# Bicycle and Pedestrian Traffic Conflicts on Shared Pavements

**Masaru KIYOTA**
Professor, Department of Civil Engineering, Saga University, 1 Honjo
Saga, 840-8502, Japan
Tel: 81-952-28-8953, Fax: 81-952-28-8190, E-mail: kiyotam@cc.saga-u.ac.jp

**Upali VANDEBONA**
Senior Lecturer, School of Civil and Environmental Engineering, The University of New South Wales, Sydney 2052, Australia
Tel: 61-2-9385-5056, Fax: 61-2-9385-6139, E-mail: U.Vandebona@unsw.edu.au

**Naomichi KATAFUCHI**
Graduate Student, Department of Civil Engineering, Saga University, 1 Honjo
Saga 840-8502, Japan
Tel: 81-952-28-8953, Fax: 81-952-28-8190, E-mail: 99tk17@edu.cc.saga-u.ac.jp

and

**Shinichi INOUE**
Lecturer, Faculty of Culture and Education, Saga University, 1 Honjo
Saga 840-8502, Japan
Tel: 81-952-28-8304, Fax: 81-952-28-8304, E-mail: inoue@cc.saga-u.ac.jp

## 1. Introduction

An opportunity to study shared usage street space became available with a revision of traffic regulations in 1978 that allowed the introduction of shared usage of footpaths among cyclists and pedestrians (Oka 1981). The amended regulation allowed Japanese planners and traffic authorities to operate without physical segregation of cyclists and pedestrians. This is a significant aid to authorities that had to deal with a large number of narrow streets where there was no scope for segregation. This paper is an attempt to look at shared operations from user point of view and focuses on aspects of safety perceptions. In particular, the paper investigates danger perception triggers with the aid of field observations to provide a better understanding about factors that threaten the sense of safety of pedestrians.

## 2. Shared pavement space usage in Japan

In Japan, pedestrians and cyclists share space at the side of roads as shown in Figure 1. It is readily observed that shared space usage strategy is adopted not only on narrow sidewalks but also on sidewalks wide enough to allow segregated usage without proper analysis about separation and integration.


Figure 1

If densities of pedestrians and bicycles are low, pedestrian cyclist conflicts are infrequent. As these densities increase, potential conflicts among road space users become more frequent. As a result, cyclists are forced to travel on shared road space at low speeds. Pedestrians are also required to be vigilant to take evasive action to avoid collision by passing bicycles. Passing bicycles pose a high level of danger to the elderly and children because of their lack of agility and lack of size, respectively.

## 3. Level of risk perceived by pedestrians

There are several ways to evaluate the level of risk perception of pedestrians in shared space. One method uses the spacing maintained by pedestrians as an indicator of the level of safety. Such a method estimates the perceived level of risk by observing the evasive behaviour of the threatened road user group (Kiyota *at al*. 1995).

A number of simplifying assumptions were made in the development of the model presented here. Focussing on a single pedestrian, it is possible to model the risk perception based on the amount of evasive action taken against a passing bicycle.

Botma (1993) evaluated the comfort and convenience of bicycle paths and pedestrian-bicycle paths based on the frequency of passing and meeting between cyclists and between pedestrians and cyclists (C.R.O.W 1993).

The method developed in this study is based on the level of risk perceived by subjects who evaluated video recordings of pedestrian and bicycle conflicts on a shared space. Video replays were analysed further to measure flow levels and spacing between pedestrians and cyclists.

## 4. Observation technique

The spacing between the pedestrians and cyclists is obtained by establishing a method to record the physical location of pedestrians and cyclists. Five short lines were drawn on the footpath at 5-meter intervals and cross marks were made on these lines at 50-centimeter intervals. These marks were made using masking tape. The spacing between road users in passing could be measured to be nearest 25 centimeters using these reference lines.

Bicycle speed is calculated based on the time taken by an individual to travel between two successive marker lines.

The spacing and speed have been also calculated and verified by using an image processor as well. For that method, images recorded by the digital video cameras were transferred to a microcomputer. For the purpose of speed measurements, the front of the heads of pedestrians and cyclists were identified in Cartesian coordinates and stored at intervals of thirtieth of seconds.

