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An Approach to Sustainable Design of Intermodal Stations

in Greater Cairo Region

Thesis submitted in fulfillment of the requirements of the degree of Doctor of Philosophy in Architecture

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Statement

This thesis is submitted to Ain Shams University for the degree of Doctor of Philosophy in Architecture.
The work included in this thesis was carried out by the author at the architectural department, Ain Shams University.
No part of this thesis has been submitted for a degree or qualification at other university.

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Abstract

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Metropolitan areas in developing countries are confronted with many traffic problems that directly affect the environment, economic development and social welfare. Public transport can offer citizens sustainable mobility. While designing to protect the public and the environment, planning procedures have to favour the implementation and improvement of public transport. Public transport can offer citizens sustainable mobility if it meets a number of qualitative objectives. The effectiveness of the design of intermodal stations is a critical factor in determining the quality of public transport. On average, public transport terminals in developing countries are not designed from an intermodal service perspective. Cairo terminals suffer many problems which affect passenger trips of which are; the lack of convenient facilities and connections between the different modes, limited pedestrian safety facilities in the intermodal area, the poor state of the station structures, unavailability of sufficient parking areas and the unavailability of modern information systems.

This thesis aims to highlight the design issues which should be considered when designing sustainable intermodal stations, such as; the intermodal connectivity between modes, safety requirements for traffic and pedestrian circulation, the environmental requirements for the station structures saving energy and water resources, and public amenities requirements. To accomplish the objectives of this research, several physical design issues are examined by reviewing previous experience with literature survey on the design of intermodal stations, thus deducing design guidelines. A sustainable design guide is used to set sustainable design priorities and goals, and develop appropriate sustainable design strategies to guide the sustainable design and decision making processes. Examples of Cairo intermodal stations are discussed and proposals are set for improvements. Based on the deduced guidelines, a computer simulation tool is designed to measure the sustainability of Cairo intermodal stations thus evaluating the existing situation in terms of sustainability and enabling decision makers to point out the deficiencies and propose the solutions for Cairo intermodal stations.

Keywords: *Sustainable Stations – Intermodals* **-** *Environmental Design*

Problem Identification

Traffic projects has regional and local negative impacts on the socioeconomic environment represented in impact on public health from increased air pollution, noise and vibrations, contamination of water and soil by spills, land take, and visual impact on aesthetics. The question is how to design consistent to the environment and with the least negative impact on it. There is a considerable scope for improvements to make traveling conditions easier and facilitate modal transfers which are still highly problematic in many developing countries. Far too often passengers are put off using different modes of transport for single journeys they have problems obtaining information and ordering tickets when the journey involves different means of transport and transferring from one mode to another can be complicated by inadequate infrastructure (lack of parking space for cars or bicycles, for example).

An intermodal system needs to be formulated in Greater Cairo Region in association with the development of public transport systems, the system requires rational development and improvement of intermodal centres (stations). Cairo terminals suffer a complete lack of integration between the transport modes, pedestrian level of service is deteriorated and the environmental issues are completely ignored in the station design. Effective integration of individual modes (including walking and cycling) and public transport operations is essential, pedestrian safety and convenience should be raised to higher levels, and environmental requirements are to be considered.

This research focuses on the design of intermodal stations in light of the design objectives which must be considered to achieve sustainability of the intermodal station project.

Objectives

Improving public transport is vital in reducing social exclusion and is essential for enhancing quality of life leading to a strong economy and a better environment. The convenient economic safe movement of people must be at the core of transport policy making and provision. An integrated approach is therefore essential and that must include a strategy for increasing the use of public passenger transport. If public transport is made more attractive by improving standards of service and organization and more accessibility to people whose mobility is limited, large numbers of people will be encouraged to use it regularly.

The objective of this research is to identify an approach to the design process of intermodal stations towards achieving their sustainability. This will involve; the provision of seemless connections between the different transport modes thus improving mobility, a convenience for passenger and pedestrian friendliness and protecting, and enhancing the quality of the environment represented in improved air quality, energy conservation, and enhancing community livability and business viability, thus attaining sustainability of intermodal stations. The research encompasses the introduction of alternatives for improving and upgrading Cairo intermodal stations. The process comprises the design of the urban and architectural elements represented in the urban design of the intermodal space and the architectural design of the station structures.

Methodology

The research discusses the sustainability of intermodal stations following a rational procedure represented in

1. Using an analytical method in assessing the sustainability of different cases of intermodal stations around the world in terms of their design and the environmental impact of their urban and architectural elements. In doing so, ***a literature survey*** for different cases in different countries of the world is introduced thus deducing criteria which could be adapted and coordinated to be applied as guidelines for the sustainable design of intermodal stations.
2. The research case study will be the proposed intermodal stations in East Cairo. A ***field research*** for the existing situation is carried out. The design of the project is evaluated in terms of achieving sustainability.
3. Scoring forms for evaluation of the design alternatives are concluded based on the deduced sustainable design guidelines and recent efforts around the world to set rating systems for the different design objectives. The scoring forms are the input to a computer programme which is designed to measure the sustainability of the design of the imtermodal stations. The prepared computer programme is applied to the existing situation of Ramses intermodal station as an example of Cairo intermodals.

4. Finally concluding how to design for sustainable intermodals after realizing the design criteria for the urban and the architectural design of the stations. Recommendations are set for the design process of the intermodal stations in Cairo thus enabling planners and designers to achieve sustainability in design of such stations.

Structure of the Research

The research consists of 7 chapters as follows:

Chapter 1 The Concept of Intermodal Stations

This chapter includes an explanation of the views and concepts of the intermodal theory, and the role played by intermodal stations in the efficiency of the intermodal public transport system with a review on the emerging new transport technologies and their impact on station design. The chapter focuses on the problem of Cairo terminals and the concept of developing the intermodal stations in Greater Cairo Region.

Chapter 2 The Sustainable Design of Intermodal Stations

This chapter focuses on deducing the design guidelines which should be followed to achieve sustainability of itermodal stations. Design issues to be discussed are; satisfying circulation needs of passengers through separation of movement at different grades, accessing other levels, shading and platforms, visibility (lighting and colour), environment (clean air), natural lighting and ventilation, ticket design and alternative ticket purchase, and specifying shopping arcades as pedestrian malls in a comfortable and safety planning.

From above concluding design criteria and guidelines which could be applied and followed in designing and planning intermodal stations and which could be adapted and coordinated to Cairo intermodal stations.

Chapter 3 Examples of Existing Best Practice Intermodal Stations

This chapter introduces different cases of intermodal station projects around the world through a literature survey. Examples of the different types of modal interchanges are presented. Examples of rail/ bus and coach interchange are culled from the United States, Europe and Far East, as well as examples of air/ rail interchange from Europe. The stations are discussed in terms of sustainability. The design concept is investigated, environmental features discussed and the socioeconomic aspects revealed.

Chapter 4 Examples of Cairo Existing and Proposed Intermodal Stations

This chapter introduces the case study of the research which is East Cairo proposed intermodal stations, using the design guidelines and criteria deduced from the previous chapters regarding their design and urban context, this shall be carried out through surveys for the present situation, the current road network in the intermodal area, the plan and location of the station. The results of earlier environmental surveys are projected regarding air quality measurements noise level measurement social awareness survey. The existing situation of the intermodal facilities is projected and evaluated in terms of their sustainability.

Chapter 5 Sustainable Design of Cairo Intermodal Stations

Consideration of alternatives and deducing the advantages and disadvantages of each alternative in terms of sustainability is carried out through this chapter and conceptual designs are introduced for the stations.

Chapter 6 Assessing the Sustainability of Intermodal Stations Projects

In this chapter, scoring forms for the evaluation of the design alternatives of intermodal stations projects are deduced based on performance indicators introduced in different rating systems around the world. The rating systems are discussed briefly. A computer programme is projected and applied to one of Cairo intermodal stations to measure its sustainability.

Chapter 7   Conclusion

The results of the research are presented and recommendations are set to guide the design process of intermodal stations in order to achieve their sustainability.

INTRODUCTION

Introduction

The unrelenting growth of transport and increased congestion have become possibly the greatest environmental threat and one of the greatest obstacles to achieving sustainable development The motor vehicle of today would wreck our towns within a decade. The adoption of polices and programs that offer citizens sustainable mobility is a must to solve such problems, while eliminating the use of private car and upgrading the use of public transport as a valuable alternative.

Competing with the private car means that the public transport service needs to be flexible efficient and reliable. Better coordination of subsystems such as bus, tram, metro and rail operations is essential for fulfilling the potential offered by public transport, thus allowing integration between all modes so that a passenger can buy a ticket covering the whole of the journey even if that includes a change from one mode to another.

The ***intermodal*** public transport system combines all passenger transport modes into a common operating environment, providing full accessibility which is a necessity on social grounds and also considered an opportunity on economic and marketing grounds. Stations play an important role in the efficiency of the system. However if intermodal traffic projects are not planned and designed according to specific environmental criteria, they may impose regional and local negative impacts on the socioeconomic environment.

The aim of this research is to introduce an approach for the process of designing intermodal stations towards realizing their sustainability. This process comprises both urban and architectural issues represented in; the access to different modes depending on layout of the stations (space design) and facilities at them and how intermodal connections are developed by designing station plazas for feeder services depending upon the future passenger demand, and the separation of movement on different levels (grades). The design process also emphasizes the provision of safe walking and cycling routes and good parking facilities, and the provision of better environmental quality, by means of natural lighting and ventilation and noise treatment. In order to achieve high levels of services for passengers, attention should be given to other design issues such as passenger information systems, ticket office design and alternative ticket purchase, specifying shopping arcades and pedestrian malls in a comfortable and safety planning, and the materials used in these different architectural elements.

To accomplish the objectives of this research, intermodal access requirements and opportunities, urban form impacts, environmental and community acceptance problems, and joint development opportunities are investigated. Several physical design issues are examined by reviewing previous experience with literature survey on the design of intermodal stations, thus introducing the key design issues for the sustainable design and deducing design guidelines for architects and planners. A research review of some case studies of existing stations in Europe, the United States and the Far East is conducted, documented and analyzed from a sustainable perspective using the deduced design guidelines**.**

The research case study will be some of the existing and proposed intermodal stations in Greater Cairo Region (GCR). A review of some of the transportation studies related to the region is introduced. A field survey for the station area is conducted. The intermodal station present situation is evaluated in terms of sustainability, and proposed designs for improving such stations are analyzed. In doing so, the following stages are followed:-

- Collecting information necessary to evaluate and understand the present situation of the intermodal station
- Defining the efficiency of the station structures to accommodate the above mentioned sustainable design issues
- Evaluating the situation using the deduced design guidelines
- Proposing the development procedures required.

To determine the sustainability of the intermodal station project, a sustainable design guide tool that can be used to overlay sustainable issues on the design of both new and renovated facilities, is used to set sustainable design priorities and goals; develop appropriate sustainable design strategies; and to determine performance measures to guide the sustainable design and decision-making processes. It can also be used as a management tool to organize and structure sustainable concerns during the design, construction, and operation phases.

After developing the strategies necessary to achieve the above mentioned goals, scoring forms (checklists) are deduced to check the sustainability of the intermodal station project, which in turn is transformed to a computer simulation tool measuring the success of the design in scoring a total of possible points with regard to sustainability of intermodal stations projects. The computer programme is applied on Ramses intermodal station, and a score is awarded for the station, thus pointing out the deficiencies, and the relative importance of their treatment.

After assembling and synthesizing current information on the design of intermodal stations to attain their sustainability, the design objectives which should be met to attain sustainability of Cairo intermodal stations are highlighted and the strategies to be applied to achieve such objectives are recommended in this research, hoping that such information will present the predictions and options for planners and decision makers.

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CHAPTER I

Chapter 1

The Concept of Intermodal Stations

1.1. Urban Expansion and the Emerging Concept of Intermodalism

Urban sprawl has become one of the main problems facing large cities, with its negative consequences on their transportation networks and overall sustainability. In quest to find more open areas and more private surroundings, people have been fleeing major cities in favour of the surrounding suburban communities, eventually many urban areas have seen their sizes double over the past decade. This rapid expansion has led to a critical shortage in infrastructure. In many communities, water, sewage and other basic city services are stretched beyond their capabilities. The worst of these problems is the transportation network. According to the world bank, the

> *"… number of mega cities (cities with over 10 million inhabitants) is expected to double within a generation. More than one half of the developing world's population, and between one-third and one-half of its poor, will then live in cities. Per capita motor vehicle ownership and use continue to grow by up to 15 to 20 percent in some countries. Traffic congestion and air pollution continue to increase. Pedestrian and other non motorized transport (NMT) continue to be poorly served. Increased use of private vehicles has resulted in falling demand for public transport and a consequent decline in service levels. Sprawling cities are making the journey to work excessively long and costly for some of the very poor".*[20]

While this problem can be seen in many metropolitan areas, perhaps the best region to examine this phenomenon is Cairo Metropolitan area. Cairo region in recent decades has been shaped by a series of events; the construction of new towns and of priority housing districts called new settlements, designed to meet the rapid expansion of Cairo, the construction of more ambitious public transport network (metro and regional railway lines), and the construction of a ring road around Cairo, delineating the urban area. Unfortunately, the transportation network in Cairo could not keep pace with the urban expansion. Today's transport network in Greater Cairo Region is characterized by low operating speeds and low patronage. Interchange facilities may seem numerous but the interchange system needs much organization.

1.1.1. Problems affecting transportation and the future of interchange

Problems affecting transportation and the future of interchange between the year 2000 to the year 2025 is the projected growth, demand on infrastructure arising purely from growth projections, imposition of limits on pollutants and noise, demands for security, opposition from green lobby and planning procedure, cost and problems of sharing investments between public and private sectors, finite limits to oil supplies, cost of fuel and volatility of supply.[1]

In light of the above statement, public transport is seen as a valuable alternative for the private car. Even if the roads could be created for predicted increases in car use the resulting destruction to the communities and fabric of cities would no longer be tolerated. Car travel threatens the health of the global environment and that of our children, it is now widely recognized that car use at present level is *not sustainable.* Railways (high speed rail systems, metro or light rail systems) represent a better long term investment, especially in technically advanced, highly congested areas. Public transport can offer citizens sustainable mobility if it meets a number of qualitative objectives at a reasonable price. Competing with the private car means that public transport services need to be flexible, efficient and reliable. As a result, the concept of ***Intermodalism*** has emerged, this has encouraged connectivity between different modes of transportation. Many airports have now become intermodals serving a variety of freight transportation modes and expanding to include passenger transportation (heavy, light, and commuter rail and bus).

Intermodalism is generally defined as

> *"the concept of transporting passengers and freight in such a way that all parts of the transportation process, including information exchange, are efficiently connected and coordinated, offering the end user with greater flexibility and service"*[31]

Another adopted definition of ***Intermodalism*** as defined by Prof. Gerhard Muller is:

> *"the concept of transporting passengers and freight on two or more different transport modes in such a way that all parts of the transportation process including the exchange of information are efficiently connected and coordinated."* [21]

For passenger transportation, an intermodal system allows a passenger to travel from one location to another, moving seamlessly between transportation modes on the same ticket, with the trip tailored to meet the passenger needs for travel information, cost, scheduling, comfort, and other considerations. Intermodal systems, by their nature should assure the most efficient, least expensive means available for movement from location to another. [19]

Many governments are embarking upon ambitious plans to have an integrated transport system where travel by air, rail, bus and car are part of a smoothly functioning and publicly regulated system. The benefits of such a system range from the social and economic integrity of towns as well as the environmental concerns. Europe is readdressing the balance in public investment between road and rail building partly under pressure from the *Influential Royal Commission on Environmental Pollution.* Ecological concerns are one of the justifications for this change in emphasis. Interesting examples of public transport integration efforts can be found in several French and German cities as well as in several cities in developing countries.

On the other hand, still a common feature of many public transport systems in metropolitan areas of some developing countries like Egypt is their complete absence of integration. Inner-city and intercity public transport systems have no interconnecting terminals, and passengers on inner-city public transport need to walk long distances when changing from one mode to another. Ticket integration or organizational cooperation is lacking to initiate integration of public transport.

The World Bank continue to argue that the public transport systems should not be

> *"… viewed as only for the poor, as the importance of public transport to all income groups in many rich European cities demonstrates. Improving efficiency in public transport must be concerned not only with keeping costs down but also with providing a flexible framework within which the less poor as well as the very poor can use public transport with confidence and comfort".*[21]

Problems in resolving disintegration include:

- *The volatility* of the market which studies do not sufficiently acknowledge.

- *Access factors;* Rail and coach stations go where the demand is but rail operators have taken second place in towns and cities to busses and coaches which can weave into the urban fabric. Airport locations have been determined by many historic factors, some of which have continued to accessibility and others are not.

- *Transport operator factors*; rail operators are seeing the value of stations that serve the car users.

- *Planning procedures and responsibilities*; while designed to protect the public and the environment, procedures are coming to be weighed in favour of the implementation and improvement of public transport. The tendency in democratic city to veer away from totalitarian control of transport infrastructure to fragment responsibility is something that impedes progress.

- *Conflicts of interest;* apart from conflicts that are resolved by public inquiries and planning procedures in general, there are examples of technical considerations overweighing an otherwise desirable development. Motorway traffic management militates against park and ride sites being placed at motorway intersections. Space and resources are inevitably limited and the role of the transport planner is to reach the best compromise.[1]

When addressing public transport from an ***intermodal perspective,*** the key points of attention are:[21]

- Integrated use of different transport modes;
- Efficient connections
- Improved coordination; and,
- Available information

Before any progress can be made in individual components of the public transport system, it is imperative that public transport as a whole becomes more accessible. Accessibility to public transport is determined by a number of quality components, as depicted in Table (1).

Table (1.1) Quality Requirements of Public Transport System [20]

Item	Parameter
System accessibility	• Needs of people with reduced mobility • Physical design of rolling stock • Design of intermodal stations • Link trip generators with public transport • Link rural and peripheral regions
Affordability	• Fare Levels • Socially desirable services
Safety and security	• Safety standards • Quality of lighting • Qualification of staff • Number of staff on duty
Travel convenience	• Journey times • Reliability frequency • Clean and comfortable • Information dissemination • Integrated ticketing • Flexibility
Environmental impact	• Emissions • Noise • Infrastructure

The view emphasizes the passenger needs and focuses on the coordination and interconnectivity of processes and information exchange as to offer passengers easy travel from origin to destination, independent the type of transport mode used. In other words, intermodal transport requires the integration of different transport modes in such a way that public transport run as a single service to passengers and as a single system. The effectiveness of the integration of the different components of the public transport system is the critical factor that determines the quality of intermodal public transport. To enhance public transport integration special attention should be given to the role played by stations in the efficiency of the system.[19]

1.1.2. The role of intermodal stations in offering sustainable mobility

Mobility has a direct link with social and economic progress, it may contribute significantly to improved life styles, enhanced social interaction and reduce poverty and social inequalities. Studies in the developed countries indicate that workers lack of mobility contributed to their inability to improve the work environments, wages and lifestyle. From a sustainable business perspective, the objective will be to expand mobility while minimizing its impacts. [13]

Developing an intermodal public transport system requires the efficient integration and interconnection of the different public transport systems. Terminals play an important if not critical role in the efficiency of the system and determine to a large extent the level of direct and indirect impact on the total traffic system. Stations play an important role in defining the intermodal access requirements and opportunities, long term urban form impacts, environmental and community acceptance and joint development opportunities.[20]

Since the design of stations is one of the more challenging and rewarding fields of practice today, most Europe is now adopting terminals (re)development polices providing station plazas with pedestrian friendly environments and intermodal facilities such as bus terminals and taxi stands constructed to enhance public transport integration. In addition the development adds commercial functions/ space to the terminals and is supported by improvement of traffic management in the surrounding area.

1.1.3. Impact of new technologies of transportation systems on station design

Part of the multimodal vision is to look forward to long range ideas and opportunities for modal options. As the time passes, technologies emerge and multimodal oriented design standards adjust the nature of land uses. Also as the community grows additional needs will be identified and additional transport options may become more feasible.

Of course today's cities and their transportation systems are much different than they were during the days when steam was king. Many alternative transit service options exist today; bus rapid transit (BRT), light rail transit (LRT), intercity bus and rail transit (heavy rail transit) and personal rapid transit (PRT). Other technologies emerged to revive intercity trains and which suggested that our concept of the role of stations need to be reexamined. For example, the station component of a high speed ground transportation system (HSGTS) should receive considerable attention, because if the stations are not located and designed well, the competitive of the high speed system will not attain its potential.[22]

There has been a revival of sorts in commuter rail and intercity transit services due to the suburbanization of metropolitan areas and resulting longer commute times and increased congestion on roadways. The train and especially the electric train (steel on steel or maglev) is actually a supremely frugal consumer of energy. The train offers the best "transport to energy" ratio (with respect to planes and autos), the majority of energy sources are associated with serious environmental problems, for example air pollution from the burning of oil and coal, the train is still the most friendly means of land transport. It is already possible to run electric trains using electricity from environmentally energy sources. Electric trains do not produce any exhaust gases. The train is also a frugal consumer of resources, since the use of materials is relatively small both for rolling stock and tracks. It also requires little land. The capacity of a two track railway line is equivalent to the capacity of an 18-lane motorway. Finally the train is a reliable means of transport, compared with road traffic, it causes much less suffering in the form of traffic accidents. [25]

Light rail transit is the modern form of what used to be called streetcars. Light-rail vehicles can operate on dedicated right of way (ROW) or on ROW shared with cars, trucks and buses. Other forms of urban mass transit exist, but it may be possible to put them into one of the technology categories above. For example, a monorail seems to be a unique transit mode, but it has some basic characteristics as heavy rail such as the separate ROW, another form is the automated guideway transit (AGT) which are likely to be found in the form of automated people movers (APMs) such as that used at large airports. An alternative to conventional transit and mobility paradigms is the application of rapid transit technology and systems, PRT is a network of small lightweight transit vehicles on raised rails, PRT acts as an individual demand responsive transportation service that is typically on elevated one-way guide ways connecting small stations spaced relatively close together. Lightrail, monorail, APM and PRT technologies are considered to be environmentally benign technologies, APMs and PRTs could provide the circulation needs inside the intermodal area. [6]

1.2. Intermodal Transport in Cairo

1.2.1. The problem in Greater Cairo Region

In developing intermodal transport in Cairo, one of the major problems that intermodal passenger transport is presently facing is the integrated approach. The European commission in its most recent White paper, summarized the problem(s) as follows:

> *"In passenger transport, there is considerable scope for improvements to make traveling conditions easier and facilitate modal transfers, which are still highly problematic. Far too often, passengers are put off using different modes of transport for a single journey. They have problems obtaining information and ordering tickets when the journey involves several transport companies or different means of transport, and transferring from one mode to another can be complicated by inadequate infrastructure".* [20]

The above comment could easily be made on the basis of the intermodal capability of the public transport network in Cairo, which suffer from a lack of convenient facilities, the absence of integration between modes and with exception of the Metro and ENR services, a complete lack of information dissemination. In developing intermodal transport in Cairo, the passenger transport is facing major problems, from an efficiency perspective the Greater Cairo Region (GCR) public transport modes (including privately operated ones) should be considered as parts of single public transport network.

Integration of public transport is at present absent because of: [19]

- Outdated and inefficient transport equipment
- A fare policy that is not integrated across public transport modes and does not reflect economic and business realities.
- The lack of efficient intermodal terminal facilities.

The results of the CREATS Intermodal survey clearly demonstrated that at present, there exists no intended intermodal public transport system and that only transport links are provided, without the necessary facilities to make these links efficient and effective.

From the perspective of the integrated transport system, it could even be suggested that the way public terminals in Cairo provide public transport does not solve any of the traffic problems but does actually add to the level of congestion. For intermodal efficiency, terminals need to provide infrastructure facilities such as private parking space, separate access lanes and dedicated stop. On average, public transport terminals are not designed from an intermodal service perspective and have poorly structured intermodal transport or no intermodal system at all. The system predominantly consists of shared taxis (microbuses) and public busses (or minibuses) stopping in the neighbourhood of these terminals to load and unload passengers. In several case of infrastructure works for- and structural recognition of public transport, intermodality was not an issue and mistakes were made in providing interconnectivity between the different modes, frequently leaving passengers with the feeling that the situation is deteriorated. [19]

Pedestrian safety condition in Cairo is terrible. Even a young and healthy man cannot walk safely in Cairo. Cars don't stop for pedestrians. Limited pedestrian safety facilities, such as Zebra crossings and pedestrian traffic signals, are installed in the city. 'Pedestrian first' should become to be a common sense. [19]

An intermodal system needs to be formulated in Greater Cairo Region, one of its requirements is the improvement of intermodal centres (stations). In this research, a number of representative terminals are discussed. In addition to a detailed description of the identified problems, intermodal solutions are proposed. It is clear that the proposed solutions as given in the sketches and layouts of intersections, squares etc. are conceptual and cannot be taken as final designs. Three types of interconnecting points (stations) are taken as example on how the interconnecting points should be rehabilitated or developed.

1.2.2. Developing Intermodal Stations in Cairo

Fig (1.1) visualizes the proposed public transport network in Cairo. As can be seen, the network is rail based, interconnecting the wings with the metro and supported by the LRT supertram of high quality and speed.

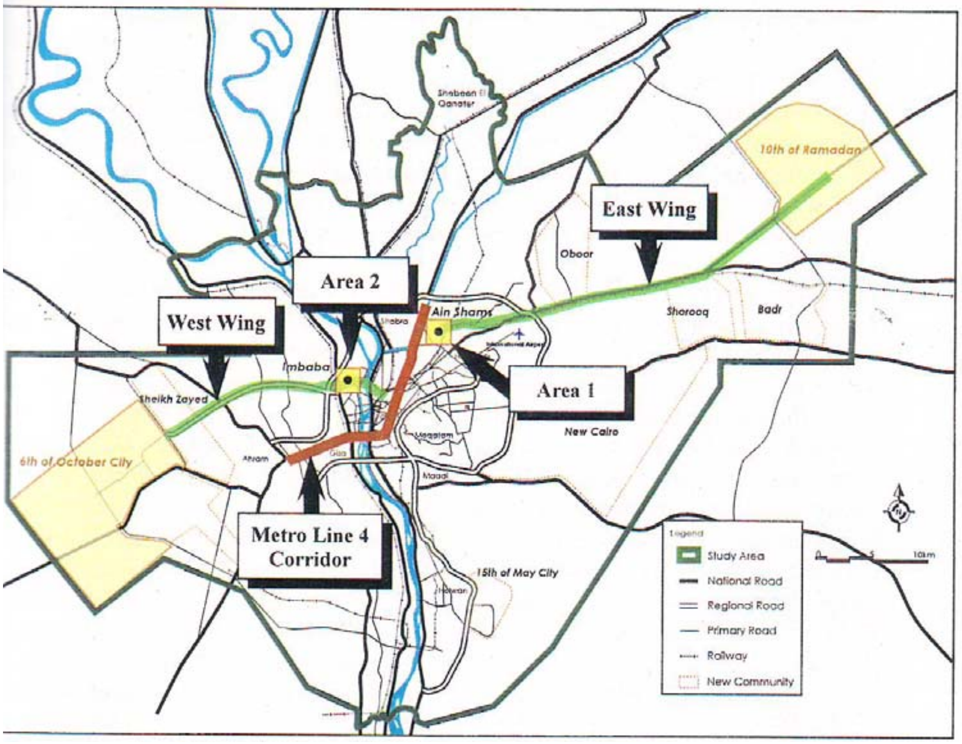


Fig (1.1) In 2012, the network will consist of three MRT lines, one supertram line and services to the satellite cities. [19]

The public transport service structuring is represented in the following networks:

- *The MRT network*

Rail-based mass rapid transit (MRT) is the corner stone for moving large volumes of persons in the highest demand corridors. Metro Line 3 is planed to run from the airport through Heliopolis to the centre of the city, and to branch to Imbaba and Bulak. Line 2 runs from Qalyub to Giza suburban. Line1 runs from El Marg north east of the city to Helwan south. Metro Line 4 (the Pyramid Line) satisfies a massive person trip demand corridor along Al Malik Faysal Street to central Giza and Cairo, and on Port Said Street and the ring road

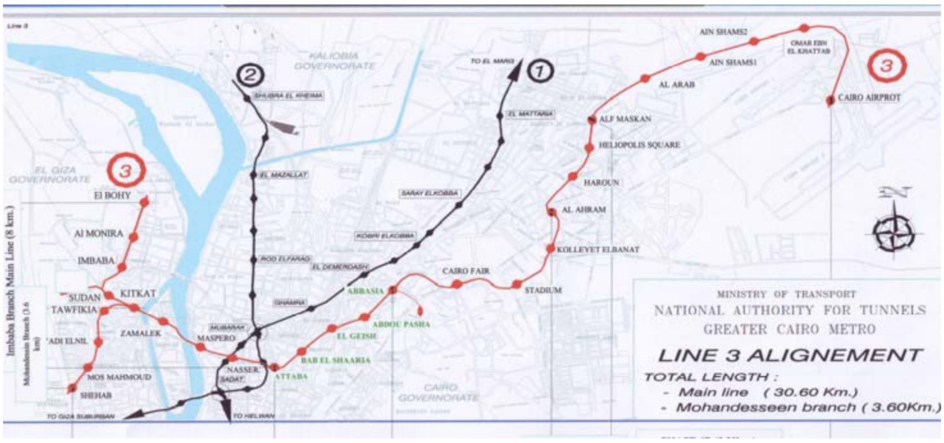


Fig (1.2) MRT Network in Greater Cairo Region [47]

- *The ENR suburban Lines*

The ENR suburban lines services is expected to extend in future in light of growing urban densities and gradual maturity of the satellite cities program. The existing suburban commuter rail lines are to be upgraded to provide enhanced service and comfort. This improvement is to focus on new rolling stock and upgraded stations.
Two new rail corridors are proposed linking Cairo with the 6th of October and 10th of Ramadan Cities (the wings). The 10th of Ramadan connection from Ain Shams Station will in the near future, consist of a single track upgrading with station turnouts, new stations, an extension of 10th of Ramadan central area, and modern diesel rolling stock. In longer term, and as warranted by demand, upgrading to double track-electrified service is possible. All improvements would maximize the use of ENR existing right of way. The 6th of October service could also ultimately consist of Dual-track operation between sixth of October city and Ramses station. However, all rights of way must be reserved immediately for this venture, with early indications favouring an alignment near Alexandria desert road.

While Rail transit systems in Egypt represents 37% of passenger trips, however there are many problems affecting passenger trips at rail stations represented in; the poor state of platforms and station buildings, number of platforms and their capacities are insufficient especially in terminal stations, unavailability of some types of concessions and the poor state of some of them like restaurants and toilets, unavailability of sufficient parking areas and unavailability of modern information systems.[43]

▪ *The tram network*

The light rail network (tram, Heliopolis Metro) has despite its high potential as an efficient mode of urban transport declined from near 400 route kms in 1971 to 226 route kms at present, and its components have been abandoned over the years.
In support of the MRT network and to enhance transport network between suburban sub-centres, the realization of three Supertram Lines is proposed in the CREATS study for the Cairo Region. These lines function as regular LRT systems. Supertram Line 1 runs from Ramses Square to Nasr City and ultimately ends in New Cairo. Supertram Line 2 connects Attaba with El Nozha. Supertram Line 3 connects Nasr City and Heliopolis with Port Said Street, as well as intermediate intermodal points with ENR, buses and Metro.[19]

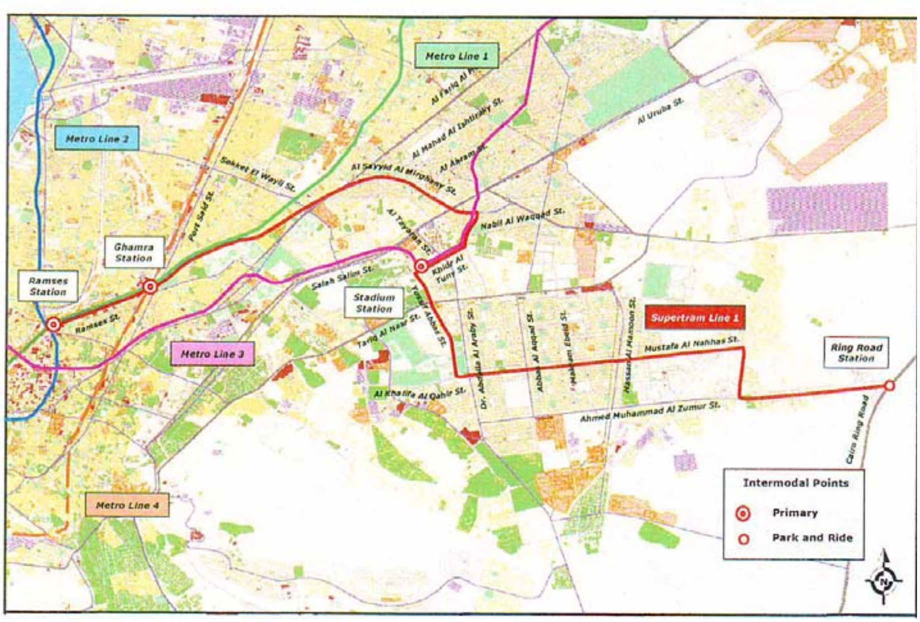


Fig 1.3. Supertrame Line 1 in An Intermodal Context [19]

▪ *Innercity bus network*

Formal bus services have suffered erosion of market share, the liberalization of regulations pertaining to private sector participation in public transport operations continue to create market opportunities for the informal bus sector. Microbuses are more accessible within a short walking distance than some formal services, nevertheless, they create a number of transport problems.

Figure (1.4) includes important interconnecting points on the network and categorizes these intermodal connections.

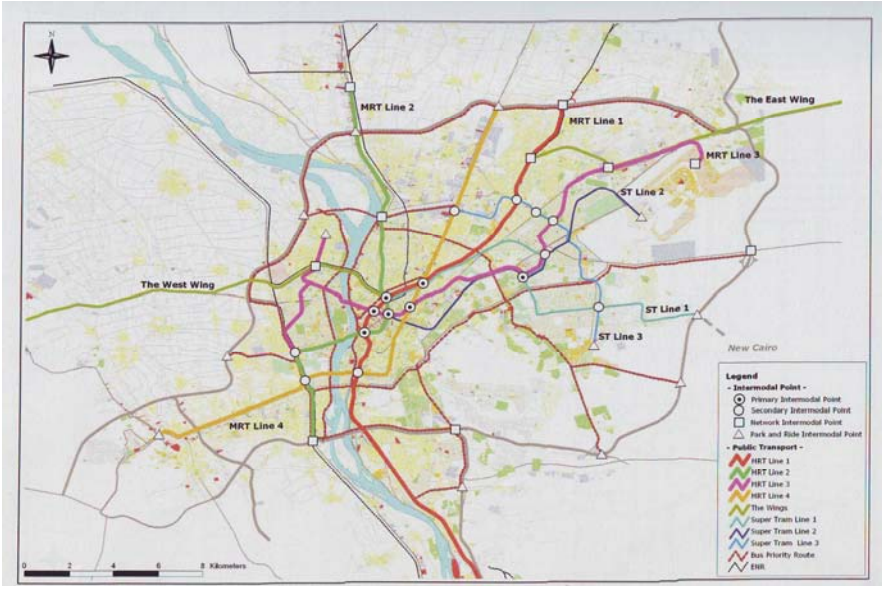


Fig (1.4) Public Transport Network and Example Terminals [19]

Located at the western extreme of Supertram Line 1 within Ramses Square, Ramses intermodal station is a critical station in the intermodal system, new designs have been conducted for the Ramsses intermodal which incorporates sustainable issues. A number of transport facilities exist within Ramses Square including one of the main ENR stations, elevated pedestrian walkways, and entrances to the underground Cairo Metro (Mubarak station, Metro Lines 1 and 2). A series of changes had been implemented under the auspices of Cairo governorate involving road closures and the relocation of shared taxi and CTA bus facilities from within the Ramses Square area to a new public transport terminal located immediately North of the ENR tracks. Major road facilities within the square include Ramses Street and the elevated 6th of October Expressway.[21]

The Ain Shams station area is expected to be one of the most important stations of the east wing in future. Ain Shams is a terminal of the Suez line of the ENR. Ain Shams station of Metro Line 1 is adjacent to the ENR station. Passengers heading to Cairo should transfer from ENR to Metro Line 1 at this station. The surrounding area of Ain Shams station will attract a large number of passengers after completion of the east wing public transport development.

Ring road station, the proposed park and ride example of Cairo intermodals, is the eastern terminus of Supertram Line 1, is located eastern Madinet Nasr near the intersection of Ahmed El Zomor Street with Cairo Ring Road. This intermodal station is expected to be an excellent opportunity for realizing a multi-use development combining both transport and commercial functions.

An intermodal station is planned to exist at Cairo airport where Metro Line 3 terminates, this will be the first of its kind in Egypt where airport/railway interchange is proposed.

1.3. Sustainable Issues in the Design of Intermodal Stations

The intermodal station is a part of city life, locked into its dense network of central facilities, it is both a city square, and part of what should be a smooth transition from public street to a seat on a transport mode. As the station is part of the compact central infrastructure of most large towns it has to be readily accessible for the flows of people using them, where rites of passage are celebrated in new forms of structure, new arrangements of interior space, and new methods of handling such large flows of people. Most countries are adopting terminals (re)development polices providing station plazas with pedestrian friendly environments and intermodal facilities such as bus terminals and taxi stands constructed to enhance public transport integration. In addition the development adds commercial functions/ space to the terminals and is supported by improvement of traffic management in the surrounding area.

Sometimes intermodal station buildings will occupy several stories and contain a mixture of uses, some of which are not transportation related. They should consist of a complex of links tailored to provide as smooth a transition as possible between various areas providing different types of transportation and other services. This suggests that the form they take, along with their multiple functions, should be determined by considering their multiple purposes, the connecting modes to be integrated, the characteristics of the people likely to use the station and the type of location in the city that has to be selected.

The approach to design sustainable stations is based upon an understanding of traveler needs and passenger concerns balanced by good proportion and skilful handling of exterior and interior volumes. There is general agreement across all stakeholders about the high importance of safety/ security, information to passengers, car parking facilities, buying tickets and waiting for modes in reasonable comfort, the intermodal station project should comprehensively address the ecological, social and economic issues in the context of its surroundings.

In brief, in order for the intermodal station project to attain its potential, the sustainable approach would be to concentrate on; successful modal connectivity in the intermodal area, ensuring safety for traffic and pedestrian circulation, assessing the environmental design requirements for the intermodal project, ensuring equitable passengers services, and revitalizing economically healthy downtown areas and suburban centres.

1.3.1. Intermodality and Layout Planning

The efficiency of intermodal terminals and stations is a critical intermodal success factor. The nature of the intermodal definitions concentrates on the physical interaction of transport modes at intermodal terminals and stations. The physical and operational actions at such terminals include; the physical layout of the terminal, segregation of different modes of transportation in intermodal terminals which can result in far greater system efficiency, the information management, the ticket distribution system and platform accessibility, these are equally important and are determining factors for the intermodal station layout. Station plazas with pedestrian friendly environments and intermodal facilities such as bus terminals and taxi stands enhance public transport integration.

1.3.2. Pedestrian safety and convenience

For public transport user walking is indespensible. Walk forms the dominant access mode across all trip purposes. The design of transportation facilities significantly affects traffic and pedestrian safety. Segregation of slow from fast traffic, careful design of intersections to maintain good sight distances to reduce turning conflicts, and to channelize traffic to enhance predictability of flows can all reduce safety problems while improving operational performance. If stations are to attract more passengers, the access needs of impaired passengers, must be taken into consideration, also location of ticket offices and booths, operational practices technologies represented in speaker phone systems and audio signals and their location.

1.3.3. Environmental Preservation

Land obviously is an essential and valuable resource, so its appropriate use is a prime consideration in the development of a high performance station building. Building on land that has been previously utilized, developing brownfields that are contaminated and grayfields that were once building sites is valuable from an ecological point of view. The reuse of existing station buildings instead of constructing new ones, the use of native and adapted, drought-tolerant plants, trees and turf for landscaping are another issues. Energy efficiency in design of station buildings and water conservation are critical factors as green building is achieving rapid penetration in the construction market. Energy efficiency in design should be enhanced to various degrees, should utilize passive solar techniques to reduce energy consumption as well. Design studies suggest that considerable energy savings can be made by maximizing natural light and ventilation.

1.3.4. Equitable People's Mobility

Equitability is closely related to welfare policy, therefore coordinated policy persuasion with welfare policy is necessary. In longer term, barrier free facilities should be equipped to assist handicapped and aged people for convenience at stations and terminals such as slope, lift toilet and so on vehicles which are friendly to those people would be one of the additional options.

1.3.5. Economy

Advertising in major public transport terminals and stations provide both ample surface area for the display of advertisements. *Retail concessions* in stations and terminals can also be designed to accommodate feasible space for small businesses catering to users, including convenience stores, branch banks, and automatic teller machines (ATMs), coffee shops and snack restaurants, newspaper and magazine vendors. *Park and ride* represented in commuter parking facilities are also a potential source of revenue for mass transit operations.

In many ways the larger the stations the more crucial are civic considerations. Franchising companies running the station as real estate need the public in order to support shops and restaurants, but paying for stations to serve as public bridges linking areas of towns offers little commercial advantage. When stations were automatically viewed as part of public services, such conflicts of interest did not occur. If the station becomes not public estate but private property, only transactions involving money will be tolerated.

1.4. Conclusion

The construction of intermodals could lead to an improvement to city environment this can be seen in the improvement in the quality of city life. Thus the whole system should be designed taking into account the need to integrate it into the urban fabric, a fundamental factor of the design from the inception of the project. Stations are a question of movement between the scales of modes speeds and human speeds. They are points of interchange in journeys, of breaks in mode and technologies and designs. The transition from the train to the platform and thence to the car, bus or cycle is a movement through technologies and designs.

The provision of both clarity and safety are prime considerations in station design, environmental requirements for energy efficiency, better indoor environmental quality and water conservation are of great importance. Another important topic is the commercial facilities such as advertising retail outlets and so on, thus can enhance the experience of passengers but only if they do not create an additional stress on the journey by getting in the passenger way. Distances between station facilities should be short, measures must be taken to improve access at station which is extremely important to the overall journey.

The research highlights the design issues which should be considered when designing sustainable intermodal stations;

- Intermodality and layout of the intermodal station, this issue focuses on successful the physical interaction between the different transportation modes, circulation needs within the intermodal station area and the separation of movement.

- Safety requirements for traffic and pedestrian circulation; this issue focuses on vehicle and pedestrian guidance, crossing safety, assessment of different levels, safety design of platforms and loading bays, entrance and exit control and safety issues in the design of parking facilities and platforms.

- Environmental requirements for station structures; since the impacts of buildings on human health is substantial, this issue focuses on air quality, lighting quality, noise, temperature, humidity, odors and vibration. Sustainable design incorporates natural lighting and ventilation, landscaping, and reuse of construction materials to achieve savings in energy, water and material resources.

- Public amenities at passenger activity spaces; this includes security and fire protection, passenger information systems, passenger service facilities, ticket offices, aesthetics, design for the physically handicapped, and maintainability and economic efficiency.

Priorities and goals are set, this include:

- ***Intermodality;*** provide convenient intermodal facilities and services offering seemless connections for passengers.

- ***Pedestrian safety and convenience:*** Create and maintain safe and attractive walkable communities to encourage more walking trips, enhance transit usage, improve public health.

- ***Environment:*** Protect and inhance the quality of the environment

- ***Equity;*** Ensure that the intermodal station project serves the passengers regardless of race, income, age, mobility impairment.

- ***Economic development;*** Support a vigorous economy by facilitating the multi-modal movement of passengers, and achieving economically healthy downtown and suburban centres.

CHAPTER II

Chapter 2

The Sustainable Design of Intermodal Stations

2.1. Introduction

In past, station buildings were designed to handle passenger movements along one axis between platforms and the forecourt. As recently as more than 50 years ago stations forecourts were no more than station approaches along which travelers plied to and fro, and where people would either take leave of their familiar surroundings or return from afar. Given this dominant axis within the station, passengers and their visitors have little trouble finding their way about.

The picture is different today, large stations are interchange points for a number of different modes, providing for connections between intercity trains, urban transit busses, autos, bicycles/motorcycles, taxis and rental cars. This means that there is now a correspondingly high number of traffic flows within the station complex, sometimes running at different levels and using different routes, thus the traveler or visitor can no longer see exactly where to go, a uniform and comprehensible information system is needed that is very easy to use.

As the construction of intermodals could lead to an improvement to city environment which can be seen in the improvement in the quality of city life, thus the whole system should be designed taking into account the need to integrate it into the urban fabric, a fundamental factor of the design from the inception of the project. The designs should take into consideration the needs of the existing urban fabric as well as its architecture and landscape. Intermodal stations should be in a good central location, a position where bus and road access is direct in the suburbs and where the interchange is easy with all forms of public transport in a large city.

The choice of site also opens opportunities for subsequent urban design or architectural expression.[10] Many railway stations buildings date from a period when the railways had a captive market, for a few or no alternative forms of transportation were available. This meant that the traveling public was less demanding. Today the customer has many options available. High speed rail or maglev travel will have to complete with several other options.

Modern transport interchanges involve complex human transactions where perception is as important as reality. Being able to read a key route, to identify the right escalator, to know the direction of mode, to be guided to the right platform is not about signage but about architectural design. Movement and urban linkage for its own sake, are essential components of station function. Where it remains a good design is essential to allow passengers to distinguish between elements of stations that are merely to do with the matter of connecting urban tissue and those that are to do with guiding travelers through stations on route to the mode.

