

# Analysis of Loading/Unloading Activity for Efficient Urban Goods Movement Plan

- Focusing on Chiba City -

Sang-Chul Park\* · Jeong-Mi Yun\*\*

\* Busan-Jinhae Free Economic Zone Authority, Busan 618-270, Korea

\*\* Lecture, Division of Urban Planning Landscape Architecture, Dong-a University, Busan 604-714, Korea

**Abstract :** *Pick-up/delivery of consumer goods to offices, shops, and restaurants in order to support urban lives is one of the most vital activities in a city. With economic growth and technological innovation, a greater variety of goods have come to be supplied, and pick-up/delivery of consumer goods has become more complex. Efficient urban goods movement in Central Business District(CBD) starts with an efficient system for loading/unloading, and pick-up/delivery activities. Loading/unloading activity may be carried out on-street, or on especially designated space inside or outside buildings. Therefore, purpose of this study is to clarify the efficient urban goods movement in CBD(also called the pick-up/delivery activity) from the three different types of loading/unloading facilities. For this purpose, the differences in loading/unloading and truck-trip activity time of each loading/unloading facility was compared by performing the simulation analysis.*

**Key words :** *Consumer goods, Loading/unloading facility, Loading/unloading activity, Pick-up/delivery activity, Simulation analysis*

## 1. Introduction

Advancement in the physical distribution systems and the diversification of goods due to changing consumer demands have resulted in transport, pick-up and delivery operations based on the Just-In-Time (JIT) concept where the required amount of goods are only delivered at the needed time. This has led to smaller lots, frequent deliveries, and minimum maintenance of stocks. As a result of the new delivery requirements, truck loading rates have decreased and the amount of truck transport has increased causing lower transportation efficiency, road congestion, traffic accident and environmental degradation. Particularly, the movement of goods vehicles in the city has caused a lot of problems due to their heavy concentration in business, commercial and wholesale districts. Furthermore, because of the lack of parking facilities, loading/unloading activities are usually carried-out on-street resulting to severe congestion, the deterioration of the pedestrian environment, and difficulty to access certain routes. It is therefore imperative that a countermeasure directed at goods movement be placed to mitigate the effects of the above transportation problems.

Thus, this study will investigate the efficiency of the three different types of loading/unloading facilities by performing a simulation analysis. It will try to compare the

differences in the loading/unloading and truck-trip activities time of each loading/unloading facility.

The procedure of the study is as follows:

- to clarify the objectives and the methodology of the study
- to define urban goods movement in CBD and identify the problems and countermeasures associated to it
- to explain the relationship between the activities of urban goods movement in CBD (loading/unloading and truck-trip) and the different types of loading/unloading facilities
- to carry out an actual survey at a Central Business District in Chiba city, Japan, 2003 in order to collect the required data needed for simulation analysis
- to perform a simulation analysis and compare loading/unloading and truck-trip activities time of urban goods movement in CBD of loading/unloading facility on on-street, off-street and inside building.

## 2. Characteristics of urban goods movement in the Central Business District(CBD) of Japan

### 2.1 Concept of urban goods movement in CBD

Physical distribution is defined as the spatial movement

\* Corresponding Author : Sang-Chul Park, separk@bjfez.net 051)979-5352

\*\* coco@pusan.ac.kr 051)510-2447

(transport, loading/unloading), time movement (deposit) and the addition of value (processing & assembling, packaging & wrapping, information) of goods that occurs as a result of trade(Kuse, 1992). On the other hand, goods movement is only the spatial movement of goods by transport means. Thus, goods movement in this study pertains to transport and is just one aspect of physical distribution.

Fig. 1 shows the spatial classification of goods movement. It can be categorized into four types: 1) international goods movement, 2) regional goods movement, and 3) urban goods movement. International goods movement involves the movement of goods between countries. Regional goods movement involves movement between cities and is characterized by long distance transportation between delivery centers. Urban goods movement is the movement of goods inside an urban area and features short distance transportation from the delivery center to the business district, commercial district, wholesaler district or the residential district and is distinguished by delivery(from one point to many points) and pick-up(from many points to one point). Especially, urban goods movement on CBD is the movement of goods in a particular area usually a business district, a commercial district, a wholesaler district, or a residential district.(Kuse, 1996)

Therefore, in this study, urban goods movement in CBD is considered as pick-up/delivery activity. Thus, pick-up/delivery activity is composed of 1) truck-trip activity, and 2) loading/unloading activity. Truck-trip activity comprises goods movement to the parking place where the goods will be loaded/unloaded, while loading/unloading activity encompasses parking of goods vehicles and movement from the parking place to the final destination where the goods will be received by the consignee.

