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150 *The Open Transportation Journal*, 2018, *12*, 150-166

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The Open Transportation Journal

Content list available at: www.benthamopen.com/TOTJ/

DOI: 10.2174/1874447801812010015O

RESEARCH ARTICLE

Comparative Analysis of Environmental Graphic Design for Wayfinding on the Exit Patterns of Mass Transit Stations

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Received: February 23, 2018 Revised: March 22, 2018 Accepted: April 18, 2018

Abstract:

Introduction:

The quality of transit services has long been recognized as a significant factor affecting passenger behavior and station quality. The objective of this paper was to compare the environmental graphic designs for passengers' decision to choose walking ways in subway stations of Bangkok Metropolis, Thailand.

Methods:

It uses the multi-stage sampling approach at various forms of station entries-exits and traffic statistics of service usage by passengers. The forms of station entries-exits can be divided into four types: 1) Silom Station (2-way exits), 2) Sukhumvit Station (3-way exits), 3) Huai Khwang Station (4-way exits), and 4) Phahon Yothin Station (5-way exits). Questionnaires were used to collect data from 445 passengers, using Likert Scale and t-test/ANOVA. The comparative analysis of directional signs was conducted with three factors as follows; 1) signs with 1-point location, 2) signs with 2-point locations, and 3) signs with 3-point locations.

Results:

The results found the signs with 2-point locations could provide additional information about the places and were suitable for the general environment of all stations. However, when adding further information about the places on the signs with 3-point locations, some limitations were found regarding the passengers' need for location information with a complex physical environment of the station. Also, when considering the passengers' attributes and behaviors, it was found that they also affected the environmental graphic design significantly.

Conclusion:

The research findings can be used as information for the environmental graphic designers to develop wayfinding system to improve for passengers' travelling in mass transit stations.

Keywords: Environmental graphic design, Wayfinding, Signage system, Location information, Subway station, Mass transit station.

1. INTRODUCTION

Graphic means colors, images, or characters that are used to represent the details of an idea [1] and convey specific information [2]. Meanwhile, designing means fixing a problem [3]. Thus, graphic designing means fixing a problem using images, colors, and characters to convey complex information so that it can be quickly and easily understood in the same way and to convey the information to a large target group by reading [2, 4]. Signage is a part of the environmental graphic design which guides people in large and complex areas to reach their destinations by using a directional graphic system [5]. Therefore, the sufficient number of signage for wayfinding system for passengers to find the way directional signs are important. Furthermore, designing them adequately and appropriately is also necessary as

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a self-guiding system for passengers [5, 6]. Hence, designing is an important factor in a mass transit system [7 - 9].

The quality of public transport is a significant factor that influences the passenger satisfaction in a mass transit system [10]. Quality is one of the main drivers for public transport services and, is essential to identify which are the attributes perceived as relevant by the passengers [10 - 12]. The quality of public transport can be analyzed from two different points of view: the service provider's and users' point of view [10, 13]. Among the quality attributes, the quality of the transportation stations is probably one of the most impacting on passengers' perception. Stations, and more specifically, subways station quality can be further decomposed into several attributes including ease to access, cleanliness, subjective (perceived) and objective security, lighting, climate control, and information availability.

Built environments usually provide passengers massive amounts of heterogeneous information. Passengers need to evaluate and select useful information. Otherwise, they would undoubtedly fall into information-overload or uncomprehending environments. Furthermore, the unfamiliarity of the environment also exacerbates the problems in decision making to go to the destinations [14]. Based on comparative studies between the commuting by above-ground trains and subway systems, which are very much different in the elements of the environments [8, 15]. The environments of subway systems directly affect the wayfinding ability of the passengers due to the visual restrictions of the environments. Without visual access to the elements of the exterior environment, subway passengers will have difficulty in remembering the routes because they are not able to take advantage of the directions of things in the environment around them [16]. Therefore, it is inevitable for passengers to be dependent on the directional or informational signs to confirm the routes and guide them to their destinations throughout the journey [17]. Based on survey data of the passengers that were familiar and unfamiliar with the subway route, the results showed that there were differences in the physical environment of the environmental graphic design, path directional signs that influent over the decision making on route selection of the passengers [9].

The objectives of this research include the following: A comparative analysis of the environmental graphic design for wayfinding among passengers who use the service in mass transport systems shall be conducted. The research locations are underground stations of the Metropolitan Rapid Transit, Chaloem Ratchamongkhon Line (MRT) in Bangkok. The research shall analyze the passengers' need regarding the location information specification for the appropriate wayfinding for various physical environment factors of the four types of subway stations which are; 1) Silom Station (2-way exits) 2) Sukhumvit Station (3-way exits) 3) Huai Khwang Station (4-way exits) and 4) Phahon Yothin Station (5-way exits). Variables in the research of environmental graphic design for the directional signs include three factors as follows; 1) signs with 1-point location, 2) signs with 2-point locations, and 3) signs with 3-point locations. The factors of physical settings that affect the passengers' requirements for location information has been analyzed and compared to support the environmental graphic design of directional signs for enhancing wayfinding system. The conceptual framework of the study has been shown in Fig. (**1**).

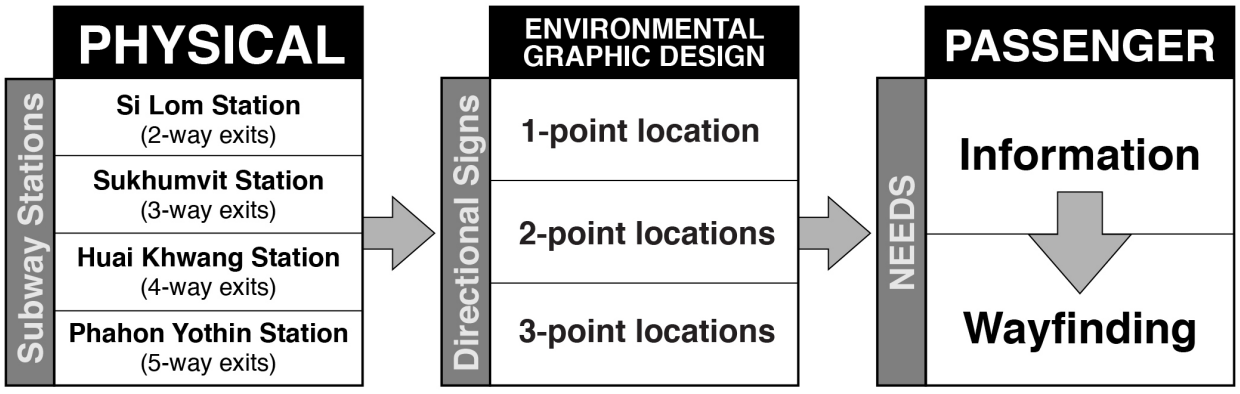

Fig. (1). Conceptual framework.

