A STUDY ON COMPARISON AND EVALUATION OF RESIDENTIAL OCCUPANCY INDICATOR IN PUSAN AND OSAKA

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abstract : Recently residential streets have severe problems because of increasing volume of on-street parking besides pedestrian and vehicles. In this study, the concept of occupancy was taken to explain heterogeneous traffic volume of the three kinds of traffic modes on the same dimension. Using the recommended occupancy indicator, this paper calculates the occupancy in residential streets in Pusan, Korea and compares it with that in Osaka, Japan. As a result, we can easily recognize the difference of occupancy characteristics of the countries. Using parking occupancy, the permitted parking volume is considered.

1. INTRODUCTION

Since residential streets are closely related to neighbor's daily life, it is an important subject that residential streets should be arranged to be safe and provide agreeable space for every user. Although formation of alternatives about street usage and the structure of street network have been studied when planning residential streets, more detailed and additional experimental research is strongly required.

Generally speaking, most residents want to use their cars in their residential areas. On the other hand, they wish to avoid the various loss caused by car use. Therefore, people and vehicles have to coexist in residential streets. In order to consider these conditions of residential streets and improve them, it is necessary to introduce an appropriate indicator. This study adopts the occupancy indicator which expresses the relation among pedestrians, vehicles, bicycles, and parked vehicles in residential streets.

The purpose of this study is to identify the characteristics of residential streets in Pusan based on the occupancy indicator, which makes it clear whether or not the existing allocation of the street space is appropriate for pedestrians, bicycles, vehicles. Also this study uses Osaka data which is compared with the occupancy indicator of Pusan.

2. RECOMMENDING THE OCCUPANCY INDICATOR

Pedestrian, vehicle, bicycle, and motorcycle are the major modes of transportation in residential streets. To analyze characteristics of the major modes of transportation, time and space occupancy indicator are used. In this study pedestrian(p), vehicle(c), and bicycle(b) are considered. However motorcycles are excluded because their volume is relatively small in residential streets in Korea.

First, we think about several dozen meters of section i in a residential street. It is assumed that the j-th arrival of traffic mode i(i=p, c, b) pass through the section at time t_{ij}. Here, speed, area module, traffic volume of mode i, and road width are expressed as v_{ij}, A_{ij}, q_i, and d. Then, space occupancy Q_{si} which is the sum of area module of all traffic modes divided by road area is shown in equation (1).

$$Q_{si} = \frac{1}{ld} \sum_{j=1}^{mi} A_{ij} \quad \text{----------} \quad (1)$$

When we take T as the sufficient time compared with t_{ij}, time occupancy Q_{ti} that is the sum of existing time of a mode divided by T shown as follows;

$$Q_{ti} = \frac{1}{T} \sum_{j=1}^{mi} t_{ij} = \frac{1}{T} \sum_{j=1}^{mi} \frac{l}{v_{ij}} \quad \text{----------} \quad (2)$$

Here using the average $\overline{v_i}$, $\overline{A_i}$ instead of v_{ij} and A_{ij} and $n_i = \frac{q_i l}{\overline{v_i}}$, space occupancy Q_{si} can be expressed as follows ;

$$Q_{si} = q_i \overline{A_i} / (d \overline{v_i}) \quad \text{----------} \quad (3)$$

And also time occupancy Q_{ti} can be shown as equation (4).

$$Q_{ti} = q_i l / \overline{v_i} \quad \text{----------} \quad (4)$$

In these days, on-street parked vehicles are increasing rapidly in residential areas, therefore it is necessary to consider deeply the occupancy indicator of vehicles. Here, we introduce $\overline{F}$, which is the total parking duration of vehicles at section i divided by T. The space occupancy of parked vehicles is expressed as equation (5) with given area module of a parked vehicle A_{pc}.

$$\text{Parking space occupancy} = (\overline{p} A_{pc}) / (ld) \quad \text{----------} \quad (5)$$

In the consideration of the influences of moving and parked vehicles, the space occupancy of vehicles is ;

$$Q^*_{sc} = Q_{sc} + (\overline{p} A_{pc}) / (ld) \quad \text{----------} \quad (6)$$

Addition to this, time occupancy Q^*_{tc} can be derived as a similar way.

$$Q^*_{tc} = Q_{tc} + \overline{p} \quad \text{----------} \quad (7)$$

In planning residential streets, a ratio of occupancy indicator may be as useful as the respective value itself. The occupancy ratio is expressed in equation (8) and (9) respective by correspondence to equation (3) and (4).

