23 Intermodal Stations: A Guide to Sustainable Design

Ola Mohamed Emad El Din Bakry

Dr. Yasser Mansour, Dr. Ruby Morcos, Dr. Ghada Farouk

Department of Architecture, Ain-shams University, Cairo, Egypt

ABSTRACT:
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. On average, public transport terminals in developing countries are not designed from an intermodal service perspective. This paper aims to highlight the design issues which should be considered when designing sustainable intermodal stations, such as; modal connectivity, 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 paper, several physical design issues are examined by reviewing previous experience with literature survey on the design of intermodal stations. Ramses intermodal station is discussed as a major station in Cairo, the present situation of the intermodal station is investigated, and recommendations are set for improvements. The paper ends by deducing design guidelines which could be applied to Cairo intermodal stations towards achieving their sustainability.

Conference Topic: Technology: Time Constraints and Future Visions
Keywords: Sustainable Stations- Intermodals - Environmental Design

1. INTRODUCTION

Mobility has a direct link with social and economic progress. Increased congestion in large cities makes public transport a valuable alternative for the private car which threatens the global environment and the health of our children. It is now recognized that car use at present level is not sustainable, railway (high speed systems, metro or light rail systems) represent a better long term investment. Developing an intermodal public system requires the efficient integration and interconnection of the different public transport systems. Terminals play an important role in the efficiency of the system**.** Stations must express the importance of travel modes through high quality design, They should be lasting and beautiful. The goal will be striving for excellence in design of intermodal stations to enhance; mobility, safety, environmental stewardship, aesthetic quality and community livability.

Cairo terminals suffer many problems which affect passenger trips at such stations; limited pedestrian safety facilities are installed in the intermodal area, other problems are the poor state of the station structures, unavailability of sufficient parking areas and the unavailability of modern information systems. Ramses station has the necessary infrastructure and structure to operate as an intermodal terminal. Although the original design of the terminal was highly efficient, the effectiveness of the different sections in the terminal has disappeared over time. The existing situation is evaluated and improvements are discussed in terms of intermodal connectivity, environmental conditions and pedestrian safety and convenience, thus developing appropriate sustainable design strategies to guide the sustainable design and decision making processes.

2. THE INTERMODAL STATION SUSTAINABLE DESIGN

2.1. Intermodality and Layout Planning

- *The site evaluation criteria* for the intermodal station location would include the following:

The proximity to major facilities and destinations such as freeway interchanges, major arterials, airports, hotels/restaurants, major employment centres, major shopping centres, and residential areas,

The community impacts 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.

Environmental impacts and traffic mitigation, impacts include noise, air quality and water quality concerns. Traffic Mitigation will deal with the local traffic capacity and traffic safety improvements required.

Potential funding sources and costs is a major issue which has to do with defining land development projects at station location that will be attractive to the developers that will undertake them.[9]

- *Layout planning:* 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 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 enhance public transport integration.[1]

2.2. Safety Requirements for Traffic and Pedestrian Circulation

- *Vehicles and pedestrian guidance*: Pedestrian circulation improvements 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.[11]
- *Crossing safety:* 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. 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.[2]
- *Accessing other levels:* 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. The siting of lifts and escalators is important. 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.[10]
- *Design of platforms and loading bays*: Platforms are built to the height of the train floor as a standard. 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 provide safety.[10] Bus stations vary in size according to the number of bays and 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. '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. Reflective signs that lists the routes serving the bus stop should be installed.[1]
- *Design of parking 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 users, they should be space-efficient and economical to operate, they should be compatible with their environs. Convenience and safety involve many issues, including proximity to major destinations, adequate access, a simple and efficient internal circulator system, adequate stall dimensions, and basic security.[5] 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.[12]

2.3. 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. Working with nature as a source of energy and

visual daylight is shaping a new generation of stations. 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.[2]

- *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. The amount of sky which can be seen from the interior is a critical factor in determining satisfactory daylighting. Rooflights give a wider and more even distribution of light but also permit heat gains which may cause overheating.[6]

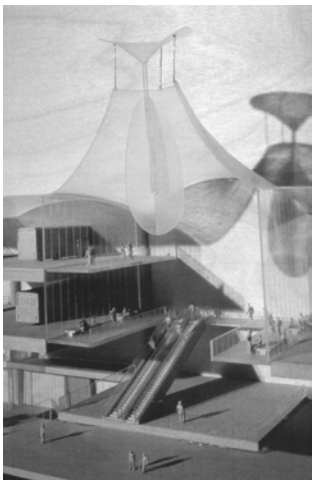

Fig (1) Partial view of interior at Transbay Terminal, roof design permitting daylight and using wind flows to ventilate and cool the building.[7]

