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PARKING DEMAND IN THE HICH TECH BUSINESS DISTRICT OF URBAN

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Abstract: With the great process of urbanization, parking problems come into prominence. This passage introduces several parking demand concepts and academic methods domestic and overseas, and also considers these area land exploiting features. Parking behaviors analysis in many kinds of commercial activities in new high-tech districts, like the number of parking, the proper relation between parking infrastructure and the building parking attraction, and the coordination between parking scales and the management measure, we get some results on business building and office building parking indexes. We compare different buildings parking equipment supply, management pattern with the land layout, and economic factor with traffic condition etc.. Then we give some advice and policy for setting up proper parking establishment to reduce the parking problems.

Based on the investigation of daily parking in the high-tech business district (HBD) and a stated preference survey of car drivers, we give a discussion on driver parking and passengers behavior of mass transit undertaken at a number of parking spots and shopping centers in Zhong-guancun, Beijing.

Key Words: parking behavior, parking investigation, parking demand model

1.INTRODUCTION

The traffic circulation in HBD is one of the most pivotal issues that requires special attention on planning and implementation stages. But practical studies report much on drivers' road-selecting behavior but not parking-selecting behavior in various studies by governmental agencies, private entities, and academic researchers. We want to propose both the influence of major parking lots and efficient utilizing of parking equipment, so it is important to classify the drivers' parking-searching behavior. In general, there are three primary groups of people who share the common roadway facilities in HBD. The first group is composed of persons who work in the HBD, the second group is visitors to HBD and the third group is drivers going through the HBD transportation network. The parking behavior of the first two groups' becomes more

critical in the peak hour for the parking demand affects traffic flows of the road network and each building park supply service. In addition, unfamiliar drivers always getting lost or spending more time looking for available parking place. Although alternative routes are typically available, they are rarely proper used.
With the fast increasing of number of vehicles on road, parking behavior is obviously one of the crucial factors that affect the performance of the transportation system in HBD. In general, a driver who is unfamiliar to the area prefers to circulate around or drive past his (or her) destination before he (or she) finds a convenient parking place. Consequently, parking lots close to the destination place are usually overcrowded while the second tier and remote parking lots, although often conveniently allocated, may be underutilized. In reality, even one who is familiar to the area sometimes spends short time on looking for an available park. In order to reduce time cost in looking for parking lot, we give the union management methods of the parking resources which includes two steps, collecting the number of office building parking space and union parking berth information guidance. Namely, suppose that impacts of background traffic may not be considered explicitly in the analysis framework, it would evidently contribute to the overall transportation system improving the parking choices in High-tech Business District traffic peak hour.

2. PARKING CONCEPTS

Parking facilities and programs are of considerable importance in traffic engineering. Most persons to urban and regional commercial centers are accessed primarily by cars. The viability of these areas depends on the availability of convenient parking facilities adjacent to or easily accessible to desired destinations, especially off-street parking facilities. And various aspects of the parking related index are introduced as follows.
Parking demand: the number of need park space in a given area at some time interval.
Parking capacity: the number of parking behavior a given area can accommodate. Parking capacity includes planning capacity and actual capacity. Planning capacity is the total parking spaces in the study area and the actual capacity is the number of park space which can be accommodated in the actual parking management and operation.
Parking turnover: Average parking times of a parking space in a given time interval.
Parking space utilization: Average service efficiency of a parking space in a given time.
Average parking duration: Average parking time of a vehicle in a given time interval, D. Parking duration is the length of time individual car taken park space. This characteristic is a distribution of individual values, and both the distribution and the average value are of great interest.
Average parking duration (D):

$$D = \frac{\sum_{x} (N_x) XI}{N_T} \tag{1}$$

where D = average parking duration (hr/veh)
N_x = no. of vehicles parked for x intervals
X = number of intervals parked
I = length of observation interval (hr)
N_T = total no. of vehicles observed
Parking turnover rate (veh/stall/hr) (NR):

$$TR = \frac{N_T}{S \times T_s} \tag{2}$$

where TR = parking turnover rate (veh/stall/hr)

S = total number of legal parking stalls

Ts = duration of the study period (hr)

Some key parameters may be computed as follows.

