# CHARACTERISTICS OF LOADING ACTIVITIES

# AND FREIGHT LOADING SPACE REQUIREMENTS FOR COMMERCIAL AREAS IN OSAKA*

By Masamitsu MŌRI**, Hiroshi Tsukaguchi*** and Ibrahim MABROUK****

Loading facilities for freight vehicles are a basic part of the modern transportation system but so far they have not been regarded as of major importance in urban transportation planning. This have led to illegal on-street parking without proper discussion about where and how they should be done.

To make countermeasures, the authors clarified loading characteristics in Osaka based on the questionnaire and observation survey in several locations. Also, through the analysis, we suggested criteria that could be considered in formulating zoning codes to adress the problems of space requirements.

## 1. INTRODUCTION

As Osaka has been a traditional commercial center in Japan, a large volume of goods are moved to the area by various types of trucks but they are hindered by a lack of loading facilities, which in turn leads to street congestion. Also, lack of co-operation between carriers and shippers makes the process of moving goods even more complex.

Because of the currently inadequate loading conditions and absence of requirement standards for loading facilities in Japan, this research is necessary to determine criteria concerning shopping streets and office buildings. So, the purpose of this paper is :
- to clarify the characteristics of loading activities in the central business district (CBD) and fringe area.
- to present a simple method for determining spatial requirements for loading activities, which can be used as criteria when formulating loading codes or planning loading areas.

Loading activities have various aspects according the different facilities for handling goods. In this research we discuss loading activities in wholesale and retail stores where countermeasures are strongly required, and also those in office buildings where such kinds of problems often exist. But we do not deal with department stores and supermarkets where

---

* Key words : Truck loading activities, loading space
** Member of JSCE, Dr. Eng., Professor, Dept. of Civil Eng., Osaka University.
*** Member of JSCE, Dr. Eng., Assistant Professor, Dept. of Civil Eng., Osaka University.
**** Member of JSCE, Post graduate student, Dept. of Civil Eng., Osaka University.
(2-1 Yamada-Oka, Suita, Osaka 565, JAPAN).

rationalization of the loading system is comparatively easily undertaken.

Some studies (1,2,3,4) dealing with problems of loading have examined various loading characteristics in several areas. Also, some guidelines for space requirements for off-loading facilities and the physical design of loading space have been described. One approach (5) described curb allocations on the basis of keeping the total costs to society to a minimum. As regards such studies in Japan, in the case of retail shopping streets, parking characteristics including loading have been investigated (6,7). Also, although there are some papers dealing with co-operation systems relating to goods transportation (8), they do not deal directly with loading activities.

## 2. ANALYSIS OF LOADING CHARACTERISTICS

### (1) Data Collection

In this study, the questionnaire and observation survey were carried out initially in the CBD and fringe area of Osaka. The details are summarized in **Table 1.**

### (2) Variation of Loading Activities

In the case of OTC, the data for monthly pick-up and deliveries show that a peak occurs in Dec. and minimum in Aug. Pick-up and delivery frequencies in Dec. were found to be 1.4 times those in Aug. This was also examined in the case of MINAMI-KYUHOJI St., from the results of the survey carried out in Aug. and Dec., the result being exactly the same. Also, daily variations of loading activities show that a peak occurs on Monday. The hourly variations for every area are shown in **Fig.1.** As shown in this figure, the peak of arrivals occurs in the morning almost always between 10:00-11:00.

### (3) Type of Vehicles

Percentage of vehicles by type is summarized in **Table 2.** As shown in this table, a high proportion of arrivals in the case of wholesale stores are of the large truck type, but in the case of retail stores and office buildings most of arrivals are of medium truck and light van types.

### (4) Purpose of Visit

The percentage of observations by purpose of visit is also summarized in **Table 2.** The percentage of deliveries was found to be about 50% in the case of wholesale stores and about 80% in the case of retail stores both in the CBD and fringe area. In the case of office buildings, the percentage is the