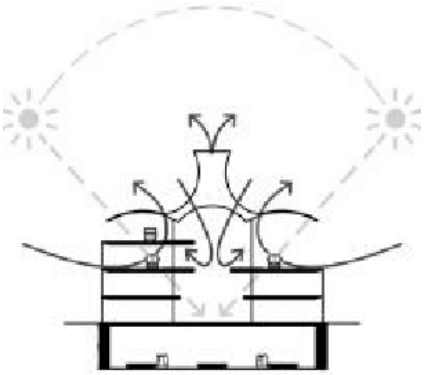

Fig (2) Conceptual diagram, daylight and natural ventilation will suffuse the terminal with sunlight and air and save energy.[7]

- *Ventilation in Station Buildings:* Air flow in the interior of station buildings may be created by allowing natural ventilation or by the use of artificial mechanical ventilation or air conditioning. Buildings using one 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, (Fig 3). [6]

- *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. Reducing heat island effect can reduce summertime energy use. Locating parking structures underground is an appropriate option. Landscape elements, improve air quality, act as a noise buffer, and mitigate heat island effects. 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. The application of

landscaping directly to the building in the form of green roofs and vertical landscaping is another innovation. *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 wind breaks absorbs carbon dioxide and generates oxygen.[4]

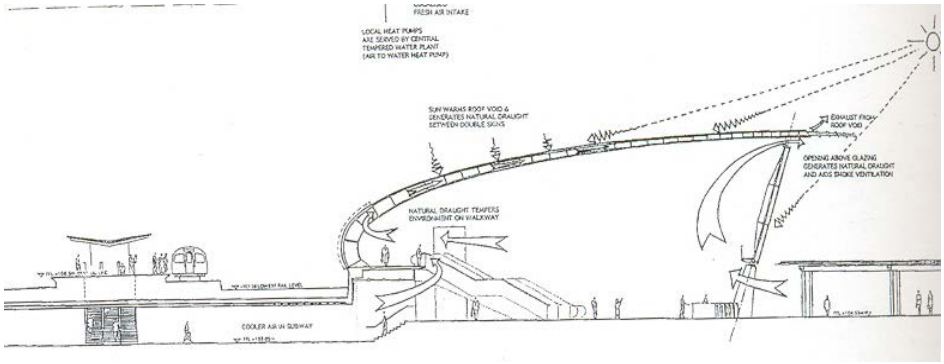

Fig (3) At Stratford regional station, the roof is designed to allow solar energy assisted ventilation, by using the chimney principle. Through a void to the concourse at the lower part of the roof, hot air streams in the space between the double skin, and is exhausted through an opening at the highest part of the ellipse.[7]

- *Noise Transmission and Acoustics:* 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. 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.[2]

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.

- *Materials and Finishing:* The materials used in station structures must appear safe and solid to passengers and staff. They 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. 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.[4]

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. 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.[3]

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.[3]

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.[3]

2.4. Public Amenities at Passenger Activity Spaces at Station Sites

- *Security and Fire protection:* 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. 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. 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]

- *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. Electronic displays and traditional timetable boards are 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.[2]

- *Passenger Service Facilities:* 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. 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.[2]

- *Design for the Physically Handicapped:* 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. Site layout should avoid steep changes in level should facilitate disabled access, the perception of layout and station entrances should be friendly to all. Disabled access by car is needed at station entrance. Textured finishes help the disabled to distinguish the safe from unsafe zones. Using textured paving to define safe limits. Providing special disabled access ticket desks, providing disabled telephone , Providing screens and barriers that are solid at ground level for detection by people using canes.[2]

3. CAIRO INTERMODAL STATIONS: RAMSES INTERMODAL STATION

3.1. Existing Transport Services

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 number of transport facilities exist within Ramses Square,the ENR station is directly linked on the CTA bus terminal, the terminus of Heliopolis Metro, 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 6 th of October Expressway.

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 Heliopolis Metro tram station is inadequate for the needs of a modern LRT station (a future Light Rail Transport system). A public transport-friendly design is required under which tram passengers would have direct access to the Cairo Underground 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. A new design should create a pedestrian island with numerous opportunities for precincts, landscaping and other amenities. [8]

3.2. Problems of Present Situation of Ramses Intermodal Station Area

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, 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 of 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.

At the same time, people wanting to change from one mode to another need to search their next shared taxi or minibus ride because a large number of the shared taxi do 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.

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.

The situation of the LRT station: The configuration of the existing light rail transit terminus station is inadequate for use by a modern LRT system 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.

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 buildings and platforms need upgrading in many aspects. The station has got 24 platforms of varying lengths and breadths. 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. Parking area is insufficient while the entire road section in front of the terminal is used by taxi and private cars for loading and unloading zones. 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.

Environmental Condition of Ramses Intermodal Area: Fine dust (PM_{10}) and carbon monoxide levels exceed heavily the Egyptian Standards. Nitrogen dioxide, Sulphur dioxide and ozone concentrations are at considerable levels, however still below the Egyptian Standards. Noise levels exceed the Egyptian standards and are higher than 70 db which causes negative impacts on health.[8]

3.3. Proposed Improvements of Ramses Intermodal Station

- *Improving Intermodality:* Resolving the congestion at the entrance of the ENR station by closing the slip road at the access of the 6th of October Expressway and reversing the direction of Shubra Bridge as microbuses will use the bridge to access the bus terminal, this will resolve the congestion under the 6th of October bridge. The implementation of a subway is necessary for the separation of movement between vehicles encroaching the Shubra bridge on their way to the bus terminal and vehicles departing the station.