$$Q_{sp} : Q_{sc} : Q_{sb} = q_p \overline{A_p} / \overline{v_p} : q_c \overline{A_c} / \overline{v_c} : q_b \overline{A_b} / \overline{v_b} \quad \text{----------} \quad (8)$$

$$Q_{tp} : Q_{tc} : Q_{tb} = q_p / \overline{v_p} : q_c / \overline{v_c} : q_b / \overline{v_b} \quad \text{----------} \quad (9)$$

In the equation (9), it can be recognized that the ratio of time occupancy obtained at t_{ij} represents the ratio of each traffic density. We investigated and studied only the space occupancy indicator in this paper.

3. FACTORS IN OCCUPANCY INDICATOR

3.1 Required Area Module for a Vehicle

Strictly speaking, it's necessary to make a survey of vehicular speed at each place or to develop a model considering various factors, because speed of vehicles is changed by the conditions of road traffic. But for practical use, this study adopts Table 1 which shows speed of vehicle surveyed on road section with different road width in Osaka. Fig.1 which was obtained based on an experiment carried out on a road in sub-urban area in Osaka, reveals the relation between the speed and the safety distance of vehicles.

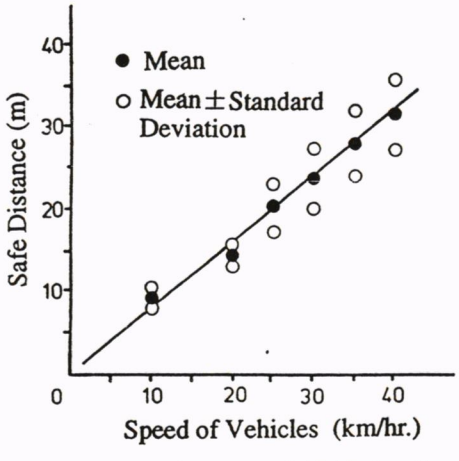

Fig.1 Safe Distance and Vehicular Speed

Table 1. Vehicular Speed by Width of Street

Width of Street	Sample size	mean	Standard deviation
11 meter (two ways)	211	34.2 km/hr.	0.76 km/hr.
8 meter (two ways)	168	28.6	0.88
(one ways)	120	28.3	0.86
6 meter (two ways)	60	23.8	2.45
(one ways)	60	25.7	0.77

The safe distance is defined as a distance in which vehicles can stop smoothly, where a person or some object appears in the front of them.
Required area module for vehicles is expressed as follows ;
area module for vehicle = (safe distance + vehicle length) × (required width of a vehicle).

3.2 Required Area Module for a Pedestrian

The level of service for pedestrian traffic becomes an indicator for evaluating pedestrian safety, comfortableness. Fruin, Pushkarev and Zupan, Mori and Tsukaguchi, etc. proposed a level of service respectively. Based on these studies, this paper uses $\overline{A_p} = 5m^2 / person\ (= 0.2\ person/m^2)$ as a required area module in nearly free walking. And we use 4 km/h as an average walking speed in residential areas.

3.3 Required Area Module for a On-street Parked Vehicle

Required area module for a parked vehicle is the area which is necessary for a vehicle arranged in a series in a parking lot, that is, $\overline{A}_{pc} = 16.5m^2/veh.$, which is the product of 6.6 meters in length and 2.5 meters in width in parallel curb parking.

4. ACTUAL TRAFFIC CONDITION AND THE OCCUPANCY IN RESIDENTIAL STREET

4.1 Actual Traffic Condition in Residential Street

In this study, we made observation surveys at several locations in residental areas in Korea and Japan. Traffic volume of vehicles, pedestrians and on-street parked vehicles in seven districts (Bugok, Jangjeon, Minrack, Mangmi, Daeyeon, Yeonsan, Gaejeong) were surveyed. Bicycle is excluded in Pusan where bicycle is not a popular transportation means, because of difficulty to use it in the steep topography. Addition to this, the number of bicycles is apt to decrease in overall Korea. The widths of the above mentioned streets were 6m. The pedestrian volume, traffic volume and on-street parking volume at each section in Pusan are shown in Fig.2 and were aggregated in an hour.

Since the deviation of pedestrian volumes varies hourly and regionally, the difference between the highest and lowest region is about 2.5 times.
The traffic volume becomes higher at 8 a.m. and 6 p.m., then it becomes lower at night. As the pedestrian and vehicular traffics in residential areas are competitive each other on safety and convenience, the decision should be made carefully in order not to take biased inefficient reslut.

