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Design guidelines for pedestrian circulation requirements of multi-modal hub stations

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ABSTRACT

Many countries are increasing their research interest in multi-modal passenger transportation design, including hub, interchange, and other typologies. Multi-modal transportation is the act of connecting and moving people and goods using at least two different modes of transportation. As a result, expanding the country's transportation system is part of its economic reform strategy. The **problem** of the paper is the lack of guidelines for pedestrian circulation requirements in public transportation stations in Egypt. This paper analyzed and evaluated the pedestrian circulation requirements in public transport stations in Egypt. With the **aim** of suggesting the design guidelines for pedestrian circulation requirements in multi-modal hub stations in Egypt. After identification, the **findings** are formed by the suggested design guidelines for pedestrian circulation requirements of multi-modal hub stations in Egypt. This paper **recommends** a framework for the design aspects of multi-modal hub stations.

1. Introduction

Transportation and circulation depend on the safe and efficient movement of people and goods. Passenger movements between platforms and the waiting halls of the station were in the past. While the Present day, big stations serve as hubs for connections between a variety of modes [1], and a user-friendly information system is required because there are now many flows within the station complex, some of which are running at different levels and using different ways Since every journey begins and ends with a walk, it makes sense that walking is one of the most relevant modes of transportation. According to transportation planning, walking is the primary mode of transportation for individuals in their daily lives. How easy a place can be walked through, and the amenities offered to passengers both affect safety [2].

1.1. Research problem statement

This paper discusses the lack of guidelines for pedestrian circulation requirements in public transportation stations in Egypt. It also analyzes and compares the pedestrian circulation requirements in Egyptian case studies (Ramses intermodal station and Adly Mansour hub station); due to the presence of some of the problems, which are:

- Increasing demand for public transportation stations.
- The inability of the area of spaces to accommodate the increase in the number of users at public transportation stations.
- Difficulty of circulation and intersections for pedestrians.
- The increase in the time it takes to move from one space to another.

1.2. Research aim

he paper aims to suggest the design guidelines for pedestrian circulation requirements in the multi-modal hubs in Egypt to help the government design and develop multi-modal hub stations. Based on a set of several rounds, As shown in Fig. 1.

- Define the pedestrian circulation requirements, guidelines, and Factors affecting pedestrian circulation.

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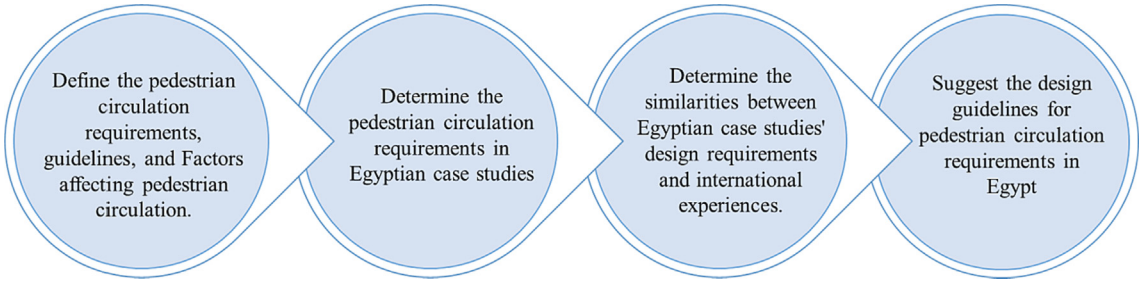

Fig. 1. Stages of Achieving paper aim. *Source:* Authors.

- Determine the pedestrian circulation requirements in Egyptian case studies (Ramses intermodal station and Adly Mansour hub station).
- Determine the similarities between Egyptian case studies' design requirements,and international experiences.
- Suggest the design guidelines for pedestrian circulation requirements in Egypt.

1.3. Research methodology

This paper takes the form of pedestrian circulation requirements in multi-modal hub stations. The paper is divided into several axes. The **first axis** specializes in the knowledge framework for pedestrian circulation requirements in multi-modal hub stations, while the **second axis** focused on a theoretical framework for defining the pedestrian circulation requirements in existing and new hub stations, and determining the problem of them,while the **third axis** of the paper focuses on the practical side by comparing the pedestrian circulation requirements in existing and new hub stations requirements, and suggesting design guidelines for pedestrian circulation requirements of multi-modal hub stations. As shown in Fig. 2.

2. Pedestrian circulation requirements

Transportation and circulation are key components of safe and effective pedestrian circulation, where the circulation paths are regarded as one of the most influential aspects of transportation stations, where the paths intersect and form many spaces, which leads to issues in the circulation paths for users, and thus an increase in the time spent in the path, an increase in densities, and a decrease in per capita share. Therefore; many countries are interested in pedestrian circulation patterns in stations [3].