The existing trams terminal station should be modified to accommodate a new LRT system. The relocation of the station and the provision of pedestrian plaza is a main design concern. This will require extending the track westward to the place of the removed Ramses statue. Passenger movement to/from the LRT station will be via the elevated walkway which links the station with both sides of Ramses square while access steps of the underground metro at the west of the LRT station will require widening to accommodate the expected high passenger flows.

- *Improving Pedestrian safety and convenience at Ramses Station:* 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. Well maintained landscaping in this area is very important, shady trees and shelters is to be provided. 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.

- *Improving the Environmental Condition:* The 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. Implementing lightwells in the new underground garage building to make optimum use of daylight 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. Noise treatments should be employed at the rail tracks and platforms.

- *Enhancing Community Livability and Business Viability:* Barrier free facilities should be equipped to assist handicapped and aged people for convenience at Ramses intermodal station such as slope, lift, toilet and so on. The ENR station will require CCTV systems mainly at platforms. Ensuring adequate levels of lighting at distant platforms is necessary. A modernized passenger information system is needed to be appiled at the ENR station and the bus terminal. The terminal can also be designed to accommodate feasible space for small business catering to users, including convenience stores, branch banks, coffee shops and snack restaurants, news paper and magazine vendors. 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.

4. CONCLUSION

The paper highlighted the design issues which should be considered when designing sustainable intermodal stations; such as, circulation needs within the intermodal station area and the separation of movement to improve mobility, safety requirements, environmental requirements for station structures focusing on air quality, lighting quality and noise, and passenger convenience which is directly related to the equity goal of sustainability.

Ramses intermodal station does not satisfy the intermodality strategies for improved linkage between the different transport modes. A deficiency in the design for pedestrian safety and convenience is notable in the station. The environmental strategies are ignored. Equity and economic development polices and strategies are not adopted. 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 paper. The improvements aimed to improve modal connectivity, enhancing the environmental performance of the structures of the stations, improving the walking environment and enhancing the vitality of the station, thus achieving the sustainability goals. Strategies to be applied for Sustainability of Cairo intermodal stations would be summarized as follows:

A. To improve mobility by designing stations to accommodate and enhance pedestrian movement, mobility of the impaired and improve vehicular travel.
   - Maintain and improve station plazas to connect bus services rail commuter rail and taxi services and pedestrian routes..
   - Maintain and improve park and ride lots.
   - Study improved access and rail improvements within the terminal area
B. To improve safety for all users and enhance passenger convenience.
   - Emphasizing effective and attractive signage that clearly conveys essential safety and directional information to travelers.
   - Implementing travel calming measures where appropriate
   - 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.

C. To improve air and water quality and to conserve energy and water and material resources

- Managing vegetation for multiple objectives: safety, air and water Quality, noise reduction, community aesthetics, and natural habitat values.
- 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.

REFERENCES

[1] Blow, Christopher (2005), ***Transport Terminals and Modal Interchanges***, Architectural Press, Elsevier, Oxford.
[2] Edwards, Brian (1997), ***The Modern Station*****,** ***New Approaches to Railway Architecture***, E & FN Spon.
[3] Hackelsgerger, Christoph (1997), ***Subway Architecture in Munich,*** Prestal Verlag, Munich. Newyork.
[4] Kibert, Charles J. (2005), ***Sustainable construction, Green Building Design and Delivery***, John Wiley & Sons, Inc., Hoboken, New Jersey
[5] Roess, Roger P., PRassas, Elena S., Mcshane William R., (2005), ***Traffic Engineering***, Third Edition, Pearson Prentice Hall, Pearson Education International.
[6] Smith, Peter F. (2005), ***Architecture in a climate of change, A guide to Sustainable Design***, second edition, Arcitectural Press, Elsevier, Oxford.
[7] The Art Institute of Chicago (2002), ***Modern Trains and Splendid Stations***, Merell Publishers Limited, London.
[8] Japan International Cooporation Agency (JICA), December 2003, Transportation Master Plan and Feasibility Study of Urban Transport Projects in Greater Cairo Region, A.R.E. (CREATS), Phase 2 final report.
[9] Shneider, Jerry B. (2004), ***The Design of Intermodal Stations for a High Speed Transportation System***, U.S. Department of Transportation (DOT), Fedral Railroad Administration, NMI Office, Washington D.C.
[10] http://www. railway-technical.com/stations.html
[11] http://www.nyc.gov/html/dep/pdf/transportation/td.fullsubwaysidewalkbx.pdf
[12] Berenguier, Claude, Nov 2006, *Why Go Underground In Urban Areas*, International Symposium on Utilization of Underground Space, Sharm El Sheikh, Egypt.