Observations were made in the largest city in Kyusyu, Fukuoka in a clear Saturday and a clear Sunday. Suitable site was selected from sidewalks which satisfied three requirements. These requirements were (a) high frequency of conflicts between pedestrians and cyclists, (b) feasibility for video recording and (c) wide effective width excluding obstacles such as parked bicycles and roadside trees. The observation site was of 20 meters length and consisted of approximately 6.3-meter wide shared space for pedestrian and bicycle movements. However, the effective width was only of 3.5 meters, as there were many illegally parked bicycles on the sidewalk. There were about 800 pedestrian cyclist incidents identified during the recording.

## 5. Effect of pedestrians on cyclists

Analysis of the relationship between bicycle speed and pedestrian density has been carried out to investigate the effect of the presence pedestrians on bicycle movement. The grid markers previously taped on the shared surface provided the means of obtaining an accurate measurement of distance traveled. The internal clock of the video-recording device provided the travel time information. The average bicycle speed when there are no pedestrians in the shared space is found to be about 12 km/hour.

The effect of pedestrians on bicycle speed is shown in Figure 2. It is acknowledged that there is a large scatter of data points shown in Figure 2. However, there is a clear indication that the bicycle speeds are depressed with the presence of more pedestrians using the shared space.

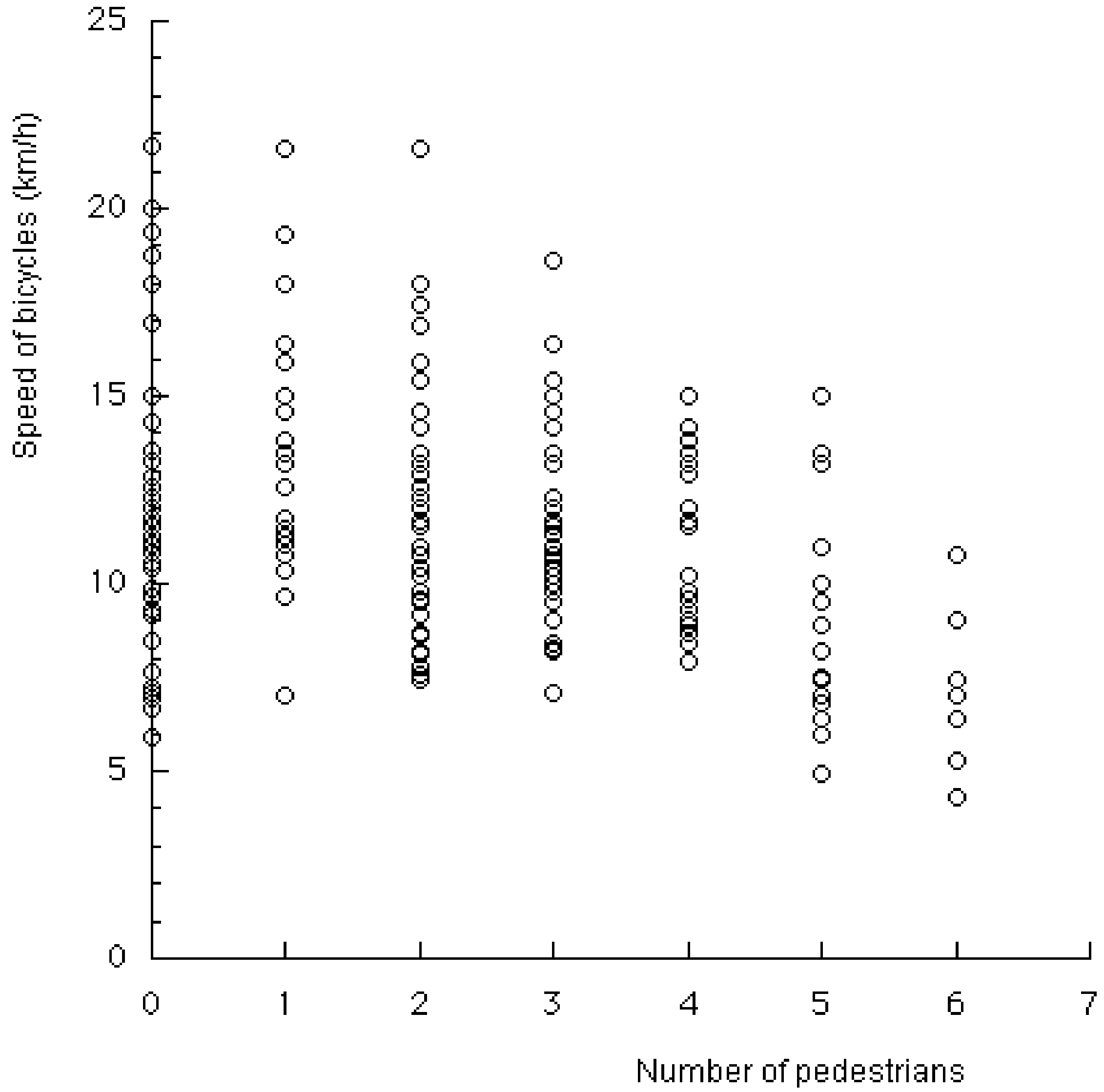


Figure 2

The reduction in bicycle speeds is relatively more pronounced with the increase in pedestrian densities. This relationship appears to be somewhat non-linear. An outcome of this analysis is the identification that cyclists experience a loss of performance with shared usage of space. As expected, the presence of pedestrians on the path is not a desirable feature from the cyclist point of view.