2.1. Stander of pedestrian circulation requirement. (International experiences)

Three successful international case studies (India -Germany - British) were selected to identify the pedestrian circulation requirements. The selection is according to several criteria; India is the world's largest and busiest transport network, while Germany's public transport network is the best and most efficient in Europe. Provide sufficient space for movement and waiting, while the history and success of the world's first railways had a reason to choose the British experience, from that, pedestrian circulation requirements represented in [4,5,6,7].

- Providing connectivity, and integration between different transportation systems to provide convenience for users [8].
- Create a clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation (entry-tick ets-waiting-departure) [4].
- Design various spaces to accommodate the maximum capacity of the passengers [7].
- Providing information centers, and services necessary for the convenience of passengers inside the main halls and ticket halls.
- Using technology that reduces the amount of time people must wait in line to buy tickets.
- The station's design must allow for free-flowing passenger movement to avoid severe congestion within the Station, particularly on platforms and escalators [9].
- Minimizing cross flows and overlapping passenger circulation to avoid obstacles in circulation [7].
- Provide horizontal, and vertical movement taking into consideration disabled persons.
- Separation of automobile and pedestrian circulation.
- Separation of pedestrians between arrivals and departures.
- Reducing walking distances.
- paths should be as straightforward as possible.
- Determining separate areas for the movement of baggage in the case of arrival from the train to the reception or vice versa [6].
- Allocating places for waiting for passengers for long periods as well as short periods.
- Provide an exit and entrance for station staff.
- Separation of the passenger's circulations from the station staff.
- Use of signs and guideboards of various levels.
- Platforms are designed to accommodate the maximum capacity of passengers [6].
- The optimal design of the cross-section of the platform in the station (parts that are forbidden to wait - movement area - waiting area) [10].

2.2. Factors affecting pedestrian circulation efficiency

Circulation requirements in multi-modal hubs indicated the main elements that should be considered to achieve pedestrian circulation efficiency [11].

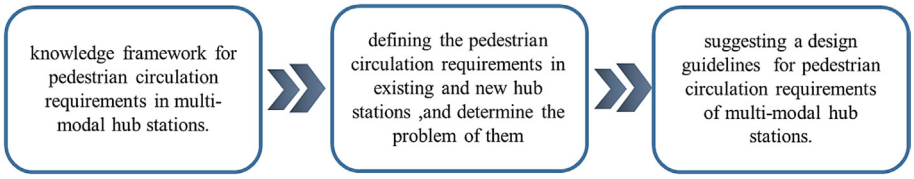

Fig. 2. Research Methodology Structure. *Source:* Authors.

- **Flow Rate** is the number of people at a certain time by the area of the spaces.
- **spatial distribution** is the number of pedestrians across the different spaces of the stations based on the types of users, their locations, their pathways, and the area allocated to the main elements [12].
- **Rate per capita** is calculated by the area of the spaces divided by the number of pedestrians in peak hours [12].
- **Density** is one of the general methods for assessing the efficiency of spaces, which gives indicators that help in the best distribution of areas. Density is calculated through the following (Density = numbers of users/area of spaces) [13].
- **Delaying** in time is calculated by (Delay time = Observation Time - Expected Time). While the Expected time is calculated by (Expected time = Distance / Standard Speed) [13].
- **Guidance signs** achieve a kind of communication between people, the architectural environment around them, and their forms differ to help them know their place in the different spaces [14].

3. Qualitative analysis of case studies

This part of the paper analyzed and evaluated the pedestrian circulation requirements in Egyptian case studies (Ramses station, and Adly Mansour station).

3.1. Case study 1: Ramses intermodal station

Ramses station is a critical station in the public transportation system in Egypt; new designs have been conducted for Ramses station, which incorporates sustainable issues. Several transport facilities exist within Ramses square including one of the main ENR (Egyptian National Railway) stations, elevated pedestrian walkways, and entrances to the underground Cairo Metro (El-shahada station, Metro Lines 1 and 2) [15]. A series of changes had been implemented under the sponsorship of the 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 station [15]. From that, the station was chosen according to certain criteria based on the following.

- One of Cairo's most significant public transportation hubs is Ramses Station.
- Several transport facilities exist within Ramses station.
- Ramses station is directly connected to central Cairo.

3.1.1. Circulation requirements for pedestrians in Ramses intermodal station

Ramses Station has the setup and configuration needed to function as a multi-modal terminal and has many Pedestrians Circulation Requirements. Which are represented in [15].