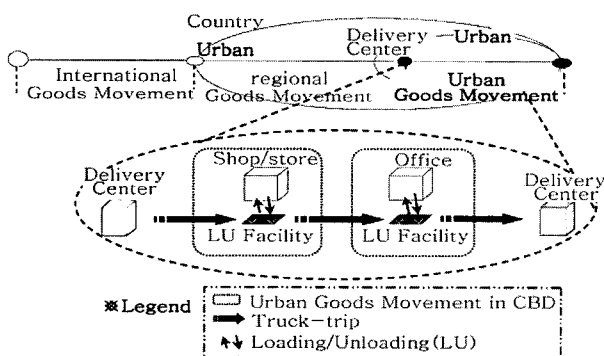


Fig. 1 Spatial boundary of urban goods movement in CBD

## 2.2 Problems and countermeasures of urban goods movement in CBD

Problems of urban goods movement in CBD can be grouped into truck-trip problems, loading/unloading problems, and problems regarding the parking of goods vehicles due to the execution of these activities. Just-in-Time has resulted to small-lot and more frequent truck-trip services. Thus, traffic density of goods vehicles increases.

The increase in the volume of goods vehicles results to numerous problems such as delayed delivery, reduced travel speed, and the confusion brought about by the inter-mixing of passenger cars and goods vehicles on road.

The countermeasures normally adapted for these are cooperative truck-trip of goods, separation of truck-trip times, provision of priority lanes and delivery route plans for goods vehicle, traffic regulation and imposition.

In the case of goods vehicles'parking, a trend where goods vehicles park on-street closed to building is very common sight due to lack of loading/unloading facilities for goods vehicle. Thus, passenger cars and goods vehicles compete with each other resulting to congestion and illegal parking.

The countermeasures to these parking of goods vehicles problems may be broken down into the following: on-street parking measures, off-street parking measures and inside building parking regulations. On-street parking measures involves the time and spatial separation of usage of the passenger car and goods vehicle at on-street loading/unloading facilities. Off-street parking measures includes control such as prohibition of on-street parking and giving parking charge discounts for goods vehicle. Inside building parking measures involves the compulsion of providing goods vehicle parking within building.

Furthermore, the horizontal conveyance of goods at pedestrian streets and inside the buildings plus the vertical conveyance of goods at elevators results to space competition between people and goods. This is due to the lack of conveyance paths and elevators for the exclusive movement of goods.

The countermeasures to these loading/unloading problems may be broken down into two: spatial separation of people and goods, and the provision of goods conveyance paths and elevators with proper design standards for the exclusive use of goods.(see Table 1)

Table 1 Problems and countermeasures of urban goods movement in CBD

	Problem	Countermeasure
Truck-trip	<ul style="list-style-type: none"> <li>• Delayed delivery</li> <li>• Reduction of travel speed</li> <li>• Inter-mixing of passenger cars and goods vehicle</li> </ul>	<ul style="list-style-type: none"> <li>• Cooperative delivery, Regulation of delivery time</li> <li>• Provision of priority lanes for goods vehicle</li> <li>• Delivery route plan for goods vehicle</li> <li>• Traffic regulation, traffic imposition</li> </ul>
Parking of goods vehicles	<ul style="list-style-type: none"> <li>• Parking congestion of passenger cars and goods vehicles at on-street parking facility</li> <li>• Increase of illegal parking</li> </ul>	<ul style="list-style-type: none"> <li>• Time and spatial separation of vehicles at on-street loading/unloading facility</li> <li>• Conduction to off-street loading/unloading facility                             <ul style="list-style-type: none"> <li>- on-street loading/unloading regulation</li> <li>- parking charge discount</li> </ul> </li> <li>• The reinforcement of the criterion on the planning of inside loading/unloading facility for goods vehicle</li> </ul>
Loading/unloading	<ul style="list-style-type: none"> <li>• Competing people and goods</li> <li>• Lack of conveyance paths</li> <li>• Lack of elevator for exclusive use of goods inside building</li> </ul>	<ul style="list-style-type: none"> <li>• Spatial separation of people and goods</li> <li>• Design standards for Conveyance paths</li> <li>• Design standards of Elevators for good</li> </ul>

### 3. Loading/unloading facilities for urban goods movement in CBD

#### 3.1 Activities of urban goods movement in CBD

In CBD, the activities of urban goods movement consist of three major activities(Fig. 2): incoming truck-trip(①), loading/unloading(②), and outgoing truck-trip(⑨).