Nevertheless, some cyclists may consider the shared space with pedestrians as a better alternative compared to sharing space with motor cars. This is indicated by the significant usage of the shared space by cyclists. In a parallel study conducted in Sydney, Australia where shared use of footpath is currently illegal, a questionnaire survey of 300 respondents has revealed that there is a considerable preparedness to accept the shared footpath usage.

The main impact of presence of cyclists on the path of pedestrians is an increased level of apprehension of personal safety. This project also investigated the effect of the age group including young children group on the manner pedestrians perceive the risk of collision.

## 6. Effect of cyclists on pedestrians

The survey sample consists of 35 youth attending the Saga University (typical age between 20 and 22 years), 38 elementary school children (age between 9 and 10 years) and 83 elderly peoples (typically above 65 years old). A liquid crystal projector was used to show these 38 video recordings of pedestrian and bicycle conflicts on a shared space not familiar to them. They were interviewed twice for the level of risk perception of each scene from pedestrian point of view. The perceived risk has been classified in a scale of 1 to 3 where 1, 2 and 3 are considered to represent not risky, somewhat risky and risky, respectively.

The risk level reported by a majority of a respondent group is named the dominant level for a particular scene. For example, the dominant level of scene 13 is 3 for university students because 74 % students reported level 3. Figure 3 shows the percentage distribution of dominant levels. On the whole, the elderly and young children feel a higher level of risk than university students do when using the shared footpath.