- Connecting diverse types of transportation in one place and providing spaces for movement between different modes
- Providing private paths and services for employees and operators in the metro station.
- Dividing the platform cross-section at the metro station, while it is not done at the railway station.
- Provide horizontal, and vertical movement taking into consideration disabled persons.
- Separation of automobile and pedestrian circulation.
- Reducing walking distances.
- Paths straightforward as possible.
- Usage of signs and guideboards of various levels.

3.1.2. Categories and numbers of users in Ramses intermodal station

The number of users was determined by the average number of passengers at peak hours. Noting that the working hours for trains are from 1 am to 5 am [16], while the working hours for the metro are from 12 am to 5 am [17]. As shown in Table 1.

The number of users in train station represents about 93 % of the total users, while metro station users represent about 7 %, due to the difference in the time of trains in each of them, so the average train time takes one hour at the train station, while the metro station is 3 min. As shown in Fig. 3.

3.1.3. Area of zones in Ramses intermodal station

The following table shows the areas of the different zones in Ramses intermodal station [16,17,18]. As shown in Table 2.

The area of zone in the train station revealed a disparity in areas, (services and shops) having the largest area among all the other zones, followed by the platforms, then the waiting hall, and the ticket area having the smallest. While the area of zones at the metro station revealed that platforms were the largest area, followed by (services and stores), and the waiting hall and ticket area were the smallest. As shown in Fig. 4.

3.1.4. Spatial distribution of users in Ramses intermodal station

According to the categories of users, their locations, their movement paths, and according to the areas allocated to the main elements, the number of users for each category in 2022 can be distributed in the different spaces of the station to estimate the volumes of pedestrian movement in the station. As shown in Table 3.

The train station has the largest number of users on the platforms followed by the waiting hall, then theticket area, and the (services and shops) have the smallest, while the metro station has the largest number of users in (waiting hall and ticket area) followed by the (services and shops).

3.1.5. Rate per capita

With the increase in the number of users in Ramses intermodal station, the per capita share decreases. From that, the per capita for the main elements in the train station ranges from 0.36 m^2 to 0.79 m^2, and the average per capita inside the train station is

Table 1
Categories and numbers of users per hour. *Source:* [17].

Modes of station	Number of users in the main elements		
	Arrivals	Departures	Total per hour
Train station	13,160	13,160	26,320
metro station	1026	1026	2052
Train& metro station	28,372		

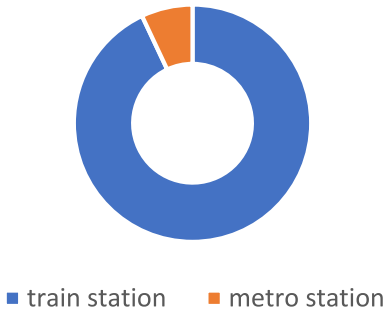

Fig. 3. Percentage of users. *Source:* Authors.

Table 2
Area of zones in Ramses intermodal station. *Source:* [17].

Modes of station	Areas in the main elements			
	Waiting hall	Ticket area	platforms	Services &shops
Train station	3000 m^2	1500 m^2	10500 m^2	15000 m^2
Metro station	2000 m^2		3360 m^2	1500 m^2

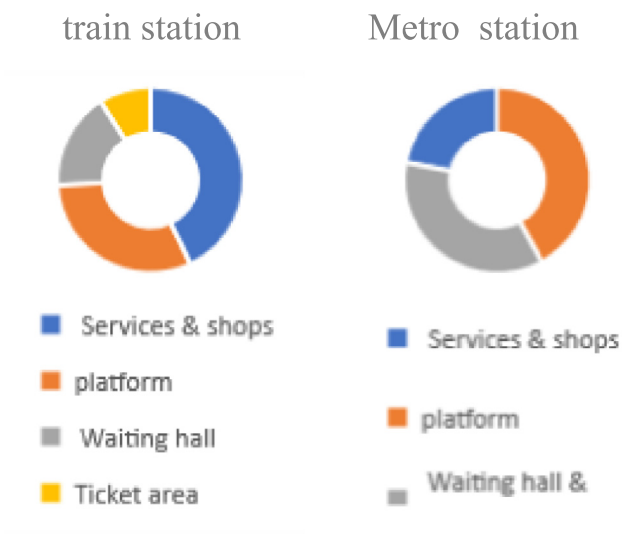

Fig. 4. Percentage of users in Ramses intermodal station. *Source:* Authors.

0.50 m^2, while the per capita in the metro station ranges between 2,40 m^2 to 3.30 m^2, and the average per capita in the metro station is 2.85 m^2, while the per capita inside Ramses intermodal station is 1.68 m^2. As shown in Table 4.