2. LITERATURE REVIEW

2.1. Wayfinding and Environment

Wayfinding is part of everyday life, and most humans are quite proficient at it. However, wayfinding is a complex activity, usually divided into several tasks or actions. Simple wayfinding, *i.e.*, without alternatives or constraints, still requires three stages: planning, route instructions, and moving [18]. Wayfinding is an individual ability to reach a

destination by a cognitive process to make connections and organize information that has been received from the physical settings from the surrounding environment to generate a cognitive map in one's mind [19, 20]. On the other hand, spatial orientation is an awareness of one's location in space [18]. The interaction processes between a person and physical settings of the surrounding environment occasionally occur, but significantly, they are similar to the decision-making processes. The action of the person to the physical settings that is the result of the interaction must have the purpose of an action, seeking for an opportunity, readiness of the environment, discreet planning, execution of planning and evaluation of the action [14]. Human behavior is caused by the relationship between the inner influence of the individual and the external influences that the individual perceives [21]. Passengers' behavior and route selection involve a wayfinding system that consists of; 1) environmental information, 2) decision, and 3) behavioral action. The most important part of the wayfinding system is the decision, which is imperative in making connections of the information in mind and leads to expression in behavior [14]. There are also personal experiences, race, religion, culture, ability to evaluate the surrounding environment, ability to comprehend signs and maps, local traffic congestion, underground retail space and the characteristics of the public transport environment development [8]. Thus, the individual perception and understanding of the surrounding environment are different.

2.2. Graphic Design and Environment

Gestalt theory stated that human perception is caused by feeling, resulting from stimuli all around that affects and generates perception without analyzing the flow of information. Humans have a multitude of sensors which are a mechanism of the five senses, which are sight (vision), hearing (audition), taste (gustation), smell (olfaction), and touch (somatosensation), the five traditionally recognized senses that send information to the brain which is the perception of feeling. Therefore, each person who perceives the same stimulus may interpret the information differently by using their existing experiences and insight self-learning results in the concept of learning or problem solving, which occurs instantly in foreseeing the way to solve a problem and understanding the interconnection of the factors of the problem [22 - 25]. The principle of the theory of interconnection state that the studies of human perception in real environments are important to study the visual and understanding abilities that help people to improve their perception skill. Perception of the importance attached to words or pictures in signs is often communicated by the size, position, and proximity of the sign to the visuals [26]. The two main types of communication, which are verbal communication and visual communication, are both different in their mechanisms and potential [4]. Signs and pictorial symbols have the purpose of being used and being part of the wayfinding system. The signage system is a part of the environmental design which is a system that helps to guide people in large and complex areas [27] to reach their destination using the directional graphics system. The beneficial use of signage can divide into four types which are Directional, Identifying, Informational, and Restrictive or Prohibitive, which facilitate the travel of passengers to their destinations quickly and more efficiently [28]. There are additional factors that affect the perception and understanding of signage system which is individual personality culture, social, and experience [9, 28].

3. MATERIAL AND METHODS

This research uses survey research for the comparison of the physical environments of the environmental graphic designs, which affect the needs of passengers in wayfinding within subway stations. This includes the steps as below:

3.1. Step 1 Choice of the Study Area and Sample Group for the Research

This research applies multi-stage sampling. Information is divided for classification purposes according to the types of electro-powered trains for mass passenger transport in Thailand [29] (Fig. **2**). It can be classified according to the service in three types:

- **The Bangkok Mass Transit System (BTS)** is an overground train system with a total service line of 36.9 km; the entire line is overground, and there are 34 stations in total.
- **The Metropolitan Rapid Transit, Chaloem Ratchamongkhon Line (MRT)** is an underground train system with a total service line of 20 km; the entire line is underground, and there are 18 stations in total.
- **The Airport Rail Link** is an overground train system that provides a connection to Suvarnabhumi Airport with a total service line of 28 km; the entire line is overground, and there are eight stations in total.