As parked vehicle stands for opposite characteristics against pedestrian and traffic

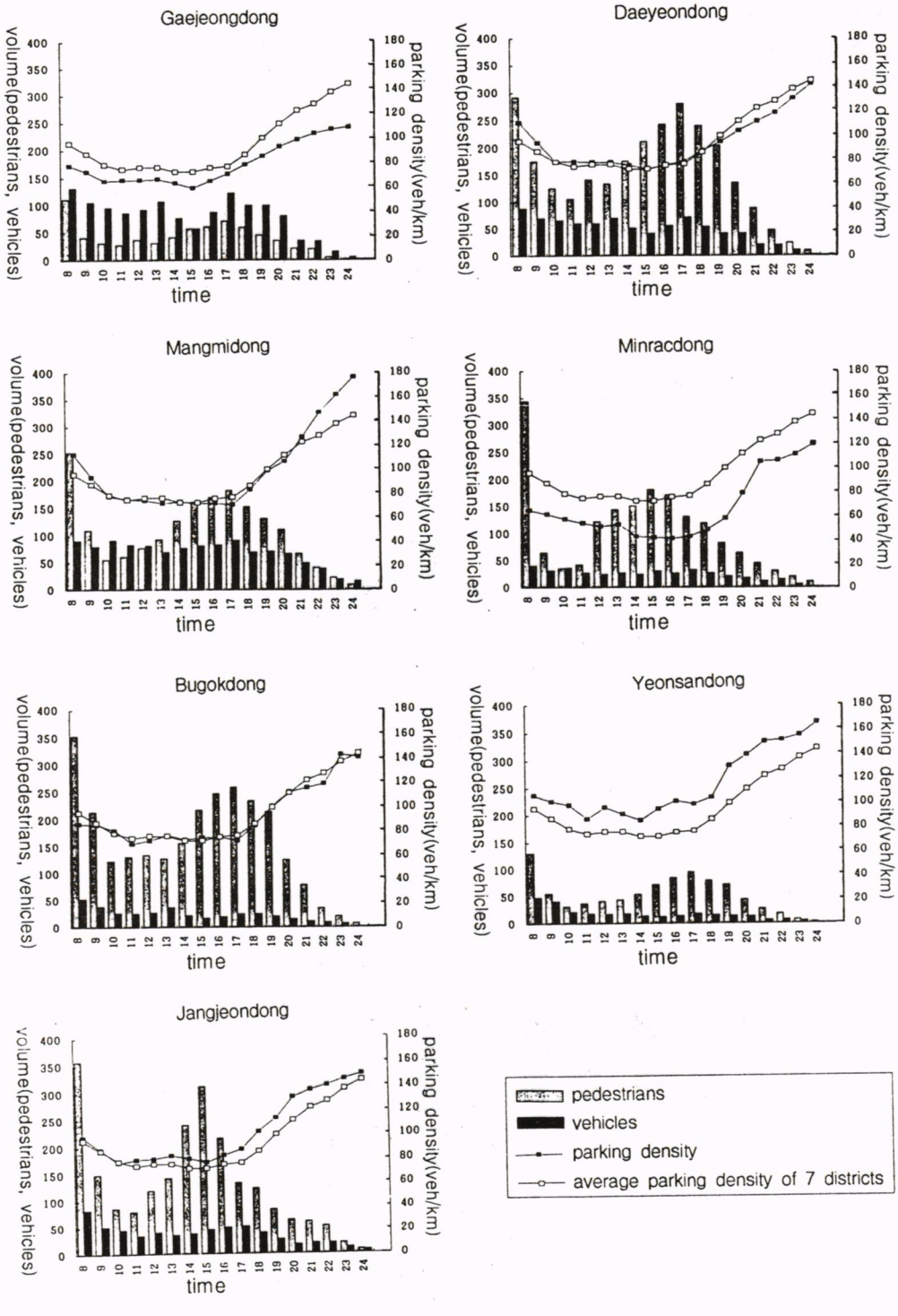

Fig. 2 Pedestrian, Vehicular volume and Parkjng density in residential streets

volume, it decreases from the morning and then reaches to minimum in the afternoon. Parking volume becomes high at night about 150 vehicles/km of parking volume was observed.