3.1.6. Density in Ramses intermodal station

The density of the main elements in Ramses intermodal station increases according to economic and social changes, and the population increase. From that, the density for the main elements in the train station ranges from 3 persons\ m^2 to 0.04 persons\ m^2, while the density in the metro station ranges between 0.4 persons\ m^2 to 0.3 persons\ m^2. As shown in Table 5.

3.1.7. Delaying in times in Ramses intermodal station

The pedestrian delay is based on measuring the total time during, which a person stops moving during the period of his transition from one point to another. This is measured mathematically through (Delay = Observation Time – Expected Time). While the expected time is calculated by (Expected time = Distance / Standard Speed). As shown in Table 6.

Note that the average standard speed equals 1.5 m/s.

The Delaying in times for the different spaces in the train station ranges from 13 s to 80 s, and the largest percentage of delays in times represents in the platforms, while the delay in times in metro station ranges from 34 s to 70 s, and the largest percentage of delays in times represents in (waiting hall & ticket area). As shown in Fig. 5.

3.1.8. Problems in circulation requirement in Ramses intermodal station

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

- Unavailability of Spatial organization of spaces.
- Circulating the main entrances to serve both arrivals, departures, and employees.
- No Separation of pedestrians between arrivals and departures.
- Unavailability of waiting places for arrivals and departures in the train station.
- No separation between ticket halls and waiting halls in the metro station.
- The shops are separated from the public movement in the train station.
- The presence of seating areas and stores on the platform obstructs pedestrian mobility in the train station.
- All types of station users' pathways intersect.
- Average per capita inside the train station is 0.50 m^2, the metro station is 2.85 m^2, while the per capita inside Ramses intermodal station is 1.68 m^2.
- Density in the train station ranges from 3 persons\ m to 0.04 persons\ m, while the density in the metro station ranges between 0.4 persons\ m to 0.3 persons \ m.
- The delaying in times for the different spaces in the train station ranges from 13 s to 80 s, while the delaying in times in metro station ranges from 34 s to 70 s.

3.2. Case study 2: Adly Mansour transport center hub

The station is situated on 30 feddans of land. The station's service switches between five different modes of transportation. The station features a private automobile parking facility with 260 car capacity and 4.5 feddans of space. There is a VIP parking area in front of the Adly Mansour train station, with space for 100 vehicles across 1.5 feddans [19]. The station contains green spaces, eight feddans of pathways, 500-meter-long tunnels, and passageways that connect the various parts of the station. On 6.5 feddans of space, including a basement, the station also has a commercial mall that serves the neighborhood around it [20].

From that, the station was chosen according to certain criteria based on the following.

Table 3
Spatial distribution of users in Ramses intermodal station. *Source:* Authors.

Modes of station	(Number of users \ hour) the main elements			
	Waiting Hall	Ticket	platforms	Services& shops
Train station	8333	4167	13,160	660
Metro station		1026	1026	–

Table 4
Rate per capita in the main elements, **Source**: Authors.

Modes of station	Per capita	Rate per capita in the main elements			
		Waiting hall	Ticket office	platforms	Services & shops
Train station	Per capita in main elements	0.36 m^2	0.36 m^2	0.79 m^2	–
	Average per capita	0.50 m^2			
Metro station	Per capita in main elements	2.4 m^2		3.3 m^2	–
	Average per capita	2.85 m^2			
Train& metro station		1.68 m^2			

Table 5
Density in the main elements. *Source:* Authors.

	Density in the main elements			
	Waiting hall	Ticket office	platform	Services & shops
Train station Density (persons\ m^2)	3 persons\ m^2	3 persons\ m^2	2 persons\ m^2	0.04 persons\ m^2
Metro station Density (persons\ m^2)	0.4 persons\ m^2		0.3 persons\ m^2	–

Table 6
Delaying in times in Ramses intermodal station. *Source:* Authors.

Modes of station	Time	Delay in the main elements			
		Waiting hall	Ticket area	platforms	Services &shops
Train station	Expected Time	400 s	360 s	1800 s	72 s
	Observation Time	440 s	380 s	1880	84 s
	Delay in times	40 s	20 s	80 s	13 s
Metro station	Expected Time	280 s		80 s	146 s
	Observation Time	350 s		120 s	180 s
	Delay in times	70 s		68 s	34 s

