Topic Area
B5 Urban Goods Movement (SIG)

Author
Sang-chul PARK Hirohito KUSE Yoji TAKAHASHI Eiichiro IWAO

Title:
A SIMULATION ANALYSIS ON LOADING/UNLOADING AND PICK-UP/DELIVERY ACTIVTIES FOR EFFICIENT GOODS MOVEMENT AT THE CBD IN JAPAN

Abstract:
Pick-up/delivery of consumer goods and commodities to offices, shops, stores, 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 and commodities have come to be supplied. Therefore, pick-up/delivery of consumer goods and commodities have become more complex. Efficient district goods movement starts with an efficient system for loading and unloading, and pick-up and delivery. Loading and unloading activities may be carried out on-street or on especially designated spaces inside or outside the buildings.

The purpose of this study is to clarify the efficient District Goods Movement (also called the pick-up/delivery activity) from the three different types of parking facilities. For this purpose, the differences in the loading/unloading and truck-trip activities times of each parking facility was compared by performing the simulation analysis,. A survey was also conducted to clarify the present situation of loading/unloading and truck-trip activities in Chiba City and collect the required data needed for simulation analysis.

A SIMULATION ANALYSIS ON LOADING/UNLOADING AND PICK-UP/DELIVERY ACTIVTIES FOR EFFICIENT GOODS MOVEMENT AT THE CBD IN JAPAN

Sang-chul PARK
Graduate student
Dept. of Information Eng. & Logistics
Tokyo University of Mercantile Marine
Tokyo-Japan
Fax 81-3-5620-6462

Hirohito KUSE
Professor
Dept. of Information Eng. & Logistics
Tokyo University of Mercantile Marine
Tokyo- Japan
Fax 81-3-5245-7369

Yoji TAKAHASHI
Professor
Dept. of Information Eng. & Logistics
Tokyo University of Mercantile Marine
Tokyo- Japan
Fax 81-3-5245-7366

Eiichiro IWAO
Graduate student
Dept. of Information Eng. & Logistics
Tokyo University of Mercantile Marine
Tokyo- Japan
Fax 81-3-5620-6462

1 INTRODUCTION

Advancement in the physical distribution systems and the diversification of goods due to changing consumer demands have resulted to 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.

2 OBJECT AND METHODOLOGY OF THE STUDY

2.1 Objectives

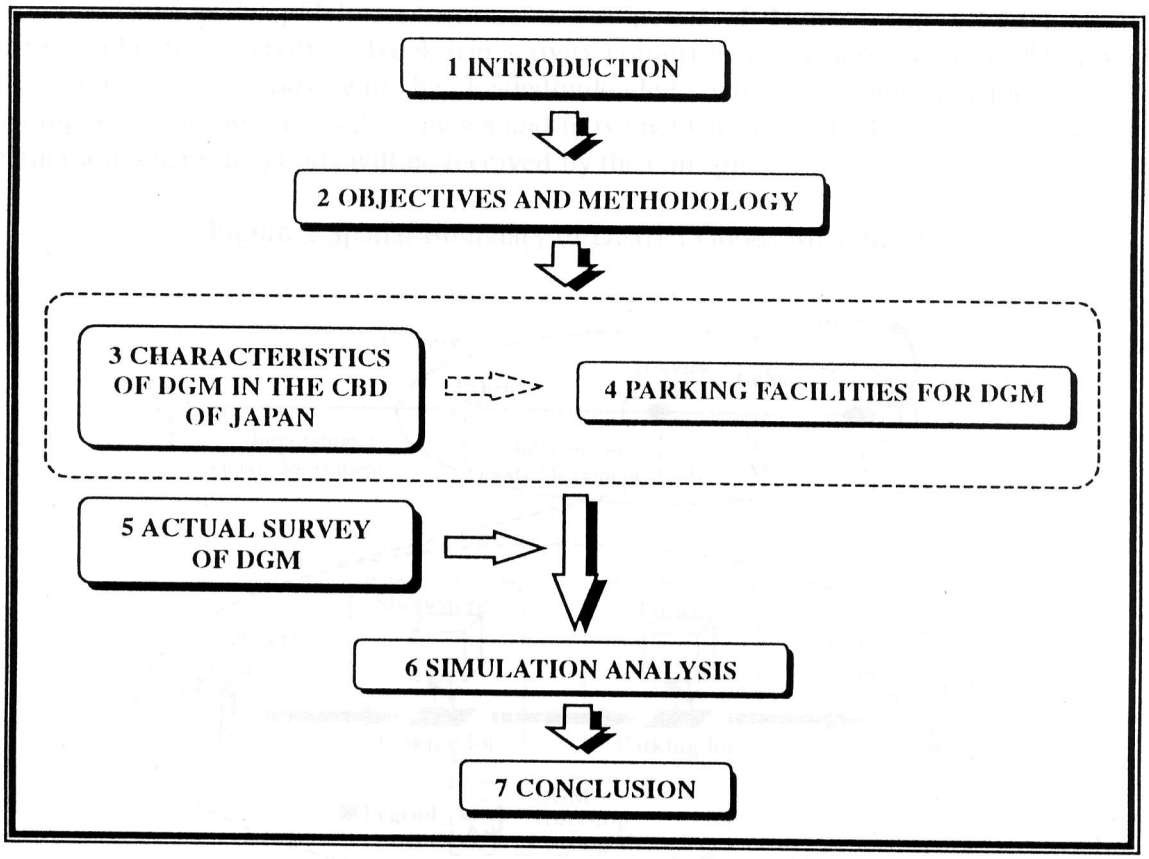
Over-utilization of on-street parking due to the prevailing insufficiency of goods movement facilities has led to policies that require the provision of off-street and inside the building parking facility for activities associated with loading/unloading and pick-up/delivery. Thus, this study will investigate the efficiency of the three different types of parking facilities by performing a simulation analysis. It will try to compare the differences in the loading/unloading and truck-trip activities times of each parking facility.

