OBSTRUCTIONS AND EFFECTIVE WIDTH OVER A STREET SIDEWALK*

by Masaaki MINAMI**, Yusuke AOYAMA*** Akira ANDO**, and Ryuichi AKATANI**

1. Introduction

Street environment should be accessible, comfortable and safety for pedestrians, such as commuters, shoppers, and tourists including elderly and disabled. The street plan, which has a barrier-free environment and also has an aesthetic sidewalk, will synthesize pedestrians and street environmental design into harmonious system. Benches, vegetations, and sculptures are located over the sidewalk. They make us comfortable and stimulate cultural life of the surrounding area[1]. Also they often promote cultural tourism, neighborhood mutual relationship, and an improved quality of life for the community

However, they sometimes become obstructions for pedestrians walking on the sidewalk. Interactions between obstructions and pedestrians are important factors for designing a street sidewalk. In recent years, some articles analyzing these obstructions have been presented and revealed how to affect pedestrians. Yoshikawa, H., Sano, M., Mihoshi, A., and Hujimori, A[2] pointed out there was no criterion about 'slope length' in the guideline for barrier-free road improvement. They made laboratory experiment with wheelchair and showed a relationship between slope length, gradient and pedestrian's power to move. Maeda, C., Kawamura, A., Takahashi, K., Nakaoka, R., and Shimizu, H.[3] was focusing on oscillation characteristics caused by roughness on a road surface according to a pavement material. Fujiyama, T. and N. Tylor[4] investigated pedestrian's walking speeds on stairs, stair-gradients and pedestrian's physical characteristics. V.P.Sisiopiku and D.Akin[5] presented observational study of pedestrian behaviors and perceptions towards various pedestrian facilities. Such facilities include signalized and unsignalized intersection crosswalks, physical barriers, midblock crosswalk shelters and so on.

This paper is focusing on a relationship between 'effective width ' and pedestrian over a sidewalk that has some obstructions. Pedestrian's spatial distribution over a sidewalk is carefully observed using a video captured data from a field survey. The analytical results are shown such as pedestrians' trajectories, pedestrians' mutual interruptions and also remaining snow affections. We find out a pedestrian's trajectory has a tendency toward the center of sidewalk caused by the obstructions even if the pedestrian is walking independently. The tendency does not always mean pedestrians' time occupation near the center of sidewalk becomes longer. It is clarified that the basic indices of pedestrians' sidewalk, such as 'effective width' and 'density' are insufficient for designing this type of sidewalk.

2. Method

(1) Study site and Geometrical data

'Zaimoku - chyou - Doori Street' in Morioka city, Japan, was selected as a case study site in this research. Morioka's citizen and tourists are quite familiar with the street and its surrounding area. On the street sidewalk, some sculptures are located to tell their stories well. The sculptures are a figure of Kenji Miyazawa and his fantasy world written in his articles that reveal Morioka's identity. A street market is held on every Sunday in a summer season that has 300 thousand customers during a year and tourists for Morioka city frequently visit there.

*Keywords: street obstruction, street environmental design, barrier-free design
**Member of JSCE, Dr. Eng., Dept. of Civil & Environmental Eng., Faculty of Eng., Iwate Univ.
(Ueda 4-chome, Morioka, Iwate, Japan, TEL019-621-6454, FAX 019-621-6460)
*** Student Member of JSCE, Dept. of Civil & Environmental Eng., Faculty of Eng., Iwate Univ.
(Ueda 4-chome, Morioka, Iwate, Japan)

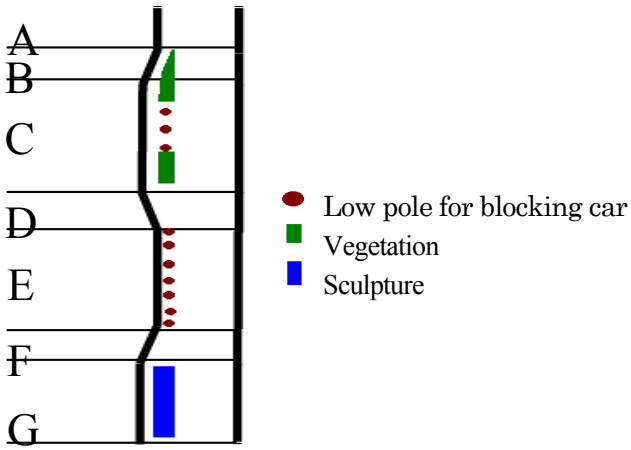


Fig. 1 Observation site (sections and obstructions)

