

Effects of On-Street Parking on Traffic Congestion at the Center of Metropolitan Tokyo and Their Measures

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ABSTRACT

This paper analyses the effects of on-street parking on traffic congestion through a case study at the centre of Tokyo, and discusses the technological and institutional problems in implementing the parking management. In the centre of Tokyo, major bottlenecks are usually found at at-grade intersections because of the reduction in road capacities mostly due to on-street parking. Although on-street parking is prohibited at almost all curbsides, the streets are actually occupied by illegally parked vehicles. This disorderly situation in which the actual on-street parking practice substantially deviates from the parking regulation causes various social problems. For appropriate parking management, revision of parking regulations and efficient enforcement are required. Needless to say, we have to restrict on-street parking at areas and times of day when it causes serious traffic congestion. However, considering the lack of capacity of off-street parking facilities, we should allow on-street parking at other places to some extent as long as it does not cause traffic congestion and accident. Then, the efficient enforcement should be implemented at the restricted places. At the same time, off-street parking spaces should be increased by technological and institutional means such as the stringent requirement of parking spaces to be furnished with office buildings, introduction of subsidiary systems for the construction of off-street parking places, the effective use of off-street parking places with the aid of the parking guidance system, and so on. With these measures, we do believe that the discipline in on-street parking can be well established.

1. On-Street Parking and Traffic Congestion

1.1 Traffic Congestion in Tokyo

In Japan, traffic congestion has become worse drastically in recent years. Especially, urban traffic congestion on weekdays is so serious that people have been tremendously affected not only socio-economically but also environmentally.

Figure 1 and Table 1 indicate the socioeconomic overview of Tokyo. The eight wards

representing the centre of Tokyo, which cover an area about a hundred square kilometers, have about 3.8 million employees. Figure 2 shows that annual total congested hours at major 455 at-grade intersections remarkably increase from 1,889 hours in 1985 to 2,121 hours in 1990. This heavy traffic congestion has reduced the average peak hour travel speed on national highways in Tokyo's 23 wards from 21.4 km/h in 1980 to 14.9 km/h in 1990[1].

Figure 1 Centre of Tokyo(the 23 Wards and the 8 Wards)

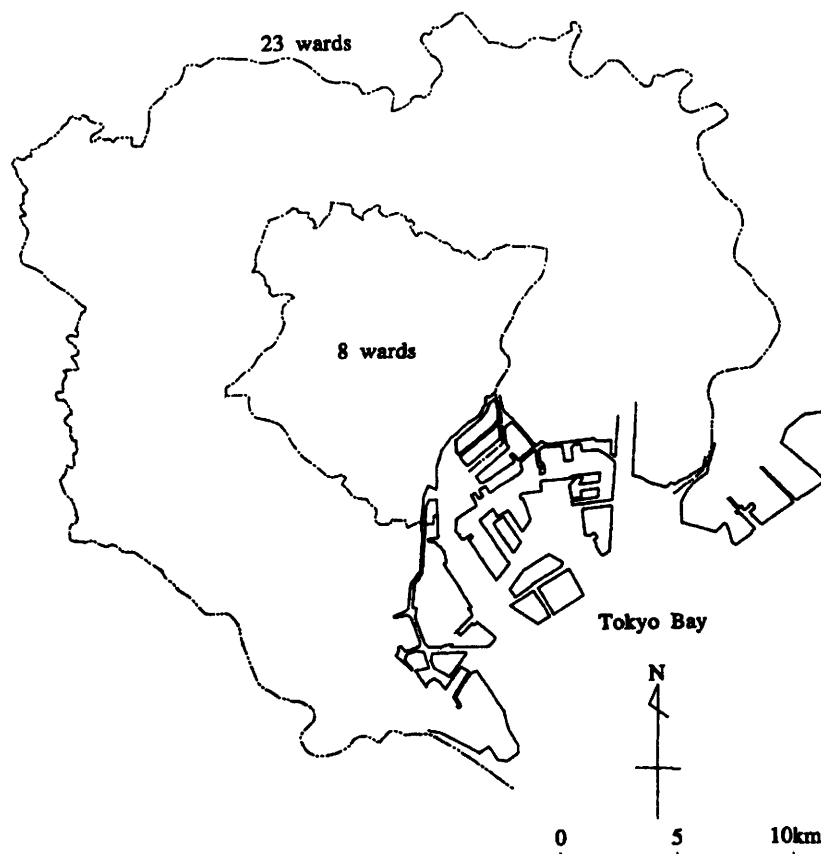
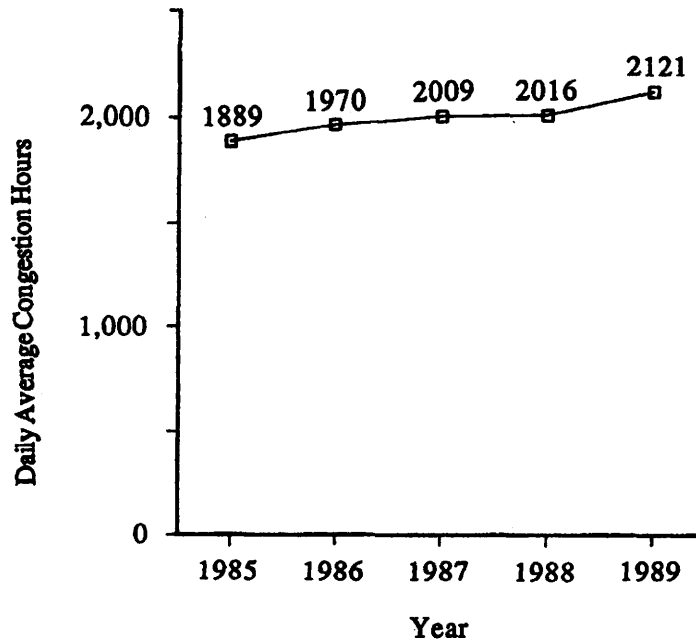