2.2 Methodology

The procedure of the study is as follows:

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

Figure 1 Flow of the Study



3 CHARACTERISTICS OF DISTRICT GOODS MOVEMENT (DGM) IN THE CENTRAL BUSINESS DISTRICT (CBD) OF JAPAN

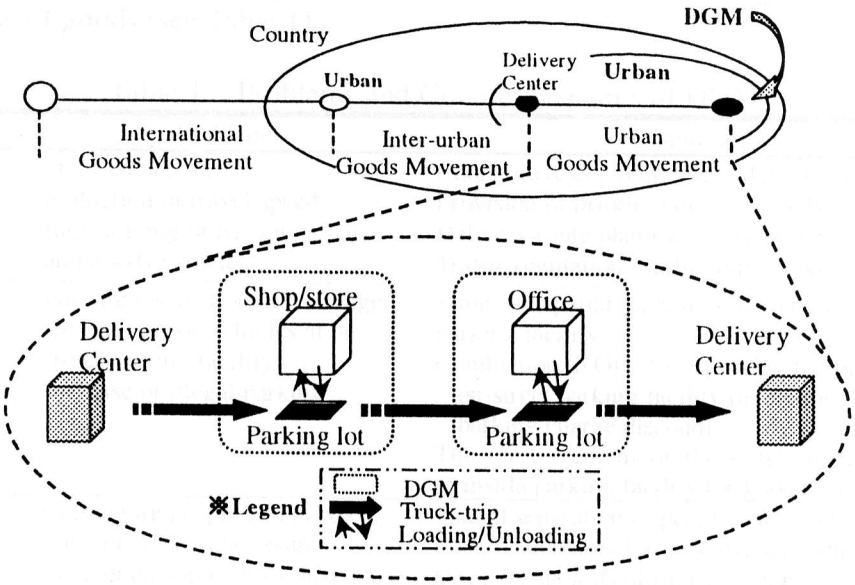
3.1 Concept of District Goods Movement

Physical distribution is defined as the spatial movement (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.

Figure 2 shows the spatial classification of goods movement. It can be categorized into four types: 1) International Goods Movement, 2) Inter-Urban Goods Movement, 3) Urban Goods Movement and 4) District Goods Movement. International Goods Movement involves the movement of goods between countries period. Inter-urban 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). District goods movement (DGM) 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) Therefor, in this study, DGM is considered as pick-up/delivery activiy. 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.

Figure 2 Spatial Boundary of District Goods Movement



3.2 Problems and Countermeasures of District Goods Movement (DGM)

Problems of DGM 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 the building is very common sight due to lack of parking 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 the 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 parking facilities. Off-street parking measures includes control such as

prohibition of on-street parking and giving parking charge discounts for goods vehicle. Inside the building parking measures involves the compulsion of providing goods vehicle parking within the 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 DGM

	Problems	Countermeasures
Truck-trip	Delayed delivery Reduction of travel speed Inter-mixing of passenger cars and goods vehicles	Cooperative delivery, Regulation of delivery time Provision of priority lanes for goods vehicle Delivery route plan for goods vehicle Traffic regulation, traffic imposition
Parking of goods vehicles	Parking congestion of passenger cars and goods vehicles at on-street parking facility Increase of illegal parking	Time and spatial separation of vehicles at on-street parking facility Conduction to Off-street parking facility -on-street parking facility regulation -parking charge discount The reinforcement of the criterion on the planning of inside parking facility for goods vehicle
Loading/ unloading	Competing people and goods Lack of conveyance paths Lack of elevator for exclusive use of goods inside the building	Spatial separation of people and goods Design standards for Conveyance paths Design standards of Elevators for goods

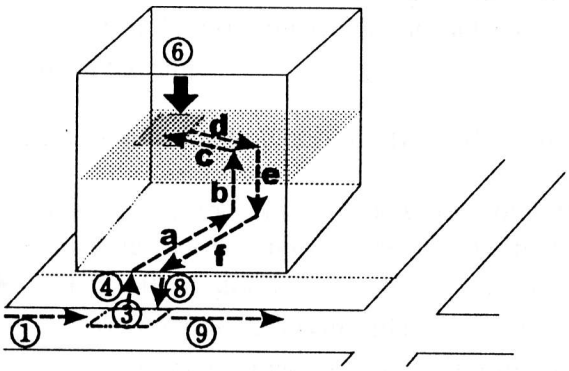
4 PARKING FACILITIES FOR DISTRICT GOODS MOVEMENT

