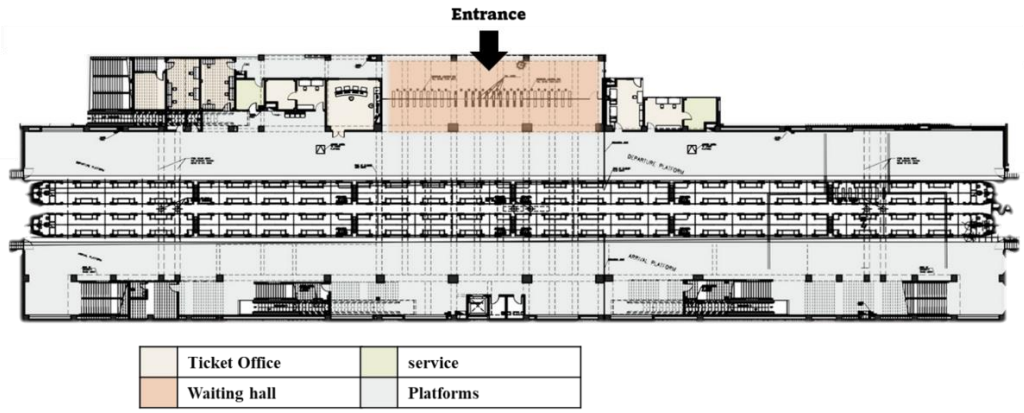

Figure 0-1: Ground floor of LRT station in Adly Mansour station**, Source:** National Authority for Tunnels.(Tunnels, 2022)

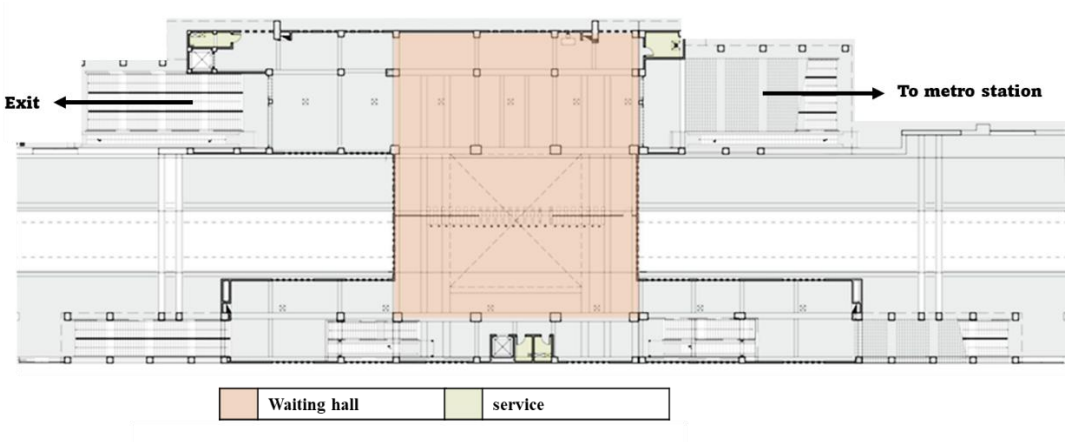

Figure 0-2: Ground floor of LRT station in Adly Mansour station**, Source:** National Authority for Tunnels.(Tunnels, 2022).

- Metro Station

The metro is Line 3 phase 4B runs along the middle of Gesr El Suez Street, beginning at Nozha station up to Adly Mansour Station with a ramp to a depot area. The extension will serve as a key section of Line 3, which is estimated to carry around 1.5 mn passengers a day. It will also alleviate traffic congestion in East Cairo, providing commuters with a faster transportation alternative.

The station consists of two floors, the ground floor includes ticket offices, waiting hall, and services**,** Figure 0-3. The first floor includes platforms, administrative and services. Figure 0-4 . while mezzanine floor includes a waiting hall for arrivals and Transfers to the LRT station. Figure 0-5

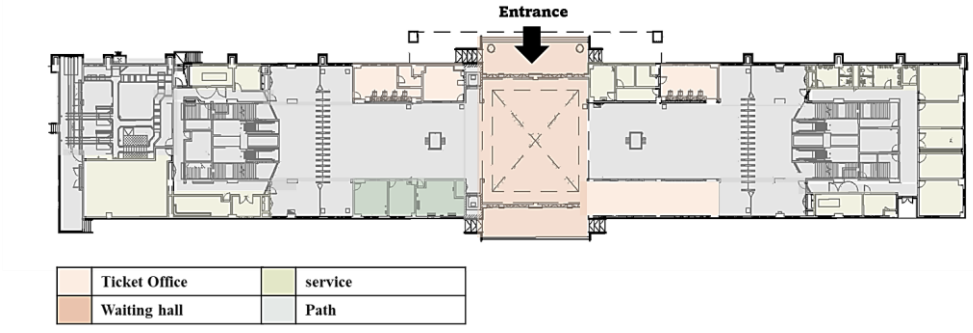

Figure 0-3: Ground floor of metro station in Adly Mansour station**, Source:** National Authority for Tunnels.(Tunnels, 2022).

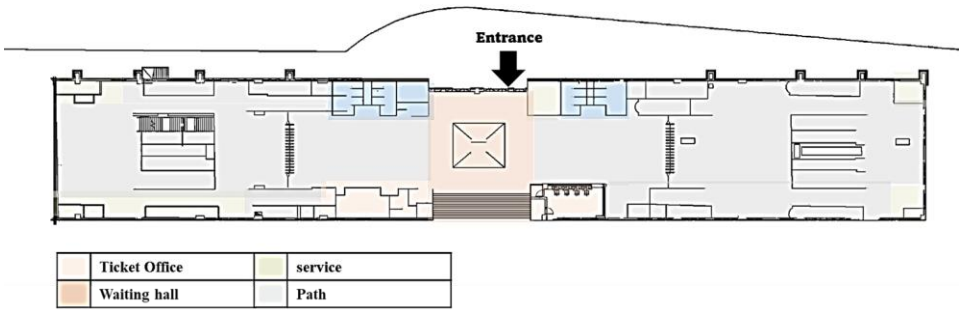

Figure 0-4: first floor of metro station in Adly Mansour station**, Source:** National Authority for Tunnels.(Tunnels, 2022).

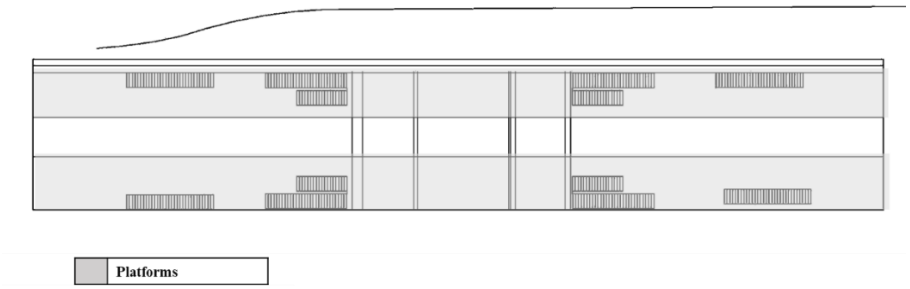

Figure 0-5: second floor of metro station in Adly Mansour station**, Source:** National Authority for Tunnels.(Tunnels, 2022).

- ## Train Station

The railway station from Cairo to Suez, the station consists of two floors, the ground floor includes platforms, ticket offices, administrative and technical offices, an information center, shops, and services, Figure 0-6. The first floor includes a waiting hall for arrivals and departures and shops. Figure 0-7. While the mezzanine floor administrative and technical offices, and services. Figure 0-8

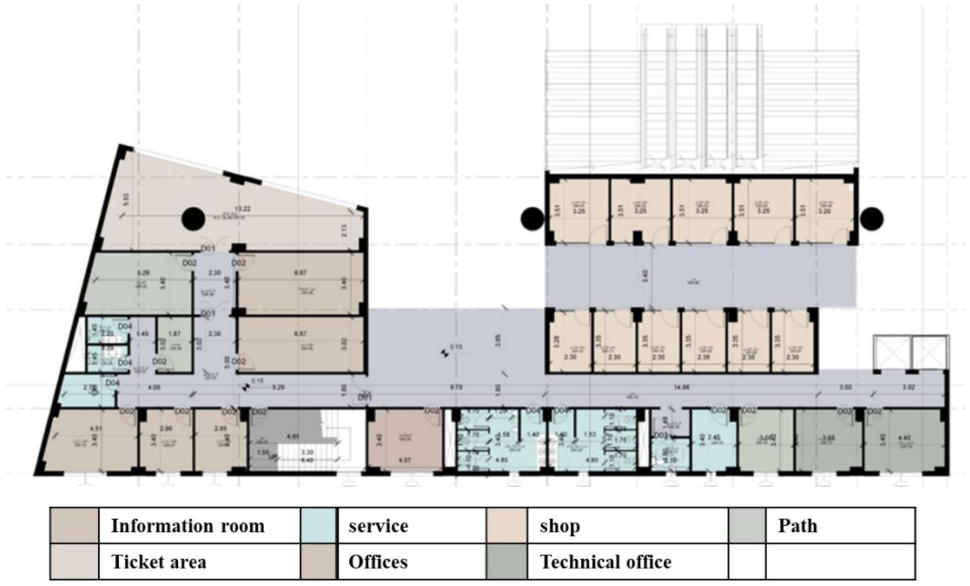

Figure 0-6: Ground floor of train station in Adly Mansour station**, Source:** National Authority for Tunnels.(Tunnels, 2022).

