Study on Walkability around Stations of Urban Railway in Bangkok

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Abstract: Although urban railways have been developed to alleviate traffic congestion in Bangkok, the number of people access/egress to stations by walking is quite small. To increase the number of users accessing to the stations by walk, improvement of walking environment is one of crucial measures. However, the conditions of walking environment around stations have not been grasped. Thus, this study focuses on walkability and intends to understand the actual conditions of walking environment around railway stations in Bangkok. Firstly, walkability was defined as the indicator represented "the ease of passing" and the method to evaluate it around the stations by giving weight to evaluation items based on AHP is developed. Secondly, measured walkability near the stations was compared with that in the station in Japan where the land readjustment project has been applied. As the result, the actual conditions of walking environment around the stations in Bangkok were clarified.

Keywords: Walking Environment, Walkability, AHP

1. INTRODUCTION

In Bangkok, traffic congestion is one of major social problems. And, the urban railways have been developed to alleviate serious traffic congestion. However, the percentage of walking (including bicycles) in terminal trip end mode has remained only around 20% (Chalermpong *et al.*, 2007). This fact indicates that the movement of residents around the station still depends on automobile traffic. Dependence on automobile traffic hinders environmental problems and resolution of traffic congestion. As this reason, it is thought that the walking environment around the stations is not sufficiently developed. Promoting the use of urban railway on foot by improving the walking environment around the station is important for reducing dependence on automobile traffic. However, the actual condition have never been grasped. Therefore, this study proposes the method to evaluate walkability around the stations of urban railways and apply this method to three railway stations in Bangkok. And those actual conditions were also evaluated.

2. LITERATURE REVIEW

Walkability is a word that indicates "the ease of walking", but it is defined in many ways. For example, Fujimoto *et al.* (2011) defined walkability as "the concept including the whole living environment that promotes walking". Also, Centers for Disease Control and Prevention (2015) defined walkability as "the idea of quantifying the safety and desirability of the walking route.

Several attempts have been done to measured walkability based on a field survey in Bangkok. For example, Chalermpong *et al.* (2007) carried out a questionnaire survey at urban railway stations in Bangkok and estimated using multinomial choice model. From the result, the tendency to walk to stations was analyzed. And, Iamtrakul *et al.* (2014) measured the importance of each factor influencing contact on foot to urban railway stations in Bangkok by using AHP. However, there are no researches which analyzed the ease of passing of roads. So, in this study, walkability as the indicator "the ease of passing" was measured and working environment near the railway stations was evaluated.

3. EVALUATION METHOD FOR WALKABILITY

First, evaluation items were set for three types of walking environments including road/sidewalk, pedestrian bridge, and crosswalk, respectively. Also, score for evaluation items were set. Four levels of services were defined for each item which characterized walking environment. In addition, the evaluation items were set based on the past research (Fujimoto *et al.*, 2011), Road Structure Ordinance (2004) and public documents (e.g. City and Regional Development Bureau, Ministry of Land, Infrastructure and Transport, 2008) issued by the Ministry of Land, Infrastructure and Transport. In these documents, detailed agreement and set values for the development of walking environment in Japan are written, so they are used as reference for setting the evaluation items. As shown in Figure 1, the score was made continuous according to the contents of each evaluation item, or discrete value type such as 1, 3, and 5.

