Analysis of the Pedestrian Infrastructure and Pedestrian Volume at Setiawangsa LRT Station

Nik Nurul 'Aziemah NIK OTHMAN[a], Abdul Azeez KADAR HAMSA[b]

[a,b]*Previously at the Department of Urban and Regional Planning, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia, 50728 Kuala Lumpur, Malaysia*
[b]*E-mail: abdazeezkh@gmail.com*

Abstract: The success of TOD depends on how effectively pedestrian network or link between transit station and surrounding land uses is provided. This paper examines the existing pedestrian facilities near the selected LRT station. Pedestrian infrastructure inventory survey and pedestrian volume survey were administered to collect pedestrian facilities and the movement of pedestrians to and from the station respectively. Seven observation points near the selected station were chosen to collect pedestrian volumes to and from the station. The major findings show that the provision of pedestrian facilities has influenced the movement of pedestrians to and from the station. The pedestrian corridor with all the necessary pedestrian facilities connecting the station and adjoining land uses has increased the pedestrian volume along that corridor. On the other hand, pedestrian corridors with the lack of pedestrian facilities decrease the movement of pedestrians to and from the LRT station.

Keywords: Pedestrian Infrastructure, Pedestrian Volume, Pedestrian Flow, LRT Station, Transit-Oriented Development (TOD).

1. INTRODUCTION

The effective design and presence of pedestrian infrastructure near transit stations is highly necessary to increase the use of public transit. It allows pedestrians to access the transit stations with ease, comfortably and safely. Walking connects different modes of transport and acts as the main feeder for public transport Ulrike Jehle et.al., (2022). Pedestrian infrastructures are the critical part of the sustainable transportation system of a city across the world Reta and Denbi (2022). The key risks to pedestrians are well documented, including infrastructure in terms of the lack of dedicated pedestrian facilities such as sidewalks, crossings, and raised medians Reta and Denbi (2022). The pedestrian facilities near the transit stations are one of the major requirements to promote transit-oriented development where it helps to increase the use of public transit whether road-based or rail-based. Adequate pedestrian infrastructure near public transport stops is crucial to foster public transport usage Ulrike Jehle *et.al.,* (2022). It is due to the necessity to walk to the station from the land uses. This paper addresses the relationship between the design of pedestrian infrastructure and pedestrian movement near and at a rail-transit station. Many studies including Ewing and Cervero (2001); Handy (1996); Frank, Engelke and Schmid (2003); Allan B. Jacobs; Garrett (2011) and Krizek (2003) have all discussed about the importance of pedestrian infrastructure design. The aim of this paper is to understand the existing pedestrian infrastructure, pedestrian volume at an LRT station and how they are related with each other for the potential use of rail-based public transportation systems. In this context, it is believed that this research on the provision of pedestrian infrastructure at Setiawangsa station and the pedestrian movements to and from the station would be useful to plan better pedestrian infrastructure connecting the station to the surrounding land uses, thereby, improving the security and comfort for the pedestrians including disabled users. The objectives of this research are 1) to examine the existing pedestrian infrastructure at and near the selected LRT station; 2) to analyze the flow of pedestrian movements between Setiawangsa LRT station and surrounding land uses; 3) to relate pedestrian infrastructure with pedestrian volume to understand the existing accessibility of the pedestrians to and from the LRT station; and 4) to provide recommendations for the improvement of pedestrian infrastructure for better accessibility to the station to increase the use of public transit.

2. LITERATURE REVIEW

Pedestrian environment is a critical element of the urban experience and exposure. Allan Jacobs (1995) explained the importance of pedestrian facilities. "It's on foot that you see people's faces and that you meet and experience them. That is how public socializing and community enjoyment in daily life can most easily occur. And it's on foot that one can be most intimately involved with the urban environment: with stores, houses, the natural environment, and with people." (Jacobs, 1995).

Garrett (2011) claimed that pedestrian infrastructure can be used for some activities such as for transportation, recreation, and fitness. The examples of pedestrian infrastructure are sidewalks, bike lanes, trails and others. There are many benefits provided by such infrastructure for the users; the types of benefits include economic and non-economic. The economic benefits are that they increase revenues and job opportunities for local businesses while the non-economic benefits include reducing traffic congestion and air pollution, as well as providing safe travel routes and a healthy environment. Good design and well-connected pedestrian infrastructure also leads to higher use of public transport. In Korea, almost 93% of access to public transportation was by walking (Ministry of Land, Infrastructure and Transport, 2024; Dalbyul Lee, 2025).