And, loading/unloading activity(②) comprises six activities: Drop-off of goods(③), incoming horizontal conveyance to building(④), incoming conveyance inside building(⑤) wherein it can be broken down into three parts: incoming horizontal conveyance inside building(a), incoming vertical conveyance(b), incoming horizontal conveyance to receiving place(c), receiving(⑥), outgoing conveyance inside building broken down into three parts(⑦): outgoing horizontal conveyance from receiving place(d), outgoing vertical conveyance(e), outgoing horizontal conveyance inside building(f), and outgoing horizontal conveyance to place of parking(⑧).

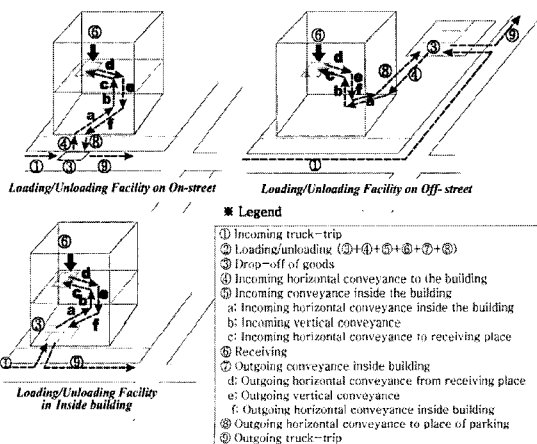


Fig. 2 Activities of urban goods movement on CBD

Fig. 2 shows the activities of urban goods movement from the viewpoint of on-street parking, off-street parking, and inside building parking. It is interesting to note that for inside building parking, there are no incoming horizontal conveyance to the building(④), and outgoing horizontal conveyance to place of parking(⑧) because the activities are carried out inside the building itself.

#### 3.2 Characteristics of loading/unloading facility types

Table 2 shows the general trend of the activity time of urban goods movement from the point of view of the different types of parking facilities. As shown in Table 3, the time of incoming and outgoing truck-trip activities changes according to the type of parking facility. Generally, the time of incoming and outgoing truck-trip activity for on-street parking is shorter than inside the building parking. For loading/unloading activity time, the following can be deduced:

Table 2 General trend of activities time of UGM on CBD

Activities \ L/u facility	L/u facility on on-street	L/u facility on off-street	L/u facility in inside building
① Incoming truck-trip	Short	Middle	Long
② Loading/unloading(L/U)	Long	Middle	Short
③ Drop off good	Same	Same	Same
④ Incoming horizontal conveyance to building	Short	Middle	Long
⑤ Incoming conveyance inside building	Long	Middle	Short
a. Incoming horizontal conveyance inside building	Long	Middle	Short
b. Incoming vertical conveyance	Same	Same	Same
c. Incoming horizontal Conveyance to Receiving Place	Same	Same	Same
⑥ Receiving	Same	Same	Same
⑦ Outgoing Conveyance inside Building	Long	Middle	Short
d. Outgoing horizontal conveyance from Receiving place	Same	Same	Same
e. Outgoing Vertical Conveyance	Same	Same	Same
f. Outgoing horizontal Conveyance inside Building	Long	Middle	Short
⑧ Outgoing horizontal conveyance to place of parking	Short	Middle	Long
⑨ Outgoing truck-trip	Short	Middle	Long

note L/U : Loading/unloading

- Generally, the time of loading/unloading activity for inside building loading/unloading facility is shorter and the time for on-street loading/unloading facility is longer.
- Drop-off of goods(③), incoming vertical conveyance(⑤ (b)), incoming horizontal conveyance to receiving place (⑤(c)), receiving(⑥), outgoing horizontal conveyance from receiving place(⑦(d)), and outgoing vertical

conveyance(⑦(e)) activity times are all equal for on-street, off-street, and inside building loading/unloading facilities.

- The times of incoming horizontal conveyance to the building(④) and outgoing horizontal conveyance to place of parking(③) follow a decreasing trend for on-street and off-street parking facilities. However, these time is not present for inside building loading/unloading facility.

The incoming and outgoing conveyance time inside building (⑤ and ⑦) follows accordingly the incoming horizontal conveyance time inside the building (⑤(a)), and the outgoing horizontal conveyance time inside the building (⑦(f)) for on-street, off-street and inside building loading/unloading facilities.