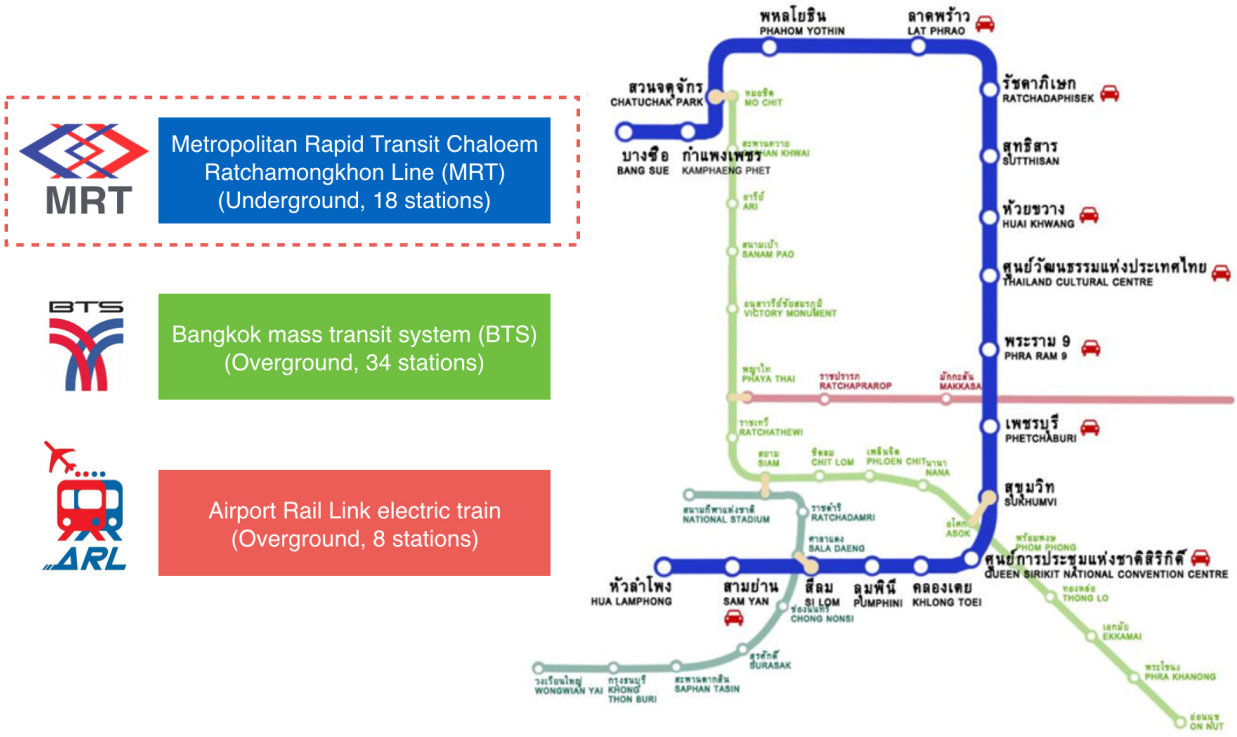

Fig. (2). Route diagram of Metropolitan Rapid Transit Chaloem Ratchamongkhon Line (MRT) [30].

This is based on a comparative study between travelling on the ground train and subway systems, which are different in the elements of the environment [8, 9, 15], and affect the mental picture or map [14, 18] of the passengers in memorizing the environment. Consequently, it is crucial for passengers to rely on the directional or informational signs to confirm the routes and guide them to their destination throughout the journey. The Metropolitan Rapid Transit has been selected to be the study area, Chaloem Ratchamonkhon Line (MRT). It has 18 stations in total. The distance between stations is about 1 km. It starts at Hua Lamphong Station, ends at Bang Sue Station [30].

Sampling criteria for the stations in the sample group for data collection in this research include: 1) Selection based on characteristics of physical environment and form of entries-exits, and 2) Selection based on the importance of stations, in order from the highest statistics of passengers who used the Metropolitan Rapid Transit, Chaloem Ratchamongkhon Line (MRT) [30]. The stations can be divided into four forms as summarized in Table **1**.

Table 1. Stations of the Metropolitan Rapid Transit, Chaloem Ratchamongkhon Line (MRT).

Form	Entries-Exits	Subway Stations	Total
1	2 ways	Silom Station, Sam Yan Station, Bang Sue Station, Khlong Toei Station.	4
2	3 ways	Sukhumvit Station, Phra Ram 9 Station, Phetchaburi Station, Lumphini Station, Kamphaeng Phet Station.	5
3	4 ways	Huai Khwang Station, Lat Phrao Station, Chatuchak Park Station, Hua Lamphong Station, Queen Sirikit National Convention Centre Station, Thailand Cultural Centre Station, Sutthisan, Ratchadaphisek Station.	8
4	5 ways	Phahon Yothin Station.	1
			18

To summarize the selection of subway stations, they were divided by their location characteristics regarding the environment and by the form of entries-exits and ordered by importance according to the amount of usage by passengers. Four principal stations were thus taken as the sample group and locations for the research; they were Silom Station (2-way exits), Sukhumvit Station (3-way exits), Huai Khwang Station (4-way exits) and Phahon Yothin Station (5-way exits). Also, a data sample from a total of 445 questionnaires from passengers was collected.

3.2. Step 2 Research Tools

The research tools have been used to collect data in this study were postal return questionnaires. The structure of the questionnaires and variables that were used in the study consisted of two parts. They include: part (1) personal attributes data about the passengers, which are the independent variables; they include gender, age, education, profession,

objective of going, frequency of going and environment; and part (2) the levels of suitability of specifying location information on directional signs, which are the dependent variables; they include signs with 1-point location, signs with 2-point locations and signs with 3-point locations. The Likert scale was used for the questionnaire what the needs of location information to help the passengers' decision to choose the way were. Reproductions of directional signs for exits corresponding to the characteristics of each station were made in four sets. The questionnaire was pilot tested with passengers and revisions were made accordingly before the actual data was collected. (Fig. **3**).

Fig. (3). Reproduction of directional signs (four sets) for passengers at each station and a 5-level measure scale (Likert scale): (**a**) Silom Station (2-way exits); (**b**) Sukhumvit Station (3-way exits); (**c**) Huai Khwang Station (4-way exits); (**d**) Phahon Yothin Station (5-way exits).

3.3. Step 3 Field Data Collection in the Research

Data of this research was collected from passengers who have used the subway train service of the Metropolitan Rapid Transit, Chaloem Ratchamongkhon Line (MRT). The timeframe in which the questionnaires were handed out was rush hour in the morning (6:00 to 9:00 AM) and the evening (4:30 to 7:30 PM). Those times are when a high number of passengers use the service. Field data were collected at four subway stations: Silom Station (2-way exits), Sukhumvit Station (3-way exits), Huai Khwang Station (4-way exits) and Phahon Yothin Station (5-way exits). The questionnaires were distributed in front of the exits and passengers were informed about the objective. They took the questionnaires with them to fill out and returned them via post as shown in Fig. (**4**).

Fig. (4). Data collection with questionnaires in front of the entries-exits of the subway stations.

3.4. Step 4 Data Analysis

Based on the data gained from the survey and analysis of data with statistic t-test and ANOVA measures, with post hoc LSD was used to a statistical significance of .05 was determined. All statistical analyses were performed using the software package SPSS 23.0 (IBM Corp, Armonk, NY, USA) for Windows.

4. RESULTS AND DISCUSSIONS

This research sets a structure for the comparative analysis of research data that consists of 5 main parts:

4.1. Analysis of Structure, Forms and Physical Environment of Subway Stations

There are 18 stations in total on the Metropolitan Rapid Transit, Chaloem Ratchamongkhon Line. They can be divided into three forms: 1) central platform, 2) side platform, 3) stack platform. This depends on the form of stations and the topographic conditions around them. Most stations have a central platform with rail tracks on two sides of the platforms. An exception is the stack platforms of some locations which have tracks on different levels. The stations can be divided into three types. They include structures with two levels, structures with three levels and structures with four levels and a platform screen door, lifts and escalators as shown in Fig. (**5**).