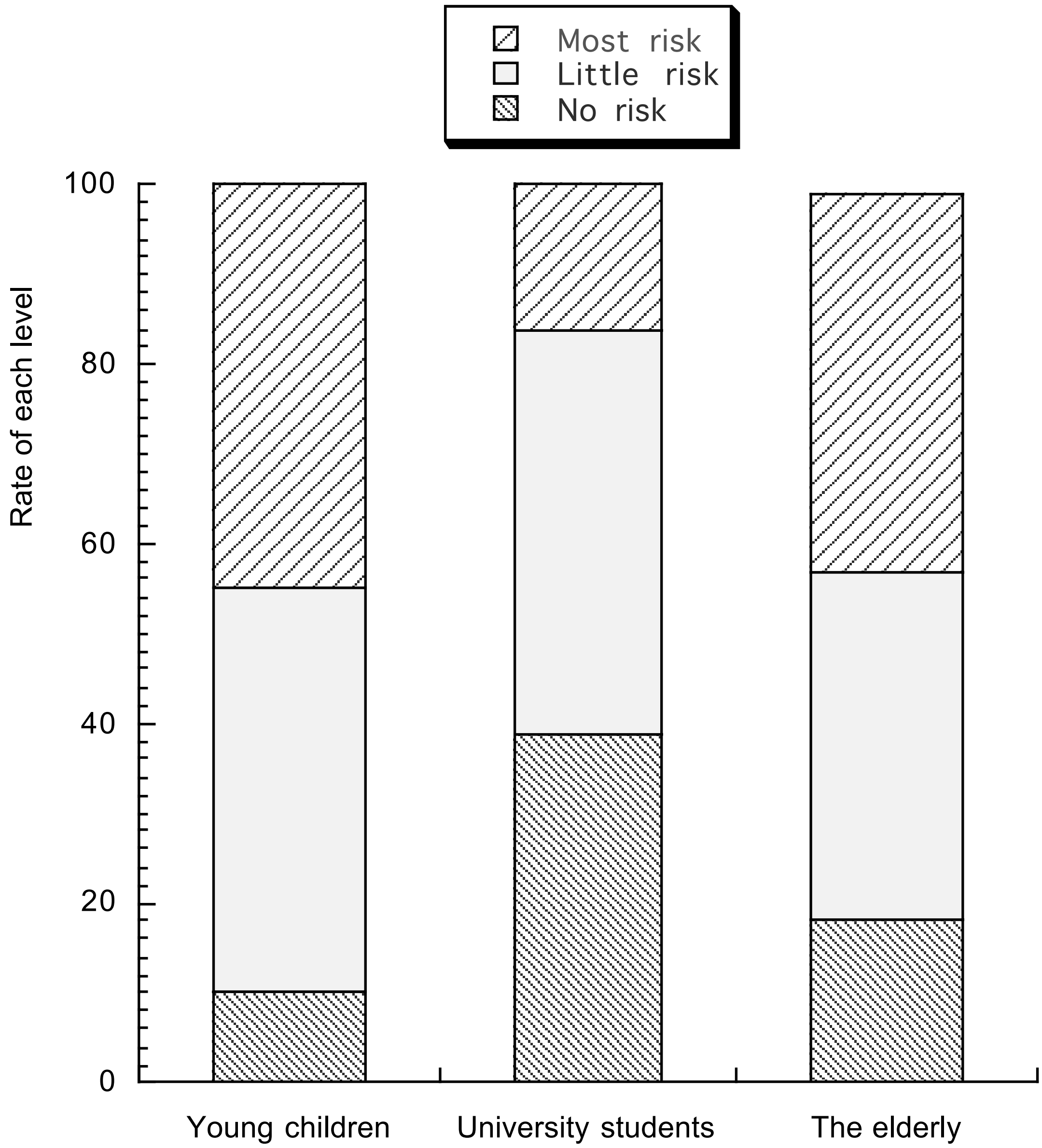


Figure 3

## 7. Level of risk perception of each scene and traffic conditions

As young children are most sensitive to danger of passing bicycles, risk perception of young children has been further analysed.

a) Speed

Figure 4 shows the relationship between bicycle speed and the percentage of children perceiving the highest risk (level 3) category. There is a considerable scatter in the data and shows a large spread. Nevertheless, contrary to our expectation, the level of risk tends to decrease with increase in bicycle speed. For example, when bicycle speed is low, the level of danger is high. The reason for this is that bicycle speed is dependent on pedestrian density. When bicycle speed is low, pedestrians cannot maintain sufficient spacing against passing bicycles. In this situation, many subjects, young children in particular, feel a high level of risk.