Table 1 Overview of the Centre of Tokyo

	Within 23 Wards	Within 8 Wards
Area [km ²]	602	109
Daytime Population ¹⁾ [10 ⁴ persons]	1,096	483
Employees ²⁾ [10 ⁴ persons]	674	386
Total Number of Car Trips Attracted ³⁾ [10 ⁴ trips]	643	272

Source:

- 1) Population Census(1985, Management and Coordination Agency)
- 2) Establishment Census(1986, Management and Coordination Agency)
& Census of Commerce(1989, Ministry of International Trading and Industry)
- 3) Road Traffic Census(1985, Ministry of Construction)



Measurement date: from January 4 to December 31(except Sundays)
 Measurement time: from 7:30 to 19:30
 Measurement place: major 455 at-grade intersections in Tokyo
 Definition of congestion: waiting queues of 300 meters or more in length
 Source: Road Traffic Year Book (1988 & 1989, Metropolitan Police Board)

Figure 2 Daily Average Congestion Hours in Tokyo

1.2 Bottleneck Intersections and On-Street Parking

Traffic capacities of streets primarily depend on those of signalized at-grade intersections. It has been observed that traffic demand exceeds the capacity only by a few percent to slightly over 10% at these bottleneck intersections in case of urban weekday congestion. The Ohme-kaido is one of radial roads which link the suburb and the centre of Tokyo. Using traffic detectors installed on this road, the traffic volumes and speeds were observed during the morning peak period. From this observation, the excess demand at the bottleneck intersection of this road was estimated as only three percent of the capacity. Another calculation was made based on the travel speed survey along this same section, and the excess demand rate was estimated as five percent. The actual excess demand would be most probably halfway between three to five percent[2]. Traffic volumes were also measured at all of the congested intersections along Ring-road #7 which passes about ten kilometers away from the centre of Tokyo. Based on this measurement, the morning-peak excess demand rate was estimated as about seven percent of the capacity.

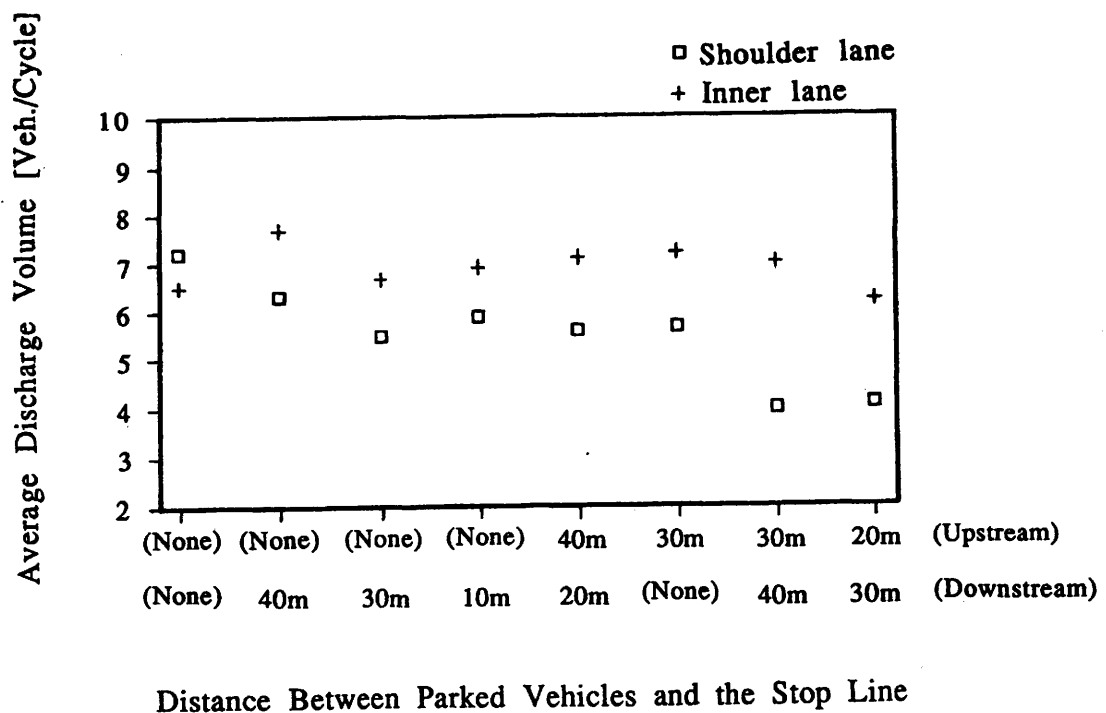
Table 2 classifies 193 bottleneck intersections within the 8 wards of Tokyo by the cause of congestion. The 152 intersections, accounting for approximately 80% of the total, have parked vehicles near the intersections all the time. The reduction of traffic capacity caused by