4.1.1. Analysis of the Physical Environment of Silom Station (2-way Exits)

Silom Station is a subway station at Phra Ram 4 Road in Bangkok at the Sala Daeng Intersection. Its location is in the city centre, in the business district of Silom Road. The subway station is 30 meters wide and 156 meters long from the ground. The platform type is a stacked platform because the building location is narrow and there are several restrictions, for example, because of the water canalization, foundation piles of pedestrian bridges and buildings. The station structure consists of 4 levels: level 1 (general passenger hall, passenger ticket selling and check facilities and display of train line maps), level 2 (platform number two; it is the level where trains stop to let passengers get on and off in the direction to Lumphini Station and towards the final destination of Bang Sue Station), level 3 (a storage room for different train system tools; this level is not open for passengers) and level 4 (platform number one; it is the level

where trains stop to let passengers get on and off in the direction of Sam Yan Station and towards the final destination of Hua Lamphong Station) as shown in Fig. (**6a**).

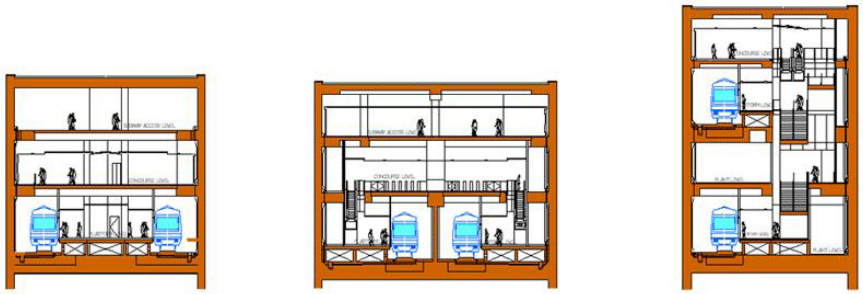

Fig. (5). Structures and forms of subway stations: (**a**) Central platform; (**b**) Side platform; (**c**) Stack platform [30].

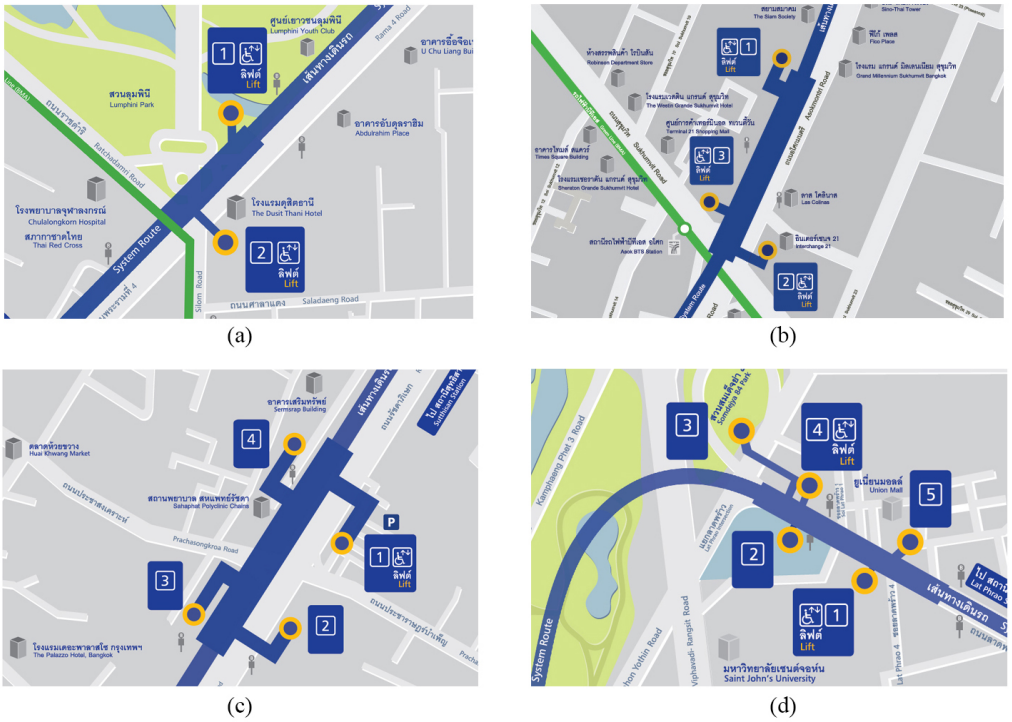

Fig. (6). Forms of entries-exits and the physical environment of the subway stations: (**a**) Silom Station (2-way exits); (**b**) Sukhumvit Station (3-way exits); (**c**) Huai Khwang Station (4-way exits); (**d**) Phahon Yothin Station (5-way exits) [30].

4.1.2. Analysis of the Physical Environment of Sukhumvit Station (3-way Exits)

Sukhumvit Station is a subway station on Bangkok's Asok-Montri Road at the Asok-Montri Intersection. It is a connection point between the BTS Skytrain Station Asok and the Sukhumvit Station, and it is the subway station where the most passengers use the service. It is a 23 m wide and 199 m long subway station, and the tracks are 17 m below the ground. Its form is a central platform. This is a station form that is used mostly for passengers who go in both directions. They can use the platform together. The station structure consists of 3 levels: level 1 (level with the shopping centre Metro Mall with open-plan style, which has different retail shops), level 2 (general passenger hall for selling and checking passenger tickets) and level 3 (the platform level) as shown in Fig. (**6b**).

4.1.3. Analysis of the Physical Environment of Huai Khwang Station (4-way Exits)

Huai Khwang Station is a subway station on Bangkok's Ratchadaphisek Road, located in an area with many

buildings and residential apartments in the city centre with hotels and entertainment places. It is a 23 m wide and 226 m long subway station and the platform is 19 m below the ground. Its form is the type of a central platform. The area inside the station consists of only two levels because the space on the very top of the station was used to build a tunnel for the Ratchadaphisek-Huai Khwang Intersection oriented at Ratchadaphisek Road. The station structure consists of two levels: level 1 (general passenger hall for shopping and checking passenger tickets) and level 2 (with rail tracks for departing and arriving passengers) as shown in Fig. (**6c**).

4.1.4. Analysis of the Physical Environment of Phahon Yothin Station (5-way Exits)

Phahon Yothin Station is a subway station on Lat Phrao Road in Bangkok at the Lat Phrao 5-way Intersection, located in an area with many buildings, offices and residential apartments; there are also several large shopping centres in the vicinity. It is a 22 m wide and 226 m long subway station and the tracks are 18 m below the ground. Its type is a central platform. The station structure comprises three levels: level 1 (level with the shopping centre Metro Mall; it has an open-plan style area and retail shops), level 2 (general passenger hall for selling and checking tickets) and level 3 (the platform level) as shown in Fig. (**6d**).