Stations are dangerous places for staff and passengers, the danger stems from modes themselves, from the pollutants that flow from modes to stations, from the dangerous nature of station structures and from the risks to personnel safety from antisocial human behaviour. [5]

The designer's task is to reduce these concerns to a minimum. Effective safety design needs to address station layout, management and training of staff, care over maintenance, lighting and surveillance. Many accidents are the fault of poor strategic design (such as placing trolley stands near staircases), poor detailed design (such as badly positioned lighting), poor management (such as allowing litter to collect), and poor maintenance (such as not repairing broken windows), designing out all risks can lead to dull station architecture. Safety planning is a matter of balancing risks against real costs in financial terms. Risk evaluation is part of the process of design. Accidents such as falling onto tracks from platforms, accidents at stations due to vandalism, personnel attack, and slipping on wet station surfaces, can be reduced by better design. [5]

Greenery is a practical consideration to the reduction of traffic stress, planting, particularly, tree planting softens the space between the buildings enhancing aesthetics, cooling out the habitat in the summer, increases community pride and increases property value.[14]

Light, especially natural light, has the benefit of focusing attention upon important spaces, such as booking halls, or of leading passengers towards platforms and entrances. Structure and light are two elements that need to be considered in unison. How light strikes a surface and highlights a detail, how it throws structure into stark relief, are necessary concerns of architects. It is the role of architecture in stations to guide passengers to avoid the use of signs and direction boards. A solution employed with underground stations is to deflect natural light down into the underground station by using glass walls or reflective shafts of translucent material. Such walls, set sometimes at angles, run from above the ground to platforms some distance beneath. Deflected light is generally easier to manipulate than artificial light, and gives a more wholesome quality to subterranean transport.[5]

Providing passive ventilation in station buildings minimizes energy consumption. A green building would use very little energy, and renewable energy would be the source of most of the energy needed to heat cool and ventilate the structure. Proper design of a building's heating ventilating, and air conditioning (HVAC) system is perhaps the most important approach for providing a healthy indoor environment.[16]

Stations need to provide psychological reassurance for passengers often disoriented by the complexity of modern travel. Station forecourts are now required to have the closest possible links with the area served by the station. Currently, commuters will very often be virtually unaware of the boundary at which the station ends and the city or suburb begins. Sustainable station design ideally provides perceptual markers, which travelers can use to orientate themselves, and which through the use of structure, space and light also uplift the spirit. Waiting areas need to provide shelter, comfort amenity and travel information.. *Concessions* such as coffee shops, refreshment counters, shopping arcades in a comfortable and safety planning can be a lucrative source of income and are expected to lead to improvement of the community

Information displays must be visible, installing wayfinding signage and installing shelters at transfer points providing short term parking spaces where possible all improve intermodal transfers.

Designing stations to be freely accessible to disabled people is a concern at all stages in the evolution of new stations, their requirements should influence the whole station concept.[5]

2.2. Intermodal Station Planning and Layout

2.2.1. Types of station locations and modal interchanges

A) Multiple railway station/ bus and coach/car interchanges)

- ***City centre station locations***

In general the remodeling or rehabilitation of an existing city centre station can be considered to be easier than designing a new city centre station because it is so constrained by existing conditions and known limitations, both on and off site, this means that several options for improving the station can be ruled out from the beginning of the design process.

The design of new city centre station presents some difficulties that are somewhat greater than those presented by an existing station. Site selection problems can be expected to be quite difficult to solve as there are so many different interest groups that will strongly advocating their favourite site. Assessing the likely impacts of the new station and its activity pattern on its surroundings, connecting the new station with modes that are not currently present at the selected site Joint development at a centre city site all present special problems depending on the reactions of competing owners and developers of existing and planned buildings.[22]

- ***Suburban, fringe and rural stations***

Suburban sites, both existing and new, can be expected to present fewer problems to the station designer than do centre city sites. There are fewer constraints to deal with, more space available because of lower existing development densities and they are likely to be fewer, less well-organized, interest groups to deal with. A big problem with these sites will often be how to accommodate the large number of autos that are likely to be used for access to the station while also trying to get some large scale developments built adjacent to the station. Automated people mover systems offers some specially attractive solutions to making this difficult trade-off. [22]

B) Airport/railway interchange(close in/ distant) stations

International and second level airports pose many special challenges for transit station designer. In those cases where it is desired to integrate the high speed facilities directly into the existing terminal, considerable care has to be exercised as only very minimal disruption to the ongoing operations of the airport terminal can be tolerated. The constraints present in the area around many airport terminals are significant. Land prices are often quite high and difficult traffic congestions problems and community opposition to further expansion of the airport (because of noise and air pollution) can be expected. [22]

2.2.2. Site evaluation criteria of intermodal stations

The site evaluation criteria for the intermodal station location would include the following: [22]

- ***Proximity to major facilities and destinations***

The overall intent is to describe how easy or hard is to reach highway facilities and important destinations from a particular station site. This includes: freeway interchanges, major arterials, international airport, second level airport, hotels/restaurants, major employment centres, major shopping centres, and residential areas.

- ***Community Impacts***

These evaluation criteria categories are particularly difficult to deal with yet they are very important to the public, they include; perceived safety and security in/ around station, conformance with local comprehensive (land use) plans, functional compatibility with existing land uses in area, urban design integration potential, visual intrusion/ integration potential, non-monetary socio-economic benefits, and possible land acquisition problems (eg. use of eminent domain).

- ***Environmental impacts and traffic mitigation***

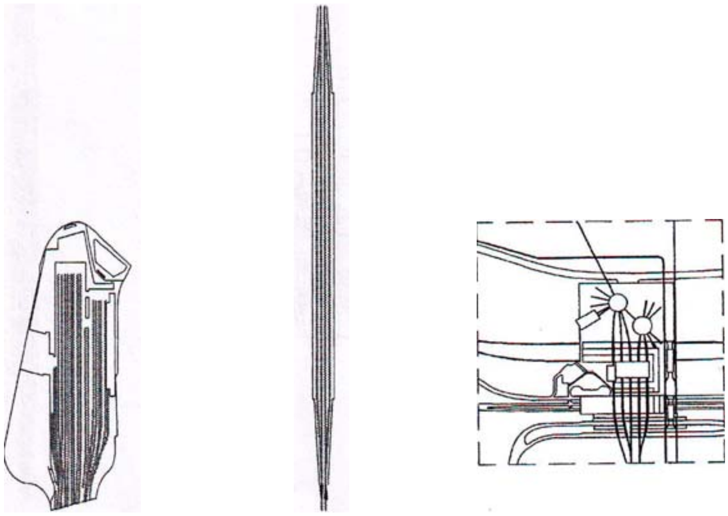
The Environmental Impacts include noise, air quality and water quality concerns. Traffic Mitigation will deal with the local traffic capacity improvemet required (eg new signals., larger intersection capacities, new freeway ramps) and traffic safety improvements required If the station has the potential for becoming a major ground transportation access hub, the auto traffic impacts can be expected to be of considerable significance, such impacts will depend largely on the size of the parking facilities that are to be provided at or adjacent to the station, the more parking that is provided, the greater will be the impacts on the surrounding community.

- ***Potential funding sources and costs***

Many station projects will include a joint development component that will make the assessment much more complex than it has been in the past. If the station is to provide facilities for several different connecting modes, some of which may not be owned or operated by a public agency, additional complexities will be encountered in making the evaluations for these participant criteria. A major issue has to do with defining land development projects at station location that will be attractive to the developers and lenders that will undertake them, tax base enhancement can occur in a variety of ways.

2.2.3 Impact of System Technology on layout of Stations and their surrounding communities.

There is an impact of system technology on the location, design and intermodal connectivity of stations. Clearly there is a strong relationship between the type of vehicle technology and the design of the station components. Two high speed technologies are practiced around the world; these are; the steel wheel on steel rail eg The French TGV and German ICE high speed rail system, and the small magplane (maglev vehicle) in the United States. The station of the French TGV and German ICE high speed rail system would be long and narrow as the large platforms lengths (400 to 480 metres) required by the TGV trains determine the size and shape of the station. In contrast a small magplane (short train) system whose vehicle size might be about 30.5 metre long, and the maglev vehicles operated at very frequent intervals, there is no need for the very long platforms that are needed by high speed rail stations, a greater number of platforms would be needed in a maglev station since there are likely to be several magplanes arriving and departing every few minutes. Figure (2.1) shows a comparison between a TGV station and a maglev station and a conventional rail station.



Conventional rail TGVstation Maglev Station

Fig.(2.1) Comparison between Conventional Rail, TGV Station, and Maglev Station

It is clear that both high speed technologies have a noise problem that is associated with the movement of their vehicles at a high speed. At lower speeds, magplanes would probably be much quieter than rail vehicles. Another consideration is to assist the attainment of air quality goals designed to reduce vehicle miles of travel (VMT) and traffic impacts of such stations on the community. The provision of a full complement of connecting modes would be economically feasible in large high speed rail stations. The non auto modes would have to be developed as the provision of adequate parking would not be easy in city centre locations and would have a traffic impact on the surrounding community. [22]

2.2.4. Providing circulation needs within intermodal station areas using environmentally benign technologies

Some way need to be devised to mitigate the congestion and parking problems that an intermodal hub generates. Circulating buses and vans often cannot offer frequent and fast service to and within these hubs because of slow roadway speeds and very significant signal delays at most intersections. Moreover, these vehicles add to the air pollution problem and have high continuing labour costs.

A high tech bus/van alternative should be formulated and evaluated for example, a clean fuel vehicle with high tech on-board and on-street electronics, reserved lanes, priority signal controls and special loading facilities. In most cases buses and vans would also require special elevated facilities and they would be quite expensive and difficult to build in highly congested areas or adjacent to existing stations. What is needed is a circulator system that would produce reductions in congestion and delay, air pollution and parking problems, especially near the ground transportation hub. Several technologies exist today that could be used to provide such a service. Many are currently providing circulation services within airport terminals.

A number of Automated People Mover (APM) systems are now in passenger service in several countries of the world. The operating mode of most APM systems is scheduled with short frequencies during peak periods. Many of the systems provide only shuttle/ loop service. Some systems operate single vehicles and other can employ trains of up to six cars. Vehicle cruise speeds range from 11kph to 60 kph. Most systems can handle grades up to 10 percent. At slow speeds, the minimum radius of curvature is 6 to 10 metres.

The circulator system is reasonably fast in congested areas, have very short waiting times, be environmentally benign (quiet, non-polluting, visually appealing), safe and secure, reliable, convenient easy to build (without significant construction time and disruption) and be reasonably inexpensive to construct, use and maintain.

A much shorter APM could be designed that does not provide for general internal circulation trips in suburban activity centres but only caters to people trying to get to/from the rail station, it could connect the station with various parking or other bus van facilities that are located close to but not directly adjacent to the station. Patrons could then make a relatively seamless transfer and a short trip to the main platforms of the rail station. The low cost, reasonably swift capacity sufficient and less visually intrusive technologies of APMs are: cable drawn systems, monorails and personal rapid transit systems (PRTs). [22]

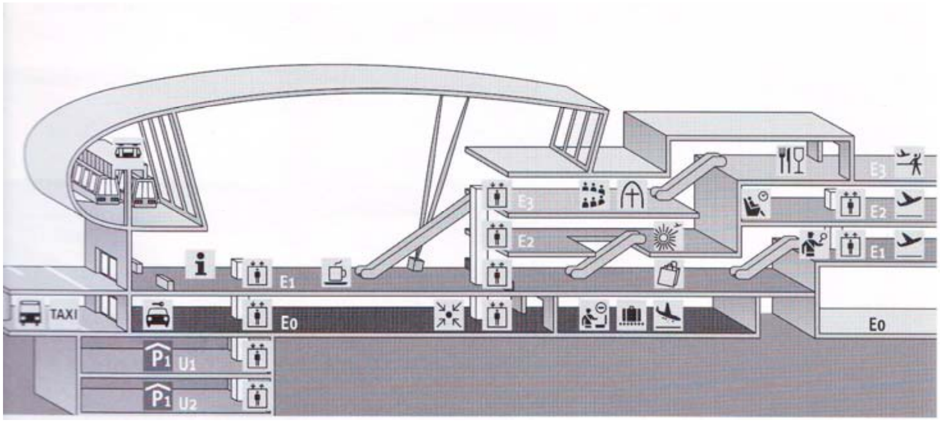


Fig (2.3) A 2.5 km suspended monorail people mover, which runs literally through the terminal, Dusseldorf International Airport, linking the national railway station to car park and terminal building. [1]

Fig (2.4) People mover linking national railway station and bus interchange to terminal building, at Brimingham Airport . [1]

2.2.5. Separation of movement at different grades. (Vertical separation)

Design solutions adopted for the intermodal system varies, these can be divided into four groups of clearly different consideration, grade level, below grade, cantilevered and tunnel.

The first solution where the traffic is on street level is the one which has the greatest impact on the surrounding area which can be overcome by constructing bridges. The second solution below grade in an open trench, this leads to a clear separation between two types of roadway since the central expressway is sunk below street level and the lateral lanes are on the same level of the surrounding areas. This solution obviously favours the integration of pedestrian and traffic bridges, making it possible for them to fit seamlessly into the urban structure.[4]

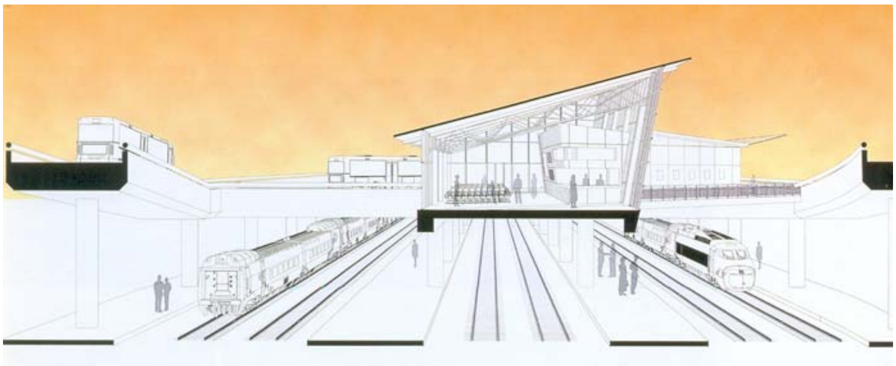


Fig (2.5) Section train and bus station at St Louis Gateway Transportation Centre Missouri USA, A two level building raised as a horizontal structure over the train tracks to provide the buildings accessibility, an adjacent elevated street is extended, so giving space for city bus station.[17]

When the terrain makes this solution Impossible the space available on the lower level is reserved for the central trunk and the lateral lanes are inserted on an intermediate level taking the form of a cantilevered structure supported by the containing walls. This cantilevered technique also creates an effective barrier which attenuates the traffic noise. Finally the tunnel solution used in the areas suitable for this design is perhaps the one which offers the best possibilities of integration into the surroundings since the strategy of entirely covering the road frees up new spaces for public amenities.[4]

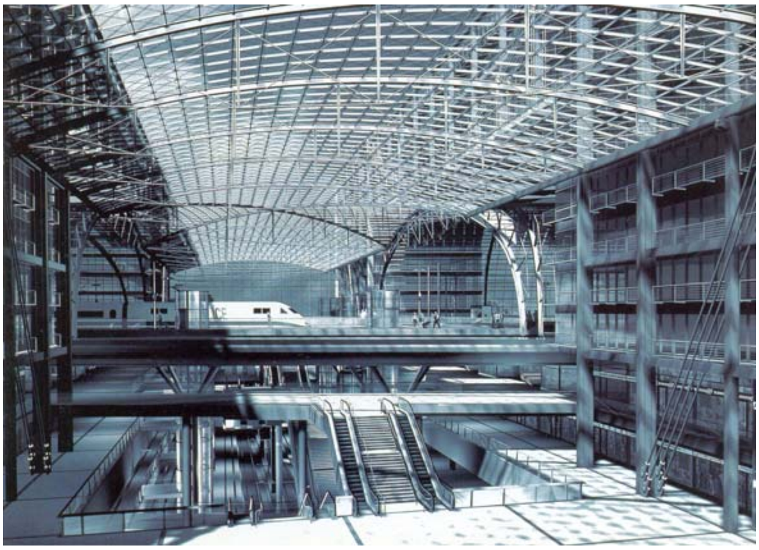


Fig (2.6) Lether Station Berlin Germany, tracks for city train and high speed trains 10 m above street level, taxi bus car and pedestrian crosses at street level and 15 m below the subway and high speed train tracks. The central hall 170 m by 50 m makes the extensive use of glass and steel construction to allow as much daylight as possible to penetrate to the lowest floors. [17]

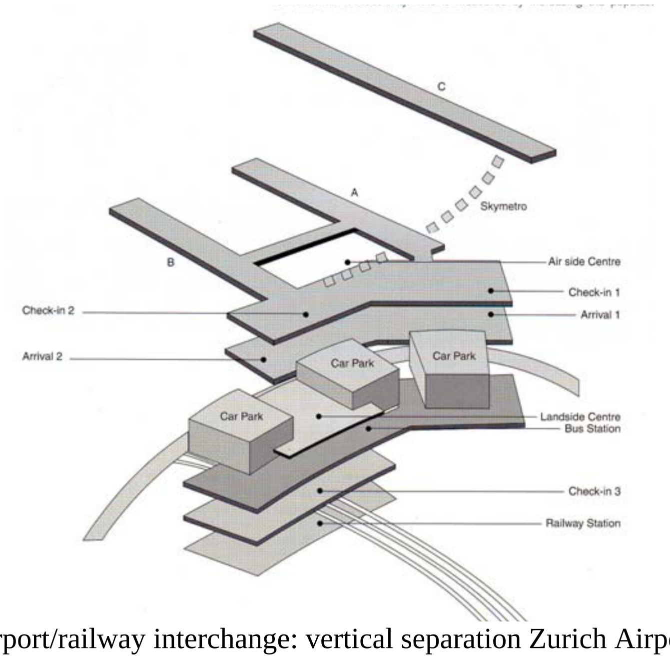


Fig (2.7) Airport/railway interchange: vertical separation Zurich Airport.[1]

2.3. Safety Requirements for Traffic and Pedestrian Circulation

One of the most critical safety problems in any street system involves the interactions between vehicles and pedestrians as in any contact between a pedestrian and a vehicle, the pedestrian is at an disadvantage. Intermodal stations which provide connections to commuter trains and numerous bus lines, are often heavily used and located in commercial areas, thus safety requirements is a main concern in the design process. [15]

2.3.1. Vehicles and pedestrians guidance

Pedestrian circulation improvements linked to mass transit access offer the opportunity to reduce vehicular congestion and improve air quality, moreover, improving security and safety. The type of improvements that may be implemented include signage, lighting, signal timing adjustments, pavement markings, corner clearances, and curb line changes where necessary.

A) Channelization

Lane arrow and line markings are used to help the road user select the appropriate lane in advance of reaching a queue of waiting vehicles and guide motorists to appropriate traffic lanes. *Stop lines* should be used to indicate the point behind which vehicles are required to stop in compliance with a stop sign, traffic control signal or some other control device.

Speed Humps and Speed tables should be constructed to create vertical constraints on speed at locations where high volumes of pedestrian activity exists.

Channelization Medians are often painted and are either located in the middle of the roadway or adjacent to a sidewalk. If the median delineates excess roadbed and is adjacent to a sidewalk, it may be recommended that a curb be constructed in order to increase pedestrian queuing space.

Pedestrian Refuge Island either painted or raised, however, raised pedestrian refuge islands provide safety benefits than painted islands. It is recommended that such medians be extended into the crosswalk to maximize pedestrian refuge space. [36]

B) Crosswalks

Different cross walk designs are used to direct pedestrians such as standard crosswalks, high visibility crosswalks and ladder crosswalks.

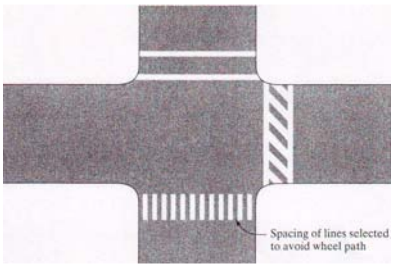


Fig (2.8) The three types of crosswalk markings, the most frequently used the two parallel white lines. Cross-hatching to provide greater focus in areas with heavy pedestrian flows. The parallel transverse markings is another option with heavy pedestrian flows.[15]

C) Curb alignment

Pedestrian Ramps provide access to the sidewalk and street for wheelchair-bound people and people with strollers and carriages. Every street corner by law must have a pedestrian ramp in order to improve access to the sidewalk network for all users.

Neckdowns extend into the roadbed, typically into a parking lane, adding pedestrian space for bus stops, subway stairs and elevators, queuing capacity for waiting pedestrians, pedestrian ramps, street furniture and fire hydrant access. [36]

Fig (2.9) Shade canopy and neckdown at Ronstadt Transit Centre, Tuscon, Arizona, USA, [18] *For Hire Vehicles (FHV) and Taxi sidewalk stands and signs* must not extend farther than one third of the width of the sidewalk. They must not unduly interfere with pedestrian circulation or unduly conflict with street furniture or the design relationship with their surroundings

D) Signal timing

Pedestrian walking speed in crosswalks is the most important factor in the consideration of pedestrians in signal timing. Walking speeds ranges between 1m/sec to 2m/sec according to the age and gender, and for physically impaired pedestrians between (0.9 and 1.25m/sec), according to these figures signal timing should be adjusted to 40 seconds. At unsignalized crossing locations, gap acceptance behaviour of pedestrians is another important consideration. *Gap acceptance* refers to the clear time intervals between vehicles encroaching on the crossing path and the behaviour of pedestrians in 'accepting' them to cross through. [15]

E) Orientation signage

Transit orientation: Some subway stations have signs near their exits that indicate the locations of bus stops. This signage is important for pedestrians making intermodal trips because they help pedestrians locate their appropriate exit, thereby limiting their contact with vehicles. Additionally, in order to ease transfers at intermodal stations, subway, bicycle and neighbourhood maps should be installed at bus shelters near large intermodal subway stations.

Destination orientation: Some of the stations are located near tourist sites or other destinations that attract people who are unfamiliar with the station. These pedestrians unlike the regular commuter, are not familiar with the local area and would benefit from destination orientation signage.

Fig (2.10) Orientation signage at bus station entrance with lift from underground station, Heathrow Airport Terminal [1]

F) Floor finishes

Floor finishes help define routes and the transition between the main functional zones of the station. Brick paving, non slip stone finishes, terrazzo and textured ceramic surfaces could all be used to guide travelers at both perceptual and practical levels. Finishes that are robust and easy to clean are essential. [5]

Fig (2.11) Identifying the edge of platforms with changes in texture and pattern is an important safety factor, Gyeongbokgung Station.[10]

2.3.2. Crossing safety at intermodal stations

Passenger bridges are generally preferable to pedestrian tunnels as a means of crossing over the tracks to distant platforms. They are usually cheaper to build and offer greater amenity than artificially lit tunnels.

Bathed in sunlight footbridges are important station landmarks, making them easier to find than tunnels. The natural light and external views give those using bridges a greater sense of direction than those crossing the tracks by other means. Footbridges should be located near the centre of platforms not far from the entrance to ticket offices and should be provided with ramps and lifts. (5)

Fig (2.12) Crossing the tracks on bridges provides welcome views, and is generally more elegant than tunnels [5]

Fig (2.13) At St. Exupery Station, the low level platforms are bathed in rhythms of sunlight taken down through breaks in the roof canopy [5]

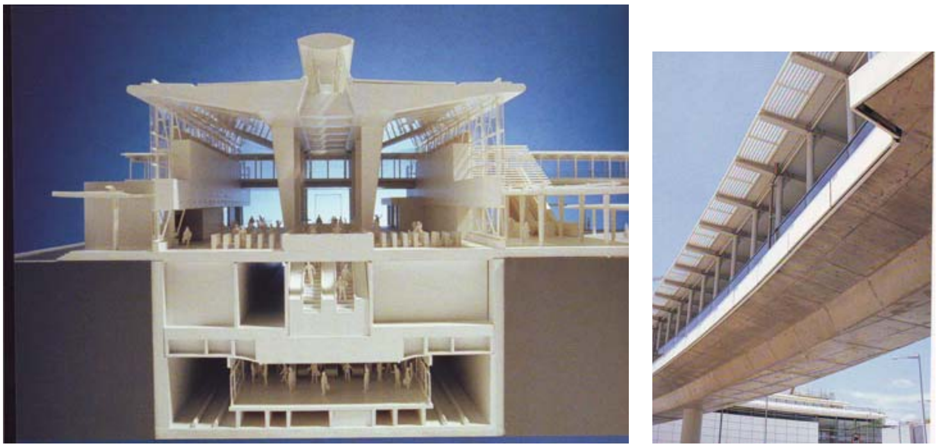


Fig (2.14) Footbridge at Tung Chung Station, Lantau, Hong Kong. Left, Sectional model, footbridge in the back ground penetrating the station. Right, view of the footbridge linking up the town square and station enclosure. [8]

2.3.3. Accessing other levels (stair design, ramps, lifts, escalators)

Vertical transportation at stations in city environments is almost as important as horizontal transportation provided by transport modes. Any station not easily accessible on the surface and which requires stairs will nowadays require lifts for the disabled. Stations with a height difference between levels of more than 4 to 5 metres will probably need escalators as well. Escalators are expensive, so the number of passengers using the facility must be at a sufficient level to make them worthwhile. Both lifts and escalators are high cost maintenance items and need to be kept in good condition. They require mandatory regular safety inspections.[38]

The siting of lifts and escalators is important. Passengers have to queue to board them so there must be space at the boarding point to accommodate large numbers of people at busy times. Such areas must be kept free of obstructions and not be too close to platform edges. Most countries require an evacuation standard to be applied to the number and location of stairs and escalators. This enables the station to be cleared safely in the minimum time.[38]

Fig (2.15) A sense of opening linkage with escalators and glass stairs, securing stability and endurance as a public space (notice the steel bars at the escalators sides) Noksapyeong Station. [10]

Fig (2.16) View of escalator, Albando Passenger Interchange, Bilbao, Spain, Bilbao Metro. [18]

2.3.4. Design of platforms and loading bays

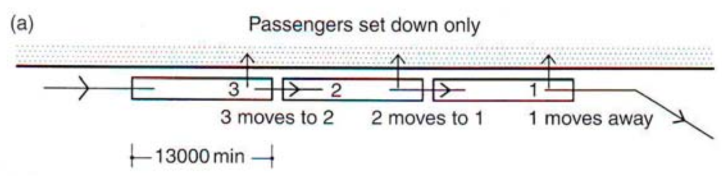
A) Station Platforms

Platforms are built to the height of the train floor, this is now adopted as standard, Platform width must be sufficient to accommodate the largest numbers of passengers expected but must not be wasteful of space. The platform should be designed to give free visual areas so that passengers can read signs and staff can ensure safety. Platform screens and doors reduce heat losses on station platforms of underground stations and allow a better degree of climate control within the stations. Platform length is determined by the mode length, the width of platforms is a product of anticipate passenger density, usually calculated as one passenger per square metre, the width has also to accommodate non-traveling station users (such as those meeting passengers, disabled travelers, and parcel vehicles), at suburban stations most people reduce the waiting time to a minimum, at intercity stations travelers tend to give themselves greater leeway.[5]

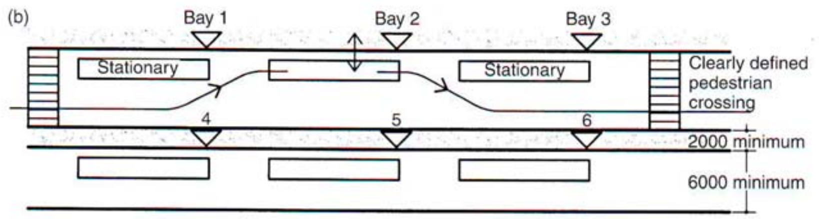
Fig (2.17) Platform screens reduce heat losses and provide safety for passengers.[8]

B) Bus Runways and Loading Bays

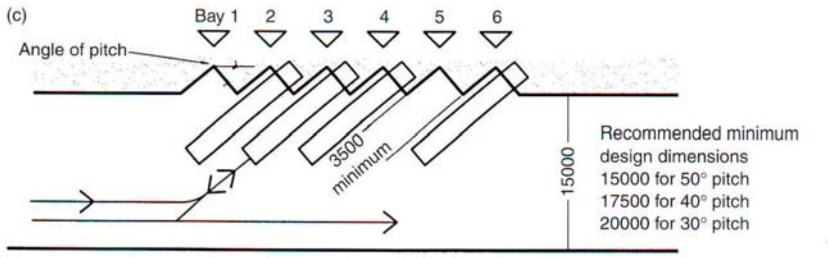
Intermodal stations frequently provide connections to numerous bus lines; however, many of those buses are located in scattered locations around the station, making intermodal transfers difficult for pedestrians. A bus terminal would provide a central location for all busses to queue so that pedestrians may locate their buses quickly and easily. Reflective signs that lists the routes serving the bus stop should be installed.[36]



(a) Shunting is used where a vehicle only sets down passengers on to their concourse before moving away to park or to a bay position for collecting passengers, this manouvre avoids waiting.



(b) Drive through bays, are fixed bay positions for setting down and/or collecting passengers. A vehicle often has to approach the bay between two stationary vehicles. It is often necessary to have isolated islands for additional bays with the additional conflict of passenger and vehicle circulation



(c) 'Sawtooth' layouts have fixed bay positions for setting down and/or collecting passengers. In practice the angle of pitch usually falls between 20 and 50 degrees this pattern reduces the conflict passenger and vehicle

Fig (2.18) Types of vehicle manouvres approaching parking bays [1]

Fig (2.19) View of bus platform with information masts at the interchange of Enschede Station (urban railway station with buses adjacent) [1]

C) Platforms shelters:

Passengers need to be protected from the elements while waiting for transport modes and staff need a reasonably sheltered working environment. Stations enclosures need to exclude rain, provide shelter from wind and allow for daylight penetration. The traditional qualities of large glazed atria like spaces in nineteenth century stations provide an admirable example today – glass is preferable to polycarbonate sheets which are easily scratched and tend to discolour. Modern glasses can provide a measure of solar protection and insulation glazed roofs are fairly lightweight and self maintaining, they are rarely entirely waterproof, but glazed station canopies provide shelter and good appearance needed, solid roofs deal more effectively with driving rain, but the lack of light beneath means that energy is consumed to light signs and routes. (5) . Bus Shelters providing waiting areas, as well as weather protection for bus passengers and serving as visible indictors of bus stops, are recommended to be narrow shelters in some cases to ensure that pedestrian traffic is not impeded on the sidewalks. [36]

Fig (2.20) Street car station in Hannover, for the roof the architect used iroko wood in the interior, and copper plate on the exterior. The pillars are stainless steel and the bench is cement, with seats made of Corian acrylic resin. [3]

Fig (2.21) The circular glass shelter at the focus of place de l'homme de Fer at Strasbourg fort the streetcar which has become a viable ecological alternative to cars and busses. A central ring 35 metre in diameter was intended to give the plaza a pedestrian scale. [3]

Fig (2.22)   Platform shelter at Sloterdijk Station Amesterdam. [5]

2.3.5. Turnstiles and Entrance/Exit Controls

Stations entrances and exits must be designed to allow for the numbers of passengers passing through them, both under normal and emergency conditions.

Fig (2.23) Ticket hall gate line at Bermondsey Station, exploiting natural light to create a clear special experience and a legible route between platforms and main station entrance (the station is covered by a translucent roof which allows sunrays to reach the rail platforms beneath). [12].

2.3.6. Parking facilities

A) Park/Ride Facilities

Parking facilities are provided as surface lots or parking garages the latter may be above ground, below ground, or a combination of both. Three key objectives in the design of parking facilities are:

- They must be convenient and safe for the intended users.
- They should be space-efficient and economical to operate
- They should be compatible with their environs. [15]

Convenience and safety involve many issues, including proximity to major destinations, adequate access facilities (including reservoir space), a simple and efficient internal circulator system, adequate stall dimensions, and basic security. The latter refer to security against theft of vehicles and security from muggings and other personnel crimes. Space efficiency implies that appropriate circulation, stall and reservoir space must be provided, parking facilities should be designed to maximize parking facilities and minimize wasted space. The third objective involves issues of architectural beauty and ensuring that the facility and vehicle trips it generates do not present a visual or auditory disruption to the environment in its immediate area.

Underground parks leave room for recreation areas and landscaping, above ground, air is less polluted, the earth provides protection by absorbing noise and vibration. In terms of security, underground facilities have limited access points thus easily secured. [24]

B) **Bicycle Motorcycle Facilities.**

Bicycle lanes are on-street paths indicated by striping, pavement markings and signs. It is recommended that bicycle lanes adjacent to parking lanes be a minimum of five feet wide. A bicycle lane should be placed between the parking lane and the travel lane. It should not be placed between the curb and the parking lane where visibility is reduced, particularly at intersections**.** A buffer between the bicycle lane and the travel lane is recommended in order to provide greater protection from motor vehicles. Bicycle parking is recommended at locations heavily used by cyclists.[36]

2.4. Environmental Design Requirements for Station structures

Considering environmental requirements for energy efficiency, better indoor environmental quality (IEQ), water conservation, all contribute to an environmentally sensitive design of station buildings. The barriers to green design are often said to be economic, but the evidence indicates that high costs associated with high energy efficiency (daylighting, natural ventilation, better glazing, smarter landscaping , more insulation, etc.) should be offset by lower costs to buy, operate and maintain larger HVAC equipment. [9]

The move towards more natural methods of *lighting*, and *ventilating* buildings is less likely to be a simple rectangular box. Working with nature as a source of energy and visual daylight is beginning to shape a new generation of stations. Not only do these stations, evolved from more ecological principles, entail fewer mechanical services and hence fewer poles and ducts, but their architectural form is more distinctive and as a consequence the station serves better as a landmark. Integration of architectural and services demands is best achieved by adopting a station building form that responds in direct fashion to the physics of air movement, and to the practicalities of lighting both natural and artificial. It should be recognized that the life of building services is shorter than that of the station by a factor of 3 to 1. Station design is therefore based upon the concept of permanent and less permanent parts.[5]

Landscape elements filter rainwater, improve air quality, act as a noise buffer, and mitigate heat island effects. In studies of heat island effects generated by buildings, it was found that clusters of trees within heat islands can produce localized drop in temperature of 2 to3 degrees. The application of landscaping directly to the building in the form of green roofs and vertical landscaping is another innovation.

Station layout and design need to consider *noise* and suction jointly so that air pressure and sound frequency are dealt with simultaneously. Noise is a matter of comfort, audibility of station announcements, and security. A noisy station is not a safe place, as cries for help cannot be heard.[5]

All building materials have emissions, some more than others and they all may contribute to a deterioration of the air quality. Proper materials selection offers a type of quality control that can save millions in remediation. [9]

2.4.1. Lighting and energy efficiency

Lighting is often the largest item of energy cost, particularly in open plans. Occupants tend to prefer natural light, especially since certain forms of artificial lighting has been implicated as the source of health problems. Energy efficient buildings should make as much beneficial use of naturally available light as possible. Also lighting is important because of the influence it has over occupant experience. [16]

Lighting impinges upon customer safety and satisfaction, upon effective station management, on energy consideration, and on smooth operation of transport modes. How the lighting is to be designed, and the relationship between natural and artificial sources are matters for the architect. However in reducing the levels of lighting at platforms, it is imperative not to reduce the number of lighting poles and fittings but to use lower wattage levels of lamps. One does not want poles of brightness and relative darkness, but a good spread of lighting along the whole length of the platform. Energy efficient luminaries should be used as a matter of course. [5]

Effective design may reduce the need for secondary signage, or at least make the role of directional signage merely one of confirming what appears obvious in the architectural and lighting treatment. Lighting needs also to take account of modes drivers' needs, to ensure that station illumination and signal lights are not in competition. [5]

A) Designing for daylight

The amount of glazing has a clear influence on the amount of daylight available. Large windows admit light but also provide heat gain and heat loss routes and thus thermal discomfort. The amount of sky which can be seen from the interior is a critical factor in determining satisfactory daylighting. High windows heads permit higher lighting input as more sky is visible. External obstructions/ buildings which subtend an angle of less than 25 to the horizontal will not exclude use of natural daylight. Adequate daylight levels can be achieved up to a depth of about 2-5 times the window head height. *Rooflights* give a wider and more even distribution of light but also permit heat gains which may cause overheating. Rooflights provide about 3 times the benefit of an equivalently sized vertical window. Rooflight spacing should be one to one-and-a-half times the ceiling height.[16]

- ***Different techniques for channeling daylight*** [16]

- *Atria* introduce light and ventilation deep into a building, the structure of the atrium roof can reduce its transparency by between 20-50 percent. This is an important factor if the ground level is meant to be predominantly naturally lit. The surface finish in respect of colour and reflectance of the atrium walls will influence the level of daylight.

- *Lightshelves* provide shade and reflect light. Sunlight is reflected from the surface of the lightshelf to the building interior where it provides additional diffuse light thus helping to provide uniform illumination. Involving corrugated reflective surface would maximize high altitude reflection whilst rejecting low altitude short wave solar radiation, this almost doubles the daylight levels in north facades.

- *Prismatic glazing* operates on refracting incoming light to produce a more diffuse distribution. Glare can be somewhat reduced and maintenance is virtually eliminated if the system is installed between the panes of double glazed units. *Halographic glazing* is under development but potentially offers advantages over prismatic glazing. A diffraction process is also used but the light output can be more finally tuned to produce particular internal light patterns.

- *Light pipes* gather incoming sunlight sometimes using a solar tracking system. The light is concentrated using lenses or mirrors and is then transmitted to building interiors by pipes. The pipes can be hollow shafts or ducts with reflective interior finishes, or may use fibre optic cable technology. A special luminaire is required to provide distribution of the light within the building. Examples of the technology are to be found in the roof of the concourse at Manchester Airport, UK.

- *The dome* is a smart technique for channeling daylight into the deep interior of a building. (16)

Fig (2.24) Dome exterior at Noksapyeong Station. [10]

Fig (2.25) Dome interior at Noksapyeong station, maximizing influx of light and its effect, after light is influxed into four underground stories through the dome, it reflects from glass finish. [10]

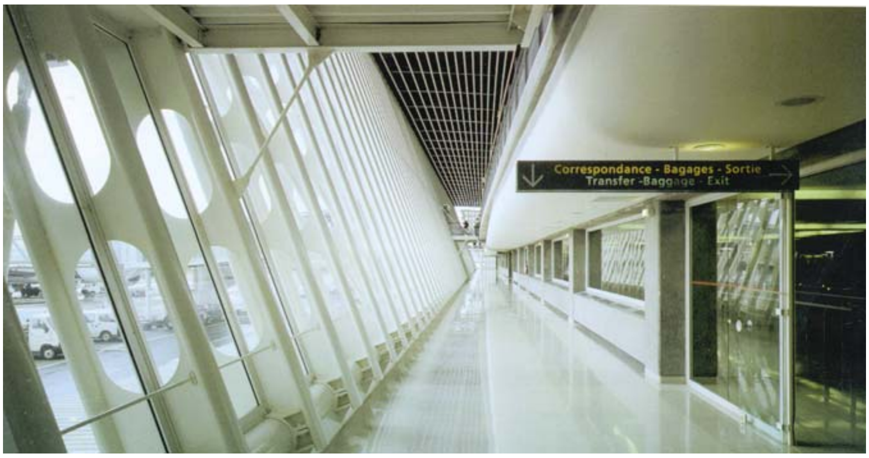


Fig (2.26) At Point a Pitre airport, Guadeloupe, the patterned metallic exterior facing covering windows of the large upper-level halls acts to filter and reflect sunlight, creating ever changing shadows on the floor throughout the day.[3]

Fig (2.27) Upper-level halls at Point a Pitre Airport, Guadeloupe. [3]

Fig (2.28) In-Town Check-In hall (ITCI) make optimum use of daylight and clarity of special configuration to assist circulation. Daylight penetrating the voids into the concourse below. Hong Kong Station. [8].

Fig (2.29) At Lyon St. Exupery Station, the escalators ascend towards the light from a large column free concourse. Space, light and expressive structure provide the means by which travelers are guided through the station. [5]

Fig (2.30) At Stansted, airport, the roof is a network of six by six metre steel tubes which inscribe modules having a repeated pattern. At the centre of each rectangle of three by three modules, is a tree of pillars, each bifurcating into four tubes and forming the node of a network. [3]

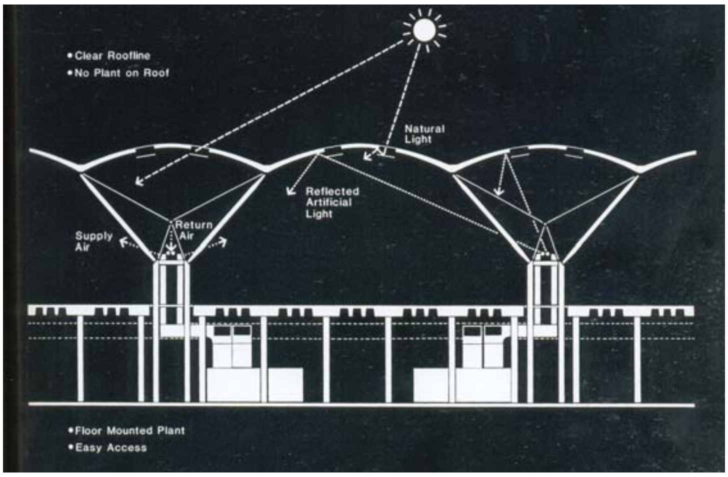


Fig (2.31) Section showing the natural lighting concept at Stansted Airport. [3]

Fig (2.32) Skylight entrance to station concourse, Tung Chung Station, Lantau, Hong Kong. [8]

Fig (2.33) Treatment of the subway opening, Almeda bridge and subway station in Valencia. [8]

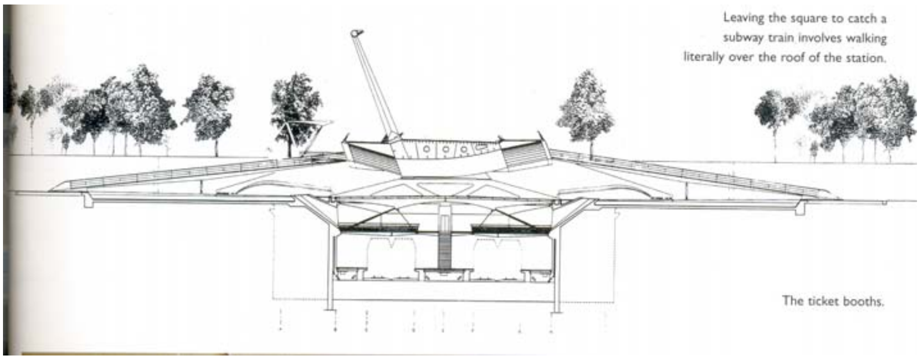


Fig (2.34) Leaving the square to catch a subway train involves walking literally over the roof of the station , Almeda bridge and subway station. [3]

Fig (2.35) Roof canopy, Rotterdam Blaak Metro station, one of the functions of walls and roof canopies of underground stations is to pull light down into subterranean courses. Curved ceiling is particularly useful in this regard. [3]

Fig (2.36) Queensland Rail's Roma Street Station, Brisbane, Queensland, Australia, Pedestrian entrance to subway

B) Artificial lighting and human failings

Lighting is an important element in providing legibility for the traveler. It is an important design task to create a well balanced lighting. In stations with sufficient daylight incidence, the light action is of special significance. The relative brightness of the core area will naturally attract passengers embarking from trains in that direction. In subgrade spaces, station platforms and subway ticket halls must have a luminous intensity of 120 lux. At stairs and escalators people are always disoriented by changes in directions or levels escalators must be free of shadowy areas and the platform edges must be clearly visible, it is agreed on the economical and energy saving installation of at least 80 percent long-field fluorescent lights, each 36 or 58 watts, and a maximum of 20 percent compact fluorescent lights in the form of spotlights. The standard lighting system for a 120 meter underground platform composes a total length of 240m of fluorescent lights. [7]

If lamps are fitted with special castings, lamp shades and reflectors, these have to be designed in such a way that changing a lamp does not take more than 30 seconds. Now there is a trend to use clusters of fluorescent lights in order to generate more light.

Lighting upgrade (Beneath elevated structure): The cobra head luminaire is in use beneath many of the elevated structure throughout cities. The lighting may be improved by using a higher wattage or by reducing the spaces between the luminaries.[36]

Fig (2.37) Artificial lighting over escalators area, at Canary Wharf Station. (12)

2.4.2. Ventilation in station buildings

Air flow in the interior of buildings may be created by allowing natural ventilation or by the use of artificial mechanical ventilation or air conditioning. Buildings using on or more of these options are said to be 'mixed mode'. The overriding principle for sustainable design should be to minimize the need for artificial climate systems and make maximum use of natural ventilation in conjunction with climate sensitive design techniques for the building fabric. [16]

A) Natural ventilation

If air flow is to be encouraged to help provide natural ventilation and cooling, the desirable design features are; a shallow plan to allow for the possibility of cross ventilation; incorporating atria and vertical towers, minimum opening areas should be about 5% of the floor area; building depth should not be more than about five times the floor to ceiling height for cross ventilation to be successful, for single sided ventilation, depth should be limited to about two and a half times the floor to ceiling height; continuous, secure background ventilation should be available using trickle vents and other devices. The deep plan building makes it impossible to employ cross flow ventilation from perimeter openings. In station buildings there is also the problem of the possibility of the existence of raised roads close to the site, generating noise and pollution.