Parking supply (P):

$$P = \left[\frac{\sum_n (N \times T)}{D} \right] \times F \tag{3}$$

where P = parking supply (veh)

N = no. of spaces of a given type and time restriction

T = time that N spaces of a given type and time restriction are available during the study period (hr)

D = average parking duration during the study period (hr/veh)

F = insufficiency factor to account for turnover--values range from 0.85 to 0.95 and increase as average duration increases

Many parking studies stress on the establishing, the distribution of accumulation with time and to determine the peak accumulation and time at which it occurs. Of course, observed accumulation is limited by parking supply, and constrained demand cannot be directly observed. Here gives some optimal models and statistic data on parking demand and supply.

3.PARKING DEMAND ANALYSIS APPROACH

Parking demand problems have been studied for many years and got much progress on approach. The conclusion can be divided into two types, the economic analysis models and parking behavior statistics models.

The first one, such as Young (1985) gave the center business district (CBD) area of Cincinnati wa5 used as a case study. Because of the geographical location, the CBD has limited alternatives to cope with major traffic demands. Gruss (1995) provided an overview of traffic management during the USA World Cup tournament in 1994. Tsukaguchi and Jung (1989) studied and developed a parking assignment model for the High-tech Business District of Osaka City, Japan. Parking demand problems, theoretically, were formulated as a linear programming model. The objective function was to minimize the modified walking distances of users from parking lots to destinations over the study period subject to the demand and supply constraints. The modified walking distance, in fact, consisted of two terms; the actual distance and the parking fee. Eldin et al. (1981) studied the parking issue in the High-tech Business District by integrating parking with the traffic assignment problem. Theoretically, two link types had been proposed in their study. They are real links and imaginary links that were utilized to connect real links with the destinations. The imaginary links consisted of searching-time links, parking links and walk links. The searching time links corresponded to the time that driver spends in finding a parking space. The parking links represented the parking fee that users had to pay for their parking. The walk links accounted for the walking time from the parking lot to the destination. The cost of real links was computed by using the BPR function.

The second one is parking behavior statistics analysis, some major parking demand analysis formula are like parking choice model, parking generation rate, the relation of parking demand with building size etc.. In this paper, parking demand analysis model is most on the second type.

- Parking choice model primarily discusses drivers' choices behavior on parking lots. In the process of choosing a park lot, a driver would consider many factors, such as, the distance of driving his car to a parking lot, the walking distance from his parking place to his destination, the time costs in waiting for a park space, parking fees and so on. To apply the disaggregate model, we propose that there are plenty of parking lots nearby, so the utility function of the n th driver chooses the i th park is:

$$U_{in} = V_{in} + \varepsilon_{in} \tag{4}$$

where V_{in} : the systematic term of the utility function of the n th driver choosing the i th park.

ε_{in} :The random term of the utility function of the n th driver choosing the i th park.

There are many relations between V_{in} and its influence factors. Generally supposes that they have linear relationship, that is

$$V_{in} = \sum_{t=1}^{k} \theta_t X_{\text{int}} \tag{5}$$

K : no. of explaining variables.

θ_k : corresponding parameter of the k th variable.

X_{ink} : The k th influence variable of the n th driver choosing the i th park.

- Parking generation rate. It is formed under the local soil using character, and get different parking demand. The parking volume is

$$P_i = \sum_{j=1}^{n} (\partial_{ij})(L_{ij}) \tag{6}$$

Where P_i- the peak hour number of parking demand in i area;

∂_{ij} -the rate of jth land use or the No. of stuff at the i area;

L_{ij}-the forecast area of jth land use in the i district;

n-the number of land use type.