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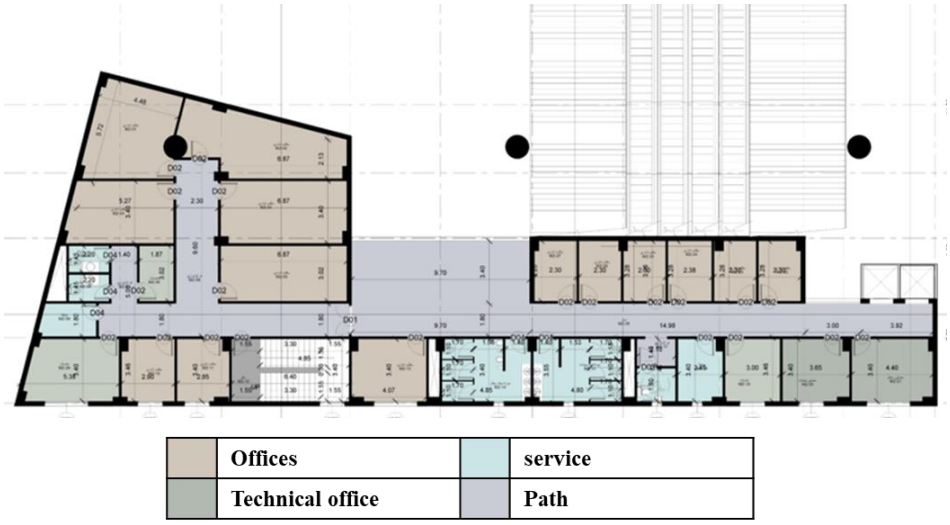

Figure 0-7: mezzanine floor of train station in Adly Mansour station**, Source:** National Authority for Tunnels.(Tunnels, 2022).

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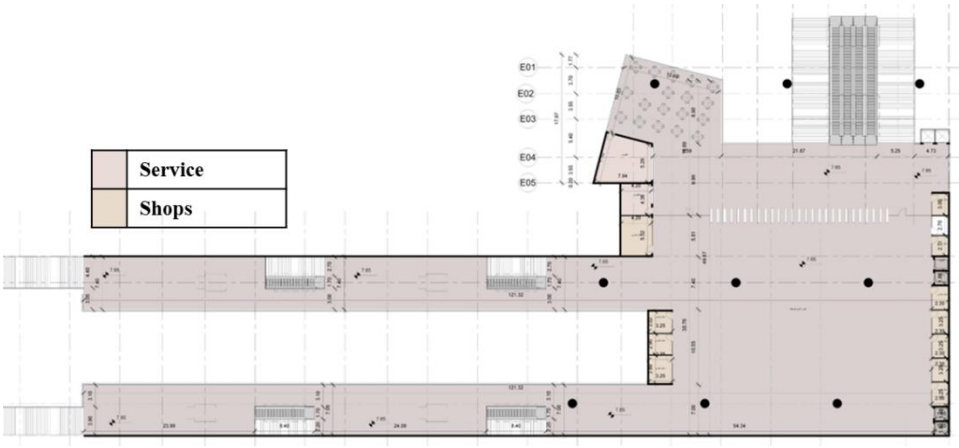

Figure 0-8: Ground floor of train station in Adly Mansour station**, Source:** National Authority for Tunnels.(Tunnels, 2022)..

- Superjet Station

The Superjet stations consists of two floors, the ground floor includes ticket offices, and services, Figure 0-9. The first floor includes administrative and services. Figure 0-10.

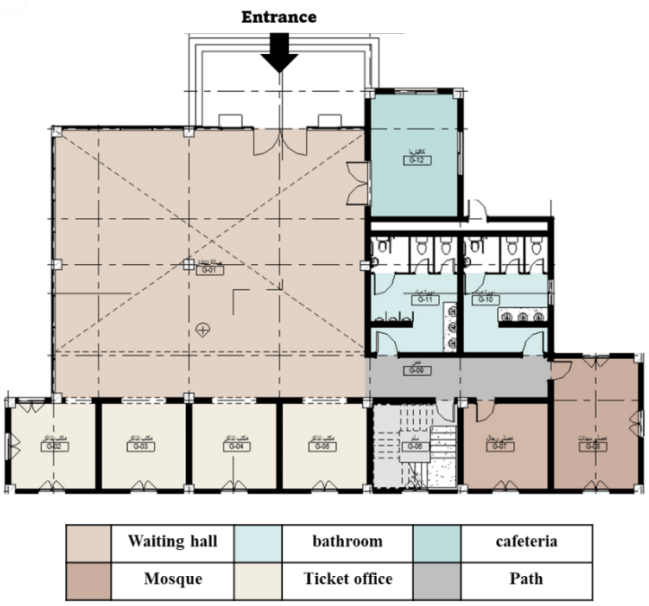

Figure 0-9: Ground floor of train station in Adly Mansour station**, Source:** National Authority for Tunnels.(Tunnels, 2022).

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Figure 0-10: Ground floor of train station in Adly Mansour station**, Source:** National Authority for Tunnels.(Tunnels, 2022).

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- **Mall**

The station also houses a commercial mall to serve the station and the surrounding area on an area of 6.5 feddans, including a basement (parking area) with a capacity of 600 cars and 2 commercial floors. Figure 0-11 Figure 0-12 Figure 0-13 Figure 0-14

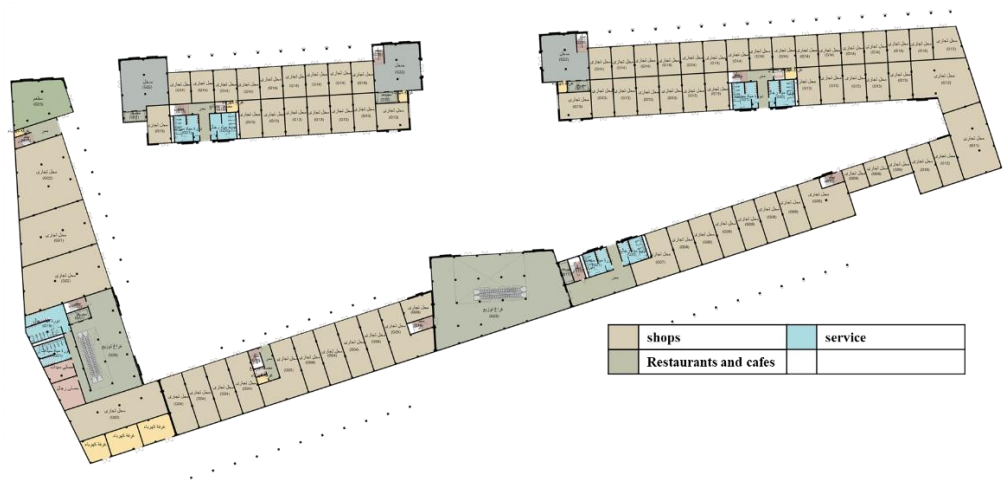

Figure 0-11: Ground floor of mall in Adly Mansour station**, Source:** National Authority for Tunnels.(Tunnels, 2022).