4.2 Application of Occupancy Indicator in Residential Streets

We investigated and studied comparatively only the space occupancy in this paper. The occupancy ratio of moving vehicles and pedestrians at each street in Pusan are illustrated in Fig.3. The occupancy ratio of moving vehicles are very high, but occupancy ratio of pedestrians is less than 20% at every region and every time of a day.

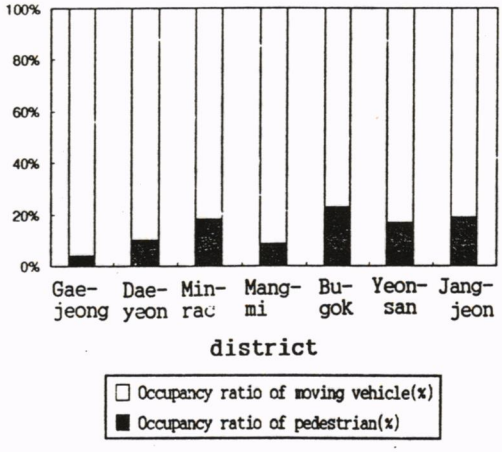

Fig. 3 Occupancy Ratio in Pusan

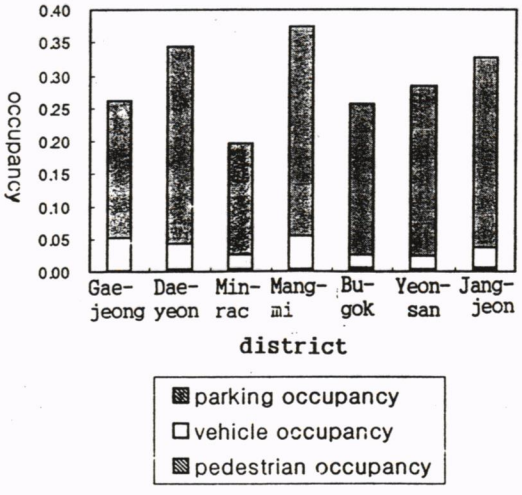

Fig. 4 Occupancy in Pusan

In this paper, occupancy indicator of on-street parking is considered besides vehicular and pedestrian occupancy indicator. Fig.4 shows the occupancy value of on-street parked vehicles at each region in Pusan. The parking occupancy can explain parking condition of the residential streets considering parking duration and street width. Accordingly, though parking density is similar to other surveyed regions, parking occupancy of a narrower street is higher than wide street's parking occupancy. In addition, Fig.5 shows the occupancy value of on-street parkedvehicles at several streets of two districts in Osaka. Comparing Fig.4 with Fig.5, the on-street parking occupancy values of Pusan mark much higher than that of Osaka. In the case of Osaka, the use of cycle is generalized and vehicles' occupancy is larger than those of parked vehicles in some streets as shown in Fig.5. These are the apparent difference between Pusan and Osaka. And Fig.6 shows the variation of occupancy values in each district. The vehicle occupancy rate of streets in Gaejeongdong is higher than that of other districts. Thus, it can be said that the main function of streets in Gaejeongdong is for through traffic movement. As the occupancy rates of pedestrian, vehicle and parking in Daeyeondong, Mangmidong and Jangjeondong districts are higher than those of other districts, streests in these districts are complex.

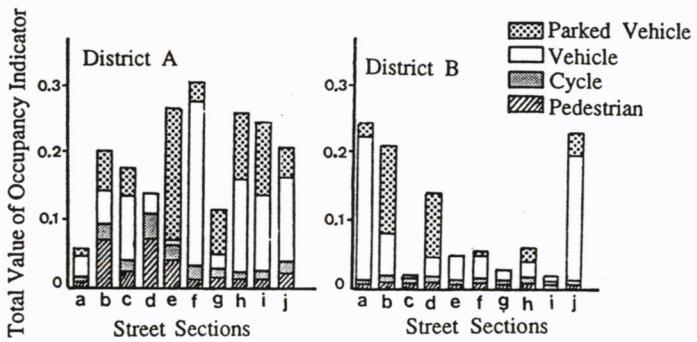

Fig. 5. Occupancy Indicatros by transportation modes

5. EVALUATION OF RESIDENTIAL STREET

In order to assign street space suitably for every traffic mode, the relation between areas of roadway and sidewalk, and indicators related to a rate of time or space used by each traffic mode has to be considered.

The occupancy indicator can play an important role as such an indicator. The vehicular occupancy ratio is often smaller than the ratio of roadway space. It means that pedestrian space is eroded and it is necessary to expand it. The occupancy indicator is effective to examine the suitability of segregation between roadway and sidewalk. Tsukaguchi and Mori showed a way to use the indicator in a case study in Osaka.