Table 1 Details of case study areas

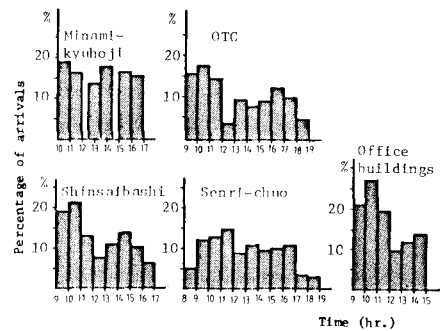| Item | | Wholesale stores | | Retail stores | | |
|---|---|---|---|---|---|---|
| | | Minami-kyuhoji | OTC | Shinsai-bashi | Senri- | Office bldgs. |
| Materials dealing with | | Clothes, bags,and acces- sories | Clothes | Miscellaneous goods for living | | (Offices and few retail stores ) |
| Location | | CBD | Fringe | CBD | Fringe | CBD |
| Co-operation system | | Non - Existent | Existent | Non - Existent | Non - Existent | Non Existent |
| Present state of loading spaces | | Very few | Almost all have | No loading spaces | Very few | Some bldgs. have |
| Ques- tionnaire | Period | - | Nov., 1982 | - | Nov., 1982 | July, 1981 |
| | No. of received/ distrib- uted sheets | - | 123/161 | - | 107/126 | 89/100 |
| Survey | Period | Aug/Dec 1981 | Dec. 1982 | July, 1983 | Nov. 1982 | Oct. 1983 |
| | No. of sites | 25 Stores | 4 Com- panies | 72 Stores | 126 Stores | 13 Bldgs. |



Fig. 1 Distribution of vehicle arrivals by hour of the day

Table 2 Percentage of arrivals by type and purpose

| Item | | Wholesale stores | | Retail stores | | |
|---|---|---|---|---|---|---|
| | | Minami-kyuhoji | OTC | Shinsai-bashi | Senri-chuo | Office bldgs. |
| Type | T1 | 48 | 72 | 7 | 12 | 11 |
| | T2 | 14 | 18 | 43 | 43 | 32 |
| | T3&C | 38 | 10 | 53 | 45 | 57 |
| Purpose | D | 57 | 49 | 83 | 79 | 82 |
| | P | 43 | 51 | 17 | 21 | 18 |

D :delivery  P:pick-up  T1:large truck
T2:medium truck  T3: light van
C :passenger car

same as for retail stores.

If we look at the percentage of 50% for wholesale stores, this percentage expresses the actual function of wholesale stores where received goods are picked up again for delivery to retail stores. Also, in the case of retail stores, the percentage of deliveries is almost the same for all hours of the day, but in the case of wholesale stores, the delivery percentage decreases while the proportion of pick-ups increases as the hours of the day proceeds.

### (5) Places Where Loading Is Being Done

In this part, we will explain the present situation as regards loading spaces and where loading is carried out.

In the case of MINAMI-KYUHOJI St., these stores are located directly near the street curb. As this one way street consists of 3 lanes, two of them for parking and only one for traffic movements, loading is carried out completely at the curb (except in the case of a few large stores) and second lane (double parking) with the respective percentages shown in **Fig.2**. The percentage of double parking was found to be 25% on average and 40% in the case of large trucks. On the other hand, 78% of double parking was done by large trucks. In the case of OTC, almost all companies have loading space as shown in **Fig.3**, and for that reason, most of loading activities are carried out inside buildings and in a few cases a small percentage is done both at the curb and inside buildings.

In the case of SHINSAIBASHI, there is no loading space at all, so, all loading activities are carried out completely at the curb. In the case of SENRI-CHUO, 89% of loading was found to be done at the curb, the rest being done in 3 small loading lots, although they are sometimes vacant.

In the case of office buildings, **Fig.4** shows the present state of loading spaces and **Fig.5** shows the percentages of loading areas. For gross floor area (GFA) of 20000 square meters or less, about 45% of loading is carried out inside buildings and 55% at the curb and others, this category of buildings representing 80% of total existing buildings. The questionnaire results also revealed that 40% of buildings have loading problems. These results indicate (when considering all types of stores and buildings) how severe the loading problems in Osaka are.