2.1. Pedestrian Infrastructure Design

There are many elements of pedestrian infrastructure. Each of these infrastructures should be adequately provided, properly functional and meet the needs of pedestrians, including physically challenged. There are a few factors to be considered in providing walkways or sidewalks, which are the availability of space within the right-of-way, the existing physical limitations at the roadside and the connectivity between the origin and destinations. Sidewalks that are separated from the roadway are preferred for pedestrians, and higher concentrations of pedestrians should be supported with the wider sidewalks or walkways width. Sidewalks provide many benefits including safety, mobility, and healthy communities. Roadways without sidewalks are likely to have as many as twice pedestrian crashes as roadways with sidewalks on both sides of the street. Table 1 shows the pedestrian infrastructure guideline:

Table 1. Pedestrian infrastructure guideline

Element	Guideline	
Walkways and sidewalks	Width	Not less than 1.5m
	Features	- Separated from vehicle - Continuous pathway - Good and direct connection between activity
	Surface	Hard, smooth, stable, non-slip material
Crosswalks	Zebra crossing	- Located at appropriate places - The stripping should be maintained and obviously visible from a distance - Installation of signage, clear obstruction and highly visible - Free from uneven level and tripping hazard
Street Furniture and Amenities	Features	- Installed at possible location along the route section - Sufficient - Well-maintained
Roof and Shades	Features	- Tress shaded shall be maintained - Installation of roof, shades or other types of shelter at the place where trees are not suitable to be planted

Source: Best practices of pedestrian infrastructure

2.2. Characteristics of Pedestrian Infrastructure

It takes several important qualities to describe a walkable community. Many ways are used to classify these, but all attempts to describe the same characteristics. The intent is for the street design to incorporate the elements that enhance the safety, security, comfort and mobility of the pedestrians. The nine primary characteristics shown in Table 2 are considered to provide a convenient description of a truly walkable community.

It is important to note that multiple factors such as convenience, safety, accessibility, service cost, flexibility and the quality of pedestrian pathways shape individual's propensity to walk (Wealthy Tsembile Maseko et.al., 2024).

2.3. Studies on Pedestrian Infrastructure

Pedestrian infrastructure is crucial to ensure the safety and mobility of pedestrians (Maria Alejandra Saltarin-Molino et.al., 2023; Guzman et.al., 2022; Saxena and Yadav, 2023). According to Karsch *et al*. (2012), few studies have investigated the U.S. pedestrian travel patterns and characteristics. While everyone can be considered a pedestrian, pedestrian trips are generally short and are often combined with other travel modes (Schwartz, 2000). For example, a study in Washington State showed that pedestrian volumes, as measured by the number of pedestrians observed on hourly basis, differed significantly between urban and suburban areas. All urban locations have a higher number of pedestrians per hour and per 1,000 residents. Urban locations have higher pedestrian volumes per 500-acre basis when compared to suburban areas (Moudon, Hess, Snyder, & Stanilov, 1997).

In a similar study of pedestrian travel behavior, O'Sullivan and Morrall (1996) showed that the average walking distance to bus stops in Calgary, Canada was 0.2 miles; walking distances to light rail transit (LRT) stations were slightly longer, at an average of 0.4 miles, with shorter walking distances to LRT stations in the central business district (O'Sullivan & Morrall, 1996).

Moreover, street design, location of services and facilities have been shown to influence pedestrian travel behavior. Shriver (1997) had compared pedestrians who traveled in "traditional" neighborhoods characterized by streets in a rectangular grid, short blocks, and numerous intersections to "modern" neighborhoods with irregular street designs and a hierarchical layout that discouraged vehicle traffic on residential streets. Karsch et al. (2012) also stated in their study that a variety of methods can be used to increase pedestrian conspicuity, including better vehicle headlights, better roadway lighting, and various environmental measures to improve sight distances and warn pedestrian crossings. Study also showed that higher level of pedestrian facilities, walking environment, and pedestrian safety increases the use of public transport (Dalbyul Lee, 2025).

Table 2. Characteristics of pedestrian infrastructure

Characteristics	Definition
Connected	The paths are connected well to both public transport and to the surrounding networks
Legible	Walking networks are clearly signposted and published in local maps and the users intuitively sense how to use the facilities
Comfortable	The routes unpolluted by excessive noise and fumes and the facilities provided should give comfort to every user so that all the facilities provided are fully utilized
Convenient	Routes are continuous, efficient, unimpeded by obstacles, and not delayed by other path users and road traffic
Pleasant	The pedestrian spaces are enjoyable, interesting, quiet and clean with qualities encouraging lingering and social interaction
Safe	Road crossing places and driveway crossings are safe from traffic danger and all surfaces provide a good grip when wet and provide even surfaces free from trip hazards
Secure	The walking environment discourages antisocial and criminal behavior due to the application of the principles of crime prevention through environmental design
Universal	Facilities are suitable for mobility and vision-impaired pedestrians through gentle gradients, visual contrast, audible and tactile features
Accessible	The facilities are easy access for the users located within an easy walking distance

Source: Principles of Network Planning (NZ Transport Agency)