Table 1 Basic geometrical data of observation site

(m)

section	width at northside	width at southside	length	facility on road
A	2.5	2.5	12.0	crosswalk
B	2.5	5.0	8.0	
C	5.0	5.0	27.0	hamp
D	5.0	2.5	10.0	
E	2.5	2.5	24.0	
F	2.5	5.0	9.0	
G	5.0	5.0	20.0	

Geometrical data of the sidewalk were measured from a field survey. The whole length of the street is 400m and the observation site is a sidewalk of 110m long on east - south part within the street. Fig. 1 shows the observation site. It also shows locations of some obstructions along the sidewalk, such as figure of Kenji Miyazawa, vegetations, and low poles for blocking cars. Basic geometrical characteristics about a width and a length of each sidewalk section are summarized on Table 1.

(2) Pedestrian's data collection and Database system development

Pedestrian's spatial trajectories are formed as a result of the interactions among pedestrians in the traffic stream and also between pedestrians and environmental characteristics of the sidewalk. The analysis of this study is mainly focusing on an interaction of a pedestrian and his/her street environment. Therefore, we examined the observation during the time period that pedestrian's flow was light and had no congestion.

The pedestrian's spatial trajectory data were obtained from field survey using two video cameras. The cameras set up at landing floors of the 4th and 7th story of a building beside the street. The cameras were placed consecutively in such a way that their fields of view were slightly overlapped.

The data collected during 13 hours on weekdays as follows.

- Dec./10/2003 8 a.m – 3 p.m
- Mar./04/2004 8 a.m – 2 p.m. (with remaining snow)

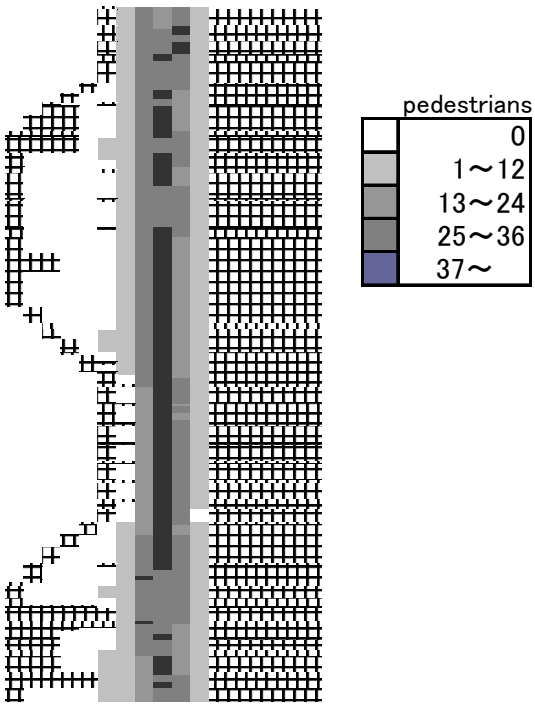
In this paper, a visual database system was developed for analyzing the data collected from the field using video cameras. Spreadsheet program was used for the basement of the visual database. The sidewalk along the observation site separates a lot of small segments of 0.5m x 0.5m to quantify a pedestrian's spatial trajectory. Each segment over the sidewalk corresponds to each cell of the spreadsheet. Macro programming was used for visualization of pedestrian's trajectories, analysis of their behavior, and also calculation of their speeds. We can see the pedestrian's distributions directly from the outputs of the database system.

