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A STUDY ON THE VULNERABILITY TO ACCIDENTS OF ELDERLY PERSONS WITH THEIR CROSSING BEHAVIOR AT NON-PEDESTRIAN CROSSING

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Abstract
Japan statistics reveal that cases of accidents involving the elderly already constitute the majority of recorded cases since 1992. The purpose of this study is to understand the crossing behavior of elderly people so that appropriate measures can be proposed to reduce the accident risk. It was discovered that most accidents involving the elderly is mainly dependent on their diminished walking ability and misjudgement of speed and distance parameters while crossing. The similar factors explain their decision to cross at non-designated pedestrian crossings. It is also shown that their behavior differs much from the other age strata.

INTRODUCTION

In 1970, the number of traffic accident fatalities was recorded at 16,765 and since then had decreased to 8,466 in 1979. However, from 1979, the number had been increasing again and was over the 10,000-level in 1988.

The number of fatalities per 10,000 persons for the elderly generation (persons more than 65 years old) has been more than that for the younger generation since 1995 (Figure-1). Nearly 60% of the accidents involving elderly persons occurred while walking (Figure-2). Many accidents occurred at "non-pedestrian crossing" or sections along the road other than designated pedestrian crossings. (Figure-3). It can be deduced from the above statistics that elderly persons are vulnerable to accidents especially when walking along non-pedestrian crossings.

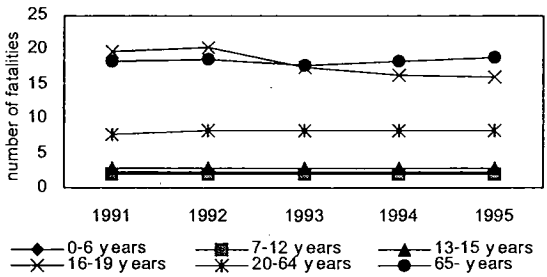

Figure 1 - Number of fatalities per 100 million population

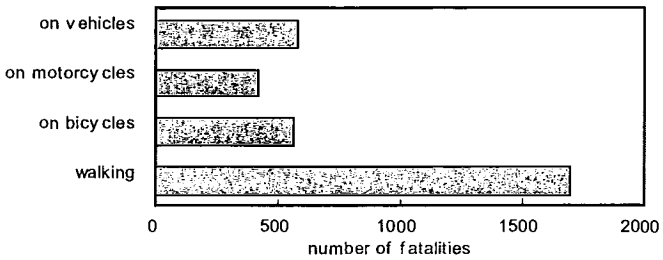

Figure 2 - Number of elderly fatalities on each mode

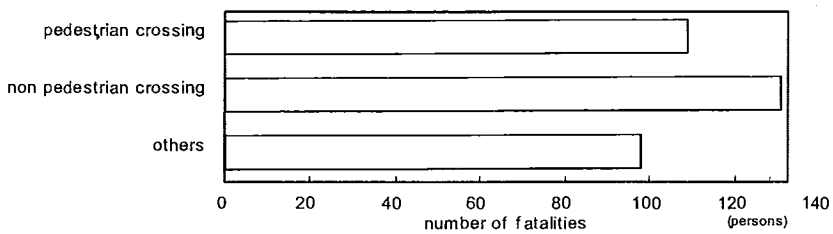

Figure 3 - Number of elderly fatalities during crossing road

One of the causes of these type of accidents is that elderly persons or the aged tend to be unaware of their diminished physical ability like slower speed in walking therefore making them susceptible to such dangerous situations.

The purpose of this study is to propose better road situations to prevent such accidents.

LITERATURE REVIEW

Studies concerning elderly pedestrians are approximately classified into three types. These are:

(1) studies about walking ability,
(2) studies on estimating the utilization of facilities/equipment on roads, and
(3) studies aimed at the influence of restrictions concerning the difficulty in using facilities/equipment on the "going out" behavior of elderly persons.