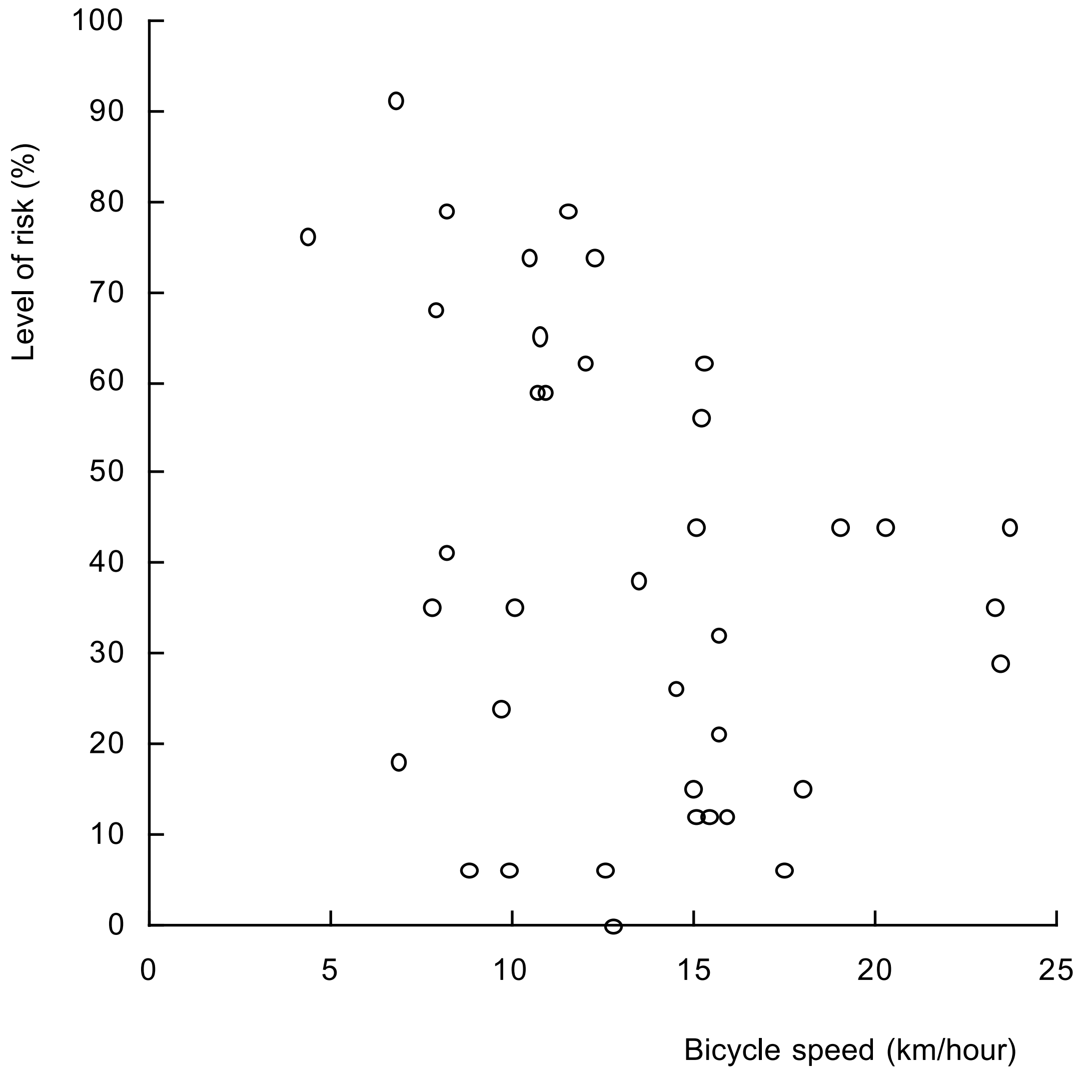


Figure 4

b) Spacing

The relationship between the level of risk of each scene and minimum spacing between the pedestrian and passing cyclist is denoted in Figure 5. As expected, the level of risk tends to decrease with the increase in spacing with bicycles. When the observed minimum spacing (from skull to skull) is less than 75 centimeters, perceived risk is high. On the other hand, the level of danger is relatively low when the observed spacing is greater than 150 centimeters.