4.2. Analysis of Travelling Behavior Among Passengers and Environmental Graphic Design in Subway Stations

Based on the specific characteristics of the physical environment of the underground stations in the field study, and to survey the travelling behavior among passengers with relation to seeing signage for choosing a way at each parting for wayfinding in subway stations, four steps of the route as below can be classified as shown in Fig. (**7**).

Fig. (7). The diagram steps of travelling behavior and the relationships between signage [30].

- **Step 1 Exit Sign:** Passengers exit from the subway trains, see the exit signs and get on the escalators to the next floor. (Fig. **8**).
- **Step 2 Directional Sign:** From the escalators, passengers see directional signs and decide to go on certain routes towards important locations to leave the subway stations. (Fig. **9**).
- **Step 3 Informational Sign:** In case that passenger cannot decide to go through a certain exit and need further information about directions, the informational sign can once more help them decide to go through a certain exit. (Fig. **10**).
- **Step 4 Confirmational Sign:** Passengers receive information about the way while they are going, which is shown on confirmational signs, and are guided to exits of the different sides of the subway stations. (Fig. **11**).

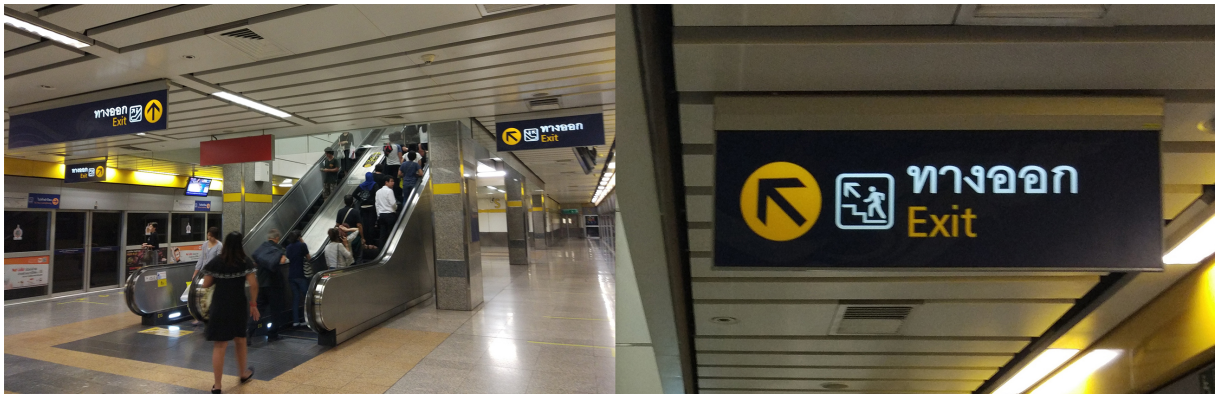

Fig. (8). Step 1 Exit Sign.

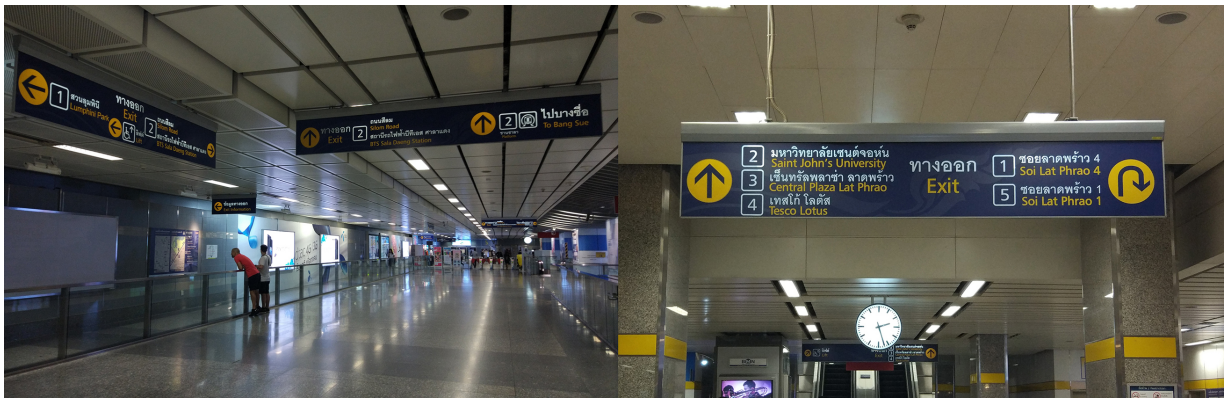

Fig. (9). Step 2 Directional Sign.

Fig. (10). Step 3 Informational Sign.

In the analysis of the travelling behavior among passengers that is related to seeing signage in underground stations in four steps, the types of signage for information and directions can be defined. They can be classified according to two characteristics; 1) Information signs with one-direction which are step 1 exit sign and step 4 confirmational sign. This group includes directional signs with 1-point location or with the objective to merely provide travelling information. The passengers do not need to choose a route. 2) Information signs with the multi-directions which are step 2 directional sign and step 3 informational sign. This group includes directional and informational signs for various routes. The passengers always need to choose a way.

Fig. (11). Step 4 Confirmational Sign.

In addition, another factor that is relevant for passengers, are the decision points, which are very important and essential for the way that passengers take action and as for the analysis of the environmental graphic designs in this research, the first decision point is in step 2 the directional sign; the informational sign in step 3 is the second decision point (they are used in cases in which passengers are not sure about the way and need further information for selecting a way). Therefore, the possibility to provide further information on the directions and important locations to the passengers in step 2 directional sign refers to an increase in opportunity for better decision making for their routes. See Fig. (**12**).

Fig. (12). Signs with information for multi-directions at present; they are located at important decision points for passengers: (**a**) Silom Station (2-way exits); (**b**) Sukhumvit Station (3-way exits); (**c**) Huai Khwang Station (4-way exits); (**d**) Phahon Yothin Station (5-way exits).