### (6) Loading Time

In general, loading time was found to be short. The percentage of vehicles staying less than 5 or 10 mins. and average loading time are shown in **Table 3.**

In MINAMI-KYUHOJI St., percentage of arrivals staying for 10 mins. or less was found to be very high due to the high occurence of double parking. For this reason, we calculated two values for average loading time in the case of MINAMI-
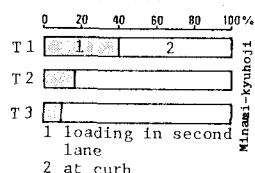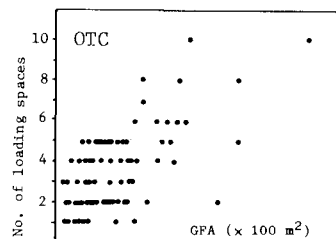


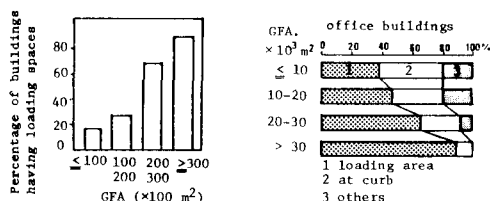Fig.2 Truck types and where loading is done

1 loading in second lane
2 at curb



Fig.3 Existing loading space



Fig.4 State of loading spaces (%)



Fig. 5 where loading is done

1 loading area
2 at curb
3 others

Table 3 Loading time (mins)

| Item | Minami-kyuhoji | OTC | Shinsai-bashi | Senri-chuo | Office bldgs. |
|---|---|---|---|---|---|
| Percentage of veh. staying ≤ 5 minutes | 79 | 71(30) 70(38) 36(50) 27(67) | 44 | 42 | 51 |
| Percentage of veh. staying ≤10 minutes | 91 | 88(30) 91(38) 74(50) 54(67) | 66 | 66 | 74 |
| Average loading time | 4.7 | 8.3 | 10.1 | 10.2 | 8.0 |

( ) : GFA (× 100 square meters)

KYUHOJI St., one when considering all arrivals (3.9 mins.) and the other when excluding double parked vehicles (4.7 mins.). In the case of OTC, this was calculated for individual building because it was found that there is a relation between GFA and loading time, but this relation was not found in other cases), this percentage was found to be less than the previous one, because the number of packages/arrivals is higher in this case than in the former due to the use of co-operation system as well as the fact that loading activities are carried out inside buildings.

In the case of retail stores, this percentage was found to be the same both in the CBD and in fringe area.

A theoretical loading time distribution was calculated for all cases using the exponential distribution and it provide an acceptable approximation of the actual distribution.

## (7) Co-operation System

Nowadays, the rationalization of goods movements has become very important for companies. In particular, rationalization is essential in the case of wholesale stores because to leave loading activities in their present condition is likely to be detrimental to their business. Generally, there are two types of co-operation systems: one is undertaken to reduce the volume of goods delivered to wholesale stores by routing goods directly to retail stores without any need to pass through wholesale stores, while the other attempts to reduce truck arrivals with no change in goods volume. Here, the latter will be explained in the case of OTC the only location considered in this paper where such a co-operation system is put into practice. In the case of OTC, wholesale stores are using a co-operation system mainly in order to reduce the transportation cost paid to carriers and subsidiary truck arrivals. The idea of this system is to pick up the goods from many wholesale companies in smaller vehicles and then these goods are reloaded and delivered once again in larger trucks parked in a nearby certain area, i.e. one truck transports goods from more than one wholesale store. Also, in some cases large trucks pick up the goods directly from wholesale stores and transport these goods elsewhere. From the investigation, it was found that 80% of wholesale companies are using co-operation system, although they also use other carriers which do not participate in the system.

Also, we studied the relation between the frequency of wholesale stores and number of non co-operation of carriers used in goods transportation (number of carriers used in co-operation system excluded) as shown in **Fig.6**. Comparing the type using the co-operation system most of the time and the other one using co-operation system occasionally, the effect of co-operation system is clearly shown, where the former uses less carriers than the latter one. This is probably leads to the reduction of truck arrivals.

## 3. GENERATION OF ARRIVALS

Generation of arrivals corresponding to the GFA was analyzed for different locations in order to examine this relationship. Factors such as number of employees and yearly income are likely to be used instead of GFA, but for designing new loading space, these factors are clearly unknown.

In the case of wholesale stores in MINAMI-KYUHOJI St., the relation between GFA and arrivals is shown in **Fig.7**. There are two regression lines corresponding to the observation surveys
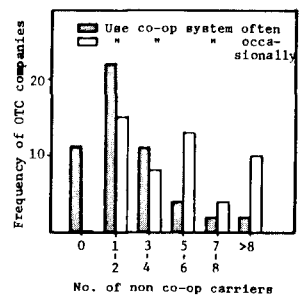


Fig.6 Non co-operation carriers used in OTC

carried out at two different times, the upper one representing 1.4 times the number of arrivals of the lower one. In the case of OTC, this relation was derived from a questionnaire concerning average arrivals in a peak month as shown in **Fig.8.** In spite of the plottings being scattered, we notice that arrivals in the case of *companies dealing with materials such as towels and fabrics are higher than those dealing with clothes.* In addition to this, the results of the survey carried out at four buildings is shown in the same figure. The generation rate of these four points also approximately corresponds to the lower line of MINAMI-KYUHOJI St., i.e. the generation of arrivals for wholesale stores in the latter case is more than that in the former, which is *partly because of the effect of the co-operation system* used in OTC.