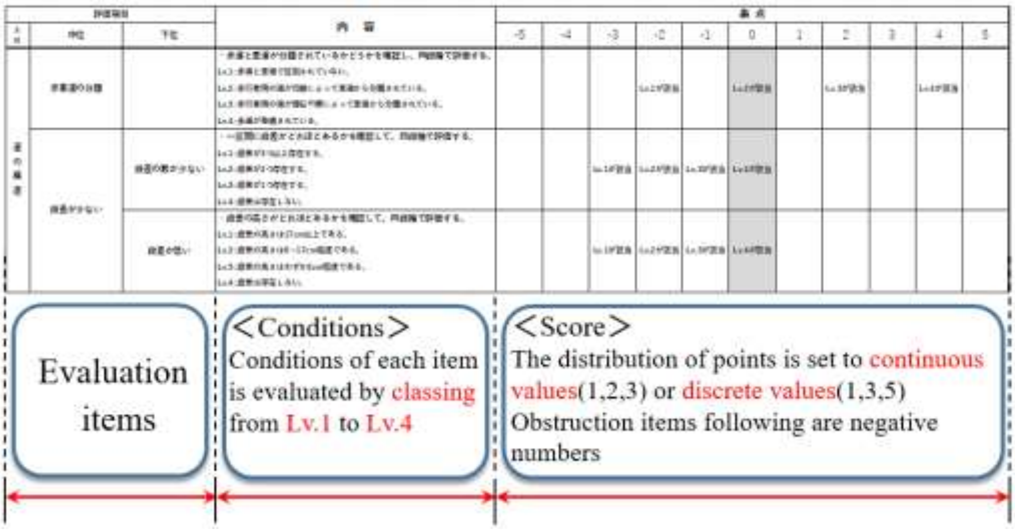

Figure 1. An example of a score table used at grading

Next, all the walkable spaces in study areas were divided into every 20～25m, and rank were selected for each evaluation items based on observation. In addition, AHP questionnaire interviewed by the experts was carried out to obtain weight of each evaluation item. The total evaluation value for each section was obtained by multiplying score for each item by their each weight.

$$\gamma_i = \alpha_1 \cdot \beta_1 + \alpha_2 \cdot \beta_2 + \cdots\cdots\cdots\cdots + \alpha_n \cdot \beta_n \quad (1)$$

Subject to,

γ_i : total evaluation value for each sections,
α_i : score points of each items,
β_i : weights (importance) of each items,
n : number of items.

In addition, in case I compare for the results of each survey point, the evaluation value of each section was standardized with using equation (2). The maximum value of the total evaluation value of each of road/sidewalk and crosswalk converted into 1 and the minimum value converted into 0. After that, the geometric mean value was obtained as shown in the formula (3). Even if walkability is poor at one section, total walkability as a route might be low. Therefore, geometric mean was employed.

$$\varphi_i = \frac{\gamma_i - \gamma_{min}}{\gamma_{max} - \gamma_{min}} \quad (2)$$

$$\pi = \sqrt[n]{\varphi_1 \times \varphi_2 \times \cdots\cdots\cdots \varphi_n} \quad (3)$$

Subject to,

φ_i : standardized walkability in section i,
γ_i : walkability in section i,
γ_{min} : the minimum value of walkability,
γ_{max} : the maximum value of walkability,
π : total walkability,
n : number of sections.

4. SURVEY METHOD

To correct data for evaluation walkability around stations in Bangkok, the following works had done.

4.1 Study Area

Three stations, namely Thong Lo station of BTS Sukhmvit line located in commercial area, Ban Thap Chang station of ARL located in new residential area around Suvarnabhumi airport and Yaek Tiwanon station of MRT purple line in north suburban residential area were selected as study areas. The reason for selecting these stations is that each of them is located in different environment in Bangkok. Each of them is located in central area, suburban area, and new residential area. And, in selecting these stations, the ease of survey around the station is also considered. In addition, Kozunomori, the station of Keisei railway was selected as the place to compare with them. Around this station, land readjustment project has been applied and good walking space is provided. By comparing walkability at the three stations in Bangkok with that in Kozunomori station, and actual conditions and problems of walking space around stations in Bangkok were extracted.

4.2 Data Collection

Data regarding walking environment was measured at the area within 400m radius circle of Thong Lo station, Yaek Tiwanon station and Ban Thap Chang station on August 27-28, 2016. Also, data was measured at the area within 400m radius circle of Kozunomori station was on November 23, 2016. The reason to collect at the area within 400m radius circle that it is the acceptable walking distance in this area based on past research (Chalermpong *et al*., 2007; Azmi *et al.*, 2015), the physical conditions of the inner roads such as width of road, steps, obstacles, surface conditions, etc. were measured and also walking environment was recorded with video cameras. The following Figures 2 to 5 are the photos showing the stations and their surrounding plus the survey scope. The survey was conducted in the area surrounded by a light blue color.