#### 4. Actual survey of urban goods movement in CBD

##### 4.1 Collection of the survey data for simulation analysis

The purpose of the survey is to understand actual activities of urban goods movement in CBD, and collect required data to be used for the simulation analysis. In this study, WITNESS by AT&T(CRC, 1992) was used for the simulation analysis. WITNESS by AT&T is a simulator that reproduces movement and conveyance of goods in the factory and in the shop. Since the situation of the flow of goods and the result of the simulation is visually displayed, the simulation software features that the user can easily detect if there are any defect in the model's procedure.

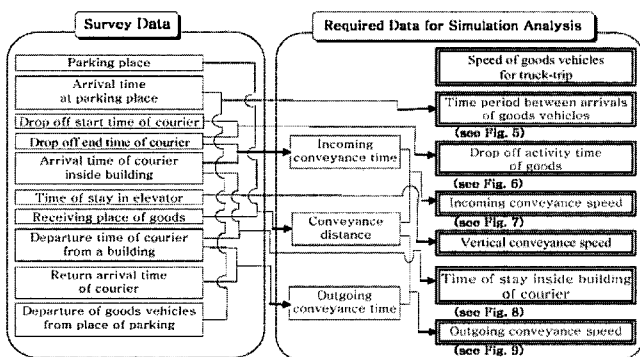


Fig. 3 Relationship between required simulation analysis data and the survey data

The required data for the simulation analysis is shown in Fig. 3. The data are broken down as follows: time period between arrivals of goods vehicles, drop-off activity time of goods, conveyance distance, conveyance time (incoming and outgoing), vertical conveyance speed, the time of stay of

inside the building of courier, and conveyance speed (incoming and outgoing).

##### 4.2 Outline of the survey

The survey area is located in the northwest direction 600 meters away from the Chiba Station of Japan Railway, and is just in the northeast vicinity of Keisei Chiba Station. Chuo-akai Road and Keisei Chiba Chuo Station Road are the main arterial roads within the area. The area is characterized by the presence of large-sized shopping centers, restaurants, shops, stores, and business offices in the vicinity of Chiba Ginza Street. Thus, this is considered as the main CBD of Chiba City. Chiba City is located in the east direction of Tokyo.(see Fig. 4) A series of observation surveys about the characteristic of loading/unloading and truck-trip activities from the arrival to the departure of goods vehicles were undertaken. The survey time was from 8:00 AM to 11:30 AM and from 12:30 PM to 16:00 PM. It carried out 5, May 2003.

In Fig. 4, the surveyed data were the location of parking place, arrival time of goods vehicles, start and end time of the drop-off of goods, arrival time inside the building of courier, departure time of the courier from the building, means of horizontal conveyance, receiving place, return arrival time of the courier, and the departure time of the goods vehicle from the loading/unloading place.

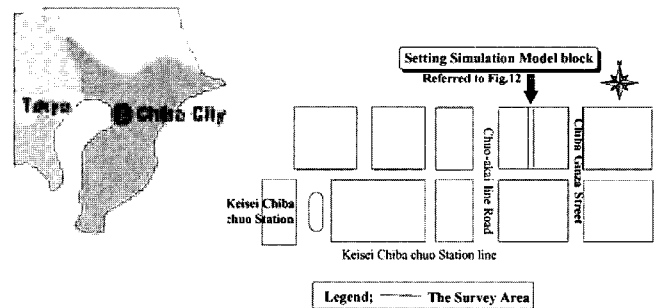


Fig. 4 CBD in Chiba city

##### 4.3 Results of the survey

- 1) Time period between arrivals of goods vehicles

Fig. 5 shows the time period between arrivals of goods vehicles. Forty-three percent(43%) of the vehicles had time period between arrivals of goods vehicles under five minutes. Meanwhile, only fifteen percent (15%) of the vehicles had parking times above 30 minutes. The result suggests that time period between arrivals of goods vehicles is usually short. The time period between arrivals of goods vehicles is approximately 14 minutes.

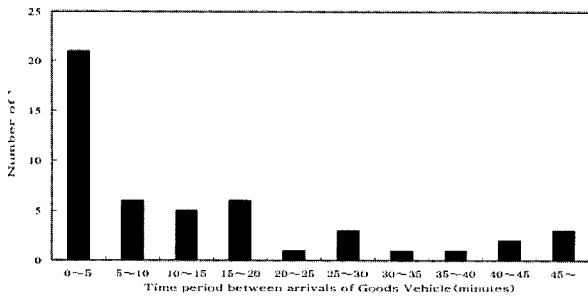


Fig. 5 Time period between arrivals of goods vehicles

2) Drop-off activity time of goods

Fig. 6 presents the drop-off activity time of goods. Forty percent (40%) of vehicles had drop-off activity time not exceeding 10 seconds. Eighty percent (80%) of vehicles had drop-off times of less than 60 seconds. These clearly show that drop-off activity is done quickly under one minute.