4.3. Analysis of the Passengers' Characteristic Levels and Travelling Behaviors

The data from the questionnaires include 445 samples of which the data collection ratios are from the similar quantity of passengers. They can be divided into the group of passengers from Silom Station (2-way exits) with 121 samples, constituting 27.2%; the group of passengers from Sukhumvit Station (3-way exits) with 109 samples, constituting 24.5%; the group of passengers from Huai Khwang Station (4-way exits), with 112 samples, constituting 25.2%; and the group of passengers from Phahon Yothin Station (5-way exits) with 103 samples, constituting 23.1%. The data showed that most were female (306 people), constituting 68.8%, followed by the male (139 people), constituting 31.2%. The sample group was aged 13-79 years (M=35.64, SD=11.59). Their educational level starting with the most common included BA (302 people; constituting 67.9%), followed by MA (103 people; constituting 23.1%), below BA (43 people; constituting 7.6%) and the least common: Ph.D. (6 people; constituting 1.3%).

The occupation that they worked in starting with the most common included: government officials/private sector employees: 368 people, constituting 82.7%, followed by pupils/students: 44 people, constituting 9.9%, trade/personal business: 18 people, constituting 4.0%, people who do housekeeping/age retirees: 15 people, constituting 3.4%. The objectives for travelling starting with the most common included: going to work: 345 people, constituting 77.5%, going

for travelling/recreation: 51 people, constituting 11.5%, going because of studies: 26 people, constituting 5.8%, and the least common: going for shopping: 23 people, constituting 5.2%.

Data on frequency of travelling and using the service starting with the most common included: usage of 5-6 times/week: 156 people, constituting 35.1%, followed by usage of more than 6 times/week: 136 people, constituting 30.6%, usage of fewer than 2 times/week: 80 people, constituting 18.0%, and the least common: usage 2-4 times/week: 73 people, constituting 16.4%. A summary is shown in Table **2**.

Table 2. Passengers' characteristic levels and behaviors.

Variables		2-way Exits	3-way Exits	4-way Exits	5-way Exits	Total (N=445)
		Silom (n=121)	Sukhumvit (n=109)	Huai Khwang (n=112)	Phahon Yothin (n=103)	
Gender:	Male	44 (36.4%)	28 (25.7%)	35 (31.3%)	32 (31.1%)	139 (31.2%)
	Female	77 (63.6%)	81 (73.4%)	77 (68.8%)	71 (38.9%)	306 (68.8%)
Age:	11-20 years	2 (1.7%)	7 (6.4%)	4 (3.6%)	6 (5.8%)	19 (4.3%)
	21-40 years	86 (71.1%)	80 (73.4%)	76 (67.9%)	50 (48.5%)	292 (65.6%)
	41-60 years	26 (21.5%)	21 (19.3%)	31 (27.7%)	42 (40.8%)	120 (27.0%)
	< 60 years	7 (5.8%)	1 (.9%)	1 (.9%)	5 (4.9%)	14 (3.1%)
Education:	Undergraduate	6 (5.0%)	15 (13.8%)	5 (4.5%)	8 (7.8%)	34 (7.6%)
	Bachelor's degree	82 (67.8%)	64 (58.7%)	78 (69.6%)	78 (75.7%)	302 (67.9%)
	Master's degree	33 (27.3%)	28 (25.7%)	25 (22.3%)	17 (16.5%)	103 (23.1%)
	Doctor's degree	0 (.0%)	2 (1.8%)	4 (3.6%)	0 (.0%)	6 (1.3%)
Occupation:	Pupils/Students	1 (.8%)	22 (20.2%)	13 (11.6%)	8 (7.8%)	44 (9.9%)
	Government official/Employee	113 (93.4%)	81 (74.3%)	94 (83.9%)	80 (77.7%)	368 (82.7%)
	Entrepreneur/Private business	2 (1.7%)	4 (3.7%)	3 (2.7%)	9 (8.7%)	18 (4.0%)
	Housekeeping/Age retirees	5 (4.1%)	2 (1.8%)	2 (1.8%)	6 (5.8%)	15 (3.4%)
Objectives:	Study	3 (2.5%)	12 (11.0%)	9 (8.0%)	2 (1.9%)	26 (5.8%)
	Work	107 (88.4%)	74 (67.9%)	99 (88.4%)	65 (63.1%)	345 (77.5%)
	Shopping	5 (4.1%)	4 (3.7%)	1 (.9%)	13 (12.6%)	23 (5.2%)
	Travelling / Recreation	6 (5.0%)	19 (17.4%)	3 (2.7%)	23 (22.3%)	51 (11.5%)
Frequency:	> 2 times/week	20 (16.5%)	32 (29.4%)	8 (7.1%)	20 (19.4%)	80 (18.0%)
	2-4 times/week	12 (9.9%)	21 (19.3%)	11 (9.8%)	29 (28.2%)	73 (16.4%)
	5-6 times/week	44 (36.4%)	28 (25.7%)	52 (46.4%)	32 (31.1%)	156 (35.1%)
	< 6 times/week	45 (37.2%)	28 (25.7%)	41 (36.6%)	22 (21.4%)	136 (30.6%)

4.4. Analysis of Variables of the Physical Environment of Subway Stations with Needs for Location Information

From the data on the mean values among the passengers regarding their need for location information to assist their decision making of the passenger groups at Silom Station (2-way exits), Sukhumvit Station (3-way exits) and Phahon Yothin Station (5-way exits), the mean levels of need for information in order from the highest values are as follows: signs with 3-point locations, followed by signs with 2-point locations and signs with 1-point location respectively. Passengers at Huai Khwang Station (4-way exits) are the exception. The order is different from all other groups and is as follows, starting with the highest mean values: signs with 2-point locations, followed by signs with 3-point locations and signs with 1-point location respectively (Table **3**).

According to the data analysis of the mean values of the need for location information among passengers, they are overall at a high level for the signs with 3-point locations and signs with 2-point locations respectively. It shows that the passenger groups demand more information on the locations, compared with the present when there are only signs with 1-point location. This is also the basic form for providing information at all stations.

Table 3. Results of the analysis of mean and standard deviation for the need of location information and the environmental variables.

Dependent Variables	Silom (n=121)		Sukhumvit (n=109)		Huai Khwang (n=112)		Phahon Yothin (n=103)		Total (N=445)	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Signs with 1-point location	3.04	1.068	3.01	1.023	3.40	.832	3.37	.929	3.20	.983
Signs with 2-point locations	3.65	.844	3.48	.939	3.69	.921	3.65	.848	3.62	.889

(Table 3) contd.....

