Analysis on Walking Distance from Truck Loading Locations to Shipper's Yards and its Application to Planning of Loading Zones

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Abstract: Delivery and pick-up trucks perform a vital distribution function of freights that is an essential component of the economic activities in urban areas. However, abundance of delivery and pick-up trucks in many central business districts in large cities, have often contributed toward severe traffic congestion. In order to improve the situation, it is effective to introduce loading zone and the distance between truck parking location and shipper's yard is likely to be affected by installation of loading zone.
The objectives of the study is firstly, to analyze characteristics of the distance between truck parking locations and shipper's yards and parking durations in different cities in Korea and Japan, secondly, to propose a suitable standard of loading zone, based on the above mentioned distance and parking duration.

Key Words: Loading Zone, Delivery and Pick-up Activities, Distance between parking location and shipper's yard

1. INTRODUCTION

Generally, freight transportation means the activity that the vehicles move freights from the individual business office to the destination or individual freight delivered to the individual business office. The parking facilities for loading and unloading freights are absolutely necessary to the vehicles that deliver and pick up freights. The parking facilities for loading and unloading freights can be often classified into the off-street and on-street parking ones. There are the exclusive parking facilities obligatorily equipped for the business office and also joint parking ones.

There are two types of on street parking facilities, one is a loading bay and the other is a loading zone. Except for off-street exclusive loading facilities adjacent to the business office, the movement activities from the parking location to the destination are required. That is, the movement activities between parking location and shipper's yard are always in need. The loading parking facilities must be secured by the people who induce freight transportation, but it is very difficult to handle the whole parking demand with such off-street parking facilities, especially, in the central business districts (CBD) which create high demand in urban areas. So, the on-street loading parking facilities such as loading zone is actually needed in the central business districts (CBD) in urban area.

The loading zone is to allow the loading vehicles to park at the section of the street and the limited time of a day. This loading zone system is popular in Europe and the United States, but it is not used in Korea and Japan yet. The appropriate analyses for the movement activities of delivery and pick-up trucks are required for the purpose of effective adjustment of the joint

loading parking facilities. The placement of the loading parking facility must be also made based on the results of the analyses. Especially, in the planning of the loading zone and loading bay, it is very important to focus on the placement of the loading parking facilities with an allowable parking duration.

Studies have been conducted on the loading parking facility (Mori et al., 1983, 1985; Tsukaguchi at al., 1994; Takada et al., 1994; Jung, 1999), and a study on activities of delivery and pick up (Tsukaguchi and Jung, 2000). Recently, a study was also undertaken on the planning of the loading zone and the loading bay, but it has not been reached to the application to the loading parking facilities in Korea and Japan (Tsukaguchi and Jung, 2000).

Thus, the objectives of this study fourfold : to analyze characteristics of the distance among truck parking locations, shipper's yards and the parking duration, to examine the placement of loading zones based on the distance and the parking duration analyzed, to identify the characteristics of activities of delivery and pick up in Osaka, Japan and Pusan, Korea, and to compare them with the characteristics in Sidney, Australia in which the loading zone are equipped.

2. DATA COLLECTION

Surveys were conducted in Osaka, Japan and Pusan, Korea, and in Sidney, Australia to identify the present conditions of the delivery and pick up trucks movement. The key survey items were the parking duration and the distance between the truck parking locations and shipper's yards. Also, the number of freights and visited business offices were surveyed. Especially, in this study, the distance from parking location to shipper's yard and the parking duration were investigated by shadowing activities of the truck drivers in survey districts. The survey districts of this study were Senba district in Osaka, Japan, KukJae market, Seomyun and Nampo-dong districts in Pusan, Korea, and York Street district in Sidney, Australia. Surveys were conducted at Semba district in Osaka, Japan on November 1994 and April 2000, and at KukJae market district in Pusan, Korea on November 1997 and at Seomyun and Nampo-dong districts in Pusan, Korea on January 2001. Also, additional surveys were conducted at six districts in Japan on December 2000, in order to examine whether deliverymen cross major streets on the way the shipper or not. Surveys were undertaken in Sidney, Australia on March 1998 and August 1999. The survey districts were outlined in Table 1.