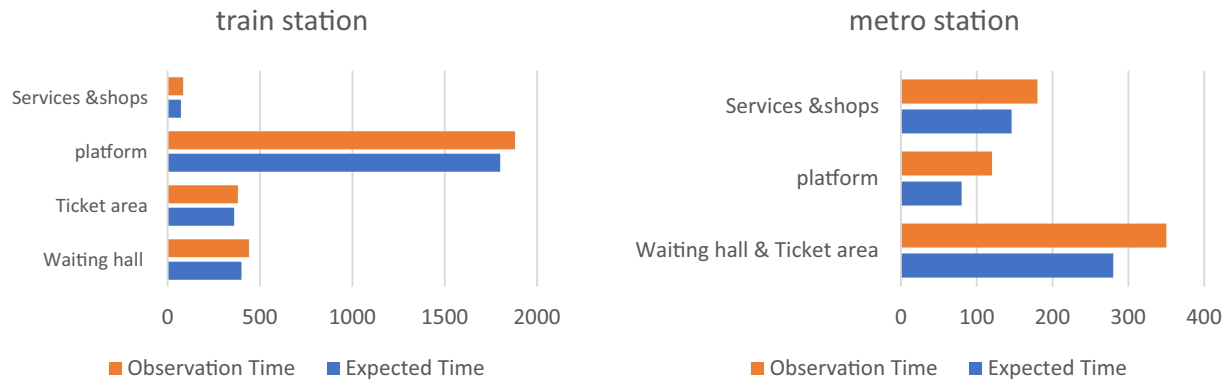

Fig. 5. Percentage of users in Ramses intermodal station. *Source:* Authors.

- Adly Mansour terminal is a transportation hub with a variety of modes of transportation. At this main central station, travelers can switch to a different mode of transportation.
- Adly Mansour station is one of the main hubs that connect the republic's cities and governorates to the New Administrative Capital.
- The station includes a full-service transportation complex and a commercial investment area on an area of 15 acres.
- Adly Mansour station connects the network of five different modes of transportation nationwide, represented by the third metro line, the LRT, the train station, and a SuperJet station, in addition to the BRT express bus and the frequency bus [21].

3.2.1. Circulation requirements in Adly Mansour transport center hub

Adly Mansour Station has many pedestrians circulation requirements, which are represented in [15].

- Connecting different types of transportation in one place and providing spaces for movement between different modes.
- Spatial organization of spaces to reduce intersections for passengers and reduce movement paths and decision points.
- The Station's design allows for free-flowing passenger movement to avoid severe congestion within the Station, particularly on platforms and escalators.
- Using technology reduces the amount of time people must wait in line to buy tickets.
- The separation between entrances and exits in LRT stations and metro stations, while the separation is not done in other modes.
- The separation between the arrival and departure halls in LRT station, while other modes are not separated.
- Separation of automobile and pedestrian circulation.
- Separation of pedestrians between arrivals and departures.

- Providing private entrances, paths, and services for employees and operators in the station.
- Providing sufficient space for movement and waiting between modes.
- Providing horizontal and vertical movement taking into consideration disabled persons.
- Paths straightforward as possible.
- Usage of signs and guideboards of various levels.
- Dividing the platform cross-section at the LRT and metro station is not done at the railway station.

3.2.2. Categories and numbers of users in Adly Mansour hub station

The number of users was determined by the average number of passengers at peak hours [16,17].

As shown in Table 7.

The number of users in metro station represents about 57 % of the total users, followed by LRT station users representing about 35 %. Then the Train station represents about 5 %, while the Superjet station achieved the least, which represents about 3 %. As shown in Fig. 6.

3.2.3. Area of zones in Adly Mansour hub station

The following table shows the areas of the different zones in the Adly Mansour hub station [16,17]. As shown in Table 8.

The area of zones in the **train station** showed that there is a discrepancy in area, with (services &shops) having the largest area among all the other zones followed by the platforms, and then the ticket area while the waiting hall achieved the least. On the other hand, the **LRT station** showed that platforms had the largest area among all the other zones followed by the waiting hall, and then the services &shops while the ticket area achieved the least. Meanwhile, the **metro station** showed that the (waiting hall &ticket area) had the largest area among all the other zones followed by the platforms area, and the (services &shops) achieved the least. However **Superjet station** showed that (the waiting hall &ticket area) had the largest area, and the (services &shops) achieved the least. As shown in Fig. 7.

Table 7
Categories and numbers of users in Adly Mansour hub station. *Source:* [17].