Figure 2. Thong Lo

Figure 3. Ban Thap Chang

Figure 4. Yaek Tiwanon

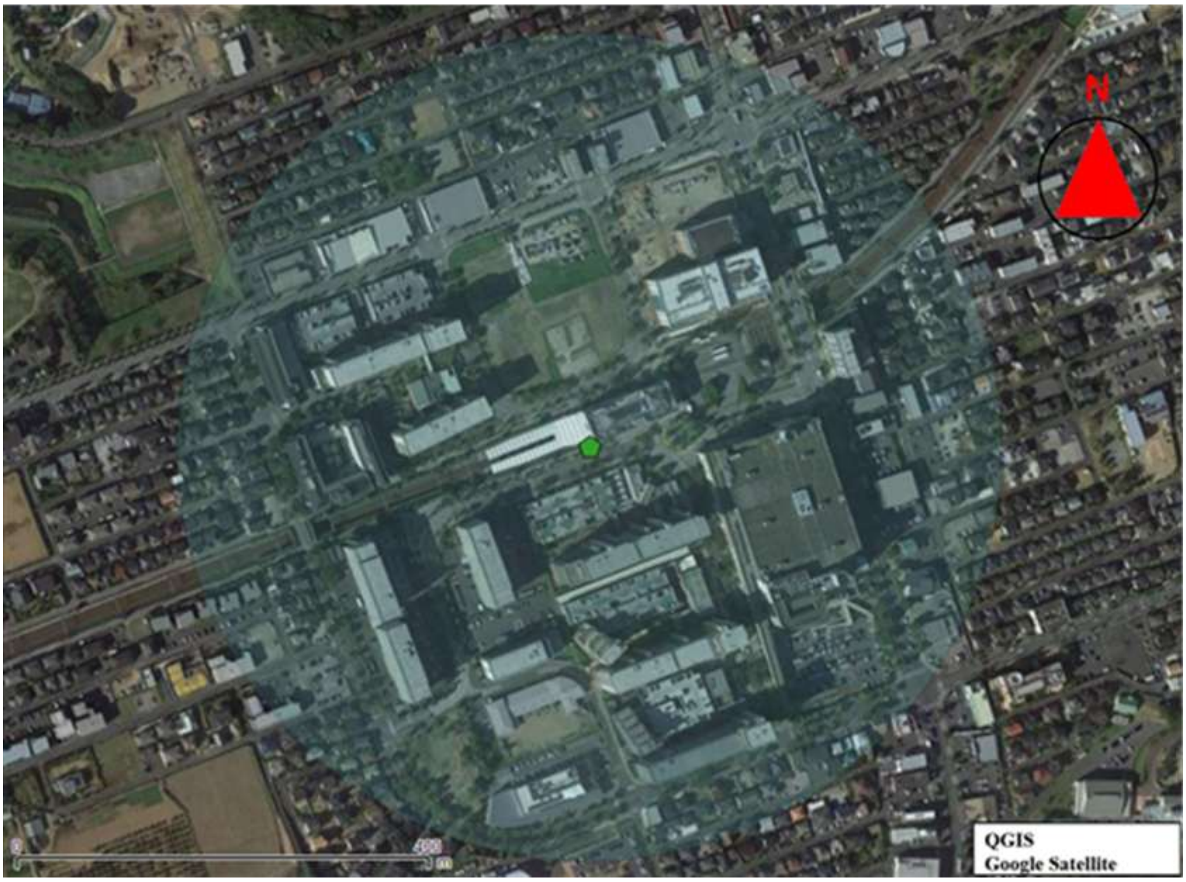

Figure 5. Kozunomori

4.3 AHP Questionnaire

To obtain walkability by road section, the weight (Importance) of each evaluation item was estimated by using AHP. AHP gives weights to each evaluation item based on the questionnaire result of experts. The advantage of using AHP is that it can objectively gain the weights with a small number of samples. In the questionnaire, each evaluation item was divided to the upper item, the middle item, and the lower item, and evaluation was done by the nine-point method. In this AHP questionnaire, evaluation was done by the nine-point method as shown in Figure 6. Seven experts who had more knowledge about walking environment in Bangkok or technical knowledge about walking environment were selected as the respondents of this question.