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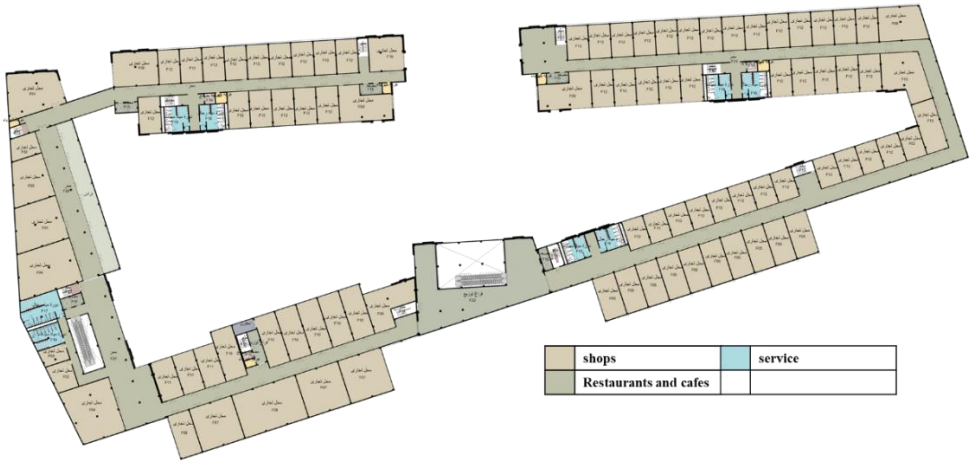

Figure 0-12: first floor of mall in Adly Mansour station**, Source:** National Authority for Tunnels.(Tunnels, 2022).

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Figure 0-13: basemen 1 mall in Adly Mansour station**, Source:** National Authority for Tunnels.(Tunnels, 2022).

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Figure 0-14: Basemen 2 in Adly Mansour station**, Source:** National Authority for Tunnels.(Tunnels, 2022).

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- ## Badr Station Component

- ### LRT stations

The LRT station to be operated extend from Adly Mansour to 10th of Ramadan City, which are: Adly Mansour Station – El Obour Station – Mostakbal – El Shorouk – New Heliopolis – Badr – Industrial Zone – Knowledge City.

The LRT is designed to accommodate 340,000 passengers daily and contribute in reducing traffic on the Cairo-Ismailia highway by about 30 percent.

The LRT station consists of two floors, the ground floor includes entrance, platforms, ticket offices, and services Figure 015- , while the first floor includes a waiting hall for arrivals and Transfers to the metro station. Figure 0-16.

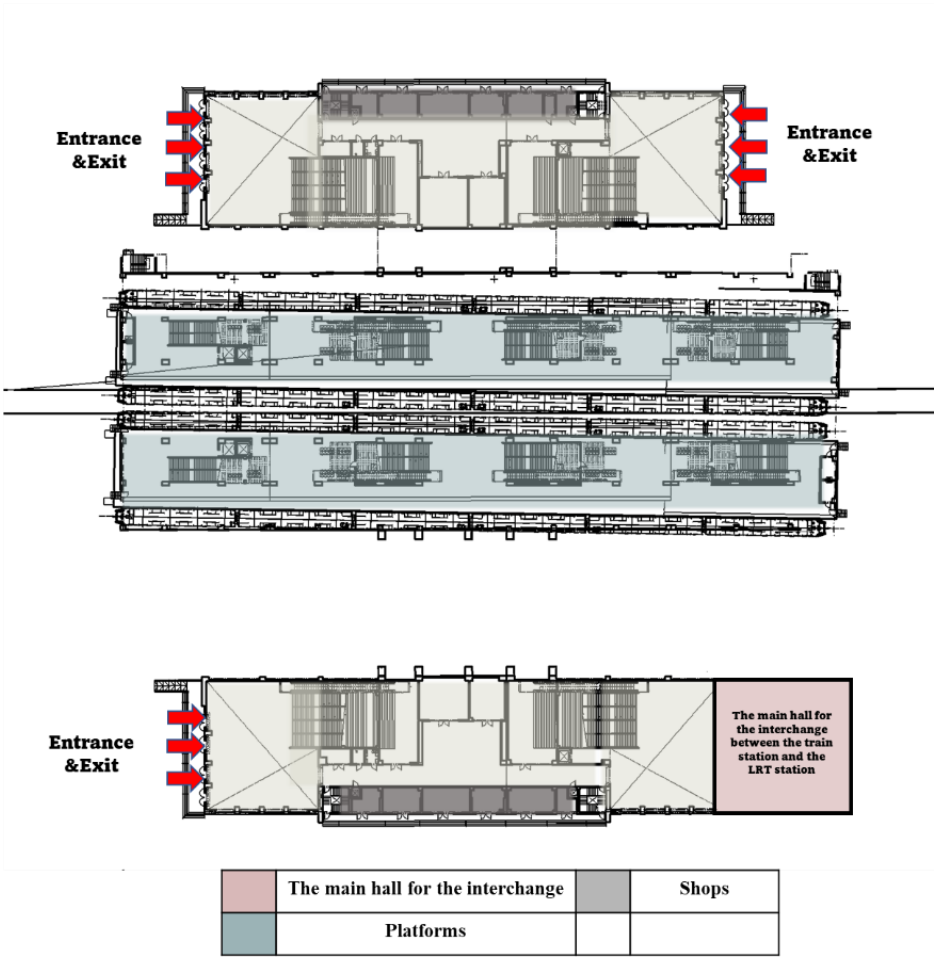

Figure 015- : Ground floor of LRT station in Adly Mansour station**, Source:** National Authority for Tunnels.(Tunnels, 2022).

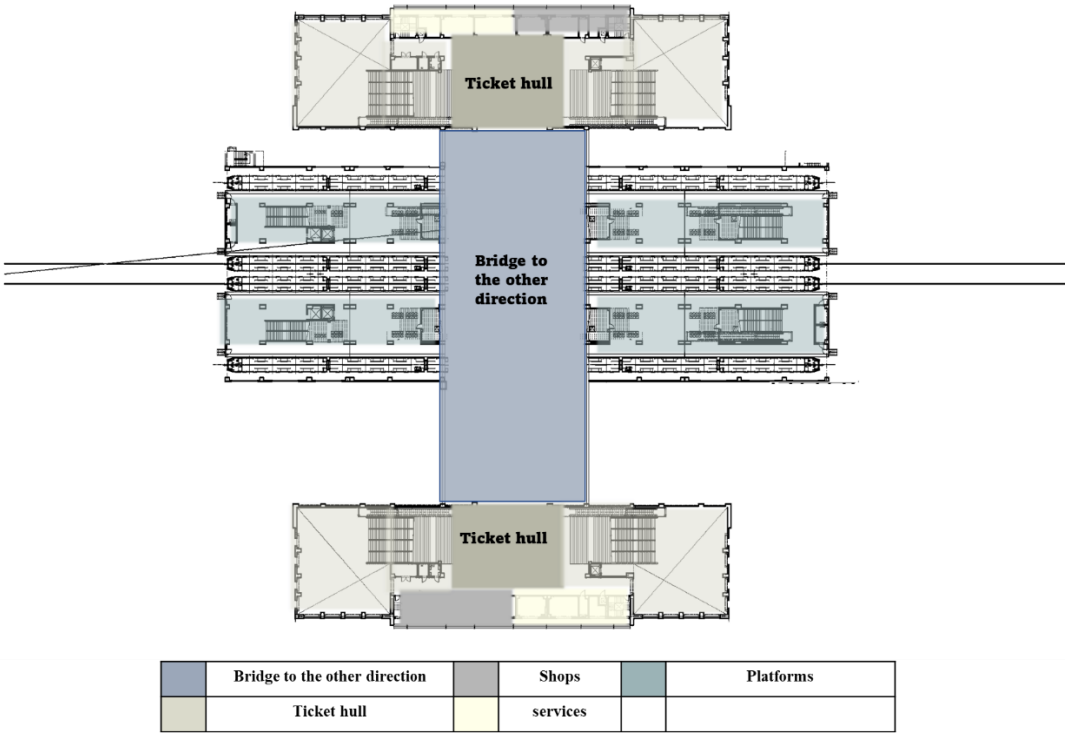

Figure 0-16 ;Ground floor of LRT station in Adly Mansour station**, Source:** National Authority for Tunnels.(Tunnels, 2022).