3. RESULTS

1) Pedestrians' trajectories - walking independently

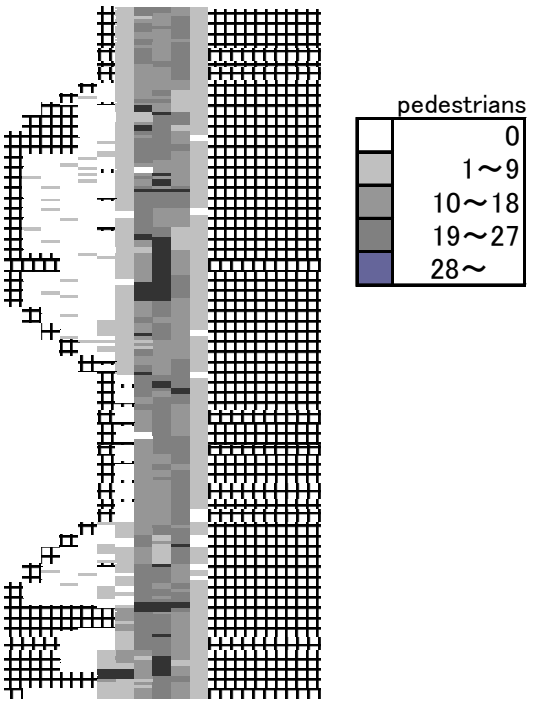
Fig.2 shows 100 pedestrians' trajectories that walk independently with no interruption from oncoming, passing, and crossing pedestrian. A half of the pedestrians walks from upper side to lower along the street. And the other walks from lower side to upper. Almost all pedestrians are walking alone with the exception of during the peak hours.

We can see the pedestrians have a tendency of walking along the center on the sidewalk even if walking independently. Pedestrians' flow nearby building faces becomes lighter. One column of segments nearby center that has only 0.5m wide are frequently used. Also we can observe trajectories are not always concentrated to the center of sidewalk because of the street environment. In the section G, it could be expected that a sculpture affects the trajectories of the pedestrians.



The number of pedestrians: total 100
50 pedestrians walking from upper side to lower
50 pedestrians walking from lower side to upper
Pedestrian's type:
Pedestrians walking independently with no interruption from oncoming, passing, and crossing pedestrians
Sampling:
Random sampling (Almost all independent pedestrian with the exception of peak hour)

Fig. 2 Pedestrians' trajectories - walking independently –



720 pieces of motionless pictures were picked up from 2 hours video picture by 10 sec. interval.
Sum of pedestrians on each segment
Pedestrian's type:
All pedestrians
Sampling:
From 8 a.m. to 9 a.m (peak hour) and
From 9 a.m. to 10 a.m

Fig. 3 Pedestrian's time occupation

2) Pedestrians' time occupation

Pedestrians' trajectories in the previous sections mean how many times the pedestrians step on each segment of the sidewalk. It has no time concept. On the other hand, pedestrians' time occupation depicted in Fig.3 mean which segment the pedestrians tend to be.

720 pieces of motionless pictures were picked up from 2 hours video picture (from 8 a.m. to 9 a.m (peak hour) and from 9 a.m. to 10 a.m) by 10-second interval. Sum of pedestrians on each segment were counted from the pictures. The pedestrians' distribution on Fig.3 is very different comparing with in the case of trajectories of Fig.2. It means that pedestrians walking on the center of sidewalk frequently do not always occupy the segments for long period of time. In sections C and G, time occupations become longer because of obstructions or a sculpture.

3) Walking direction changing behavior

Pedestrian's walking direction changing behavior is shown in Fig.4. A pedestrian changes his/her walking direction for some reasons. The reasons include interruptions from another pedestrians, geometric structures, obstructions of a sidewalk, and so on.

In Fig.4, pedestrians' walking directions are primarily from upper side to lower side. The number of pedestrians is 70. Pedestrians are walking independently with no other pedestrian's interruptions. 5 columns painted with dark color along the almost whole span of the sidewalk mean pedestrians' trajectories walking straight. If pedestrians larger than 10% change the direction to the right or left at a previous segment, the segment of the direction is painted with dark color in the figure. The figure shows the changing directions have a tendency to the center of the sidewalk.

4. CONCLUSIONS

In this paper, we examined pedestrians' walking trajectories on a sidewalk with some obstructions through a careful observation. An analysis of pedestrian's behavior that is affected by street various environments is not enough within a traffic-engineering research field today. We have no standard criterion or useful methodology how to define an effective width on a sidewalk considering with such obstructions. The comprehensive analytical framework has been presented to quantify a spatial distribution of pedestrians who choose a route almost unconsciously.

The findings we got from observation and analysis are the followings.

1) Effective width of a sidewalk, which has some obstructions, becomes smaller. Width of the sidewalk on the study site is at least 2.5m geometrically. However, pedestrians tend to walk on around 1m wide near the center even if walking independently.