Table 1. Outlines of survey districts

District		Road ratio(%)	Floor area ratio(%)	Land use
Osaka		23.3	289	Commerce & Business
Pusan	Kukjae market	27.5	260	Commerce
	Seomyun	28.3	255	Commerce
	Nampo-dong	28.0	270	Commerce
Sydney		30.3	700	Commerce & Business

From the results of the surveys, there was no big difference in ratios of road and capacity between Senba district in Osaka, Japan and KukJae market district in Pusan, Korea, but the floor area ratio at York Street district in Sidney, Australia was two times higher than those at the above mentioned districts in terms of the dense land-use.

Reviews on the actual conditions of loading parking management in the above cities are done. The on-street parking activities including the loading parking are extensively restricted and the on-street parking facilities such as loading zone are not secured at the urban districts in Osaka, Japan. Also, the off-street loading parking facilities are not enough and most of loading parking activities are illegal. There are no-parking zone and no loading zone at urban districts in Pusan, Korea and in Osaka, Japan. However, the enforcement for illegal parking activities is conducted along the main arterials and not conducted in the survey districts for this study. Additionally, there is the loading zone equipped in Sidney, where the maximum allowable parking duration in for wagon type vehicle and large truck are 15min and 30min, and deliverymen could get the parking permits for their freight trucks with no charge. Also,

surveillance for illegal parking is enforced by policemen in Osaka and by county officers in Pusan, but by traffic wardens in Sidney. On arterial, no loading parking activities is allowed in Sidney, but lots of those in Osaka, and half of those in Pusan. Thus, comparison of the transportation system between the countries should be drive carefully. However, there is essentially no big difference in the behavior of deliverymen from parking location to shipper's yard.

3. CHARACTERISTICS OF DISTANCE FROM PARKING LOCATION TO SHIPPER'S YARD AND PARKING DURATION

1) Distribution of distance from parking location to shipper's yard

The distance distribution from parking location to shipper's yard in survey cities was shown in Figure 1. There was no difference in distributions between the survey districts in Osaka and those in Pusan, but some difference between the survey district in Sidney and those in Osaka, or Pusan. Figure 1 shows that there is significant difference at the level of 0.01 as the results of chi-square test. The average distances from parking location to shipper's yard in Osaka, Pusan, and Sidney were shown to be 12.9m, 10.2m, and 38.7m, and the 85 percentile values were 21.8m, 43.0m, and 83.0m. In addition, the loading parking durations were shown to be 6.4min, 5.5min, and 14.8min in Osaka, Pusan and Sidney, where the number of data used were 453, 603, and 100, respectively. The loading zone may be affected the differences in the loading parking duration among the cities.

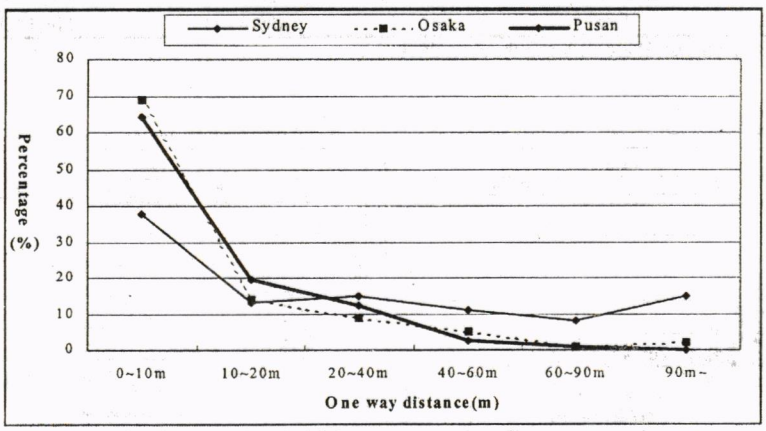


Figure 1. Distribution of distance from parking location to shipper's yard

Table 2. Average distance and parking duration

District		Sample	Average distance(m)	Parking duration(m)
Osaka		453	12.9(21.8)	6.4
Pusan	Kukjae market	128	9.11(35.0)	4.9
	Seomyun	201	10.84(58.0)	6.2
	Nampo-dong	274	9.87(35.0)	5.1
	Total	603	10.2(43.0)	5.5
Sydney		100	38.7(83.0)	14.8

Note: 85 percentile values are indicated in the parenthesis.