- **Train Station**

The railway station from Cairo to Suez consists of two floors, the ground floor includes platforms, ticket offices, administrative and technical offices, an information center, shops, and services. Figure 0-17 The first floor includes a waiting hall for arrivals and departures and shops. While the mezzanine floor administrative and technical offices, and services. Figure 0-18

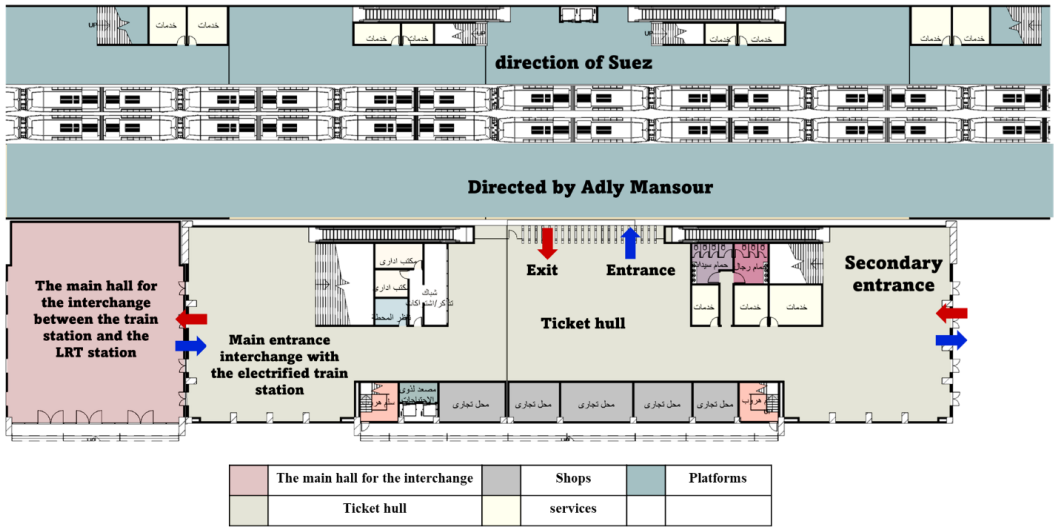

Figure 0-17 : Ground floor of train station in Badr station**, Source:** National Authority for Tunnels.(Tunnels, 2022).

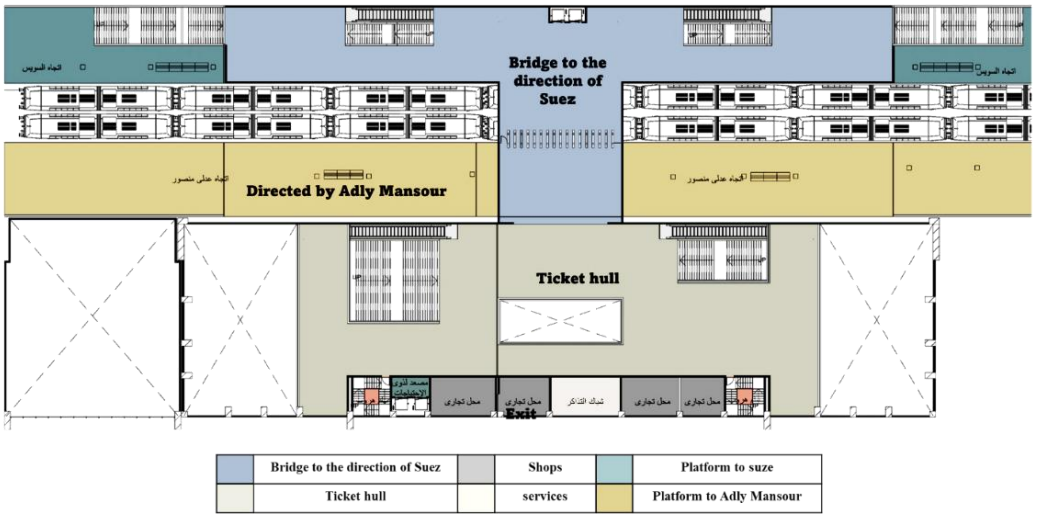

Figure 0-18 : mezzanine floor of train station in Badr station**, Source:** National Authority for Tunnels.(Tunnels, 2022).

- Arts and Culture Station Component

- LRT Station

The first stage of the LRT comprises 12 stations, including Adly Mansour, Badr City, the Culture and Arts City in the NAC, and New Obour.

The LRT can accommodate up to 500,000 passengers per day, with 30,000 passengers per hour in each direction. The trip duration from Adly Mansour, the starting point of the LRT, to the New Administrative Capital station, the final point, will not exceed 45 minutes. Each train carriage can carry 300 passengers, with a total capacity of 1,300 passengers .

Upon the completion of the three phases of the LRT, the service will cover a distance of 103.3 kilometers with the ability to accommodate up to one million commuters daily through 19 stations connecting several districts nationwide.

The LRT station at Arts and culture station at the new administrative capital consists of three floors, the ground floor includes shopping areas, restaurants, a Mall axis, and services. **Figure 0-19**, while the first floor includes a waiting hall for Arriving and departing, a Waiting area, Ticket Hall, and administrative offices. Figure 0-20. while the second floor includes Platforms and services. Figure 0-21

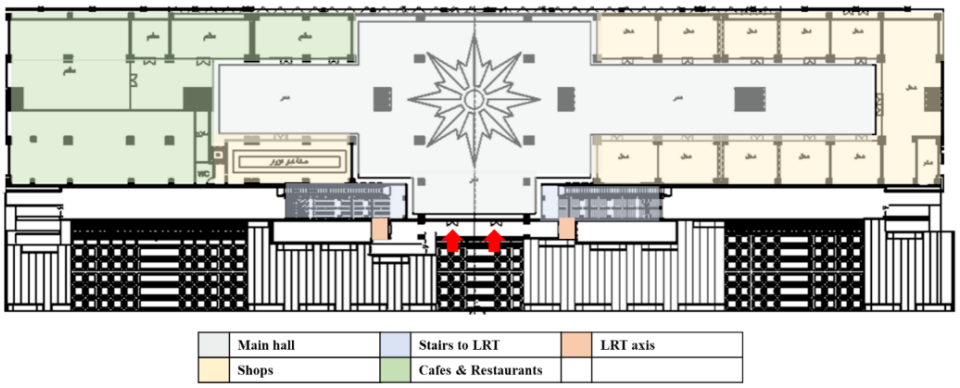

Figure 0-19 : ground floor of LRT station at Arts and culture station at the new administrative capital, **Source:** National Authority for Tunnels.(Tunnels, 2022).

Figure 0-20 : the first floor of LRT station at Arts and culture station at the new administrative capital, **Source:** National Authority for Tunnels.(Tunnels, 2022).

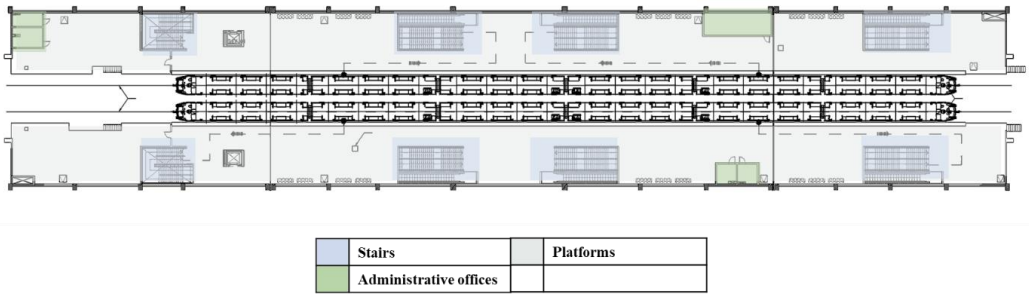

Figure 0-21: the second floor of the LRT station at Arts and Culture station at the new administrative capital, **Source:** National Authority for Tunnels.(Tunnels, 2022).

- ## Monorail station

The Monorail station from Adly Mansour station to the Arts and Culture station at the new administrative capital consists of three floors, the ground floor includes shopping areas, restaurants, a Mall axis, and services, while the first floor includes a waiting hall for arrivals and departures, ticket offices, administrative and technical offices, an information center, and services, Figure 0-22. The second floor includes platforms. Figure 0-23

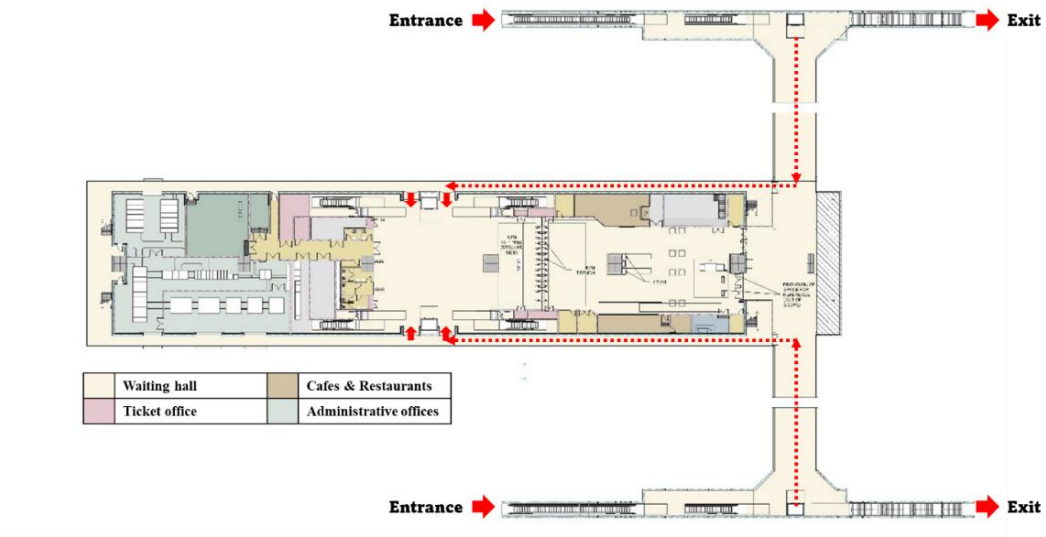

Figure 0-22 : the first floor of LRT station at Arts and Culture station at the new administrative capital, **Source:** National Authority for Tunnels.(Tunnels, 2022).