	Important				Same			Important		
Pair comparison value αij	9	7	5	3	1	1/3	1/5	1/7	1/9	
	5	4	3	2	1	2	3	4	5	
A Structure of Sidewalks	*	*	*	*	*	*	*	*	*	B Environment of Sidewalks
A Structure of Sidewalks	*	*	*	*	*	*	*	*	*	C Equipments on Sidewalks
B Environment of Sidewalks	*	*	*	*	*	*	*	*	*	C Equipments on Sidewalks

1: Same
2: A little important
3: Important
4: Very important
5: Critical important

Sign	Name	Evaluation Content
A	Structure of Sidewalks	It means whether the structure of sidewalks is suitable for pedestrians or not
B	Environment of Sidewalks	It means whether sidewalks are clean, safety and convenient for pedestrians or not
C	Equipments on Sidewalks	It means whether equipments help pedestrians exists on sidewalks or not

Figure 6. An example of question of AHP questionnaire

From the result of the questionnaire, weight of each evaluation item is calculated by the following procedure. Firstly, the comparison result is multiplied by pair comparison value α to create a pair comparison matrix as shown in Figure 7.

	A. Structure	B. Environment	C. Equipment
A. Structure	1	2.649	5.743
B. Environment	0.378	1	4.211
C. Equipment	0.174	0.237	1

Figure 7. An example of a pair comparison matrix

Secondly, the geometrically averaged comparison value of each item is divided by the sum of the geometric mean values to find weight as shown in Figure 8..

	A. Structure	B. Environment	C. Equipment	Geometric Means	Weight
A. Structure	1	2.649	5.743	1.915	0.549
B. Environment	0.378	1	4.211	1.095	0.314
C. Equipment	0.174	0.237	1	0.477	0.137
				3.487	1

Figure 8. An example of obtaining weight

Results to estimate weights for each item both on roads and sidewalks are shown in Figure 9. In the upper item, the weight for the structure of the road was as high as 0.621, and in the middle item, the weight for pedestrian-vehicle separation was high. Similarly, in the case of a pedestrian bridge, as shown in Figure 10, the weight for the structure of the pedestrian bridge was the highest at 0.794 and the weight on the footbridge's environment was 0.206 at the upper items. In the middle item, the weight for the width of the pedestrian bridge was high. In the case of crosswalk, as shown in Figure 11, the weight for the crossing facility was the highest at 0.794 and the weight on the crosswalk environment was 0.206 at the top item.