4.1 Activities of District Goods Movement

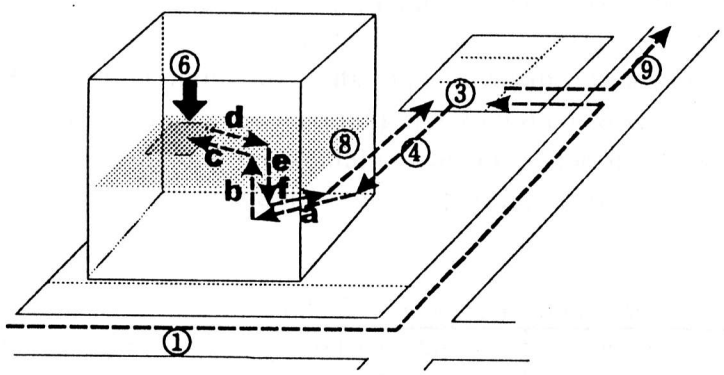
The activities of DGM consist of three major activities (Fig. 3): ①Incoming truck-trip, ② Loading/unloading, and ⑨ Outgoing truck-trip. And, ② Loading/unloading activity comprises six activities: ③Drop-off of goods, ④Incoming horizontal conveyance to the building, ⑤Incoming conveyance inside the building wherein it can be broken down into three parts: (a) Incoming horizontal conveyance inside the building, (b) Incoming vertical conveyance, (c) Incoming horizontal conveyance to receiving place, ⑥Receiving, ⑦ Outgoing conveyance inside building broken down into three parts: (d) Outgoing horizontal conveyance from receiving place, (e) Outgoing vertical conveyance, (f) Outgoing horizontal conveyance inside building, and ⑧Outgoing horizontal conveyance to place of parking.

Figure 3 shows the activities of DGM from the viewpoint of on-street parking, off-street parking, and inside the building parking. It is interesting to note that for inside the building parking, there are no ④Incoming horizontal conveyance to the building, and ⑧Outgoing horizontal conveyance to place of parking because the activities are carried out inside the building itself.

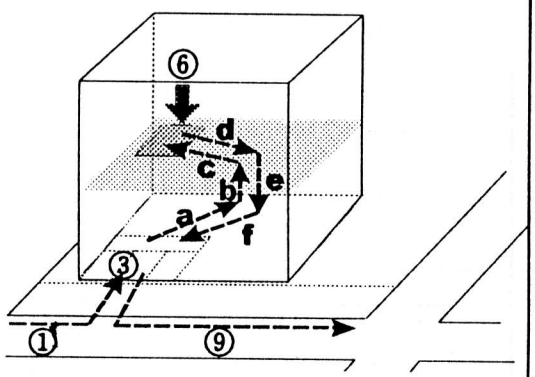
Figure 3　Activities of District Goods Movement



On-street Parking



Off-street Parking



Inside building Parking

※ Legend

① Incoming truck-trip
② Loading/unloading (③+④+⑤+⑥+⑦+⑧)
③ Drop-off of goods
④ Incoming horizontal conveyance to the building
⑤ Incoming conveyance inside the building
a; Incoming horizontal conveyance inside the building
b; Incoming vertical conveyance
c; Incoming horizontal conveyance to receiving place
⑥ Receiving
⑦ Outgoing conveyance inside building
d; Outgoing horizontal conveyance from receiving place
e; Outgoing vertical conveyance
f; Outgoing horizontal conveyance inside building
⑧ Outgoing horizontal conveyance to place of parking
⑨ Outgoing truck-trip

4.2 Characteristics of Parking Facility Types

Table 2 shows the general trend of the activity times of DGM from the point of view of the different types of parking facilities. As shown, 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:

- Generally, the time of loading/unloading activity is short for inside the building parking facility and is long for on-street parking facility.
- 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 the building parking facilities.
- The times of Incoming horizontal conveyance to the building (④) and outgoing horizontal conveyance to place of parking (⑧) follow a decreasing trend for on-street and off-street parking facilities. However, these times are not present for inside the building parking facility.
- The incoming and outgoing conveyance times inside the building (⑤and ⑦) follow 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 the building parking facility.

Table 2 General Trend of Activities Time of DGM

Activities \ Parking facility	On-street Parking facility	Off-street Parking facility	Inside building Parking facility
① Incoming Truck-trip	Short	Middle	Long
② Loading/unloading	Long	Middle	Short
③ Drop off Goods	Same	Same	Same
④ Incoming horizontal Conveyance to the building	Short	Long	Nothing
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	Long	Nothing
⑨ Outgoing Truck-trip	Short	Middle	Long

※ Note: "same" means that the times for on-street, off-street and inside the building parking are equal for each activity