One solution is to provide each quadrant of the floor plan with large lightwells doubling up as air delivery shafts. In a building relying solely on the buoyancy of natural ventilation, control is critical. [16]

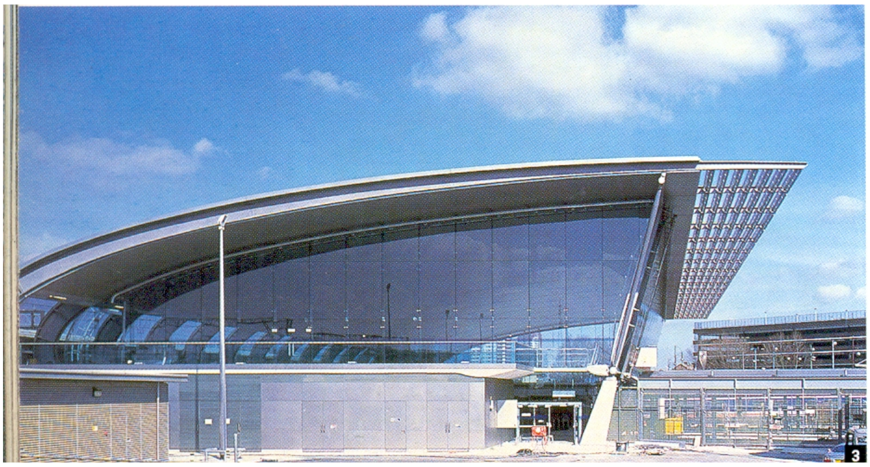


Fig (2.38) Stratford regional station façade, Stratford regional station[17]

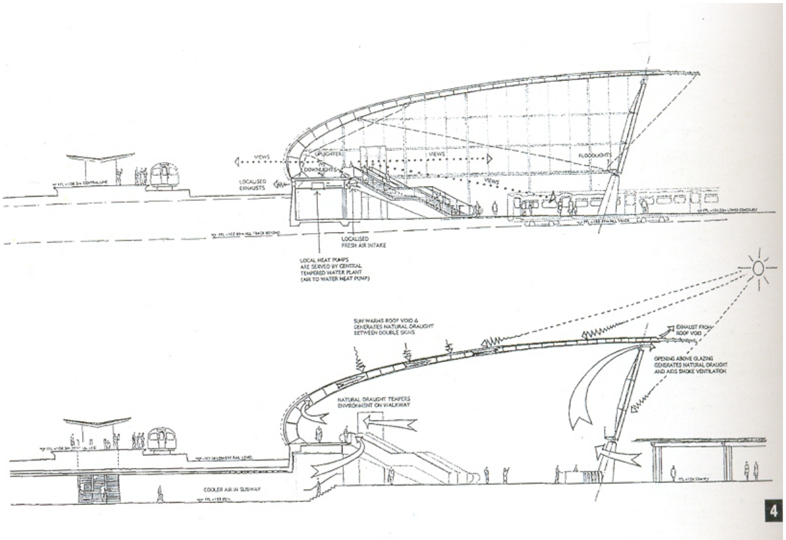


Fig (2.39) Principles of illumination and cooling at Stratford regional station, the roof is designed to allow solar energy assisted ventilation, by using the chimney principle. Through a void to the concourse at the lower part of the roof, hot air streams in the space between the double skin, and is exhausted through an opening at the highest part of the ellipse. Thus circulation and comfortable temperatures on hot days inside the building are guaranteed. [17]

B) Mechanically Assisted ventilation

In station buildings, it is unlikely that natural ventilation on its own will be adequate. A degree of mechanical assistance is necessary to achieve an adequate rate of movement around the building. Mechanical assistance should not be confused with air conditioning which is a much more complex operation. Mechanical ventilation involves air flow and movement provision using fans and air and possibly supply/extract air ducts. However in its basic form, no cooling system is incorporated and therefore the lowest air temperature which can be supplied is usually restricted to ambient conditions. Air conditioning involves the cooling of the air using refrigeration system. In temperate climates, the thermal inertia of a building structure combined with controlled air flow, should be sufficient to avoid excessive overheating except for a few hours each year. Immediately air conditioning is specified, energy use increases substantially. (16)

Mechanical ventilation is needed at station entrances, in sitting areas and alongside ticket offices. Casual gains from equipment may be such that – all-year round comfort is best achieved by packaged air conditioning units (such as the ticket office). The maximum permitted circulation of treated air and the use of pumps is a sensible way of reducing energy costs. Large concourse areas often require to be separately smoke vented: this has serious consequences for the visual appearance of the space, and is an obvious constraint upon design. [3]

Fig (2.40) Exterior vent detail, Tung Chung Station, Lantau, Hong Kong [8]

2.4.3. Landscape approaches for an environmentally sensitive design of station buildings

The location of the facility on the site, the type and colour of the exterior finishes, and the materials used in parking and paving all affect the thermal load on a building and hence the design of the heating and cooling systems. Carefully designing the exterior lighting will minimize the impact of light pollution and eliminate unnecessary illumination of the buildings surroundings *(light trepass*) .

Reducing heat island effect can reduce summertime energy use. Non roof heat islands can be reduced by providing shade or using light coloured materials for parking and paving. Locating parking structures underground is an appropriate option. Roof heat island effects can be reduced by using eco-roofs, vegetative roofs, light coloured, or highly reflective roofs.

Some of the innovations include the application of landscaping directly to buildings in the form of green roofs, or living or eco-roofs, and the use of vertical landscaping, especially for skyscrapers. Living roofs can filter pollution and heavy metals from rain water and help protect the original water supply, it is an aesthetic feature and also helps to support climatic stabilization. *Vertical landscaping* can reduce energy consumption, a 10% increase in vegetated area can produce 8% in annual cooling load savings. The vertical landscape creates a microclimate at the façade of each floor, and can be used as windbreaks absorbs carbon dioxide and generates oxygen, and improves the well being of the occupants by providing greenery throughout the building. [9]

Light trepass poses a number of problems ranging from being a mere nuisance to causing safety problems when it blinds pedestrians and drivers. It also may affect the normally daily life cycle of human wellbeing and may affect the migration patterns of birds. Another negative lighting condition is light pollution which prevents views of night sky. The location, mounting height and aim of exterior luminaries must all be taken into account to ensure that lighting energy is used efficiently and for its intended purposes. To prevent light pollution:

- Parking areas and street lighting should be designed to minimize upward transmission of light.
-Exterior building and sign lighting should be reduced and turned off when not needed.

- Computer modeling of exterior lighting systems should be used to design exactly the level and quality of lighting. [9]

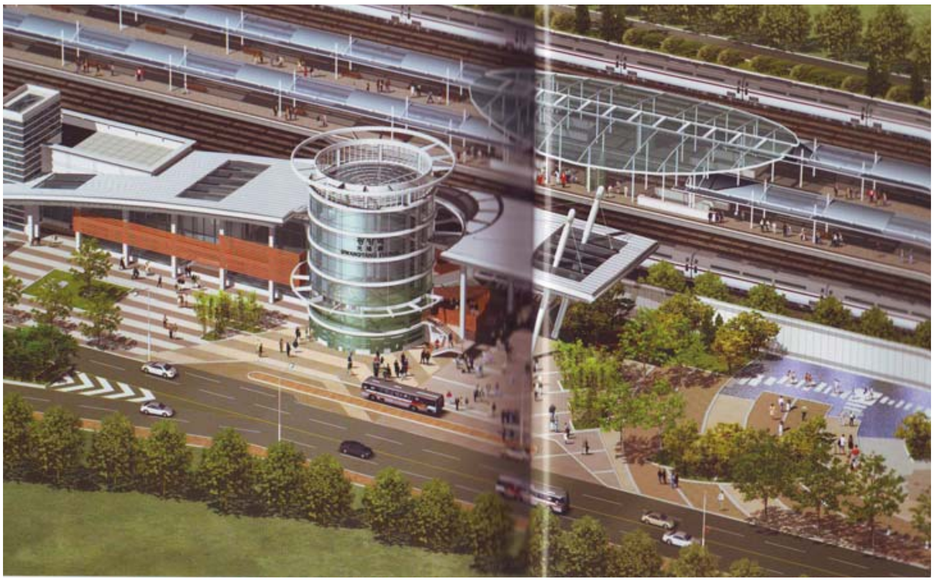


Fig (2.41) The use of light coloured materials for paving and planting shade trees reduce heat island effect as well as providing pleasant environments for users. Gwangyang Station.[10]

Fig (2.42) At Gimpo Airport Station, natural lighting is provided from landscaped area of the ground level. [10]

2.4.4. Noise transmission and Acoustics

Noise can be controlled by three main means: by placing tracks of trains below ground, by using sound absorbing materials in the construction of tunnels, cuttings and station buildings; and by using noise deflectors. In case of trains the contact noise between train wheels and track can be reduced by laying rails on a continuous ballast bed resting on rubber mats. New Dutch stations has also used grooved resonators beneath the platform edges to reduce the high pitched noise caused by the contact between wheel and rail, and plywood boxes concealed in suspended ceilings of stations to dampen low-pitched noise. Noise deflectors can be trackside free standing screens, not unlike those used at airports. At stations designers can use angled walls to deflect noise away from sensitive areas. Walls essential for structural purposes can be either angled, curved or given greater substance in order to deflect or absorb noise. The most sensitive areas for noise are ticket offices, waiting rooms and platforms. [5]

Noise from air handling systems, lights transformers and other sources can cause discomfort for the occupants of buildings.
The basic premise of creating an acoustically acceptable indoor environment is to ensure that sound levels in particular areas of a building are at or below an acceptable range. [9]

Voice announcement systems: Public address voice systems need to be readily audible and clearly understood. As many stations use voice announcements in emergencies, the public address system has to be capable of effective communication under normal operation of the station and in the event of fire or terrorist attack. Delivering clear intelligible speech messages depends upon the quality of the equipment and the acoustics of the space. System design and architectural design need to be related if travelers waiting at platforms are to receive clear messages.

2.4.5. Materials and finishing

The materials must appear safe and solid to passengers and staff. They must be durable and easy to clean and thus economical.[7]
Finishes encompass a wide range of products including paints varnishes, stains and sealers, their primarily purpose is to serve protection against corrosion, weathering and damage, they also add aesthetic value to building materials. The amount of solids is a good indicator of the VOC

emission potential of the finish. Water-based finishes are typically low-emitting while organic solvent based finishes are likely to be high-emitting. [9]

The primary concern regarding the effects of acoustical ceiling tiles on the indoor air quality is the occurrence of microbial growth on either mineral fibre or fiberglass tile exposed to moisture,. Another concern is that porous tiles can absorb VOCs and reemit them.

A) Flooring:

Flooring materials must be highly durable, skid and abrasion proof and fire resistant. Patterning should not show dirt. The materials should be easily replaceable, low liquid absorption and resistant to strong cleaning agents. Granite has shown the best performance in regard to these requirements. This is why it has been the only flooring material used in the recent years in light hues in order to achieve a friendly atmosphere and a better light reflection. As a security precaution, a 70 cm strip of lighter coloured granite with a rough surface is placed along the outer platform surface, adjoined by a 25 cm strip of contrasting blackish granite with ten grooves as a tactile safety precaution for the blind. [7]
Concrete paving blocks in platform finishes have good visual impact, good slip resistance, excellent wear qualities and repairs are easily undertaken. On the other hand, Terrazzo tiles are only suitable where kept dry have 'Up market' appearance, excellent wear qualities but repairs are expensive. [7]

B) Walls:

Wall surfaces, claddings and possibly paint coatings must be easily cleanable (without being worn or scratched). Decorative elements should be easily replaceable. In subway structures a light reflection rate of 50% for walls is a stipulated standard, this is generally achieved with light and friendly colours.

Apart from the construction and maintenance costs, there are no restricting factors for wall designs. This turns them into one of the most important and rewarding parts of the design. . [7]

C) Ceilings:

In case of suspended ceilings, they have to be as light-coloured and light weight as possible., the reflection rate must be above 80% and should not weigh more than 10 kg per square metre. In some cases, in underground station structures, light reflecting ceilings often with a semi matte luster are installed to increase luminosities and make the low shell places appear higher. Open slatted ceilings have now been abandoned, since they largely absorb the light and have sharply angled lower edges which collect dust. [7]

D) Paint elevated structure:

The elevated structures should be painted a light, reflective color in order to reflect the light and reduce shadows.[36]

E) Finishings and service details:

Due to the fact that the public transport companies do not dispose large budgets for thorough cleaning operations except for the floors, planners assume intervals of five to ten years for a general cleaning of the numerous individual structures. All details like sections, skirting, tubes belonging to the station index strips- should not have visible dust trap surfaces. Dust cannot settle on them if they are inclined at an angle more than 80 degrees to the horizontal plane, and this is of particular importance for glass panes in light fixtures, which must not be dimmed by dust.

Fig (2.43) The design of seats in particular helps to establish quality in interior design. Elegant lines, robust design and the use of easily cleaned materials help in maintaining good appearance over a long period of time, Lille Europe Station.[5]

Fig (2.44) At Stratford Station, elaborate finishes with fire hazard potential are avoided and durable uncoated constructional materials like concrete, glass and stainless steel are very simple and should feel as right in 50 years as it is now[12]

2.5. Public amenities at passenger activity spaces at station sites

2.5.1. Security and Fire protection

One of the principle purposes of station design is to generate in the traveler a sense of security. This is achieved in four main ways:- by careful attention to layout and detail, by design that encourages people to adopt a territorial attitude and exercise surveillance, by good lighting and by the use of CCTV.

The objective in designing for security is to reduce station crime and to give travelers a greater sense of their own security. Greater emphasis may be put upon ensuring natural surveillance opportunities, high levels of lighting and frequently positioned cameras.[5]

Criminal activity can be reduced by shelters have all round visibility, modern transparent shelters have proved safer than traditional more ornate designs. Lighting conveys a sense of safety and security, it conveys a sense of ease and allows people to use platforms and staircases without fear. In general people perceive a brightly lit area than a gloomy one.

Fire separation of 1-2 hours between concourse and ticket office and between enclosed platforms and restaurant areas is sometimes required, fire screens, doors or self closers and sprinklers may all be necessary. As a general rule designers should zone and separate fire-risk areas as much as possible rather than tackle the problem as an engineering and constructional issue later. Materials behave in different ways in the event of fire and their relative toxicity varies. The management of fire safety influences the articulation of the station into its constituent units, the choice of structure, cladding and finishes.

2.5.2. Passenger information systems (PIS)

Information displays mounted in public areas must be visible in all weather conditions (noting that some electronic displays are very difficult to see in sunlight conditions). There are two types of information-constant and instant. Constant information can be described as that which describes the services and fares available, this can be displayed on posters and fixed notices. Instant information is that which changes daily or minute by minute, this is better displayed electronically or mechanically.
By way of electronic displays and traditional timetable boards is normally provided in the core area fairly close to ticket points. They are placed at or above head height to allow groups of people to use them at once and this also reduces vandalism.[38]

Customer care policy places great emphasis up on rapid dissemination of modes information to travelers, as this is usually electronic, the cabling and upgrading of the facility need to be taken into account at the design stage.

2.5.3. Passenger service facilities

Passenger activity spaces play the role of public space which is a medium of promoting pedestrian movement, a location of social interaction, a tool for urban management, a show case, a selling point for the developer, a system of signs to assert different identities [11]

Passenger Space Standards: As a general rule, designers need to allow for 3 m^2 per passenger in station courses, 2 m^2 per passenger in core areas and 1 m^2 per passenger on platforms. The rule of figures will vary in airport stations as passengers use trolleys. There is likely to increase pressure income from concourse areas, and this means attracting more people past retail outlets. The slower passengers go the more likely they are to wander into shops and cafes. Efficiency and speed of movement can run counter to ambitions for maximizing retail profit from the public areas of stations. [5]

A range of *customer facilities* is required to make the traveler's journey more comfortable, this include seating, telephones, toilets, etc…., factors to consider are the grouping into loose units of certain of the facilities and the logical siting of others. Robustness of design is also important, bench seating has to survive being in the open, the effect of pollution and vandalism. [5]

A) Waiting areas

Waiting areas need to provide shelter, comfort amenity and travel information. . [5]

Landscaping: Well maintained trees, shrubs and other plants, alone or combined with specialized urban design treatments, may provide pedestrian circulation as well as improve the environment for pedestrians. Improved landscaping is recommended at the traffic islands. [36]

Street furniture: Well-designed and appropriately placed street furniture amenities, such as benches and trash cans, improve pedestrian circulation and conditions. [36]

B) Toilets

Any operators responsible for stations will have to decide whether they are prepared to pay for the installation of toilets and the management and maintenance of such facilities. Nowadays it is considered good marketing to provide good restroom, baby changing and toilet facilities. They will not be cheap to provide and they will require regular inspections to ensure the safety and cleanliness of the premises. In spite of all difficulties toilets must be considered a requirement, if for no reason than the public expect them. If they are installed, they must be designed to a high standard and then kept spotlessly clean throughout the day.

C) Public telephones and other communication equipment

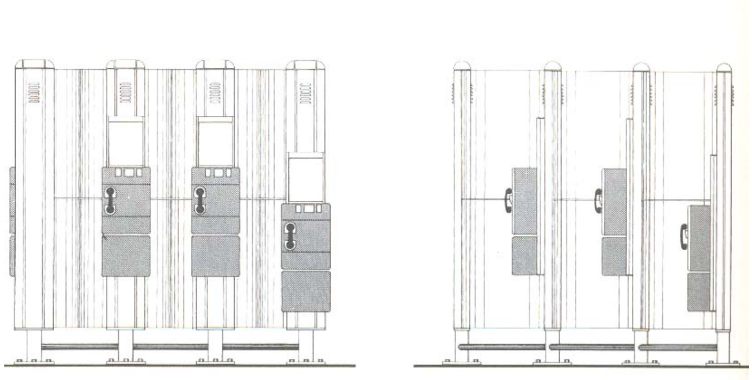


Fig (2.45) Telephones at Waterloo International Station

D) Concessions

Concessions can be a lucrative source of income. The normal types of concessions are coffee shops, refreshment counters and small lunch rooms, plus pharmacies, dry cleaners, news paper shops and flower shops. Larger stations are able to provide space for so many shops that they are almost shopping malls in their own right. This attracts customers and it provides a sense of community. Specifying shopping arcades as pedestrian malls in a comfortable and safety planning which is expected to lead to improvement of the community. In such a process account should be taken of the land pattern of the surrounding area. . [5]

2.5.4. Ticket office design

The design must provide enough space for people queuing and disabled people, the ticket issuing machine must be accessible to wheelchair users. Counters should be accessible, ticket vending machines another alternative to ticket office, purchasing tickets by telephone or on the internet, tickets could also be available from new agents or other shops. Ticket halls should be spacious areas where the quality of materials, finishes and lighting is of the highest specification . [5]

2.5.5. Aesthetics

The station design is guided by aesthetic considerations that lead to the real formal integration of the system into the city as a whole. The architectural form of stations could serve as a land mark. Stretching trees in the open air attenuates the hard asphalt, the solutions adopted to resolve the difficult question of lighting is another aesthetical feature, some interesting features of the lighting design are the continuous windows in the concrete walls of the colours of the architectural elements should be adapted to the surrounding context.

2.5.6. Design for the physically handicapped

Stations must be designed that disabled people can move with ease and comfort, dignity and safety. Disabled provision is a legal and moral responsibility. In addition to disability, architects need to design stations so that people can cope conveniently with young children or heavy baggage. By good design it is possible to limit or even eliminate the difficulties faced by disabled travelers. The main points to consider in the design of stations of disabled people are as follows:

Site choice and layout should avoid steep changes in level should facilitate disabled access, the perception of layout and station entrances should be friendly to all.

Car parking: disabled access by car is needed at station entrance

Station entrances should be clearly signed, should be level with non slip materials, automatic slide doors are preferred to swing doors and should be at least 1200 cm wide. Kickplates on doors are needed for wheelchair users, glass doors should be readily identified. Increasing the width of routes at doorways

Station signs: Installing clear warning and directional signs (some may be in Braille), the location of signs and their height and type are all related factors, wheelchair users need signs near to their head level (say 130 cm). illuminated signs should be lit to a level of 50 lux over the ambient light level. Raised lettering Braille and tactile station maps all help to make travel more convenient to different levels of impairment.

Station navigation is a question of signage and perception of station routes by architectural means. The use of lighting should guide those with impairment to the key station areas. Similarly the use of floor finishes and patterning needs to distinguish major from minor routes. Increasing the levels of lighting, especially at entrances and staircases. Blue markings are used to delineate parking spaces for persons with disabilities.

Station surfaces: textured finishes help the disabled to distinguish the safe from unsafe zones. Using textured paving to define safe limits

Changes in level is both a technical issue and a psychological one. Disabled travelers do not want to feel segregated, routes and level changes designed for disabled access should be available to all. In fact the higher level of provision with regard to details such as the provision of handrails makes travel easier for all. At station entrances, ramps for wheelchair users should be designed so that everybody is encouraged to use them and the same is true of station lifts. Providing lifts to supplement stairs or ramps, avoiding short flights of steps by installing ramps, and providing additional handrails for staircases

***Toilets*:** The minimum space for disabled toilet with wheelchair access is 150cm x 200cm
Providing special disabled access ticket desks, providing disabled telephones, Providing screens and barriers that are solid at ground level for detection by people using canes

2.5.7. Maintenance

The fashion for glass station roofs raises the obvious question as to how they are to be cleaned, maintained and repaired. Health and safety regulation place restrictions upon methods of cleaning and lay down standards at the design stage regarding access. Designers of glazed structures need to address at the conceptual stage how maintenance is to be carried out- both for replacement and regular cleaning. One system adopted is similar to a car wash that travels the length of the train roof on a wheel gantry.[7]

Cleaning the inside surfaces of glass is equally important. The dust and fumes from trains quickly discolours glass, specially the areas directly above railway tracks. Brake dust is toxic, discolouring and adheres to glass. Regular cleaning is essential if the station is to retain its bright image.

Durability and maintenance are also related factors. Where painted steelwork is employed designers need to provide the means for regular repainting. Steel structures above glazed roofs pose a particular difficulty, the specification for steel work in some stations consists of four coatings, the final one being applied on site. Within the life of a typical station, the protective coatings on steel structures will need to be renewed, how this is to be undertaken without disrupting the life and operation of the station is a design question, not merely a maintenance one. [5]

Attention to how building is cleaned to prevent the introduction of harmful chemicals into the indoor environment. Alterations and renovations of the building should be carried out with the same level of care as was the construction process to ensure that high level of IAQ is maintained in spite of changes to the building.

Materials that have been exposed to moisture and contamination while being stored during construction can negatively affect IEQ. Materials should be checked for moisture infiltration prior to their installation to verify if they do not contain excessive levels of water and later they might contribute to mold and mildew in the building. [9]

Because the HVAC system plays an important role in indoor environmental quality it is imperative that it should be installed and maintained properly. Certain components of the HVAC can be more easily contaminated than others, particularly porous ductwork linings that are used for insulation and sound control. Protection of HVAC systems prior installation and during construction should be considered to avoid contamination. Proper maintenance of HVAC systems is necessary to maintain good IEQ. [9]

2.6. Conclusion

- ***Intermodality and layout planning:***

As the intermodal station is part of city life, there is a need to integrate it into the urban fabric. Two basic questions should be considered, regarding the physical and operational characteristics of the intermodal site. Firstly, examining the congestion and intermodal transfer and other problems that these stations might be experiencing. Secondly, the physical site constraints dealing with the resistance to a major expansion of activity at the intermodal hub. It is expected there are differences in the elevations of the guideways of a high speed ground transportation system, urban rail and people mover modes. This might pose the most difficult design problem as there would need to be barrier free-cross platform corridors for passengers.

Many factors influence the design of the station layout. There is a strong relation between the vehicle technology and the design of the station layout components. The number and lengths of platforms of the TGV and the maglev determine the size and the shape of the station. To assist the attainment of air quality and energy savings goals, there is a need to the provision of non-auto modes introduced in the APM systems which are environmentally benign, safe, easy and inexpensive to construct use and maintain. The remodeling of existing stations in metropolitan areas need to accommodate the new transport technologies and integrate them into the existing ground transportation system. Assessing the impacts of the new technologies on station layouts and the new activity pattern on the surroundings and defining the negative impacts that such service would bring is an essential criterion in the alternatives evaluation process. Complex questions related to including the private sector as a joint development component in the station project and the land development projects that would be attractive to the developers should be resolved.

Vertical separation of movement is adopted between different types of traffic lanes. The containing walls supporting a cantilevered structure could act as an effective noise barrier separating the rail lines below and the traffic lateral lanes of the cantilevered structure. The tunnel and underground station solutions frees the space above for public amenities. Underground parks also leave room for recreation and landscaping and are easily secured.

- ***Pedestrian safety and circulation needs***

Layout of the station should be logical, main facilities should be located in step by step progression. Travelers should be presented with clear routes to pedestrian ways, access roads, car parks, taxis ranks, bus stops, etc. ideally these routes should be under cover, well lit and safe to use. Segregation of movement is important. Those arriving and departing from different transport modes should not share a narrow entrance, and pedestrians, car and cycle movements should be zoned into distinctive areas. The circulation areas are connected horizontally and vertically in connecting the different transport modes. Hierarchies of movement should be achieved using principle stairs and escalators as direct extensions to the major routes.

External signs and directional maps are also important. Architectural means should be employed to signal the significant access points such as suspended canopies over main entrances and architectural cues can be employed to deflect movement. Construction, materials and lighting are key elements to exploit, to give recognition of where the deflected corridor or access stair is going. Using contrasting colours, textures or materials are clearly discernible to those with disabilities. A good design is one in which the passenger knows where to go without the need to read direction signs. The role of structure (column, wall and roof) takes on more than a constructional function. It has a secondary role in giving meaning to the circulation pattern adopted.

- ***Environmental requirements***

Sustainable landscapes incorporates the use of light coloured materials for paving and planting shade tress thus reducing the heat island effect as well as providing pleasant environments for the users. Living roofs can filter pollution and vertical landscaping can reduce energy consumption through cooling load savings. Use of light coloured and highly reflective roofs together with vegetative and eco-roofs also contribute to the reduction of heat island effect. Careful design of exterior lighting systems eliminates light pollution.

To provide a healthy physiological and psychological environment for station users, natural daylight should be maximized wherever possible creating a sense of wellbeing and reducing a sense of enclosure. Lighting impinges upon travelers safety and comfort. The integration of daylighting with efficient electric lighting systems would contribute to the reduction of energy consumption. Providing ample ventilation for pollutant control and thermal comfort should be achieved through natural ventilation. The use of the chimney principle has proved succession in guaranteeing comfortable temperatures on hot days in station buildings. Mechanically assisted ventilation is needed at station entrances in sitting areas and along side ticket offices, large concourse areas require separate smoke venting.

Providing appropriate building acoustical and vibration conditions contribute to human comfort. This could be achieved through the use of sound absorbent materials in the construction of tunnels, cuttings and station buildings, the grooved resonators beneath platform edges and noise deflectors. Voice announcement systems should be of high quality in order to be audible and clearly understood.

- ***Public amenities and community livability***

An interchange should be an uplifting experience, the design should emphasize the interchanges role as a portal to different transport modes, provide a welcoming environment to the traveler and create interest by emphasis of the arrival and departure points. Imaginative use of lighting can give many opportunities for holding interest, and variety and colour enhance this effect. The architectural expression of the interchange should reflect the culture of this century and the technology of contemporary travel. Robust design should give the interchange a sense of permanence. An interchange should be designed with good sight lines between different modes of transport, to assist wayfinding and add a sense of interchange experience. The geometry of the interior and choice of materials should ensure a calm interior together with soft internal landscaping thus providing variety. Concessions can be a lucrative source of income, the station project should be attractive to the developers.

Stations must be designed so that disabled people can move with ease and comfort and safety. Typical measures are: providing lifts to supplement stairs or ramps, avoiding short flights of steps by installing ramps, increasing width of routs and doorways, increasing the level of lighting by using textured paving to define safe limits, providing additional handrails, providing special disabled access ticket desks, providing disabled toilets and telephones, providing screens and barriers that are solid at ground level for detection by people using canes, and installing clear directional signs. The guidelines which could be deduced from the above discussion is summarized in the following table:

Table 2.1. Design guidelines for sustainability of intermodal stations

Goal	Strategies
1. Intermodality Provide convenient intermodal facilities and services offering seemless connections for passengers.	- Maintain and improve plazas, to connect different modes and pedestrian routes - Maintain and expand park and ride lots - Provide information on transportation modes - Encourage private employers to provide shuttle service to intermodal facilities. - Study improved access and rail improvements within the terminal area.
2. Pedestrian safety & convenience Create and maintain safe and attractive walkable communities to encourage more walking trips, enhance transit usage, improve public health.	Ensure that transportation facility design respond to pedestrian travel needs and promote community walkability by the following steps: - Access signal pedestrian cycles in light of the aging population for adequate timing for safe crossing. - Employ traffic calming techniques such as narrowed lanes, speed tables, and lane markings. - Provision of footbridges and tunnels for safe crossing. - Provision of escalators, lifts for accessing other levels. - Increase the width of sidewalks, and reduce street pavement width where possible to reduce crossing length (neck-down) - Improve transit rider safety on and off of buses (bays)
3. Environment Protect and enhance the quality of the environment *(Air, water, noise, energy, community livability)*	- Utilize environmentally benign travel modes (rail, cable driven, bicycle and pedestrian). - Expand vegetated buffers to improve air quality, act as a noise barrier, mitigate heat island effects, infiltration, and improve the visual quality. - Use recycled water for irrigation and maintenance - Utilize natural lighting and ventilation for energy efficiency in station buildings -Take prudent and cost effective measures to minimize noise pollution.
4. Equity Ensure that the intermodal station serves passengers regardless of race, income, age, mobility impairment, or geographic location	- Provide equitable service outcomes to all populations. - Emphasize public transportation and include services for disabled people and provide information. - Provide technical and financial assistance to private non profit, highly specialized transportation operators serving needs of handicapped persons.
5. Economic development Support economy by facilitating the multi-modal movement of passengers	- Use the transportation investments to support the economic vitality of downtown and suburban centres as well as brownfields and provide service facilities - Introduce joint development opportunities

CHAPTER III

Chapter 3

Examples of Existing Best Practice Intermodal Stations

3.1. Introduction

This chapter captures potent examples of intermodal station projects where airport/railway interchange and railway/bus and coach interchanges are presented. Examples are culled from Europe, North America and Far East where personal mobility is most concentrated.

High speed trains in Europe are linking airports directly to cities which would otherwise have been connected by air journeys and train connections to city centres. A real interchange in an airport means more than just getting to the airport by public transport, it gives choice of modes. The TGV stations located at the Roissy-Charles De Gaulle and Lyon St. Exupery airports are European examples that are noteworthy in that they encourage a significantly more intense level of competition between train and plane. There is much to be learned about how people make modal choice decisions when provided with a reasonably comparable (ie travel time and cost) train/plane choice.

Railway/bus interchange station examples, such as San Fransico Transbay terminal, Stuttgart main station and kowloon station in Hong Kong are significant examples to be addressed and discussed in terms of sustainability.

City centre locations of rail/bus and coach interchanges can offer considerable benefits in terms of sustainable development potential in case efforts are made to develop the areas on top of and adjacent to the station, whether conventional rail or high speed rail stations. Located in downtown San Fransisco, the Transbay terminal proposes broader development goals for the surrounding area; a new high rise mixed income housing, new offices, a hotel, a conference centre, educational facilities and retail outlets, thus fostering the growth of the terminal.

Located in the eastern part of Lisbon, Oriente station is a symbol of the revitalization and transformation of a formerly brownfield, a future housing area is open towards the square on the eastern side of the train station. Another example for saving precious city centre land is found in

Stuttgart main station, by placing the rail tracks below the street level, the land above was saved for developing parks and access roads.

Kowloon station is another example of a modal interchange facility located in a high dense urbanized area. The station functions fit within "the box" structure underground, each element of this transit interchange is linked by a central concourse, which intern is connected by an atrium to the development above and around the station.

This chapter captures the interest in these buildings as representing a new experience in travel. Integral structures/ linked and contiguous structures, vertical and horizontal separation are considered, a rail park and ride interchange mainly serving long distance travel, including parking, spacious circulation and provision for a light rail terminus (using environmentally friendly vehicles) at the rail station, with the aim of reducing long distance car trips. Circulation and assessing different station levels are important issues to discuss in the addressed examples, landscaping is of critical importance especially at station forecourt, as it is used to delineate the areas for pedestrian and vehicle movement and as they should provide "natural" shelters for people to wait in. Significant sustainable design features including optimizing natural ventilation, designing the roof and exterior walls to maximize natural lighting, and capturing rain water to maintenance and irrigation are revealed in the above mentioned examples.

3.2. Railway/ bus and coach /car interchange

3.2.1. Transbay Terminal San Fransisco California, USA
Estimated Completion 2008

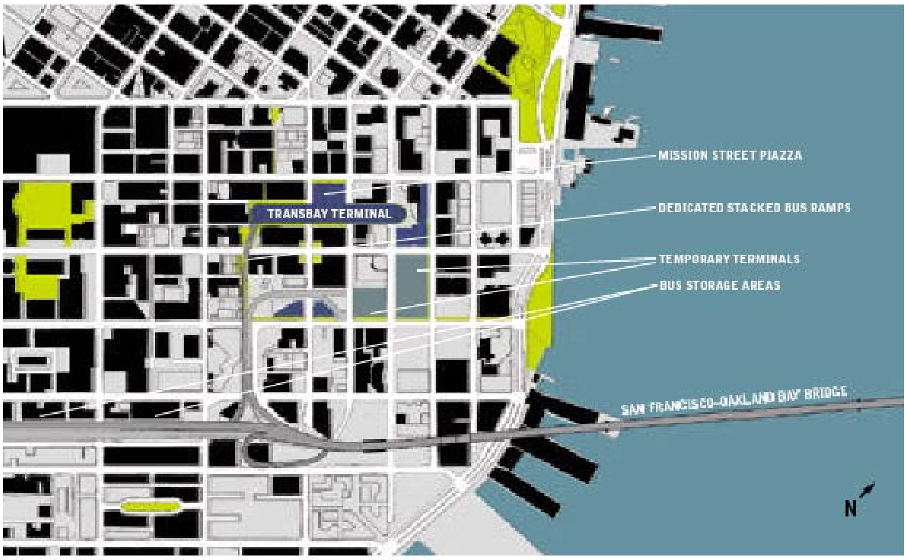


Fig (3.1), Transbay terminal location, San Fransisco bay. [17]

A multimodal transit facility of 55,750 square metres is proposed to meet the increasing travel demands of the San Fransisco bay region and the state of California. It is being planned as an environmentally sustainable design that will facilitate travel and connections of bus and rail passengers using services provide by several transit systems. Located in downtown San Francisco, the terminal will serve as a link between trains of the Caltrain Peninsula lines, when these are extended to the new terminal, and trains serving the east bay. The new facility will also provide links to other cities via conventional rail services and an eventual high speed rail lines between San Fransisco and Los Angelos and other points. The bus component, another significant part of the station, has fifty bays on two levels, to accommodate up to 35,000 daily bus passengers. [17]

A) Design concept

The lead planning team has stated that the new building should be designed to encourage and accommodate new transit ridership while also being a memorable public structure- a celebrately building that is an appropriate gateway to and from San Francisco.

A plan for new high rise, mixed-income housing in the surrounding neighbourhood, along with the potential for new offices, a hotel and conference centre, educational facilities, and retail outlets, seeks to address broader development goals for the area. [17]

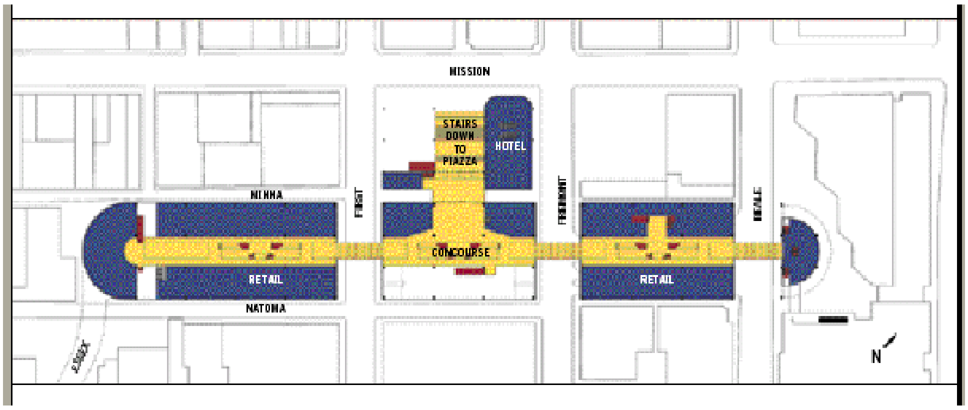


Fig (3.2) Transbay terminal, land use development [28]

The proposed design is a five level facility, 400 metres long and 50 metres wide, with a structural framing system that permits unimpeded vehicular and pedestrian movement both horizontally and vertically. Well distributed access points permit people to enter, pass through, and exit the facility at multiple locations along the street and second-floor concourse level. [17]

One subterranean level (-30') is planned for train service, accommodating conventional rail and high speed intercity rail service. Three platforms serve six through tracks with planned access from all three terminal blocks. This will provide convenient and efficient circulation to and from the trains and easy connection with other forms of public transport. Extensive service baggage and operation facilities for future high speed rail are programmed into the train level, below grade space extending the mission street will provide essential mechanical space support joint development uses and offers potential future connections to other streets.

The street level (+/-0') includes the lobby for Greyhound bus routes and accommodates buses and trolley coaches. It also includes access points to trains below and to commuter busses up. The central block houses a major hotel and a public plaza, a grand stair leading to the terminal concourse as well as space for taxi service. The southern half of the block serves as the lobby for the train ticketing, waiting and baggage handling, also providing access down to the trains and up to the busses. The block west includes retail space a second transit lobby and service space for ventilation of below grade train hall. [34]

The next level up is the concourse level (+20'), that functions as a long bridge, connecting the various blocks one full storey above street level. accessed by the great plaza stair, or escalators and elevators in numerous locations along its length. The concourse level provides a safe pedestrian environment with all the usual services for ticketing, dining and shopping. The upper two levels are programmed for commuter busses and Greyhound and other private bus operators. [34]

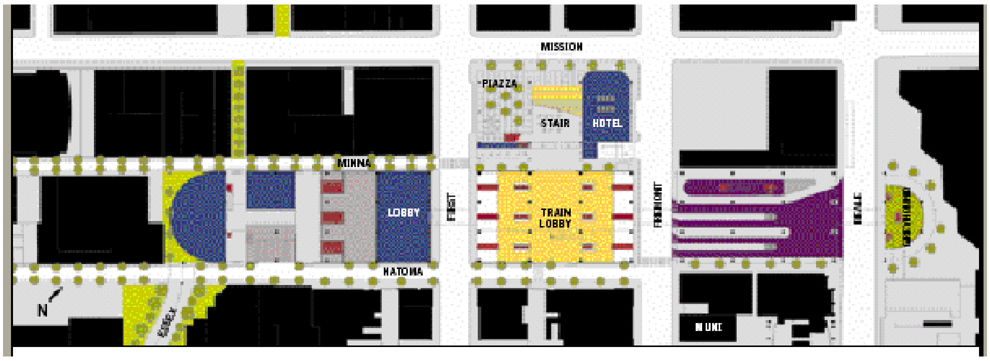


Fig (3.3). Mixed use development shown in dark blue in and around the terminal will foster the growth of Transbay district. [34]

Fig (3.4), Transbay Terminal at night [17]

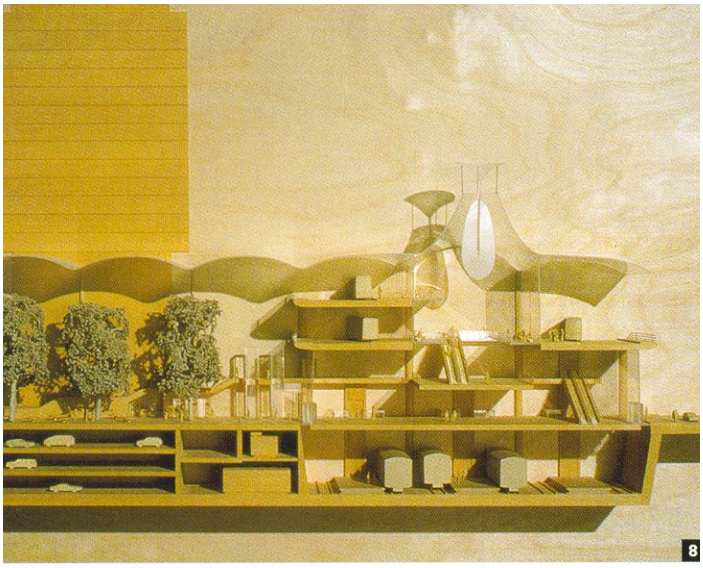


Fig (3.5). Computer rendering of building cutaway. [17]

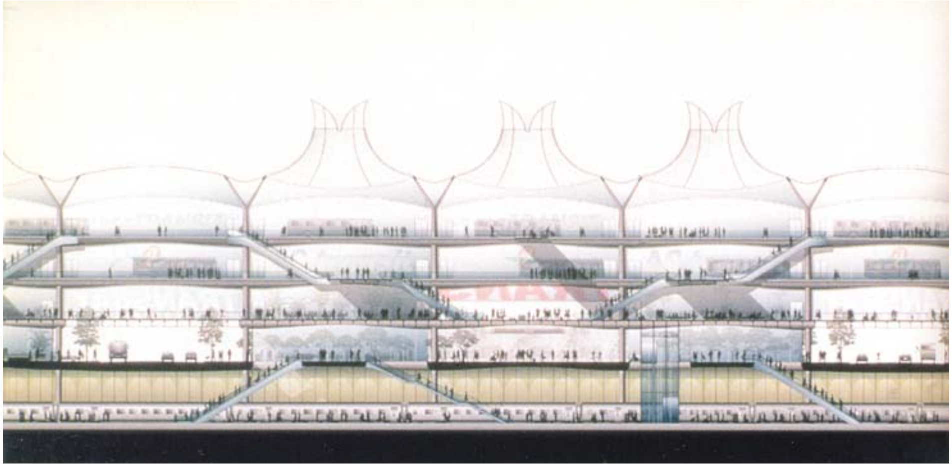


Fig (3.6) Transbay Terminal partial section [17]

▪ ***Vehicular and pedestrian circulation***

Careful consideration of the terminal site has resulted in a design seamlessly integrated into the natural pedestrian and vehicle flow of the surrounding neighbourhood. Well distributed access points permit people to enter, exit or pass through the facility at multiple locations along the street and concourse level, spanning three busy streets. The new terminal building will locate internal pedestrian along a concourse one storey above street level, leaving the flow of vehicular on First, Fermont and Beale Streets undisturbed.

Ramps connecting the terminal directly to the Bay bridge will allow efficient transit operations and will help alleviate congestion on the already heavily trafficked streets surrounding the terminal. [34]

Via an exclusive ramp from the Bay Bridge, busses will enter the terminal building and dock at the sawtooth platform bays on the upper levels. After disembarking passengers will see the city surrounding them through the glass roof overhead, they will experience an effortless sense of wayfinding with the facilities visible from the escalator ride.

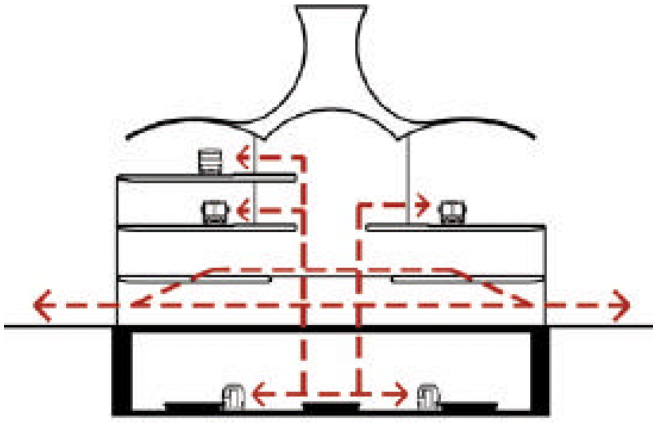


Fig (3.7), Pedestrian circulation diagram. The experience on the sidewalk below will be marked by visual and physical permeability of the structure with passers by able to look within the terminal to a variety of levels. [34]

Dedicated bus ramps and entry points create a smooth unimpeded vehicle flow. Multiple access points in all directions enable pedestrians to enter and pass through the facility at the street and concourse levels. Within the terminal passengers will use stairs, elevators and escalators to circulate effortlessly between levels, the broad concourse and platforms to reach their bus and train. These circulation elements are bound together in a central atrium that allows clear wayfinding for passengers.

B) Environmental considerations

By virtue of it being a public transportation facility, the new Transbay terminal is an environmentally sound sustainable project. Significant sustainable design features include:

- ***Optimizing natural ventilation:***

The design is based upon a wide ranging sustainable approach to the terminal building that uses the reliable prevailing wind flows to ventilate and cool the facility, harnesses solar energy for passive heating and cooling.

- ***Designing for daylight***

The design permits sunlight to permeate the building by designing the roof and exterior walls to maximize natural lighting. Large carefully placed columns will support the floor levels and the dramatic flooring roof without impeding pedestrian movements. The glass roof will allow daylight to enter deep into the terminal and be a window to breathtaking panoramas of downtown San Fransisco. [17]

Light flows down through the transparent roof onto the central circulation spine animating the pedestrian shopping opportunities surrounding the broad public walkway.