There had been many studies on accidents involving elderly persons and used traffic data in a macroscopic point of view. Their purposes were to find characteristics of accidents. However, there are only few studies relating walking abilities of elderly persons and accidents. In this study, we try to find the relationship between accidents and crossing of elderly persons at non-pedestrian crossing.

CHARACTERICTICS OF ACCIDENTS INVOLVING ELDERLY PEDESTRIANS

Study Area

In this study, it is indispensable to look into available data on traffic accidents. We already have statistics on the accidents that happened in Aoba-ward, Yokohama-City from 1988 to 995. The data had been organized in a GIS system enabling us to see graphically where the accidents happened. By using this GIS system, it is possible to compare accident points between elderly and non-elderly.

Accidents

In the study area, 11,154 traffic accidents were recorded and 1,627 of which (14.2% of total) have been those involving pedestrians and cars. 599 happened at non-pedestrian crossings with 51 having elderly persons as victims. (see Figure-4)

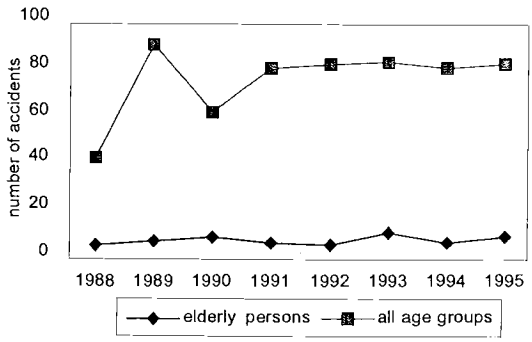

Figure 4 - Number of accidents during non pedestrian crossing

State of accidents at non-pedestrian crossing in Aoba ward

As can be seen in Figure-4, the number of accidents that occurred at non-pedestrian crossings and the number of accidents involving elderly persons are both relatively stable at 70 per year for the former and 10 per year for the latter. Figure-5 shows the ratio of accidents that happened during different times of a day. It was found out that accidents happened between 0800 and 1000 hr or 1500 and 1800 hr, whereas accidents involving all ages occurred approximately between 1400 and 1900 hr.

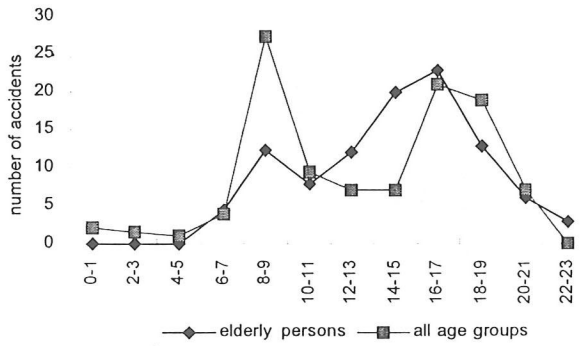

Figure 5 - Number of accidents during non pedestrian crossing in each time period

Comparison of accident characteristics between elderly and non-elderly

Several statistical items were analyzed to understand the characteristics of accidents at non-pedestrian crossing. The items included road width, speed limit, and the speed at which drivers feel dangerous. Figure-6 shows the speed at which drivers feel a danger that accidents may happen for roads having widths between 5.5 and 9.0 meters. It can be said that elderly persons encounter accident at speeds dispersed between 10 and 40km/h whereas non-elderly persons encounter accident at speeds centered between 20 and 30km/h. It is obvious that the range of speeds at which elderly persons feel that it is possible to cross at non-pedestrian crossing without danger of collision is different from that at which non-elderly persons feel.