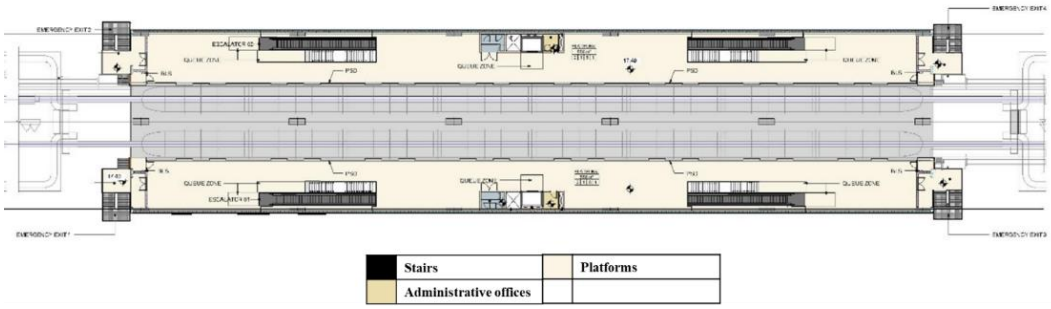

Figure 0-23 : the second floor of the Monorail station at Arts and Culture station at the new administrative capital, **Source:** National Authority for Tunnels.(Tunnels, 2022).

- ## Mall

The mall in the Arts and Culture station at the new administrative capital consists of two floors, the ground floor includes shopping areas, restaurants, a LRT axis, and services, while the first floor includes a shopping areas, restaurants, a monorail axis, and services. Figure 0-24 , Figure 0-25

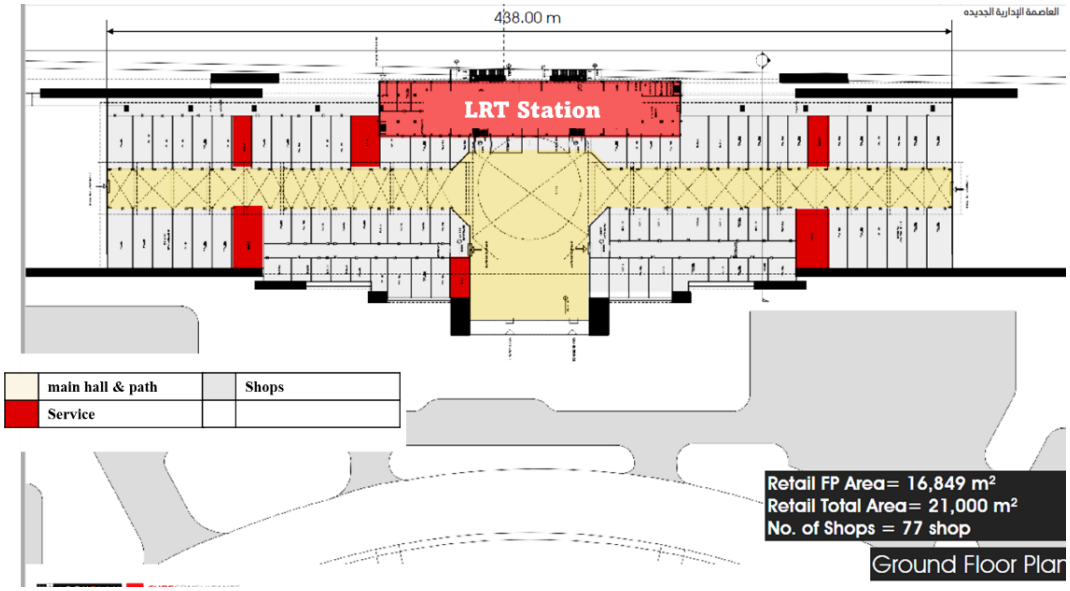

Figure 0-24 : Ground floor of the mall at Arts and Culture station at the new administrative capital, **Source:** National Authority for Tunnels.(Tunnels, 2022).

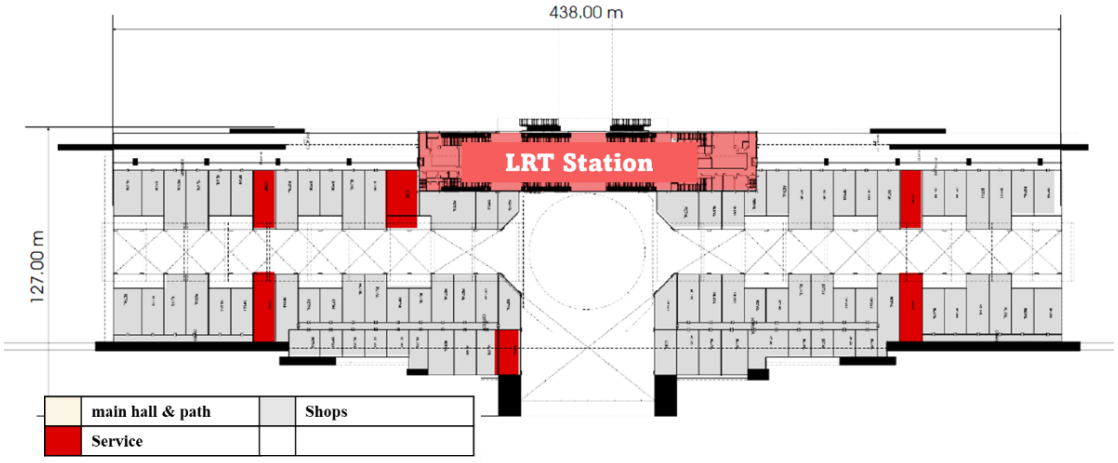

Figure 0-25 : first floor of the mall at Arts and Culture station at the new administrative capital, **Source:** National Authority for Tunnels.(Tunnels, 2022).

Appendix 2 --- Survey weight of the framework

requirements	point		Secondary requirements	Researchers										Percentage%	Wight
				1	2	3	4	5	6	7	8	9	10		
functional requirements	30	Quality	- Connecting different types of transportation in one place	80	90	80	80	90	95	90	90	90	90	87.5	1.28
			- Optimal use of areas	60	60	80	90	90	70	80	80	70	60	74	1.08
			- Provide special spaces for operators.	80	80	80	60	100	80	80	90	70	80	80	1.17
			- Station entrances provide a connection between the station and the surrounding streets, ensuring that all passengers have easy access to the entrances.	70	85	80	80	100	90	90	100	80	80	85.5	1.25
			- The station entry must provide clear and direct access to the local footpath system.	80	90	100	90	100	100	80	100	90	90	92	1.34
			- The departure concourse and platforms should each have a shared ceiling with unobstructed broad-span structural systems.	80	80	100	50	80	100	70	70	50	80	76	1.11
			- Station interiors must include partition walls that allow for a flexible area.	70	85	70	50	90	50	80	90	90	90	76.5	1.12
			- Provide usability requirements.	60	80	80	60	70	90	70	100	80	80	77	1.12
			- Use a unified ticket.	60	85	40	40	50	50	70	100	10	95	60	0.88
			- The use of electronic tickets to reduce the need for ticket halls.	60	90	60	50	60	100	90	100	80	85	77.5	1.13
			- Consider using analytical techniques or computer-aided modelling tools to confirm the movements and capacity of station users, especially at passenger decision points, queuing locations, and cross flows.	60	70	70	80	60	85	80	90	20	70	68.5	0.99
			- Make it simpler for town/city maps, directions, and directional signs that adhere to third-party local wayfinding strategies to be presented about exterior facilities inside the station.	80	90	80	70	80	95	80	100	90	80	84.5	1.23