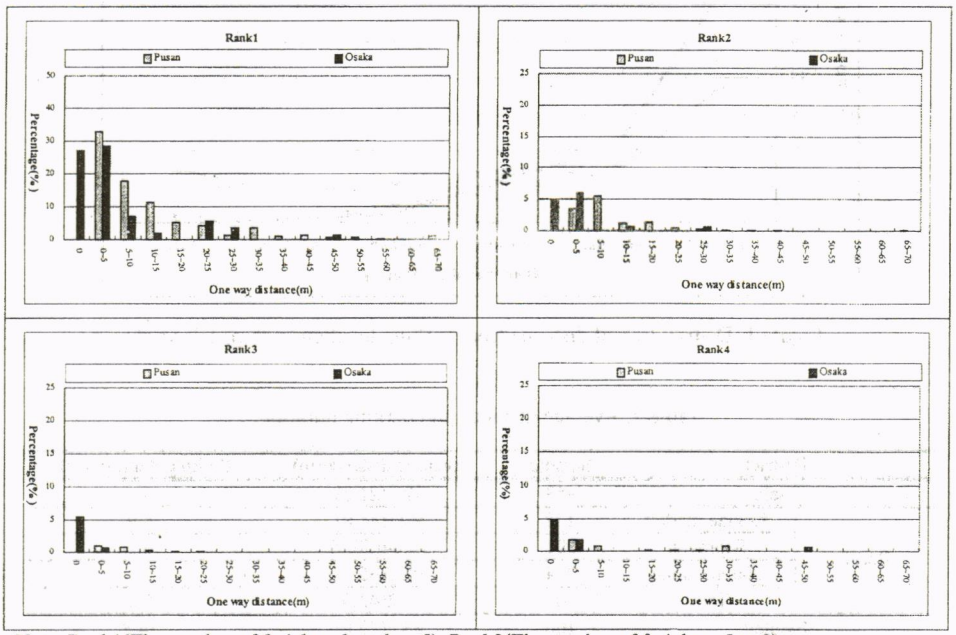
2) Distance from parking location to shipper's yard and parking duration depending on the number of freights

The number of offices, which deliverymen visited, was classified into a single office and multiple ones. The number of offices in Osaka and Pusan was compared in Table 3. Table 3 shows that over 80% of freight deliverymen were dropping in a single office in Pusan and Osaka. In this study, the distance from parking location to shipper's yard and the parking duration were investigated depending on the number of freights, when deliverymen dropped in a single office. Thus, freights were ranked depending on the number of freights and the ranks were rank1(less than 5), rank2(5 to 9), rank3(10 to 14), and rank4(the greater than 15). Figure 2 shows distribution of the distance from parking location to shipper's yard by rank. The distance from parking location to shipper's yard decreases as the number of freights increases. The similar phenomena can be seen in Osaka and Pusan. Also, the parking duration and the number of freights are closely connected as shown in Figure 3. That is, the parking duration increases as the number of freights increases in Osaka and Pusan. The similar results are obtained in Osaka and Pusan.