on-street parking depends on the parking location, lane width, turning percentages, heavy vehicle percentages, and signal control. From Figure 3 illustrating a survey example, a vehicle parked at 30 meters behind the stop line seems to reduce the capacity of the shoulder lane by about 30%. This reduction rate is remarkably high compared with the excess demand mentioned before. Therefore, at those intersections, the congestion could be well eliminated by removing the vehicles parked on streets.

Table 2 Measures against Daily Congestion in the 8 Wards

Measures	Number of Intersections
Removal of On-Street Parking	152
Adjustment of Traffic Signal	33
Improvement of Intersection Geometry	6
No Short-Term Countermeasures	2
Total	193

Source: Reference [2]



Source: Survey report on influence of on-street parking (1990, Ministry of Construction)

Figure 3 Intersection Capacity Reduction by On-Street Parking

As we have discussed, 152 intersections are congested due to the on-street parking in the 8 wards. The number of approaches at these intersections is 206, and supposing vehicles parked within the section 50m from the stop line of these approaches are removed, then the number of removed vehicles would total 1,500. On the other hand, the number of parked vehicles on streets within the same area during the peak period was about 77,000 as shown in Table 3. As the removal rate is only about 2% ($=1,500/77,000$), there would be hardly any impact on the traffic activities in the centre of Tokyo, but this would have a substantial improvement in the capacity of the intersections.

1.3 Actual Situation of Parking Regulations and Enforcement

Table 3 shows that on-street parking is prohibited at almost all curbsides which account for 99.7% of streets with more than 4.5 meters width within Tokyo 23 wards. Therefore, 160,000 on-street parked vehicles, accounting for about 87% of the total on-street parked vehicles within the 23 wards, are regarded as illegal under the present regulations. Although the considerable number of policemen, and traffic wardens are in charge of parking enforcement, the strict enforcement is physically impossible under the regulation prohibiting on-street parking all over the places. Currently, approximately 480,000 parking violations are caught annually, which means average 1,300 violations are caught per day, and half of these vehicles are removed by wreckers. Compared to the total number of parking violations, this number is too small.

Table 3 Parking Regulations and Violation Enforcement in Tokyo

	Tokyo Pref.	Within the 23 Wards
Number of Parked Vehicles at a moment ¹⁾ [10^4 veh.]	21	18.5
Number of Illegally Parked Vehicles at a Moment ¹⁾ [10^4 veh.]	18.5	16
Percentage of Street Length with Restricted Parking ¹⁾	97.3	99.7
Number of Parking Violations Enforced [10^4 /year]	48	----
Number of Illegally Parked Vehicles Removed by Wreckers [10^4 /year]	24	----