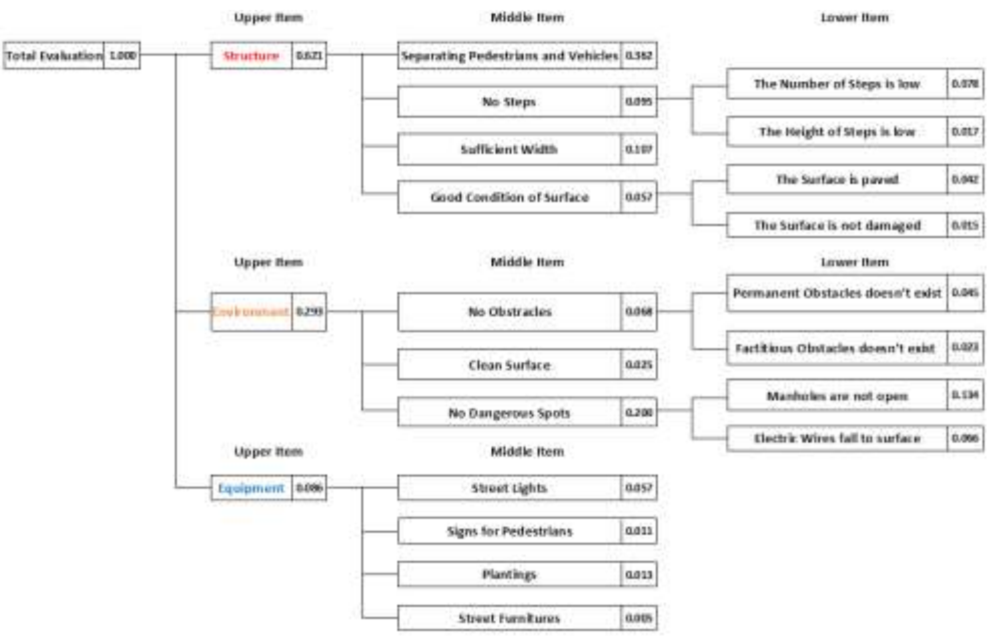

Figure 9. Results of weighting on roads and sidewalks

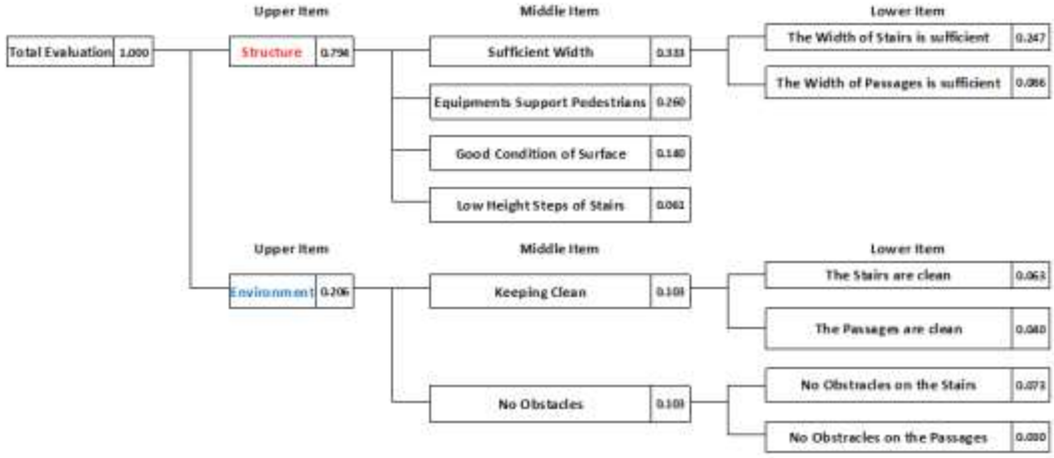

Figure 10. Results of weighting on pedestrian bridges

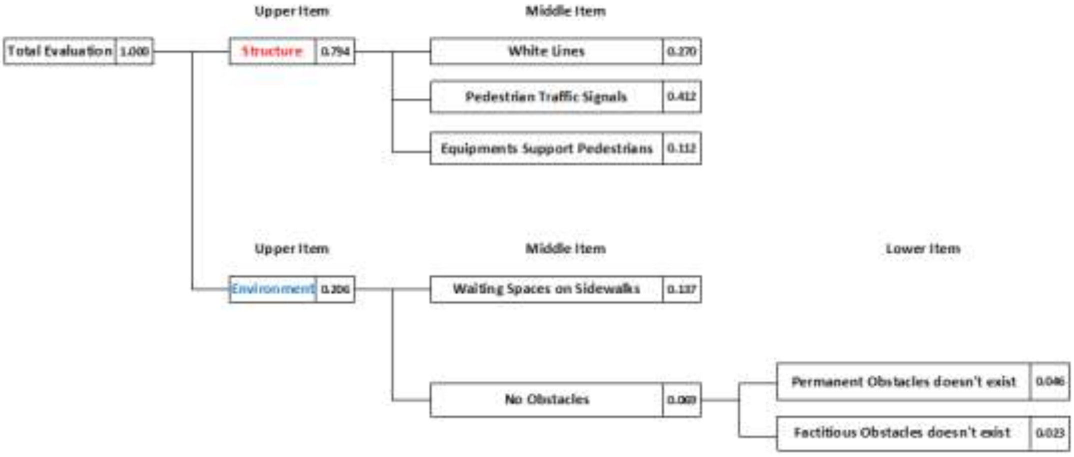

Figure 11. Results of weighting on crosswalks

5. EVALUATION RESULT FOR WALKABILITY

The evaluation results for each study area are depicted by using GIS as shown in Figure 12 to Figure 15 below.