5 ACTUAL SURVEY OF DISTRICT GOODS MOVEMENT

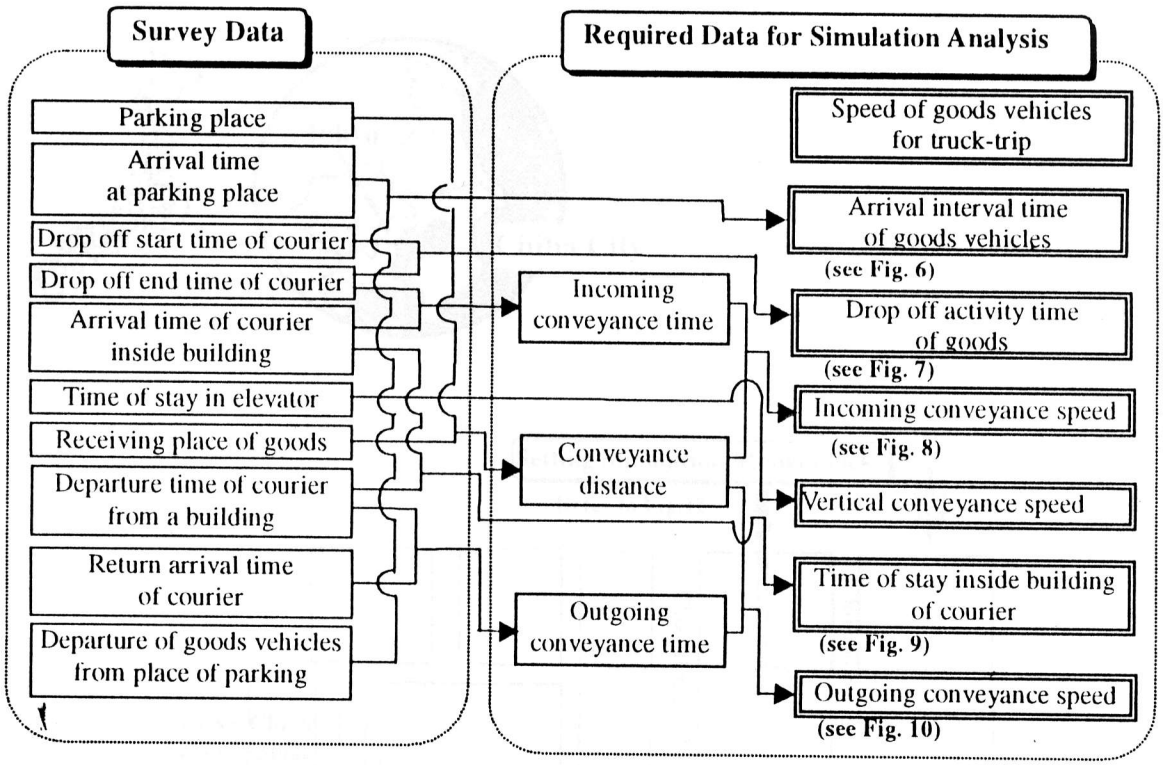
5.1 Purpose of the Survey

The purpose of the survey is to understand actual activities of DGM, and collect required data to be used for the simulation analysis.

In this study, WITNESS™ by AT&T 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 This simulation software features that the user can easily detect if there are any defect in the model's procedure.

the required data for the simulation analysis is shown in Figure 4. The data are broken down as follows: arrival interval time 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).

Figure 4 Relationship between Required Simulation Analysis Data and The Survey

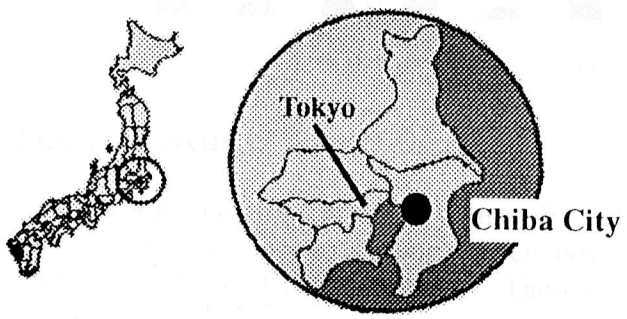


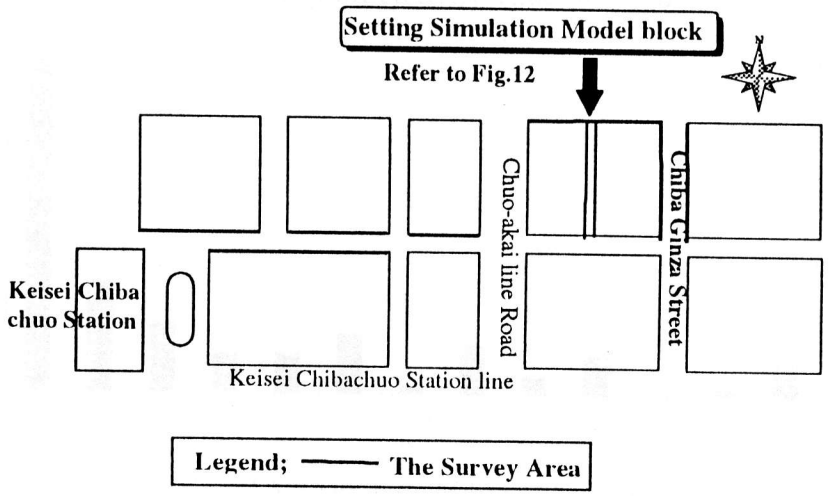
5.2 Scope and Methodology of the Survey

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 Central Business District (CBD) of Chiba City. Chiba City is located in the east direction of Tokyo.(see Fig. 5)

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* to11:30 *AM* and from 12:30 *PM* to 16:00 *PM*. In Figure 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 parking place.