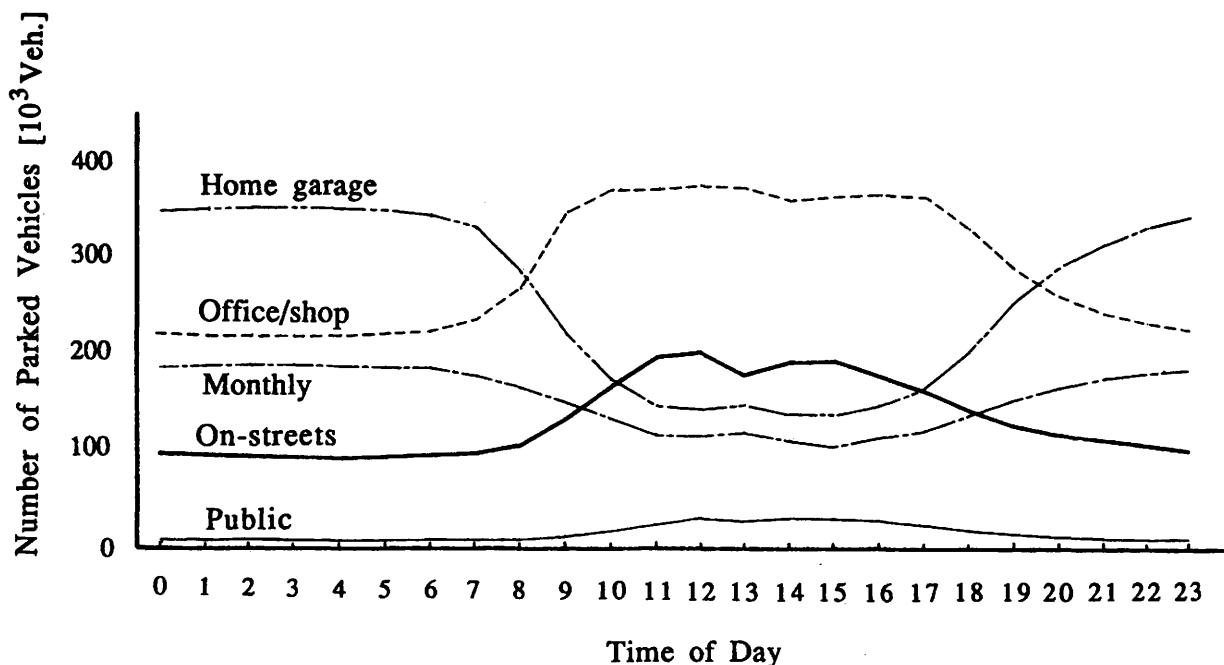
Source: Road Traffic Year Book (1988 & 1989, Metropolitan Police Board)

1) Survey date: from 14:00 to 17:00, April 26, 1989

Surveyed streets: 4.5 meters or more in width

1.4 Balance Sheet of Parking

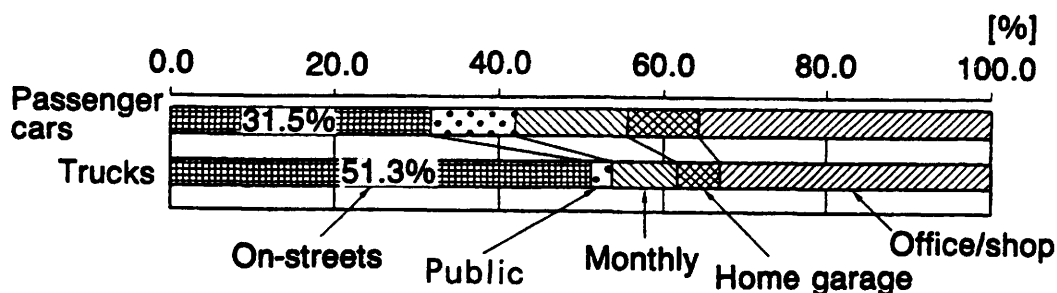
Figure 4 illustrates the change in the number of parked vehicles over 24 hours within the 23 wards by parking places. Vehicles parked at homes or monthly contracted parking places during the night change parking places to offices or streets during the daytime. In the daytime, vehicles parked at off-street public parking places are just 10 percent of the total number of vehicles on streets.



Source: Road Traffic Census(1980, Ministry of Construction)

Figure 4 The Number of Parked Vehicles Over 24 Hours within the 23 Wards

Figure 5 shows the share in the number of trips by parking place within the 8 wards. The shares of the on-street parking of passenger cars and commercial vehicles are about 30% and 50%, respectively. Compared with Figure 4, we can see that the shares at the centre are higher than those at suburban areas. Especially, the usage of commercial vehicles of off-street public parking places is low because commercial vehicles tend to be parked near their destinations for easy handling of the goods, and because there are few wide off-street parking places trucks can enter.



Source: Road Traffic Census(1985, Ministry of Construction)

Figure 5 Ratio of Number of Trips by Parking Places within the 8 Wards

Table 4 shows the relationship between the parking demand and the off-street parking capacity in the 23 wards. For the off-street public parking places, about 83% of their lots are used on the average. Therefore, out of the total on-street parked vehicles of 185,000, only about 10,000 vehicles could be moved to off-street even if the off-street public parking spaces were fully utilized. To take into account the maximum walking distance between a parking place to the destination, let us look at the parking situation for each of 75 smaller zones within the 23 wards whose average area size is about eight square kilometers. There is just one zone where all the on-street parked vehicles could be moved to the off-street public parking places. On the other hand, there are considerable number of unused lots in off-street monthly contracted parking places even in peak hours. These unused lots could be partially utilized as public parking places during the period of high parking demand.