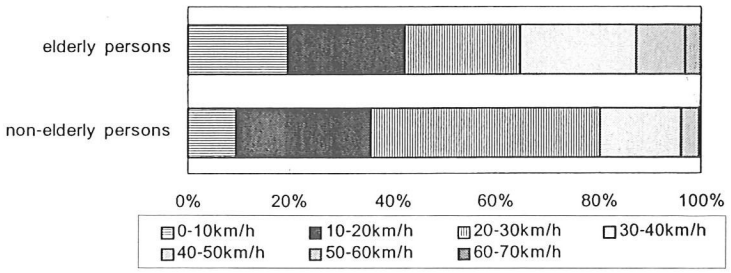

Figure 6 - The speed of vehicles which drivers feel dangerous when the accidents occured

Figure-7 shows width and speed limit on the roads where accidents happened. It was found that the roads where accidents occurred frequently have speed limits between 30 and 40km/h and widths between 5.5 and 9.0 meters. On such roads, drivers feel that they can drive without caring about the existence of pedestrians. Interestingly enough, on such roads also, pedestrians feel that they can safely cross at non-pedestrian in spite of the velocity of cars. It is thought that such road situations wherein both drivers and pedestrian seem to feel safe give rise to accidents.

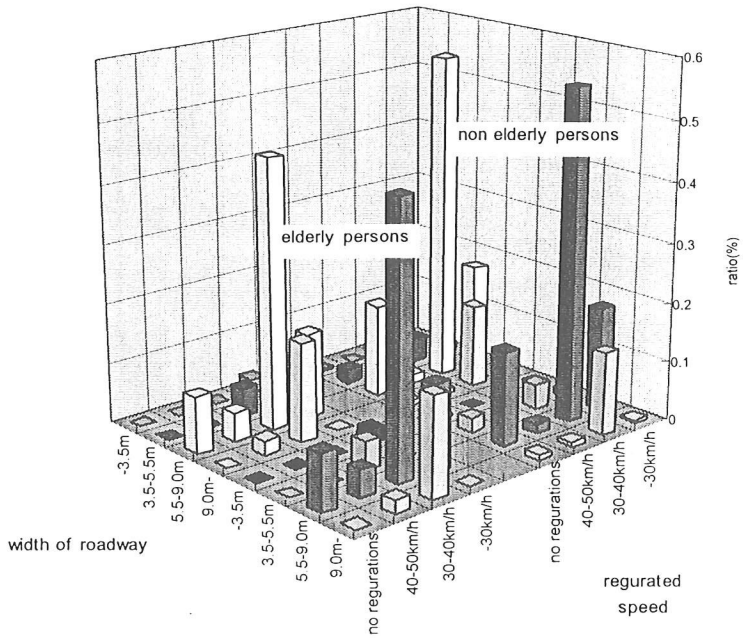

Figure 7 - Width of roadway and regulated speed at the position where accidents occur

Comparison of accident locations by GIS system

Comparison of accident area between elderly and non-elderly was made using the GIS as tool. The area where elderly persons encountered accidents is more dispersed than those for non-elderly persons. It is assumed that the reason for this is that elderly persons had accidents near their houses because their sphere of activities is limited (Figure-8, and Figure-9).

ACTUAL INVESTIGATION OF CROSSING BEHAVIOR AT NON-PEDESTRIAN CROSSING

Outline of investigation

It is necessary to investigate actual conditions because it is difficult to find the relationships concerning crossing behavior by analysis of accident data inside the laboratory.

As stated in section 3-4, most of the roads in accident points have width between 5.5 and 9.0 meters. From this criterion, two investigation points, Aobadai and Ichigao were selected. Investigation hours were decided to be between 1500 and 1700 hr, the time when accidents frequently occur.

The investigation procedure involved setting a video camera at locations where we can take a wide panoramic view of the study area. Pictures to show the state of pedestrians and cars were taken and spontaneous interviews with persons who crossed at non-pedestrian crossing were conducted. Interviewers asked about their age and frequency of crossing at non-pedestrian crossing. The number respondents was 107, with 16 elderly persons.