Figure 5 Central Business District of Chiba City



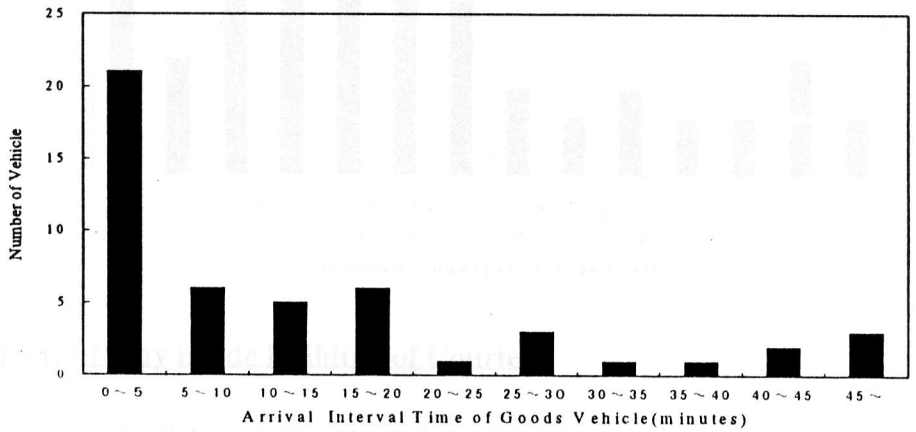


5.3 Results of the Survey

5.3.1 Arrival Interval Time of Goods Vehicles

Figure 6 shows arrival interval time of goods vehicles. Forty-three percent(43%) of the vehicles had arrival interval time of goods vehicles under five minutes. Meanwhile, only fifteen percent (15%) of the vehicles had parking times above 30 minutes. The result suggests that goods vehicles parking time is usually short. The arrival interval time of goods vehicles is approximately 14 minutes.

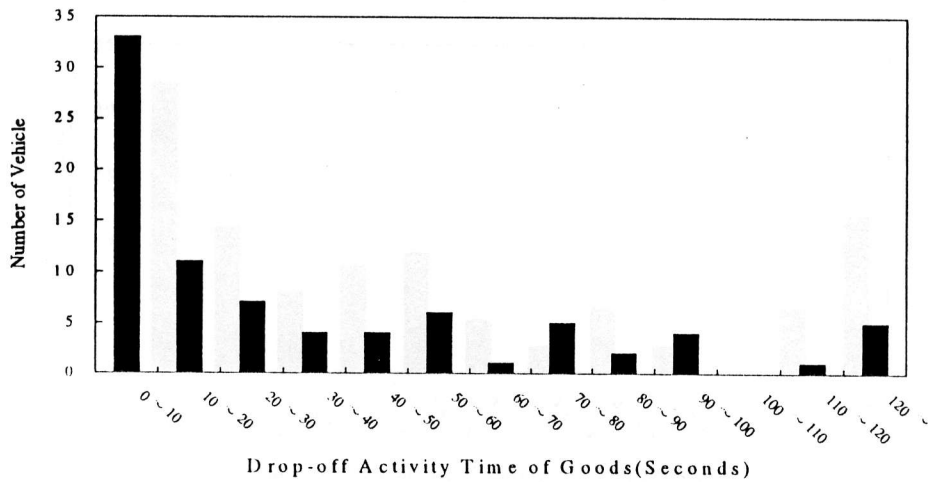
Figure 6. Arrival Interval Time of Goods Vehicles



5.3.2 Drop-off Activity Time of Goods

Figure 7 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.

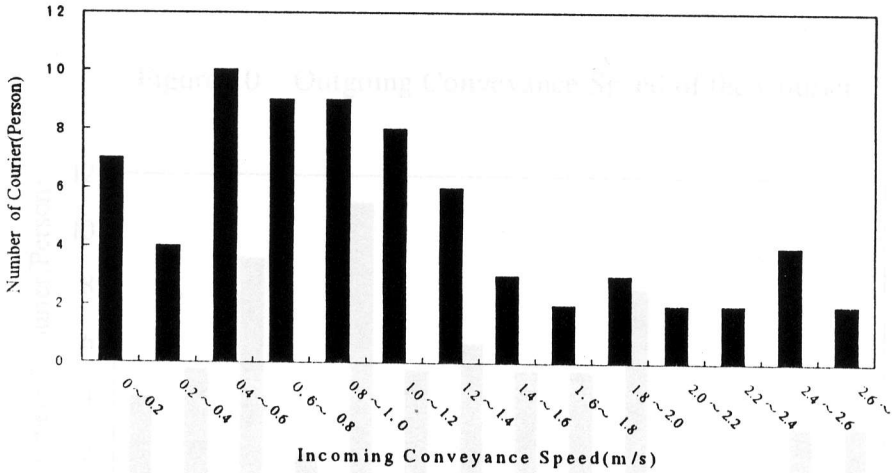
Figure 7 Drop-off Activity Time of Goods



5.3.3 Incoming Conveyance Speed of Courier

Figure 8 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.

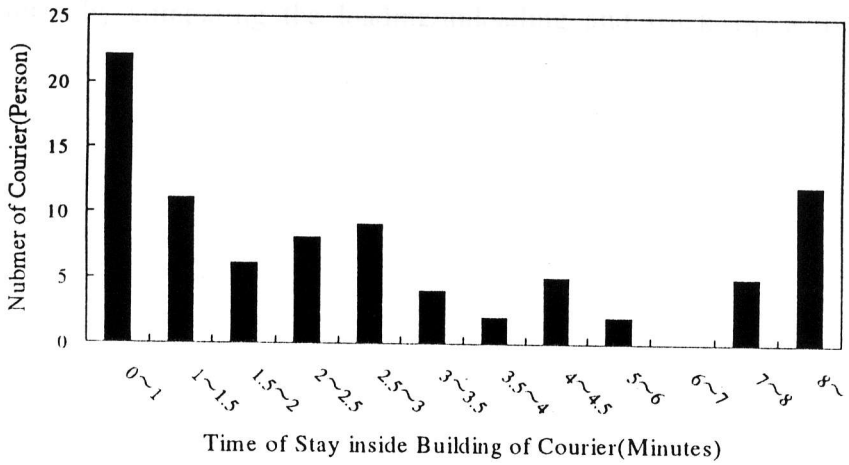
Figure 8 Incoming conveyance speed of courier



5.3.4 Time of Stay inside Building of Courier

Figure 9 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.