Dependent Variables	Silom (n=121)		Sukhumvit (n=109)		Huai Khwang (n=112)		Phahon Yothin (n=103)		Total (N=445)	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Signs with 3-point locations	4.13	.966	3.70	1.050	3.53	1.215	3.70	1.187	3.77	1.125

The ANOVA data analysis found that the need for specifying location information to assist the passenger's decision making is different according to 2 factors; 1) signs with 1-point location at the significance level of p<.05=.002 and 2) signs with 3-point locations at the significance level of p<.05=.000. Meanwhile, for signs with 2-point locations, the need for location information among the respondents at all stations did not differ (Table **4**).

Table 4. Results of the analysis of mean differences for the need of location information and the environmental variables.

Dependent Variables		Sum of Squares	df	Mean Square	F	*p*
Signs with 1-point location	Between Groups	14.516	3	4.839	5.146	.002*
	Within Groups	414.684	441	.940		
	Total	429.200	444			
Signs with 2-point locations	Between Groups	2.962	3	.987	1.251	.291
	Within Groups	348.094	441	.789		
	Total	351.056	444			
Signs with 3-point locations	Between Groups	23.593	3	7.864	6.441	.000*
	Within Groups	538.483	441	1.221		
	Total	562.076	444			

*p<.05 is the level of significance.

When a paired comparative data analysis of the signs with 1-point location, the signed form that is used at present, was conducted in pairs, it was found that the passenger groups at Huai Khwang Station (4-way exits) and Phahon Yothin Station (5-way exits) had the highest mean values for the need of further location information, and they were different from the passenger groups at Silom Station (2-way exits) and Sukhumvit Station (3-way exits). Based on the comparative analysis in pairs for signs with 3-point locations, it was found that the passenger groups at Silom Station (2-way exits) had the highest need for location information and was different from all other station groups. It can be explained as follows. For the stations with little complexity of the physical environment, such as Silom Station (2-way exits), the passenger group has a need for more location information for wayfinding than that at present where there are signs with 1-point location. Further information on the locations can be added with signs with 3-point locations. However, if the location's physical environment is more complex and the passengers have a need for further location information, the directional sign design containing a lot of venue information requires caution with regards to environmental graphic design. This is because the information that exceeds the passengers' limit will affect the need for less location information for wayfinding. This is another important factor (Table **5**).

Table 5. Results of paired comparative analysis on the need for location information with the environmental variables.

Dependent Variables		$\bar{x}$	Silom	Sukhumvit	Huai Khwang	Phahon Yothin
Signs with 1-point location			3.04	3.01	3.40	3.37
	Si Lom Station	3.04	-	.802	.005*	.012*
	Sukhumvit Station	3.01		-	.003*	.007*
	Huai Khwang Station		3.40	-	-	0.804
	Phohon Yothin Station	3.37				-
Signs with 3-point locations			4.13	3.70	3.53	3.70
	Si Lom Station	4.13	-	.003*	.000*	.004*
	Sukhumvit Station	3.70		-	.252	.991
	Huai Khwang Station	3.53			-	.254
	Phohon Yothin Station	3.70				-

*p<.05 is the level of significance.

4.5. Comparative Analysis of Personal Attributes and the Need for Location Information

For better understanding of the data, the researcher analyzed the relationships between the variables of the passenger group's specific characteristics referred to as independent variables; 1) gender, 2) age, 3) education, 4) occupation, 5) objective of travelling, and 6) frequency of travelling, with variables regarding the need for location information; 1) signs with 1-point location, 2) signs with 2-point locations, and 3) signs with 3-point locations, which are the dependent

variables in this research as follows.

4.5.1. Comparative Analysis of the Gender Variables and the Need for Location Information

The data analysis with t-test showed the level of need relating to the factors of the environmental graphic design of directional signs to specify location information for wayfinding as follows. Females have a higher level of need for location information than males with every factor, except for the signs with 1-point location. This is the form of the sign that is used at present and males have a higher mean value than females here. Also, the following was found: The form of the signs with 3-point locations is associated with differences between the genders. This shows that females are considered more than men regarding the information of locations in the design for wayfinding (Table **6**).

Table 6. The table shows mean values and standard deviations of the need for location information with the gender variables.

Dependent Variables	Male (N=139)			Female (N=306)			*t*-value	*p*
	$\bar{x}$	S.D.	Priority	$\bar{x}$	S.D.	Priority		
Signs with 1-point location	3.23	.927	3	3.19	1.009	3	.437	.468
Signs with 2-point locations	3.51	.920	2	3.67	.872	2	-1.718	.212
Signs with 3-point locations	3.73	.967	1	3.79	1.191	1	-.495	.001*

*p<.05 is the level of significance.

4.5.2. Comparative Analysis of the Age, Education, Profession, Objective and Frequency of Travelling Variables with the Need for Location Information

According to the ANOVA data analysis of the passenger groups' specific characteristics regarding age, it was found that the passenger groups had different needs for location information on the directional signs with regards to signs with 3-point locations. When the paired comparative analysis, it was found that the passenger group aged 20-60 years old had a higher level of need for location information which was different from the passenger group with lower age. This explains the relationship between age and the design to facilitate wayfinding.

From the data analysis of the passenger groups regarding their education level, it was found that there were differences relating to signs with 3-point locations at the statistical significance level of P<.05=.020 (Table **8**). When the paired comparative analysis, the passenger group with an education level of BA or higher, the level of the need for further location information of directional signs was higher compared to the passenger groups with the lower level of education. Additionally, the differences between the passenger groups with lower qualification than BA and those with higher qualification than BA were found. This shows that excessively low educational level affects the level of the need for signs with further location information.

Regarding the data analysis of the passengers' different occupation, it was found that there were differences from two factors; signs with 1-point location at a statistical significance level of p<.05=.002 and signs with 3-point locations at a statistical significance level of p<.05=.000 (Tables **7**, **8**). When the paired comparative analysis data for signs with 1-point location, it was found that the unemployed groups, such as housekeepers/retirees, had a lower level of the need for location information than all other occupation groups. They were different from the employee groups, such as student and civil servant/private. However, for the paired comparative analysis for signs with 3-point locations, it appeared that the housekeepers/retiree groups had a higher need for further location information than the present signs, with 1-point location. Furthermore, it was found that the level of need for location information among the government official/private sector employee groups was higher than those in the other groups, and was different from the student, entrepreneur/private business groups who had a lower level of need for location information. This explains of work factors with a diversity of professions, activities, and environment of passengers on their way at the various stations.