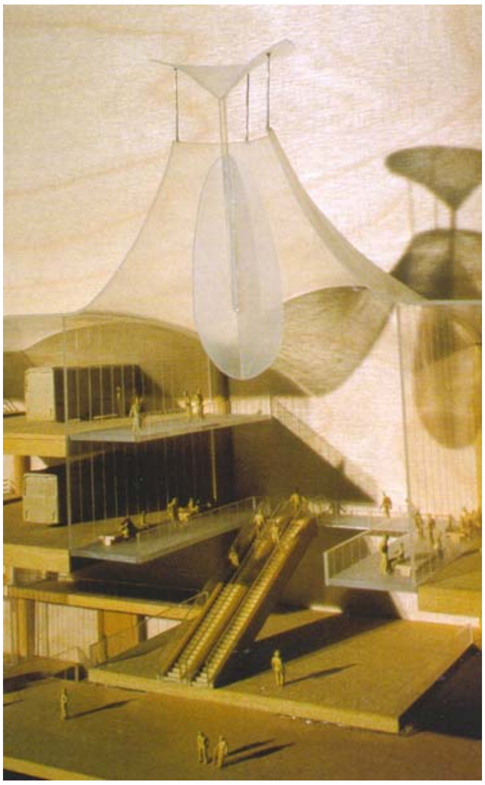


Fig (3.8) Model, partial view of interior, roof design permitting daylight and using wind flows to ventilate and cool the building. [17]

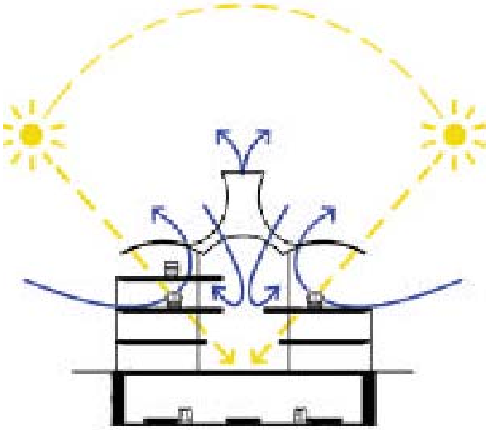


Fig (3.9) Conceptual diagram, daylight and natural ventilation will suffuse the terminal with sunlight and air and save energy.

- ***Water for maintenance and irrigation:***

The design of the roofs is based on capturing rain water to maintenance and irrigation. [17]

C) Economic and social territory

By the year 2010, the terminal will have become a market place of public transportation services. New high rise, mixed income housing in the surrounding neigbourhood, the possibility of new office space, a major new hotel and downtown conference and educational facilities will draw an 18 hour population into the terminal to use its services, enjoy its retail and restaurants and carry out the commerce of a great city.

By the year 2020, the terminal will potentially serve 10,000 bus passengers, and 12,000 train passengers, during peak hours. The 50 bus bays will meet the growth forecast and will have sufficient latent capacity to meet further service. Moreover, joint development within the terminal will contribute an estimated $ 400 million in revenue towards construction and will help to defray future terminal cost.

The Transbay terminal building itself will embody the principles of access, equity, and exchange that underline the concept of regional public transportation. Design elements are open and public spirited, the Mission street plaza spans the length of the building to the grand concourse such that the vast and exciting community of commuters, visitors, retailers, and shoppers will be visible from all levels of terminal. [34]

3.2.2. Stuttgart Main Station

Estimated Completion 2008

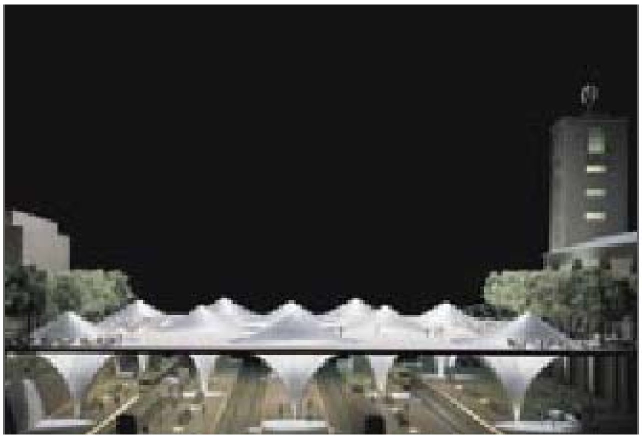


Fig (3.10) The new central station at Stuttgart [28]

The new Stuttgart main station is proposed to link the southern Germany to the European high speed railway network. 250,000 people will use the station on trains, trams and buses everyday. The project takes into account all aspects of ecological, resource saving and sustainable building.

A) Design concept

The idea of this station is a complete reconstruction of the existing main station of the German city of Stuttgart. New rail tracks are built and the existing terminus is converted into a through station in order to enable departing trains to attain higher velocities immediately after leaving the station. The tracks will run 12 metres below the street level, will also save precious city land for development, parks, and access roads.

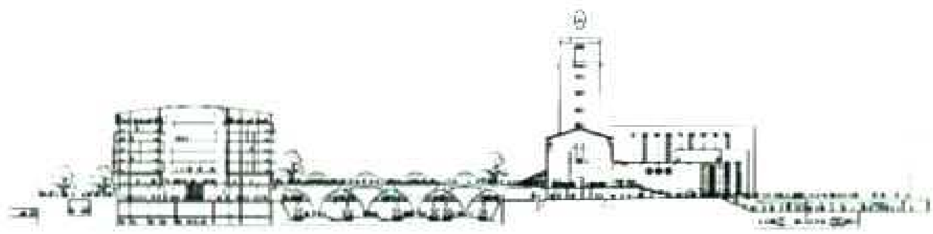


Fig (3.11) Section through station [17]

Fig (3.12) Cutway Model [17]

The station design integrates the existing station building within a new setting, creating a landmark that at the same time responds to the surrounding area of the city. The new station concept still keeps the old station hall, the most important entrance to the new station, a transparent glass dome, leans directly on it and seems to double its size. The whole platform area is built under ground level turned by an angle of 90 degrees to the old one. The platforms are spanned by a concrete shell structure, made to be walked on. Four glass domes mark the span of the underneath surface of the station on the ground level and serve as entrances to it. Light is provided through large glass partholes (lighteye) with diameters of 15 metres. These mediate between the underground area and the square above as well as its surroundings[17]

B) Environmental considerations

A major consideration has been the provision of ecological solutions. Care has been taken not to affect the rich subsoil mineral-water resources. Locating the platforms underground results in a considerable reduction of the noise level of the station activities. By covering the roof with soil it is expected that the climate inside the station will not exceed 25 degrees Celsius in summer without additional cooling. [17]

The volume of the building is reduced to the minimum. The reusability of the formwork elements and the prefabrication of the modular components facilitated the efficient and profitable planning of the construction process. The functional requirements of the station were met by modular and replaceable finishing elements. This ensured a long service life for the building. [34]

Fig (3.13) Model view of platform area showing dispersal of daylight [17]

The design proposes to stretch the park which is adjacent to the existing station over the top of the new subterranean tracks and platforms with a monumental and continuous station hall illuminated by natural light that will fall into the space through large circular 'light eyes'. The underground station with its 28 lighteyes also reduces light pollution during the night. The construction depth of the efficient shell was able to be reduced to one hundredth of span resulting in the use of much less material. The station will operate without supplied energy. The 'zero energy' station requires no heating, cooling or mechanical ventilation.

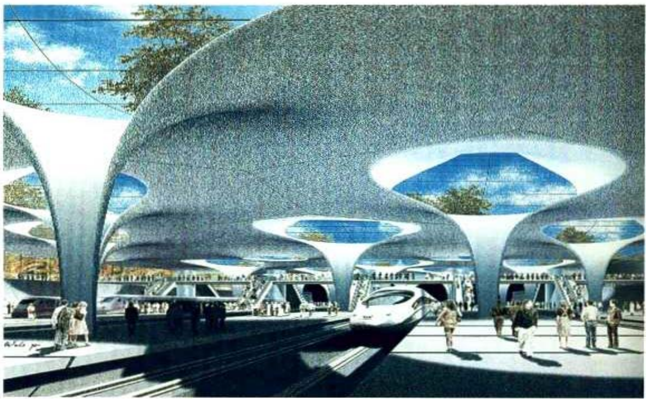


Fig (3.14) Station hall, a continuous space [28]

Fig (3.15) The surface-penetrating 'lighteyes' are the key characteristics of the design of the load bearing structure. [34]

- ***Ecological quality and energy conservation***

The use of natural energy resources means that a high level of visual and thermal comfort is achieved with hardly any consumption of primary energy. The station with an average daylight quotient over 4%, has supplementary lighting in which differentiated use of direct and indirect light enables a maximum specific connection value of 3-9 W/m2 to be achieved. The natural ventilation and air extraction system using natural draughts in conjunction with thermal air flow creates a maximum airflow rate of 1.0-1.5 m/sec. on the platform. The high comfort is achieved without the addition of thermal energy, and this is reflected in a mean felt temperature on the platform of 20 -22ºC in summer and 5-8ºC in winter. About 20% of the electricity in Stuttgart is gained from ecological energy, the station lighting is powered by the eco-electricity, supplied by the utility provider, or via photovoltaic cells located on the northern station building. [34].

- ***Structure material and durability***

The continuous form of the shell type concrete roof creates a highly efficient load bearing structure which is only subject to pressure load and has a structural height that is as little as 1/100 of the span, resulting in the use of much less material. The use of advanced high strength concrete and cement grades means that the material properties can be selected so that the durable exposed concrete surfaces form the finished building. Low emitting materials are used throughout.[34]

C) Social and economic territory

The new station will give Stuttgart a new centre. In 10-20 year, the old tracks may well be replaced by a new urban district. The castle gardens are Stuttgart's lungs and will only gain in importance as the city expands. The park will be extended from the edge of the downtown core across the underground railway station. The 'light eyes' will establish an experiential sense of the subterranean station even to passers by above ground. The historic building and the new station link the old and new sections of the city. The large booking hall of the Bonatz building is the section of the station that is closest to the city. The concept transforms the old station into a meeting place with restaurants and shops, opening the floor of the existing station hall in order to interconnect all levels of new station and to integrate the historic fabric into the new design.[34]

- ***Ethical standards and social equity***

The Schlossgarten Park is the most important public green space Stuttgart, and it extends smoothly above the new station, the roof of the station is an integrated part of the park landscape, with the removal of the overground railway lines, the city will benefit from additional 42,000 m^2 on the roof of the new station. The 420 m long platforms are reflected on the outside by the 'eyelet' skylights. The platform level and the park are thus merged. The station as a whole, with its exterior plazas, walkways and platforms, forms a new central urban public space and a social meeting point which creates a pedestrian link between the Stuttgart 21 development and the present city centre. The historical Bonatz building is integrated into the station. The station has been planned in its entirely consideration of the needs of the people with restricted mobility. It offers a barrier free access on every level. The needs of blind and passengers with a hearing disability were also taken into consideration.[34]

- ***Economic performance and compatibility***

Under Stuttgart 21, it is possible to reach Stuttgart airport and the New Mess exhibition centre in just 8 minutes from Stuttgart city centre. The volume of passengers is expected to increase on long distance and local routes by up to 50% by the year 2015, 4200 jobs will be created per year.

- ***Contextual response and aesthetic impact***

The identity of the nature like structure creates a long lasting aesthetic elegance of the load bearing structure. The interlinking of the public pedestrian paths and the concealed building structure correspond to the simple urban spatial setting with its subtle lines of sight. [34]

3.3.2. Oriente Station, Lisbon,

Completed: 1998

Fig (3.16) Overall view of Oriente Station with bus stations in foreground

Not only is this station an important interchange between different types of transport-high speed and standard trains, regional bus lines, metro, tram, and cars with its parks and ride facilities but it also became the main component and the symbol of the revitalization and transformation of the formerly decaying industrial area of the eastern part of Lisbon. [17]

A) Design concept

The station is made out of three self-contained parts and is divided into two levels. The raised level holds the platforms for the national train network; the lower level connects to the underground and emerges at the surface to serve as an entrance the Expo grounds (a part of the new city park) and also to connect with the third element of the project, a major bus terminal for the city. The elevated train station platforms is formed by a bridge-like structure raised 11 metres of the ground, 78 metres wide and 260 metres long, and the bus terminal is located immediately to the west. The bus station is accessed by a central spine or pedestrian walkway that leads to sweeping glazed canopies that are positioned as ribs along the main axis. [17]

The square on the eastern side of the train station is open towards the original grounds and the future housing area. An arched canopy marks the entrance to the station on this side. The main hall is a connecting square just in the centre between the square on the eastern side on the western side. It offers an easy access to the trains above and the metro below. Below this level is an underground parking, which if it were at ground level, would present an obstacle, both visual and physical for pedestrians. Instead trees have been planted to create a hospitable setting. [17]

From afar the most visible part of the station is its platform area, which also symbolizes the building's role in bringing new life to the area. With its glass and steel canopies over platforms looking like palm trees with interwining branches, the station conveys a picture of an oasis, a fertile zone, that welcomes travelers. With its concealed lighting, it makes a welcoming impression at night, too. Oriente Station expresses its strong character through the accentuation of a structural system that creates a powerful image both from a distance and up close. [30]

- ***Vehicle and pedestrian circulation***

The four platforms of the station are reached through ramps or cylindrical glass lifts. These platforms serve eight lines of tracks. [30]

Transiting through the space there is almost no awareness of the load of trains that the columns support. The movement of columns as they describe their arches makes an interesting setting together with the hanging bridges, connecting tunnels, lifts and elevators. [30]

The station has been criticized as inefficient, because the ticketing booths exist as scattered elements all over the place instead organized in a central office. In this respect Calatrava's vision was perhaps more fitted to the Swiss context, where the architect is based. [30]

B) Environmental Design features

- ***Designing for daylight***

The sky of Lisbon is bright and the heat of the sun implacable; however the metal and glass palms form a sort of floating oasis with the view of the river, where perhaps the only technical failing is its lack of protection from cross winds.

Fig (3.17) pedestrian walkways and the glazed canopies that are positioned as ribs, parapets are made of glass. [30]

▪ ***Structure and material durabilty***

Perhaps the distinction of the project elements through the use of material and structure gives to the station a strange sense of fragmentation but each of the pieces is masterfully synthetic in themselves.

The main material is concrete, the bridge parapets are made of glass, and the pavement is the typical stonework used in the streets of Lisbon. Metal appears again as the connection to the bus station and as the colossal cantilevered roof that signals the gate to the Expo grounds.

C) Social and economic territory

The project however sparks a question about the relation between architecture and society. The station consists of two very dramatic and visible parts; the raised level of platforms which resembles a floating oasis, and the ground level which resembles a cave. [30]

▪ ***Contextual response and aesthetic impact***

The platforms are roofed by a metal structure 25 metres high. This elegant solution consists of a series of slender pillars that split on the top and connect with each other to create a continuous folding structure. Consistent with the rest of Calatrava's work the analogies from the natural world jump into people's minds; the group of pillars resemble palm trees or lilies, and in a geometric sense it is not far from the also floral fan vaults of the British perpendicular gothic. The structural elements are painted white and the nerves of these so-called palms spread out to hold a folding glass roof where geometry and organic shapes find a synthesis in abstraction. [30]

If the raised level stands like an oasis, the ground level is a cave; a huge man made cavern that shelters the movement of the people from one form of transport to the other. And if the train platforms lie somewhere within the vegetal kingdom, the ticket hall below is more animal. The concrete arches that define the spatial structure of this space resemble the rib structure of some extinct creature, yet their proportion and arc give an impression of stability and lightness. The span of this roof is simply mind-blowing, even after experiencing the rest of the structural feats that make up the project. The bus station is rather straight forward in the structural sense, but no less expressive.

Fig (3.18) The group of pillars forming the platforms roof resemble palm trees.[30]

Fig (3.19) concourse area, Oriente Station [30]

Fig (3.20) Entrances to the station and raised platform beyond [17]

3.3.3. Kowloon Station, Hong Kong, China

Completed 1997

Fig (3.21) Kowloon Station, overall view at night. [17]

Kowloon Station is the largest station on the route connecting the centre of Hong Kong and the new airport at Chek Lap Kok in west kowloon. The new rail link is a 34 km route, the development area is 13.5 hectares containing 1,000,000 square metres of hotel, office, retail, and residential accommodation, organized around a main square that has Kowloon Station at its core. The station is intended not only to serve the transport needs of the area, but is also conceived as the central focus of the area, contributing to its identity. [17]

A) Design concept

Kowloon Station is a transit interchange bringing together three rail lines, airport check-in facilities, and bus and other road transportation. Each element is linked by a central concourse which, in turn is connected by an atrium to the development above and around the station. From a distance, the station reveals a sweeping, curved roof that creates a distinctive reference point in spite of the fact that it is the lowest building in the development area. The roof is anchored by four towers that create a monumental open space between them, a gateway to the stations. Underground the form and geometry are highly rational and straightforward. The station functions fit within a structure of 300 metres by 180 metres known as "the box", subdivided by modules of 12 square metres each. It is constructed of reinforced concrete and incorporates three suspended levels above ground and two levels below ground. The functions are organized by floor: train platforms at the lowest levels;

arrivals level with internal drop off roads and in-town-check in for airport passengers; departure level associated with taxis, buses, and private car park; station entry from the surrounding developments; and the uppermost level, which allows entry directly from the area called Kowloon Station Square. [17]

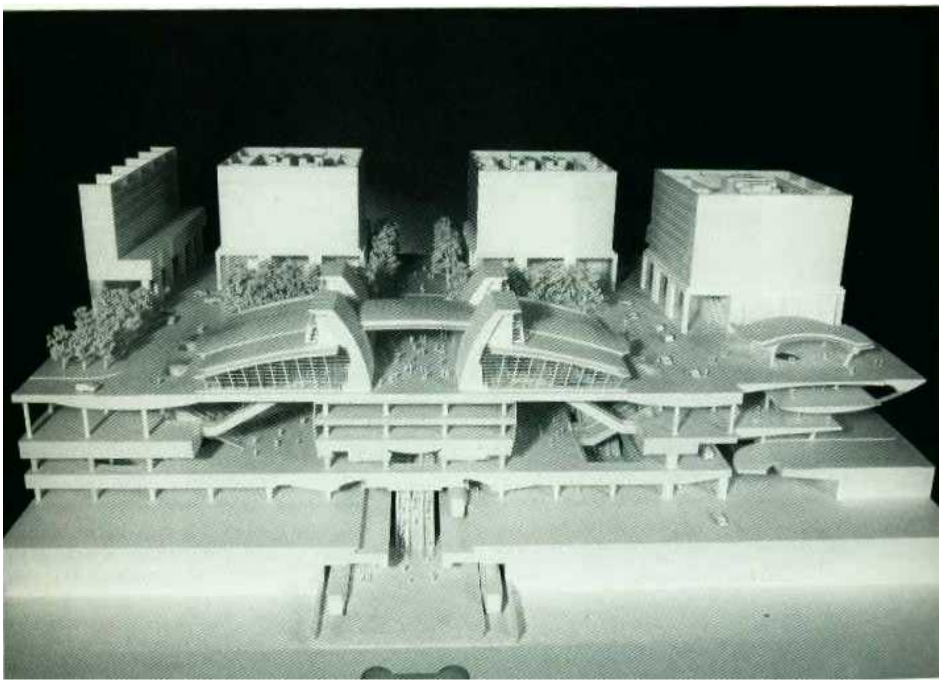


Fig (3.22), Kowloon Station , design concept, "the box".[5]

At kowloon station a central concourse resolved the problem of providing complex interconnections between the rail lines and other modes of transport. This single large space, filled with movement is an echo of grand stations of a bygone era. However the traditional vocabulary of train stations stops there. The train itself is not seen from the station areas, rather an emphasis is made on the traveler and the services needed more like a modern airport.

The station uses an abundance of escalators connected in the central open areas for a visually dynamic effect, but more importantly to concentrate vertical movement in a single volume, thereby contributing to the easy understanding of the organization of the space.

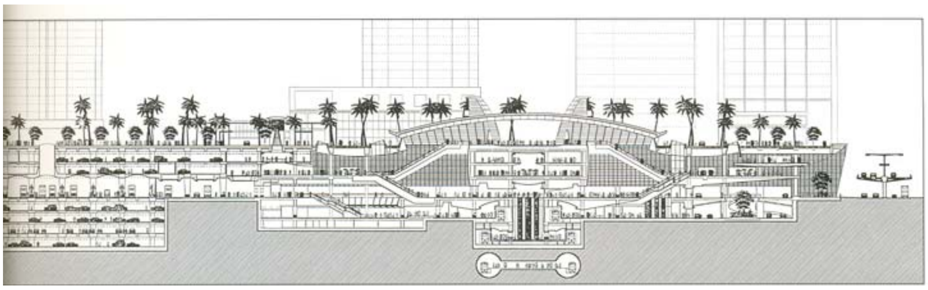


Fig (3.23) Longitudinal Section, Kowloon Station

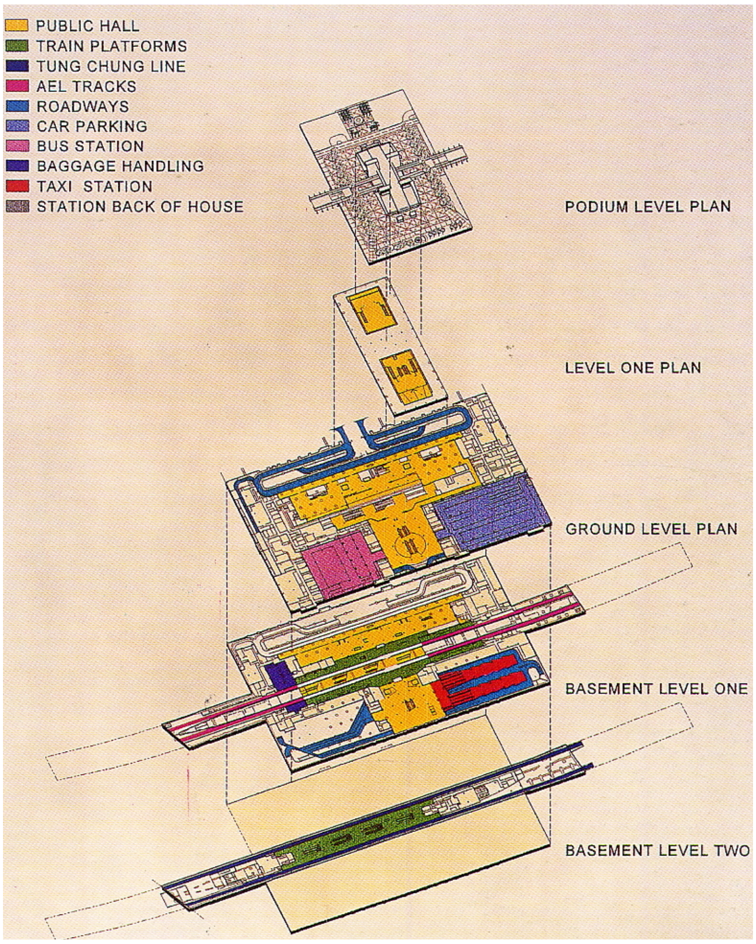


Fig (3.24), Dissected axonometric indicating levels and uses [17]

Fig (3.25) Section and urban context [17]

Fig (3.26) Kowloon Station, Main station entrance

Fig (3.27) Kowloon Station, In-town check in hall

B) Environmental design

The architects have used extensive glass to make the central space a great light filled hall that allows natural light to penetrate to the levels below. Light is taken down to the lowest levels of the station by clever manipulation of the building section. The complex programme of functions is contained not within a single rectangular building but is an open framework of elements beneath the curved roof. Light is taken into the catacombs of the platforms via diagonal paths of deflected light. The arrangement benefits for the use of a central spine of station offices whose curved glazed walls act as reflectors.

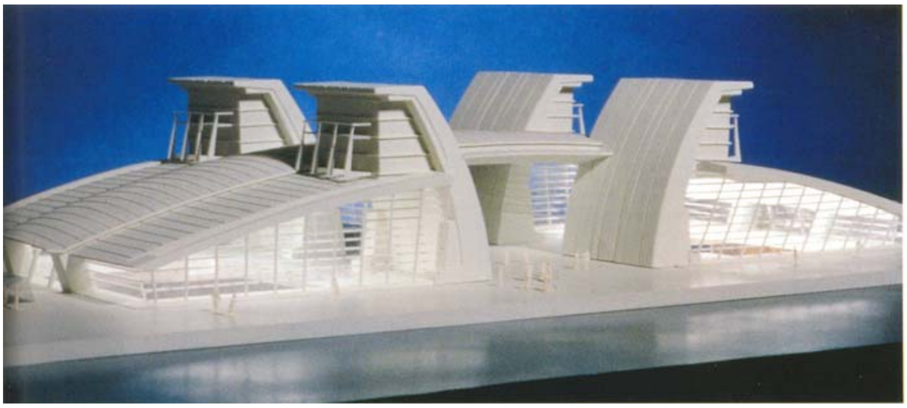


Fig (3.28), Kowloon Station, Concourse roof model. The roof is anchored by four towers that create a monumental open space between them, a gateway to the stations. Light is taken to the catacombs of the platforms via diagonal paths of deflected light.

Fig (3.29), Kowloon Station, Concourse area, light is deflected through the curved glazed walls

3.3. Airport/Railway interchange

3.3.1. Lyon St Exupery Airport TGV Station

Completed in 2003

Fig (3.30) Lyon St Exupery TGV Station and airport terminal, aerial view.[1]

The TGV station at the Lyon St Exupery International Airport is located on a TGV route that is being built to bypass the Lyon urbanized area so that faster travel times to cities south of Lyon (e.g. Marseille, Montpelier) can be provided. This station is especially interesting because it provides a very direct link between the TGV and air transportation. The interesting visual design of this station portrays the train/plane connection concept quite well. The airport is quite central in a large number of French and other European cities and thus evolves as a major European hub. Everyday the airport mobilizes 5,000 employees. [33]

A) Design Concept

The original terminals were designed with a curved plan shape, the smaller as the terminal national and the larger as the terminal international. Then the TGV station was added in the early 1990s, connected to the terminals by moving walkways. The TGV station provides 18 high speed trains per day, half serving Paris within 110 minutes. The most recent project is the complete remodeling and extension of terminal 2, formerly the domestic terminal. This work was completed in 2003, and rounded off a programme to raise the aitrport's annual capacity from 4 million to 8 million passengers per year.[1]

By virtue of its location, Lyon is a hub, and is served by a multiplicity of small airlines and aircraft, as well as European and international flights. The link between the two terminals improves transfer times between international and domestic flights, and the target is 20 minute transfer times. The proximity of the TGV station not only improves surface links with the airport, but makes possible the integration of transport systems.

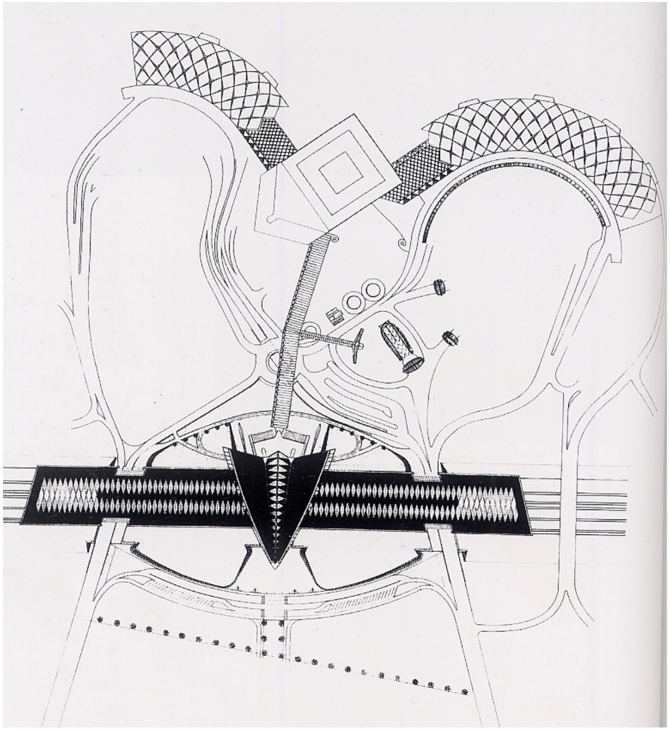


Fig (3.31) Lyon St. Exupery TGV Station and airport terminal, layout

The station is located near the centre of an airport complex for which a long term development was planned. The total airport site includes 2100 hectares. Construction of the TGV Station was initiated in 1998 and completed in 1994. Eight sets of tracks are included in the design of this station, six of which are for the TGV only. The platforms will be 500 m long and the station is designed to allow trains to pass through it at 300 kph. Airline counters are located inside the station, facilitating passenger and baggage check in procedures for those arriving on the TGV. the station will be linked directly to the airline terminals with a covered moving walkway that is 180 metres long. The construction cost of the TGV station alone is estimated to be about 650 million FFr. The covered walkway cost additional 67.5 million FFr. An underground parking facility that includes 1200 was opened and cost about 85 million FFr. This brought the total number of parking spaces at this airport to about 6200. The overall development plan envisions the St. Exupery International Airport as a European scale multimodal platform for passengers and freight combining airways, the TGV, super highways and state-of-the art telecommunications facilities. [22]

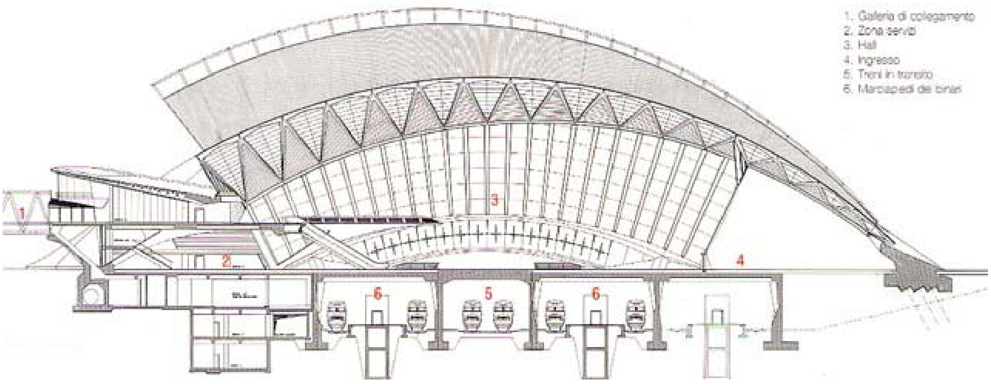


Fig (3.32) Airport stations consist of expansive public circulation areas connected by staircases and escalators. Here in this plan and section of Lyon- St. Exupery Station, angles and curves are used to direct passenger movement through the termini. .[5]

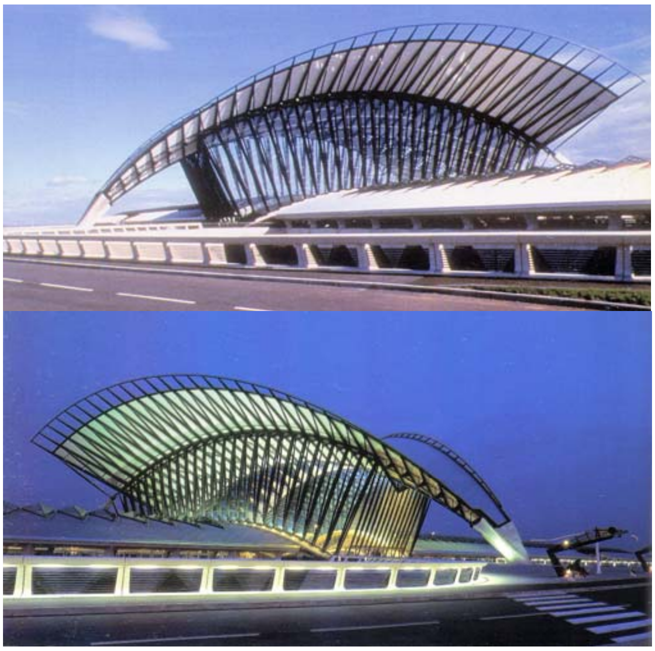


Fig (3.33), Lyon, St Exupery TGV Station, Night view and daytime vies of the station main facade.[3]

Fig (3.34) Lyon St. Exupery TGV Station, view of roof.[3]

- ***Aesthetics***

The character for the station design expresses its function in its volumes, and relates visually to its surroundings, at the same time it reflects the technical development of the TGV high speed train and evokes the dreams of the Atlantic coast. The station features large stretches of canvas that provide comfortable shade and soft interior lighting. Other materials and forms were used to suggest sand, sea and blue skies. Cream coloured concrete and wavy roof lines are two examples. Many other nautical fixtures and fittings were used to provide visual continuity for the passenger.

Fig (3.35) The building takes on the appearance of a bird, although a bird with a lighter, more ethereal appearance. The concrete roof over the platform area, almost at ground level. The steel roof traverses almost perpendicularly overhead. [3]

Fig (3.36) interior View of lobby. The lobby's two inside stairways are reminiscent of a bird's foot. .[3]

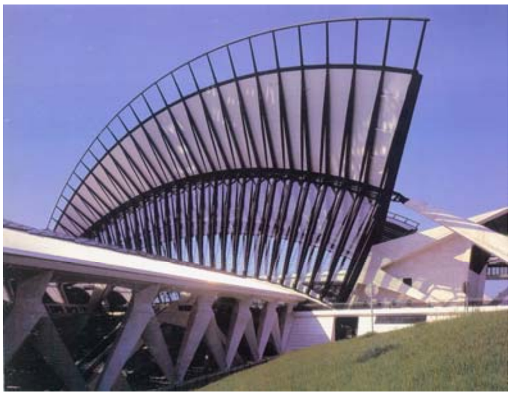


Fig (3.37) beginning from the concrete vertex facing the entrance, two identical bifurcating steel arches define the large triangular space comprising the main hall facing the entrance. .[3]

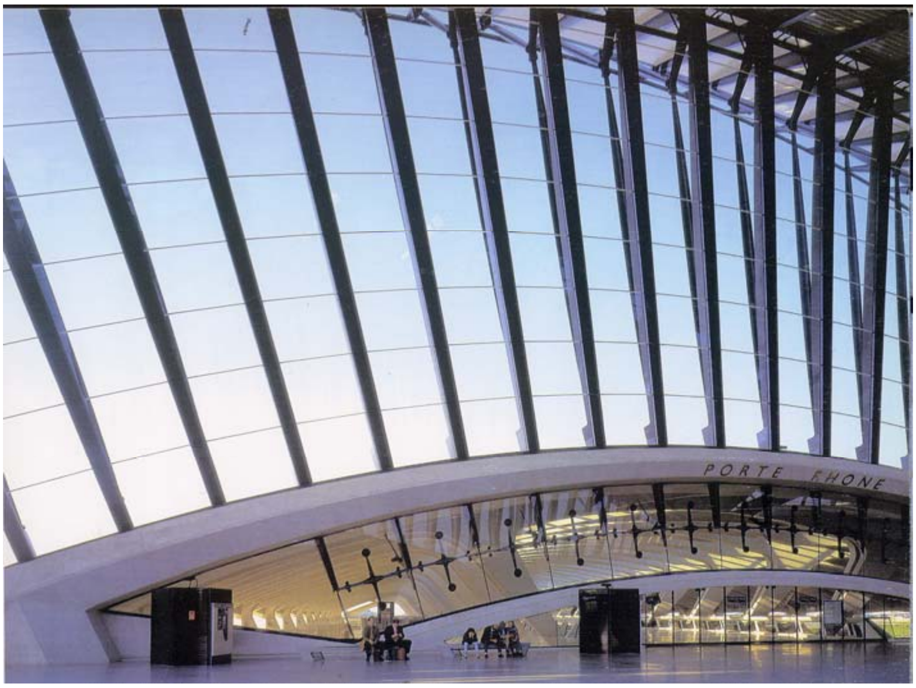


Fig (3.38) View of the access to the platforms from the lobby. Two roof components intersect over the hall .[3]

B) Environment considerations [33]

The Lyon Chamber of Commerce and industry has adopted a policy within the scope of its environmental management system, composed of five key objectives:

- To respect environmental regulations and pilot its implementation
- To prevent nuisances and pollution by controlling them or by treating them with trained personnel
- To incite its partners to respct the environment by making them aware and informing them of environmental issues and by implementing environmental clauses in contracts
- To continuously improve its environmental performances using plan and specific indicators
- To be transparent in its environmental management through providing information and through consultation.

- ***Noise pollution***

As the principle environmental impact of airport activity, noise is the subject of multiple measures of control, management and dialogue.

If the manager is not directly responsible for most of the noise resources, he shares his tasks of managing and improving noise pollution with the French civil aviation authorities and the air traffic controllers, air companies and aeroplane pilots.(Respect regulations - Measure impacts)

- ***Air quality***

The airport combines several potential sources of atmospheric emissions: air traffic, traffic of land vehicles and other fixed sources present on the site such as the thermoelectric power station.
(Known sources - Measure emissions - Reduce pollution from land vehicles)

- ***Water quality***

The airport has undertaken to protect water, a rare and fragile resource, by managing its consumption and by monitoring pollution and the treatment of waste water and rain water.
(Reduce water consumption - Manage waste water)

- ***Energy***

As the margins to reduce energy consumption are restricted for reasons associated with air, security and safety, the airport is endeavouring to reduce the impact it has on the environment by favouring less polluting sources of energy.

Natural lighting is provided through the glass which provide comfortable shade and interior lighting

Fig (3.39) Terminal 2 landside interior.[1]

Fig(3.40), interior of TGV station natural lighting is provided through the roof.[1]

- ***Waste management***

The diversity of airport activities produces a wide range of waste. Since 1999, the airport has adopted a selective waste collection approach throughout the site, in conjunction with a unique service provider to collect, transport and eliminate the waste in funded centres.

C) Social and economic territory

- ***Employment:***

The Sato Employment Shceme was set up in 1996 in order to allow resident populations to benefit fully and as a priority from the economic impact of the airport.

A new service called Sato Employment was launched in October 2001. A reinforced partnership with French national employment Agency enables two full time people to combine their skills for the service of the companies of the site and job seekers.

- ***Local initiatives:***

The airport participates in the local initiatives of resident associations by means of financial aid or the provision of lots.

- ***Sound insulation**:*

Owners of houses situated in the noise pollution plan can claim financial aid in order to carry out the sound insulation of their house. [33]

3.2.2. The Roissy TGV Station at Charles de Gaulle International Airport

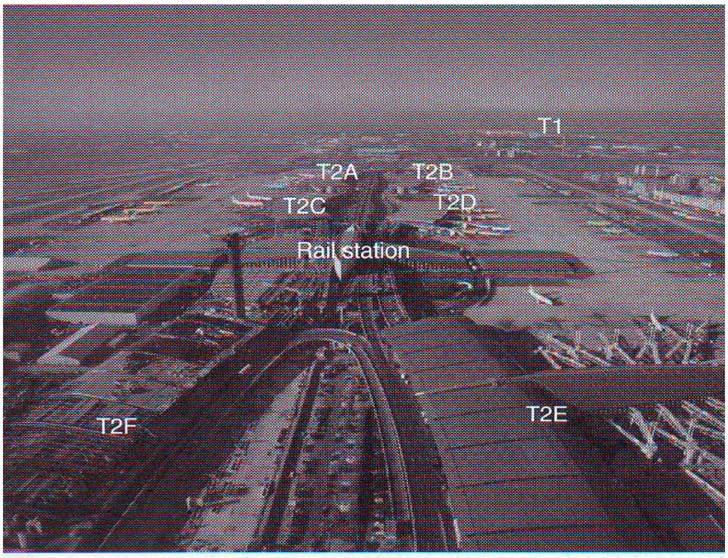


Fig (3.41) The Roissy TGV Station at Charles de Gaulle International Airport, aerial view [1]

A) Design concept

The airport comprises three terminals, the first hollow drum shaped terminal is now quite separate from the terminal 2.

Terminal 2 comprises six modular terminals, the first four are terminals 2A to 2D, each with approximately six contact gates that are followed by the contiguous railway station surmounted by a hotel. The rail tracks at low level intersect the axis of the terminal buildings. Two more terminals numbered 2 E and 2 F, have been developed beyond the rail station. [1]

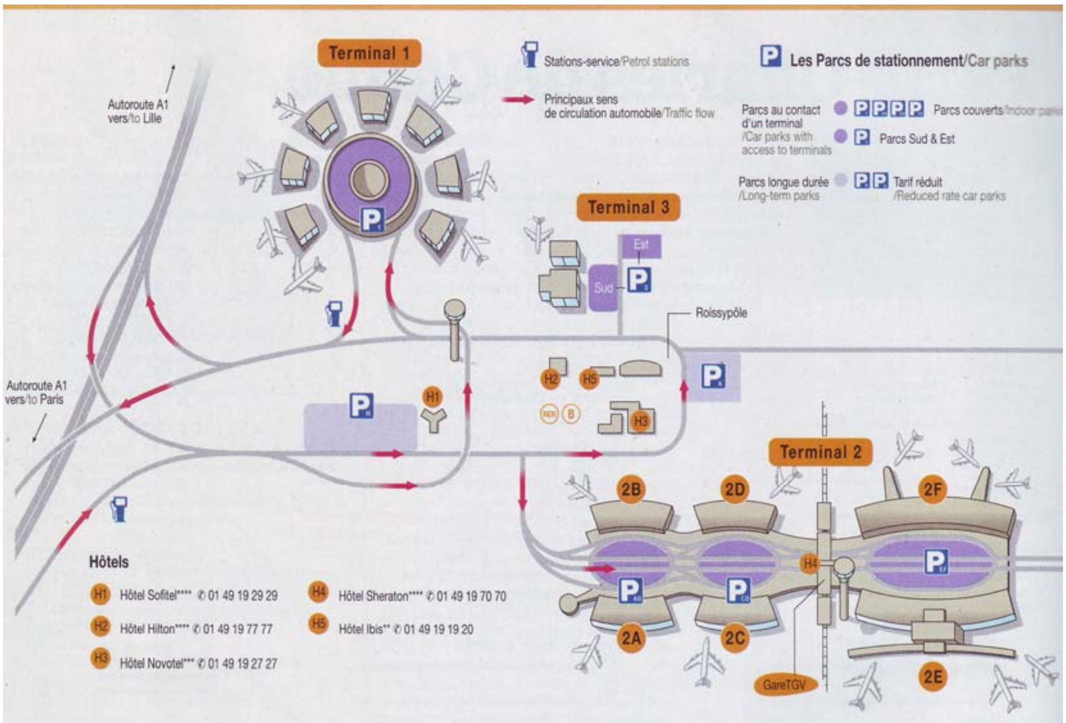


Fig (3.42) Airport layout showing the three terminals [26]

The TGV station is adjacent to an RER station that will provide direct and reasonably fast service (about 20 minutes) to Gare du Nord in Paris. A 250-room luxury hotel is built on top of the TGV station at the airport to be connected to TGV platforms.

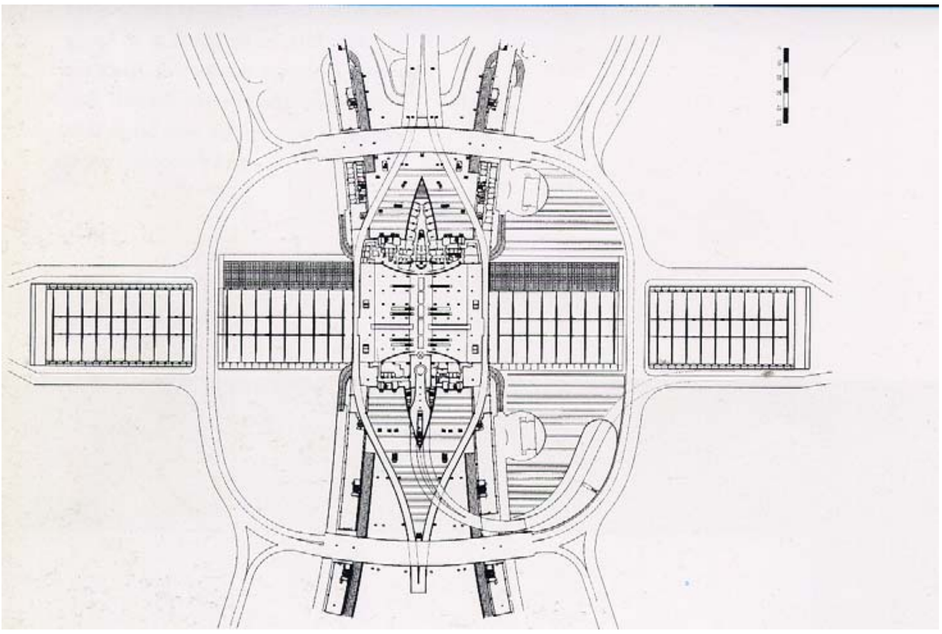


Fig (3.43) The Roissy TGV Station at Charles de Gaulle International Airport, Station layout [5]

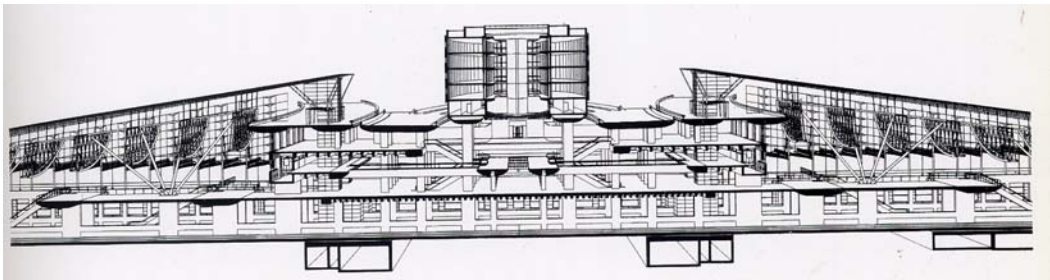


Fig (3.44) Cross sections of the interchange module and of the hotel.[3]

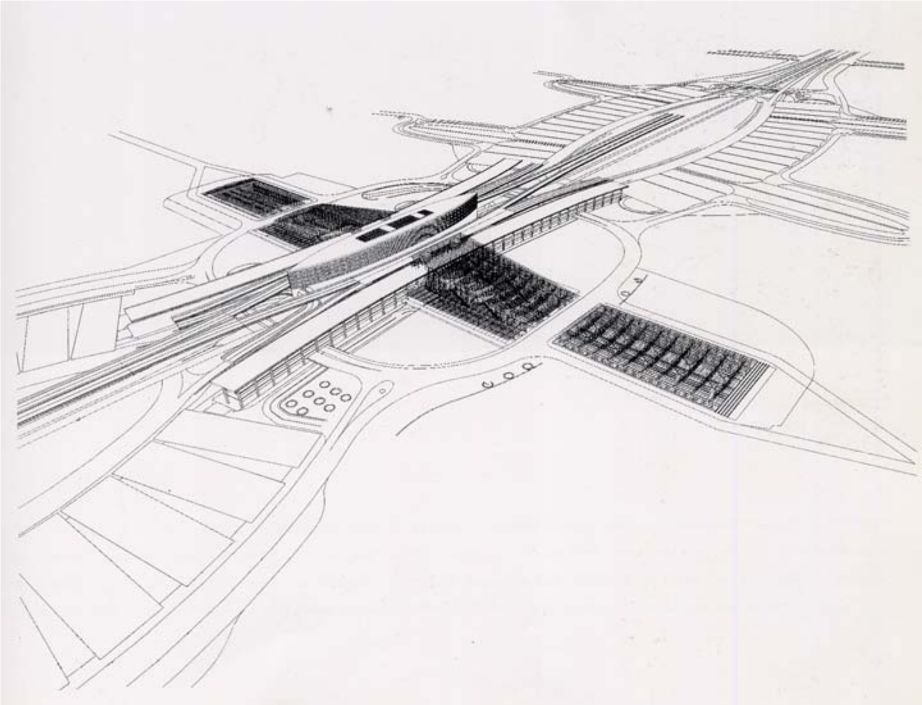


Fig (3.45) an axonometric drawing of the interchange module and of the hotel. [3]

Fig (3.46) The hotel has been built along the axis of growth of the airport. [3]

The station includes 6 TGV tracks (two for through trains) and two tracks for RER trains for a total of eight tracks. Fig (3.46) provides a cross sectional view of this station along the line of TGV travel. The baggage tunnels are located under the TGV tracks. This scheme appears to represent a significant vulnerability of terrorism. The location of the people mover is also shown in the figure.