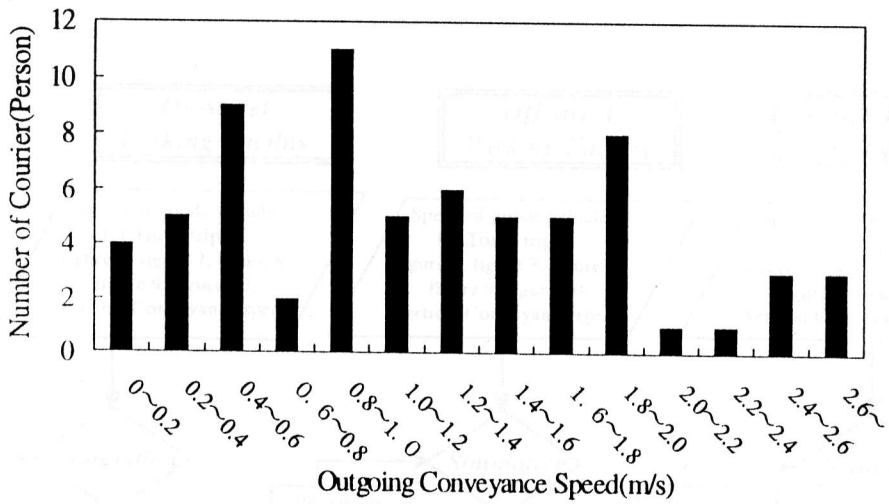
Figure 9 Time of stay inside building of courier



5.3.5 Outgoing Conveyance Speed of Courier

Figure 10 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.

Figure 10 Outgoing Conveyance Speed of the Courier



6 SIMULATION ANALYSIS

6.1 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 District Goods Movement activities according to each type of parking facility (on-street, off-street, and inside the building parking facility) by comparing the loading/unloading and truck-trip activities times of each.

6.2 Flow of the Simulation Analysis

The simulation flow is illustrated by Figure 11.

- Carry-out simulations for each parking 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

Figure 11 The Simulation Analysis Flow

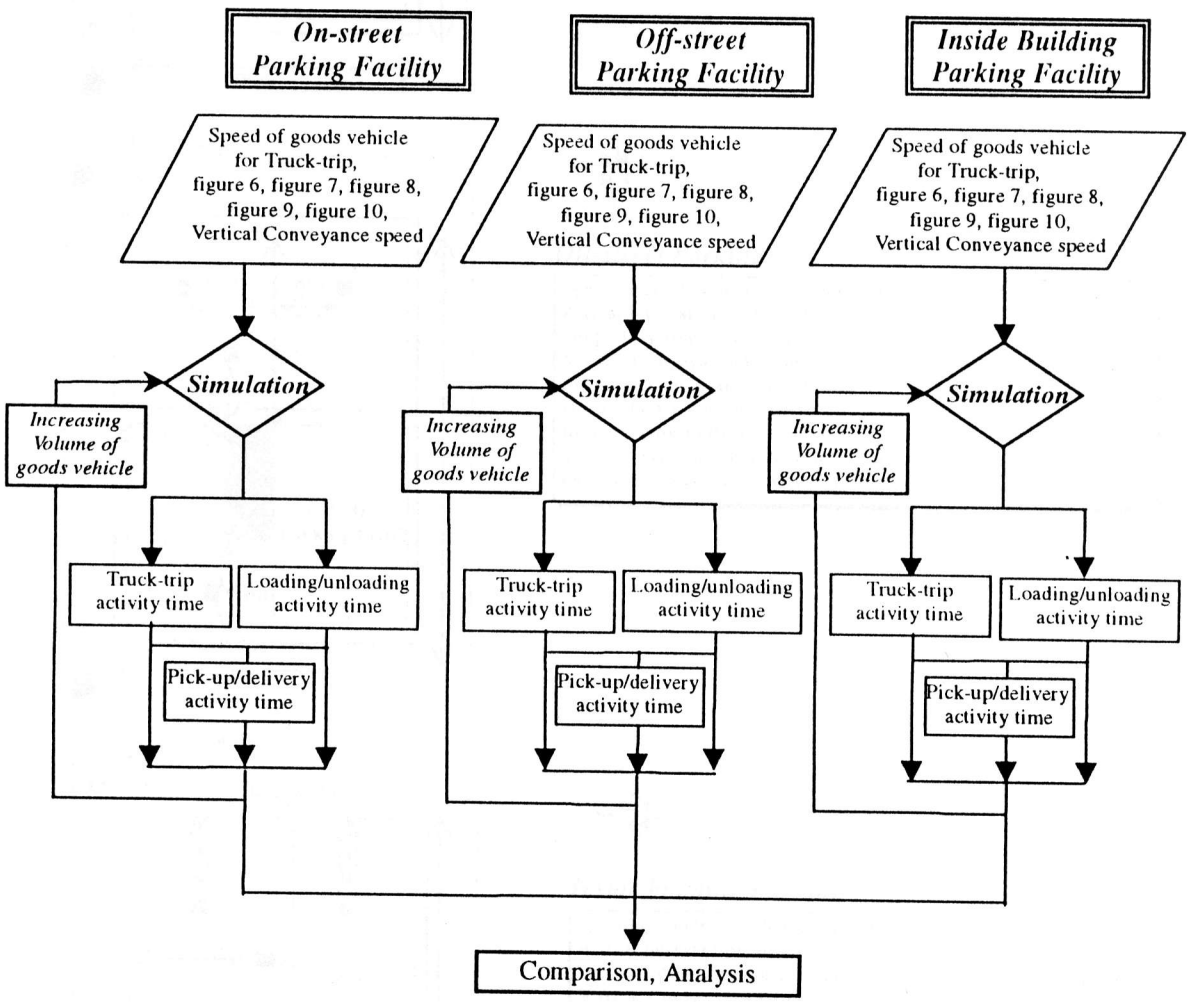
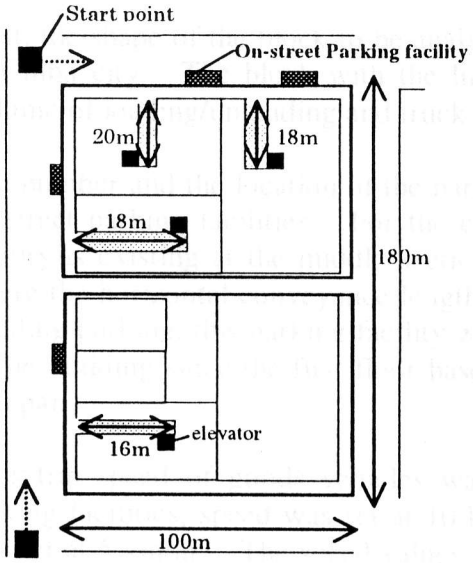
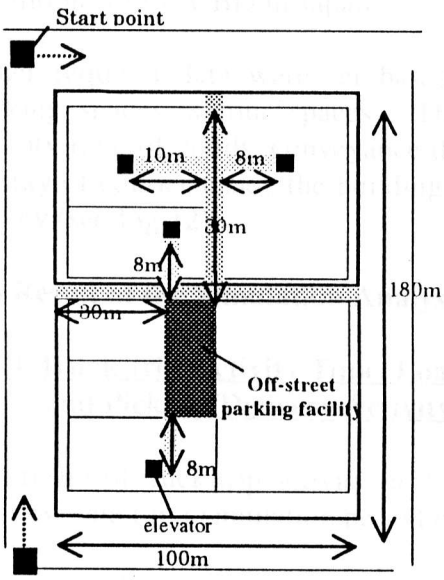