Table 4 Parked Vehicles and Parking Places within the 23 Wards on Weekdays

	On-Street	Off-Street (Public)	Off-Street (Others)
Number of Parked Vehicles [10^4]	18.5	5.2	---
Number of parking lots [10^4]	1.3	6.2	53.6
Occupancy [%]	---	83.1	---

Source: Actual situation of on-street parking and parking places
(1989, Metropolitan Police Board)

Survey date: from May 20 to June 20, 1989.

Surveyed off-street parking places: 10 or more vehicles in capacity

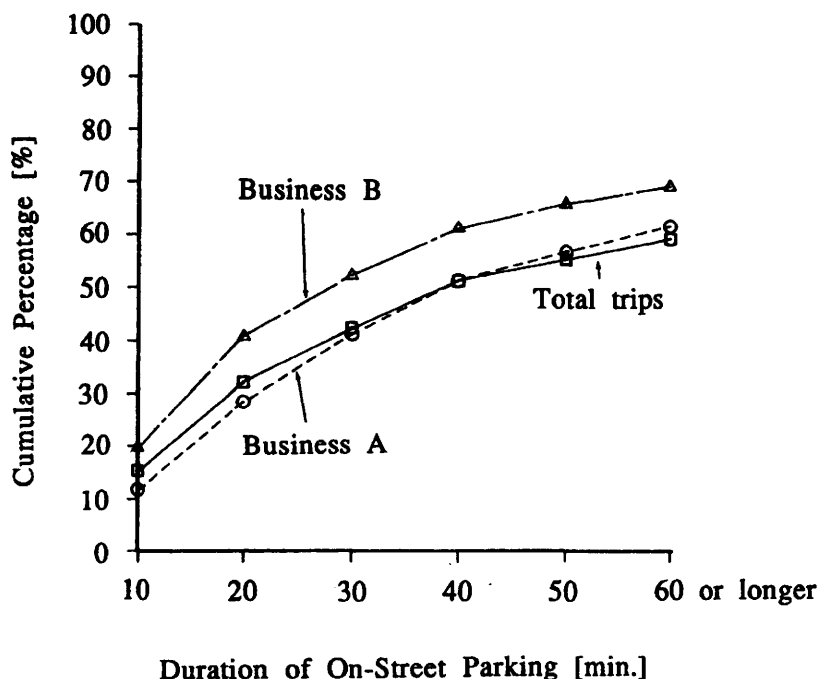
2. Basic Policy on Parking

2.1 General Remarks

In principle, vehicles should be parked not on streets but off streets. However, under the condition mentioned above, the present urban activities could not be maintained if all the vehicles parked on streets were removed.

In reality, a part of on-street parking should be legal, if their actual harm on traffic capacity and safety is allowable. We should, however, keep making effort to build off-street parking places so that on-street parked vehicles can be gradually switched to off-streets.

Figure 6 illustrates the cumulative distribution of the duration of on-street parking in the 23 wards by trip purpose. The number of trips whose duration of parking is shorter than 30 minutes is accounted for 42% of the total. Especially, 50% of the business B trips which carry goods is shorter than 30 minutes in duration. Therefore, the off-street parking spaces should be reserved for the parking demand with the duration more than 30 minutes. And on-street parking facilities should be spared primarily for the demand with the shorter parking duration.



Source: Road Traffic Census(1985, Ministry of Construction)

Business A: without handling goods

Business B: with handling goods

Total Trips: Total trips including those for business A and business B

Figure 6 Cumulative Distribution of the Duration of On-Street Parking in the 23 Wards by Trip Purpose

To allow on-street parking, the following basic conditions have to be met: 1) On-street parking facility should not hinder the construction of off-street parking places. 2) Every road user should have equal opportunity to use the on-street parking place. And 3) On-street parking place should be used by trips with destinations in the same district as the parking place.

On locations where on-street parking is allowed, the parking charge and the time limit have to be appropriately determined to satisfy the above conditions. Namely, the parking charge per unit time of duration should increase as the duration gets longer. And the level of the charge should be equal to or even slightly higher than that of the off-street parking places.

The introduction of efficient enforcement measures are also important so as to greatly concentrate the enforcement into illegally parked vehicles which actually harm traffic capacities and safety.

These revisions of parking regulations and enforcement can be expected to bring the following effects: 1) Usage of off-street parking spaces will be improved due to the stringent enforcement against the illegal on-street parking. 2) The rate of turnover of on-street parking lots will be improved because on-street parking charges shorten the parking duration. 3) A part of the parking demand will shift out of peak hours due to the strengthened enforcement. 4) The on-street parking demand that cannot be managed by the above effects 1) to 3) would be restrained.