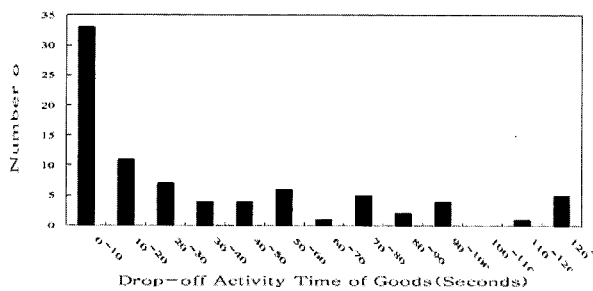


Fig. 6 Drop-off activity time of goods

3) Incoming conveyance speed of courier

Fig. 6 shows the incoming conveyance speed of the courier coming from the parking place and going into the building. Eighty-six percent (86%) of the total number of courier had speed less than 1.0 m/s. The average incoming conveyance speed is 0.50m/s.

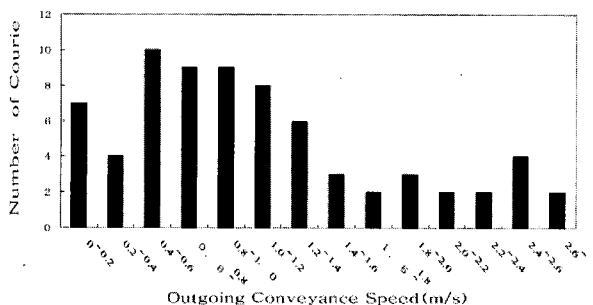


Fig. 7 Incoming conveyance speed of courier

4) Time of stay inside building of courier

Fig. 8 presents the time of stay of the courier inside the building. Forty-three percent (43%) of the total number of courier had lengths of stay under two minutes. Some

couriers had high frequencies in the over seven-minute interval and the 2 to 3 minute intervals. Thus, it can be deduced that the time of stay of the courier inside the building depends on the physical arrangement of the building itself and the conditions of the goods' receiving place. The average time of stay inside the building of courier is 2 minutes and 37 seconds.

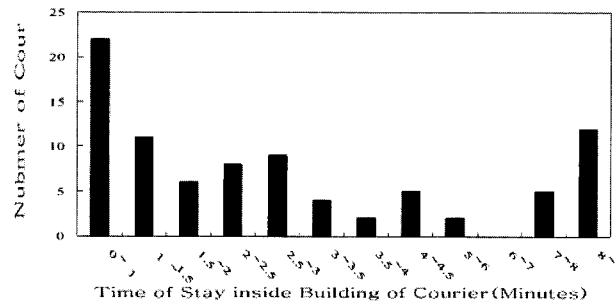


Fig. 8 Time of stay inside building of courier

5) Outgoing conveyance speed of courier

Fig. 9 shows outgoing conveyance speed of the courier from the building to the parking place. Sixty-two percent (62%) of the total number of the courier had outgoing conveyance speeds of less than 1.0 m/s. The average outgoing conveyance speed of courier is 0.84 m/s. This value is 1.7 times faster by comparison with the incoming conveyance speed since the courier no longer carries any goods to himself.

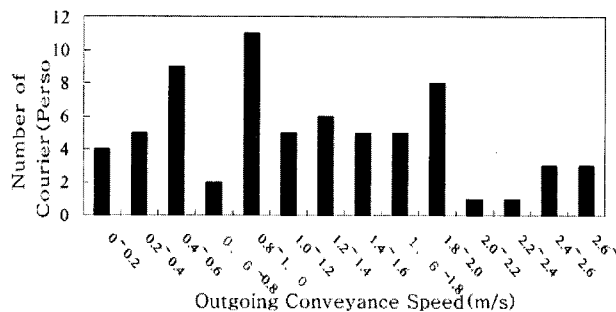


Fig. 9 Outgoing conveyance speed of the courier

5. Simulation analysis

5.1 Purpose of the simulation analysis

The purpose of carrying-out a simulation analysis using the data taken from the actual survey in Chiba City is to clarify the efficiency of urban goods movement in CBD activities according to each type of loading/unloading (on-street, off-street, and inside the building parking facility) as the volume of goods vehicles is increased. Thus, it will compare the loading/unloading and truck-trip

activities of each according that the volume of goods vehicles is increased.