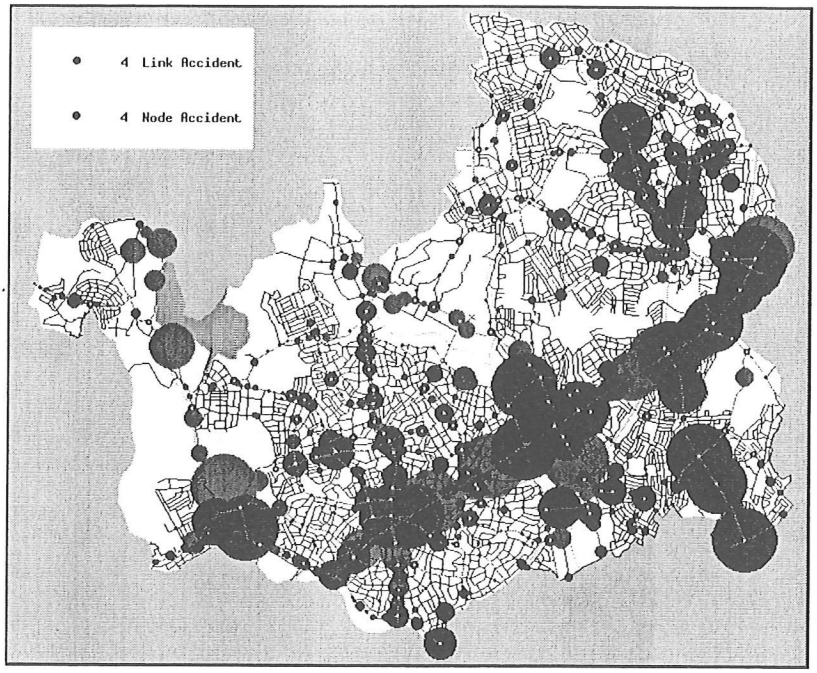

Figure 8 - State of all accidents in Aoba ward by GIS

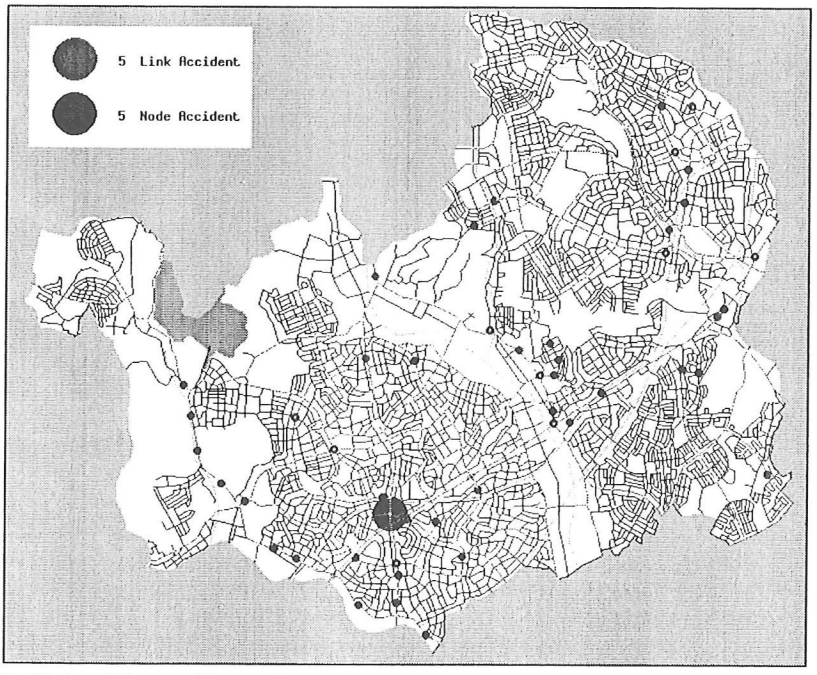

Figure 9 - State of the accidents elderly persons had in Aoba ward by GIS

The investigation aimed at four points.