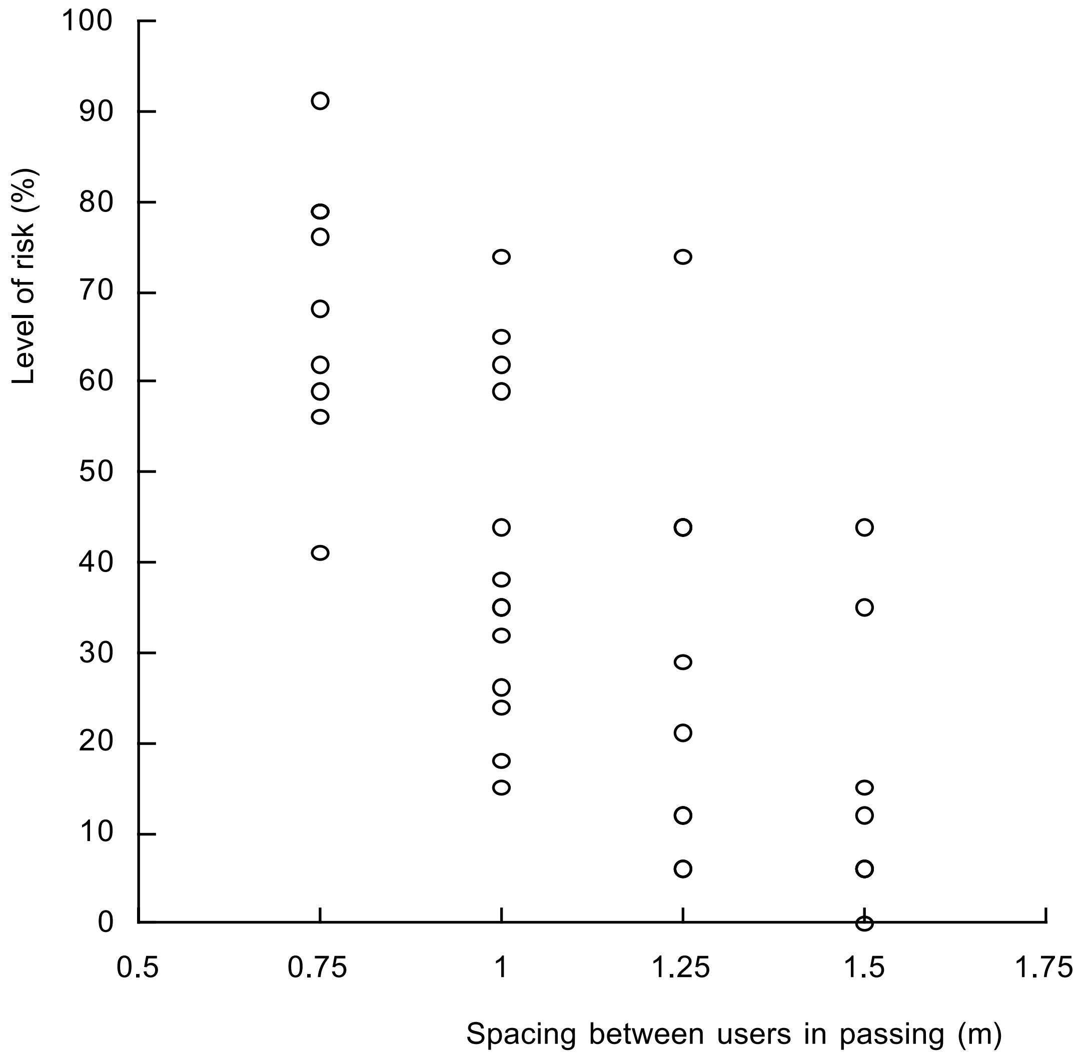


Figure 5

## 8. Model to predict risk perception of pedestrians

Risk is perceived when the danger level exceeds a certain threshold level. A modeling framework to incorporate this concept is available in discrete choice modeling, widely used in travel behaviour analysis (Ben-Akiva and Lerman, 1989). According this model, the level of perceived risk, D, and the threshold $D_0$ are expressed, respectively, as follows:

$$D = \sum a_i x_i \quad \text{for } i = 1,2,3$$

$$D_0 = b$$

Parameters $a_i$ and b are calibrated based on observed data. In the project, $x_1$, $x_2$, $x_3$ denote the spacing between users in passing, the bicycle speed and pedestrian density, respectively. Consequently, the probability that D exceeds $D_0$ is available from a logit formulation.