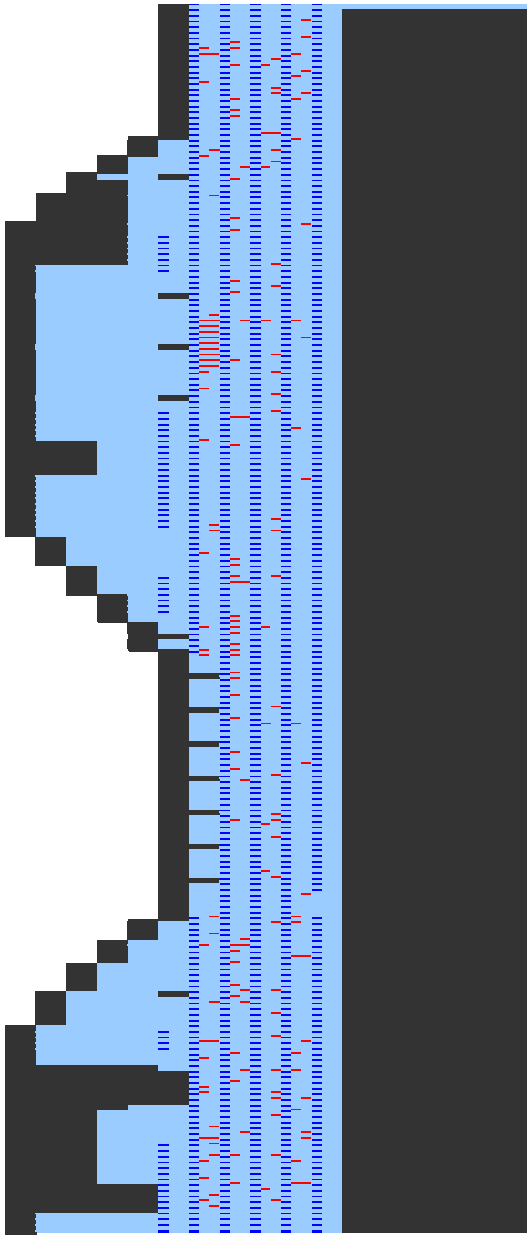
2) Interruptions with other pedestrians and remaining snow as a local factor make the sidewalk narrow and also pedestrians' behaviors become unexpected. But, pedestrians have a tendency toward the center along the sidewalk as well.

3) Spatial distributions of pedestrians' trajectories were very different from pedestrians' time occupations. Pedestrians walking on the center of sidewalk did not always occupy the segments for long period of time.

3) Obstructions are not only furniture but also pedestrians who are standing or walking slow around there. Pedestrians' speeds are various in this type of sidewalk. It is difficult to show the characteristics of pedestrians' distribution by use of a density of pedestrians flow quantitatively.

4) Effective width in a design or improvement planning process should be decided considering with interactions between street obstructions and pedestrians' behavior.

In future studies, interactions between pedestrian's attributes and street environment will be analyzed more in depth.



Pedestrian's primary walking direction:
From upper side to lower
The number of pedestrians: 70 pedestrians
Pedestrian's type:
Pedestrians walking independently with no interruption from oncoming, passing, and crossing pedestrians
Walking direction changing behavior:
If pedestrians larger than 10% change the direction to the right or the left at the previous segment, the segment of the direction is painted

Fig. 4 Walking direction changing behavior

REFERENCES

1) Ando, A., Akatani, R., Sasaki, Y.: Evaluation of Streetscape Considered the Sensitivity of Subject for Landscape (in Japanese), Journal of Infrastructure Planning and Management, No.737, vol.4-60, pp.133-pp.146, 2003

2) Yoshikawa, H., Sano, M., Mihoshi, A., Hujimori, A.: Gradient and Height Difference on a Sidewalk considering Barrier-Free (in Japanese), 59th JSCE Annual Conference, 2004 (CD-ROM)

3) Maeda, C., Kawamura, A., Takahashi, K., Nakaoka, R., Shimizu, H.: Fundamental research on the riding comfort of the wheelchair by the various pavement materials (in Japanese), 59th JSCE Annual Conference, 2004 (CD-ROM)

4) Fujiyama, T., N. Tyler: An Explicit Study on Walking Speeds of Pedestrians on Stairs, 10th International Conference on Mobility and Transport for Elderly and Disabled People, 2004(CD-ROM)

5) V.P.Sisiopiku, D.Akin: Pedestrian: Pedestrian Behavior and Perceptions towards various Pedestrian Facilities: an Examination based on Observation and Survey Data, Transportation Research Part F 6, pp249-274, 2003