Using the occupancy indicator, an allowed number of parked vehicles in residential

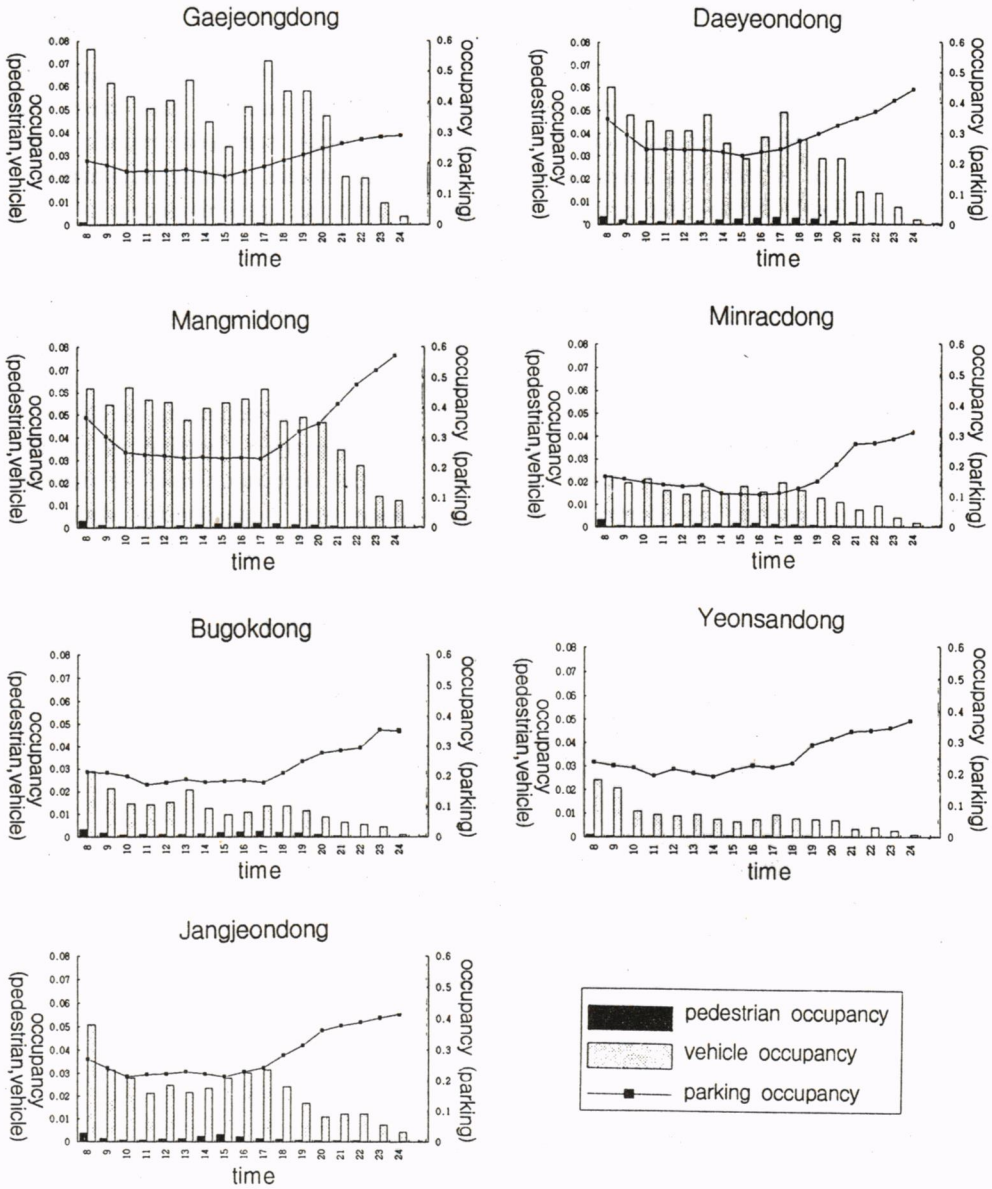

Fig. 6. Variation of occupancy values

streets with certain traffic volume and road width can be obtained. Because there is no garage law in Korea yet, we have to consider visiting vehicles to a residential area and the resident's vehicles at the same time. On the other hand, since the garage law has been instituted in Japan, only visiting vehicles to residential areas are to be considered.