Table 3. Number of offices visited by deliveryman

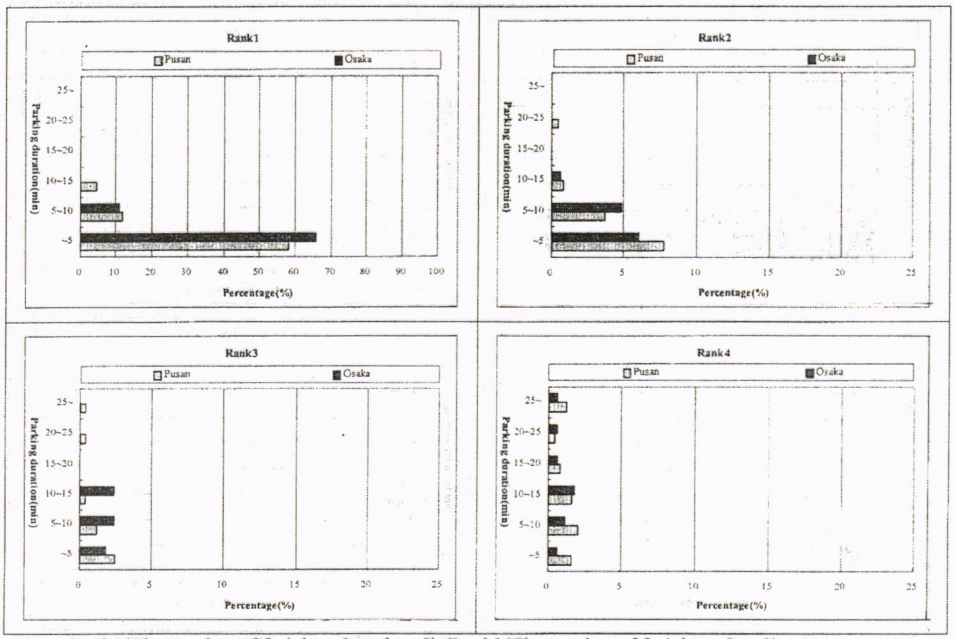
District		Sample	Single office	Multi office
Osaka		453	372(82.2)	81(17.8)
Pusan	Kukjae market	128	100(78.1)	28(21.9)
	Seomyun	201	164(81.6)	37(18.4)
	Nampo-dong	274	225(82.1)	49(17.9)
	Total	603	489(81.1)	114(18.9)

Note: Percentages(%) are shown in the parenthesis.



Note: Rank1(The number of freights : less than 5), Rank2(The number of freights : 5 to 9),
Rank3(The number of freights: 10 to 14), Rank4(The number of freights : the greater than 15)

Figure 2. Distribution of the distance by ranks in Pusan and Osaka



Note: Rank1(The number of freights : less than 5), Rank2(The number of freights : 5 to 9), Rank3(The number of freights: 10 to 14), Rank4(The number of freights : the greater than 15)

Figure 3. Distribution of parking duration by ranks in Pusan and Osaka

3) Parking duration and distance from parking location to shipper's yard

The parking duration means the sum of the hours that are required to load and unload freights, and to move them from the parking location to the destination. Accordingly, the parking duration expected to increase as the distance from the parking location to the destination increase. The relationships between the distance from parking location to shipper's yard and the parking duration in Osaka and Pusan, were shown respectively in Figure 4 and Figure 5. And the relationships between parking duration and distance analyzed by ranks, were shown in Figure 6 (Pusan) and Figure 7 (Osaka). Especially, the relationships between parking duration and distance as shown in Figure 6 and Figure 7 were closely connected on only rank1.