### 5.2 Flow of the simulation analysis

The simulation flow is illustrated in Fig. 10.

- Carry-out simulations for each loading/unloading facility (on-street, off-street and inside the building)
- Perform simulation by changing the volume of goods vehicle from 1.0 to 3.0 times
- Compare and analyze the simulation result for each type of facility

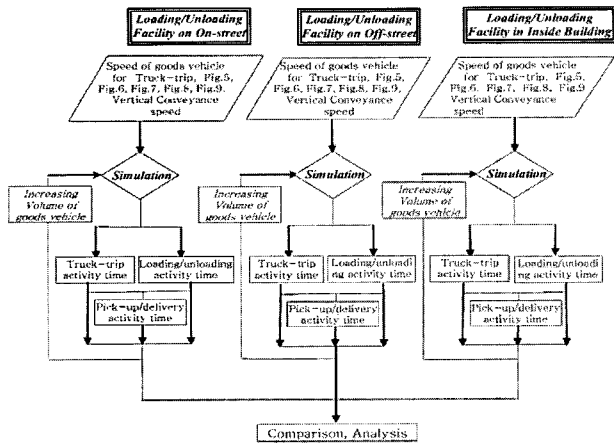


Fig. 10 The Simulation analysis flow

### 5.3 Setting the simulation model

First, the shape of the block to be analyzed was set based on the actual urban goods movement survey done in Chiba city. The block with the highest volume of arriving goods vehicle, and high volume of loading/unloading and truck-trip activities was selected. And total of number of arriving goods vehicle is 90 vehicles

The number and the location of the parking places were assumed as the same as the actual on-street parking facilities. For the case of off-street parking, it was assumed that this facility is existing at the middle section of the block since this will be the ideal location where the horizontal conveyance length will be at a minimum. For the case of inside the building parking, this parking facility was assumed to be located at the 2nd floor basement of the building since the first floor basement is usually devoted for passenger car parking in Japan.

Truck-trip speed of goods vehicles was assumed as follows: at on-street and off-street parking facilities, speed was set at 10 km/hr, at inside building parking facility, speed was set at 5 km/hr. The speed values were set up after taking into consideration the road conditions of the CBD in Japan.

Other required data were set based on actual data from the survey. The number of parking spaces is four spaces. The arrival interval time of goods vehicles, drop-off activity time of goods, conveyance distance and speed (incoming and outgoing), and time of stay of courier inside the building were all based on the distribution of the result of the survey (see Fig.11).

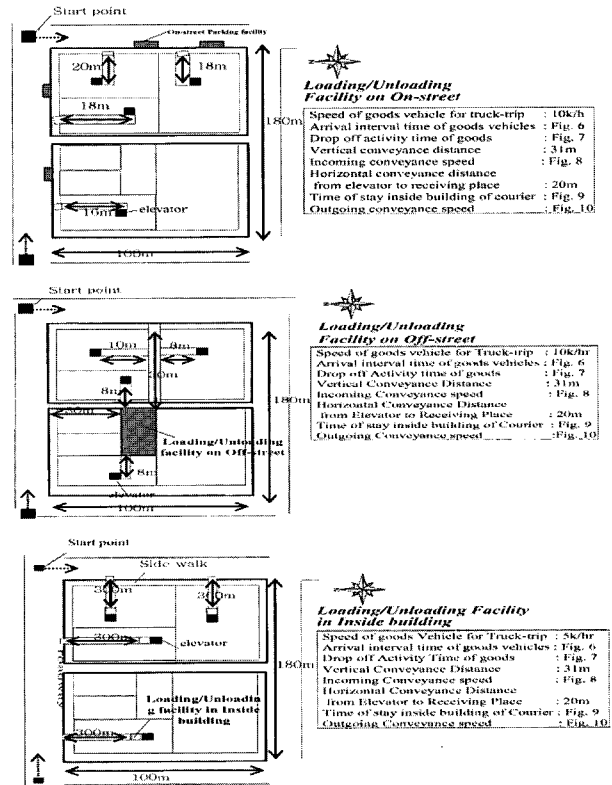


Fig. 11 Setting block and required data of the simulation

### 5.4 Result of the simulation analysis

#### 1) The three type of time

The result of truck-trip activity time, loading/unloading activity time and pick-up/delivery activity time for a simulation period of eight hours are presented in Fig. 12, 13 and 14.