Figure 12 Setting Block and Required Data of the Simulation



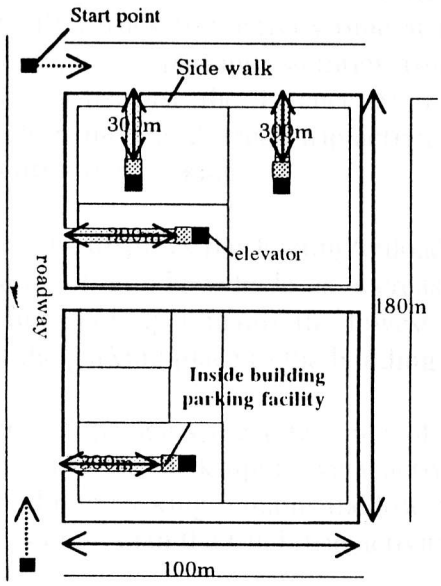
On-street Parking

Speed of goods vehicle for truck-trip	10k/h
Arrival interval time of goods vehicles	figure 6
Drop off activity time of goods	figure 7
Vertical conveyance distance	31m
Incoming conveyance speed	figure 8
Horizontal conveyance distance from elevator to receiving place	20m
Time of stay inside building of courier	figure 9
Outgoing conveyance speed	figure 10



Off-street Parking

Speed of goods vehicle for Truck-trip	10k/h
Arrival interval time of goods vehicles	figure 6
Drop off Activity time of goods	figure 7
Vertical Conveyance Distance	31m
Incoming Conveyance speed	figure 8
Horizontal Conveyance Distance from Elevator to Receiving Place	20m
Time of stay inside building of Courier	figure 9
Outgoing Conveyance speed	figure 10



Inside building Parking

Speed of goods Vehicle for Truck-trip	5k/h
Arrival interval time of goods vehicles	figure 6
Drop off Activity Time of goods	figure 7
Vertical Conveyance Distance	31m
Incoming Conveyance speed	figure 8
Horizontal Conveyance Distance from Elevator to Receiving Place	20m
Time of stay inside building of Courier	figure 9
Outgoing Conveyance speed	figure 10

6.3 Setting the Simulation Model

First, the shape of the block to be analyzed was set based on the actual DGM 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.

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 the 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.12).

6.4 Result of the Simulation Analysis

6.4.1 Truck-trip Activity Time, Loading/Unloading Activity Time, and Pick-up/Delivery Activity 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 Figure 13, 14 and 15.

Figure 13 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 parking facilities (on-street, off-street, and inside the building parking facilities) 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.

Figure 14 displays the loading/unloading activity time. It can be deduced that even if the volume of goods vehicle 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.

Figure 15 presents the total time of the truck-trip and loading/unloading activities time (also called the pick-up/delivery activity time). Pick-up/delivery activity time for inside the building parking remains the lowest because the influence of loading/unloading activity time is more than the truck-trip activity time.