3. BACKGROUND OF SETIAWANGSA LRT STATION

The location of Setiawangsa LRT station is under the jurisdiction of Ampang Jaya Municipal Council (MPAJ). MPAJ consists of 4 Planning Blocks (BP). Setiawangsa station is located under BP 2 which is BP2.5 Setiawangsa LRT Station (KJ5) is a rapid transit station which is located at the north of Kuala Lumpur, Malaysia. It is a part of the Kelana Jaya Line, which is formerly known as the PUTRA Line. The station was opened on June 1, 1999, as part of the second segment encompassing 12 stations, including Masjid Jamek station and Terminal PUTRA (not including Sri Rampai station) and an underground passage. Setiawangsa station is owned by Syarikat Prasarana Negara from 2002 until now and is operated under RapidKL. The preceding station to

Setiawangsa station is Sri Rampai station, while Jelatek station is the station after Setiawangsa as shown in Figure 1.

Setiawangsa LRT station is situated in north of Kuala Lumpur along Jalan Jelatek, the borders of the hilly areas of Semarak on the west and a housing scheme officially known as AU1 which is also known as Taman Keramat Permai to the east. Furthermore, the station is also located on the border between Kuala Lumpur city limits and Ampang Jaya city limits in Selangor. The station takes its name from Taman Setiawangsa, which is a large housing scheme located just northeast of Jalan Jelatek. This station serves the localities of AU1, Semarak and Taman Setiawangsa. This LRT station was selected due to the combination of high population density and mixed land use near the station which would eventually increase the ridership patronage at the station. The population density of the Setiawangsa was close to 9200 people per square km in 2020. It was observed that most of the users of the Setiawangsa LRT station were high school, university students and working age populations.

Figure 1. Kelana Jaya line

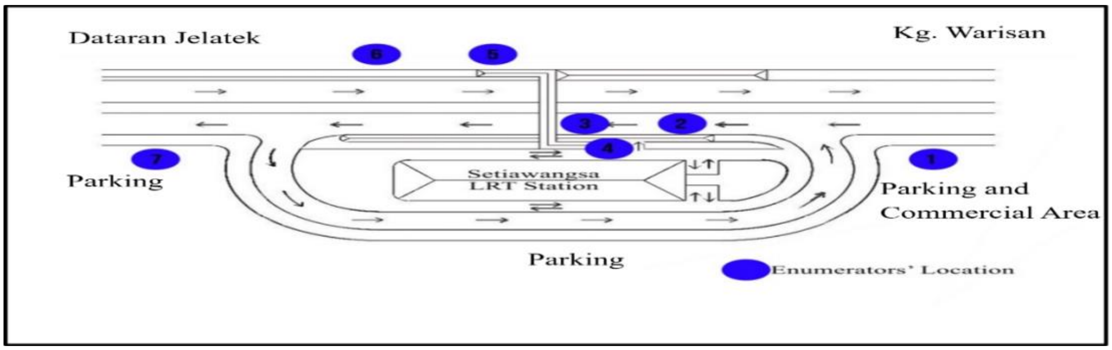
4. METHODOLOGY

4.1 Pedestrian Infrastructure Inventory Survey

A pedestrian infrastructure inventory survey was administered to collect data on pedestrian infrastructure near and at the selected LRT station. The elements of pedestrian infrastructure that were collected include walkways and sidewalks (width, features and surface); crosswalk (zebra crossing and overbridge crossing); street furniture and amenities (benches, lighting and signages) and roof and shades (rooftops walkways). This data was collected by observing each of these elements near and at the Setiawangsa LRT station. The location of each of these elements of pedestrian infrastructure was identified by a map. Photos showing the conditions of each element of pedestrian infrastructure were also taken during the field inventory survey.

4.2 Pedestrian Volume Survey

Seven enumerators were positioned at various locations near the LRT station to count the number of pedestrians entering and leaving the Setiawangsa LRT station. Figure 2 shows the position of enumerators at and near the selected LRT station and the surrounding activities around the LRT station. The pedestrian survey was administered at the selected LRT station during peak hours to examine the maximum flow of pedestrian movements in and out of the station. The pedestrian volume at each of the selected positions near the station was counted by using traffic counters. This survey was conducted on one of the weekdays starting from 4.00 p.m. to 7.00 p.m. at every 15-minute interval. The pedestrian volume survey was conducted during evening peak hours because of relatively high pedestrian movements at this hour where the users of LRT were generally seen commuting for different trip purposes.