Figure (3.47), provides a second cross section that is perpendicular to the TGV and RER tracks. It shows the two through TGV tracks as well as four other TGV tracks for trains that stop at the airport. The two RER tracks are on the left side of this diagram. Note the people mover vehicles located directly above the TGV tracks. Fig (3.48) provides a 3-D view of the station that shows the relative locations of the TGV, RER, and people mover vehicles and platforms.

This TGV station is connected to terminal one with a cable drawn peoplemover system that will provide continuous service between terminal 1 and terminals 2.

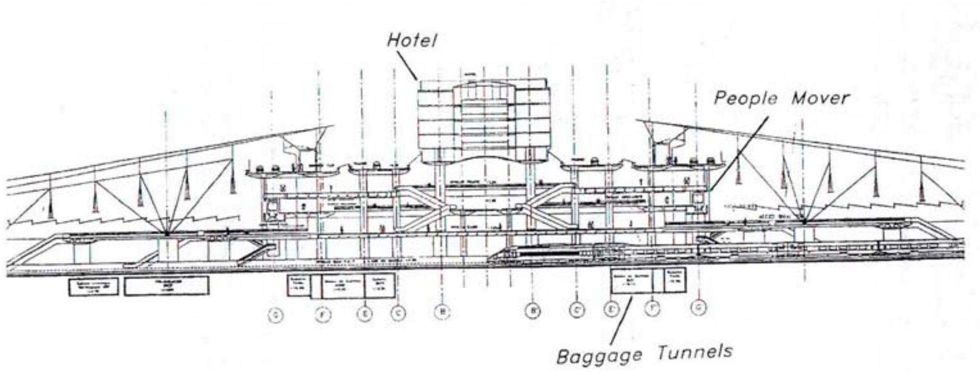


Fig (3.47) cross section diagram of TGV Station taken along TGV/RER route[22]

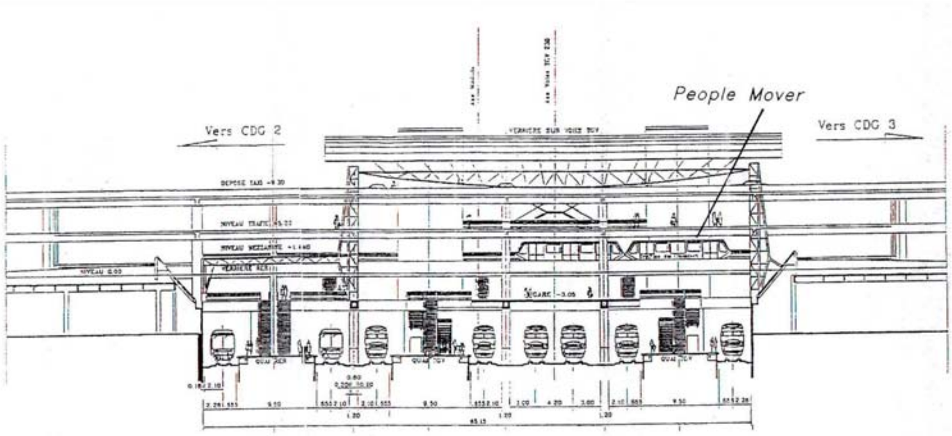


Fig (3.48) cross section diagram of TGV station taken perpendicular to TGV/RER route, showing the 6 TGV tracks, the two RER tracks are on the left side of this diagram. The people mover vehicles located directly above the TGV tracks[22]

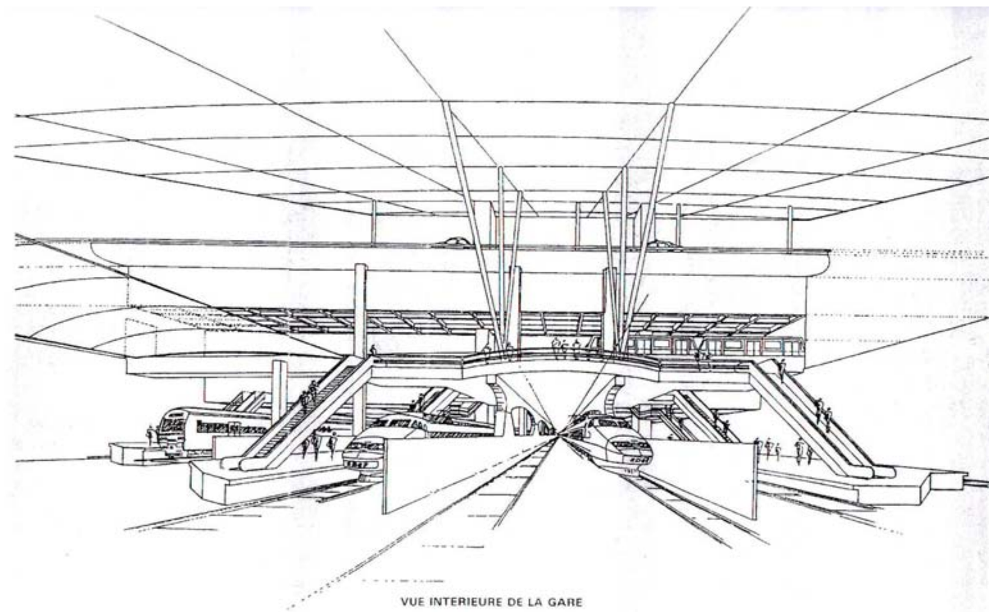


Fig (3.49) 3 D View interior of the station showing relative locations of the TGV, RER and people mover vehicles and platforms. [22]

▪ ***Intermodality***

This station provides greatly improved access between RCDG airport and many cities in France and other parts of Europe. The TGV service competes effectively with air inter service, perhaps diverting a significant number of passengers to the TGV from the domestic French airline.

The station itself features a high level of intermodal connectivity. Travel to Paris is easily done on the RER line now and it is even easier for persons arriving via TGV.

Persons arriving via TGV will also be able to obtain a rental auto easily at the airport. Other TGV passengers who need to get to terminal one for an intermodal flight will need to make a short peoplemover trip from Terminals 2 to do so. The time needed for this people mover trip is estimated to be 8-10 minutes.

Fig (3.50) TGV Station adjacent to RER station [1]

▪ ***Pedestrian circulation***

An interesting feature of terminal 2C is the luffing ramps. The introduction of segregated passenger routes on different levels in the airside parts of the terminal leads to the need for passengers to descend ramps from and to each of these levels in order to enter the fixed end of a loading bridge. An economy measure is the use of a single ramp which pivots at the fixed end of the loading bridge, at a level approximately halfway between the two levels of the terminal. This moves on rails from one level to the other according to whether passengers are embarking or disembarking. (1)

Fig (3.51) View of rail station and adjacent aircraft stands [1]

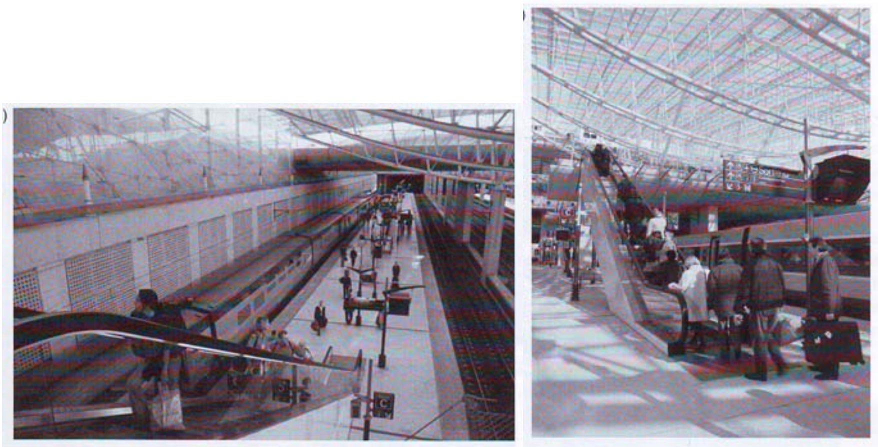


Fig (3.52) Views of escalators at the TGV Station [1]

B) Environmental design features

▪ ***Energy***

A great deal of glass is used in the construction of the station so that natural light will be present in nearly all of its interior spaces. This enhances the ability of the passengers to orient themselves easily as well as reducing the high energy cost of using artificial lighting in such a large facility. Special robotic systems have been designed to wash these large areas of glass to keep them clean.

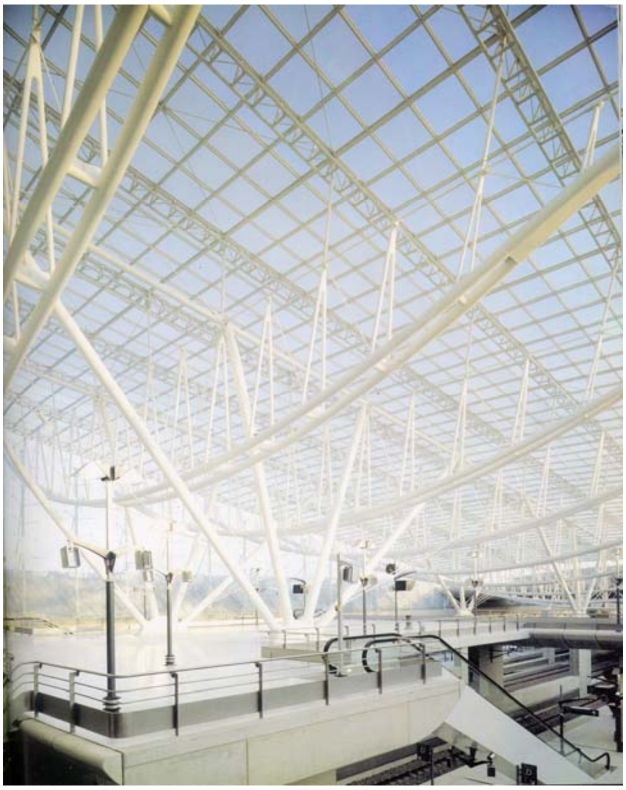


Fig (3.53) View of the lobby level and of the platform level, natural lighting is provided through glass roof. [3]

▪ ***Noise***

Great care has been taken to insure that the noise and vibration from the passage of through trains at high speed will not cause problems for the people in the airport terminals. One innovative concept is being developed to reduce the startle effect of a fast moving (230 km/hr) through train. It involves the generation of an artificial noise that gradually increases as a high speed train approaches the station. Since most of the noise (about 80%) from a train comes from wheel/rail contact, numerous noise traps near the tracks have been incorporated into the design of the station to keep noise levels on the platforms down to about 60 Db levels. In addition, a magnetic braking system is developed to reduce noise and to reduce wear on the wheels.

C) Social and economic territory

The TGV station is also seen as an important facility in term of attracting business firms to locations at the airport. These airport locations are especially attractive to firms whose employees must travel globally as well as those whose employees must travel to other European cities given the high costs of a business location in Paris.

The airport handles 48 million passengers per year. Usage of public transport and the rail station, with both local services and high-speed long distance services is currently as follows:

Buses	14%
Local rail	16.5% (35 minutes to central Paris)
TGV	3%

The level of competition between air and TGV service is high, many people in cities like Nantes and Lille take the TGV to the RCDG airport rather than fly. Other effects are the replacement of some bus services by the TGV. [1]

3.4. Conclusion

- **Intermodal Connectivity**

The selected examples of rail/bus and coach interchange have shown a complete integration of the different transport modes. The Transbay Terminal in San Fransisco has been successful in separating the movement of vehicles and pedestrians both horizontally and vertically providing convenient and efficient circulation. The Kowloon station is another example of city centre station which succeeded to resolve the problem of providing complex interconnections between the different transport modes through a central concourse.

While city centre locations are desirable for a number of reasons, there are also some cases where by passing the city centre can help maximize overall route speed while minimizing cost. The TGV station at the RCDG Airport and Lyon Airport are examples of national hubs that are not destinations around the world. The French have given a very strong emphasis to integrating connecting modes (auto and transit) with their TGV stations. Much could be learned from a careful study of how these connecting modes are used after they have been operational for a year or so. Of particular importance is the degree to which the transit modes (Metro, Tram and Bus) compete effectively with auto as the primary access mode to/from the station. The RCDG airport TGV/RER station provides a setting for the study of the relative utility of connecting modes.

A key design question is how much auto parking and roadway facilities should be provided adjacent to the station for particular levels and types of transit service. If the transit facilities are found to be little used while the auto facilities are heavily used, easy auto access and substantial amounts of auto parking should be provided.

- **Integration of vehicular and pedestrian circulation**

Successful integration of vehicular and pedestrian circulation through the intermodal station area and the surrounding neighbourhood are manifest in the Transbay terminal. The well distributed access points for passengers, the location of internal pedestrian through one storey concourse area above street level, together with the dedicated bus ramps and entry points create an unimpeded vehicle flow. An important issue is the visual and physical permeability of the structure which enables the pedestrians to find their way through a variety of levels.

Locating the escalators in the central open area in Kowloon station contributes to successful way finding and the ability of pedestrian to understand the organization of the space. The hanging bridges and the connecting tunnels which signify Oriente station allows smooth transition through the space. The link between the two terminals at the Lyon St. Exupery Airport, and the connection of the St Exupery TGV station to them through a moving walkway improves the intermodal links and saves transfer time.

An interesting feature of terminal 2C at Charlle De Gaulle Airport is the luffing ramps and the introduction of segregated passenger routes at different levels; and the ramps that lead to loading bridges which in turn move on rail from one level to the other.

The very long platforms (about 1/3 mile) needed by two connected 10 car TGV trainsets do require some long walking distances for rail passengers. However, in some cases a mid platform stairway or escalator to a connecting mode has been provided to reduce them, these are seen in the Roissy TGV airport station. In other cases, moving beltways have been provided to reduce walking requirements as has been seen in St. Exupery TGV airport station. Still some stations in the Paris area are referred to as "monsters" because of the length of the walking distances and the rather complex maze of connecting corridors and stairways that one must negotiate to make a connection to another mode. Great efforts are made to accommodate the needs of disabled people and to reduce the effort required to make intermodal connections in these monster stations.

The internal design of the operating stations discussed in this chapter was generally very good in terms of informational and directional signs, current train schedules on numerous TV monitors and automated signboards, maps showing the makeup of TGV trains so that one can determine the locations of 1st and 2nd class coaches. Little baggage handling activity is notable on the TGV platforms. The baggage handling system built at the RCDG Airport uses a system of tunnels located under the TGV tracks.

- **Environmental design features**

Special attention is given to protecting waiting passengers from the noise, wind and vibration effects of high speed through trains. These measures include an artificial noise generation system (RCDG) that is designed to reduce the startle effect of a through train, thick concrete walls to reduce noise, air pressure and vibration, and special noise traps to contain and cancel the noise to the extent possible. Thick glass panels are being used to allow waiting passengers to see the through trains passing by at high speeds as well as to allow daylight to penetrate into all parts of the station interior.

It is not clear at this point how important it will be to provide a cover (i.e. roof) over the tracks of a station that is designed to allow for the passage of through trains at high speed until the noise and vibration attributes to the selected high speed technology are known. No definite answer to this question can be derived, a closely related issue relates to the construction of buildings on top or of directly adjacent to high speed stations that allow high speed passthroughs.

Daylight and natural ventilation suffuse the Transbay terminal with sunlight and air, and save energy. The design of the roofs is based on capturing rain water to maintenance and irrigation.

The large circular 'light eyes' in Stuttgart Main Station provide natural light as well as views of the green park which extends above the station. The construction depth of the efficient shell was able to be reduced to one hundredth of span resulting in the use of much less material. The station will operate without supplied energy. The 'zero energy' station requires no heating, cooling or mechanical ventilation.

In Kowloon station, light is taken into the catacombs of the platforms via diagonal paths of deflected light. The arrangement benefits for the use of a central spine of station offices whose curved glazed walls act as reflectors.

At Roissy Charle De Gaulle station, natural light is present in nearly all of its interior spaces, thus reducing the high energy cost of using artificial lighting in such a large facility. Special robotic systems have been designed to wash these large areas of glass to keep them clean.

- **Economic and social territory**

- Ethical standards and social equity

The Transbay terminal will be a functional and physic landmark in the city bringing together its many amenities required a building with substantial footprint. The design nearly weaves itself into the dynamic city fabric, its success rests on the concepts of permeability and flow applied nearly every aspect of the design.

Stuttgart station as a whole, with its exterior plazas, walkways and platforms, forms a new central urban public space and a social meeting point which creates a pedestrian link between the Stuttgart 21 development and the present city centre. The historical Bonatz building is integrated into the station.

Lying in the vegetal kingdom, the group of pillars forming the platforms roof in Orient station resemble palm trees. The pavement is the stonework which is used in the streets of Lisbon.

- *Economic performance*

In Stuttgart Main station is significant through the use of much less material. The volume of the building is reduced to the minimum. The reusability of the formwork elements and the prefabrication of the modular components facilitated the efficient and profitable planning of the construction process.

Concrete, steel and glass are the used structural materials in most of the examples discussed which contributes to the required issues of structure durability and maintenance.

- *Local initiatives*

The Transbay terminal will become a market place of public transportation services. New high rise, mixed income housing in the surrounding neighbourhood, the possibility of new office space, a major new hotel and downtown conference and educational facilities will draw an 18 hour population into the terminal to use its services, enjoy its retail and restaurants and carry out the commerce of a great city.

The Lyon airport participates in the local initiatives of resident associations by means of financial aid or the provision of lots. The TGV station at Charlle De Gaulle is also seen as an important facility in term of attracting business firms to locations at the airport.

- *Joint development opportunities*

A key element in the station area development projects that have been carried to date has been the close working relationship between the public agencies and private business involved. These organizational and functional relationships are quite intricate, however, they are clearly very important and deserve detailed analysis.

Table 3.1 Application of Table 2.1. (Design guidelines for sustainability of intermodal stations) to the selected examples of rail/bus and coach interchange.

Sustainable design issues	Transbay Terminal	Stuttgart station
Intermodality		
- Maintain and improve plazas	√	√
- Maintain and expand park and ride lots	√	
- Provide information on transportation modes	√	√
- Private shuttle service to intermodal facilities.		√
- Improved access and rail improvements within the terminal area.	√	√
Pedestrian Safety and Convenience		
- Access signal pedestrian cycles in light of the aging population for adequate timing for safe crossing.	√	
- Employ traffic calming techniques such as narrowed lanes, speed tables, and lane markings.		
- Provision of footbridges and tunnels for safe crossing.	√	
- Provision of escalators, lifts for accessing other levels.	√	√
- Increase the width of sidewalks, and reduce street pavement width where possible to reduce crossing length		
- Improve transit rider safety on and off of buses (bays)	√	√
Environment		
- Utilize environmentally benign travel modes		√
- Expand vegetated buffers to improve air quality, act as a noise barrier, mitigate heat island effects, infiltration, and improve the visual quality.	√	√
- Use recycled water for irrigation and maintenance	√	√
- Utilize natural lighting and ventilation for energy efficiency in station buildings	√	√
-Take prudent and cost effective measures to minimize noise pollution.	√	√
Equity		
- Provide equitable service outcomes to all populations.	√	√
- Emphasize public transportation and include services for disabled people and provide information.	√	√
- Provide technical and financial assistance to private non profit, highly specialized transportation operators serving needs of handicapped persons.		√
Economic development		
- Use the transportation investments to support the economic vitality of downtown and suburban centres as well as brownfields and provide service facilities.	√	√
- Introduce joint development opportunities	√	

Table 3.1 (continued) Application of Table 2.1. (Design guidelines for sustainability of intermodal stations) to the selected examples of rail/bus and coach interchange.

Sustainable design issues	Oriente Station	Kowloon Station
Intermodality		
- Maintain and improve plazas	√	√
- Maintain and expand park and ride lots	√	√
- Provide information on transportation modes	√	√
- Private shuttle service to intermodal facilities.		
- Improved access and rail improvements within the terminal area.	√	√
Pedestrian Safety and Convenience		
- Access signal pedestrian cycles in light of the aging population for adequate timing for safe crossing.	√	√
- Employ traffic calming techniques such as narrowed lanes, speed tables, and lane markings.		
- Provision of footbridges and tunnels for safe crossing.	√	√
- Provision of escalators, lifts for accessing other levels.	√	√
- Increase the width of sidewalks, and reduce street pavement width where possible to reduce crossing length		
- Improve transit rider safety on and off of buses (bays)	√	√
Environment		
- Utilize environmentally benign travel modes		
- Expand vegetated buffers to improve air quality, act as a noise barrier, mitigate heat island effects, infiltration, and improve the visual quality.	√	
- Use recycled water for irrigation and maintenance		√
- Utilize natural lighting and ventilation for energy efficiency in station buildings	√	
-Take prudent and cost effective measures to minimize noise pollution.	√	√
Equity		
- Provide equitable service outcomes to all populations.	√	√
- Emphasize public transportation and include services for disabled people and provide information.	√	√
- Provide technical and financial assistance to private non profit, highly specialized transportation operators serving needs of handicapped persons.		
Economic development		
- Use the transportation investments to support the economic vitality of downtown and suburban centres as well as brownfields and provide service facilities.	√	√
- Introduce joint development opportunities		

Table 3.2 Application of Table 2.1. (Design guidelines for sustainability of intermodal stations) to the selected examples of airport/railway interchange.

Sustainable design issues	**Lyon St Exupery Station**	**RCDG Station**
Intermodality		
- Maintain and improve plazas		
- Maintain and expand park and ride lots	√	√
- Provide information on transportation modes	√	√
- Private shuttle service to intermodal facilities.		√
- Improved access and rail improvements within the terminal area.	√	√
Pedestrian Safety and Convenience		
- Access signal pedestrian cycles in light of the aging population for adequate timing for safe crossing.	√	√
- Employ traffic calming techniques such as narrowed lanes, speed tables, and lane markings.	√	√
- Provision of footbridges and tunnels for safe crossing.	√	√
- Provision of escalators, lifts for accessing other levels.		
- Increase the width of sidewalks, and reduce street pavement width where possible to reduce crossing length (neck-down)	√	√
- Improve transit rider safety on and off of buses (bays)		
Environment		
- Utilize environmentally benign travel modes	√	√
- Expand vegetated buffers to improve air quality, act as a noise barrier, mitigate heat island effects, infiltration, and improve the visual quality.	√	√
- Use recycled water for irrigation and maintenance	√	
- Utilize natural lighting and ventilation for energy efficiency in station buildings	√	√
- Take prudent and cost effective measures to minimize noise pollution.	√	√
Equity		
- Provide equitable service outcomes to all populations.		
- Emphasize public transportation and include services for disabled people and provide information.	√	√
- Provide technical and financial assistance to private non profit, highly specialized transportation operators serving needs of handicapped persons.		
Economic development		
- Use the transportation investments to support the economic vitality of downtown and suburban centres as well as brownfields and provide service facilities	√	√
- Introduce joint development opportunities	√	√

CHAPTER IV

Chapter 4

Examples of Cairo Existing and Proposed Intermodal Stations

4.1. Introduction

Public transport development in Cairo in recent decades has been characterized and shaped by a series of milestone events, these include the construction of a rail mass rapid transit system (metro), formal bus services have suffered erosion of market share, the liberalization of regulations pertaining to private sector participation in public transport operations continue to create market opportunities for the informal bus sector. Microbuses are more accessible within a short walking distance than some formal services, nevertheless, they create a number of transport problems. Trolley bus lines have been abandoned over the years as have components of the light rail system (tram, Heliopolis Metro). The light rail network has despite its high potential as an efficient mode of urban transport declined from near 400 route kms in 1971 to 226 route kms at present. The suburban railway network has largely stagnated without major enhancements of service despite radical intensification of urban development within the rail catchments, only one new line linking the Giza city with the 6th of October city (26 km) using an end station located several kms from the 6th of October central area. Fare levels are not merely controlled, they are frozen for the benefit of the poor, while paralleling problems have arisen in particular, are yielding insufficient cash flow to allow upgrading of services and fleet renewal. Uncertainties in funding have catalyzed a shortage of maintenance investment on rail public transport systems, particularly the light rail to a lesser degree suburban rail services. Formal bus services are constrained in the route structure they offer and fares they may charge. Concurrently the aging fleet must serve an ever expanding catchments, including linkages with outlying communities. Service frequencies are as a result, declining throughout the system. [19]

As a result of the scarce domestic resources in the political arena, long term tactical as well as strategic planning for the provision of public transport is severely constrained. The Metro is the only urban public transport service offering reliable, high speed service with peak period commercial speeds near 35 km per hour at 3 to 3.5 minutes headway. Commercial operating speeds of the light rail network average some 15 km/hour with main problems being outdated equipment and considerable delays at grade intersections with road traffic. While ENR services reach some 40 km/hr. All bus services operate in a mixed traffic at an average scheduled commercial speed of 15-20 km/hr considerably less in central areas.

The realization of a balanced and multimodal environment presents a continuing challenge in Cairo. Coordination among the different transport modes and between public transport and private cars is minimal. Independent scheduling, uncoordinated route structure, and independent fare structures do not facilitate interchange among the various urban public transport modes. Two significant barriers seem to prevent such coordination; first there seems to be little institutional cooperation among the different agencies planning and operating public transport services and shared taxi services, secondly, current fare policies of the individual modes do not facilitate cooperation among the various operators. Fare and subsidy structures of the different modes are set in isolation of each other. [19]

Cairo terminals suffer many problems which affect passenger trips at such stations of which are; the poor state of the platforms and station buildings, number of platforms and their capacities are insufficient, unavailability of some types of concessions and the poor state of some of them like restaurants and toilets, unavailability of sufficient parking areas and the unavailability of modern information systems and announcing systems. [43]

4.1.1. Public transport service structuring

Forecasts for Cairo regional area suggests a population of 17.05 million in 2010 and 19.67 million in 2022 i.e. 21.3% 21.2% of the total Egyptian population respectively.[23] The form and extent of public transport services is influenced by a variety of factors, among them urban form, multimodal consideration and historic practices.

A) Urban form: the urban area was 30,000 hectares, the anchor of this pattern has been the central core areas of Cairo, and Giza which together house near 1.6 million persons and provide in excess 1.6 million employment opportunities. Thus in terms of public transport services, an important issue becomes evident; the type, modal composition and extent of the public transport system must be structured so as to satisfy a variety of transport needs ranging from longer distance suburban trips to shorter, but high density, movements within the urban core.

B) New communities axes: the current structure, and future coordination of the urban fabric within the new community axes is dynamic and is expected to catalyze a need for various public transport technologies whose allocation will vary over time.

C) Passenger references: public transport services carried a total of 12.44 million daily trips in 2001, this represents 68% of all motorized trips, in general, year 2022 public transport demand within GCR will account for more than half of all motorized trips and aggregating to some 17 - 22 million daily person trips. The implications in terms of transport planning are clear, there exists a compelling need to focus on the movement of persons rather than the movement of vehicles.

D) Sector performance: the evolution of public transport supply and demand in GCR over recent decades suggests that formal sector public services have with notable exception of the Metro, suffered a decline in market share, the experiences of Cairo are not dissimilar from those of large cities in emerging countries. A primary pressure is the continuing growth in the rate of motorization and shift to private mode of transport at the expense of public modes. A rationalization of public transport systems is needed with each system allocated in such a manner that utilizes its relative strengths, by their speed capacity and type of service. Intermodal connectivity under such a scenario is absolutely essential. [19]

4.1.2. Polices adopted for intermodal system sustainability

Developing an intermodal public transport system reliant upon a public and private sector partnership requires the efficient integration and interconnection of the different public transport elements. This interconnectivity relates on the one hand to the (important) role of terminals and on the other hand on the hierarchy of public transport systems.

A) Investment sustainability: Proposing the introduction of fuel tax as local embarked tax for urban transport improvement of the area to secure investment sustainability (should not be limited to road, it should be spent for all urban transport related improvements) [19]

B) Operational sustainability: Financial revenue for the operators of the system should be of appropriate level to continue service supply. If the financial revenue is not sufficient, the operators would reduce service frequency, drop maintenance quality. Fare level of public transport is highly political because it relates to the living standard of people. However self sustainable operation by appropriate fare level should be secured to make public transport operators sustainable. The common ticketing system intends to promote public transport usage by providing convenience to passengers.

C) Administrative sustainability: An integrated administrative body, which is responsible for all urban transport issues covering the whole metropolitan area, with robust financial base would be the first priority to be established, as potential financial source, the fuel tax, toll revenue, parking charge revenue should be considered. [19]

4.1.3. Necessary considerations for sustainability of Cairo intermodal stations

A) Environmental preservation

Existing situation in the intermodal project area should be evaluated for its environmental condition. This evaluation is related to the air quality and noise levels. The survey would also identify the expected environmental impact for the proposed intermodal project.

B) Equitable people's mobility:

Equitability is closely related to welfare policy, therefore coordinated policy persuasion with welfare policy would be necessary.
In longer term, barrier free facilities should be equipped to assist handicapped and aged people for convenience at stations and terminals such as slope, lift, toilet and so on. Vehicles which are friendly to those people would be one of the additional options. [19]

C) Safety facilities for pedestrians:

For public transport users, walking is indispensable, however, pedestrian safety condition in Cairo is terrible, even a young and healthy man cannot walk safely in Cairo. Cars do not stop for pedestrians. Limited pedestrian safety facilities, such as pedestrians Zebra crossings and pedestrian traffic signals are limited in the city, pedestrians first should become a common sense. [19]

D) Modal connectivity:

Walk forms the dominant access mode across all trip purposes. There is little formal coordination among motorized public transport modes, routes/lines intersect at major stations or terminals, there is no formal planning in terms of service coordination or passenger transfer needs.

E) Retail concessions:

Stations and terminals can also be designed to accommodate feasible space for small business catering to users, including convenience stores, branch banks and automatic teller machines (ATMs) coffee shops and snack restaurants, news paper and magazine vendors. Also, major public transport terminals and stations provide both ample surface area for the display of advertisements. [19]

F) Park and Ride:

Commuter parking facilities are also a potential source of revenue for mass transit operations. [19]

4.1.4. Types of intermodals in Greater Cairo Region

Three different types of interconnecting points are discussed in the public transport intermodal network in Cairo: [21]

A) Primary interconnecting points:

These are locations where all public transport modes coverage and where high numbers of passengers transit from one mode to another and access to enter the public transport. These terminals are centrally located in the network. Ramses is an example of a primary city centre intermodal point.

B) Secondary interconnecting points

These are suited on the intersection of two different types of public transport, example Metro line and Supertram or bus terminal. Their functionality is similar to the primary interconnecting points, but the number of modes converging in the terminal and the number of passengers per day using that terminal is less.

C) Network interconnecting points:

These are located at the boundaries of the network with intercity public transport. The level of intermodal complexity is low in these types of terminals. Ain shams terminal is an example of a railway based network interconnecting point where existing facilities and construction constraints make its rehabilitation more complex.

D) Park and Ride interconnecting points:

These provide dedicated parking services for private cars and connect with the public transport network.

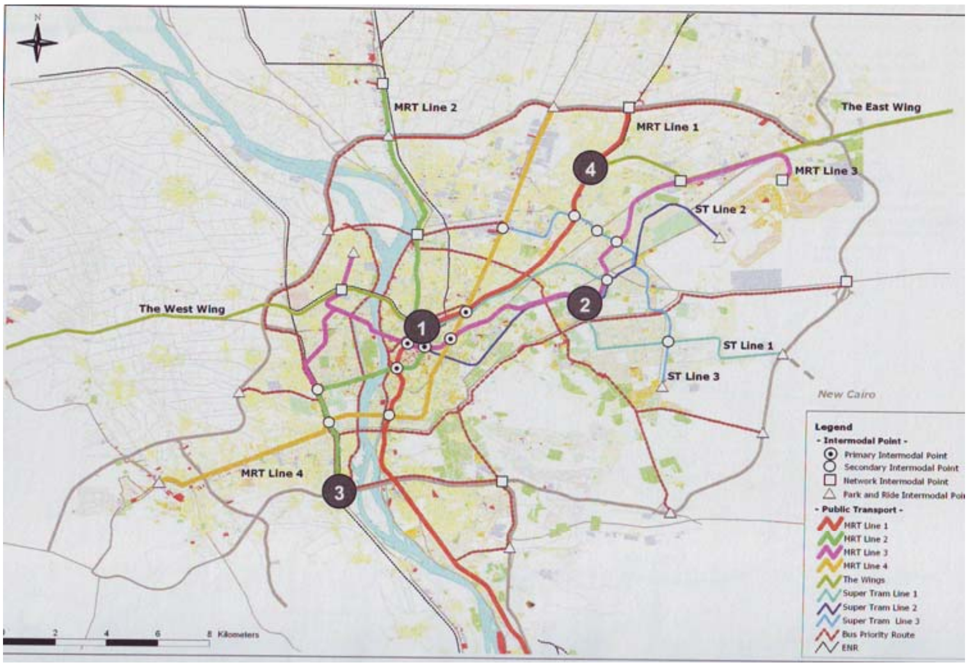


Fig (4.1) Public Transport Network and Example Terminals [21]

4.2. Primary Intermodal Stations

Ramses Intermodal Station (City centre)

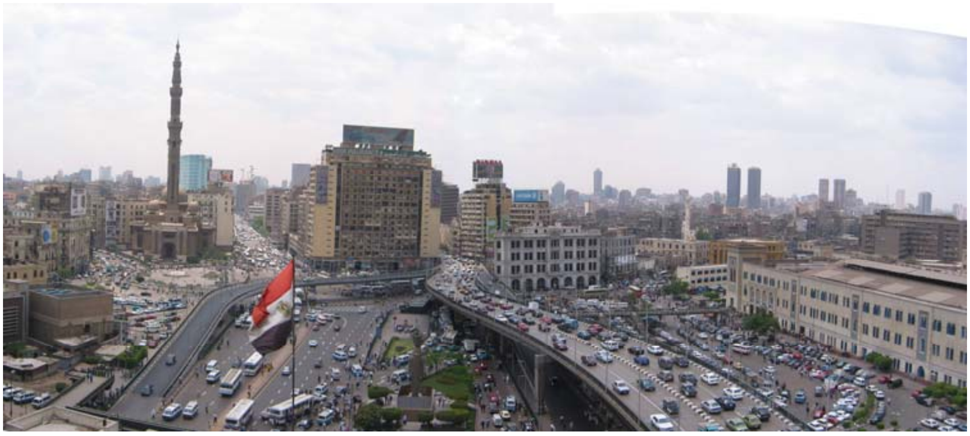


Fig (4.2) Ramses intermodal station, aerial view [47]

Ramses station is one of the most important public transport stations in Cairo, as it involves the main ENR station and a number of different modes services. A series of changes had been implemented involving road closures and the relocation of shared taxi and CTA bus facilities from within the Ramses Square area to a new public transport terminal located immediately North of the ENR tracks. The location of the existing Cairo Metro tram station is inadequate for the needs of a modern LRT station. A public transport-friendly design is needed, under which tram passengers would have direct access to the Cairo Metro via a widened stairway connection adjacent to the LRT station, while interchanges with other modes can be achieved via a modernized elevated walkway. No person need cross any road. The new design should create a pedestrian island with numerous opportunities for precincts, landscaping and other amenities.

4.2.1. Existing transport services

A number of transport facilities exist within Ramses square including one of the main ENR stations which is directly linked to the CTA bus terminal, the terminus of Heliopolis Metro (the future LRT 1), elevated pedestrian walkways and entrances to the underground Cairo Metro (Mubarak Station, Metro Lines 1 and 2). Major road facilities within the square include Ramses street and the elevated 6th of October Expressway. Figure (4.3) represents major traffic flows and major transport elements, and a shematic of the road infrastructure. [21]

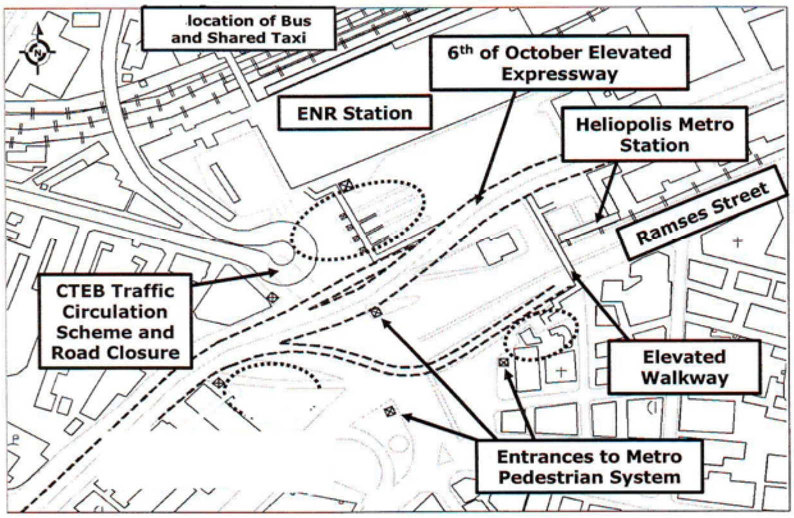


Fig (4.3) Major transport elements : Ramses Square.[21]

4.2.2. Problems of the present situation of Ramses intermodal station area

A) Traffic and pedestrian circulation

In principle, Ramses station has the necessary infrastructure and structure to operate as an intermodal terminal, Railway, metro, tramway, bus and shared taxis are linked via the elevated pedestrian way and via the metro passage. However, major traffic problems occur near the terminal and even further on Ramses Road next to the tramway terminus, traffic problems arise as a consequence of the problems near the station (trigger neck congestion). Ramses railway terminal has huge problems at the entrance and exit points. Traffic wanting to reach the terminal needs to cross the access ramp toward 6th of October expressway and gets blocked at the entrance hindering other traffic on the street. Arriving traffic via the small street in front the NAT building (minibuses and shared taxis) gets stuck and starts unloading its passengers at that point or at any free space around the removed statue. In particular shared taxis use the road in front of the railway terminal to avoid entering the terminal. This chaotic situation negatively affects traffic on all access points and hinders through-traffic.

Fig (4.4) Slip road between Ramses street and access ramp to 6th of October expressway and vacant area of the removed statue

Fig (4.5) Entrance to ENR station intruded by vehicle traffic flow

At the same time, people wanting to change from one mode to another need to search their next shared taxi or minbus ride because a large number of the shared taxi does not use the designated terminal, adding to the already problematic situation outside the terminal.

Mini busses and shared taxis further crowd the streets and the terminal to transport the people to and from this area. This concentration of traffic and persons generates huge congestion and the problem is further aggravated by the traffic and pedestrian behaviour and by the illegal merchants selling their products in the middle of traffic.

Fig (4.6) Congestion problem under 6th of October expressway ramp

Fig (4.7) Minibuses crowd the streets to load and unload people.

Both the entrance and the exit of Ramses terminal are fully congested, making the traffic inside the terminal difficult if not impossible. The problems are not only a consequence of the situation outside the terminal, but are even more so caused by the chaotic behaviour of taxis and private vehicles that load and unload passengers in the terminal area.

B) The situation of the LRT station

The existing Heliopolis metro terminus station configuration is inadequate for use by a modern LRT system such as Supertram Line 1, from a number of perspectives, including inadequate platform space, inadequate platform length and a lack of pedestrians amenities. The current location is seriously constrained to the south by Ramses street and to the North by NAT building complex.

Fig (4.8) The current location of the LRT (Heliopolis Metro) terminus

C) The situation of the Egyptian National Railway (ENR) station

The ENR station at Ramses square is Cairo's major railway terminal and is of a high relative importance for the whole country of Egypt. However the station building and platforms need upgrading in many aspects.

Fig (4.9) Ramses ENR station main entrance

The station has got 24 platforms of varying lengths and breadths (ranging between 188m to 481m in length and between 2.5m to 8.5m in breadth). The vertical level of platforms vary considerably between 88cm - 102cm (standard should be 91.5cm - 92.5cm). The status of the platforms vary between good and moderate. Many of the platforms need to be extended and widened. Ticket desks are insufficient in number. Seats and shelters are insufficient and need modernization. Messages revealed through the announcing systems are not clear. Toilets and cafes need renovation. Information displays and orientation signage are insufficient and need modernization. [43]

Parking area is insufficient the occupancy percentage ranges between 0% to 174%. More space for Kiss and ride facilities need to be provided. The status of the tunnels crossing under the platforms are good in respect of lighting and ventilation and also with respect to the materials used in walls ceilings and floorings. [43]

Fig (4.10) Paid parking at the west side of Ramses ENR station.

Fig (4.11) Paid parking in front of Ramses ENR station.

Although the original design of the terminal was highly efficient, the effectiveness of the different sections in the terminal has disappeared over time. The parking space of private cars (paid) is overcrowded while the entire road section in front of the terminal is used by taxi and private cars for loading and unloading zones. Even the new paid parking which has been demolished was not going to solve the problem as long as its development is not part of a comprehensive restructuring of the terminal.

Any solution to the problem needs to address the terminal and the access to the terminal simultaneously. On the other hand the design of the terminal has to be adopted to intermodal needs, while traffic flows to and from the terminal need to be redirected to guarantee a better more fluent throughput.

Fig (4.12) Ahmad Helmi bus terminus at the north of the ENR station

Fig (4.13) Ramses ENR station platforms and platform shelters

Fig (4.14) Natural lighting and ventilation provided through roof canopy

4.2.3. The environmental condition in the project area

A) Air quality survey

The measured concentrations were compared with the air quality standards of Egypt (Executive Regulations to Environmental Law No.4 of 1994) for air quality in terms of NO2, SO2, CO, PM10, and O3

Table (4.2) Air quality survey at Ramses intermodal area [21]

Station location	NO2 Nitrogen Dioxide		SO2 Sulphur Dioxide		CO Carbon Monoxide		PM10 Particulate Matter 10µm		O3 Ozone	
Ramses square	Meas	Egy Std.	Mea	Egy Std.	Mea	Egy Std.	Mea	Egy Std.	Mea	Egy Std.
	$\mu g/m^3$		$\mu g/m^3$		$\mu g/m^3$		$\mu g/m^3$		$\mu g/m^3$	
	123	150	68	150	14.4	10	211	70	55	120

From table (4.1) we can conclude the following:

- Fine dust (PM_{10}) and carbon monoxide levels exceed heavily the Egyptian standard
- Nitrogen dioxide, Sulphur dioxide and ozone concentrations are at considerable level, however still below the Egyptian Standard.

B) Noise level survey

Traffic produces noise that can cause considerable annoyance. It can interfere with daily life. Disruptive sounds have noise levels higher than 70 db which causes negative impacts on health. Table (4.2) shows noise levels at Ramses Square site

Table (4.2) Noise level survey at Ramses intermodal area [21]

Location	Day 7 am – 6 pm	Evening 6 pm – 10 pm	Night 10 pm – 7 am
Limits of ES	55	50	45
Ramses Square	81.55	82.88	80.92

From table (4.2) it is clear that noise levels exceed the Egyptian standards and are higher than 70 db.

4.2.4. Forcasts for Ramses Intermodal Station

Demand forcasts confirm that Ramses Station will retain its current dominant role. Thus in terms of station planning, adequate pedestrian capacity for movements between the metro and supertram Line 1 are vitally important. The locations of entry points of the metro (stairs to the underground Mubarak station) are seen in critical terms. However other avenues of pedestrian movement must also be considered. In particular, the elevated series of walkways around the periphery of Ramses square are seen as a particular asset of this offer, in parallel with multiple metro entry points, excellent opportunity for movement of people to/from the various public transport services with minimal need to cross busy streets and roads within Ramses square.

By the year 2022, some 74,500 daily boarding movements are expected, with the vast majority (60,000 persons per day) entering the supertram after an initial journey on the Cairo metro (table 4.3). The expected adverse and positive socioeconomic impacts of the Supertram Line 1 is shown in table (4.4).