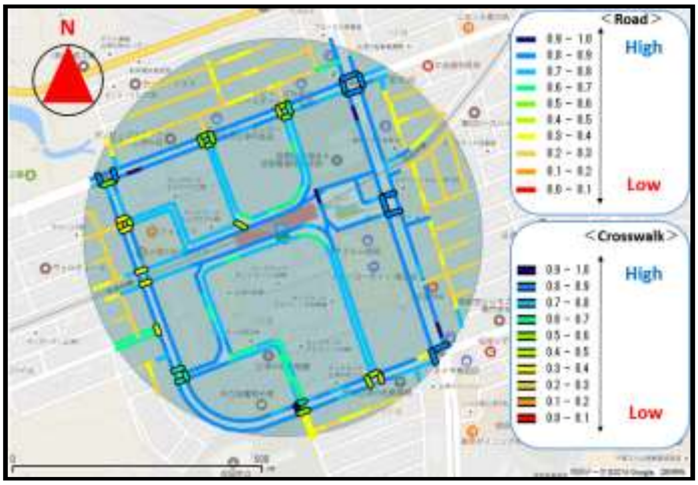

Figure 12. Kozunomori

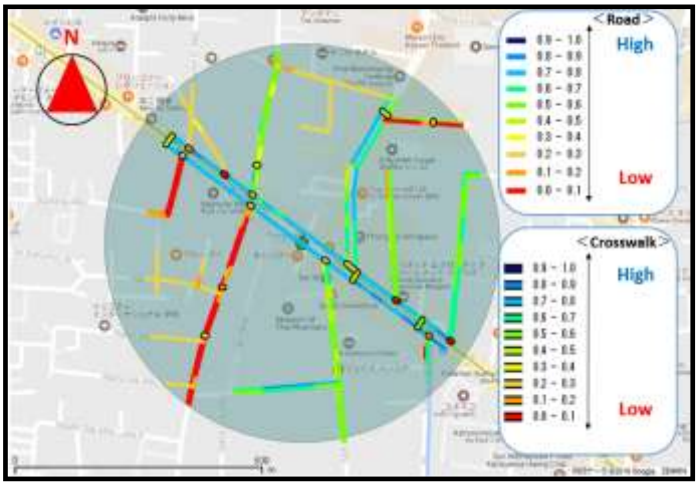

Figure 13. Thong Lo

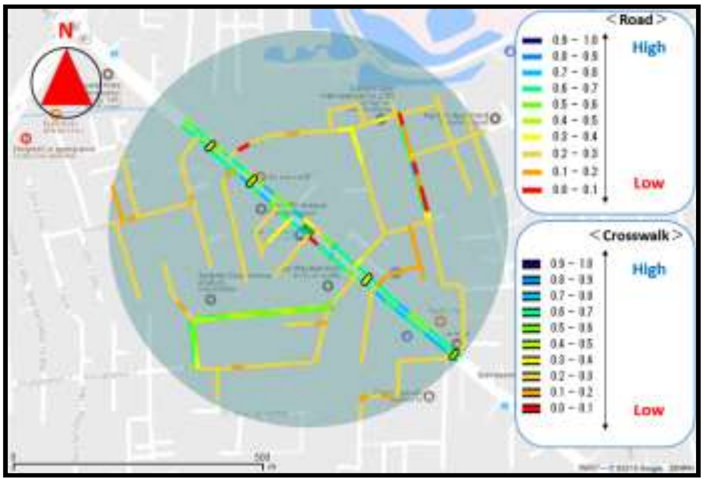

Figure 14. Yaek Tiwanon

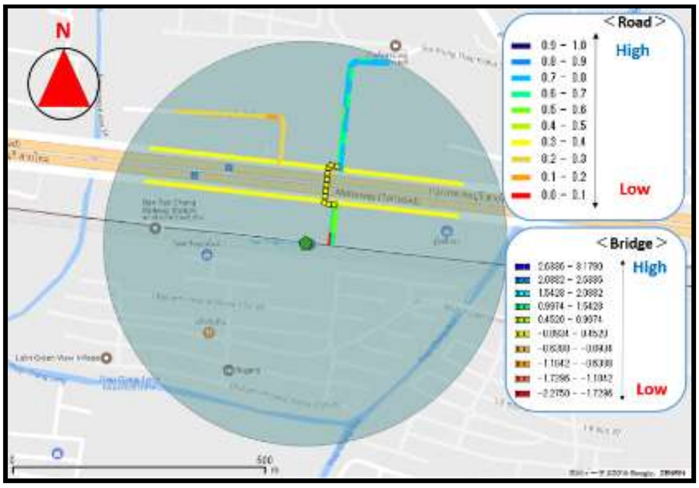

Figure 15. Ban Thap Chang

In these figures, a section having a color close to blue is a section with high walkability, conversely while a section with color close to red means low walkability. Shown in Figure 12, at Kozunomori station it can be seen that the road along the main trunk line and the central part have good walkability relatively. On the other hand, as shown in Figure 13 to 15, around three stations in Bangkok, it can be seen that there are sections with low walkability even along the main trunk line. In addition, in the side road part of Kozunomori station, the total evaluation value is at least 0.3 or more at minimum, but in three stations in Bangkok, there are a section of 0.2 or less in the side road part. So, around urban railway stations in Bangkok, there are several problems in walking environments, and it is judged that walkability is not high.

6. COMPARISON OF RESULTS

Comparison of results was conducted for each of three survey targets: sidewalk / road, pedestrian bridge, crosswalk. Total walkability was used for comparison of results

6.1 Road / Sidewalk