Modes of station	Number of users in peak hour at Adly Mansour station		
	Arrivals	Departures	Total in peak hour
Train station	1000	1000	2000
LRT Station	8086	6690	14,776
Metro station	12,000	12,000	24,000
Superjet station	500	500	1000
total	21,586	20,190	41,776

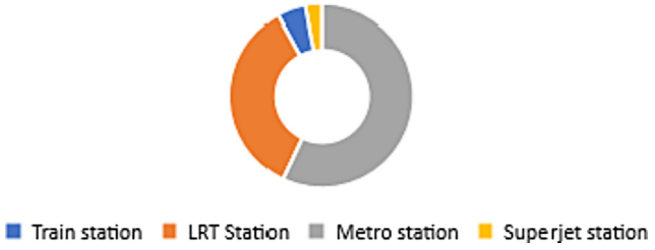

Fig. 6. Percentage of users. *Source:* Authors.

3.2.4. Spatial distribution of users in Adly Mansour hub station

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

3.2.5. Rate per capita in Adly Mansour hub station

With the increase in the number of users in the Adly Mansour hub station, the per capita share decreases. From that, the per capita for the main elements in the **train station** ranges from 0.48 m^2 to 8.57 m^2, and the average per capita inside the train station is 3.39 m^2, while the per capita in the **LRT station** ranges between 0.10 m^2 to 0.36 m^2, and the average per capita in the LRT station is 0.27 m^2, while the per capita in the **metro station** ranges between 0.10 m2 and 0.36 m2, and the average per capita in the metro station is 0.20 m^2, while the per capita in the **Superjet station** ranges between 0.81 m^2 to 1.84 m^2, and the average per capita in the Superjet station is 1.825 m^2, while the per capita inside Adly Mansour hub station is 1.50 m^2. As shown in Table 10.

From that, the LRT station and metro station achieved the least rate per capita in Adly Mansour hub station.

3.2.6. Density in Adly Mansour hub station

The density of the main elements in Adly Mansour hub station increases according to economic, and social changes and the population increase. From that the density for the main elements in the **train station** ranges from 1 person \ m^2 to 2 persons\ m^2, while the density in the **LRT station** ranges between 3 person\ m^2 to 15 persons\ m^2, while the density in the **metro station** ranges between 3 persons\ m^2 to 17 persons\ m^2, while the density in the **Superjet station** ranges 1 person\ m^2. As shown in Table 11.

3.2.7. Delaying in times in Adly Mansour hub station

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

3.2.8. Problems in circulation requirement in Adly Mansour hub station

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

- The intersection of pedestrian and car traffic, and the pedestrian tunnel is far from the metro exit.
- Long distances to move from LRT to any other modes.
- Long distances to get from the train station to any other mode.

Table 8
Area of zones in Adly Mansour hub station. *Source:* [17].

Modes of station	Areas in the main elements			
	Waiting hall	Ticket area	platform	Services &shops
Train station	250 m^2	260 m^2	3630 m^2	15000 m^2
LRT Station	870 m^2	120 m^2	1650 m^2	350 m^2
Metro station	1800 m^2		1760 m^2	410 m^2
Superjet station	305 m^2		–	230 m^2

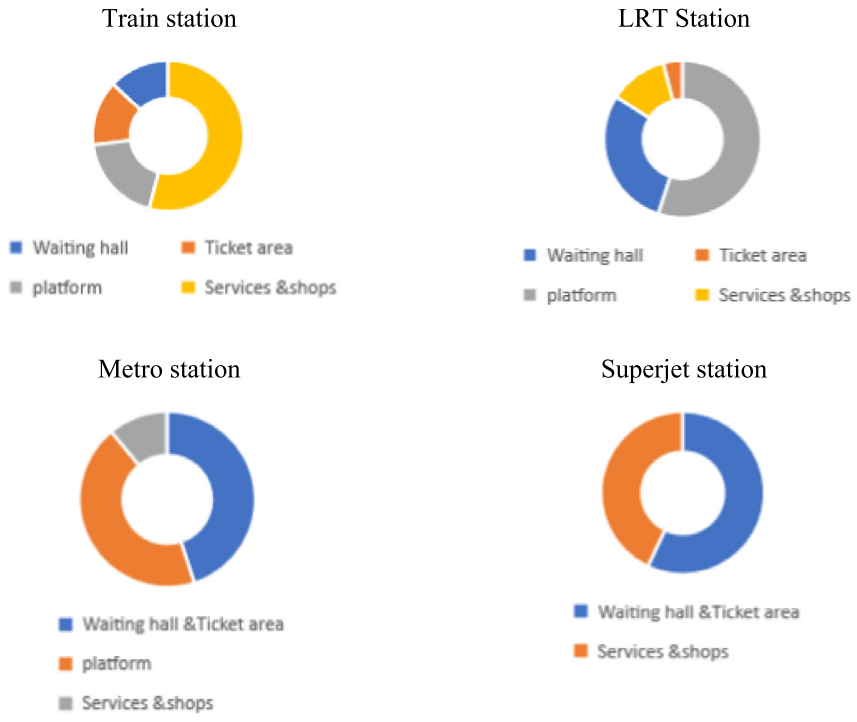

Fig. 7. Percentage of users in Adly Mansour hub station. *Source:* Authors.