Table (4.3) Year 2022 boarding passenger by principle access mode
Ramses Station – Supertram Line 1 [21]

Access mode	Daily passengers
Walk Shared Taxi Urban Bus Cairo Metro	9,000 2,000 3,500 60,000
Total	74,500

Table (4.4) Expected adverse and positive socioeconomic environmental impacts of the supertram project [21]

Adverse socioeconomic environmental impacts in the existing situation	Expected positive socioeconomic environmental impacts after project implemntation
- Bad performance of existing facility - long travel time for passengers - Nuisance - High operation costs - poor accessibility	- reduction of travel time for passengers - increased economic development - improved mobility - increased safety

Further positive impacts expected on the social and physical environment in the project area are:

- A number of car users will start using the supertram and therefore there will be less air pollution and less energy consumption. There will be no significant increase of noise levels
- There will be a more free flowing traffic pattern and as a result a reduced number of accidents
- Safety for pedestrians will be increased by the construction of pedestrian grade separations and other amenities.
- There are new possibilities for planting of trees and landscaping.

4.3. Network Intermodal Station

Ain Shams Station (Suburban)

This station is a terminal of the Suez line of the ENR. Ain shams station of Metro Line 1 is adjacent to the ENR station. Passengers heading to Cairo should transfer from ENR to Metro Line 1 at this station. Ain Shams station has two platforms and three trains can stop at the station at the same time. Station facilities are very basic with one ticket office which also serves as a general office for the railway

The Ain shams station area is expected to be one of the most important stations of the east wing in future. The surrounding area of Ain shams station will attract a large number of passengers after completion of the east wing public transport development. The station is located 10 km to the northwest of Cairo CBD. Population within a 800 m radius area of the station was 455,000 and its population density was about 2,300 person/ha in 2001. The estimated population is 584,000, in 2022. [20]

Fig (4.15) Ain Shams intermodal station, MRT station adjacent to ENR station

4.3.1. Land use pattern

The current land use pattern around Ain Shams Station is shown in figure (4.16). The major characteristics of land use patterns are residential/commercial use, such as grocery stores and other shopping stores. A bus stop, a taxi terminal are in dispersed locations due to the lack of an integrated transport terminal.

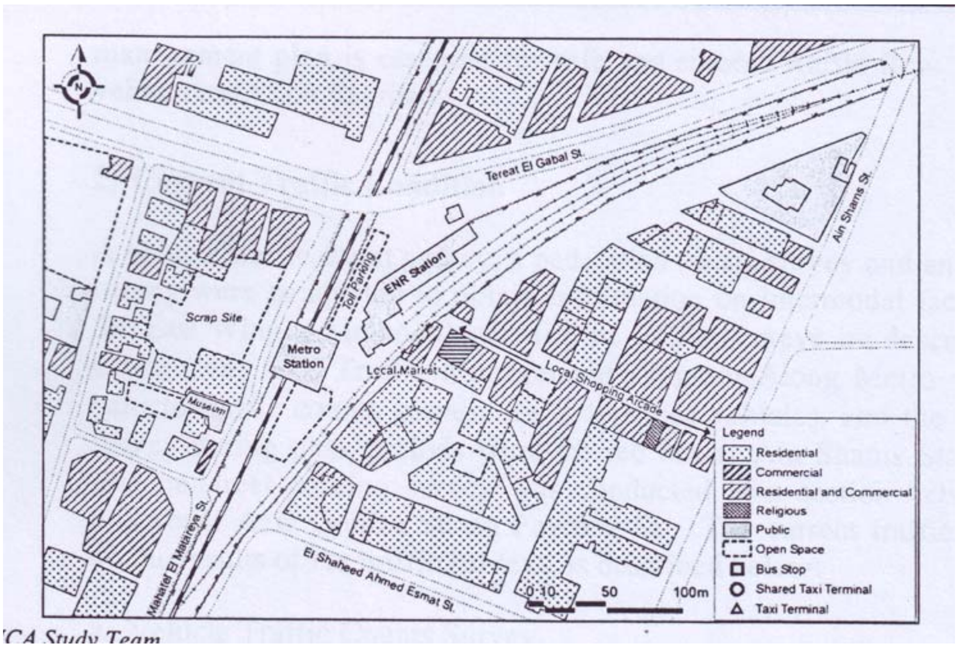


Fig (4.16) Land use pattern in the vicinity of Ain Shams station [20]

The western part of the station area is a high density residential area. Most residences are within mid-rise residential buildings. However, high rise residential buildings have been constructed in recent years due to a moderation of building coverage regulations. There is a local market on the east side of ENR Ain Shams Station and a local shopping arcade along a road from the market to Ain Shams street. An informal transfer terminal exists with illegally converted shared taxis on many alleyways in this area.

The eastern part of the area is also a residential area with mid to high rise residential buildings. An inefficient land use pattern is observed in this area, as there are vacant lands only used for scrap sites and an old building is located near to the station. Meanwhile, Mathaf El Matareya street, which is located in front of the metro station, is always crowded with existing taxis and through traffic, as well as various kiosks.

The northern part of the station is a narrow area, there is one bus stop serving passengers to/ from Ramses station under the flyover, as well as a toll parking area for private cars between Metro Line 1 station and ENR station.

4.3.2. Existing transport services

A) Eyptian National Railway (ENR)

ENR operates 7 suburban railway lines in the Greater Cairo Region. The Suez line which connects Ain Shams, Obour, Darb El Hag, Shorooq and Robeiky stations, respectively,is illustrated in Fig (4.17). The Ain Shams to Robeiky section of the Suez line is a single track with a distance of 45 km. Trains operated on the Suez line have been used for more than 40 years, therefore it would not be possible to use them for a railway service for commuters. It is expected that the East wing public transport will transport massive volumes of commuters to/from Cairo. Modern trains would be necessary for a high speed, comfortable commuter transport system.

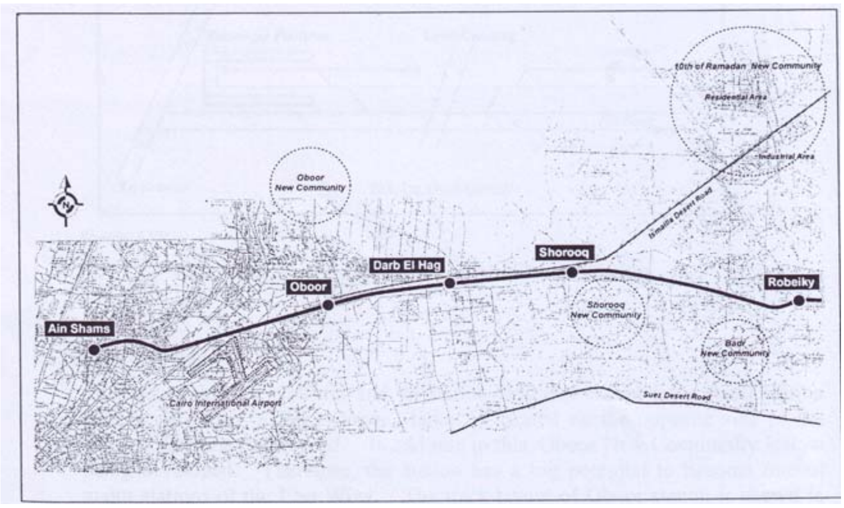


Fig (4.17) Route map of existing Suez Line. [20]

The present railway station is of poor quality and is not designed taking into account the pedestrians, in special the passenger transfer from/to Metro and should be completely replaced to be capable of functioning as a terminal station for the future East Wing.

Table (4.5) Number of passengers arriving/departing at Ain Shams ENR Station (in 2004). [43]

Time	vacancies	school	occasions
Arriving	5475	9045	8455
Departing	6290	10391	9713

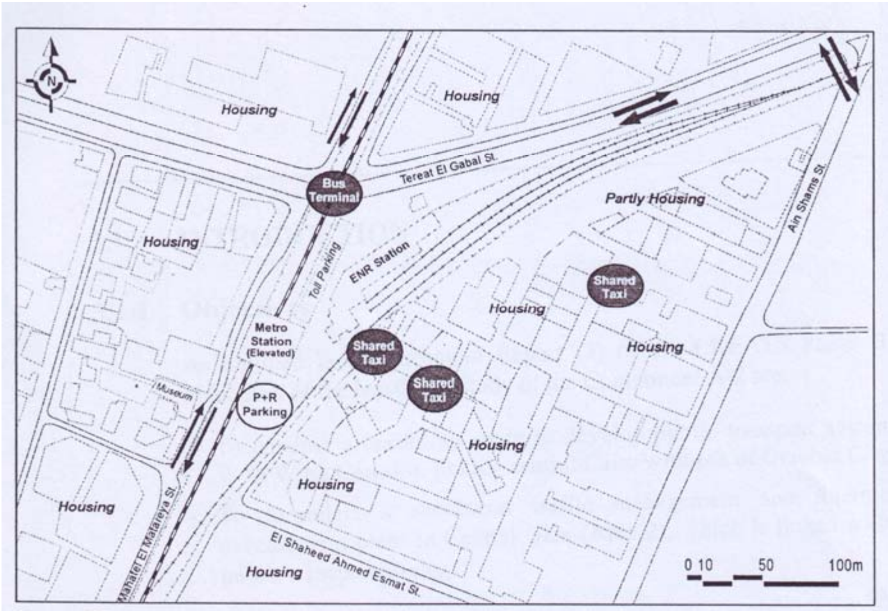


Fig (4.18) Ain Shams Station present situation [20]

B) Metro Line 1

In 2022, 212,000 passengers per direct per day are estimated to use Metro line 1 at Ain Shams station. Of which, 100,000 are transferred from public transport. The number of passenger by each mode is as following table:

Table (4.6) Number of passenger demand of Metro Line 1 by mode (1 direction) at Ain Shams Station (in 2022). [20]

	Wing	bus	Mini Bus	Shared Taxi	Taxi	Car	Walk	Total
No of Passenger per day	82,000	20,250	4,750	63,000	12,000	5,000	25,000	212,000

C) Road and bus services

The existing road along the East Wing is represented by the Ismailia Desert Road which connects the new communities along the corridor. Shared taxi is a major road based public transport service connecting

Cairo and the new communites along the corridor. The travel time from 10th of Ramadan city to Cairo is 1 hour.

Although no CTA bus service is provided between 10th of Ramadan and Cairo CBD at present, a private bus company (East Delta Bus) operates between the area and the city. Travel time to Cairo is one and a half hour.

4.3.3. Problems of Intermodality at Ain Shams

The ENR Ain Shams station presently interconnects the following public transport services:

- Metro Line 1 into Cairo
- Small bus terminal
- Shared taxi service near the terminal

Metro line 1 station could be described as a good operating station, given it is elevated and efficiently structured. The metro is, at present, the most efficient type of public transport and should therefore be considered as a strategic link to the future east wing connection.

The shared taxis requires total restructuring. At present, the service is limited to illegal taxis operating in the small streets behind the railway line. Accessibility from both the railway and metro stations is through illegal passes over the railway line. Offering an efficient shared taxi services in these streets is impossible, given that the streets are small and very crowded, creating a dangerous situation.

Finally, a small P&R parking place is located between the railway and metro station. The parking is difficult to access and many people randomly park their cars in the surrounding narrow streets. The new terminal will need to foresee efficient P&R facility to accommodate increasing numbers of persons making use of the P&R facility.

Although several public transport modes are available at that location, intermodal transport is non existent because the integration of services is completely absent.

4.3.4. Current Traffic Condition

A) Vehicle traffic survey

Table (4.7) Traffic volume at the East Wing [20]

Location	Street	section	Maximum two direction hourly traffic volume (PCU)
Ain Shams Station	Ain Shams St.	Northern	1,920
		Southern	2,911
	El Mashroaa St.	Western	2,063
		Eastern	444

PCU: passenger car unit

B) Pedestrian traffic survey

Table (4.8) Pedestrian traffic volume at the East Wing [20]

Location	Street	section	Maximum two direction hourly pedestrian traffic volume (Pax)
Ain Shams Station	Ain Shams St.	Northern	222
		Southern	199
	El Mashroaa St.	Western	1,105
		Eastern	786

C) On-street parking survey

Parking occupancy on Fayrooz street fluctuates between 60% and 100%. Fig (4.19) shows that the lowest occupancy rate is observed during business hours.

Fig (4.19) On Street parking

Fig (4.20) On street parking

Fig (4.21) ENR station Building

Fig (2.22) View of ENR station platforms and tracks

Fig (4.23) Matehaf El Matareya Street.

Fig (2.24) Metro Line 1 Station

4.3.5. Environmental condition

A) Air quality survey

Table (4.9) Air Quality Survey at Ain Shams intermodal area [20]

Station location	NO2 Nitrogen Dioxide		SO2 Sulphur Dioxide		CO Carbon Monoxide		PM10 Particulate Matter 10µm		O3 Ozone	
Ain Shams Area	Meas	Egy Std.	Mea	Egy Std.	Mea	Egy Std.	Mea	Egy Std.	Mea	Egy Std.
	$\mu g/m^3$		$\mu g/m^3$		$\mu g/m^3$		$\mu g/m^3$		$\mu g/m^3$	
	53.8	150	15	150	5.7	10	113	70	93.1	120

From table (4.9) we can conclude the following:

- Fine dust (PM_{10}) and carbon monoxide levels exceed heavily the Egyptian standard
- Nitrogen dioxide, Sulphur dioxide and ozone concentrations are at considerable level, however still below the Egyptian Standard.

B) Noise level survey

The following table shows noise levels at Ain Shams station site

Table (4.10) Noise level survey at Ain Shams intermodal area [20]

Location	Day 7 am – 6 pm	Evening 6 pm – 10 pm	Night 10 pm – 7 am
Limits	45-55	40-55	35-45
Ain Shams Station area	76.9	76.8	73.5

From table (4.10) it is clear that noise levels exceeds the Egyptian standards and are higher than 70 db.

4.4. Park and Ride Intermodal Station

Proposed Ring Road Intermodal Station (Fringe)

Ring road station is the eastern terminus of Supertram Line 1, and is located eastern Madinet Nasr near the intersection of Ahmed el Zomor Street with Cairo Ring Road. The current site for this station is a vacant land, with the exception of the ring road CTA bus terminal on the north side of El Zomor Street. Demand forcasts confirm that ring road station will emerge as the highest load point for Supertram Line 1 by year 2022. this is fueled by a variety of catalysts including continuing growth in Madinet Nasr in areas which are currently vacant, intensification of existing landuses, and primarily, accelerating growth in New Cairo. This urban conurbation, whose size is expected to ultimately reach approximately three quarters of a million persons, obviously represents a considerable contributor to supertram ridership. However, the speed of New CAIRO population growth, and the spatial distribution thereof , remains flexible and subject to market mechanisms. [21]

At present, CTA bus service is provided from the ring road bus terminal (which will be incorporated and enlarged within the LRT Ring Road station concept) into New Cairo (fig 4.26). Private operators also link some areas, such as Rehab, with Madinet Nasr and Heliopolis.

Year 2022 demand forcasts, show the strong reliance of boarding passengers upon shared taxi and bus modes (table 4.5)

The park and ride potential is noted given the strategic location of Ring Road station adjacent to the Cairo ring Road, a major grade separated and access controlled facility.

Table (4.11) Forcasts for daily passengers by different modes in 2022. [21]

Access mode	Daily passengers
Walk	9,400
Shared Taxi	38,800
Urban Bus	34,000
Park and Ride	15,000
Total	97,200

4.4.1. Proposed conceptual design

Ring Road station is an excellent opportunity for realizing a multi-use development combining both transport and commercial functions.
Population within a ten kilometer radius of the station is expected to more than double, growing from some 663 thousand in year 2001 to 1.42 million in year 2022. [21]

The population within the influence area can be considered as generally falling within higher income ranges. Thus when considering purchasing power, the middle to higher income population consists of some half million persons per year 2022. this would be considered the primary candidates for the commercial services. [21]

Concessions

It is conceivable that the type of shopping centre should be a large suburban shopping mall. Firstly, there is no constraint on area since the station will be located at what is now a vacant land. Secondly the station has large parking supply for park and ride spaces which could be available for customer parking. Thirdly, transport infrastructure, in particular the supertram and the ring road, offer excellent options linking shopping facilities with the customers hinterland. The kinds of shops included in this development would be clothing, appliances, restaurants, coffee shops, supermarket and Cineplex. The station also offers a potential for including information centre facilities dispensing transportation maps and timetables and available services for tourists. [21]

Park and ride spaces

The peak hour during the morning would catalyze a parking need of 1400 spaces and an aggregate morning total of 4000 park and ride spaces. A total of 5000 spaces is programmed to also account for needs of the shopping centre.

4.4.2. Circulation concept

The combination of busiest station on Supertram Line 1, thousands of parking spaces, pronounced bus and shared taxi activity as well as a presence of a shopping centre confirms that a large number of pedestrians will be traveling between and within these activity precincts. To avoid conflicts between vehicles and people, to enhance safety and to maximize operational efficiencies, several considerations are important in terms of defining a site circulation concept (Figure 4.25)

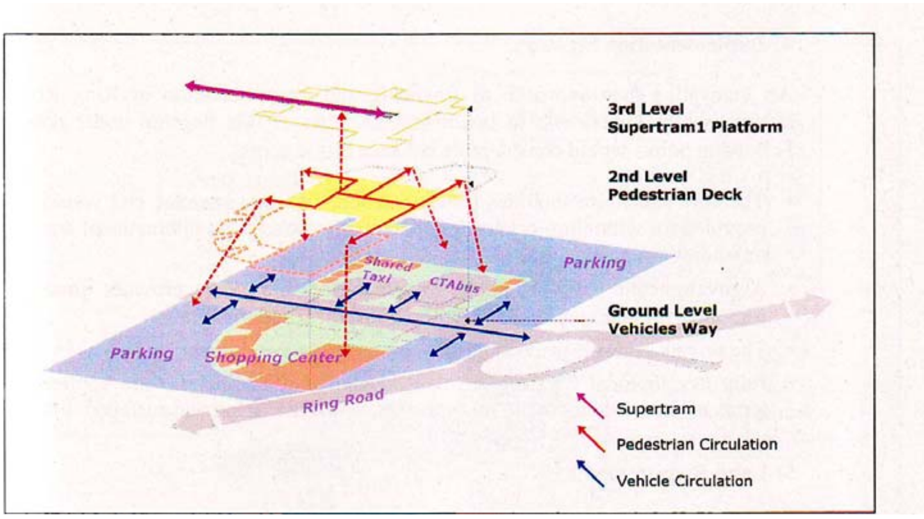


Fig (4.25) Site circulation concept at Ring Road Station [21]

- Ground level precincts are largely reserved for vehicles. These include through movements through Zumor Street, vehicles entering the/departing the park and ride lots, vehicles frequenting the shopping centre, as well as buses and shared taxis entering /leaving the shared taxi terminal and bus terminal.
- Pedestrians walking between and within transport activity precincts, or frequenting the shopping centre, must be able to do so without crossing streets and with minimum interaction with vehicles. Thus an elevated pedestrian deck is proposed spanning both sides of Zumor street and providing connection with the bus terminal, supertram station, park and ride lot and shopping centre. Conveniently located stairs, and strategically site elevators for handicapped and elderly, are a must.

The pedestrian deck clearly implies a need for an elevated supertram station (the only elevated station on the system). An elevated supertram alignment will also be necessary to accommodate the potential future extension of the Supertram to new Cairo, which will require bridging the Ring Road proper and the Zumor street interchange complex. Furthermore, a grade separated LRT alignment will ensure interference free (between LRT and road vehicles) operation along the track branching from the main line into the proposed supertram depot. [21]

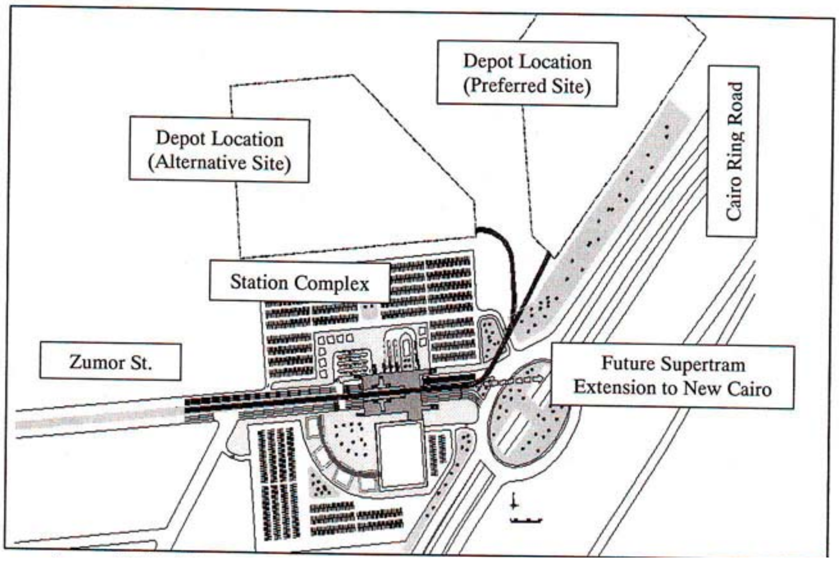


Fig (4.26) Spatial requirements of Ring Road Station and Supertram Depot [21]

The supertram station and track system, if constructed at the same level as the pedestrian deck would literally bisect the deck and block pedestrian movements unless pedestrians physically walk across the track. This is undesirable from a safety and supertram operations point of view. The supertram station must therefore be slightly elevated above the pedestrian deck; in effect, pedestrians would walk below the supertram complex, and reach the actual platforms via stairs or escalators.

4.4.3. The role of Private sector and joint development opportunities in the implementation strategy

An innovative new approach to financing and implementation of Ring Road station is highly desirable to facilitate realization of this flagship undertaking. Following points would considerably enhance this process:

- The core supertram facilities (tracks, station, fixtures, systems, etc.) would be provided for within project costing, potentially sourced via international donors or lending agencies.
- A governmental entity, or public-private partnership group, provides financial resources for land, parking and public transport feeder facilities.
- The private sector is responsible for commercial development.
- Joint development "transit oriented development" principles are applied in terms of asset development, management, revenue sharing and sustainability. [21]

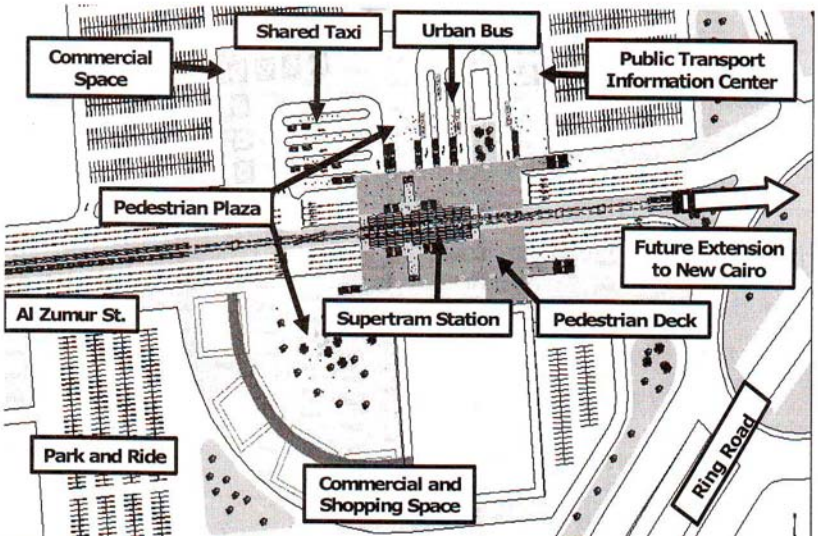


Fig (4.27) Principle components ring road station [21]

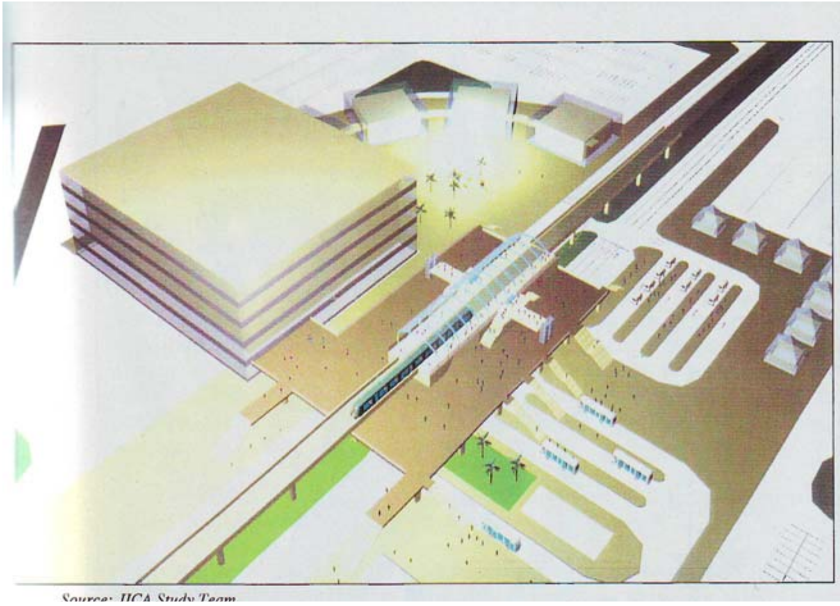


Fig (4.28) Aerial View of the Ring Road multi-use development [21]

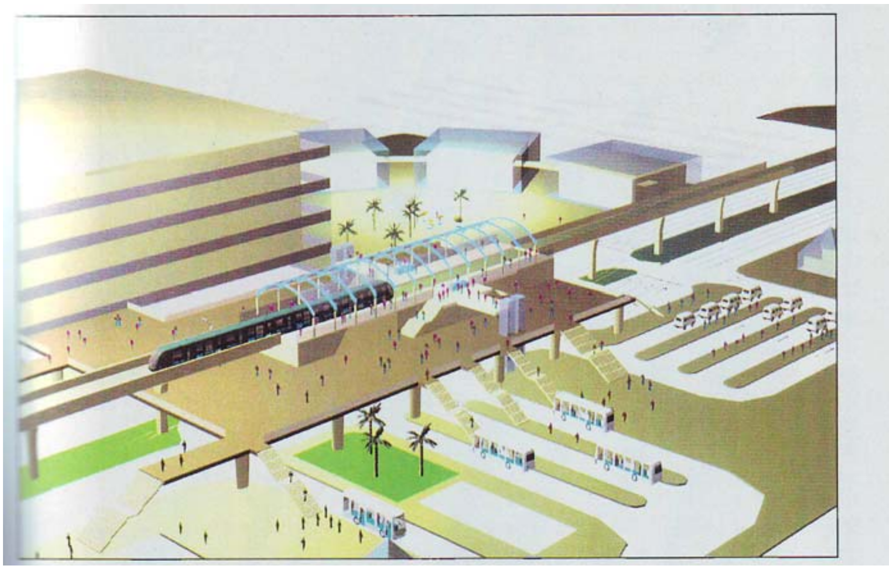


Fig (4.29) Principle public transport elements of Ring Road Station [21]

Fig (4.30) Station concept showing different levels [21]

Fig (4.31) Prototypical median station concept [21]

4.5. Conclusion

Table (4.12) Application of Table 2.1. (Design guidelines for sustainability of intermodal stations) to the present situation of Ramses and Ain Shams station

Intermodality Strategies	Ramses	Ain Shams
- Maintain and improve plazas, to connect different modes and pedestrian routes		
- Maintain and expand park and ride lots	√	
- Provide information on transportation modes		
- Encourage private employers to provide shuttle service to intermodal facilities.		
-Study improved access and rail improvements within the terminal area.	√	
Pedestrian Safety and Convenience strategies		
- Access signal pedestrian cycles in light of the aging population for adequate timing for safe crossing.		
- Employ traffic calming techniques such as narrowed lanes, speed tables, and lane markings.		
- Provision of footbridges and tunnels for safe crossing.	√	
- Provision of escalators, lifts for accessing other levels.		
- Increase the width of sidewalks, and reduce street pavement width where possible to reduce crossing length (neck-down)		
- Improve transit rider safety on and off of buses (bay position)		
Environmental Strategies		
- Utilize environmentally benign travel modes	√	
- Expand vegetated buffers to improve air quality, act as a noise barrier, mitigate heat island effects, infiltration, and improve the visual quality.		
- Use recycled water for irrigation and maintenance	√	
- Utilize natural lighting and ventilation for energy efficiency in station buildings	√	√
-Take prudent and cost effective measures to minimize noise pollution.		
Equity Strategies		
- Provide equitable service outcomes to all populations.		
- Emphasize public transportation and include services for disabled people and provide information.		
- Provide technical and financial assistance to private non profit, highly specialized transportation operators serving needs of handicapped persons.		
Economic Development Strategies		
- Use the transportation investments to support the economic vitality of downtown and suburban centres as well as brownfields and provide service facilities		
- Introduce joint development opportunities		

From the above table, it is concluded that:

- Ramses intermodal station does not satisfy the intermodality strategies for improved linkage between the different transport modes. The same is recognized for Ain Shams intermodal station.

- A deficiency in the design for pedestrian safety and convenience is notable for both stations.

- The environmental strategies are ignored in both stations.

- Equity goals are not achieved in both stations

- Economic development polices and strategies are not adopted.

It is clear that both stations do not satisfy the sustainable design strategies thus wide improvements is needed for both of them in order to function effectively in terms of sustainability.

CHAPTER V

Chapter 5

Sustainable Design of Cairo Intermodal Stations

5.1. Introduction

Ramses square is the focal point of major transportation modes and lines in Cairo and has got different zones of influence. The history of the square goes back to the epoch of Mohamed Ali who developed the square to be a large park in 1844, then in 1858, at the epoch of Abbas Pasha, the railway station was completed. After the British invasion, the railway station was demolished in 1882 because of the explosion of a military store located at the station building. On 1893, a new station was erected according to an advanced Islamic style of architecture designed by the British architect Edwin Pans. This square which is of an important historical and urban value is needed to be redeveloped in order to meet with the existing urban and traffic conflicts. An international competition was issued by the Egyptian government, in October 2007, in order to reach the best solution of the square in light of a comprehensive planning vision of Cairo city centre.

When proposing a new design for the intermodal station area, it should result in qualitative progress in its urban and cultural settings. Improving mobility in the intermodal area is a priority. Redeveloping the square to meet with the existing urban and traffic conflicts should consider the details of the square. The proposed urban planning should consider negatives such as the 6th of October access ramp. A detailed analysis of the square leads to the proposed conceptual urban design which deals with the problems of the intermodal area.

The Ramses intermodal station exhibits strong features of intermodality, but there exists some defects in the intermodal system of the station which could be remedied by adopting design solutions that implement strong connectivity of the different transport modes. High levels of service for vehicle and pedestrian circulation is an issue dealing with safety and passenger convenience. The ENR station buildings represent the focal point of the intermodal station area, thus they should accommodate various passenger needs, such as security systems, modern information systems and a modernized ticket office design. Upgraded passenger facilities for pedestrian convenience represented in waiting areas, concessions and other facilities all of which complying with the standard requirements for the impaired population should enhance the livability and the economic vitality of the intermodal area thus achieving the sustainable design goals.

In the age of sustainable development Suburban and rural stations are a vital economic and community magnets. The Ain Shams suburban area is devoid of good architecture, the rail tracks divide its surrounding area, thus the Ain Shams suburban station has therefore to bridge areas of urban land in a meaningful and distinguishable fashion. It proclaims an interest in using good design for wider social benefit. With population of new communities growing fast in East Cairo, the Ain Shams intermodal station have a key role to play by attracting jobs back from the city centre to the new communities.

The proposed design of the station need to recognize that the station is a crossing point an urban interchange and a valuable social or meeting place. The Ain Shams suburban station can be seen as a deck bridging the railway track and uniting two suburban districts this helps to heal the divisions caused by railways in suburban areas. As road crossings over railways are often widely spaced in suburban station and the place shared by people who are not always railway travelers, thus the station has to address the symmetry of the division imposed by railway tracks and the asymmetry of the function of the station. The asymmetry is one of scale between pedestrian movement and the speed of trains and of organization of the linear flows of passengers from car parks to ticket offices

Environmental issues should be addressed in the proposed designs of both stations to ensure that the new projects embrace the principles of environmental stewardships. The proposed designs of both stations are perceived as conceptual designs which can help guide decision maker to the strategies the final design should adopt.

5.2. Proposed Improvements of Ramses Intermodal Station

5.2.1. Improving Intermodalilty in Ramses Intermodal Area

A) Relocating the access ramp of the 6th of October flyover

A first and critical improvement is solving the problem caused by the access ramp of the 6th of October expressway. Transport studies emphasized that this access ramp is causing a great congestion problem in the intermodal area, traffic entering the terminal conflict with traffic accessing the 6th of October bridge, and a natural result is a congestion problem at El Galaa St. The Japan International Cooporation Agency (JICA) study team pointed out the problem but did not introduce a practical solution for solving it. They hypothesized that this ramp should be extended beyond the main entrance of the ENR station but will require some traffic diversions in the intermodal area. Practically, this ramp could not be extended to prevent such a conflict in traffic movement as there are many constraints; the space available between the pillars of the 6th of October bridge and the Egypt Post office building is not sufficient, besides, the height of the 6th of October bridge would not allow the implementation of this solution. Therefore, another solution for this ramp should be introduced.

Perhaps an appropriate solution would be demolishing the existing ramp completely from the intermodal station area and implementing a new access ramp near the intersection of Nafak El Sabteya street with El Galaa street. This will require the demolision of a small administrative building for the ENR hospital. Studying the traffic flow in the surrounding area shows that the existing access ramp serves those coming from Shubra through Ahmed Badawi subway to access the 6th of October bridge on their way to the west sector of Cairo, while traffic from east sector of Cairo accesses the bridge from Ghamra and Salah Salem Street, the portion of the East sector traffic wanting to reach El Galaa Street and the ENR station usually uses the 6th of October exit ramp at Mahmasha called (Shubra exit ramp). Thus transferring the access ramp from Ramses Square to the proposed site at Nafak El Sabteya Street will not negatively affect the east sector traffic, on the contrary, it will help to solve the congestion problem under the 6th of October flyover at El Galaa Street.

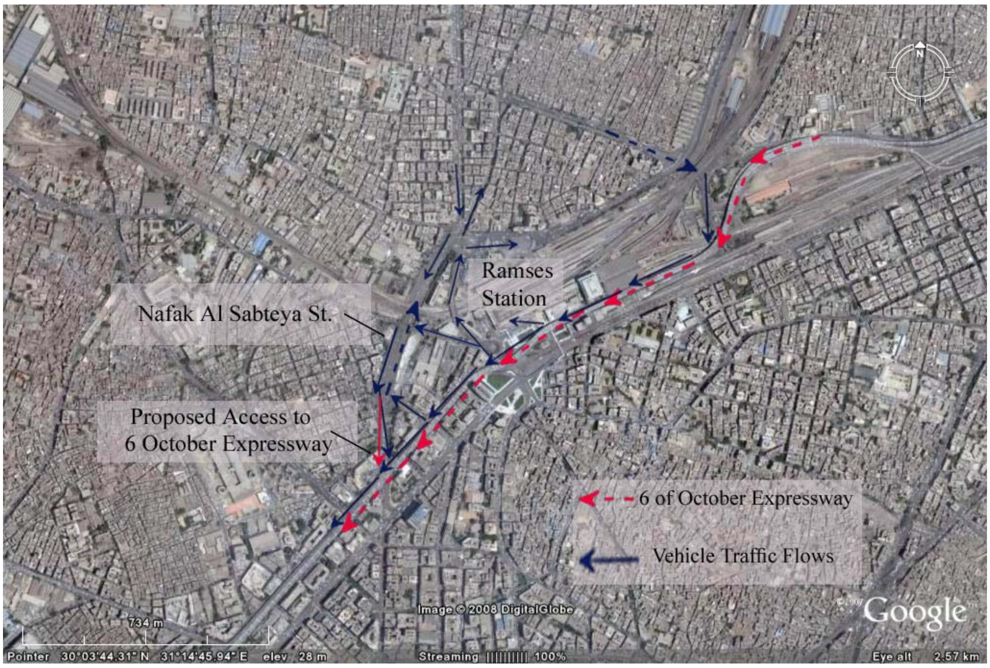


Fig (5.1) Ramses intermodal station layout and surroundings showing the proposed access of the 6th of October Expressway. [The researcher]

B) Resolving the congestion under 6th of October flyover

A second improvement is solving the problem of the microbuses (shared taxis) which crowd El Galaa Street by stopping to load and unload passengers. This problem occurred obviously after the traffic authorities have reversed the traffic direction on Shubra Bridge which was their shortest way to reach their designated terminal at Ahmed Helmi north of the ENR station. Nearly all passengers using the intermodal area confirmed that reversing the direction of this bridge has resulted in more complexity of the situation in the intermodal area. They agreed that returning to the first situation will have many advantages; the congestion caused by microbuses under the 6th of October flyover in El Galaa street will be resolved as microbuses will use Shubra bridge to reach their legal terminal, besides, pedestrians will not have to walk all the way in El Galaa Street to catch a microbus from the illegal stop near Azbakia police station. Separation of movement between vehicles encroaching the Shubra bridge on their way to Ahmed Helmi bus terminal and vehicles leaving the ENR station area will be necessary. This can be resolved by lowering the road under the access of Shubra Bridge to the vehicles departing the station.

C) Siting of the light rail transport (LRT) station

The relocation of the LRT station to accommodate the new light rail system should consider the placement and extent of the LRT station which must be of adequate dimension to accommodate the proposed length of the supertram (65 metres), offer opportunity for track switching of trains, and be able to safely accommodate a crush load of two full trains (600 waiting passengers) and 600 existing passengers. Furthermore, any LRT facilities must be cognizant of physical constraints posed by other existing form of transport including columns, supports for the 6th of October Expressway, as well as alignment and facilities of the underground Metro Line and Mubarak station.

An important improvement is creating a new site for the light rail transport (LRT) station. The JICA study team reviewed five options for siting the LRT station, these are;

- Placing the station adjacent to the ENR
- Placing the station roughly under Ramses Street
- Extending the track westward and constructing an elevated LRT station
- Placing the station several hundred metres east of the current terminal beyond the influence of NAT building complex
- Extending the track westward to the place of the removed Ramses statue.

The first three options were rejected for the high cost, the need to lower roads for grade separated crossings, and the extensive underground foundations and utilities in the area. The fourth was rejected as for all practical purposes the intermodal function of the LRT has been destroyed, passengers wanting to interact with metro access stairways would now face a long walk between the LRT and the Metro access stairways. For all LRT passengers extensive interaction with road traffic is foreseen under this scenario which is both undesirable from both traffic (delays and accidents) and passenger (safety and convenience) points of view.

The fifth and last of the reviewed solutions was considered the most appropriate but emphasizes the closure of two slip roads which divide the Ramses island, their closure is feasible from two points of view; they are optional routes for accessing El Galaa Street and the 6th of October Expressway, also public transport vehicles consume considerable space loading and unloading passengers while pedestrian flows often dog the streets. The closure should be implemented as the supertram will carry some 430, 000 person per day. The solution also requires the demolition of an ENR structure at the west of the NAT building complex.

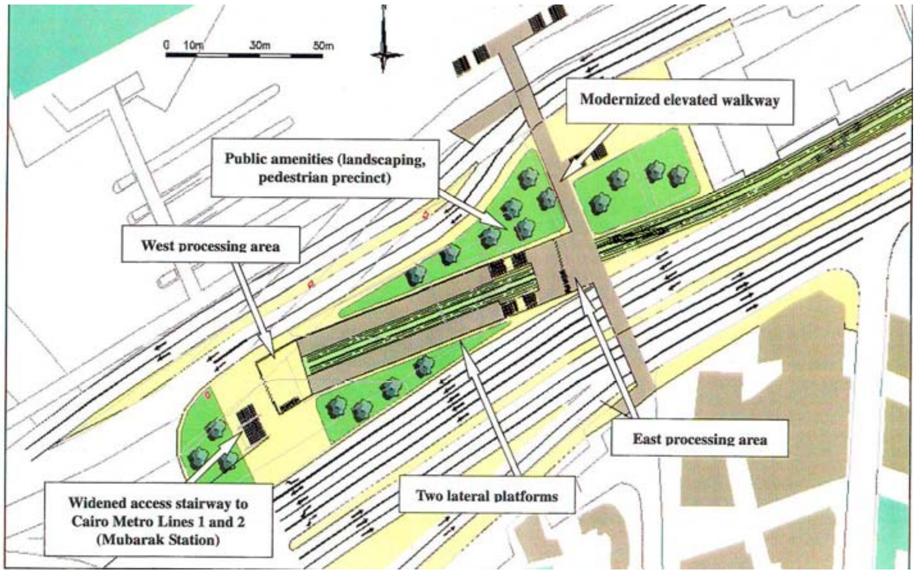


Fig (5.2) Preferred concept for Ramses Station of Supertram Line 1 [21]

The LRT station is located in a constrained area, a central platform to accommodate crush loading (600 persons waiting, 600 persons alighting) can be convenient for passengers in terms of choice but would require a central platform dimension that is not compatible with available space, thus lateral platforms are provided, requiring the installation of variable message signage for announcement of next departure platform.

A problem arises in this solution adopted by the JICA team; the elevated walkway to the east of the present LRT station will require raising its height to accommodate the catenaries of the new supertram. Increasing the height of the elevated walkway is not practical unless a comfortable mean of accessing it is provided. People are reluctant to use it with its present height so they will not attempt to use it if the height is increased. The installation of escalators will solve the problem.

Passenger movement to/from the LRT station is therefore possible without the need to cross any street. The elevated walkway links the station with both sides of Ramses street, while the all-important metro access steps west of the LRT station links the supertram and the metro. The steps will require widening to accommodate the expected high passenger flows. Reviews of Mubarak station as built drawings suggest that no impediment to such widening exists, nor does the widening impinge on 6th of October Expressway footings. Processing areas for ticket purchase, system entry and system exit are located at both platform ends. The eastern processing area is elevated at a part of the modernized pedestrian walkway, while the western processing area lies adjacent to the widened metro steps.

The implementation of the preferred design catalyzes a pedestrian island, with numerous opportunities for pedestrian precincts, landscaping and other pedestrian amenities. The entire concept is expected to considerably beautify Ramses square.

5.2.2. Improving Safety for Pedestrian and Traffic Circulation

As discussed in the previous chapter, the pedestrian safety condition is deteriorated in Ramses intermodal area. The presence of many fences all around the sidewalks to prevent the pedestrians from approaching the vehicle traffic roads, did not solve the problem of vehicle pedestrian conflict. Pedestrians are always trying to overpass these fences by jumping or removing some of the steel bars in the fence to pass through and reach their destinations. The reason for this attitude is that pedestrians have to walk for so long distances (exceeding 500 metres) beside the fences to reach their required destinations.

Fig (5.3) Traffic and pedestrian flows at Ramses intermodal station
[The researcher]

Pedestrian flows in the intermodal station area are represented in figure (5.3), and conflicts between them and the vehicle traffic are shown. Pedestrians arriving from the ENR suburban lines east of the station move along a narrow street at the east of the Post office building, they walk a long distance along the fenced sidewalk at El Galaa street to reach the Metro Station entrances and get stuck by the traffic approaching the entrance of ENR station. If they decide to use the footbridge, they have to share a narrow access at that sidewalk, this access forms an obstruction to the large flows of passengers rather than a welcoming approach to the footbridge. Fig (5.4) shows a schematic for the major circulation opportunities.

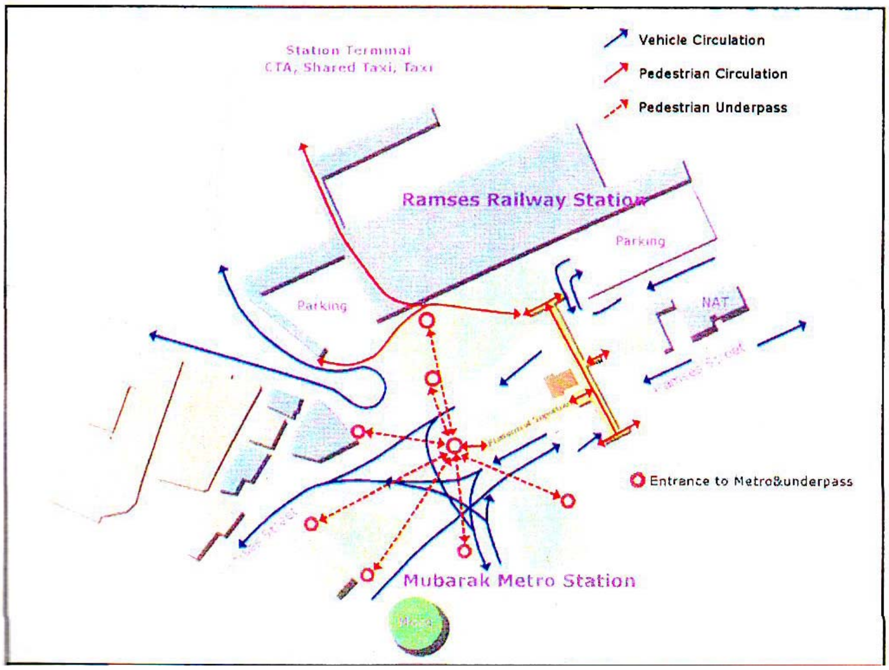


Fig (5.4) Major circulation opportunities in Ramses intermodal area [21]

A) Crossing Safety

The present elevated walkway in the intermodal station area eliminates grade crossings, but raising the bridge height for more than 4 metres to accommodate the supertram catenary would require escalators to be installed especially at the heavily used accesses of the footbridge. The most critical areas for substituting stairs with escalators will be at the supertram platforms, and the access stairs of the footbridge at the station main entrance which should be removed and transferred a few metres to be located at the pedestrian plaza above the underground garage.

A successful improvement implemented in the intermodal area in November 2002 is the three underground tunnels crossing the railway tracks connecting the platforms and connecting Ahmed Helmi bus terminal at the north of the ENR station to the rest of the intermodal station area. Two of these tunnels are heavily used while the third one is ignored and almost unknown for most of the pedestrians accessing the intermodal area. This tunnel is located at the west of the ENR station linking the small parking at the west to the bus terminal at the north. The access to this tunnel from the bus terminal is screened by two small old buildings, one is an old deteriorated small mosque and the other is a two level social building shown in, Fig (5.5).