On the sidewalks / roads, as shown in Figure 16, the results of Kozunomori station is 0.59, Thong Lo station is 0.45, Yaek Tiwanon station is 0.31, Ban Thap Chang station is 0.40 were obtained. Obstacles such as stall and street parking, status of development of the sidewalk, the width of the roads and sidewalks were mentioned as elements that influence the magnitude of walkability. Especially, the presence or absence of development of sidewalks was considered to be more important so that the total evaluation value of walkability tended to be remarkably low in the section where the sidewalk are not developed. For that reason, Yaek Tiwanon station, where sidewalks were not well developed on side roads, got a particularly low rating.

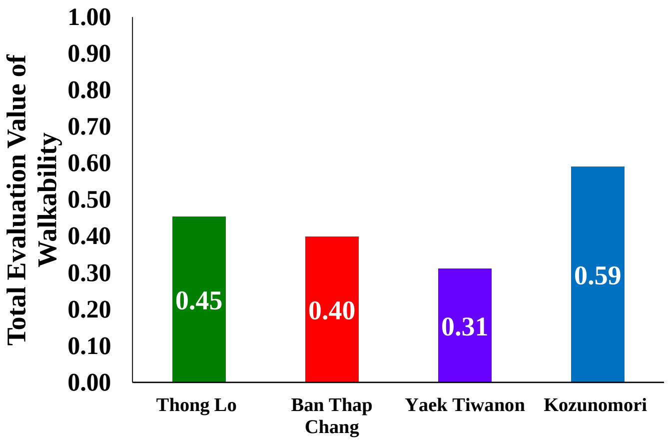

Figure 16. The evaluation result about road/sidewalk

6.2 Pedestrian Bridge

Pedestrian bridge exists only in Ban Thap Chang in all study areas. Equipment such as roofs and handrails has been developed for the crosswalk, and as shown in Figure 17, the total evaluation value is 0.175.The result is normal compared with the maximum value of 3.179 and the minimum value of -2.275. On the other hand, although the width of the staircase and the height of the step are important in the questionnaire, on the other hand, there are also problems that the actual width is narrow and the step is too high.