- Peak hour in-out Traffic flow model. The model is

$$q_{peak-hour} = Q \cdot r = r \cdot R \cdot N = KN \tag{7}$$

where $q_{peak-hour}$ -vehicle volume in peak hour;

Q -the number of daily parking;

r -the proportion of flow/peak hr in the daily parking volume;

R -turnover of parking space;
N -the number of parking supply;
K -constant, $K=r*R$, coefficient traffic flow in peak hour

- Europe city model:

$$P = 2CK/100 \tag{8}$$

where P-the parking demand;
C-the capacity of road;
K-the rate of non pass through capacity

- The model of urban road planning design, it give the assess of parking space

$$P = 5.4X^{0.833}(n/0.032)^{0.48} \tag{9}$$

where P-the demand of parking;
X-shopping center area scale, by $1000m^2$ unit;
n- planning vehicle/per capita

- Parking demand link with traffic trip attraction, the relation is given as follows:

$$P = N(1-a)/R \cdot [1/(1+f)] \cdot b \tag{10}$$

where P——the demand off-street parking space;
N——the number of attract note ;
R——parking space rate;
a——the rate of other traffic flow;
f——the parking space ratio of on-street with off-street;
b——coefficient in peak hour

To give the relation of parking demand and supply, we take an information questionnaire survey, and collect over 500 sheets in zhong-guancun high-tech developing district in Beijing where there are many enterprises or firms, their buildings are divided into three kinds , like office buildings, electron-shopping including supermarket, and electron-shopping with business. Then we compute the three land uses generating trips and the need for parking space with some models above. The studied district is shown as figure 1.

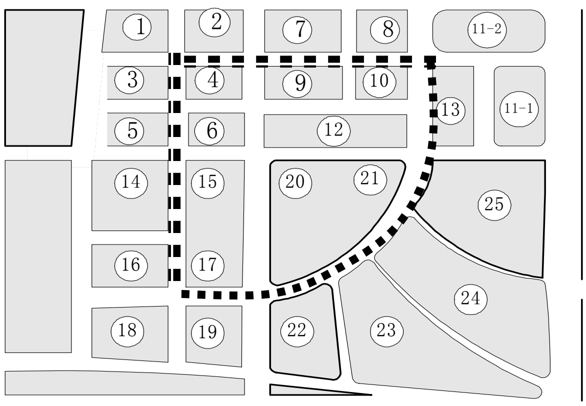

Figure 1 Study Area of Zhong-guancun High-tech District
①…buildings, ▪▪▪▪▪▪▪▪ traffic aisle

4.DISCUSSION

For off-street facilities, manual observation can be supplemented by garage and lot license records. Several key characteristics of off-street facilities are generally recorded: private versus public operation, surface lot or garage, self-park or attendant-park operation, and metered versus collection-booth payment of fees. The parking facilities in Zhong-guancun district are all off-street and public operation, in addition, there is a underground circumfluence aisle with about 10 thousand parking space.

The most critical aspects of the utilization of parking space are accumulation and duration. Parking accumulation is the total number of vehicles parked at any given time.

From the information questionnaire of study area in zhong-guancun district, we get the parking characters office building, electron-shopping and supermarket, and electron-shopping with business three kinds building parking, shown in table 1-4.

Table1. Parking Rate of Three Kinds of Building

	The rate of visiting car (including taxi)	The rate of Taxi in visiting car
Office building	55%-65%	35%-40%
E-shoping	75%-80%	20%-35%
E-shoping+ building	65%-75%	20%-25%

Table2. Duration and Turnover of Parking

	duration（hr）	turnover（space/day）
Office building	2.52	3.7
E-shoping	1.02	4.38
E-shoping+ building	1.58	4.27

Tables3. Parking Flow in Peak Hour

		Drive in (peak hour)	The rate of peak hour	Drive out of peak hour	The rate of peak hour
Office building	pm	252	24.2%	206	19.8%
	pm	146	14%	221	21.2%
E-shopping	am	125	17.8%	118	15.9%
	pm	122	17.4%	131	17.6%
E-shopping+ building	am	165	16%	133	13.1%
	pm	125	12.13%	150	14.85

Table4. Traffic Flow Rate of Building and Parking Turnover

	traffic rate of peak hour/100m^2	turnover（space/day）
Office building(OB)	0.47-0.89	3.7-4.5
E-shopping(E-S)	0.65-1.15	4.5-5.5
E-shopping+ building(E+B)	0.78-1.28	3.5-4.5

With the formula (7) and others, the generating traffic flow of each building is given in the table 5.