			- Considering people with special needs, and Information for users who are blind or visually impaired is provided using near-field, mobile, and loop technologies.	90	70	80	80	100	70	70	100	60	70	79	1.15
			- Sufficient parking all around the station.	50	90	100	70	70	90	70	80	20	30	67	0.98
			- System integration (structure, space, materials, lighting, communications, and mechanical)	80	95	90	90	80	90	80	90	90	70	85.5	1.25
			- Maintain visual/aesthetic continuity with the rest of the system while incorporating site-specific aspects. (Physical, visual interconnection, and Aesthetic form)	80	80	90	90	80	70	80	80	90	85	82.5	1.20
			- Their design should reflect the preservation and beauty of the surrounding area. The new station design must not isolate the existing historic structures.	90	65	70	100	90	90	60	100	85	65	81.5	1.19
		Zoning	- Functional integration according to social and environmental changes, and providing service and commercial spaces	60	85	90	60	70	70	60	80	90	90	75.5	1.10
			- Providing waiting areas and restrooms inside the main halls and ticket halls and places for decision-making and providing services for them	80	90	100	50	80	80	70	70	70	85	77.5	1.13
			- Concourses for arrival and departure ought to be placed strategically below and/or above the platforms.	80	90	90	90	90	100	70	100	90	80	88	1.28
			- Place information, TVs, and ticket booths in locations that do not obstruct other people's access to the space or interfere with important station functions.	70	80	85	70	80	100	90	100	90	90	85.5	1.25
			- integrating spatial layout, lighting, and surface finishes with other architectural components can be made to be straightforward and legible with no need for signage.	70	90	95	30	70	60	70	90	80	80	73.5	1.07
		Area	- Design spaces, and platforms according to the number of passengers at peak hours	80	90	95	90	90	80	70	90	80	70	83.5	1.22
			- Determine expected number of demands for both travelers and non-travelers.	60	90	95	80	80	90	80	80	60	70	78.5	1.14
			- Considering the individual's share in the different spaces.	90	90	85	70	90	90	70	90	70	70	81.5	1.19

			- Each function should have its own space, which should be divided up according to the importance of each function. The most room must be dedicated to free circulation.	70	80	80	80	70	60	90	100	80	80	79	1.15
		Other	-												
			-												
			-												
			-												
circulation requirements		Accessibility	- The station's design must allow for a free-flowing passenger to avoid severe congestion within the station, particularly on platforms and escalators.	80	85	95	80	90	75	80	100	80	80	84.5	1.79
			- Reducing Walking distances should be kept to a minimum.	60	80	60	60	60	80	60	70	60	60	65	1.38
			- Paths should be clear and straightforward as feasible.	80	85	70	80	90	90	80	100	90	90	85.5	1.81
			- A passenger's movement must be unhindered from the time he enters the Station until he leaves.	80	80	75	70	90	80	70	100	85	85	81.5	1.73
			- Segregation of arriving and departing passengers.	60	70	50	70	70	70	70	95	10	90	65.5	1.39
			- The separation between the people movement and vehicles	80	90	75	80	80	90	90	70	90	90	83.5	1.77
			- Define separate areas for the movement of baggage	50	70	85	60	60	20	60	60	5	5	47.5	1.01
			- Using technology will reduce time for people that have to wait in lines to buy tickets	50	65	65	100	50	95	70	80	40	40	65.5	1.39
			- All platforms should be parallel and of the same length.	60	80	75	60	60	90	70	100	90	90	77.5	1.64
			- The platform is divided into parts, the first of which is at the edge a warning area, then a movement area, followed by a waiting area, and there is a line separating the prohibited area from the waiting area	80	80	95	60	90	90	80	100	95	95	86.5	1.83
	25	provid	- providing Waiting space to reduce passenger interference in the circulation area.	90	70	95	70	90	70	70	70	70	70	76.5	1.62
			- Providing clear and consistent directional signage.	90	85	85	80	100	100	80	90	95	90	89.5	1.89
			- Sufficient space for movement and waiting	90	65	85	80	100	100	80	90	80	80	85	1.80

			- clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation. A sequence in motion (entry-tickets-waiting-departure)	80	75	60	90	90	90	60	70	80	80	77.5	1.64
			- motility (elevators, escalators, moving walkways and assistive devices like wheelchairs for the physically disabled)	90	80	95	90	100	80	50	100	75	75	83.5	1.77
			- Cycle tracks & cycle parking	50	0	40	40	50	20	0	0	20	20	24	0.51
		Other	-												
			-												
			-												
			-												
Environmental design requirements	**10**		- Using biophilic design to achieve a comfortable healthy environment inside the station	50	55	40	80	50	60	70	50	20	20	49.5	0.87
			- Using local, weather-resistant, and recyclable materials	60	50	80	80	70	30	50	60	10	20	51	0.89
			- Rainwater collection and reuse	60	0	10	90	50	10	80	40	5	10	35.5	0.63
			- Reducing the operating cost and saving energy	70	30	20	90	60	10	70	20	5	10	38.5	0.68
			- Increasing green spaces inside and around the station	40	70	60	90	40	70	60	20	65	70	58.5	1.03
			- Respecting the privacy of the site	70	90	60	80	60	90	70	40	70	70	70	1.23
			- Good open spaces around the station/ plaza/ creating a fresh environment/pedestrian-friendly atmosphere	60	80	80	80	70	85	80	50	65	60	71	1.25
			- Using glass which allows natural light	80	95	100	80	80	80	100	80	5	10	71	1.25
			- Provide natural ventilation.	60	40	60	80	70	30	30	40	5	10	42.5	0.75
			- In the public areas of the Station, material finishes of elements should be highly durable, low maintenance, and require less frequent cleaning.	80	70	60	90	90	90	80	100	70	70	80	1.41
			-												

			-														
			-														
			-														
Safety and security requirements	**25**	Be Safety and Secure by Design	- The Station design should promote security for the passenger.	80	80	60	90	100	90	80	90	85	80	83.5	1.91
			- Created with the least amount of potential for accidents and health risks. The following strategies are to be used, but are not restricted to them: - Appropriate and sufficient illumination - Slip-resistant surfaces for walking - Proper use of safety rails and guards.	80	85	90	70	80	90	80	80	75	85	81.5	1.86
			- Stations ought to be built with safety and security in mind, independent of technology.	90	85	50	50	90	95	70	100	70	85	78.5	1.79
			- Controlling entrances and exits	80	80	50	60	90	90	80	70	85	80	76.5	1.75
			- The more accident-prone locations, like the platform and vertical circulation components, require special care.	80	70	50	80	100	80	70	90	65	70	75.5	1.73
			- Using materials that are durable and resilient.	90	80	60	70	90	70	80	80	75	80	77.5	1.77
			- Utilizing secure and thoughtful design to assess and mitigate the risk of hazards, whether they are caused by humans or nature.	80	50	80	60	70	70	70	60	75	50	66.5	1.52
			- Protection of personal property	10	55	10	50	30	10	50	10	60	50	33.5	0.77
			- Provide emergency requirements	70	75	80	40	90	90	70	20	70	80	68.5	1.57
			- Providing a safe for users and protection from weather conditions.	80	60	60	60	90	95	70	40	80	30	66.5	1.52
			- Provide guide signs.	90	90	80	70	100	100	80	80	90	90	87	1.99
			- Alarm systems	80	90	80	80	100	100	80	90	90	90	88	2.01
		Manageme	- Provide maintenance requirements	70	85	80	70	90	60	70	70	85	85	76.5	1.75
			- When elevator or escalator maintenance is required, consider providing alternative accessible paths either proactively or reactively.	80	80	70	70	80	95	80	30	80	80	74.5	1.70
			- Enabling effective station upkeep and cleaning.	60	80	80	60	70	80	70	20	0	80	60	1.37

		Other	-															
			-															
			-															
			-															
Socio-economic requirements	**10**	Socio	- Integrating station amenities with the surrounding open space.	50	75	70	70	80	60	70	60	30	80	64.5	1.02
			- The creation of a connected network of public areas, bike lanes, and platforms.	40	10	10	70	60	30	60	40	25	10	35.5	0.56
			- Creating warm station settings that encourage people to travel, work, and shop.	70	60	20	70	60	10	70	60	40	60	52	0.82
			- Raising the standard of well-being (cultural, human behavior ...etc.)	80	50	30	70	70	20	70	30	25	50	49.5	0.79
			- Awareness and education through information centers and screens	80	60	70	70	80	90	80	40	65	60	69.5	1.10
			- Well-balanced and social justice	30	30	80	60	40	50	60	20	70	20	46	0.73
			- Humanitarian needs (Availability of food- Availability of drinks- Safety and Security)	80	50	90	60	90	80	80	80	80	50	74	1.17
		Economic	- Providing investment and rental spaces	90	80	100	70	90	40	90	95	90	50	79.5	1.26
			- Take advantage of the site	80	90	80	70	80	90	90	90	70	50	79	1.25
			- Reducing resource consumption	70	50	60	80	70	0	60	10	50	50	50	0.79
			- Use of renewable resources	30	50	10	80	30	0	30	0	30	50	31	0.49
		Other	-															
			-															
			-															
			-															