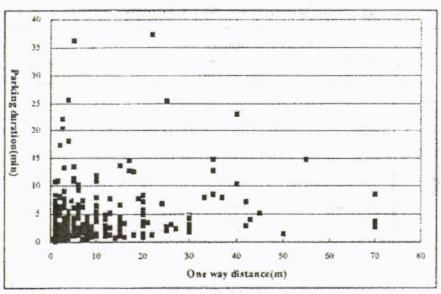


Figure 4. Relationships between parking duration and distance in Pusan

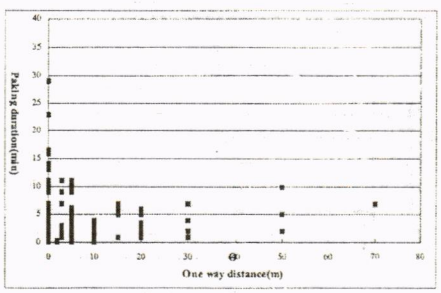
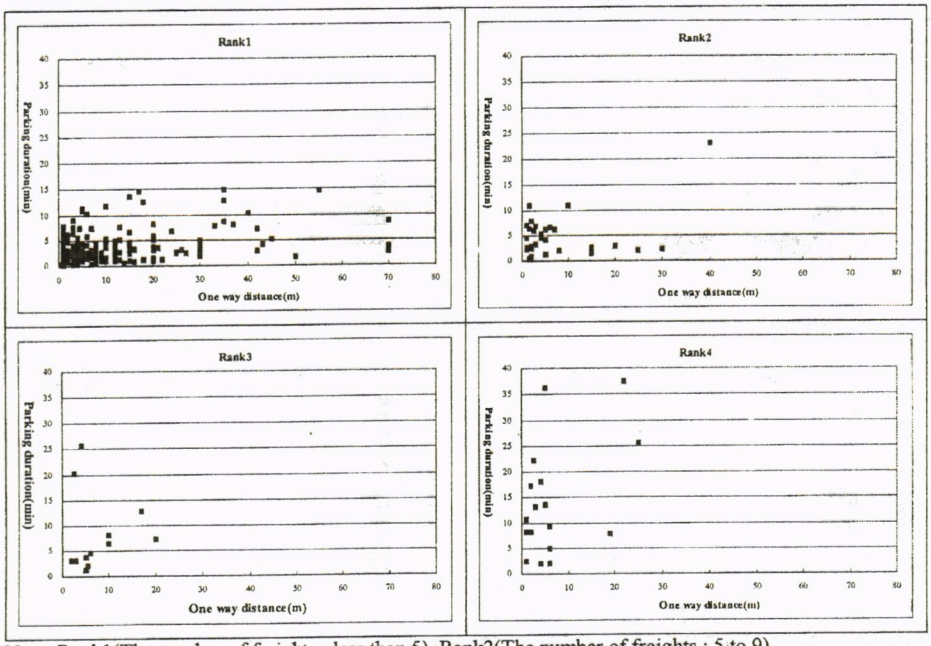
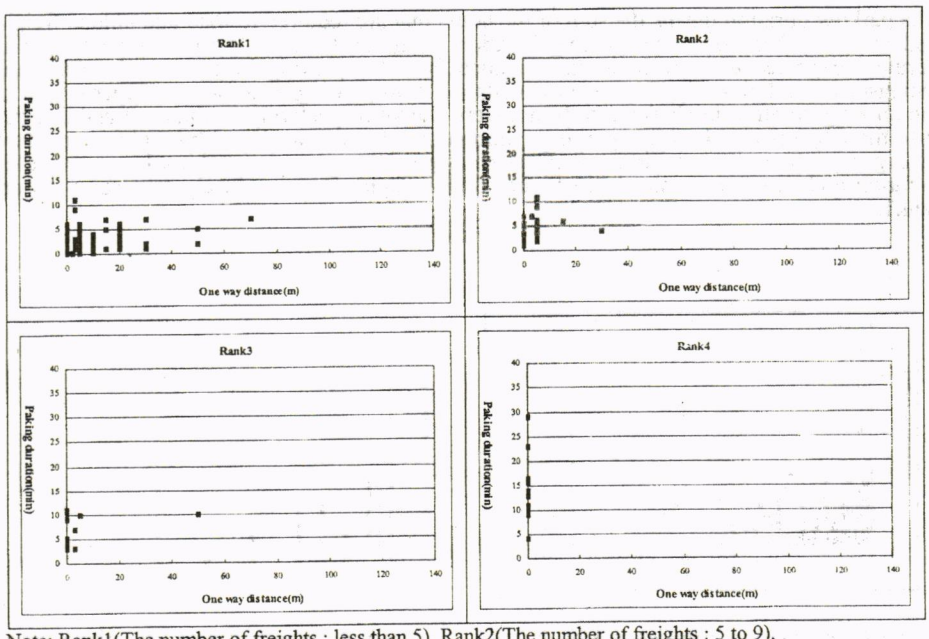


Figure 5. Relationships between parking duration and distance in Osaka



Note: Rank1(The number of freights : less than 5), Rank2(The number of freights : 5 to 9),
Rank3(The number of freights: 10 to 14), Rank4(The number of freights : the greater than 15)

Figure 6. Relationships between the parking duration and the distance from parking location to shipper's yard in Pusan