1. How far is the length between pedestrians and pedestrians crossing which makes them want to cross non-pedestrians' crossing?
2. How fast is the speed of approaching cars and how far is the length between pedestrians and approaching cars when pedestrians began to cross at non-pedestrian crossing?
3. What degree of actions do pedestrians and drivers do to avoid danger when pedestrians cross at non-pedestrian crossing?
4. What factors do pedestrians depend on to decide whether to cross or not at non-pedestrian crossing?

Characteristics of crossing behavior at non-pedestrian crossing

Using the video footage taken, the number of elderly and non-elderly persons who crossed the road at the study area were counted (Table-1). According to the counts made, the ratio of elderly person's crossing at non-pedestrian crossing (3 out of 4) is higher than that of non-elderly person's. From this result, it can be said that elderly persons tend to shorten their crossing length more than non-elderly persons.

Table 1 - Outline of survey

Date	16 January – 14 March, 1997	
Place	Aobadai, Ichigao	
Number of Survey	8	
	All age groups	Elderly persons
Non-Pedestrian Crossing (A)	2,836	106
Pedestrian Crossing (B)	15,641	412
Ratio (A)/(A+B)	15.3%	20.5%
# of Persons Interviewed	81	15
Traffic Flow (vehicles)	9806	

From the interview results, it was discovered that only a few elderly persons cross at non-pedestrian crossing locations other than the ones they are accustomed to. At the Ichigao area, there were many elderly persons who have houses near the survey point. It had been a habit for them to cross the same location of non-pedestrians' crossing. They consider it safe to cross these usual points. From the above finding, it can be said that elderly persons distinguish between roads where they feel they can cross at non-pedestrian crossing safely and those that are not.

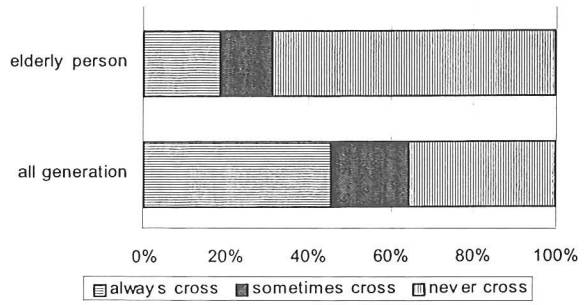

Figure 10 - Frequencies of the crossing at non-pedestrian crossing

Figure-11 shows the observed action performed by pedestrians to avoid collision with approaching cars. Elderly persons move less than non-elderly persons. It can be said that elderly persons are not so concerned about the approaching cars as much as non-elderly persons.