Fig. 12 shows the result of truck-trip activity time after performing the simulation. Generally, truck-trip activity time at the on-street parking facility is the lowest among the three types of loading/unloading facilities (on-street, off-street, and inside building) because the distance from the parking lot is shorter. If the volume of goods vehicle is increased, truck-trip activity time for inside the building parking becomes lower than off-street parking.

Fig. 13 displays the loading/unloading activity time. It can be deduced that even if the volume of goods vehicles is increased, loading/unloading activity time for inside the

building parking remains the lowest because there is no horizontal conveyance distance from the parking place to the building.

Fig. 14 presents the total time of the truck-trip and loading/unloading activities time (also called the pick-up/delivery activity time). Even if the volume of goods vehicles is increased, pick-up/delivery activity time for inside the building parking and on-street parking remains nearly equal.

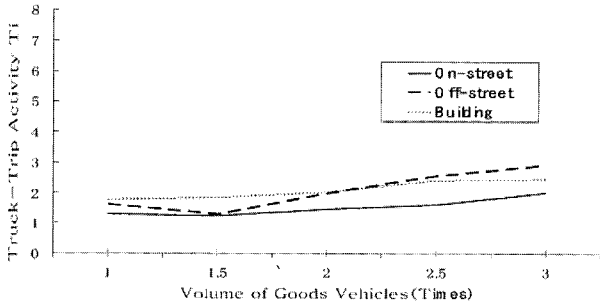


Fig. 12 Truck-trip activity time

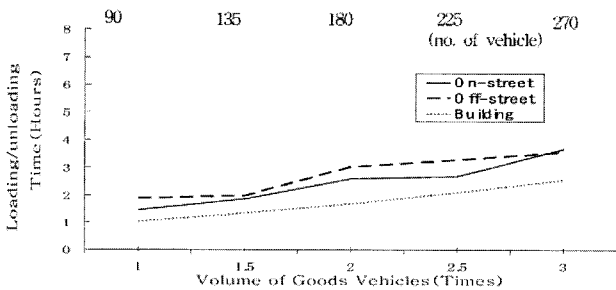


Fig. 13 Loading/unloading activity time

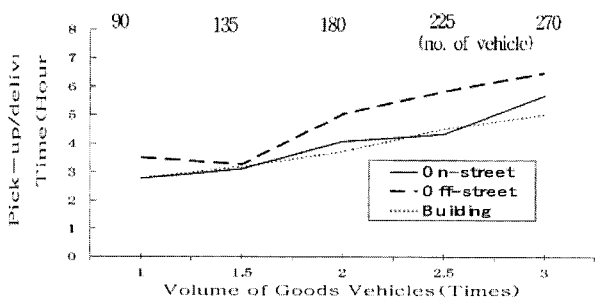


Fig. 14 Pick-up/delivery activity time

(Truck-trip activity time+loading/unloading activity time)

2) Significance of the results of the simulation analysis

From the simulation analysis, the loading/unloading activity time from the actual survey and the simulation analysis for eight hours differs by only about 5 minutes. Thus, this implies that the simulation model can be applied. Time of the simulation analysis is divided into truck-trip activity time, loading/unloading activity time and vacant

time for each parking facility.

Table 3 shows the percentages of each time (truck-trip activity time, loading/unloading activity time, vacant time) for each volume of goods vehicle and each type of loading/unloading facility. The vacant time is defined as the period where the parking place is not used by a vehicle.

Comparison of the result of the simulation analysis for each parking facility type reveals the following:

Table 3 the result of simulation analysis

(unit : no. of vehicle, %)

Loading/unloading facility	Increasing the volume of goods vehicle Activity time	Increasing the volume of goods				
		90	135	180	225	270
Loading/unloading facility on on-street	Truck-trip(①+⑨)	16.26	15.51	18.24	20.28	25.10
	Loading/unloading(②)	18.45	23.35	32.58	33.68	45.95
	Vacant time for parking place	65.30	61.14	49.19	46.05	28.96
	Total percentage(%)	100	100	100	100	100
Loading/unloading facility on off-street	Truck-trip(①+⑨)	20.11	16.08	24.75	31.90	36.37
	Loading/unloading(②)	23.50	24.67	38.01	40.92	44.57
	Vacant time for parking place	56.39	59.26	37.24	27.19	19.06
	Total percentage(%)	100	100	100	100	100
Loading/unloading facility in inside building	Truck-trip(①+⑨)	22.12	22.91	25.25	29.94	30.65
	Loading/unloading(②)	12.87	16.80	21.11	26.27	31.89
	Vacant time for parking place	65.02	60.30	53.65	43.79	37.47
	Total percentage(%)	100	100	100	100	100