Source: Fieldwork Survey, 2015

Figure 2. Enumerators' location

4.3. Pedestrian Level of Service (LOS)

The pedestrian level of service near the selected LRT station was also analysed. The data needed to analyze the LOS were area of the pedestrian walkways and pedestrian volume. To analyze the LOS, the confined area of the pedestrian walkways was measured by using a measuring tape. For example, the total pedestrian along both directions during 15-minute time interval is divided by the area of the walkways to determine the pedestrian LOS at each selected point.

$$\text{LOS} = \frac{\text{Pedestrian Volume}}{\text{Pedestrian Walkway Space}}$$

5. ANALYSIS AND FINDINGS

5.1 Pedestrian Infrastructure Design

5.1.1. Width of walkways and sidewalks

The surrounding areas of the Setiawangsa LRT station were provided with pedestrian walkways where pedestrians can move with ease without worrying about potential conflicts with any moving vehicles. The pedestrian walkways were connected between surrounding areas and the LRT station. The findings on the width of pedestrian walkways are illustrated in Table 3.

Table 3. Width of pedestrian infrastructure

Characteristics	Findings		
Width	Less than 1.5m  Walkways located at Point 1	1.6 meters  Walkways are located at Point 2 and 3	2.2meters  Walkways is located at Point 4 which is a pedestrian bridge
	3.6 meters  Walkways is located at Point 5	1.7 meters  Walkways located at Point 6	2.1 meters  Walkways located at Point 7

5.1.2. Features of pedestrian walkways and sidewalks

Pedestrian walkways were observed to be continuous and directly connected to its surrounding land uses. Table 4 shows the details of the features of the pedestrian walkways at Setiawangsa LRT station.

Table 4. Features of pedestrian walkways and sidewalks

<table>
<tr><td>Characteristics</td><td colspan="6">Findings</td></tr>
<tr><td rowspan="4">Features</td><td colspan="6">Continuous Pathway</td></tr>
<tr><td colspan="2">
Walkways at Point 1 connecting the pedestrians to the parking area at the other side of the road.</td><td colspan="2">
Walkways at Point 3 is continuous to the entrance of Setiawangsa LRT station.</td><td colspan="2">
The walkway at Point 5 connects pedestrian to residential area, Kg. Warisan.</td></tr>
<tr><td colspan="6">Direct connection between activity</td></tr>
<tr><td colspan="3">
Walkways at Point 2, Point 3 and Point 4, provide a direct connection between activities. For example, it connects pedestrians straight to the Setiawangsa LRT station.</td><td colspan="3">
Walkways at Point 1 provides a direct connection to the commercial area. Unfortunately, there were many motorcycles parked along the pedestrian walkways.</td></tr>
</table>

Source: Fieldwork Survey, 2015

5.1.3. Surface of pedestrian walkways and sidewalks

Table 5 shows the surface conditions of the pedestrian walkways at and near Setiawangsa LRT station. The surface conditions of pedestrian walkways were hard, smooth, stable and it is also paved with non-slippery material.

Table 5. Surface conditions of pedestrian walkways and sidewalks

Characteristics	Findings		
	Hard, smooth, stable, non-slip material		
Surface Conditions	 Walkways at Point 1 provided with a non-slippery material which is known as interlocking pavers.	 Point 2 and Point 3 were also provided with non-slippery material for the pedestrian walkways, interlocking pavers.	 Point 4, which is the pedestrian bridge was provided with tiles for its surface.
	 Pedestrian walkway at Point 5 was also provided with non-slippery material which is tar. However, there was damage to the walkways which may harm the pedestrians, especially children.	 Point 6 was provided with tiles for the surface material. During the survey, it was raining heavily which caused the tiles to be wet and made the walkways slippery for pedestrians.	 Pedestrian walkway at Point 7 was provided with non-slippery material which is also known as tar.

5.1.4. Crosswalk

Two types of crosswalks were identified namely zebra crossing and elevated pedestrian crossing. Figure 3 illustrates the details of both zebra and elevated pedestrian crossing near Setiawangsa LRT station.

Zebra crossing

A zebra crossing was provided at two locations near Setiawangsa LRT station. However, the colour of the zebra crossing was faded and as a result makes it less obvious to the pedestrians. Furthermore, only one of the zebra crossings was provided with a signage indicating its location to the drivers of the moving vehicles.

Figure 3. Zebra crossing

Elevated Pedestrian Crossing

Elevated pedestrian crossings are usually provided at locations with a high volume of traffic and heavy pedestrian crossings such as schools, shopping areas, train stations etc. for the pedestrians to cross from one side of the road to another side safely. One elevated pedestrian crossing is provided at Setiawangsa station to ease the movements of pedestrians.

Surprisingly, many pedestrians were observed not using the elevated crossing to cross from one side of the road to the other side connecting the LRT station. Instead, they were seen crossing the road at the road level without using the pedestrian elevated crossing. It was the case even with pedestrians with children. Figure 5 shows a pedestrian crossing the road at the road level instead of using a pedestrian elevated crossing.