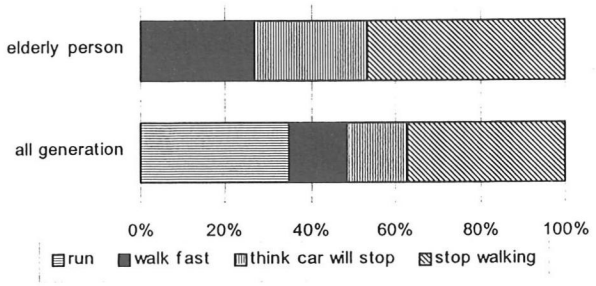

Figure 11 - Action when car approaches

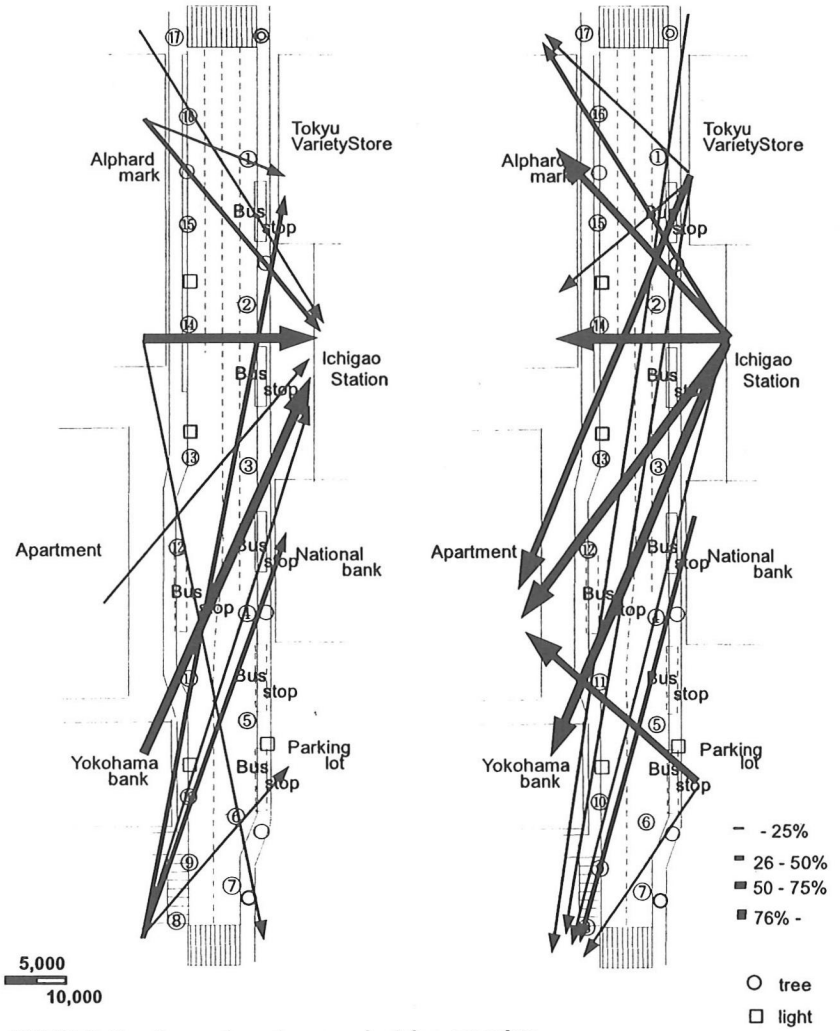

Figure 12&13 Ratio of crossing at non-pedestrian crossing from left to right (left side) and from right to left(right side)

CHARACTERISTICS OF CROSSING BEHAVIOR AT NON-PEDESTRIAN CROSSING IN THE STUDY AREAS

Comparison of OD between crossing at pedestrian crossing and at non-pedestrian crossing

Figure-12 and Figure-13 show the ratio of the non-pedestrian crossings against all crossings on every crossing locations at the Ichigao area on January 17,1997. According to the figures, the ratio of non-pedestrian crossings increases as the length between pedestrian and pedestrian crossing increases. From this finding, it can be said that the walking length influences the crossing decision behavior.

Analysis of the cause of crossing at non-pedestrian crossings

Figure-14 and Figure-15 show the ratio of crossing at non-pedestrian crossing and the difference between the length when crossing at non-pedestrian crossing and when crossing at pedestrian crossing. It is clear that as the difference is gets lager, the ratio correspondingly increases for every generation. The distribution of the dots on these figures will be very similar to that of a logistic curve with the difference in length defined as explanatory variable and the ratio defined as criterion variable.

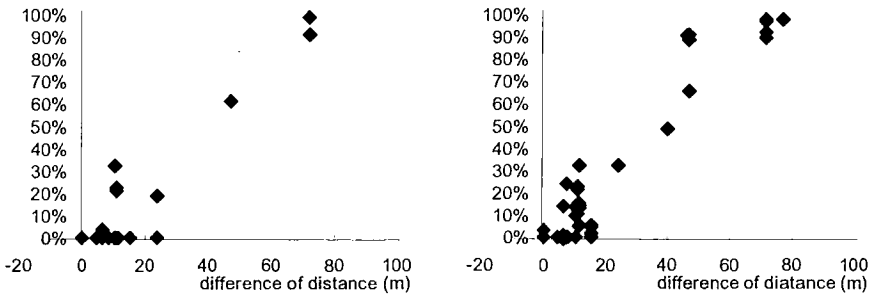

Figure 14&15 - Relationship between the ratio of crossing and the differences of distance (elderly person: left side and all generation: right side)

Figure-16 and Firure-17 show similar trends for every generation. It is shown that the difference in length for elderly persons corresponding to the 50% point of the ratio is shorter than for non-elderly persons. Elderly persons manage to cross at pedestrian crossing more than non-elderly persons.