Figure 13 Truck-trip Activity Time

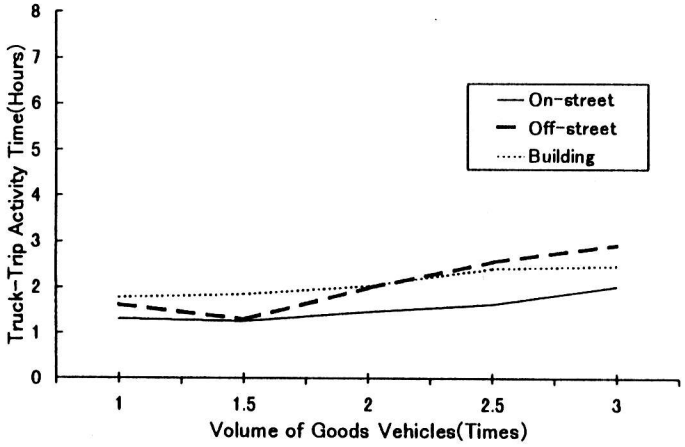


Figure 14 Loading/unloading Activity Time

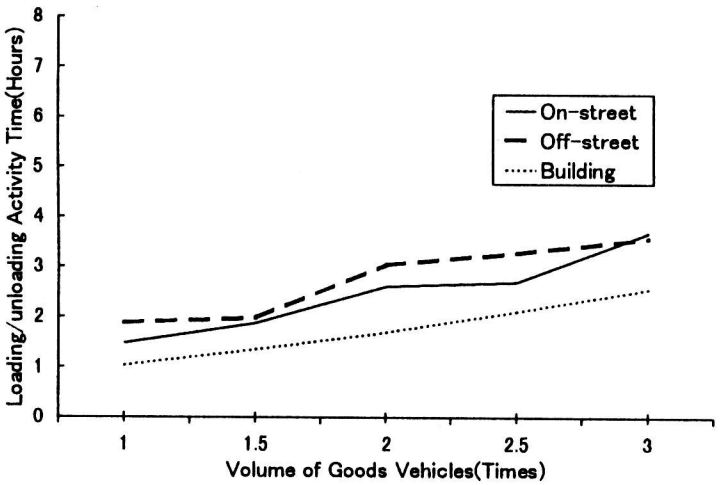
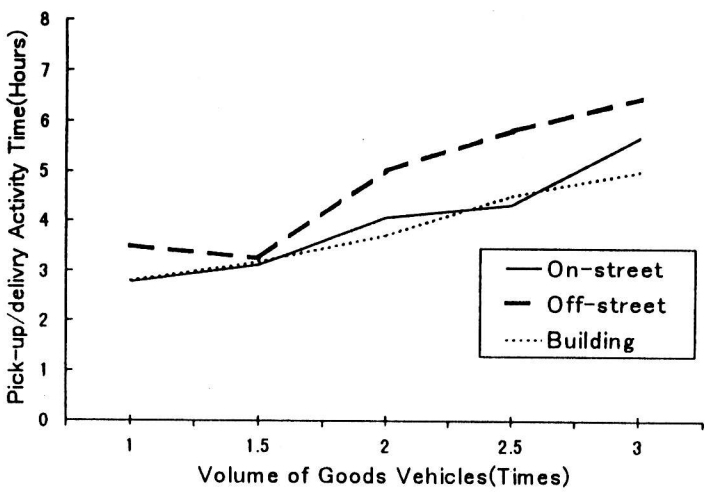


Figure 15 Pick-up/delivery Activity Time
(Truck-trip Activity Time +Loading/unloading Activity Time)



6.4.2 Significance of the Results of the Simulation Analysis in DGM

By the result of 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.

The time of this 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 parking 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:

- In the case of *on-street parking facility* and *inside the building parking facility*, if the volume of goods vehicles is increased, the increase in the loading/unloading activity time is much more than the increase of the truck-trip activity time. 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 short.

- For the *off-street parking facility*, if the volume of goods vehicle is increased, the increase of the loading/unloading and truck trip activities times are nearly equal. Thus, by reducing loading/unloading and truck-trip activities times through the improvement of conveyance paths from the off-street parking place to the building, and the provision of exclusive roads or priority lanes for goods vehicles, pick-up/delivery activity time can be short.

Table 3 the result of simulation analysis

(unit: %)

Parking facility	Increasing the volume of goods vehicles / Activities	1.0	1.5	2.0	2.5	3.0
On-street Parking facility	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
Off-street parking facility	Truck-trip	20.11	16.08	24.75	31.90	36.37
	Loading/unloading	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
Inside the building facility	Truck-trip	22.12	22.91	25.25	29.94	30.65
	Loading/unloading	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

7 CONCLUSION

In this study, the efficiency of District Goods Movement of each parking facility was done by comparing the differences in the loading/unloading and truck-trip activities times from each parking facility (on-street, off-street, inside the 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 needed for the simulation analysis. From the simulation analysis, the following may be concluded: 1) for *on-street parking* and *inside the building parking facility*, reducing the loading/unloading activity time is enough to make pick-up/delivery activity be more efficient, 2) for *off-street parking facility*, improving both the loading/unloading and truck-trip activity times will result to efficient pick-up/delivery activity.

An effective District Goods Movement at the CBD of Japan can be systematically done if the results of the study will be incorporated and the appropriate spaces for off-street and inside the building parking facility will be planned in the future.

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