The demolition of the two buildings will open an opportunity to transform this area to a pedestrian plaza serving those queuing to/from the bus and shared taxi terminal and passengers directed to access the footbridge to reach the LRT station and those directed to the underground metro accesses

Fig (5.5) The buildings proposed to be demolished at the west of the ENR station

B) Providing Pedestrian Sidewalks and Palzas

The present planning of the Ramses intermodal area lacks the effective design of sidewalks, greenways and pedestrian plazas. Many zones in the intermodal station area could be transformed to pedestrian plazas which can delineate pedestrian movement from vehicle traffic. The first area which can function as a pedestrian plaza is the vacant area above the underground park and ride facility, this will be a central plaza where large numbers of pedestrians would access. The flows of passengers arriving from the suburban ENR lines at the east of the intermodal area should be attracted to this plaza thus delineating them from the sidewalk in front of the Post office building at El Galaa Street. This requires the opening of the closed path a few metres to the west of the Post office building to allow direct access from the platforms to this plaza. Also this plaza would accommodate pedestrian flows to/from the underground tunnel crossing the railway tracks and pedestrian flows from the LRT station across the footbridge. Well maintained landscaping in this area is very important, shady trees and shelters is to be provided, pedestrian walkways and paths should be spacious (minimum 1.8 metres in width). This will provide a pleasant walkable area thus encouraging passengers to use the plaza.

A second pedestrian plaza is required at the west of the ENR station thus linking the passengers of the underground metro and supertram, as well as the passengers of the ENR station, to the bus and shared taxis terminal.

This plaza should be fenced with a green buffer zone to reduce the effect of pollution caused by the vehicle traffic on Shubra bridge. Improving walking environment will require the provision of a greenway for pedestrian movement at the present west parking area leading to the underground tunnel which crosses the west railway tracks leading to the proposed plaza.

A third plaza is required in the vacant island at Ahmed Helmi bus terminal. Shady trees and shelters are essential in this area. The three plazas will complete with the already existing plazas of the underground metro accesses at the frontage of the ENR station and at the Ramses island where the supertram station is proposed.

Improvements of sidewalks in the intermodal area can be achieved by widening the pavement at the north and south entrances of the ENR station buildings. Planting shrubs at regular intervals and using light coloured paving materials is essential to attenuate the harshness of the asphalt at the parking area at the station main entrance and at the bus terminal area (fig 5.6).

C) Vehicle and pedestrian guidance

Vehicle and pedestrian guidance is a main issue which has to do with improving safety in the intermodal station area. The types of improvements needed in the Ramses intermodal area include; the channelization of the movement of vehicles and pedestrians through the construction of medians and through pavement markings, signage to guide the vehicles and the pedestrians, signal timing adjustments, curb line changes and lighting.

Fig (5.6) Proposed Design of Ramses Intermodal Station Layout

A channelization median at the kiss and ride park in front of the ENR station building should delineate the kiss and ride park area from the vehicle traffic lane entering and exiting the station. A portion of the kiss and ride park should be dedicated for taxi stands. It is obvious in the present situation of the intermodal area that it completely lacks lane arrow and line markings. Lane markings should be indicated to guide the vehicle traffic to the direction of flow, speed humps should be installed at ENR station bus terminal entrances. All grade crossings have been eliminated inside the intermodal station area in the proposed design, signal timing adjustments will be needed at the road intersections with the entances and exists of the intermodal station area.

Signs for accessing the different locations of the intermodal station area need to be installed to help pedestrians locate the appropriate exits and walkways, thereby limiting their contact with vehicles and the walking distances. Subway signs to be placed within a specified radius of subway tunnels and the underground metro station.

The modifications will improve circulation and provide safety for passengers. Fig (5.7) shows the proposed planning of the front area of the station, and the separation of movement between vehicle traffic encroaching the Shubra bridge and vehicles exiting the station.

Fig (5.7) Proposed design of ENR Station, reconstructing of parking area and landscaping. [The researcher]

D) Designing the Platforms and Loading Bays

- Platforms of the railway station: The situation of the platforms of the railway station is not bad but requires some modifications to achieve the standard requirements, this shall be according to the passenger density (1 passenger/square metre). Most of the east tracks serving the suburban lines will need widening of the platforms. A width not less than 4 metres is required at platforms serving trains with passenger capacity of 600. Adjacent platforms not acquiring this standard could be unified to form one central platform serving tracks on both sides, this will require the removal of any partitions or kiosks at the platform, this solution could be applied to platforms 4 and 5 as an example.

As heights of the platforms of the station vary, this should be modified according to the height of the train floor. Heavy rail systems have a standard height of 92 cm. The edges of the platforms should be identified with changes in texture and pattern as an important safety factor. All entrances and exits to platforms of the ENR station should be opened and freed from any obstructions to allow for the large number of passengers to exit under normal and emergency conditions.

- Bus runways and loading bays: Pedestrians should be able to locate their bus or shared taxi easily as the time of modal transfer is calculated from time of entering the intermodal station area till the time the passenger boards his required mode. The sawtooth layout, which has proved the most practical bay position in terms of safety, could be applied at the bus terminal as the space available is sufficient to accommodate this solution. Reflective signs that list the routes serving the bus stop and information masts are needed at the bus terminal. Bus stop shelters need to be modernized and more shelters to be installed. Acrylic resins such as Corian would be a suitable material for seats of shelters as they are of high durability and easy to clean.

5.1.3. Improving the Environmental Quality

A) Lighting and energy efficiency

Ramses intermodal station incorporates three types of structures; the ENR station buildings, the underground metro station and the new underground park and ride garage. The three structures need to be studied from an ecological point of view. It is obvious that the three structures ignored the importance of exploiting natural light through them. The ENR station is a brick enclosure for the concourse area and the station platforms. Wooden shutters are used in the facades of the buildings while open arches signify the entrances to the station. Some of these arches have been closed and the area enclosed by them has been used as for ticketing. A feature of the concourse area is its gloominess, artificial lighting is used during daytime to illuminate this area. The concourse area is enclosed by ticket booking offices and employees' offices from the north, station entrance an a café from the south, and seven arches from the west. Four of the seven arches are closed and dedicated for ticket booking and a small mosque which does not satisfy passengers' needs. Substituting artificial lighting with natural lighting will require opening the seven arches at the west of the concourse area to help exploiting natural light inside, thus accounting for great energy savings. Also the transition to glass replacing the wooden shutters used in all the ENR buildings will be needed to exploit natural light and also as these buildings will be remodeled to different functioning.

The second type of structure is the underground metro station. This type of structure could not be remodeled to exploit natural light, as the ticket floor lies at a great depth (-15m). Designing for daylight for underground structures is an issue to be dealt with at the design stage. The third type of structure is the underground park and ride garage which is composed of two underground levels. Perhaps this structure could be modified to attenuate large lightwells in the roof (the pedestrian plaza above). This will make optimum use of daylight which will penetrate the void to the garage level below thus accounting for at least 25% of energy savings and at the same time will provide spatial configuration to assist circulation in the pedestrian plaza proposed.

B) Ventilation and energy efficiency

As natural ventilation is a sustainable design issue, thus deficiency in design should be compensated with mechanical ventilation. The maximum recirculation of treated air is a sensible way for reducing energy costs. Mechanical ventilation will be needed at station entrances and alongside ticket offices. The ENR station platforms are open from the sides and the roof canopy is designed to the requirements of natural lighting and ventilation, thus no modification is required at the platform area. Opening the west arches at the concourse area would assist natural ventilation as well as natural lighting.

The large lightwells in the underground garage roof will not only exploit natural light to the parking area but will double up to serve as air delivery shafts. The underground metro station has its own ventilation system which depends on mechanical ventilation and air conditioning systems, modifications to substitute the air conditioning systems with mechanical ventilation ones is beyond the scope of this study as this is an electromechanical design issue.

C) Landscaping approaches

Efficient landscaping is essential for both reduction of thermal loads on station structures and reduction of the high levels of CO^2 emissions in the intermodal station area. Applying vegetation and shady trees, to the station plazas and walkways reduces heat island effects and thus the thermal loads on the underground structures as well as the ENR structures. The use of light colours for pavements and pedestrian walkways will also assist in such reduction. The attenuation of buffer zones at the plazas edges and at the channelzation medians will assist in reducing pollution ratios from the adjacent vehicle roads. Pathway shelters are to be provided especially at long walkways as well as the elevated walkway (footbridge).

D) Noise control

The most effective solution for dealing with the problem of noise and vibration caused by the approaching trains is placing the tracks below ground, this solution could be adopted at Ramses railway station if funding is available, it will require lowering the tracks at a distant of 500 m from both east and west directions. This concept is suitable for city centre locations of stations, especially in a congested city like Cairo, as it frees the land above ground for important developments. The execution of this solution is less obstructive to communities above ground but its advantages must be set against its disadvantages such as the ecological problems and security concerns. Resting the ballast of the rail track on rubber mats and using grooved resonators beneath platform edges will be a practical and easily applicable solution.

As noise in the Ramses intermodal area exceeds the standard levels permitted, local plans should participate by means of financial aid to owners of buildings in order to carry out the sound insulation of their buildings. Managing vegetation in the intermodal area will assist noise reduction.

5.2.4. Improving Community Livability and Business Viability

A) Security

The ENR station lacks CCTV systems while this is provided in the underground metro station. The ENR station will require the installation of these systems mainly at platforms. Ensuring adequate levels of lighting at distant platforms is necessary.

B) Efficient passenger information system

The present location of the information displays of the station is suitable but the system needs modernization. Constant information should be supplied by this system so that passengers need not inquire about services and fares available at the information desks or the ticket offices. Instant information provided by electronic displays should be adjusted to change minute by minute according to the arrivals and departures of trains. The same system should be applied at the bus terminal thus saving time.

C) Ticket office design

The best area to accommodate the ticket offices of the ENR station would be the central building which already entails half of the ticket offices of the station. A larger portion of the ground floor of this building, occupied by military services and the station supervisor room, should be transformed to ticket offices to compensate for the removed ticket offices at the west where the mosque is proposed to be located. Presently there exist 22 ticket offices which need to be increased to approximately 37 offices, the space available may not be sufficient to the required number of ticket offices, thus substituting some of them by ticket vending machines may satisfy the requirements. Ticket offices should have windows overlooking both waiting areas and platforms, which could be beneficial to safety.

D) Passenger service facilities

- *Waiting areas*: The proposed pedestrian plazas should provide seats with shelters, advertisement and travel information as well as some kiosks for newspapers so that they may serve as waiting areas. The station building at the west which is serving as a ticket office should be transformed to a mosque to compensate for the demolished one at the north of the station and the transformed small praying area under the west arches of the station building.

- *Parking*: The park and ride underground will serve long parking but providing kiss and ride park in front of the ENR station main entrance is necessary. The underground park consists of two levels, its capacity is 300 cars, which is not sufficient. The garage should involve lifts for those with physical impairments. The CBD area which Ramses square is one of its three poles involves other parking garages but linkage is needed between them and Ramses intermodal station. Unfortunately, there is no space to implement any of the environmentally benign technologies of people mover systems to link those parking garages with the Ramses intermodal station. Another underground parking should be constructed in the intermodal station area with a capacity of at least 600 cars. Perhaps the most suitable area to implement this underground garage is under the bus terminal of Ahmed Helmi.

- *Concessions*: The main area which could accommodate concessions (shops, cafes and advertisement stands) would be the area of the ENR station. The present parking area at the west of the ENR station which is proposed to be transformed to a pedestrian plaza could accommodate an open café where passengers have clear sight of the arrival of their trains thus guiding passengers more effectively. Providing shelters and greenery in this vital area would increase community aesthetics and passenger convenience.

The buildings of the ENR station are composed of three floors, presently, the first and second floors are occupied by the ENR employees' offices as well as some rooms of the ground floor. Developing the ground and first floor to be concession areas, serving not only the railway station but the whole intermodal area, would be a lucrative source of income to the intermodal station, thus guaranteeing maintenance costs as well as economic development. The ground floor will entail waiting areas where stands for advertisement are located, small cafes and tourism offices. The first floor will encounter a retail area. the buildings will require escalators and lifts to suit their new function.

- *Toilets*: toilets zone is at the west of the ENR station near the entrance, the toilets need complete renovation. Disabled toilets are needed. Inviting colours of finishes would be preferable than the white and chrome vision of hygiene which is presently provided.

- *Designing for physically impaired passengers*: The design of the ENR station from car park to train, needs to evolve with disabled and the aging population needs in mind. Station entrances are deficient of ramps for wheel chair users, this should be designed so that everybody could use them and the same is true of station lifts. Ramses as a railway terminal station to almost the whole Egyptian country providing the main means of transportation for an increasing number of population with impairment of one kind or another, thus designing in excess of the minimum statutory standards is essential. Better design for light, sound and materials plays an important part to create an accessible environment.

5.3. Proposed Improvements of Ain Shams Intermodal Station

Transforming this terminal into an intermodal terminal is somehow complex, given a number of constraints. The public transport services in this station will not change in the future but will only upgrade with the ring railway line (linking 10^{th} of Ramadan City).

The objectives would be:
- To provide station plazas for feeder services (bus and Shared taxis) depending upon the future passenger demand thus improving intermodal linkage
- To provide a central accessible pedestrian plaza linking the ENR station with the metro station for pedestrian safety and friendliness
- To improve or upgrade the intermodal station facilities for providing passenger and pedestrian convenience.

5.3.1. Improving Intermodality at Ain shams Intermodal Area

The site can be transformed into an efficient and functional intermodal terminal as it will accommodate a mass transit system to link Ain Shams with 10^{th} of Ramadan City and thus connecting the new communities on the line with Cairo. Whether this mass transit system is a conventional rail system or an electric mass transit system is a matter of discussion according to the cost analysis of either systems and depending the agglomeration of the new communities served by the line.

A) Developing the bus terminals for providing feeder services

Developing bus terminal plazas is necessary for providing feeder services not only for the passengers but also for the large number of local residents. The surrounding area of Ain Shams station is devided by Metro

Line 1 alignment and flyover of Tereat El Gabal St. a station plaza is necessary built for east and west each side of the station.

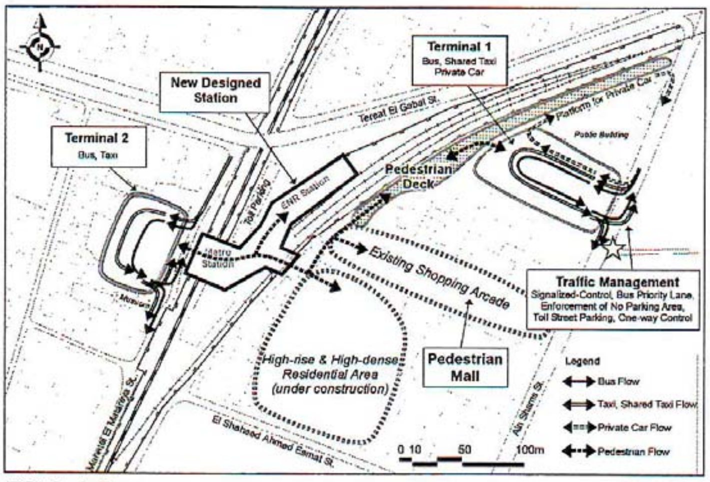


Fig (5.8) Concept map of the Ain Shams Station [20]

B) Extending the Metro station

The existing elevated metro station is in the new design extended to the railway station that is demolished to provide the necessary space. The terminal will be accessible from both sides so that the illegal crossing of the railway tracks is prevented in the future. To increase the functionality of the terminal, a second level can be build where small shops are located. Both the metro platform and the railway platform will be accessible via the terminal as well as the bus station and an upgraded P&R parking. The bus terminal, which at present is only a stopping place, will be upgraded with a quay and a bus shelter. These improvements are necessary to accommodate passengers.[20]

Elevating the terminal will also improve access to and from the P&R parking, and the free space in between the railway and metro line can be rehabilitated to develop an efficient park and ride terminal. If necessary additional park and ride facilities can be developed under the bridge and opposite to the metro line where the old and abandoned buildings could be removed.

C) Developing a Shared Taxi Terminal

A very important measure for the viability of the area around the terminal is the development of a large shared taxi terminal along the railway line. At present there is a narrow street connecting the market place with Ain shams street. This street can be widened and a shared taxi terminal can be created near the elevated entrance to the intermodal terminal. The constructions imply that some buildings have to be removed. Widening the access road to the terminal is possible because there is sufficient waste between the housing and the street.

5.3.2. Improving Safety for Pedestrian and Traffic Circulation

A) Crossing Safety

It is essential that the ENR station will be rebuilt with vital intermodal functions. Specially to build an elevated pedestrian deck linking with Metro station would be efficient for 80% of the East Wing passengers who expected to transfer to Metro Line1 in 2022, as well as the deck would extend to link the eastern side of the station to prevent illegal crossing of the track and secure the pedestrian safety. The new East wing station should be designed with 5 metres width and 120 metres long platform. To ensure that pedestrian flows are controlled and do not reduce the efficiency of the terminal, the illegal access points should be closed off and sufficient fencing should be put in place to force pedestrians to use the designed paths, The first illegal access is via the street at the end of the railway quay for the train to Obour. The second illegal access point is at the market place in front of the metro and railway terminals. Given that there is no public access to the terminal from that side. A hole was made in the brick wall and people cross the railway tracks to enter one of both terminals. They also use this illegal crossing to travel from one side of the terminal to the other.

B) Providing Pedestrian Sidewalks and Plazas

Station plazas should be planned at the east and west side of the station. East side should be planned bigger than the west side taking into account traffic circulation and access roads. As the station is designed to be a hub thus plaza of bus rapid transit should serve as a link to the other transport modes and as a community open space. Connection between the two plazas shall be through the pedestrian deck. Accessing the deck shall be by using escalators. Translucent canopies providing shelters over the escalators will define the atmosphere of the plaza.

The proposed design of Ain Shams intermodal station is illustrated in the concept design in fig (5.9)

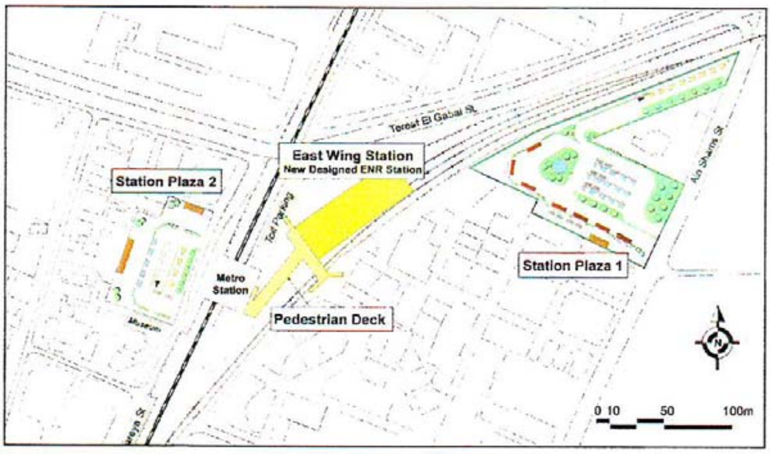


Fig (5.9) Proposed Planning of Ain Shams Intermodal Station Layout [20]

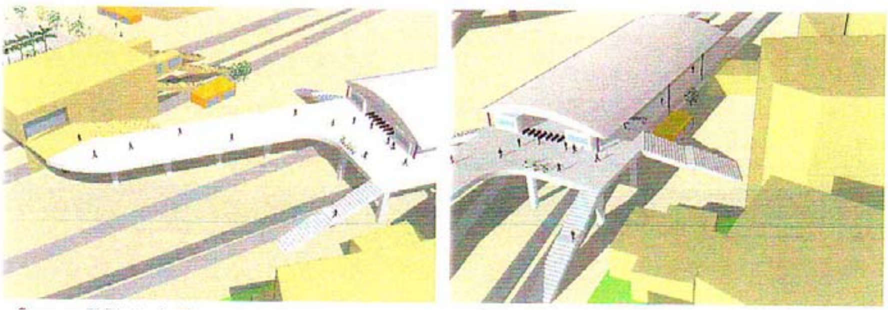


Fig (5.10) Images of the proposed pedestrian deck [20]

Fig (5.11) Proposed plan of Station Plaza 1 [20]

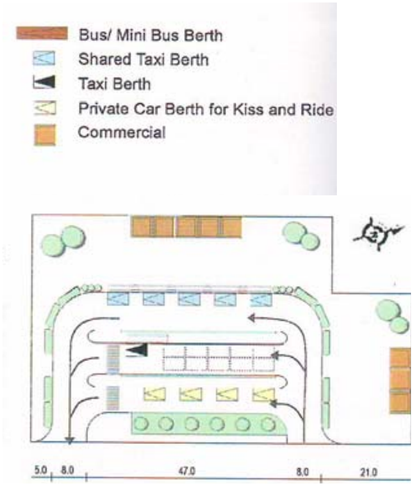


Fig (5.12) Proposed plan of Station Plaza 2[20]

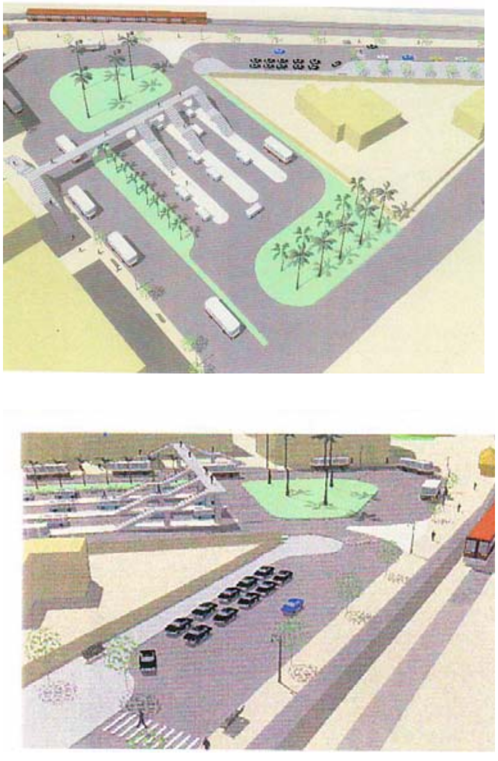


Fig (5.13) Images of plaza 1 (East plaza) [20]

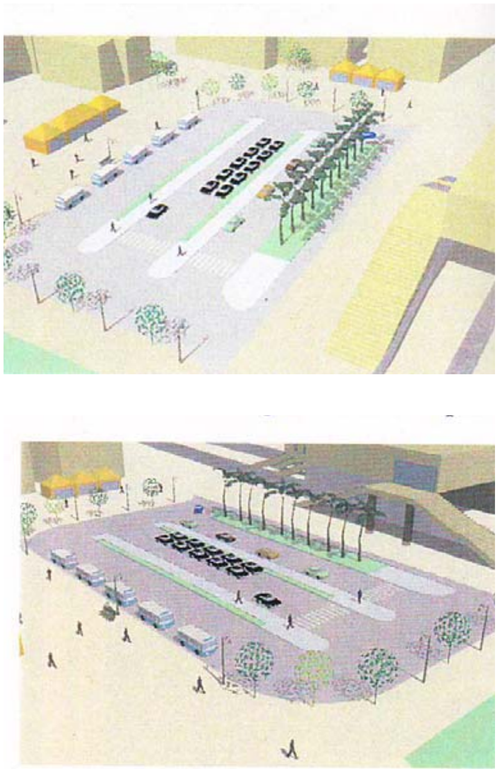


Fig (5.14) Images of Station plaza 2 (West plaza) [20]

C) Vehicle and Pedestrian Guidance

Formulating traffic management system and safety facilities achieving a smooth circulating system through introducing:
bus priority lane, One way circulating system, Signalized controlled intersections and enforcement on no parking areas.

- *Neckdowns:* Constructing a larger zone for sidewalk corner extensions will decrease the distance for pedestrians to cross at the plazas. Ramps at the intersections with Mathaf El Matareya street and El Fayrouz street would have to meet with ADA standards.

- *Signalized intersections:* Currently the number of signalized intersections are insufficient in the station area of Ain Shams. It is important that modern signal lights at intersections should be installed to control both motor vehicles and pedestrian traffic.

- *Lighting:* a major component of the design is lighting through the plazas and the pedestrian deck. In particular lights will be located along the edges of the plaza where the major circulation routes lead to and from the bus enteries.

D) Designing the Platforms and Loading Bays

- Rail Station platforms: the two present platforms would be insufficient for the number of arriving trains if this station is to function as a hub. There exists a sufficient area to construct a third platform at the east of the existing platforms.

- Bus loading bays: Drive-through bus bays are suitable for compact areas like Ain Shams intermodal area, bus front destination signs should be installed thus facing the arriving passengers from the rail station exits.

5.3.3. Improving the Environmental Quality

A) Achieving energy efficiency goals through natural lighting and natural ventilation

The architecture of the structures of the intermodal station at Ain Shams must exploit light and openness. The existing ENR building will be completely demolished and a new two level building should be constructed to provide space for the station different facilities. The new building from the beginning of the design stage should set a priority goal which is to achieve factor 10 in Energy savings. The elevated structure, opened from four sides at its two levels, would permit natural lighting and ventilation. No air conditioning or even mechanical ventilation systems will be needed at such structure. The metro station at Ain Shams is an elevated structure depending on natural lighting and ventilation as well as a mechanical ventilation system, thus the structure is an energy efficient building and need no modification.

B) Landscape approaches

Retaining vegetated buffers and trees within rights of ways for emission reduction and also for infiltration, thus preserving water cycle. The use of recycled water for irrigation and station maintenance is a common sense. Applying shady trees and drought tolerant plants at station plazas will help reduce thermal loads on station structures. Shelters to be provided at station plazas and pathways

C) Noise

Buffers zones at vehicle right of ways help in noise reduction. If heavy conventional rail will be the technology implemented at Ain Shams ENR station, thus the same techniques discussed before for rail resting the ballast of the rail track on rubber mats and using grooved resonators beneath platform edges will be easiest applicable solution.

5.3.4. Improving Community Livability and Business Viability

A) Security

The ENR station will require the installation CCTV systems mainly at platforms. Ensuring adequate levels of lighting at distant platforms is necessary. Shelters should have all round visibility at ENR platforms as the plazas of the bus terminal.

B) Efficient passenger information system

The ground level of the ENR station structure will be the best location for the information displays as it is the first point to be reached by passengers arriving from the new communities. Constant information should be supplied regarding services available by the different modes at the intermodal station. Instant information of the arrival and departure of the trains of the new communities line should be displayed minute by minute.

C) Ticket office design

The ground level of the proposed new building of the ENR station could accommodate a central ticket office where booking for the different transport modes is available. In this station the concept of the integrated ticket system would be essential. The station will link the new communities with CBD of Cairo, passengers making daily trips will benefit as they will use one ticket to access the different modes. Thus the ticket office should be designed to accommodate the large numbers of passengers who will approach the it counters. Another successful solution will be the provision of ticket vending machines.

D) Passenger service facilities

- *Waiting areas:* the plazas will serve as a different function, they can be a meeting place, a place to sit while waiting for the bus or a place to relax after a day of shopping. Water fountains seating and other amenities that serve people using the plaza should be installed.

- *Parking facilities:* The various access roads (parallel to the railway, metro and under the bridge) are in very poor condition. The analysis made regarding the traffic flows on the streets determines the number of P&R parking that will be necessary. This analysis should also identify the optimal routing for both the bus and the private cars that want to access respectively the bus and the central P&R facility.

- *Concessions:* An improvement to the current shopping arcade would be specifying it as a pedestrian mall. This will require keeping out shared taxis and through traffic in the current arcade which is located at east side of the station, thus providing comfortable and safety for the pedestrians, which is expected to lead to empowerment of the community.

The station plazas should be planned including small scaled commercial facilities such as newspaper kiosks, café, and small restaurants.

5.4. Conclusion

Intermodality at Ramses station:

The supertram, a modern LRT system, embodies many desirable characteristics: human scale planning, environmentally friendly operation, convivial image, medium capacity, urban transit capability and cost efficiency and facilitates the intermodal connections from major activity centres of East Cairo to all forms of urban transport at Ramses intermodal station. Thus the existing trams terminal station should be modified to accommodate the new LRT system. The reloaction of the station and the provision of pedestrian plaza is a main design concern.

The slip road access the 6th of October Expressway is an optional route, its closure should be implemented, (the supertram will eventually carry some 430,000 persons per day [2]; more than could ever be carried by the slip road). This action is an excellent opportunity to implement the sustainability slogan: move people, not vehicles.

Formal coordination among motorized public transport modes, routes/lines that intersect at the terminal requires formal planning in terms of service coordination or passenger transfer needs. Providing pedestrian plazas at the bus terminal north of the station will improve the intermodal linkage

Pedestrian safety and convenience at Ramses Station

For public transport users, walking is indispensable, safety facilities, such as pedestrians Zebra crossings and pedestrian traffic signals should be installed in the intermodal station area.

In terms of station planning, adequate pedestrian capacity for movements between the metro and supertram Line 1 are vitally important. The locations of entry points of the metro (stairs to the underground Mubarak station) are seen in critical terms. However other avenues of pedestrian movement must also be considered. In particular, the elevated series of walkways around the periphery of Ramses square are seen as, in parallel with multiple metro entry points, an excellent opportunity for movement of people to/from the various public transport services with minimal need to cross busy streets and roads within Ramses square.

The implementation of this design catalyzes numerous opportunities for pedestrian precincts, landscaping and other pedestrian amenities. This concept is expected to considerably beautify Ramses square.

Environmental Condition at Ramses

This evaluation of the environmental condition related to the air quality and noise levels shows high level of pollution. The use of buffers to delineate vehicle traffic from pedestrian movement will enhance the environmental quality of the station area. The intermodal station structures did not consider the environmental requirement and the ecological concerns thus modification are proposed in the new design for achieving energy efficiency goals. Reducing energy consumption by the new garage building through the lightwells serving also as ventilation shafts is a solution which should be adopted. The opening of the arches of the ground floor of the ENR station buildings would exploit light and ventilation to the concourse and concessions areas. Substituting the wooden shutters with glass windows will save energy consumption by artificial lighting. Noise treatments are employed at the rail tracks and platforms.

Intermodality at Ain Shams station:

Without the multiplicity of uses that characterize bigger stations, the AIN Shams station will function as a suburban intermodal station providing linkage with new communities of East Cairo. The upgrading of the station will focus on pedestrian movement and modal connectivity through the construction of two plazas at the east and the west of the station. A pedestrian deck will link the ENR station with metro and bus station.

Providing larger zones for sidewalks and providing corner side extensions will contribute to pedestrian safety and comfort

Pedestrian safety and convenience at Ain Shams station

The station area will be a gathering public space for the passengers of the East Wing communities and also for the inhabitants of the Ain Shams area. Light will accent the community, the news kiosks provide human presence and visual anchor, and the cantilevered translucent canopies will define the atmosphere of the plaza and will create a strong night-time presence. Trees will be added to complete a boarder around the plazas.

Environmental Condition at Ain Shams

As the ENR building will be completely demolished, thus there is an opportunity to design which adopts the strategies of and energy efficiency better indoor environmental quality. The provision of shady trees and greenery should be a feature of the plaza. Noise treatments are employed at the rail tracks and platforms.

Economic and Social Territory at the improved stations

Equity is closely related to welfare policy, therefore coordinated policy persuasion with welfare policy would be necessary.
Barrier free facilities should be equipped to assist handicapped and aged people for convenience at both stations such as slope, lift, toilet and so on. Vehicles which are friendly to those people would be one of the additional options.

Retail concessions: the terminals can also be designed to accommodate feasible space for small business catering to users, including convenience stores, branch banks and automatic teller machines (ATMs) coffee shops and snack restaurants, news paper and magazine vendors.
Park and Ride: commuter parking facilities are also a potential source of revenue for mass transit operations. Providing additional parking lots in the form of underground lots is essential

CHAPTER VI

Chapter 6

Assessing the Sustainability of Intermodal Stations Projects

6.1 Assessing the Sustainability of the Intermodal Stations Using World Wide Rating Systems

Transportation planning has begun to emphasize multimodal approaches to meeting the challenges of congestion, air quality, infrastructure concurrency and quality of life. Therefore communities have realized the necessity of measuring the deficiencies and improvements in transportation systems. Rating systems are being developed around the world to measure the performance of projects. Calculated scores for the projects nominated by assigning points based on the extent to which the project achieves the intended goals of sustainability are awarded.

The methods for evaluating intermodal projects in terms of sustainability are based on the goals, objectives and strategies identified in Chapter 2. This would include the intermodal linkage performance, the pedestrian level of service performance, and the environmental performance, thus promoting equity and economic development.

6.1.1. Measuring the efficiency of intermodal linkage at intermodal stations

The Transportation Improvement Program (TIP) developed in the United States created a ranking (rating) system to measure the performance of intermodal projects. Intermodal linkage is one of the steps accomplished. The MAG Intermodal Management System (IMS) created by TIP is similar to many ISTEA management systems already underway. It focuses upon intermodal facilities (stations) and is intended to analyze the connections between all transportation modes that could be used by persons traveling or commodities being shipped. It focuses on enhancing mobility, and accessibility to/from interregional facilities. This attempts to increase availability to travel choices, enhance the efficiency and connections between modes and augment the opportunities for the coordination of polices adopted and investments made by the public and private sectors, thus enhancing the efficient functioning of the intermodal system.[35]

Projects to be evaluated through the IMS should be given (different weighted scores based on the magnitude of activity at each intermodal terminal. In general a transportation project benefiting a busy terminal should receive a higher score than a project benefiting a terminal with light usage.

6.1.2. Measuring the performance of pedestrian level of service at intermodal stations

Currently, there is no standard level of service (LOS) performance measures for bicycle or pedestrian facilities, but the evolution of such measures has begun. Several recent efforts have identified, both qualitatively and quantitatively, the characteristics that create a good bicycle or pedestrian environment. However none of the existing methodologies fully account for the range of bicycle and pedestrian improvements that could be implemented through plans for congestion management systems or other long range planning efforts.[27]

Several efforts have initiated development of a quantifiable bicycle and pedestrian level of service LOS measures. The most notable is the Florida Roadway Condition Index (RCI) which expands on the early Bicycle Safety Rating Index developed to predict bicyclist-motorist crash exposure. Pedestrian LOS measures are considerably less developed than bicycle LOS measures. Qualitative attributes of pedestrian friendly environments are described but not quantified in several sources. One study analyzed pedestrian signal delay to define a pedestrian LOS. Others assess sidewalk ratio, connectivity, delay, and hazard to measure the quality of a pedestrian trip accessing transit. The LUTRAQ (Land Use, Transportation, Air Quality) study evaluated the quality of pedestrian facilities to predict transit trips, assessing the ease with which streets could be crossed, as well as sidewalk continuity, street density, and topography. [27]

The Gainesville bicycle and pedestrian LOS performance measures evaluate roadway corridors using a point system of 1 to 21 that results in LOS ratings from A to F. Some of the performances measures applied by the Gainesville LOS rating could be successfully applied for the evaluation of intermodal station project. Pedestrian LOS evaluation criteria involve the provision of basic facilities, conflicts, amenities, motor vehicle LOS, maintenance, and multimodal provisions. The pedestrian LOS ratings similarly describe the charachteristics and attractiveness of facilities but also predict the likelihood of roadway compliance with the Americans with Disabilities Act (ADA). [27]

6.1.3. Measuring the Environmental performance

The high performance building movement worldwide is being propelled by the success of building assessment methods, in particular Leadership in Energy and Environmental Design (LEED) in the United States and the Building Research Establishment Environmental Assessment Method (BREEAM) in the United Kingdom. Both methods take complex arrays of numerical and non numerical data and provide a score that indicates the performance of a building according to the scoring and weighing system built into the method. LEED-NC 2.1, the current version of the United States Green Building Council (USGBC) assessment standard for new construction, is being applied to a wide range of public and private buildings. The Comprehensive Assessment System for Building and Environmental Efficiency (CASBEE) is relatively new building assessment approach created for Japanese construction. In Australia. Green star is the building assessment system advocated. The GBtool and the Minnesota Sustainable Design Guide (MSGD) Version 2.0 are other sustainable design assessment systems.[9]

In general building assessment systems are created for the purpose of promoting high performance buildings, and some like LEED are specifically designed to increase market demand for sustainable construction. Developers are faced with 2 choices when designing a building assessment system; either to use a single number to describe the building's overall performance or to provide an array of numbers for the same purpose. A single number representing a score for the building has the virtue of being easy to understand but if a single number is used to assess or rate a building, the system must somehow convert the different units describing the building's resource and environmental impacts into a series of numbers that can be added together to produce a single over-all score. Both the advantage and disadvantage of the single number assessment is its simplicity. [9]

The LEED standard provides a single number that determines the building assessment or rating, based on accumulation of points in various impact categories which are then totaled to obtain a final score. LEED-NC employs a point system to award a platinum, gold, silver or certified rating based on how many specific predetermined criteria in several categories the building successfully addresses. .[9]

LEED-NC 2.1, the current version of the (USGBC) assessment standard for new construction, is now being applied to almost every type of building except single family homes. It is structured with seven prerequisites and a maximum of 69 points divided into six major categories. Prerequisites are conditions that must all be successfully addressed for a building to be eligible for consideration as a LEED rating. .[9]

Exceeding the requirements of the LEED standard is the next rung on the ladder of truly sustainable construction. This effort would encompass features like; the built environment would fully adopt closed looped materials practices, landscaping would provide shade, food amenity and storm water uptake. Energy use by buildings would be reduced by a Factor of 10 or more below that of conventional buildings. The source of energy would be the sun or other solar derived sources such as wind power or biomass. Geothermal and tidal power both non solar energy sources would also be employed as renewable forms of energy.

Factor 10, a concept developed by the Wuppertal Institute in Germany, suggests that long term sustainable development can be achieved only by reducing resource consumption (energy, water and materials) to 10 percent of its present levels. Another concept, Factor 4, suggests that technology presently exists to immediately resource consumption by 75 percent. .[9]

In this research LEED-NC 2.1 has been used as a reference for the rating of the environmental design prerequisites with the introduction of Factor 4 and factor 10 as a futuristic factor to achieve in the sustainable design of the intermodal station project. [9]

6.2. Deducing Scoring Forms for Measuring the Sustainability of Intermodal Stations

The above rating systems have been used as a reference for the possible points which could be awarded for the different sustainable design issues which should be satisfied in the intermodal station design. Three forms of checklists of the performance measures have been deduced based on the design guidelines and criteria which have been highlighted in Chapter 2. The first scoring form will include the performance measures of intermodality. A score out of 47 points as a maximum which could have a mean deviation of 10 points according to the number of modes in the intermodal station project, will be awarded according to the satisfaction of intermodality issues in the planning and design of the intermodal station project.

The second scoring form includes the performance measures for pedestrian level of service which a score out of 20 points will be awarded according to the satisfaction of safety and passenger convenience issues in the design of the intermodal station. The third scoring form includes the performance measures for environmental requirements with a score out of 40 points according to the satisfaction of environmental issues in the design of the intermodal station project. These sustainable design guide scoring forms will amount for a total calculated score according to the extent the project achieves sustainability.

6.3. Deducing a Computer Programme Simulation Tool

A computer programme simulation tool is deduced from the above mentioned sustainable design guide scoring forms, the concept of the programme is simple. The performance measures of three design objectives of the intermodal station project; intermodality, pedestrian level of service, and environment are the input of the programme. The possible points which sums up to 107 points as a maximum with a deviation of 10 points according to the number of transport modes the station incorporates are the reference. The project code will be entered to the programme, and the number of points the project satisfies for each credit will entered. The programme will evaluate the sustainability of intermodal station project according to the total score the project achieves in the three categories. Following are the evaluation ratings and the percentages of scores:

- Projects with scores of 75% or more will be awarded a gold rating.
- Projects with scores between 74% and 56% will be awarded a silver rating.
- Projects with scores between 55% and 48% will be awarded a bronze rating.
- Projects with scores between 47% and 48% will be awarded a rating.
- Project with scores of 37% or less will not be awarded a rating.