In the case of SENRI-CHUO, the relation between GFA and arrivals resulting from the survey shows scattered plottings as shown in **Fig.9.** However, excluding stores dealing with fresh foods, we can detect a trend in the generation of arrivals. As for retail stores, it is better to calculate two types of generation units, one of them corresponding to GFA and the other corresponding to stores as shown in **Table 4,** that is because there are indispensable goods movements to every store regardless of GFA.

Comparing these two types of generation unit, in the case of the former, the highest generation is found in stores dealing with fresh foods, and in the case of the latter, in stores dealing with fresh foods, stationary and furniture.

In the case of office buildings, the relation in **Fig.10** resulting from the survey data shows a high correlation.

As the results of the survey, some relations between GFA and generation of arrivals were obtained with high correlation coefficients, but in other cases, it was somewhat difficult to get a high correlation coefficients. Also, if GFA is fixed, generation of arrivals for retail stores is more than for wholesale stores.



Fig.7 GFA vs. daily arrivals



Fig.8 GFA vs. daily arrivals
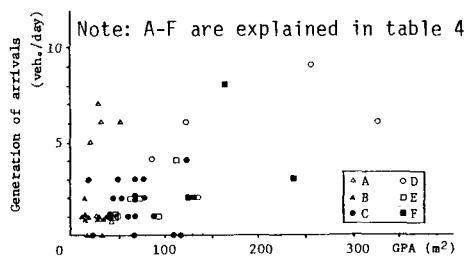


Fig.9 GFA vs. daily arrivals

Table 4 Generation rate/
unit area,store

| Item | | No. of stores | Veh./ 50 m$^2$ | Veh./ store |
|---|---|---|---|---|
| | Eating & drinks | 41 | 2.6 | 2.8 |
| Foods | A Fresh foods | 6 | 7.2 | 4.6 |
| | B Other foods | 11 | 2.8 | 1.2 |
| | Total | 17 | 4.4 | 2.4 |
| C Clothes | | 18 | 1.2 | 1.7 |
| D Stationaries, toys | | 5 | 1.8 | 5.6 |
| E Miscellaneous, bags | | 7 | 1.3 | 1.8 |
| F Furnature, electrics | | 3 | 1.3 | 4.3 |

## 4. SIMULATION APPROACH FOR DETERMINING LOADING SPACE REQUIREMENTS

As analysis shows that loading problems are mainly due to the lack of loading space, the aim now is to calculate the space requirements to meet demand for curb and off-curb loading spaces in the commercial areas of Osaka. The required space is influenced mainly by the volume and
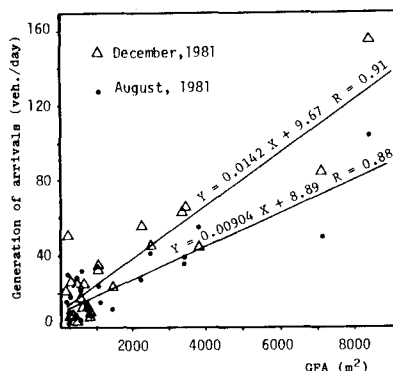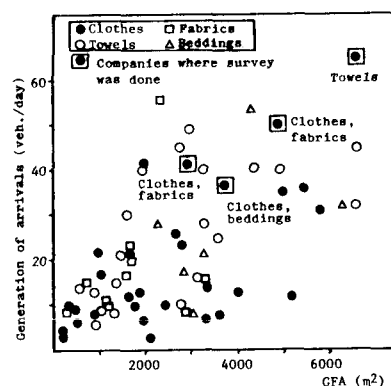
the transportation system of goods. In particular, rationalization of goods movements such as the introduction of co-operation systems, has a large effect on the volume of goods and in turn on truck arrivals. However, since it is difficult to estimate the future condition of goods transportation system, we propose the required space corresponding to the present condition of goods movements in each area. The issue is examined here based on the results of the survey carried out at the previously mentioned locations.