Figure 4. Pedestrian bridge crossing

Figure 5. Pedestrian crossing the road

5.1.5 Street furniture and amenities

Three types of streets furniture and amenities were identified at and near the LRT station which are benches, lighting and signage. Figures 6 and 7 show the details of the street furniture and amenities:

Benches

Points 2 and 3 were provided with benches. However, the benches were only provided with one row and not many people were able to sit on the benches. Furthermore, there is one transit stop located at Point 5 but unfortunately there were no benches provided in that area. As can be seen in the figure 7, some people were forced to stand while waiting for the taxis and buses.

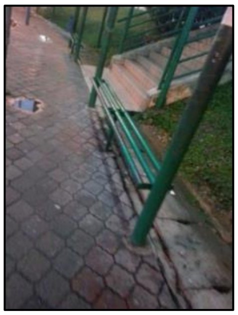


Figure 6. Benches at Point 2 and Point 3

Figure 7. Transit stop at Point 5 with no benches

Lighting

Each pedestrian walkway with roof was installed with lighting. However, some of the lighting was not functioning at the time of the survey. Lighting is important as it enhances the safety of the pedestrians at night.

Signage

There were not many directional signages provided at and near the station. The only directional signage was located before the entrance to the LRT station. Other than that, there were signages such as warning signs and no-parking signs.

5.1.6 Roof and Shades

Two types of pedestrian walkways were identified which are pedestrian walkways with roof and pedestrian walkways without roof. Most of the pedestrian walkways near Setiawangsa LRT station were provided with roofs which protect the movement of pedestrians from extreme weather conditions.

5.2 Pedestrian Volume

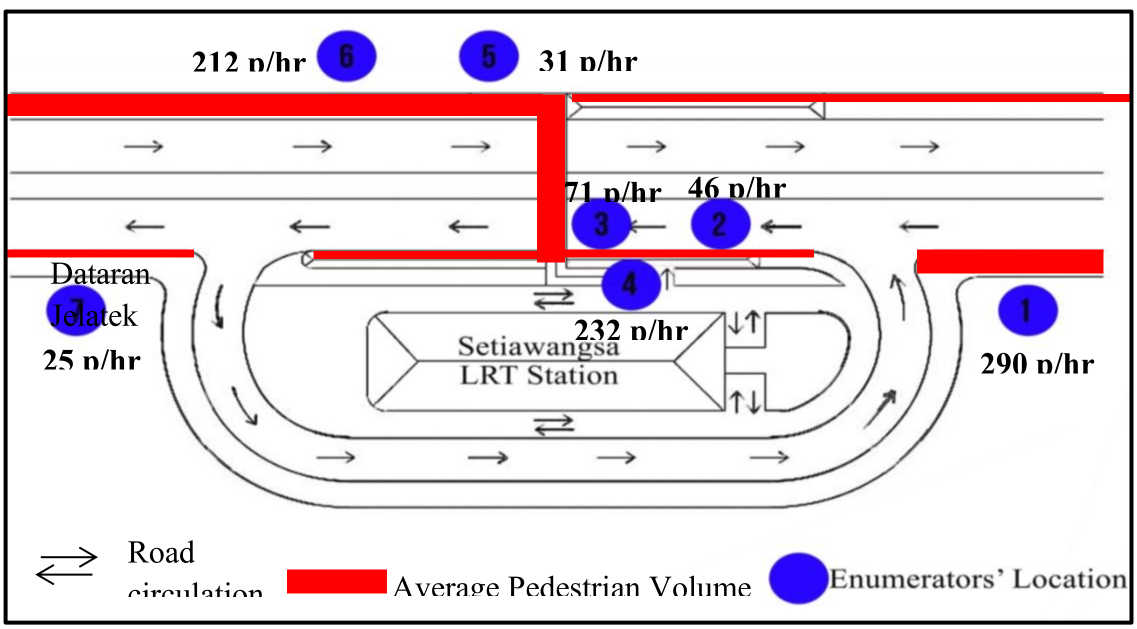
The survey on pedestrian volume was conducted to analyze the flow of pedestrian movements between Setiawangsa station and its surrounding land uses. Seven points were selected between the LRT station and its surrounding land uses for the survey. One enumerator was stationed at each of these seven points to conduct the survey. Table 6 shows pedestrian volume to LRT station from surrounding land uses and table 7 the hourly pedestrian volume between the LRT station and the surrounding land uses at each of the survey points.