The data analysis with ANOVA did not find differences for the factor of objectives of travelling (Table **8**). However, when the paired comparative analysis of data, it appeared that there were differences for signs with 3-point locations and the group of passengers with the objective of going to work had the highest level of need for location information which was different from the passenger group who was going to study, Which had the lowest level of need for location information. This shows that various factors related to work and activities have an impact on the need for further information about the travelling locations for wayfinding.

The analysis of data with the variable of frequency of travelling with a need for location information among the groups of passengers found that there were differences with regards to signs with 3-point locations at a statistical significance level of p<.05=.003 (Table **8**). When the paired comparison, it appeared that the group of passengers who

used the subway service with a frequency of more than 6 times/week was different from all other passenger groups. Also, for the comparative analysis of the need level for location information in all groups, it was found that an increased frequency of travelling affects decreases the level of need for location information. This shows that factors of experience and familiarity with locations to enhancing the wayfinding.

Table 7. Results of the analysis of mean difference of signs with 1-point location and passengers' attributes and behaviors variables.

Dependent Variables		Sum of Squares	df	Mean Square	F	*p*
Occupation	Between Groups	14.558	3	4.853	5.161	.002*
	Within Groups	414.642	441	.940		
	Total	429.200	444			

*p<.05 is the level of significance.

Table 8. Results of the analysis of mean difference of signs with 3-point locations and passengers' attributes and behaviors variables.

Dependent Variables		Sum of Squares	df	Mean Square	F	*p*
Age	Between Groups	17.979	3	5.993	4.858	.002*
	Within Groups	544.097	441	1.234		
	Total	562.076	444			
Education	Between Groups	12.414	3	4.138	3.320	.020*
	Within Groups	549.663	441	1.246		
	Total	562.076	444			
Occupation	Between Groups	34.664	3	11.555	9.661	.000*
	Within Groups	527.413	441	1.196		
	Total	562.076	444			
Objectives	Between Groups	9.766	3	3.255	2.599	.052
	Within Groups	552.311	441	1.252		
	Total	562.076	444			
Frequency	Between Groups	17.055	3	5.685	4.600	.003*
	Within Groups	545.021	441	1.236		
	Total	562.076	444			

*p<.05 is the level of significance.

CONCLUSIONS AND RECOMMENDATIONS

A comparative analysis between the passengers' levels of need for location information and each different factor suggests that every factor has a relationship showing differences in terms of the need for location information with environmental graphic design of directional signs to assist the decision making for wayfinding in subway stations of the Metropolitan Rapid Transit, Chaloem Ratchamongkhon Line as follows;

Issues related to the physical environment influence the behavior of travelling. From the survey summary showing the relationship between the current passengers' travelling behaviors and the visibility of the signage in all four steps through the subway stations. The signage group with multi-directions of those state directions and information for various routes; they are important and necessary for passengers for decision making; this is in step 2 directional sign and step 3 informational sign. Thus, the approaches to solve the problems of wayfinding and the possibility to show more location information on the routes for the passengers in step 2 directional sign are likely to increase the opportunity and alternatives for passengers to choose correct ways.

Regarding aspects of the physical environment of stations which have an impact on the level of need for location information. When the differences between directional signs and the level of need for location information for each station of the physical environment are analyzed, it can be concluded that the form of signs with 2-point locations provides additional location information to a decent extent and is suitable for the general environment of every station. However, if there is a need for additional information for wayfinding using signs with 3-point locations, the station's physical environmental must not be too complicated such as Silom Station (2-way exits) or Sukhumvit Station (3-way

exits). This is because specifying the location information, the amount of further information and the stations' physical environmental are related to each other. This affects the needs and wayfinding of passengers. Therefore, providing further location information on the directional sign must be careful.

Aspects of the characteristics of passengers, including gender, age, education, occupation as well as objective and frequency of travelling are components that affect the level of need for location information. Regarding the variable of gender, it was found that females had a higher need for further location information than males. Females focus on minor details, and there is a need for more information in diverse locations for decision making in wayfinding. This is different to males, who focus on memorizing the way as a whole while they are travelling.

Accordingly, there were some differences between the signs with 3-point location to three variables; age, education level, and profession. For the variable of age, the passenger groups of 20-60 years of age had an increasing level of need for further location information which was different from the passenger group of lower age. The reason why the group with low age affected in terms of travelling was that the group of passengers lower than 20 years was the group of students. For the variable of education level, the passenger group with an education level of BA or a higher had higher level of need for further location information than the group with lower education level than BA. Their everyday-life routines in commuting were not diverse locations. Their daily destinations were relatively constant which is different to the group of passengers with a higher or working age. For the variable of the profession, the group of passengers who were housekeepers/retirees had an increasing level of need for further location information which was different from the other groups because they always had various travelling objectives.

Regarding the variable of the objective of travelling, there were differences regarding signs with 3-point locations as well. The passenger group with travelling objective to work had a higher need for further location information and this was different from the student group corresponding to the age and occupation variables. Hence, the factors related to working, diverse objectives and activities affect the need for further location information for travelling in every-day life. Lastly, regarding the variable of the frequency of travelling, it was found that there are differences regarding signs with 3-point locations. The passenger groups who used the train services more than 6 times/week were different to all other groups. A higher frequency of travelling leads to a decrease in the level of need for further location information among passengers. This shows that experience and familiarity with locations are a factor that supports wayfinding.

The recommendation of this research focused on studying the environmental factors which influence specifying of information for directions in environmental graphic design, the acknowledgement of the passengers' needs and restrictions for specifying information and understanding differences in terms of specific characteristics of travelling, with the intention to have appropriate environmental graphic design that does not negatively affect the passengers' wayfinding. However, this research did not cover very complicated physical environment problems which require the addition of location information on the directional sign that exceeds the passengers' limit. This is an issue that requires further in-depth study to discover the suitable methods and support the wayfinding for passengers in subways or other mass transport stations, which can support the development of wayfinding systems beyond the present standards.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The author declares no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

The research presented in this paper was partially supported by Nation Research Council of Thailand (NRCT). We would like to thank the Multidisciplinary Design Research Program, Faculty of Architecture, King Mongkut's Institute of Technology Ladkrabang (KMITL).

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