Figure 17. The evaluation result about pedestrian bridge

6.3 Crosswalk

On crosswalk, as shown in Figure 18, the geometric means in Kozunomori station is 0.57, in Thong Lo station is 0.26, in Yaek Tiwanon station is 0.35 and in Ban Thap Chang station is N/A. In the questionnaire, it was found that development of pedestrian traffic signal, the presence or absence of facilities considering pedestrians, and development of standby spaces in sidewalk are more important in crosswalk. Among these, the result that the development of pedestrian traffic signal is more important was obtained, so the crosswalks around Kozunomori station where many pedestrian traffic signals are being maintained became relatively high evaluation. Although there were pedestrian traffic signals around Thong Lo station as well, they did not operate normally, which caused the evaluation to be lowered. And, as the reason why the result of Thong Lo station is lower than that of Yaek Tiwanon station is the disappearance of the white line and the small number of standby space at the sidewalk are mentioned.

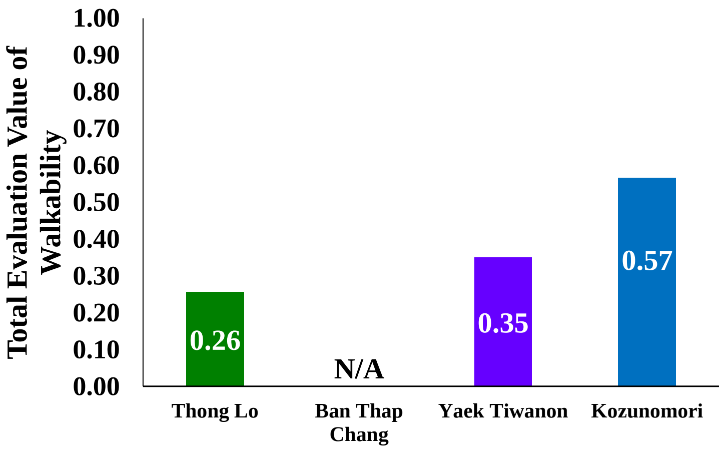

Figure 18. The evaluation result about crosswalk

7. CONCLUSION

As the result of the evaluation of the walking environment in this research, the current situation and problems of the walking environment around the stations are grasped. Problems common to walking environments around the three stations where the survey was conducted include narrow width of the road, large number of obstacles and steps, bad condition of the road surface, poor development of the sidewalk. In addition to these, the low condition of maintenance of crosswalk can be cited as a problem around Thong lo station. Furthermore, as the results of the AHP questionnaire showed a tendency to emphasize the structures and facilities of road/sidewalk, crosswalk, and pedestrian bridge, it is necessary to improve these to improve walkability. Further improvement of urban railway is planned in the Bangkok (Mass Rapid Transit Authority of Thailand, 2017), but in order to solve the above problems, it is thought that it is necessary to consider the system and criteria for improving the walking environment around the station. Also, about evaluation method, it is necessary to consider how to reflect elements that have not been reflected in the current evaluation such as road slope and traffic volume of car traffic. In this research, by evaluating the walkability around the surveyed station, the problems of the walking environment around these stations were extracted. These results can be considered as reference materials in considering future walking environments. In order to investigate effective proposals for improving walking environment around the stations, it is necessary to continue further research. But, A simple and effective method that can be proposed at the moment is to reduce obstacles on the street. The value of the weight of the obstacle item is not so high but, it is thought that it is possible to improve the walkability cheaply and quickly rather than developing sidewalks.

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