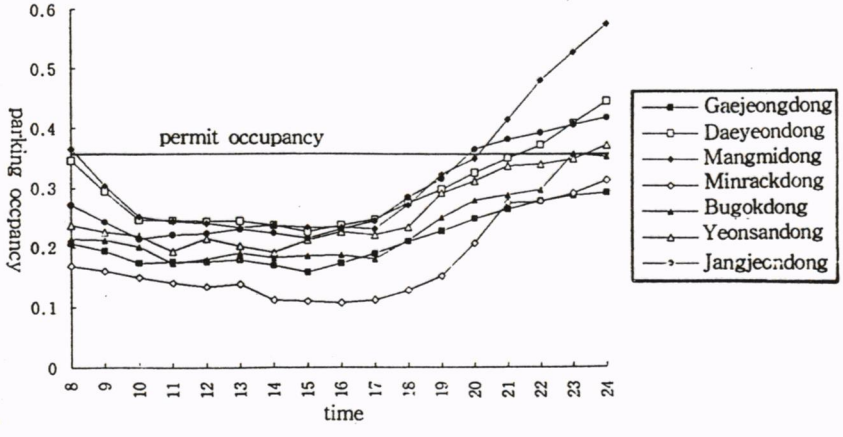

Fig. 7. Parking Occupancy per time

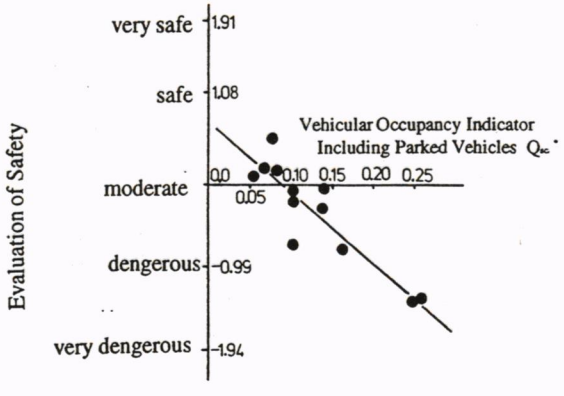

Fig. 8. Occupancy Indicator and Evaluation of Safety

It is important to consider on-street parking besides vehicular and pedestrian traffic when calculating the occupancy indicator. Especially in the case of Pusan and Osaka where the occupancy of on-street parking is very high, the parking has to be considered. If on-street parking is allowed under a certain region where parked vehicles do not decrease pedestrian safety and interfere vehicular traffic.
Firstly, permit occupancy for on-street parking is defined as follows. If on-street

parking on both sides at a 6m wide local street, vehicles can not pass through the street in an emergency. Therefore, only one side parking is permitted. The maximum number of one side parking within 100m is about 13 vehicles. And traffic volume is assumed to maintain at the existing levels. In this condition, the permit occupancy which is calculated by equation (6) is shown in Fig. 7. Fig.7 shows that the occupancy of any street is higher than the allowed occupancy at most districts when the resident's cars are included in on-street parked vehicles.

But because this permit occupancy is not obtained based on consideration of pedestrian safety, it has to be reconsidered. Here, a questionnairs was carried out in Osaka to find out residents' awareness on safety of the streets in front of their houses. These streets are ranked from 1 to 5 which correspond to categories: very safe, safe, moderate, dangerous and respectively. Assuming the distribution of each value as normal, the value is modified as shown in the vertical axis of Fig.8, where moderate is equal to 0.0. According to a survey, the relation between vehicular occupancy indicator including parked vehicles Q^*_{sc} and an indicator on evaluation of safety was obtained and illustrated in Fig.8. If moderation is a temporal criterion of residential street planning, Q^*_{sc} should be less than 0.09 as shown in Fig.8. There is a very large difference between this value and the permit occupancy described above. Therefore, it is necessary to decrease on-street parked vehicles in Pusan, by institution of garage law and so on.

6. CONCLUSION

The general conclusions in this study are shown as follows ;

1) To explain the heterogeneous traffic volumes of the traffic modes on the same dimension, occupancy indicators of pedestrian and vehicle were recommended.

2) Occupancy indicators of pedestrian and vehicular traffic in Pusan were calculated to explain the characteristics of residential streets, and also they were compared with the occupancy in Osaka.

3) The occupancy of on-street parked vehicle is very high because of no garage law. It is quite important to check the suitability of segregation of roadway and sidewalk in Pusan, because sidewalks in Pusan are not sufficient.

4) The permitted parking volume in residential streets in Pusan was considered quantitively.

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