Table 6. Pedestrian volume to Setiawangsa LRT station

TIME	To Setiawangsa LRT Station						
	Point 1	**Point 2**	**Point 3**	**Point 4**	**Point 5**	**Point 6**	**Point 7**
4:00 – 4:15	17	3	5	10	1	11	2
4:15 – 4:30	20	7	11	14	4	16	1
4:30 – 4:45	22	5	9	17	2	21	5
4:45 – 5:00	20	9	14	15	2	19	2
5:00 – 5:15	23	4	7	18	1	22	5
5:15 – 5:30	31	6	10	29	3	28	3
5:30 – 5:45	18	13	9	30	5	11	4
5:45 – 6:00	24	10	13	53	8	13	10
6:00 – 6:15	36	9	8	53	5	23	-
6:15 – 6:30	47	14	4	65	3	20	5
6:30 – 6:45	21	4	3	49	6	29	5
6:45 – 7:00	27	5	3	70	2	28	1
TOTAL	**306**	**89**	**96**	**423**	**42**	**241**	**43**
OVERALL	**1240**						

Table 7. Hourly Pedestrian volume from and to Setiawangsa LRT station

TIME	Hourly Pedestrian Volume from and to Setiawangsa LRT Station						
	Point 1	**Point 2**	**Point 3**	**Point 4**	**Point 5**	**Point 6**	**Point 7**
4:00 – 7:00	290	46	71	232	31	212	25



Source: Fieldwork Survey, 2015

Figure 8. Average pedestrian volume

Figure 8 shows the average pedestrian volume between LRT stations and surrounding areas at each of the selected points. The average pedestrian volume was 290 pedestrians per hour at Point

1, 232 pedestrians per hour at Point 4, 212 pedestrians per hour at Point 6, 71 pedestrians per hour at Point 3, 46 pedestrians per hour at Point 2, 31 pedestrians per hour at Point 5 and lastly 25 pedestrians per hour at Point 7.

5.3 Pedestrian Level of Service (LOS)

The pedestrian level of service was determined to identify the operating performances of the pedestrian walkways connecting LRT station and surrounding land uses. Table 8 shows the level of service for pedestrian flow rate on walkways. Thus, LOS for each measurement point will be referred to table 8.

Table 8. Guidelines for level of service for pedestrian flow rate

LOS Grade	Space (m^2/p)	Pedestrian Flow Rate (p/15 min/m)
A	> 12	< 7
B	3.7 – 12	23 – 7
C	2.2 – 3.7	23 – 33
D	1.4 – 2.2	33 – 49
E	0.6 – 1.4	49 – 82
F	< 0.6	> 82

Source: Highway Capacity Manual

In table 9, Point 5 has the widest pedestrian walkway width among all the seven points which is 3.6m followed by Point 4 (2.2m), Point 7 (2.1m), Point 6 (1.7m), Point 2 and Point 3 (1.6m) and lastly Point 1 (1.4m).

As can be seen in Table 9, the level of service at Point 1, Point 4 and Point 6 started with LOS B, then changed to LOS C, LOS D and finally ended with LOS E. In other words, first the pedestrian began to be aware of other pedestrians, then the movements of the pedestrian became more restricted due to the increase in the number of the pedestrian volume. Then, finally the volumes had approached the maximum limit of the walkway capacity, with frequent stoppages and interruptions to the pedestrian flow. Therefore, it is recommended to widen the width of the pedestrian walkways because these Points have a large movement of pedestrians.

Meanwhile, the level of service at Point 3 had started and ended with LOS B. At this Point, the movement of the pedestrians was still maintained as LOS A except that they are made aware of the presence of other pedestrians along the pedestrian walkways.

Apart from that, Point 5 and Point 7 have a good Level of Service. The pedestrians were able to move in the desired path without altering their movements and the movements of pedestrians at these Points were free flow. Table 9 also shows that during the entire 3 hours of the survey, Point 2, 5 and 7 started and ended with LOS A. There were not many pedestrians seen at this point, and as a result the LOS at this point was in a free flow condition. Moreover, the adequate size of the walkways was also a factor for maintaining the speed and movements of the pedestrians without restrictions. Therefore, the size of the walkways should be maintained to ensure that the LOS at these Points has a better flow of pedestrian movements without creating any conflicts.

Thus, to facilitate free movement of the pedestrians and to avoid potential conflicts with other pedestrians while they pass through the pedestrian walkways, an appropriate width of the walkways is recommended to maintain the performance of the pedestrian walkways in the future.