Note: Rank1(The number of freights : less than 5), Rank2(The number of freights : 5 to 9),
Rank3(The number of freights: 10 to 14), Rank4(The number of freights : the greater than 15)

Figure 7. Relationships between the parking duration and the distances from parking location to shipper's yard and in Osaka

Thus, in the rank1, the relationships between the time required for the movement of freights (y), where the time required for loading was excluded from the parking duration, and the distance from the parking location to the shipper's yard (x) can be expressed as follows;

For Pusan, $y = 0.0406x + 0.287$ .....(1)
For Osaka, $y = 0.0486x + 2.058$ .....(2)

In case of Pusan and Osaka, Mutiple R is respectively 0.55, 0.49. And it is significant at the level of 0.01. Actually, the movement distance of the deliverymen in charge of freight movement was twice because the distance from the parking location to the shipper's yard was one-way distance. Based on the analyses of movement speed of freights from this point of view, the average movement speed of freights was shown to be 49.3m/min in Pusan, and 41.2m/min in Osaka. Additionally, table 4 shows the relationships between the locations of destinations and parking locations in six surveyed districts in Osaka. About 50 % of the freights were delivered without crossing major roadways such as a and d. Only less than 1 % of the freights were delivered with crossing major arterials such as b, c, and c'.

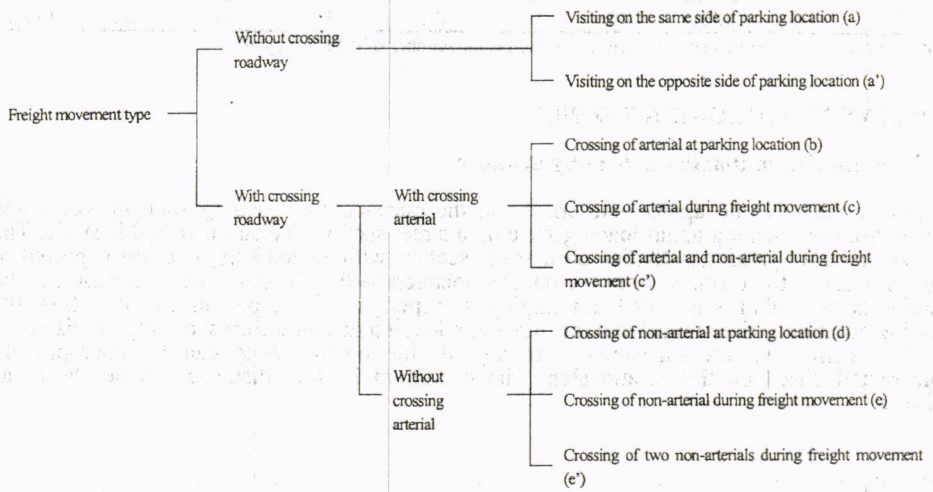


Figure 8. Type of freight movement

Table 4. Type of movements based on locations of office and parking location – with or without crossing street

District	a	a'	b	c	c'	d	e	e'	Total
A	36	1	0	0	0	11	6	1	54
	(66.7%)	(1.9%)	(0%)	(0%)	(0%)	(20.4%)	(11.1%)	(1.9%)	(100%)
B	29	5	0	0	0	12	10	8	64
	(45.3%)	(7.8%)	(0%)	(0%)	(0%)	(22.8%)	(15.6%)	(12.5%)	(100%)
C	13	4	0	1	0	13	19	7	57
	(22.8%)	(7.0%)	(0%)	(1.8%)	(0%)	(22.8%)	(33.3%)	(12.3%)	(100%)
D	12	5	0	0	2	8	18	10	55
	(21.8%)	(9.1%))	(0%)	(0%)	(3.6%)	(14.5%)	(32.7%)	(18.2%)	(100%)
E	30	2	0	0	0	17	2	4	55
	(54.5%)	(3.6%)	(0%)	(0%)	(0%)	(30.9%)	(3.6%)	(7.3%)	(100%)
F	24	13	0	0	0	10	9	3	59
	(43.6%)	(23.6%)	(0%)	(0%)	(0%)	(18.2%)	(16.4%)	(5.5%)	(100%))
Total	144	30	0	1	2	71	65	32	344
	(41.9%)	(8.7%)	(0%)	(0.3%)	(0.6%)	(20.6%)	(18.9%)	(9.3%)	(100%)

Note: Top is the number of data surveyed and bottom is the percentage.