As mentioned in the fourth effect, the adequate parking management not only increase the road capacity but also restrain the traffic demand. In other words, the parking management policy can be the urban traffic management policy which balances traffic demand and capacity of road facilities.

2.2 Types of On-Street Parking Facilities

Public on-street parking facilities have been classified into two groups: parking spaces with parking meters or parking ticket machines installed and operated by the police based on the Road Traffic Law and the "on-road parking spaces" reserved based on the Parking Place Law.

There are 11,042 spaces with parking meters or parking ticket machines within the 8 wards in 1989. For these spaces, the time limit is 60 minutes and the parking charge is 300 yen uniformly. In principle, these lots are not installed along arterial roads. The "on-road parking spaces" have not been introduced within the Metropolis of Tokyo. In principle, these lots are built in the Zone to Provide Parking Places, a commercial district with busy traffic, but not along primary arterial roads.

In addition, the Ministry of Construction is planning to introduce another type of on-street parking facilities along primary arterials, the Parking Belt on the Road. This parking space can be realized by using parts of stop strips, road-side plants, and pedestrian walk in order not to harm the traffic capacity of roadways. The parking charge will not be flat but depend on the parking duration.

2.3 Parking Regulation and Enforcement

Since the regulation just uniformly prohibits on-street parking all over the places as mentioned earlier, parked vehicles really causing traffic congestion cannot be efficiently removed. This is the major reason why road users do not support the regulation and enforcement very much. Also, the inefficient enforcement may perhaps decrease the use of off-street parking places.

Needless to say, we have to restrict on-street parking at areas and times of day when it causes serious traffic congestion such as near intersections. However, considering the lack of capacity of off-street parking facilities, we should allow on-street parking at other places to some extent, as long as it does not cause traffic congestion and accident.

The discipline in on-street parking can be established only by a combined efficient enforcement and regulation. First, the limited number of enforcement staff must be assigned to appropriate locations and time periods. Second, the more efficient enforcement tools, such as the Denver boots, should be introduced as well as the removal of illegally parked vehicles by wreckers which needs not only labor and time but also stock spaces of removed vehicles.

In our system, a police puts a notice of parking violation on the vehicle and the driver must pay the violation fine at the designated police station. However, according to the nationwide sampling survey by the Police Department in 1986, about half of those drivers did not report themselves without paying the violation fines. This was due to the difficulty in finding the violator afterwards, since only the vehicle driver and not the owner had the responsibility of parking violation.

To cover the loophole of the enforcement, a new system was introduced in 1987. In this

new system, once the notice is put on an illegally parked vehicle, it can be taken off only in attendance of a police; otherwise, the person who takes the notice off is punished, be he or she the vehicle driver or the owner. The percentage of attendance of violators to the police has increased to approximately 80 to 90% in the new system.

The Road Traffic Law was revised from the beginning of 1991 to hold a vehicle owner (mainly an administrator of a business industry) responsible for the parking violation. That is, an owner must control the use of the vehicle so as to follow the parking regulation. Also, the violation point and fine become heavy. The effectiveness of the revision cannot be evaluated yet. (The point system has been introduced where certain amount of fines and points are imposed on violations as penalties. If the points accumulate to six or more, the driving license is suspended for 30 to 90 days or canceled.)

3. Off-Street Parking

As mentioned above, the off-street parking spaces are definitely insufficient in the centre of Tokyo. Compared to foreign cities as in Table 5, we can recognize the insufficiency of the off-street parking spaces. Although the number of parking spaces in Tokyo per unit area is not smaller than other cities, the spaces per employment is far below the western standards. Let us next discuss several major points in facilitating off-street parking spaces.

Table 5 Off-Street Parking Spaces in World Major Cities.

	1000 Employments	Area [ha]	Parking Spaces	Parking Spaces per 1000 Employments	Parking Spaces per Area[ha]
Tokyo 8 wards ¹⁾	3,867	10,916	184,961	48	17
Tokyo 23 wards ²⁾	6,740	60,181	610,984	91	10
Paris ³⁾	1,810	10,540	727,100	402	69
Frankfurt(Center) ⁴⁾	114	2,500	28,365	249	11
London ³⁾	1,984 ⁵⁾	30,141 ⁵⁾	132,188	67	4
Washington D.C. ⁶⁾	511	15,718	175,852	344	11

Parking spaces include not only off-street parking spaces but also on-street spaces of parking meters, parking tickets, etc.

1) and 2): The figures include privately used spaces as well as public parking spaces and monthly contracts. Source: Present situation of on-street parking and parking places (1989, Metropolitan Police Board).

3): Report on Road Traffic in European Cities, Ministry of Construction, 1986.