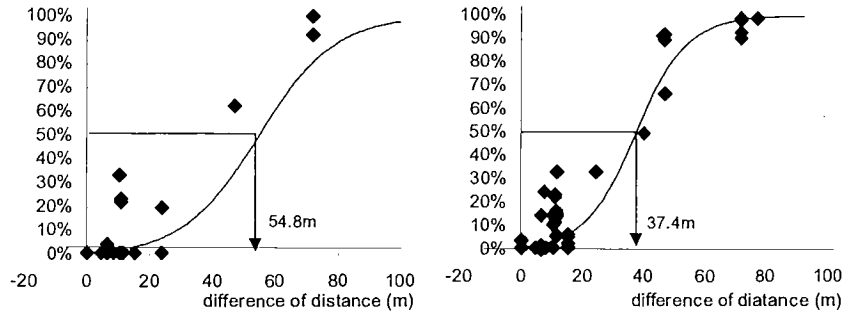

Figure 16&17 - Relationship between the ratio of crossing and the differences of distance (elderly person: left side and all generation: right side)

ANALYSIS OF ACTIONS WHEN CROSSING AT NON-PEDESTRIAN CROSSING

Velocity of approaching cars and distance between pedestrians and approaching cars

The velocities of approaching cars when pedestrians began to cross at non-pedestrian crossing were measured to see the velocity pedestrians recognize as safe when starting to cross. The approaching cars were divided into two types: (1) the cars which pedestrians could pass in front of, and (2) the cars which pedestrians could not pass while they cross at non-pedestrian crossing. The former is called "passed cars" and the latter is called " not passed car".

The distance between pedestrians and approaching cars were measured by points plotted on the investigation area. The velocity of the approaching cars were measured by establishing a speed trap length and measuring the elapsed time of passage through the trap length. The speed trap length is established well before the possible location where pedestrians will cross. Figure-18 shows the relationship between the velocity and the distance for both "passed cars" and "not passed cars". It can be said that the relationship as to the distance and location of approaching cars is different for every generation.

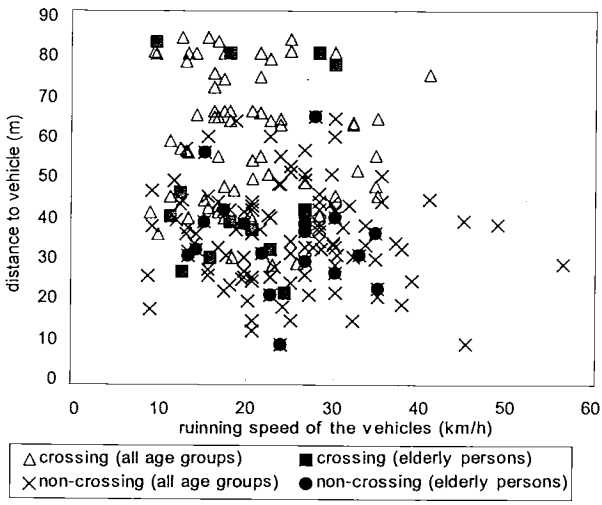

Figure 18 - Relationship of the speed and distance to the coming vehicle

Actual time of approach time and calculated time of approach

Figure-19 shows the relationship between actual time of approach and calculated time of approach. Actual time of approach means how long it took for approaching cars to reach the point where pedestrians passed since they began to cross. Calculated time of approach means how long it took for approaching cars to reach the point if they had kept on moving at the same speed when pedestrians began to cross. The area below the line indicates that the approaching cars decreased speed as a reaction to the pedestrians' crossing. 21% of elderly persons are in the area and 8% of all age groups are in the area. From this result, it can be said that elderly persons misjudge speeds and distances during crossing more than all age groups.