Table 9. Pedestrian level of service

TIME		LEVEL OF SERVICE						
		Point 1 (Flow Rate)	**Point 2 (Flow Rate)**	**Point 3 (Flow Rate)**	**Point 4 (Flow Rate)**	**Point 5 (Flow Rate)**	**Point 6 (Flow Rate)**	**Point 7 (Flow Rate)**
	Width	**1.4m**	**1.6m**	**1.6m**	**2.2m**	**3.6m**	**1.7m**	**2.1m**
4.00 – 4.15		**C** (27)	**A** (3)	**B** (9)	**B** (10)	**A** (1)	**B** (15)	**A** (1)
4.15 – 4.30		**C** (32)	**A** (5)	**B** (10)	**B** (14)	**A** (1)	**B** (19)	**A** (2)
4.30 – 4.45		**D** (36)	**A** (6)	**B** (13)	**B** (18)	**A** (1)	**B** (19)	**A** (3)
4.45 – 5.00		**D** (37)	**B** (10)	**B** (14)	**B** (15)	**A** (1)	**B** (22)	**A** (1)
5.00 – 5.15		**D** (39)	**A** (3)	**A** (6)	**B** (17)	**A** (0.5)	**B** (23)	**A** (3)
5.15 – 5.30		**D** (45)	**A** (5)	**B** (15)	**B** (20)	**A** (2)	**C** (24)	**A** (3)
5.30 – 5.45		**E** (57)	**B** (10)	**B** (14)	**B** (23)	**A** (1)	**C** (25)	**A** (5)
5.45 – 6.00		**E** (55)	**B** (10)	**B** (13)	**D** (36)	**A** (3)	**D** (39)	**A** (6)
6.00 – 6.15		**E** (63)	**B** (7)	**B** (10)	**D** (35)	**A** (3)	**D** (39)	**A** (2)
6.15 – 6.30		**E** (77)	**B** (12)	**B** (7)	**D** (41)	**A** (4)	**E** (51)	**A** (5)
6.30 – 6.45		**E** (72)	**A** (6)	**B** (11)	**D** (40)	**A** (4)	**D** (44)	**A** (3)
6.45 – 7.00		**E** (94)	**A** (6)	**B** (9)	**D** (48)	**A** (4)	**E** (54)	**A** (1)

5.4 RELATIONSHIP BETWEEN PEDESTRIAN INFRASTRUCTURE AND PEDESTRIAN VOLUME

It is apparent from Table 10 that Point 1 has a higher average pedestrian volume when compared with other selected points. This can be explained by comparing the differences in the characteristics of the pedestrian infrastructure at each point.

According to the guidelines of pedestrian infrastructure characteristics, Point 1 consists of all pedestrian infrastructure elements such as continuous walkways, direct connectivity to the land use activities, provision of zebra crossing, lighting and roof and shades facilitating convenient, ease, comfortable and safe movement of pedestrians. However, the walkways' width at Point 1 was found to be not fulfilling standards as specified in the pedestrian infrastructure guidelines. On the other hand, even though the pedestrian walkway width at Point 7 meets the pedestrian infrastructure guidelines which is 2.1m, the average pedestrian volume at this point was low. Point 7 has the lowest average pedestrian volume due to the absence of important pedestrian infrastructure elements such as crosswalk, roof and direct connectivity between the LRT station and the surrounding land uses. Malaysia is subjected to hot and rainy weather for most of the days in a year and therefore, providing roof along the walkways is important to increase the movement of pedestrians and hence pedestrian volume. The findings reveal that it is important to consider pedestrian walkways with continuity, direct connectivity, crosswalks, furniture and amenities, roof and shades when providing walkways connecting LRT station and the surrounding land uses. The width of the pedestrian walkway is not a major factor for the movement of pedestrians between LRT station and its surrounding land uses even though its provision is highly required.

Table 10. Pedestrian infrastructure and average pedestrian volume

Point	Pedestrian Infrastructure						Average Pedestrian Volume
	Walkways Width	Continuous	Direct Connectivity	Crosswalk	Street furniture & Amenities	Roof and Shades	
1	1.4m	✓	✓	✓	- Lighting	✓	290
2	1.6m	✓	✓	-	- Benches - Lighting	Halfway Roof	46
3	1.6m	✓	✓	-	- Benches - Lighting	Halfway Roof	71
4	2.2m	✓	✓	-	- Lighting	✓	232
5	3.6m	✓	✓	-	- Lighting	Halfway Roof	31
6	1.7m	✓	✓	-	- Lighting	-	212
7	2.1m	✓	-	-	- Lighting	-	25

Source: Fieldwork Survey, 2015

6. CONCLUSIONS

The provision of pedestrian infrastructure at and near the LRT station is very important for pedestrians to move with ease, comfortably and safely without having any difficulties accessing the station. Good conditions and efficient pedestrian infrastructure will increase the movement of pedestrians to and from the stations and thus increase the passenger ridership of the rail-based public transportation system. Thus, it is imperative to ensure continuous and direct connection between the LRT station and adjoining land uses. This paper has shown that various elements of pedestrian infrastructure such as continuous and direct connection of walkways, crosswalk, lighting and roofs, in fact, would increase the movement of pedestrians between LRT stations and adjoining land uses, as evident at survey points point 1 and point 4 near the station and as a result increase the use of public transportation system. On the other hand, absence of key pedestrian infrastructural elements such as direct connectivity between LRT station and adjoining land uses and crosswalk, as seen in point 7, would decrease the movement of pedestrians indulging in lack of accessibility to the station. The findings from this paper show that adequate provisions of pedestrian infrastructure connecting the station and adjoining land uses are important to increase pedestrian volume facilitating increased use of public transport to promote transit-oriented development.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude and appreciations to the Ministry of Education Malaysia for providing research grant for this research project (Project ID.: FRGS-14-106-0347).