Appendix 2 --- Survey weight of the framework

requirements	point		Secondary requirements	Consulting engineering offices designed and implemented										Percentage%	Wight
				1	2	3	4	5	6	7	8	9	10		
functional requirements	30	Quality	- Connecting different types of transportation in one place	95	90	90	90	90	80	90	80	80	90	87.5	1.28
			- Optimal use of areas	70	80	80	70	90	60	60	80	90	60	74	1.08
			- Provide special spaces for operators.	80	80	90	70	100	80	80	80	60	80	80	1.17
			- Station entrances provide a connection between the station and the surrounding streets, ensuring that all passengers have easy access to the entrances.	90	90	100	80	100	70	85	80	80	80	85.5	1.25
			- The station entry must provide clear and direct access to the local footpath system.	100	80	100	90	100	80	90	100	90	90	92	1.34
			- The departure concourse and platforms should each have a shared ceiling with unobstructed broad-span structural systems.	100	70	70	50	80	80	80	100	50	80	76	1.11
			- Station interiors must include partition walls that allow for a flexible area.	50	80	90	90	90	70	85	70	50	90	76.5	1.12
			- Provide usability requirements.	90	70	100	80	70	60	80	80	60	80	77	1.12
			- Use a unified ticket.	50	70	100	10	50	60	85	40	40	95	60	0.88
			- The use of electronic tickets to reduce the need for ticket halls.	100	90	100	80	60	60	90	60	50	85	77.5	1.13
			- Consider using analytical techniques or computer-aided modelling tools to confirm the movements and capacity of station users, especially at passenger decision points, queuing locations, and cross flows.	85	80	90	20	60	60	70	70	80	70	68.5	0.99

			- Make it simpler for town/city maps, directions, and directional signs that adhere to third-party local wayfinding strategies to be presented about exterior facilities inside the station.	95	80	100	90	80	80	90	80	70	80	84.5	1.23
			- Considering people with special needs, and Information for users who are blind or visually impaired is provided using near-field, mobile, and loop technologies.	70	70	100	60	100	90	70	80	80	70	79	1.15
			- Sufficient parking all around the station.	90	70	80	20	70	50	90	100	70	30	67	0.98
			- System integration (structure, space, materials, lighting, communications, and mechanical)	90	80	90	90	80	80	95	90	90	70	85.5	1.25
			- Maintain visual/aesthetic continuity with the rest of the system while incorporating site-specific aspects. (Physical, visual interconnection, and Aesthetic form)	70	80	80	90	80	80	80	90	90	85	82.5	1.20
			- Their design should reflect the preservation and beauty of the surrounding area. The new station design must not isolate the existing historic structures.	90	60	100	85	90	90	65	70	100	65	81.5	1.19
		Zoning	- Functional integration according to social and environmental changes, and providing service and commercial spaces	70	60	80	90	70	60	85	90	60	90	75.5	1.10
			- Providing waiting areas and restrooms inside the main halls and ticket halls and places for decision-making and providing services for them	80	70	70	70	80	80	90	100	50	85	77.5	1.13
			- Concourses for arrival and departure ought to be placed strategically below and/or above the platforms.	100	70	100	90	90	80	90	90	90	80	88	1.28
			- Place information, TVs, and ticket booths in locations that do not obstruct other people's access to the space or interfere with important station functions.	100	90	100	90	80	70	80	85	70	90	85.5	1.25
			- integrating spatial layout, lighting, and surface finishes with other architectural components can be made to be straightforward and legible with no need for signage.	60	70	90	80	70	70	90	95	30	80	73.5	1.07
		A	- Design spaces, and platforms according to the number of passengers at peak hours	80	70	90	80	90	80	90	95	90	70	83.5	1.22

			- Determine expected number of demands for both travelers and non-travelers.	90	80	80	60	80	60	90	95	80	70	78.5	1.14
			- Considering the individual's share in the different spaces.	90	70	90	70	90	90	90	85	70	70	81.5	1.19
			- Each function should have its own space, which should be divided up according to the importance of each function. The most room must be dedicated to free circulation.	60	90	100	80	70	70	80	80	80	80	79	1.15
		Other	-												
			-												
			-												
			-												
circulation requirements		Accessibility	- The station's design must allow for a free-flowing passenger to avoid severe congestion within the station, particularly on platforms and escalators.	75	80	100	80	90	80	85	95	80	80	84.5	1.79
			- Reducing Walking distances should be kept to a minimum.	80	60	70	60	60	60	80	60	60	60	65	1.38
			- Paths should be clear and straightforward as feasible.	90	80	100	90	90	80	85	70	80	90	85.5	1.81
			- A passenger's movement must be unhindered from the time he enters the Station until he leaves.	80	70	100	85	90	80	80	75	70	85	81.5	1.73
			- Segregation of arriving and departing passengers.	70	70	95	10	70	60	70	50	70	90	65.5	1.39
			- The separation between the people movement and vehicles	90	90	70	90	80	80	90	75	80	90	83.5	1.77
			- Define separate areas for the movement of baggage	20	60	60	5	60	50	70	85	60	5	47.5	1.01
			- Using technology will reduce time for people that have to wait in lines to buy tickets	95	70	80	40	50	50	65	65	100	40	65.5	1.39
			- All platforms should be parallel and of the same length.	90	70	100	90	60	60	80	75	60	90	77.5	1.64
	25		- The platform is divided into parts, the first of which is at the edge a warning area, then a movement area, followed by a waiting area, and there is a line separating the prohibited area from the waiting area	90	80	100	95	90	80	80	95	60	95	86.5	1.83

		providing	- providing Waiting space to reduce passenger interference in the circulation area.	70	70	70	70	90	90	70	95	70	70	76.5	1.62
			- Providing clear and consistent directional signage.	100	80	90	95	100	90	85	85	80	90	89.5	1.89
			- Sufficient space for movement and waiting	100	80	90	80	100	90	65	85	80	80	85	1.80
			- clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation. A sequence in motion (entry-tickets-waiting-departure)	90	60	70	80	90	80	75	60	90	80	77.5	1.64
			- motility (elevators, escalators, moving walkways and assistive devices like wheelchairs for the physically disabled)	80	50	100	75	100	90	80	95	90	75	83.5	1.77
			- Cycle tracks & cycle parking	20	0	0	20	50	50	0	40	40	20	24	0.51
		Other	-												
			-												
			-												
			-												
Environmental design requirements	**10**		- Using biophilic design to achieve a comfortable healthy environment inside the station	60	70	50	20	50	50	55	40	80	20	49.5	0.87
			- Using local, weather-resistant, and recyclable materials	30	50	60	10	70	60	50	80	80	20	51	0.89
			- Rainwater collection and reuse	10	80	40	5	50	60	0	10	90	10	35.5	0.63
			- Reducing the operating cost and saving energy	10	70	20	5	60	70	30	20	90	10	38.5	0.68
			- Increasing green spaces inside and around the station	70	60	20	65	40	40	70	60	90	70	58.5	1.03
			- Respecting the privacy of the site	90	70	40	70	60	70	90	60	80	70	70	1.23
			- Good open spaces around the station/ plaza/ creating a fresh environment/pedestrian-friendly atmosphere	85	80	50	65	70	60	80	80	80	60	71	1.25
			- Using glass which allows natural light	80	100	80	5	80	80	95	100	80	10	71	1.25
			- Provide natural ventilation.	30	30	40	5	70	60	40	60	80	10	42.5	0.75