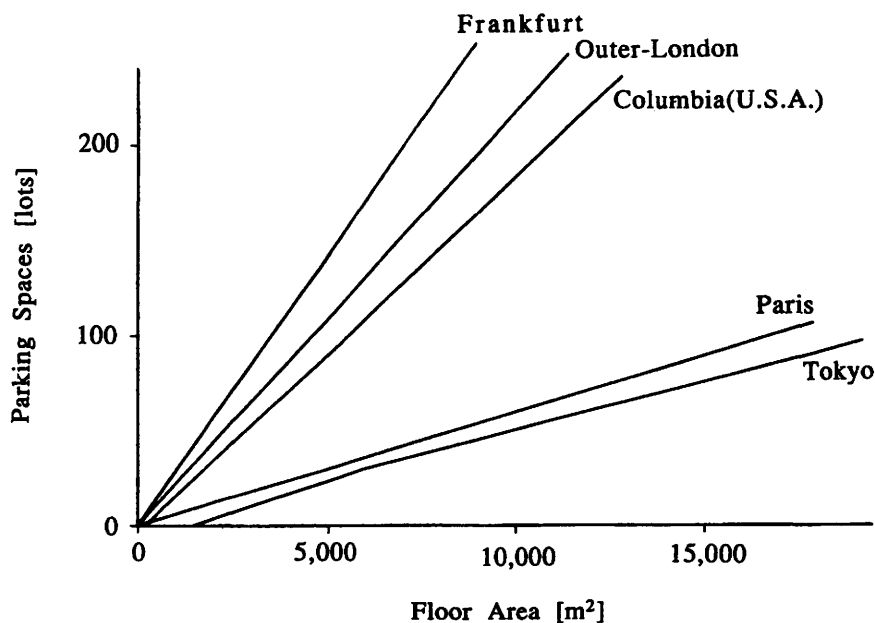
4): Reference [5].

5): Inner London, Data of Dept. of Employment, 1981.

6): Road Research: Evaluation of Urban Parking Systems, OECD, 1980.

3.1 Parking Requirement

In the 'Zone to Provide Parking Places', a building with a certain level of the floor space is required to furnish parking spaces regulated in the Parking Place Law. In Tokyo's 23 wards, parking spaces to be furnished play a primary role sharing a large percentage out of the total number of off-street parking places. For instance, about 240,000 spaces have been prepared under the above requirement out of the total 280,000 statistically comprehensible parking spaces [7].



Frankfurt: For an office building, 35 [m²/lot].

Outer-London: In Sutton, 46 [m²/lot].

Columbia: For an office building with more than 186 m² floor space in the commercial district, 56 [m²/lot].

Paris: For the commercial district, U.A., the parking space must be more than 15% of the floor space (25 m²=1 parking space).

Tokyo: About 30% reduction in the required space is applied to a building with the floor space of more than 10,000 m².

Source: Reference [5].

Figure 7 Parking Requirements in World Major Cities

Figure 7 compares the parking requirements among cities in western countries. Our requirement was revised in June 1990, in which, roughly speaking, a building with more than 1500 square meter floor spaces must reserve one parking spaces per 200 square meter floor spaces in a large city like Tokyo. Although the revised regulation requires more parking spaces than before, the Japanese requirement is still far below the standards of other western cities [5].

Paris has similar requirement to ours, but at least one parking space is required regardless of the floor space, and loading and unloading spaces of freight trucks are regulated. (Note that some cities require quite small parking spaces to restrain traffic demand: e.g., the City of London requires only one parking space per about 1,115 square meters.) Also, our requirement is further below those in Singapore and Madras where the vehicle ownerships are much less than in Tokyo [8,9].

Our requirement is inferior not only in quantity mentioned above but also in quality. Since the parking demand would vary depending on the use of the building, the requirement should be determined for each type of buildings. In most western cities for example, the requirement for a hospital or a hotel are based on the number of beds, and for a theatre, the number of seats.

As mentioned above, even if an off-street parking place is built, it is likely to be used in monthly contracts because of less maintenance and labor expenses. However, to shift parked vehicles from on-street to off-street parking places, the more off-street public parking spaces are required. Therefore, the regulation would be necessary to specify the minimum amount of required public parking spaces as well as the total number of spaces.

About half of road traffic in Tokyo is made by trucks which are frequently parked at curbsides causing traffic congestion. However, the loading and unloading spaces are not legally required yet. Each of buildings and shops in a dense commercial district should be urgently regulated to reserve a certain amount of loading and unloading spaces or a common loading facility. Generally, the loading and unloading spaces should be close to the destination and the duration of parking is not very long. Thus, technological and institutional system should be made so that the loading and unloading spaces are prepared at curbsides on roads. Users of the curbside loading and unloading facilities must of course pay the equivalent charge to the benefit received.