- In the case of on-street loading/unloading facility, if the increase in number of goods vehicles is from 90 vehicles to 270 vehicles, increase in the loading/unloading activity time (when 90 vehicles is 18.45%, 270 vehicles is 45.95%) is longer than the increase of the truck-trip activity time (when 90 vehicles is 16.26%, 270 vehicles is 25.10%). Thus, by reducing loading/unloading activity time through the provision of conveyance paths, pick-up/delivery activity time (truck-trip activity time plus loading/unloading activity time) will become shorter.
- For the off-street loading/unloading facility, if the number of goods vehicle is increased, the increase in the loading/unloading activity time (when 90 vehicles is 23.50%, 270 vehicles is 44.57%) is longer than the increase of the truck-trip activity time (when 90 vehicles is 20.11%, 270 vehicles is 36.37%). Thus, by reducing loading/unloading activity time through the improvement of conveyance paths from the off-street parking place to the building, pick-up/delivery activity time can be made shorter.
- For inside building loading/unloading facility, if the number of goods vehicles is increased, the increase in the loading/unloading activity time (when 90 vehicles is

12.87%, 270 vehicles is 31.89%) is longer than the increase of truck-trip activity time (when 90 vehicles is 22.12%, 270 vehicles is 30.65%). However, if the number of goods vehicle does not increase, the difference in truck-trip and loading/unloading activity time is large (that is, truck-trip activity time is greater than loading/unloading activity time). Therefore, by reducing truck-trip activity time through the provision of exclusive roads or priority lanes for goods vehicles, pick-up/delivery activity time (truck-trip activity time plus loading/unloading activity time) will become shorter.

Therefore, from this simulation analysis, the suggestion points are as following;

First, in present number of goods vehicles, the highest usage is at off-street loading/unloading facility. Generally, this facility is not widely equipped at the downtown. But from this simulation, the usage of this facility is very high, it is politically urged to built this at the proper sites.

Second, in the case of number of goods vehicles increased, on-street loading/unloading facility is more used. Because this facility is closer to arrival building, it makes the high turnover rate of parking lots and the increased usage rate of this facility. But we have to also consider the traffic congestion caused by this facility, It is necessary to guide it from on loading/unloading facility to off-road loading/unloading facility or loading/unloading facility inside building.

Third, loading/unloading activity in building is the lowest. Even though the working time in the building is estimated to the shortest, but no-secure of conveyance paths and the difficulties of vertical conveyance cause to the low usage. It is necessary to find out good approach to maximize the usage of loading/unloading facility inside building by improvement of facility which is related to loading/unloading activity in building.

## 6. Conclusion

In this study, the efficiency of urban goods movement in CBD of each loading/unloading facility was done by comparing the differences in the loading/unloading and truck-trip activity time from each loading/unloading facility (on-street, off-street, inside building) through the use of a simulation analysis. An actual survey in the Central Business District at Chiba City in Japan was performed to collect the required data for the simulation analysis.

From the simulation analysis, the following may be concluded: 1) for on-street parking and off-street parking

facility, reducing the loading/unloading activity time is to make pick-up/delivery activity more efficient, 2) for inside building parking facility, reducing the truck-trip activity time will result to efficient pick-up/delivery activity.

Since the paper is a basic study for effective urban goods movement in the CBD of Japan, it has many limitations owing to the insufficiency of survey data. Hence, in the future, the following subjects must be addressed: 1) the need to collect detailed data for urban goods movement in CBD, 2) to analyze the problem of queuing and spillover to the adjacent traffic lane of parking delivery vehicles, and 3) to comprehend the trade-offs that could occur between parking facility costs and pick-up/delivery times through simulation analysis.

## Reference

- [1] CRC Research Institute, Inc., (1992), WITNESS Release 6.0 Manual, (Japanese)
- [2] Kuse, H., Takahshi, Y., and Oh, Dong-Kun(1992), "Basic Mechanism of Accumulation and Renewal of Physical Distribution Facilities in Tokyo", The sixth World Conference on Transportation Research, Lyon, France, p.26-50.
- [3] Kuse, H. (1996). "Physical Distribution and Transportation in Urban Districts", City Planning Review. p.18. (Japanese)
- [4] Takahashi, Y., Hyodo, T., Kuse, Hirohito., (1995) "An Analysis on the Distribution Channel of Consumption and Effect of Cooperative Pick and Delivery Service", The first Conference of the East Asia Society for Transportation Studies, Manila, Philippines.

---

**Received** 21 March 2005

**Accepted** 23 June 2005