			- In the public areas of the Station, material finishes of elements should be highly durable, low maintenance, and require less frequent cleaning.	90	80	100	70	90	80	70	60	90	70	80	1.41
		Other	-														
			-														
			-														
			-														
Safety and security requirements	**25**	Be Safety and Secure by Design	- The Station design should promote security for the passenger.	90	80	90	85	100	80	80	60	90	80	83.5	1.91
			- Created with the least amount of potential for accidents and health risks. The following strategies are to be used, but are not restricted to them: - Appropriate and sufficient illumination - Slip-resistant surfaces for walking - Proper use of safety rails and guards.	90	80	80	75	80	80	85	90	70	85	81.5	1.86
			- Stations ought to be built with safety and security in mind, independent of technology.	95	70	100	70	90	90	85	50	50	85	78.5	1.79
			- Controlling entrances and exits	90	80	70	85	90	80	80	50	60	80	76.5	1.75
			- The more accident-prone locations, like the platform and vertical circulation components, require special care.	80	70	90	65	100	80	70	50	80	70	75.5	1.73
			- Using materials that are durable and resilient.	70	80	80	75	90	90	80	60	70	80	77.5	1.77
			- Utilizing secure and thoughtful design to assess and mitigate the risk of hazards, whether they are caused by humans or nature.	70	70	60	75	70	80	50	80	60	50	66.5	1.52
			- Protection of personal property	10	50	10	60	30	10	55	10	50	50	33.5	0.77
			- Provide emergency requirements	90	70	20	70	90	70	75	80	40	80	68.5	1.57
			- Providing a safe for users and protection from weather conditions.	95	70	40	80	90	80	60	60	60	30	66.5	1.52
			- Provide guide signs.	100	80	80	90	100	90	90	80	70	90	87	1.99
			- Alarm systems	100	80	90	90	100	80	90	80	80	90	88	2.01
			- Provide maintenance requirements	60	70	70	85	90	70	85	80	70	85	76.5	1.75

			- When elevator or escalator maintenance is required, consider providing alternative accessible paths either proactively or reactively.	95	80	30	80	80	80	80	70	70	80	74.5	1.70
			- Enabling effective station upkeep and cleaning.	80	70	20	0	70	60	80	80	60	80	60	1.37
		Other	-												
			-												
			-												
			-												
Socio-economic requirements	**10**	Socio	- Integrating station amenities with the surrounding open space.	60	70	60	30	80	50	75	70	70	80	64.5	1.02
			- The creation of a connected network of public areas, bike lanes, and platforms.	30	60	40	25	60	40	10	10	70	10	35.5	0.56
			- Creating warm station settings that encourage people to travel, work, and shop.	10	70	60	40	60	70	60	20	70	60	52	0.82
			- Raising the standard of well-being (cultural, human behavior ...etc.)	20	70	30	25	70	80	50	30	70	50	49.5	0.79
			- Awareness and education through information centers and screens	90	80	40	65	80	80	60	70	70	60	69.5	1.10
			- Well-balanced and social justice	50	60	20	70	40	30	30	80	60	20	46	0.73
			- Humanitarian needs (Availability of food- Availability of drinks- Safety and Security)	80	80	80	80	90	80	50	90	60	50	74	1.17
		Economic	- Providing investment and rental spaces	40	90	95	90	90	90	80	100	70	50	79.5	1.26
			- Take advantage of the site	90	90	90	70	80	80	90	80	70	50	79	1.25
			- Reducing resource consumption	0	60	10	50	70	70	50	60	80	50	50	0.79
			- Use of renewable resources	0	30	0	30	30	30	50	10	80	50	31	0.49
		Other	-												
			-												
			-												
			-												

- **الملخص**

يتنامى دور النقل في الحياة الاقتصادية والاجتماعية في جميع أنحاء العالم، وأصبح الطلب على التنقل نشاطا حياتيا يوميا متزايدا، لذلك سعت هذه الدول إلى اعتماد أنظمة النقل بمختلف أنواعها والالتزام بمبادئها ومن ثم تطبيقها بشكل عام وفي محطات نقل الركاب بشكل خاص. وذلك لأن الأوضاع الحالية لمحطات نقل الركاب تعاني من مشاكل اجتماعية واقتصادية وصحية للركاب والمشغلين. لذلك، تهدف الدراسة إلى استخلاص المبادئ التوجيهية لتصميم المحطات المحورية متعددة الوسائط وتقييم واقتراح تحسينات لدراسات الحالة المصرية في مصر، بحيث تتكون الدراسة من جزأين، **الجزء الأول** يشمل ومراجعة الأدبيات والمعرفة. يتم ذلك من خلال المسح الدقيق والتحليل وتقييم الأعمال والأوراق والكتب المنشورة مؤخرًا والمتعلقة بمجال البحث الرئيسي ومراجعة أهمية المحطات المحورية متعددة الوسائط ومكوناتها و تحليل دراسات حالة دولية ناجحة (الهند – المانيا - بريطانيا) تم اختيارها وفقا لمجموعة من المحددات المختلفة .**الجزء الثاني** تحليل دراسات الحالة المصرية (محطة عدلي منصور – محطة بدر – محطة الفنون والثقافة) والوصول إلى متطلبات التصميم المستخدمة في المحطات المصرية والمشكلات القائمة واقتراح مبادئ توجيهية لتصميم محطات الركاب متعددة الوسائط وتقييم دراسات الحالة المصرية. وتوصي الدراسة تطبيق المبادئ التوجيهية التصميمية التي تقترحها الدراسة لتطوير كفاءة المحطات المصرية، واستخدام إنترنت الأشياء (IoT) في المحطات متعددة الوسائط.

وكانت الاضافة العلمية هي تقديم مبادئ توجيهية شاملة لجوانب التصميم المعماري في إطار نظام النقل العام، مع التركيز على تقييم واقتراح الارشادات التصميمية للمحطات متعددة الوسائط الحالية (محطة عدلي منصور، محطة بدر، ومحطة الفنون والثقافة بالعاصمة الادارية الجديدة). ويهدف ذلك إلى تحسين تصميم المحطات الحالية وتعزيز جودتها وكفاءتها، وتوفير بيئة مريحة وآمنة للركاب . وتتضمن الدراسه مجموعة من المتطلبات التصميميه المختلفه لجوانب التصميم المعماري في نظام النقل العام، وتشمل المتطلبات علي (متطلبات وظيفيه - متطلبات خاصه بحركه المشاه - متطلبات الامن والسلامه - متطلبات بيئيه - متطلبات اجتماعيه واقتصاديه). وبناءً على هذه المتطلبات ، يتم تقديم تقييم مفصل للمحطات المتعددة الوسائط الحالية (محطة عدلي منصور- محطة بدر -محطة الفنون والثقافة بالعاصمه الاداريه الجديده). ويتضمن التقييم تحليلًا شاملاً للمحطه وتحديد المتطلبات المستخدمه بها ودراسه تفصيليه للعمليات الحسابيه الخاصه بمسارات حركه المشاه وتحديد نقاط القوة ونقاط الضعف في التصميم الحالي وتحديد المشكلات. بناءً على التقييم، يتم اقتراح الارشادات التصميمية الملائمة لتحسين المحطات المذكورة.

إقرار

أقر أنا الموقع أدناه بأن هذة الرسالة مقدمة في جامعة عين شمس، كلية الهندسة، قسم الهندسة المعمارية للحصول على درجة دكتوراة الفلسفة في الهندسة المعمارية؛ وأن العمل الذي تحتويه هذة الرسالة قد تم إنجازه بمعرفة الباحث.

هذا ويقر الباحث أن العمل المقدم هو خلاصة بحثه الشخصي؛ وأنه قد إتبع الأسلوب العلمي السليم في الإشارة إلي المواد المأخوذة من المراجع العلمية كل في مكانه في مختلف أجزاء الرسالة.

وهذا إقرار مني بذلك؛؛؛

إســراء هانـي فاضل السيد

التوقيع

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التاريخ / / /

تعريف بمقدم الرسالة

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تاريخ الميلاد : 26 فبراير 1994

محل الميلاد : الشرقية – مصر

أخر درجة جامعية : ماجستير العلوم في الهندسة المعمارية

مجال التخصص : الهندسة المعمارية

الجهة المانحة : كلية الهندسة بشبرا جامعة بنها

تاريخ المنح : 2020

تاريخ مناقشة رسالة الدكتوراة : 2024

جامعة عين شمس
كلية الهندسة
قسم الهندسة المعمارية

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إعداد

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لجنة الإشراف

أ.د. ليلي محمد خضير التوقيع/ .....

أستاذ إدارة المشروعات والتنمية المستدامة

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العنوان: تقييم تأثير التصميم المعماري على أداء محطات الركاب متعددة الوسائط في مصر

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الدراسات العليا

ختم الإجازة

أجيزت الرسالة بتاريخ

/ /

موافقة مجلس الكلية

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موافقة مجلس الجامعة

/ /

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جامعة عين شمس – كلية الهندسة

قسم الهندسة المعمارية

القاهرة؛ مصر

2024