Table 9
Spatial distribution of users in Adly Mansour hub station. *Source:* Authors.

Modes of station	(Number of users \ hour) in the main elements			
	Waiting hall	Ticket	platforms	Services& shops
The train station	520	305	1000	175
LRT Station	2420	335	6690	5331
Metro station	5000		12,000	7000
Superjet station	375		500	125

Table 10
Rate per capita in different spaces. *Source:* Authors.

Modes of station	Main Elements	rate per capita in the main elements			
		Waiting hall	Ticket office	platform	Services & shops
Train station	Per capita in spaces	0.48 m^2	0.88 m^2	3.63 m^2	8.57 m^2
	Average per capita	3.39 m^2			
LRT Station	Per capita in spaces	0.36 m^2	0.36 m^2	0.25 m^2	0.10 m^2
	Average per capita	0.27 m^2			
Metro station	Per capita in spaces	0.36 m^2		0.15 m^2	0.10 m^2
	Average per capita	0.20 m^2			
Superjet station	Per capita in spaces	0.81 m^2		–	1.84 m^2
	Average per capita	1.825 m^2			
Train& metro station		1.50 m^2			

- Long distances to move from any mode to the SuperJet station.
- Long walks underground.
- Long distances to move from any mode to shops.
- The waiting room and tickets at the SuperJet station are very small.
- The ticket halls for the LRT are very small.
- The departure halls of LRT are exceptionally large.
- The cross-section of some parts of the train platforms does not exceed 2 m.

- Average per capita inside the train station is 3.39 m^2, the LRT station is 0.27 m^2, the metro station is 0.20 m^2, the Superjet station is 1.825 m^2, while the per capita inside the Adly Mansour hub station is 1.50 m^2
- Density in train station ranges from 1 person \ m^2 to 2 persons\ m^2, LRT station ranges between 3 persons\ m^2 to 15 persons\ m^2, metro station ranges between 3 persons\ m^2 to 17 persons\ m^2, while Superjet station ranges 1 person\ m^2.

Table 11
Density in different spaces. *Source:* Authors.

Modes of station	Density (person\ m) in the main elements			
	Waiting hall	Ticket office	platform	Services & shops
Train station	2 persons\ m^2	1 person \ m^2	1 person \ m^2	1 person\ m^2
LRT Station	3 persons\ m^2	3 persons\ m^2	4 persons\ m^2	15 persons\ m^2
Metro station	3 persons\ m^2		7 persons\ m^2	17 persons\ m^2
Superjet station	1 person \ m^2		–	1 person\ m^2

4. Findings

By studying the pedestrian circulation requirements in international studies, studying, and analyzing the pedestrian circulation requirements in Egyptian case studies (Ramses station, and Adly Mansour station). We can compare between circulation requirements of multi-modal hub stations in Egypt and International experiences, determine the common design requirements, and the individual requirements for each. As shown in Table 12.

The requirements for pedestrian circulation in Egyptian case studies (Ramses station, and Adly Mansour station) share with international experiences in some requirements. However, some of the design requirements needed to efficiently the stations design was overlooked, from that, some common circulation requirements between Egyptian and international experience, which presented in.

- Providing connectivity and integration between different transportation systems to provide convenience for users.
- Create a clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation (entry-tick ets-waiting-departure).
- The Station's design must allow for free-flowing passenger movement to avoid severe congestion within the Station, particularly on platforms and escalators.
- Minimizing cross flows and overlapping passenger circulation to avoid obstacles in circulation.
- Provide horizontal and vertical movement taking into consideration disabled persons.
- Separation of automobile and pedestrian circulation.
- Separation of pedestrians between arrivals and departures.
- Reducing walking distances.
- Paths should be as straightforward as possible.
- Provide an exit and entrance for station staff.
- Separation of the passenger's circulations from the station staff.
- Usage of signs and guideboards of various levels.
- Platforms are designed to accommodate the maximum capacity of passengers.
- The optimal design of the cross-section of the platform in the station (parts that are forbidden to wait - movement area - waiting area).
- The average per capita share inside the stations is 1.5 m^2 regarding the movement paths.

From that, the authors suggest design guidelines for pedestrian circulation requirements of multi-modal hub stations in Egypt. As shown in Table 13.

There are many design requirements necessary to achieve the efficient performance of stations in general, and pedestrian circulation paths in particular. Which are Circulation and Space Planning, and Accessibility, while Accessibility is divided into two axes the

Table 12
Compare between circulation requirements of multi-modal hub stations in Egypt and International Experiences. *Source:* Authors.