Table 5. Average movement distance by locations of office and parking location

District	a	a'	b	c	c'	d	e	e'	Total
A	19.9m (36)	53.0m (1)	- (0)	- (0)	- (0)	15.5m (11)	83.0m (6)	90.0m (1)	28.3m (54)
B	9.0m (29)	34.2m (5)	- (0)	- (0)	- (0)	37.3m (12)	104.1m (10)	147.3m (8)	48.4m (64)
C	12.4m (13)	61.3m (4)	- (0)	75.0m (1)	- (0)	24.1m (13)	58.7m (19)	68.6m (7)	41.9m (57)
D	11.7m (12)	81.6m (5)	- (0)	- (0)	67.0m (2)	18.5m (8)	55.3m (18)	67.2m (10)	45.4m (55)
E	14.0m (30)	46.0m (2)	- (0)	- (0)	- (0)	22.4m (17)	74.0m (2)	114.5m (4)	27.3m (55)
F	20.1m (24)	64.5m (13)	- (0)	- (0)	- (0)	19.8m (10)	63.2m (9)	91.3m (3)	40.1m (59)
Total	15.2m (144)	60.3m (30)	- (0)	75.0m (1)	67.0m (2)	23.4m (71)	67.2m (65)	98.5m (32)	38.9m (344)

Note: Top is average movement distance and bottom is the number of data surveyed.

4. PLANNING OF LOADING ZONES

1) Computation of maximum loading distance

Currently there are no appropriate criteria in the placement of loading zone in Korea and Japan. So, the planning about loading zone on a street section is examined in this study. The illegal on-street parking activities on a street section without loading zone are expected to reduce because the distance from the parking location to the shipper's yard increases, if the loading zone system is installed and employed properly. If the upper limit of the allowable parking duration is determined and the maximum loading distance corresponding to this upper limit is computed, the placement planning of the loading zone can be appropriately constructed based on this relationship. The maximum loading distance can be shown as follows.

$$d=(T_0-t_k)*(\frac{V_k}{2}) \quad \text{.....(3)}$$

Where d : Maximum loading distance,
T_0: Upper limit of the allowable parking duration(15min or 20min)
t_k: Loading time by the number of freights (Rank k),
[Loading time = Parking duration - Freight movement time]
V_k : Freight movement speed of Rank k, and
K: Rank by the number of freights
(Rank 1: less than 5, Rank 2: 5 to 9, Rank 3: 10 to 14, and rank 4: greater than or equal to 15)

In case of rank1 as shown Figure 6 and Figure 7, the relationships between the distance from the parking location to shipper's yard and the parking duration were closely connected. Also, the maximum loading distance corresponding to the parking duration could be estimated, when the above equation (3) is applied with the parking duration in which freight movement time is excluded. The maximum loading distance of Rank 2 to 4 could be estimated on the assumption that the movement activity of Rank 1 is iterated. First of all, the loading time t_k is ranked to be in Table-6, on the basis of the number of freights surveyed in field. V_k applied in this study, are estimated 41.2m/min in Osaka and 49.3m/min in Pusan by equation (1), (2).

The maximum loading distance corresponding to the parking duration estimated by ranks are shown in Table 7, when the maximum allowable parking duration of 15min and 20min are

used. Especially, in case of Pusan, the average movement speed of freights is shown to be about 47m/min in Table 8, it is no difference that the value was estimated by equation (1). Accordingly, it is thought to be appropriate freight movement speed that was estimated by equation (1).