REFERENCES

Allan B. Jacobs (1995) Great Streets, The MIT Press.

Ayse Ozbil (2010) Dissertation topic proposal. Walking to the station: The effects of urban form on walkability and transit ridership.

Charlotte Department of Transportation (2007) Pedestrian & Bicycle Level of Service Methodology for crossing at Signalized Intersections.

Cervero, R. and K. Kockelman (1997) Travel demand and the three D's: Density, diversity and design. *Transportation Research D* 2, 199-219.

Dalbyul Lee (2025) The impact of the walking environment on the use of public transportation by the transportation vulnerable. *KSCE Journal of Civil Engineering*, 29(5), 1-9.

Del Peterson (2011) Transit Ridership and the Buil environment. Issue August.

Ewing, R., Cervero, R. (2001) Travel and the built environment – a synthesis. Transportation Research Record 1780, 87–114.

Frank, L., P. Engelke, and T. Schmid (2003) Health and community design: The impact of the built environment on physical activity, Washington, DC: Island Press.

Garrett (2011) Pedestrian and Bicycle Infrastructure: A National Study of Employment Impacts, Political Economy Research Institute University of Massachusetts, Amherst.

Guzman, L.A., Arellana, J., Castro, W.F. (2022). Desirable streets for pedestrians: using a street-level index to assess walkability. *Transp. Res. Part D: Transp. Environ*, 111, 103462.

Handy, S. (1996) Methodologies for exploring the link between urban form and travel behavior. *Transport Research Part D*-Transport Environment 1(2), 151–165.

Kenneth J. Dueker and Martha J. Bianco (1998) Effects of Light Rail Transit in Portland: Implications for Transit-Oriented Development Design Concept.

Korea Ministry of Land, Infrastructure and Transport (2024) MOLIT Statistics System, https://stat.molit.go.kr.

Maria Alejandra Saltarin-Molino, Adriana Moros-Daza, and Carolay Camacho-Sanchez (2023) Taking steps forward: Innovative evaluation of pedestrian infrastructure through a multivariate analysis, *Case Studies on Transport Policy*, 14, 1-10.

Michael R. Bloomberg & Amanda M. Burden (2006) New York City Pedestrian Level of Service Study Phase I.

Mohd Norhisham Bin Azlan (2010) Level of Service for pedestrian Walkway at Bus Terminal.

Nur Syahida Binti Raidine (2013) A Study on the Pedestrian Volume Pattern and Pedestrian Infrastructure Provision in IIUM Gombak Campus.

Nagui M. Rouphail, Joseph E. Hummer, Joseph S. Milazzo II & D. Patrick Allen (1998) Capacity Analysis of Pedestrian and Bicycle Facilities Task Order 8: Pedestrian-Bicycle Research Program.

Loetterle, F. E. (2001) Riding the Rails: Light-Rail Transit Market Areas in the Twin Cities. University of Minnesota Center for Urban and Regional Affairs: Cura Reporter, 2. 2-8. Retrieved Feb 5, 2011.

Loo. P.Y. Becky, Chen Cynthia and Chan Eric TH (2010) Rail-based transit-oriented development: Lessons from New York City and Hong Kong. *Landscape and Urban Planning*, 97, 202-212.

Michael R. Jones 2013 Spatial Analysis of Influences on Ridership on the Hiawatha Light Rail Transit System in the Minneapolis/St. Paul Metropolitan Area. Vol 16.

Reta, T. M. and Denbi, T. J. (2022) Assessment of Pedestrian Infrastructures of Road Transport: A Case Study of Jimma Town, Journal of Sustainable Development of Transport and Logistics, 7(2), 41-52.

Saxena, A., Yadav, A.K. (2023). Clustering pedestrians' perceptions towards road infrastructure and traffic characteristics. *Int. J. Injury Control Safety Promotion,* 30 (1), 68–78.

Sherry Ryan and Lawrence F. Frank (2009) Pedestrian environment and transit ridership. *Journal of Public Transportation*, 12, 39-57.

Ulrike Jehle, Cara Coetzee, Benjamin Buttner, Elias Pajares and Gebhard Wulfhorst (2022) Connecting people and places: Analysis of perceived pedestrian accessibility to railway stations by Bavarian case studies. *Journal of Urban Mobility*, 2, 1-18.

Wealthy Tsembile Maseko, Jacob Adedayo Adedeji, Ndakhona Bashingi and James Honiball (2024) Evaluating the Current State of Pedestrian Facilities in Peri-Urban and Urban Areas: A Case Study of Pietermaritzburg City, The Open Transportation Journal, 18, 1-11.