Fig.10 GFA vs. daily
arrivals

Two models were designed:

**Model A** : for curb space loading, this model is used for calculating the number of loading spaces which can be designed and allocated at the curb. The results can be applied in the case of shopping streets having no loading space.

**Model B** : for off-curb space loading, this model is used for calculating off-street loading space required to be assigned inside buildings.

In this study, the criteria we proposed here are to provide sufficient loading space to serve loading activities with allowance of 5% or 10% of arriving vehicles having to wait a few minutes and allawances of 5% or 10% of arriving vehicles at the curb to engage in illegal parking.
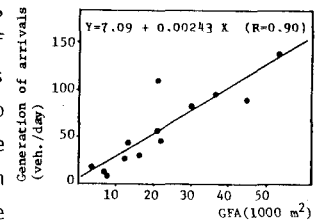
**(1) Required Data For Simulation Model**

In this study, regarding loading activities as a queueing problem, space requirements were calculated by a simulation technique.

Table 5 Generation rate of arrivals (veh./1000 $m^2$/hour)

| Minami-kyuhoji | OTC | Senri-chuo | Office bldgs. |
|---|---|---|---|
| 2.70 | 1.04 | 3.25 | 0.45 |

The input information required for this model are the expected time between arrivals and the service time both of which are considered as stochastic variables to match with the exponential distribution,and the number of vehicles to be simulated. Arrivals corresponding to 1000 square meters of GFA per hour were determined for different locations and these values are shown in **table 5.** This was calculated as follows:

In the case of MINAMI-KYUHOJI St. and office buildings, hourly arrivals corresponding to GFA were calculated from the relations shown in **Figs.7 and 10.** In the case of OTC, the arrivals corresponding to GFA were calculated from the survey results. In the case of SENRI-CHUO, demand was calculated from all the data of the survey.

After calculating the arrivals corresponding to GFA, the average intervals between arrivals were calculated. Loading time for each location was obtained as shown in **table 3.**

**(2) Results and Analysis**

The output results for each case are :

- the percentage of vehicles engaged in illegal parking .....in the case of model A and,
- the percentage of waiting vehicles and corresponding maximum number of waiting vehicles .....in the case of model B.

From the output of the simulation model, some relations between GFA and percentage of waited vehicles were drawn up. For convenience, these relations were redrawn in a simple way as a relationship between GFA and the corresponding required loading space from which it is possible to determine the required space for any known area. These relations are shown in **Figs. 11 and 12.**

From these figures, regardless of the number of stores, when we compare the requirements for

the same GFA, retail stores require more space than wholesale stores because of higher generation frequencies. Also, comparing wholesale stores (OTC, MINAMI-KYUHOJI), OTC needs more space than MINAMI-KYUHOJI, although the generation rate for the former is smaller than of the latter because the loading time in OTC is much longer than that in MINAMI-KYUHOJI.

## 5. APPLICATION OF THE RESULTS

To deal with present loading problems, we propose here the following applications of our results.

### (1) Validity of Applications

As our results were deduced from a survey, we cannot say that they have universal application, but they should be able to be used to determine loading space requirements for other similar corresponding locations.

**Wholesale Stores :** In the case of shopping streets in the CBD where there is no loading space, space requirements can be calculated using the results of MINAMI-KYUHOJI resulting from model A, and space can be allocated at the curb to be used by many stores. Since at that place it is impossible to allocate loading space for every store and there is no space to design loading lots under present
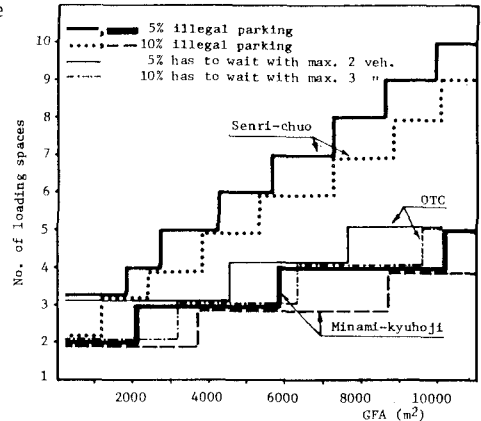