Table 6. Parking duration and loading time by ranks in Osaka and Pusan

Rank (The number of freights)	Pusan, Korea		Osaka, Japan	
	Parking duration (min)	Loading time (min)	Parking duration (min)	Loading time (min)
Rank1 (1-5 less then)	3.7	2.9	2.4	2.2
Rank2 (5-9 less then)	4.9	4.0	4.7	4.6
Rank3 (10-14 less then)	8.2	7.5	7.1	6.9
Rank4 (15 over then)	13.6	12.6	14.2	14.2

Table 7. Maximum loading distance by ranks in Osaka and Pusan

Rank (The number of freights)	Maximum loading distance (m)	
	Pusan, Korea	Osaka, Japan
Rank1 (1-5 less then)	298	263
	422	367
Rank2 (5-9 less then)	136	107
	197	159
Rank3 (10-14 less then)	62	56
	103	90
Rank 4 (15 over then)	15	4
	46	30

Note: Top is maximum loading distance when the maximum allowable parking duration of 15min and bottom is maximum loading distance when the maximum allowable parking duration of 20min.

Table 8. Average freight movement speeds observed in Pusan

Survey district	Seomyun	Nampo-dong	Kukjae market	Average
Average speed(m/min)	56.02	42.66	42.30	47.00

2) Loading Zone Interval

The loading zone has been introduced and in force in Sidney. The loading distance is relatively long when compared with those in Osaka and Pusan. Also, the loading parking is allowed from 7 am to 6 pm or 9:30 am to 3:30 pm during the weekdays, and 7 am to 10 am on Saturday in Sidney. In addition, the allowable parking duration is applied differently, depending on the types of vehicles. The allowable parking duration of wagon type and large truck are 15 min and 20 min. Most of the vehicles are composed of wagon type's vehicles. The average movement speed of freights is 38.7m/min, and the 85 percentile value is 83.0m/min under the same condition. In case of Sidney, the extent of the loading zone in the urban business district is thought to be about 100m when the maximum parking duration of

15min is allowed. According to the results in Table 7, if the parking duration of 15 min or 20min is allowed, it is judged that the extent of loading zone is effective about 150m or 200m in pusan and 100m or 150m is effective in Osaka.

5. CONCLUSION

From the above analyses of parking duration and loading distance from parking location to shipper's yard in the survey districts, the conclusions were drawn:

i) There is no big difference in the loading distance in Osaka and Pusan, but there is some difference in loading distance between Sidney and the two cities.
ii) The functional relationship between the parking duration and loading distance is formed when the number of freights is small in Pusan and Osaka. There is no big difference between the values estimated in this study and the average value of freight movement speeds observed on each district.
iii) The extent of loading zone and loading bay are proposed. If 15min and 20min are allowable parking duration, respectively, the reasonable extent of loading zone are about 150m and 200m in Pusan, and 100m and 150m are reasonable extent of loading zone in Osaka.

In addition, this study is expected to contribute to the planning of the off-street parking facilities as well as the on-street parking facilities to a certain extent.

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REFERENCES

a) Journal Papers

Jung, H.Y. (1999) Analysis on the characteristics and directions of loading in the central commercial area in the Pusan, **Journal of the Easten Asia Society for Transportation Studies, Vol.3, No.3.**

Mori, M., Tsukaguchi, H., Mabrouk, I. (1985) Characteristics of loading activities and freight loading space requirements for commercial areas in Osaka, **Infrastructure Planning Review, No.2.(in Japanese)**

Tsukaguchi, H., Jung, H.Y. (2000) Analysis on truck operator's behavior form parking location to shipper's yard. **Journal of Traffic Science Society of Osaka, Vol. 30, No.2.**

Ying, P.D., Takada, T., Michiyoshi, T. (1994) A cooperative delivery depot that reduces and smooths goods distribution in urban areas, **Papers on City Planning, No.29.(in Japanese)**

Tsukaguchi, H., Jung, H.Y. (2000) Analysis on delivery and pick-up trucks movement and application to planning of truck loading zone, **Papers on City Planning, No.35.(in Japanese)**

b) Papers Presented to Conference

Tsukaguchi, H., Iida, K., and Nakaya, T. (1994) Parking management system related to leading and unloading activities in commercial areas, **Proceedings of The Japan Society of Civil Engineers, No.494/IV-24**