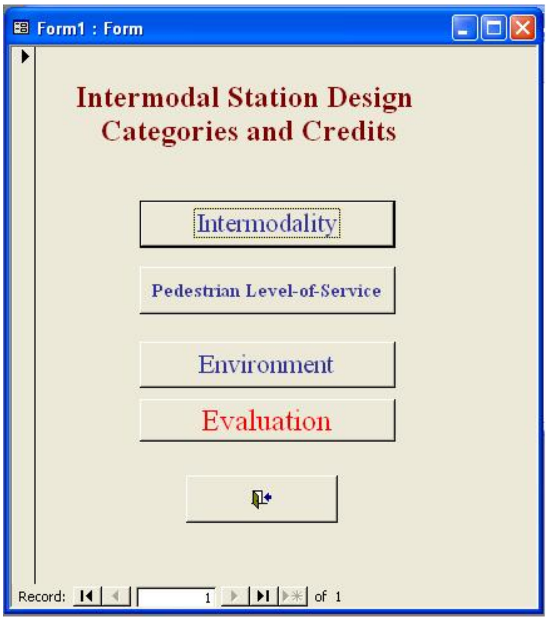


Fig (6.1) Computer model including the three categories of the sustainable design of intermodal stations

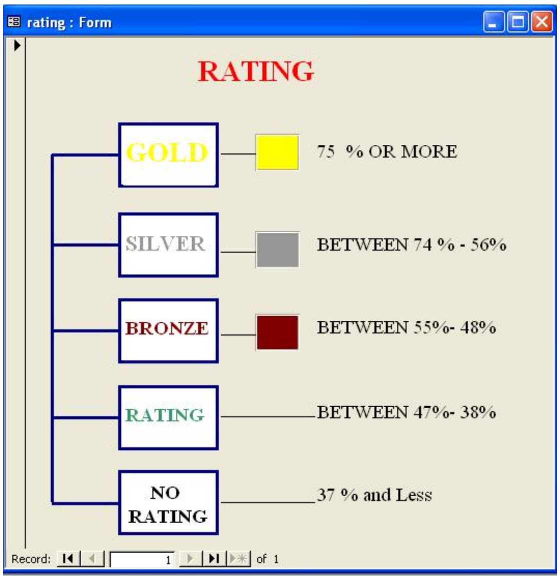


Fig (6.2) Computer model including the percentages of scores and the rating awarded for the intermodal project

<table>
<tr><th colspan="6">Table 5.1 Overview of Intermodal station sustainable design categories and credits
Intermodality</th></tr>
<tr><td>Intermodality</td><td colspan="5">Provide convenient intermodal connection for passengers between all modes to encourage greater use of public transport</td></tr>
<tr><td></td><td></td><td colspan="4"></td></tr>
<tr><td>Prerequisite 1</td><td>Increase use of park and ride lots</td><td colspan="4">Required</td></tr>
<tr><td>Prerequisite 2</td><td>Increase use of bicycles</td><td colspan="4">Required</td></tr>
<tr><td>Prerequisite 3</td><td>Expand use of rail systems</td><td colspan="4">Required</td></tr>
<tr><td>Prerequisite 4</td><td>Facilitate movement between modes</td><td colspan="4">Required</td></tr>
<tr><td colspan="2">Performance Indicator</td><td colspan="3">Rating possible points</td><td>Ref</td></tr>
<tr><td>Credit 1</td><td>Number of mode-to-mode transfers available at interregional intermodal terminals (1-5) points, (1) point for each mode of access added</td><td colspan="3">5</td><td>IMS</td></tr>
<tr><td>Credit 2</td><td>Parking availability at interregional intermodal terminals (1) point for designated, secure parking available within 1/4 mile of the terminal</td><td colspan="3">1</td><td>IMS</td></tr>
<tr><td>Credit 3</td><td>Availability of side walks at or near intermodal terminals, (1-2) points depending on magnitude of pedestrian improve meet as follows: (1) point for site sidewalks provide secure easy to follow, well lighted connections to access modes, (2) points for offsite connections (sidewalks, plazas, or pedestrian malls)</td><td colspan="3">3</td><td>IMS</td></tr>
<tr><td>Credit 4</td><td>Travel time by mode between each terminal and major activity centres (1-5) points, (1) for each mode of access depending on the percentage of accessibility provided
20% of designated activity centres accessible within 30 minutes
40%, of designated activity centres accessible within 30 minutes
60% of designated activity centres accessible within 30 minutes
80%, of designated activity centres accessible within 30 minutes
100% of designated activity centres accessible within 30 minutes</td><td>1
2
3
4
5</td><td>No of mode</td><td>Point x mode
5x5=25</td><td>IMS</td></tr>
</table>

Table 5.1 (continued) Overview of Intermodal station sustainable design categories and credits Intermodality			
Performance Indicator		Rating possible points	Ref
Credit 5	Transfer time required to use access modes at each terminal (1-5), 1 point for each mode accessible within 15 minutes. Accessible time would be the number of minutes elapsed from the terminal entrance to the boarding point of each mode plus the mean arrival time of each mode	5	IMS
Credit 6	Ordinances (regulations) affecting site design, location, operation or access to terminals, (1) point for local ordinances that do not restrict access by various modes, and (2) points for local ordinances enhancing access by various modes.	2	IMS
Credit 7	Access roads, (1) one point for each road accomplished between an interregional passenger terminal and the nearest access controlled highway.	1	
Credit 8	Accidents on access routes to/from terminals railroad at grade crossings, (1) point for a project, proposed for funding by a Safety Management System, (3) points for each at grade railroad crossing eliminated on a designated intermodal access route near each intermodal passenger terminal	4	
	Intermodality total	**47**	

Table 5.2 Overview of Intermodal station sustainable design categories and credits **Pedestrian Level-of-Service**			
Passenger safety and convenience	Create and maintain safe and attractive walkable communities to encourage more walking trips, enhance transit usage, improve public health.		
Prerequisite 1	Improve walking environment	Required	
Prerequisite 2	Increase walking mode share	Required	
Prerequisite 3	Reduce bicycle and pedestrian injuries	Required	
Performance Indicator		Rating possible points	Ref
Credit 1.1	Sidewalk width greater than 1.53m	1	LOS Rating
Credit 1.2	Off street parallel alternative facilities such as greenways and pedestrian plazas	1	LOS Rating
Credit 1.3	Vehicles and pedestrians guidance: signage, appropriate lighting, , pavement markings, corner clearances, and curb line changes	1	LOS Rating
Credit 2.1	Signal timing adjustments in light of the aging population and physically challenged to provide adequate timing for safe crossing, and reduced turn conflict. Pedestrian Signal Delay 40 Sec Or Less	1	LOS Rating
Credit 2.2	Employ traffic calming techniques such as narrowed lanes, speed tables, traffic roundabouts and lane markings. Posted speed limits of 56 kph (0.5) points. Reduce street pavement width where possible to reduce crossing length (neck-down) crossing width 18.3 m or less (0.5) points	1	LOS Rating
Credit 2.3	Medians present	1	LOS Rating

Table 5.2 (continued) Overview of Intermodal station sustainable design categories and credits Pedestrian Level-of-Service			
Performance Indicator		Rating possible points	Ref
Credit 3	Availability of footbridges and tunnels to eliminate grade and rail crossings	1	-
Credit 4	Effective design for accessing other levels for difference more than 4 m between levels *(stair design, ramps, lifts, escalators)* while meeting the evacuation time standards	1	-
Credit 5.1	Safety issues in the design of platforms and loading bays	1	-
Credit 5.2	Sufficient shelters and seats for waiting at platforms	1	-
Credit 6	Efficient design of Entrances and exits under normal and emergency conditions.	1	-
Credit 7	Adequate design of Parking facilities	1	-
Credit 8.1	Security using CCTV and fire protection	1	-
Credit 8.2	Efficient Passenger information systems PIS	1	-
Credit 8.3	Well maintained landscaping (shade trees), Well designed street furniture	1	LOS Rating
Credit 8.4	Efficient ticket office design	1	-
Credit 8.5	Aesthetics	1	-
Credit 8.6	Toilets design ensuring safety and cleanliness, public telephones, concessions in compliance with ADA.	1	-
Credit 8.7	Maintenance and robustness of materials	1	-
Credit 8.8	Availability of information to transportation modes, and their costs, including services for disabled people.	1	-
	Pedestrian Level of service total	**20**	

Table 5.3 Overview of Intermodal station sustainable design categories and credits Environment			
Environment:	Protect and enhance the quality of the environment.		
Prerequisite 1	Improve air quality	Required	
Prerequisite 2	Conserve water	Required	
Prerequisite 3	Conserve energy	Required	
Prerequisite 4	Enhance community livability and visual quality through IEQ improvement	Required	
Prerequisite 5	Conserve resources and raw material extraction	Required	
Performance Indicator		Rating possible points	Ref
Credit 1.1	Reduction of VMTs and SOVs through utilization of environmentally benign travel modes (rail, cable driven, bicycle and pedestrian).	1	-
Credit 1.2	Retained and expanded vegetated buffers to improve air quality	1	-
Credit 1.3	CFC reduction in HVAC Equipment to avoid ozone depletion	1	LEED rating
Credit 2.1	Water efficient landscaping (reduce by 50%) Using native and adapted drought-tolerant plants ,trees and turf	1	LEED rating
Credit 2.2	Water efficient landscaping (Use of recycled water for irrigation)	1	LEED rating
Credit 2.3	Innovative wastewater technology	1	LEED rating
Credit 2.4	Reduction of water consumption (Use of recycled water for maintenance) (20%)	1	LEED rating
Credit 2.5	Reduction of water consumption (30%)	1	LEED rating

Table 5.3 (continued) Overview of Intermodal station sustainable design categories and credits Environment			
Performance Indicator		Rating possible points	Ref
Credit 3.1	Optimize energy performance (20% new/10% existing)	2	LEED rating
	Optimize energy performance (30% new/20% existing)	2	LEED rating
	Optimize energy performance (40% new/30% existing)	2	LEED rating
	Optimize energy performance (50% new/40% existing)	2	LEED rating
	Optimize energy performance (60% new/50% existing)	2	LEED rating
	Achieving Factor 4 in energy savings (75% reduction in new buildings)	1	-
	Achieving Factor 10 in energy savings (90% reduction in new buildings)	1	European Union
Credit 3.2	Incorporating Renewable energy (5%)	1	LEED rating
	Incorporate renewable energy (10%)	1	LEED rating
	Incorporate renewable energy (20%)	1	LEED rating
Credit 4.1	Carbon dioxide monitoring	1	LEED rating
Credit 4.2	Use low Emitting materials	1	LEED rating
Credit 4.3	Thermal comfort complying with standards	1	LEED rating
Credit 4.4	Thermal comfort permanent monitoring system	1	LEED rating

Table 5.3 (continued) Overview of Intermodal station sustainable design categories and credits Environment			
Performance Indicator		Rating possible points	Ref
Credit 4.5	Indoor chemical and pollutant control	1	LEED rating
Credit 4.6	Increase ventilation effectiveness	1	LEED rating
Credit 4.7	Construction IAQ management plan	1	LEED rating
Credit 4.8	Daylight and views (daylight 75% of spaces)	1	LEED rating
Credit 4.9	Daylight and views (daylight 90%)	1	LEED rating
Credit 4.10	Appropriate building acoustical and vibration conditions (noise level < 60 Db)	1	standards
Credit 5.1	Reuse existing buildings	1	LEED rating
Credit 5.2	Using materials with low impact during their life cycle	1	
Credit 5.3	Use recycled content products and materials (specify 25%)	1	LEED rating
Credit 5.4	Use recycled content products and materials (specify 50%)	1	LEED rating
Credit 5.5	Use locally manufactured materials	1	LEED rating
Credit 5.6	Use durable materials	1	
Credit 5.7	Use materials from renewable resources	1	LEED rating
	Environment total	**40**	

6.4. Applying the Computer Simulation Tool to Cairo intermodal Stations

The deduced computer programme is suitable for measuring the performance of Cairo intermodal stations. Applying the model on Ramses station as an example of Cairo intermodals will be based on a score of 107 points as Ramses intermodal station incorporates five types of transport modes. The existing situation of the station is evaluated through the programme as will follow.

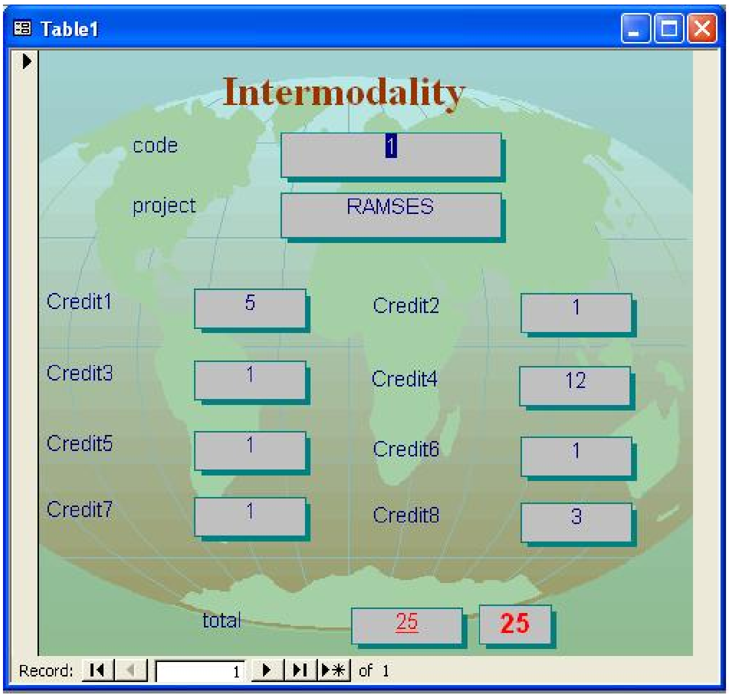


Fig (6.3) Computer model measuring the performance of intermodality at Ramses Intermodal Station

As can be noticed, the intermodality score of Ramses intermodal station is 25 points out of 47 points. This is due to the low score achieved in credit 4 (12 points out of 25) points which determines the percentage of accessibility to the designated activity centres within 30 minutes as the underground metro is the only reliable mode of the five available transport modes.

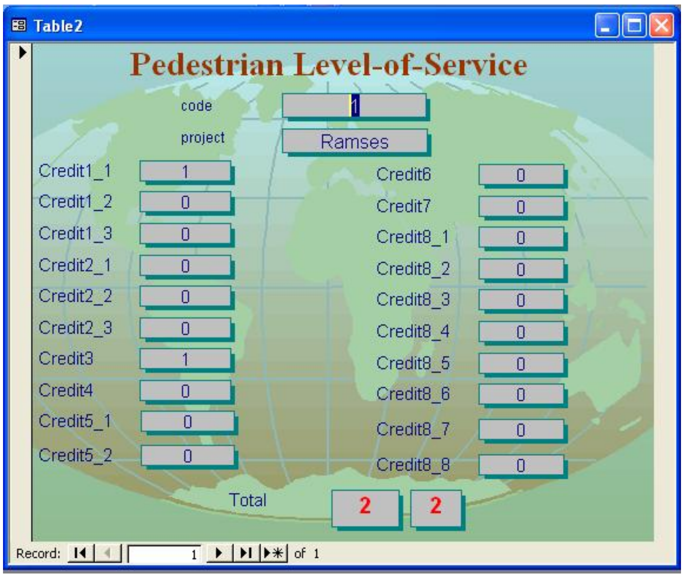


Fig (6.3) Computer model measuring the performance of pedestrian level of service at Ramses Intermodal Station

As can be deduced from figure (6.3), the score of the pedestrian level of service is very low (2 points out of 20 points). The only scores were for the availability of footbridges and the compliance of the sidewalk width with the standards.

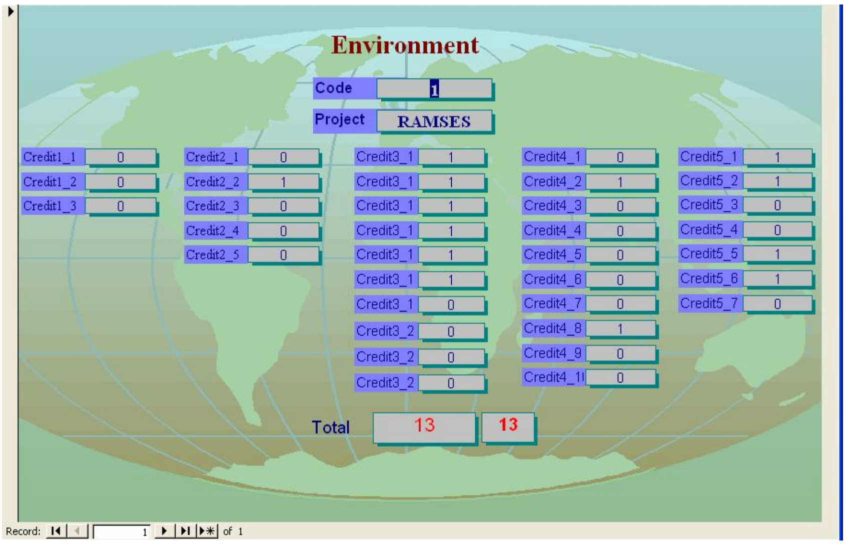


Fig (6.4) Computer model measuring the environmental performance of Ramses Intermodal Station

The environmental score for Ramses intermodal station is 13 points out of 40 points which is considered a low score, most of the environmental requirements were not satisfied in the existing situation of the station, especially those related to optimization of energy performance in new buildings and the incorporation of renewable energy. Also those related to the acoustical and vibration conditions and pollutant control.

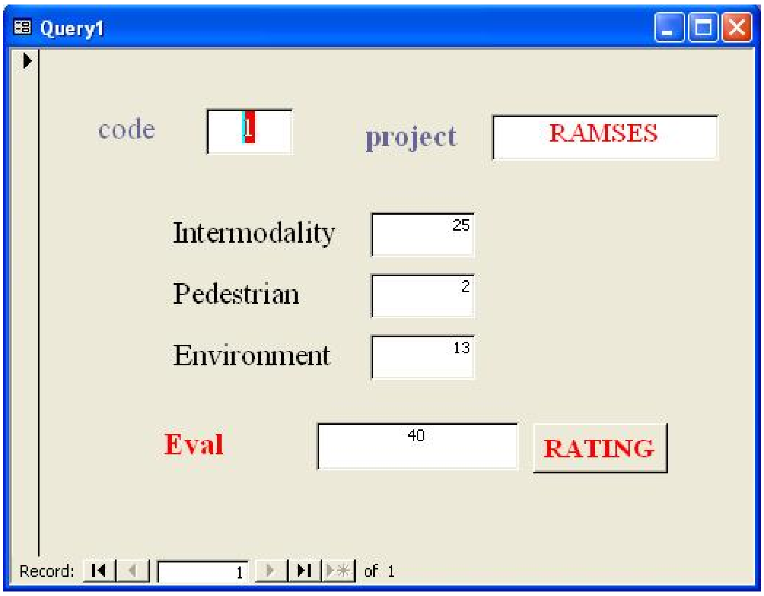


Fig (6.4) Computer model showing the final score of Ramses Intermodal Station

The final score of Ramses intermodal station is 40 points of 107 points which hardly achieves a "Rating". Most of the scores were lost in the pedestrian level of service category and the environmental category which means that both categories need special attention to resolve the problems related to their performance.

6.5. Conclusion

The sustainability of intermodal stations are determined by the success of the design to achieve high performance scores in terms of intermodality, pedestrian level of service and passenger convenience, and satisfying the environmental requirements. Complying with worldwide standards, rating systems have succeeded to set performance indicators which determines to what extent the different projects achieve the intended objectives. Rating systems for environmental performance are the most qualified. Other efforts have been conducted to measure intermodality performance and safety management, also pedestrian level of service. These are new emerging systems which could have missed some of the requirement of the intermodal station project to achieve sustainability.

This research aimed to introduce a measurement tool for the sustainable design of intermoal stations. The research has put a sustainable deign guide tool which could be in the form of scoring forms, or to make it easier, a computer simulation model, which help the designer to set design priorities for the design of sustainable intermodal stations.

Satisfying the three above mentioned design categories will help achieving sustainability main goals thus promoting equity, enhancing economic development and preserving the environmental quality.

The computer simulation tool which is deduced to measure the performance of the intermodal project, is specially designed to Cairo intermodal stations but could be applied on Intermodal station projects in regions similar to Greater Cairo Region. These regions could achieve high scores in terms of intermodality as high dense development is urban areas is a concept adopted by sustainable development. Also regions with climatic conditions similar to that of Cairo could achieve high scores for energy efficiency if the design adopts the concept from the beginning.

Ramses station present situation has failed to achieve high scores. The designer task is to consider the sustainability objectives represented in improved mobility, safety and security, environmental stewardship and community livability, thus achieving the goals of sustainability.

CHAPTER VII

Chapter 7

Conclusion

Urban congestion has been a major issue for many years. Many metropolitan areas have been facing the negatives of this problem on their transportation systems. Given the transportation demand cycle, it is not always possible to solve congestion problem through expansion of capacity. Traffic engineers therefore are involved in the development of programs and strategies to manage demand in both time and space and to discourage growth where necessary. A real question is not how much capacity is needed to handle demand but rather how many vehicles and/or people can be allowed to enter congested areas within designated time periods. The effective integration of multimodal transport systems is a major goal in maximizing efficiency and minimizing costs associated with all forms of traffic.

While designing to protect the public and the environment, planning procedures have to favour the implementation and improvement of public transport. The tendency to veer away from totalitarian control of transport infrastructure to fragment responsibility is something that impedes progress, but requires a new cycle of private investment. Politically public transport is important for a number of reasons. First, on well trafficked routes, public transport is a more efficient mover of people and causes less congestion, air pollution and carbon dioxide per person per trip than private cars, ie., it can be economically and environmentally desirable. Second, it potentially allows those without access to a car at any particular time-a majority of the population (female, elderly, from an ethnic minority, poor or disabled) – to function in society, hence it is socially desirable. However, rail-based systems tend only to be implemented in corridors of high demand, generally, they do not operate in areas with less than 300,000 inhabitants.

Rail lines can now hook up more rationally with airports, bus stations, and even car parks. The move to the suburbs has put increasing demand on the train as a viable link with the centre of cities. In some suburban communities the station is the new focal point of the community. Train travel certainly provides ecological incentives to make it the mode of choice, particularly because traveling by train uses proportionally less energy per person than private cars or air planes. Stations involving rail aviation intermodal passenger facility whether bringing passengers from light rail, heavy rail, commuter rail or from multiple modes into the airport have become a central strategic solution employed by transportation planners to support long term plans to achieve sustainable increases in airside volume. To meet planning objectives the airport rail station must address passengers and employees concerns for reliability, convenience, access and service locations.

The design of intermodal stations should express the importance of travel modes through high quality design. Stations that create a focal centre and gathering place, rather than introducing an infrastructural divide within a city, can contribute to, and indeed, elevate the quality of life of an area.

Modal connectivity at intermodal terminals is an issue which has to do with travel convenience. Walk forms the dominant access mode across all trip purposes while there is little formal coordination among motorized public transport modes. Routes/lines intersect at major stations or terminals while there is no formal planning in terms of service coordination or passenger transfer needs. In order for the intermodal system to be reliable, journey times to major activity centres, transfer time between different transport modes inside the intermodal station area information dissemination and integrated ticketing system are main parameters.

Pedestrian level of service for passenger safety and convenience is a main goal in the intermodal station sustainable design. Strategies should be set to create and maintain safe and attractive walkable communities to encourage more walking trips, enhance transit usage and improve public health. Successful integration of vehicular and pedestrian circulation through the intermodal transport area and the surrounding neighbourhood is inevitable. Special consideration to separation of movement of vehicles, and the integration of pedestrian and traffic bridges and the construction of sidewalks and plazas should be given. Other considerations are signage, pavement markings, better lighting for vehicle and pedestrian guidance, employing traffic calming techniques and adjusted signal timing. Effective design of accessing other levels, safety issues in the design of platforms and loading bays and well maintained landscaping are important issues.

When designing the intermodal station project from a sustainable perspective, *green design* issues should be introduced. The green design, or the *ecologically sustainable design* describes the application of sustainability principles for protecting the quality of the environment. In the context of green buildings, resource efficiency means high levels of energy and water efficiency, appropriate use of land and landscaping, the use of environmentally friendly materials, and minimizing the life-cycle effects of the building's design and operation. Measuring the performance of station buildings to determine their relative environmental impacts, resource efficiency and potential effects on human health is necessary to determine if key green building objectives are being met.

The intermodal station project must determine all the needs of passengers using it. It should provide *equitable service* outcomes to all population. It should directly benefit low income, elderly and disabled population.

Supporting a vigorous *economy* is a national goal which could be achieved by facilitating the multimodal movement. In order to the sustainable station project to attain its potential, it should move people efficiently to their destinations, maintain healthy street centric downtown areas and suburban centres and offer joint development opportunities. Using the transportation investments strategically will support the economic vitality of the traditional downtown and suburban centres as well as brownfields as well as encouraging the private sector to participate in the intermodal station developments.

The examples culled from Europe, North America and Far East addressed design issues which cope with the above mentioned design objectives. Starting to function in the year 2008, the Transbay Terminal in San Fransisco introduces a new vision for the futuristic design of a railway/bus and car interchange located in dense development areas. The Roissy TGV station at Charle de Ggaulle airport and the Lyon St Exupery Airport TGV station, are examples of national hubs that features strong modal linkages in their design, these are models which can be learnt from when designing for successful intermodality at airport/railway interchange stations

Nevertheless, we can expect to see an even richer variety of approaches in the future, if of course station architects are given the opportunity, budget and support necessary to tackle such an important task.

7.1. Results

The main design objectives which must be achieved when designing for sustainability of intermodal stations are; improved mobility and modal linkage (intermodality), improved safety and passenger convenience, improved environmental quality, and attaining community livability and business viability thus achieving equity and economic development goals.

- ***Intermodality*** requires the provision of convenient intermodal facilities and services offering seemless connections for passengers. The objectives are to increase use of park and ride lots, increase use of bicycles, expand use of rail systems and facilitate movement between modes. This requires planning the station layout for Intermodalitity requirements. The factors which affect the shape of the layout of the station include:

At railway station/bus and car interchange

- The new technologies adopted for rail systems have progressively converged the dimensional standards of railways around the world. Platforms and related bridge structure, and concourses are designed according to such conversions.

- Bus stations vary in size according to the following and apart from the obvious physical constraints of the site; the number of bays, the vehicle manouvre used namely, shunting, drive-through and sawtooth, the choice of manouvres will be influenced by the size and proportions of the site available.

- Car parking types, these arise from the chronological order for patterns of development. Car parks come before public transport linkages, the car park adjacent to the terminal becomes a prime location for the ground transport interface. Car parking structures are an integral part of the interchange.

At airport/railway interchange;

- The rail station is preferable to be located within convenient walking distance of the terminal. Ideally the rail station should be located within 500 feet of the terminal building, thereby avoiding the need for passengers to ride a shuttle or transfer to a people mover system to access the terminal building. The rail station should be located adjacent to the baggage claim areas where passenger select from the available travel modes *(Modal split)*.

- For small scale operations, side by side arrivals and departures on a single level are suitable, thus minimizing the need for passengers to change levels climb stairs or use escalators. In two level terminals, all kerbside activities can take place at ground level, escalators and lifts have to be provided to take departing passengers up to the boarding level. Majority of large scale terminals now adopt the configuration of vertical stacking of arrivals and departures, departures facilities are invariably at the high level, usually accompanied by an elevated forecourt, with baggage handling and arrivals facilities below. It is essentially economic and convenient for passenger and baggage movement, departing passengers arrive at elevated forecourt and move either on the level or down a short distance by ramp to the aircraft loading point. Arriving passengers also after leaving the aircraft, move downwards to baggage reclaim and landside facilities. Vertical segregation is suitable for high volumes of passengers.

- Subject to local conditions, 50% of passengers may use private cars and taxis. Many types of bus and coach will call at the departures forecourt. In order to provide the shortest route for the greater number of passengers, coach and bus bays should be located closest to the terminal doors.

▪ ***Safety facilities for pedestrian circulation.***

As walking is indispensable for public transport users, pedestrian safety condition is a priority. The safety design considerations include;
Elevation of pedestrian transportation to a priority level. Every trip involves walking, thus there is a need to ensure that all pedestrian facilities accommodate the needs of the physically disabled and to recognize pedestrian planning considerations as a priority to be fully integrated in all transportation and land use planning processes. This requires improving safety of the right of way including pavement, signage, signalization, lighting, sidewalks and traffic calming. The following are the main safety issues:

- Vehicle and pedestrian guidance, crossing safety such as zebra crossings and pedestrian traffic signals

- Crossing safety and siting of pedestrian footbridges to be located near the centre of platforms.

- Accessing other levels (vertical transportation) through stairs, lifts and escalators that should not be too close to platform edges and applying evacuation standards to the number and location of stairs and escalators, entrance exit controls

- Safety requirements in designing platforms and loading bus bays are to be considered and identification of the edge of platforms with changes in texture and pattern

- Convenience and safety for parking areas, underground facilities have little access points, thus easily secured.

- **Environmental design requirements**

These considerations deal with environmental enhancements including noise and vibration impacts reduction, energy efficiency in facility design and construction thus dealing with the provision of natural ventilation and lighting, the role of landscaping in minimizing the thermal loads on buildings and water savings, reduction of materials use and their durability.

- Lighting is often the largest item of energy cost, particularly in open plans. Energy efficient buildings should make as much beneficial use of naturally available light as possible. The amount of sky which can be seen from the interior is a critical factor in determining satisfactory daylighting.

- The overriding principle for sustainable design should be to minimize the need for artificial climate systems and make maximum use of natural ventilation in conjunction with climate sensitive design techniques for the building fabric.

- The location of the facility on the site, the type and colour of the exterior finishes, and the materials used in parking and paving all affect the thermal load on a building and hence the design of the heating and cooling systems. Carefully designing the exterior lighting will minimize the impact of light pollution. Reducing heat island effect can reduce summertime energy use. *Landscape elements*, improve air quality, act as a noise buffer, and mitigate heat island effects

- Noise is a matter of comfort, audibility of station announcements, and security. Noise can be controlled by three main means: by placing tracks of trains below ground, by using sound absorbing materials in the construction of tunnels, cuttings and station buildings; and by using noise deflectors.

- The materials must be durable and easy to clean and thus economical. Finishes encompass a wide range of products including paints varnishes, stains and sealers, their primarily purpose is to serve protection against corrosion, weathering and damage, they also add aesthetic value to building materials. Materials with low VOC emissions are recommended.

- **Public amenities at passenger activity spaces**

- *Security:*

In case of air travel in particular but also in principle for large distance rail, the checking for passengers and their possessions requires the installation of suitable equipment and strategic location of the check point in order to ensure both that no passengers evade or avoid the checking procedures. Passive and active security features would include video or audio monitoring of platforms and station areas, well lit corridors, and visible elevators.

- *Fire protection:*

Building design legislation places an assembly of large numbers of people require special consideration of means of escape in case of fire, as well as the normal controls on the standard of building construction.

- *Needs for passengers with reduced mobility:*

Legislations recommend a level of service to be achieved in airport terminals and a discipline to be applied to all passenger terminals. It advocates the drawing up of disabled access assessment plans, with stars recorded for various measures, culminating in a total score for a building and the award of overall, gold, silver and bronze stars ratings.

- *Passenger service facilities:*

Space standards at concourses, core areas and platforms will vary according to the type of station. Although there is an inevitability about the length of a railway station platform or an airport pier, design can mitigate the strain of walking distance by providing passengers conveyors (moving walkways).

Wherever large numbers of people assemble, and particularly wait, they need catering and business facilities, and many number of shopping opportunities. Other design features to enhance passenger comfort and convenience will be providing passengers amenities such as telephones, benches, vending machines, concession areas and sheltered waiting areas.

- **Economic development**

Terminal operators requirements: the owner and the operator of the terminal will be out to make the maximum return on investment and this will probably involve collecting revenue from the transport operator and the commercial concessionaire rather than the passengers or the public.

7.2. Deducing a Design Guide Tool for Measuring the Sustainability of Cairo Intermodal Stations

Attempting to determine the sustainability of intermodal stations, a design guide tool that can be used to overlay sustainable issues is deduced based on the above deduced guidelines, thus determining the performance measures to use the tool to organize and structure sustainable concerns during the design process. A review of different rating systems adopted around the world has been briefly introduced. Possible rating points such as those introduced by the Intermodal Management System (IMS) created by TIP which focuses on enhancing mobility and accessibility to/from interregional intermodal facilities, the Gainesville bicycle and pedestrian LOS performance measures, and the Leadership in Energy and Environmental Design (LEED) rating system, are used as references for the design tool introduced through this research. Scoring forms are deduced to check the sustainability of the intermodal station project, sustainable performance indicators which suit the condition of the greater Cairo region were taken while those not suitable were abandoned.

A computer simulation tool (programme) has been introduced in this research based on the deduced scoring forms. The programme is designed to be applied on Cairo intermodal stations thus evaluating the existing situation in terms of sustainability goals. The simulation tool can also be used to set strategies to be applied to new conducted designs of intermodal stations to achieve sustainability.

7.3. Designing for Sustainability of Cairo Interrmodal Stations

Cairo terminals suffer many problems which affect passenger trips at such stations, of which are; limited pedestrian safety facilities, poor state of platforms and station buildings, unavailability of sufficient parking areas and the unavailability of modern information systems. Also the environmental condition of the intermodal station area is deteriorated. The design of station buildings does not consider natural lighting, adequate ventilation levels inside the buildings, and noise reduction at platforms from whooshing trains.

The research has highlighted the design guidelines which should be followed to introduce a station design responding to the goals of sustainability which should be achieved at Cairo intermodal stations. This helped introducing proposals for intermodal stations such as Ramses city centre intermodal station and Ain Shams suburban intermodal station., thus setting recommendations for improvements of both stations.

As Ramses station has the necessary infrastructure to operate as an intermodal terminal the existing situation could be upgraded to enable the station to function effectively as the main railway terminal for the whole Egyptian country. This requires the application of the design guidelines which has been highlighted in this research. The Improvements aimed to improve intermodal connectivity between modes, enhancing environmental performance of station structures, improving the walking environment and enhancing the vitality of the station thus achieving the sustainability goals. Ain shams plays a vital role as a network suburban station which will connect the East Cairo new communities the CBD of the city. Thus the station should be upgraded to perform its intended role of facilitating the multimodal movement in the region, thus attracting employment opportunities and investments to the new communities

The deduced computer simulation tool was used to measure the sustainability of Ramses station as an important example of Cairo intermodal stations and a score for the existing situation of the station has been set. This will enable designers to point out the deficiencies and propose the solutions to obtain a higher score for the station.

7.4. Recommendations

- Unconnected bus and railway stations should be a thing of the past. Bus and railway stations will emulate standards at airports. Disconnection at the interchange should be remedied and an urban connecter should join the different modes of public transport, air rail and road.

- Pedestrian safety should be a priority when designing for vehicular and pedestrian circulation.

- Environmental enhancement should be a major consideration
- Unattractive public spaces should be remedied and the transport node should be a community hub.

- Low density unproductive land at the interchange should be remedied and enhanced commercial and social potential should result.

Much more attractive public transport will limit the need for unsustainable personal transport.

The goal will be striving for excellence in design of intermodal stations to enhance safety, security, mobility, environmental stewardship, aesthetic quality, and community livability. Following are the objectives which should be met to attain sustainability of Cairo intermodal stations

A. To improve mobility by designing stations to accommodate and enhance pedestrian movement, cyclists and the mobility of the impaired as well as improving vehicular travel.

Strategies to be applied:

- Maintain and improve plazas, to connect bus services to rail, commuter rail and taxi services, and pedestrian and bicycle routes
- Maintain and improve connections and amenities at existing terminals
- Maintain, improve, and expand park and ride lots
- Provide information on all forms of transportation available to public. Information should include how to access services, costs, and where tickets may be purchased. Provide information to help elderly and disabled passengers.

- Encourage private employers to provide shuttle service to intermodal facilities.
- Study improved access and rail improvements within the terminal area
- Coordinate and support efforts to consolidate baggage and passenger security screening for multi modal trips where feasible
- Integrate and pursue recommendations from transportation studies
- handling and arrivals facilities below.

B. To improve safety for all user and enhance passenger convenience.

Utilize context sensitive design solutions which respond to the environs in which they are located, while adhering to appropriate requirements for safety and capacity through utilizing best management practices and most current design standards in all areas of design. Enhance pedestrian safety and convenience by improving the appearance and creating inviting public spaces through traffic calming, pedestrian amenities, view corridors and attractive landscaping, where appropriate, thus enhancing ***community livability*** *and* ***business viability***.

Strategies to be applied:

- Emphasizing effective and attractive signage that clearly conveys essential safety and directional information to travelers.
- Implementing travel calming measures where appropriate to slow traffic speeds.
- Redesign curb cuts and improve sidewalk conditions to facilitate movement of wheelchair-assisted travelers. Utilize the most effective crosswalks designs based on industry research.
- Urban parking garages should have ground floor retail, to create more walkable environments.
- Treating Transportation corridors through the intermodal area as greenways that have the appearance of parkways and boulevards.

It is worthy to study the availability of the promotion of bike/bus/train intermodal connections at Cairo intermodal stations, nevertheless, this will require studying the availability of dedicated bike roads linking the different activity centres to the intermodal station area, and thus marketing the availability of bike racks and providing bicycle facilities at major intermodal centres

C. To improve air and water quality and to conserve energy, water and material resources

Consider environmental enhancements, noise reduction, and energy efficiency, in facility design and construction through

Strategies to be applied:

- Managing vegetation for multiple objectives: safety, air and water Quality, noise reduction, community aesthetics, and natural habitat values. Encourage the retention and use of vegetated buffers to reduce air quality impacts and to serve as noise barriers.

- Adopting a station building form that responds in direct fashion to the physics of air movement, and to the practicalities of lighting both natural and artificial

- Reuse of existing station buildings and choosing building materials with low impact during their life cycles and of high durability

The above mentioned environmental strategies are considered the main strategies which should be applied to Cairo intermodals. more futuristic strategies which could be applied will be the adoption of the concept of factor 10 for energy, water and material consumption in the design of new stations.

List of Abbreviations

ADA	**:**	Americans with Disabilities Act
AGT	**:**	Automated Guideway Transit
APM	**:**	Automated People Mover
BREEAM	**:**	Building Research Establishment Assessment Method
BRT	**:**	Bus Rapid Transit
CASBEE	**:**	Comprehensive Assessment System for Building and Environmental Efficiency
CBD	**:**	Central Business District
CCTV	**:**	Closed Circuit Television
CREATS	**:**	Cairo Regional Area Transportation Study
CTA	**:**	Cairo Transportation Authority
ENR	**:**	Egyptian National Railway
FHV	**:**	For Hire Vehicle
GCR	**:**	Greater Cairo Region
HSGTS	**:**	High Speed Ground Transportation System
HVAC	**:**	Heating, Ventilating and Air Conditioning
IAQ	**:**	Indoor Air Quality
IEQ	**:**	Indoor Environmental Quality
IMS	**:**	Intermodal Management System
ITE	**:**	Institute of Transportation Engineers
ISTEA	**:**	Intermodal Surface Transportation Efficiency Act
JICA	**:**	Japan International Cooperation Agency
K&R	**:**	Kiss and Ride
LEED	**:**	Leadership in Energy and Environmental Design

LOS	**:**	Level of Service
LRT	**:**	Light Rail Transit
LUTRAQ	**:**	Land Use, Transportation, Air Quality
MSDG	**:**	Minnesota Sustainable Design Guide
MRT	**:**	Mass Rapid Transit
NAT	**:**	National Authority for Tunnels
NMT	**:**	Non Motorized Trips
PIS	**:**	Passenger Information System
P&R	**:**	Park and Ride
PRT	**:**	Personal Rapid Transit
RCDG	**:**	Roissy Charles De Gaulle
RCI	**:**	Roadway Condition Index
ROW	**:**	Right Of Way
SOV	**:**	Single Occupant Vehicle
TGV	**:**	Train de Grande Vitesse
TIP	**:**	Transportation Improvement Programme
USGBC	**:**	United States Green Building Council
VMT	**:**	Vehicle Mile Travel
VOC	**:**	Volatile Organic Compounds

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بإقليم القاهرة الكبرى

رسالة مقدمة للحصول على درجة دكتوراه الفلسفة
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المستخلص

علا محمد عماد الدين بكرى. مدخل للتصميم المستدام لمحطات ربط وسائل النقل بإقليم القاهرة الكبرى. **دكتوراه الهندسة المعمارية**، كلية الهندسة جامعة عين شمس، ٢٠٠٨

يشكل النمو المتزايد فى حجم حركة النقل و الاختناقات الناجمة عنه تهديدا كبيرا للبيئة و معوقا فى طريق التنمية المستدامة. لذا كان لابد من تبنى السياسات و البرامج التى تحقق للمواطنين الانتقال فى صورته المستدامة عن طريق تقليص استخدام السيارة الخاصة و تطوير استخدام وسائل النقل العامة كحل بديل. و يتطلب تحقيق المنافسة بين السيارة الخاصة و وسائل النقل العامة أن تحقق خدمة النقل العام المرونة و الكفاءة و الاعتمادية عليها، و ذلك من خلال التكامل بينها جميعا بحيث يستطيع المواطن الوصول الى مقصد رحلته الانتقالية من خلال تذكرة واحدة حتى إذا تطب ذلك التبديل بين عدة وسائل مختلفة. و يحقق هذا الهدف الربط بين وسائل النقل المختلفة و التى تعمل فى منظومة بيئية واحدة و بالتالى توفر الاتاحية الكاملة و التى لها دورا هاما و ملحا على المستوى الاجتماعى و الاقتصادى. و تلعب محطات ربط وسائل النقل دوراً أساسياً فى هذه المنظومة. لكن إذا لم يتم تصميم هذه المشروعات على اساس معايير بيئية خاصة يمكن أن تتسبب فى تأثيرات محلية و إقليمية على البيئة الاجتماعية و الاقتصادية.

و يقدم هذا البحث مدخل لعملية تصميم محطات ربط وسائل النقل بهدف تحقيق الاستدامة لها. و يتضمن التصميم عناصر تخطيطية و عناصر معمارية. و تتمثل العناصر التخطيطية فى تصميم الموقع العام للمحطة و الخدمات المتاحة بها و كيفية ربط الوسائل المختلفة على مستويات مختلفة محققة حركة آمنة للمشاه و راكبى الدراجات. و تتمثل العناصر المعمارية فى تصميم أرضيات المحطات و المظلات و الوصول للمستويات المختلفة بالمحطة، و الرؤية الجيدة و التهوية و و الارشادية لأماكن الركوب و المغادرة و الحصول على التذاكر. أيضا تصميم المراكز التجارية و المحال بصورة محققة لعنصر الأمان و غير متعارضة مع الأداء الوظيفى للمحطة. و يتعرض البحث للمواد المستخدمة فى هذه العناصر المعمارية و كيفية تنفيذها و صيانتها. و لتحقيق هذه الأهداف يقوم البحث باستعراض نماذج لمحطات ربط وسائل النقل فى دول العالم المختلفة و استنباط الخطوط الإرشادية لعملية التصميم من منظور الاستدامة؛ يلى ذلك استعراض لحالة الدراسة و هى محطلت ربط وسائل النقل بإقليم القاهرة الكبرى. يتم تقييم الوضع الحالى للمحطات عن طريق جمع البيانات اللازمة للتقييم و الوقوف على مدى كفاءة منشآت المحطات و اقتراح متطلبات التطوير.

و يقوم البحث بتحليل جميع المعلومات المتوفرة لعملية تصميم و تنفيذ هذه المحطات على اساس بيئى لتحقيق استدامتها بحيث يمكن الوقوف على النقاط الهامة فى تصميم هذه المحطات و بالتالى تقديم الحلول التصميمية و التى تمكن المعماريين و المخططين من الاستعانة بها فى اتخاذ القرارات التصميمية الخاصة بهذه المحطات.

التعريف بمشكلة البحث:

تعد مشروعات النقل من المشروعات التى لها تأثير سلبى على البيئة الاجتماعية و الاقتصادية و التى تتمثل فى تأثيرها على الصحة العامة للمواطنين الناتج عن تلوث الهواء و الضوضاء و الاهتزازات، تلوث المياه و التربة، نزع ملكية الأراضى و التلوث البصرى. و السؤال هنا هو كيف يمكن تصميم هذه المشروعات بحيث يكون لها أقل تأثير سلبى على البيئة المحيطة. و هناك اتجاه عام لتحسين ظروف الانتقال للمواطنين و التى أصبحت مشكلة كبيرة ناتجة عن احتياج المواطن لركوب أكثر من وسيلة نقل للوصول الى هدف رحلته، لذا فان هناك احتياج لوضع نظام متكامل لتحسين ظروف الانتقال و هذا النظام يتطلب إنشاء مراكز (محطات) لربط وسائل النقل.

لعل إقليم القاهرة الكبرى من الأقاليم التى تحتاج الى تشكيل نظام ربط لوسائل النقل بها يكون متكاملا مع تطوير وسائل النقل العام. هذا النظام يتطلب تطوير محطات ربط وسائل النقل بالإقليم بما أنها تعانى من عدم التكامل بين وسائل النقل المختلفة و تدنى المستوى الخدمى لمستخدمى المحطات، كما يتجاهل تصميم المحطات الجوانب البيئية.

يناقش هذا البحث استدامة هذه المحطات من حيث ؛ تصميم فراغ المحطة، التصميم المعمارى لها و المواد المستخدمة بها و كيفية التنفيذ لعناصرها المعمارية و صيانتها بدون التعارض مع وظيفتها المحققة للاستدامة، و حصر التأثير البيئى للمشروع من الناحية الاجتماعية و الاقتصادية.

هدف البحث:

يعتبر تطوير خدمة النقل العام أمرا حيويا للاقلال من العزلة الاجتماعية و تحسين مستوى المعيشة مؤديا بذلك إلى اقتصادا قويا و بيئة أفضل، فيجب ان تكون حركة الانتقال للمواطنين الاقتصادية و الآمنة فى بؤرة اهتمام السياسة العامة للنقل، و يتضمن هذا استراتيجية لزيادة استخدام وسائل النقل العام. و الهدف من هذا البحث تقديم البدائل التصميمية لتطوير خدمات محطات ربط وسائل النقل لتوفير مستوى خدمى أفضل للمواطنين و إيجاد حلول أفضل للمشاة واضعين فى الاعتبار المتطلبات المستقبلية لمستخدمى هذه المحطات، و ذلك من خلال مدخل بيئى للتصميم لتحقيق هدف الاستدامة، و هذه العملية تتضمن الجوانب المعمارية و التخطيطية لهذه المحطات و بالتالى استخلاص قوائم لتقييم البدائل التصميمية محددة بذلك التاثيرات الايجابية و السلبية على البيئة الاجتماعية و الاقتصادية.

منهجية البحث:

يناقش البحث استدامة محطات ربط وسائل النقل باتباع الآتى:

١- استخدام المنهج التحليلى فى تقييم استدامة عدة نماذج لمحطات ربط وسائل النقل على مستوى العالم فى مدن لها ظروف مشابهة لمدينة القاهرة، من خلال استعراض التصميم و عناصره و مدى ملاءمته للبيئة و تأثيره عليها، و يتم ذلك من خلال بحث نظرى مقالى، و بالتالى استخلاص معايير يمكن توفيقها و تطبيقها كملامح تستخدم فى حالة الدراسة و هى إقليم القاهرة الكبرى و الوصول إلى قوائم تقييمية للبدائل التصميمية.

٢- منهج البحث الميدانى فى دراسة المحطات المقترحة فى منطقة شرق القاهرة فى تققيم الوضع الحالى لها و تقييم المقترحات التصميمية لها من حيث التصميم المعمارى و التاثير البيئى فى حالة تنفيذ هذه المشروعات.

٣- و فى النهاية استنتاج كيفية التصميم للمحطات المستدامة بعد تحديد المعايير التصميمية من حيث:
المحتوى العمرانى و العناصر المعمارية و موادها و طرق تركيبها و صيانتها و فى النهاية الوصول لتحديد مدى تحقيق هذه المحطات للاستدامة من الناحية البيئية و الاقتصادية و الاجتماعية، وبذلك الوصول للتوصيات للمصممين و المخططين.

هيكل البحث:

الفصل الأول: فكرة محطات ربط وسائل النقل

يتضمن هذا الفصل شرح لنظرية ربط وسائل النقل و كيفية تطبيقها، الاستدامة كهدف فى تصميم محطات ربط وسائل النقل و أهمية التقييم البيئى لها و دوره فى تحقيق الاستدامة.

الفصل الثانى: التصميم المستدام لمحطات ربط وسائل النقل

يتعرض هذا الفصل للخطوط الارشادية فى تصميم محطات ربط وسائل النقل التى يجب أن تتبع لتحقيق أهداف الاستدامة و المتمثلة فى فصل مسارات الحركة للمشاة والمركبات' معايير الأمان' المعايير البيئية و كيفية إحياء المحطات لتلبية متطلبات مستخدميها.

الفصل الثالث: النماذج العالمية لمحطات ربط وسائل النقل

يعرض هذا الفصل لنماذج مختلفة من محطات ربط وسائل النقل فى مدن مختلفة من العالم و يتم تحليل هذه المحطات فى ضوء استدامة تصميمها و تأثيره البيئى. و تتمثل العناصر التصميمية لهذه المحطات فى كفاءة تنظيم الحركة بداخلها، تصميم الأرضيات و الأرصفة و المظلات و كيفية الوصول للمستويات المختلفة و توفير المناخ الصحى و كيفية الحصول

علـى التـذاكر و تـوفير الخـدمات التجاريـة. و بالتـالى اسـتخلاص المعـايير التصـميمية لهـذه المحطات.

<u>الفصل الرابع:</u> التصميم المستدام لمحطات ربط وسائل النقل بإقليم القاهرة الكبرى

حالـة الدراسة فى هذا البحث هى محطات ربط وسائل النقل فـى منطقـة شـرق القـاهرة. و يـتم تقييم الوضع الحالى من خلال البحث الميدانى. و الوقـوف علـى مشـاكل هـذه المحطـات، مـن خـلال اسـتعراض شـبكة الطـرق المحيطـة بالمحطـة، تخطـيط المحطـة، و التقيـيم البيئـى مـن خلال قياس معدلات التلوث و حالة المنشآت و بذلك يتم تقييمها من منظور الاستدامة.

<u>الفصل الخامس:</u> وضع مقترحات البدائل التصميمية لمحطات ربط وسائل النقل بإقليم القاهرة الكبرى

يستعرض هذا الفصـل تقيـيم المقترحـات مـن حيـث اسـتدامتها مسـتعينين فـى ذلـك بالمعـايير التصـميمية المسـتنتجة مـن الفصـول السـابقةز يـتم تقيـيم البـدائل مـن حيـث مـدى الاسـتدامة لمحطات حالة الدراسة.

<u>الفصل السادس:</u> طرق قياس الاستدامة لتصميم محطات ربط وسائل النقل

يعـرض هـذا الفصـل طـرق قيـاس الاستدامة لتصـميم محطـات ربـط وسـائل النقـل و اسـتنتاج القوائم التقييمية لها من حيث عناصر التصميم المعمارى و التأثير على البيئة الاقتصـادية، و يقدم برنـامج تطبيقـى للحاسب الآلـى يمكّن المصـمم مـن قيـاس مـدى تحقيـق تصـميم المحطـة لأهداف الاستدامة.

<u>الفصل السابع:</u> الاستنتاج

النتائج و التوصيات للتصميم المستدام لهذه المحطات و كيفيـة ملاءمتهـا للمنـاطق الموجـودة بها و مدى تأثيرها على البيئة الاجتماعية و الاقتصادية.