Fig.11 Loading space requirements in wholesale stores and retails stores in CBD & fringe area
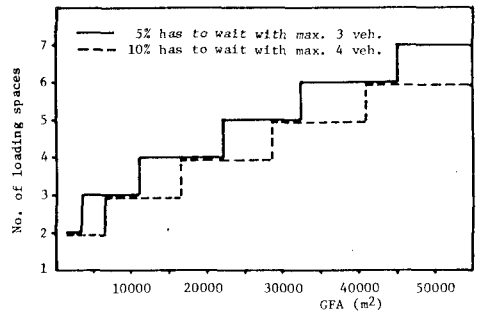


Fig. 12 Loading space requirements for office buildings

conditions, we cannot avoid using the curb-side for loading activities. In the case of wholesale buildings (using a co-operation system) in fring area, we can say that in principle, each building has to have its own loading space. So, space requirements can be calculated using the results for OTC, and then space must be designed inside the buildings.

**Retail Stores :** Every store does not need its own loading space, but loading lots which can be used by group of stores mainly for the purpose of delivery (since the results of the survey shows that about 80% of arrivals were for delivery) are necessary. Also, in some cases, it is necessary to prepare the curb-side for loading with no allowance for illegal parking. Number of required spaces can be determined by using the results of SENRI-CHUO.

**Office Buildings :** In the case of office buildings, required loading space inside the buildings can be obtained from **Fig. 12.** As far as large buildings which have not enough loading space, a part of the parking area could be designed to become a loading area, but for small buildings which have no or insufficient parking area, loading activities cannot be avoided from being carried out outside.

For all cases, when allocation of loading space is required at curb, marking or loading meters have to be installed.

### (2) Future Consideration

Since calculation of loading space depends on generation rate and loading time, modification

of our results is recommended if a co-operation system is applied in the future in order to consider its effect.

**Generation rate :**

In our calculations, we related truck generation to GFA. But as the results shows that co-operation systems have an effect on the generation rate of arrivals, it is desirable to have a model which can express the effect of any type of co-operation system between wholesale stores or carriers. In this case, generation rate will be a function of GFA and effect of co-operation system. This means that criteria will change and loading space will decrease, and calculations will have to be carried out again.

**Loading Time:**

Our survey shows that loading time is affected by various factors such as the place where loading is being done (at curb or off-street loading space) and volume of goods.

When a co-operation system is used, the volume of goods will be changed. So, in this case effect of co-operation has to be considered.

As loading space is a function of generation rate of truck arrivals and loading time, any change in these factors will affect the requirements, so, in this case additional surveys to yield more details about the mechanism of goods transport systems have to be carried out and consequently it is recommended that modification of these criteria be carried out.

## 6. GENERAL CONCLUSION

Loading characteristics in Osaka were clarified for different locations using the data from the questionnaire and the survey. Through an analysis of these characteristics the paper suggested guidelines that could be considered in formulating zoning codes to address the problems of space requirements for wholesale and retail stores both in the CBD and in fringe 8areas and also for buildings in the CBD. Such codes have to be enforced by law for loading space in areas where loading activities are carried out in order to eliminate loading problems.

REFERENCES

1) Marconi, W. : Commercial Vehicles in a Large Central Business District, Traffic Engineering, Vol.41, No.5, 1971.
2) Ahrens, G.A., Forstall K.W., Guthrie, R.U., and Ryan, B.J. : Analysis of Truck Deliveries in a Small Business District, TRR, No.637, 1977.
3) Christiansen, D. : Off-Street Truck-Loading Facilities in Downtown Area : Requirements and Design, TRR, No.668, 1978.
4) Habib, P.A., and Crowley, K.W. : Space Allocation Guidelines for Off-Street Loading Facilities, TRR, No.668, 1978.
5) Habib, P.A., and Crowley, K.W. : Economic Approach to Allocating Curb Space for Urban Goods Movement, TRR, No.591, 1976.
6) Akiyama, T. and Yamakawa, H. : Characteristics of Goods Movements by Vehicles in Neighborhood Shopping Streets, Annual conference of the Japan Society of Civil Engineers, 1977 (in Japanese).
7) Akiyama, T. and Yamakawa, H. : A study of Traffic Regulation in Commercial Areas, Annual conference of the Japan Society of Civil Engineers, 1979 (in Japanese).
8) For example, Kashima, S. : The Impact Analysis Model of Freight Transport by Joint Contract Carriers, Papers of the Annual Conference of the City Planning Instite of Japan, No.18, 1983 (in Japanese).