The model calibration results have shown that, as the value of t statistic is small, the variables denoting the bicycle speed and pedestrian density can be eliminated from the model. Only the spacing between users in passing remains is in this model.

The resulting model is:

$D = -9.08x_1$

$D_0 = -8.54$

The model is deemed adequate, as the choice reproducibility (84.2%) and goodness-of-fit measure (0.36) are satisfactory.

## 9. Evaluation of improvement plan

As mentioned above, it is possible to reduce the probability of risk that pedestrians perceive against bicycle traffic by means of widening the user spacing. The planners can indirectly control this variable by means of changing width of sidewalk. The effect of different spacing is evaluated and shown in Table 1. When spacing between cyclist and pedestrian is less than or equal to 1.0 meter, about 40 % of pedestrians perceive risk from a passing bicycle. As spacing increases, the level of risk decreases. Therefore, it is necessary to maintain sufficient spacing over 1.0 meter on the footpath.

| Spacing between users in passing | The probability that pedestrians feel danger |
|---|---|
| 75 cm | 0.86 |
| 100 cm | 0.39 |
| 125 cm | 0.06 |
| 150 cm | 0.01 |

Table 1 Traffic volume per hour.

The relationship between minimum spacing between users and pedestrian density has also shown considerable scatter in data. However, according to this data analysis, to ensure a 1.0 meter spacing in a 3.5 meter wide 5 meter stretch of road considered here, the number of pedestrians has to be limited to 4. Thus, presence of more pedestrians than 4 warrants a segregation method to ensure a safe environment. On the other hand, less than 3 pedestrians in shared space would be ideal from cyclist point of view as there would be minimal impact on speed as seen in Figure 2.

## 10. Conclusions

The shared use of footpaths by bicycles and pedestrians has provided more opportunities to traffic and transport planners in Japan seeking to optimize the use of urban road space available. The research work presented here addresses the issue of level of risk perceived by users of the shared space. This project has been successful in providing some analytical evidence into the need for further investigation of shared footpath policies.

One manifestation of the increased level of collision risk is the widening of spacing between users in passing. The methodology presented here has allowed monitoring the bicycle speeds and spacing users in passing in an unobtrusive manner and to analyze the effect of pedestrian densities on cyclist mobility.

It has been possible to demonstrate that bicycle speeds are declining with increased pedestrian densities in the shared footpath. However, the perceived risk has not declined with reduced bicycle speeds as shown by the analysis.

It has been also established that the perception of collision risk from the point of view of pedestrians on the shared space is dependent on the physical abilities of those on foot. The age group has been selected as the descriptive variable for the purpose of analysis of this aspect. The elderly and primary school children are clearly more apprehensive of bicycles on the shared footpath compared to young adults represented by University students.

A risk forecasting model has also been developed. The discrete choice model shows that cyclist pedestrian spacing is the primary descriptor of risk perception.

## References

Ben-Akiva M. and Lerman S. R. (1989) Discrete Choice Analysis – Theory and Application to Travel Demand -, The MIT Press, England.

Botma H. (1995) Method to Determine Level of Service for Bicycle Paths and Pedestrian-Bicycle Paths, Transportation Research Record No. 1502, 38-44, Transportation Research Board.

C.R.O.W (1993) Sign Up for The Bike; Design Manual for A Cycle-friendly Infrastructure, Center for Research and Contract Standardization in Civil and Traffic Engineering Record 10, The Netherlands.

Kiyota M., Sumi T., Oheda Y. and Tanaka T. (1995) Cyclists' Behavior Model of Keeping away from the Passing Automobile in a Local Street (in Japanese), Journal of Infrastructure Planning and Management 524/_-29, 131-134.

Oka N. (1981) Urban and Transportation (in Japanese), Iwanami Press, Japan.