In the residential district in the city, the parking spaces are clearly insufficient. We should reserve enough parking garages for residents as well as spaces for visitors. The parking requirement should also be stringent for a large apartment. To overcome the shortage of parking spaces in the residential district, the Ministry of Construction recently changed the policy to the proper direction by moderating the parking space restriction so as to facilitate the larger parking spaces and garages, provided that the environmental quality can be kept. It is also time for us to seriously consider the introduction of the resident permit with the appropriate charge along roads unless the on-street parking causes congestion.

3.2 Subsidiary System

A three-story underground ramp parking is under construction at the commercial district in Shibuya-ward because of no available surface ground. The construction cost raises up to 23 million yen (= 180,000 US \$) per lot [10]. This parking is furnished a grant of 25% of the total construction cost and a 20-year loan with low interest rate of about 4.55% for the rest. Assuming that the average duration of parking per lot is 6 hours a day and the maintenance cost is 250,000 yen per year, the considerably expensive parking charge of about 800 [yen/hour/vehicle] must be imposed to get the profit. As you see from this example, the construction of an off-street parking needs quite a lot of fund, and therefore, it is very difficult to start a profitable parking business in the centre of Tokyo.

Although we have several subsidiary systems and preferential treatments of taxes for

parking construction, the support is very limited and depend on parking size, type, location, etc. For the current situation of Tokyo area, the more subsidy is demanded, especially increase of the share of the grant without interest and the subsidy to the private sector.

However, how much subsidy should be provided and how much parking charge should be imposed are questions requiring quite a lot of research and discussion. Generally, the parking charge must be determined from the balance of parking supply and demand. For the supply side, the charge must be sufficient to cover the expense of the construction and operation for profitable business. While for the demand side, there must be the appropriate level of traffic and parking demand for our urban life. Clearly the demand depends not only on the parking charge but also on other factors such as parking availability, regulation, enforcement, and so on. Therefore, the level of subsidy and the parking charge must be determined comprehensively with these other factors in urban transportation planning.

3.3 Parking Operation

The limited off-street parking spaces must be used efficiently. For the parking guidance, parking locations and their space availability are two key information for users. Several interesting experiments have been done such as the telephone parking guide, the use of a car radio, the two-stage block information system by variable message signs, and so on.

To increase public parking capacity and profit, the following new ideas have been introduced. Considering the fact that monthly contracted spaces cannot be always full, some of those spaces are open to the public in hourly rate during the period of high parking demand. A shopping district issues parking tickets which can be commonly used for several parking places within the district. A ticket coupon and a monthly pass are issued at the discount price. The shuttle bus serves for parking places at distant places. Some city offices open their parking spaces to the public on week ends.

4. Closing Remarks

- 1) In the centre of Tokyo, major bottlenecks are usually found at at-grade intersections because of the reduction in road capacities mostly due to on-street parking.
- 2) In principle, vehicles should be parked not on streets but off streets. However, considering the lack of off-street parking spaces, a part of on-street parking should be allowed, if their actual harm on traffic capacity and safety is acceptable.
- 3) We should introduce the efficient enforcement measures to maintain the revised parking regulation.
- 4) We should also keep making effort to build off-street parking places so that on-street parked vehicles can be gradually switched to off-streets. The parking requirements of office buildings and loading and unloading facilities should be stringent, and the appropriate subsidiary systems should be introduced.
- 5) The limited off-street parking spaces should be used efficiently by means of the parking guidance systems, the combined use of monthly contracts with public parking places, etc.

References

1. Road Traffic Census, Ministry of Construction
2. Masaki K., et al: Explanation of and Countermeasures against Traffic Congestion, IATSS Research, PP. 53-63, Vol. 13, No. 2, 1989.
3. The Committee for the Proposal on Improvement of On-Road Parking: Proposal Concerning a New Policy for On-Road Parking, IATSS Review, pp. 247-261, Vol.12, No.4, 1986.
4. Kobayashi, Y. and Nakashita, H. : Parking Measures in Europe, Traffic Engineering, Vol.21, 1986 (in Japanese).
5. Mission of Observation of Parking in European Countries : Report on Parking Situations and Policies in European Countries, May 1990 (in Japanese).
6. TOYOTA Traffic Environment Committee : Parking Spaces in Urban Areas, TOYOTA Traffic Environment Report, August 1990 (in Japanese).
7. Ministry of Construction : Parking Policy in the Road Planning, March 1990 (in Japanese).
8. Levinson, H.S. : Zoning for Parking - A Global Perspective, ITE Journal, November 1984.
9. Niitani, Y. : Historical Examination on Urban Parking Policy and the Future Tasks, Traffic Engineering, Vol.21, 1986 (in Japanese).
10. Ministry of Construction : Report on Off-Street Parking Planning under Consideration of Characteristics of On-Street Parking, March 1990 (in Japanese).