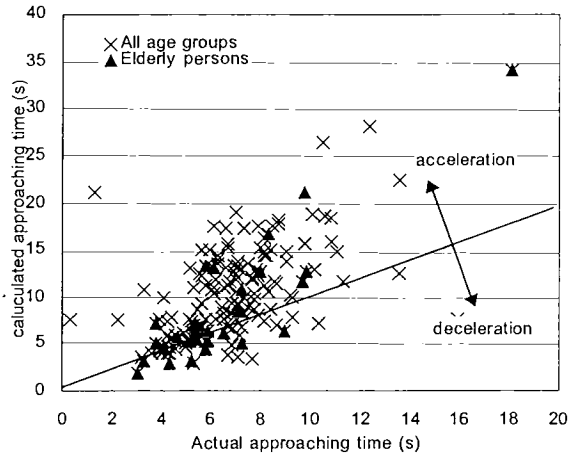

Figure 19 - Actual approaching time and calculated approaching time

ANALYSIS OF DECISION TO CROSS AT NON-PEDESTRIAN CROSSING

Investigation was done to see what factors pedestrians consider in deciding to cross at non-pedestrian crossing. It was done using the method of discriminant analysis. Table-2 shows the result of this analysis. Below are the important findings.

(1) From the comparison of the parameter on approaching cars' velocity, the absolute value for the elderly is less than that for the non-elderly. This shows that elderly persons care about the velocity less than for all age groups.

(2) From the comparison of the parameter on distance between pedestrians and approaching cars, the absolute value of elderly is less than that of all age group. This shows that the distance from the approaching cars that elderly persons want to keep is longer than that for all age groups.

(3) If figures for parameter in (1) are divided by the figures for parameter in (2) we obtain the distance that pedestrians want to keep from approaching cars when they assume a walking of 1.0meter/second. Upon doing this, the value obtained for elderly persons is larger than that of all age group. This shows that elderly persons consider the distance from approaching car more in deciding to cross as compared to all age groups.

Table 2 - Results of discriminant analysis for pedestrians' decision making on crossing road

	Elderly Persons	All Age Groups
Running Speed of the Coming Vehicle	-0.21	-0.24
Distance to the Coming Vehicle	0.05	0.08
Ichigao Dummy	-0.12	-0.69
Vehicles Dummy Coming from Right Side	0.22	0.48
Error Rate (%)	34	26
Running Speed per Distance	4.2	3.0

CONCLUSION

In this study, comparison of crossing at non-pedestrian crossing between elderly and all age groups was made to explain the elderly persons' crossing behavior using several views. Generally, elderly persons are concerned in crossing safely, but when they cross at non-pedestrian crossings, they tend to misjudge and misperceive distance and speed parameters making the crossing activity often dangerous. To avoiding this danger, urban planning should incorporate countermeasures like trying to decrease the running velocity of automobiles.

REFERENCES

Akiyama, T. et al, (1996) An analysis of the characteristics of walking for the elderly person, **Proceeding of the 51st Conference of JSCE**, 170-171 (in Japanese)

Habu, K., Mihoshi, A. and Kato, H., (1993) Concept of "Mobility handicapped person" and analysing of their trip in Habikino, Osaka, **Proceedings of Infrastructure Planning 16(2)**, 199-202 (in Japanese)

Katakura, M. and Morohashi, M., (1989) An analysis of the traffic accident involved elderly person, **Proceedings of the 44th Conference of JSCE**, 408-409 (in Japanese)

Shimizu, K. and Kimura, K., (1989) A study on the characteristics of walking for the elderly person at intersection, **Proceedings of the 44th Conference of JSCE**, 288-289 (in Japanese)