International circulation requirements	Egyptian case studies					
	Ramses		Adly Mansour			
	train	metro	train	LRT	metro	Superjet
(1) Providing connectivity and integration between different transportation systems to provide convenience for users.			✓	✓	✓	
(2) Create a clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation (entry-tickets-waiting-departure).			✓	✓	✓	
(3) Design various spaces to accommodate the maximum capacity of the passengers						
(4) Providing information centers and services necessary for the convenience of passengers inside the main halls and ticket halls						
(5) Using technology that reduces the amount of time people must wait in line to buy tickets.						
(6) The station's design must allow for free-flowing passenger movement to avoid severe congestion within the Station, particularly on platforms and escalators.				✓		✓
(7) Minimizing cross flows and overlapping passenger circulation to avoid obstacles in circulation.				✓		
(8) Provide horizontal and vertical movement taking into consideration disabled persons.		✓	✓	✓	✓	✓
(9) Separation of automobile and pedestrian circulation.	✓	✓	✓	✓	✓	
(10) Separation of pedestrians between arrivals and departures.				✓		
(11) Reducing walking distances.	✓	✓	✓	✓	✓	
(12) Paths should be as straightforward as possible.	✓	✓	✓	✓	✓	✓
(13) Determining separate areas for the movement of baggage in the case of arrival from the train to the reception or vice versa.						
(14) Allocating places for waiting for passengers for long periods as well as short periods.						
(15) Provide an exit and entrance for station staff.			✓	✓	✓	
(16) Separation of the passenger's circulations from the station staff.		✓	✓	✓	✓	
(17) Usage of signs and guideboards of various levels.	✓	✓	✓	✓	✓	✓
(18) Platforms are designed to accommodate the maximum capacity of passengers.				✓	✓	✓
(19) The optimal design of the cross-section of the platform in the station (parts that are forbidden to wait - movement area - waiting area).				✓	✓	
(20) The average per capita share inside the stations is 1.5 m^2 regarding the movement paths.			✓	✓		✓
	✓	Verified		Unverified		

Table 13
Guidelines for pedestrian circulation requirements. *Source:* Authors.

		Guidelines for pedestrian circulation requirements of multi-modal hub stations in Egypt
Circulation and Space Planning		• Connectivity and integration between different transportation systems to provide convenience for users. • Spatial organization of spaces to reduce intersections for passengers and reduce movement paths and decision points. • The station's design must allow for free-flowing passenger movement to avoid severe congestion within the Station, particularly on platforms and escalators. • Design various spaces to accommodate the maximum capacity of the passengers. • Usage technology that reduces the amount of time people must wait in line to buy tickets. • Information centers and services necessary for the convenience of passengers inside the main halls and ticket halls.
Accessibility	The separation between	• Entrances and exits. • Arrivals and departures. • The arrival and departure halls. • Exit, entrance for station staff, and pedestrian circulation. • Pedestrian circulations and station staff. • Pedestrian circulations and the movement of baggage. • Places for waiting for passengers for long periods as well as short periods. • Automobile and pedestrian circulation.
	Providing	• A clear, logical, and sequential spatial structure for the station that corresponds to the order of the passenger's activities and supports effective passenger circulation (entry-tickets-waiting-departure). • Space for movement and waiting. • Horizontal and vertical movement taking into consideration disabled persons. • Signs and guide boards of various levels. • Straightforward path as possible. • Reducing walking distances. • Escape paths separate from pedestrian, staff, and operator paths.

first axis is the separation between (Arrivals and departures - Pedestrian and station staff – Exit and entrance…. Etc.), while the second axis interested in Providing more spaces and elements.

5. Conclusion

The aim of this paper is mainly to suggest the design guidelines for pedestrian circulation requirements in multi-modal hub stations in Egypt. The Authors were able to partially fulfill this aim by analyzing and evaluating the pedestrian circulation requirements in Egyptian case studies (Ramses station, and Adly Mansour station). as follows.

- Define the pedestrian circulation requirements, guidelines, and Factors affecting pedestrian circulation.
- Determine the pedestrian circulation requirements, analyzing, evaluating, and define the problems in Egyptian case studies (Ramses station, and Adly Mansour station).
- The result of the paper is determining the similarities in the design requirements of Egyptian case studies (Ramses station, and Adly Mansour station), and international experiences. From that, the author suggests design guidelines for pedestrian circulation requirements of multi-modal hub stations in Egypt.
- This paper recommends finding a framework for the design aspects of multi-modal hub stations.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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