Table5. Each Building Generating and Attract Traffic Flows（veh/peak hour）

	Building	Building area	Parking space	Traffic flow with area: The no. of generating flow in peak hour(am)	Traffic flow with area: The no. of generating flow in peak hour (pm)	P=Rrn model	Average (am+pm)
1	LX (OB)	25000	250	504	481	462.5	492
2	Lenovo (OB)	45000	300	908	867	742.5	887

3 (OB)	25000	200	504	481	495	492
4 (E+B)	40000	320	807	771	792	789
5 (E+B)	45000	300	908	867	742.5	887
7 (OB)	35000	300	706	675	742.5	690
8 (E-S)	25000	200	504	481	495	492
9 (OB)	40000	320	807	771	792	789
10 (OB)	25000	200	504	481	495	493
13 (E+B)	45000	360	2019	1927	891	1973
11-1 (E+B)	40000	350	807	771	866.25	789
14 (OB)	45000	300	908	867	742.5	887
16 (E+B)	35000	250	706	675	618.75	690
17 (E-S)	50000	300	1009	964	742.5	986
18 (E+B)	30000	240	606	579	594	592
19 (E+B)	60000	400	1211	1156	990	1183
21 (E-S)	50000	900	1009	964	1255.5	986
22 (E+B)	80000	600	1614	1541	1485	1577
23 (E+B)	120000	900	5368	6168	4335	5768
25 (E-S)	100000	600	2018	1927	1620	1972
11-2 (OB)	25000	200	504	481	420	492

According to the statistics data, we get the average owns of car 0.245-0.3325/per capita in table 6.

Table6. Coefficient of Employee Proportion and Owns Car

	proportion	Coefficient of car owns
Company high class governor	6%~10%	1
Company inside class governor	15%~20%	0.5
High class	35%~40%	0.2
Employee	30%~45%	0.1

Computing parking demand with formula(9) (min car own 0.245，max car own 0.3325) and the parking demand rate in table 4,and four results shown in table 7,and definite the average value as the parking demand, comparing the balance of supply and demand shows in table 8

Table7. Employee Parking Demand

No/building	Parking space	min(person owns car)	The rate with min car own	max(person owns car)	The rate with max car own	Min generating parking	max generating demand
1 LX (OB)	250	156	0.622633	180	0.720929	117	222
2 Lenovo (OB)	300	220	0.733333	253	0.8466297	211	400
3 (OB)	200	155	0.778291	180	0.901161	162	287
4 (E+B)	320	230	0.719539	266	0.833133	188	356
5 (E+B)	300	220	0.733333	253	0. 8466297	292	517
7 (OB)	300	206	0.686713	238	0.795126	164	311
8 (E-S)	200	155	0.778291	180	0.901161	117	222
9 (OB)	320	230	0.719539	266	0.833133	188	356
10 (OB)	200	155	0.778291	180	0.901161	118	223

13 (E+B)	360	194	0.53945	235	0.655363	351	576
11-1 (E+B)	350	176	0.503009	213	0.611082	312	512
14 (OB)	300	220	0.733333	253	0.8466297	211	400
16 (E+B)	250	206	0.824056	238	0.954151	164	311
17 (E-S)	300	277	0.924291	321	1.07021	235	445
18 (E+B)	240	181	0.754951	209	0.874136	195	345
19 (E+B)	400	322	0.806916	373	0.934304	390	690
21 (E-S)	900	277	0.308097	321	0.356737	325	575
22 (E+B)	600	410	0.683614	475	0.791537	376	712
23 (E+B)	600	574	0.958285	665	1.109571	564	1068
25 (E-S)	600	493	0.82326	571	0.953229	650	1150
11-2 (OB)	200	155	0.778291	180	0.901161	195	320

Table8. the Balance Information of Demand with Supply of Parking Space

	1	2	3	4	5	7	8	9	10	13	11-1
supply	250	300	200	320	300	300	200	320	200	360	350
demand	169	290	197	260	340	230	169	260	169	339	303

	14	16	17	18	19	21	22	23	25	11-2
supply	300	250	300	240	400	900	600	600	600	200
demand	290	230	320	233	444	375	493	718	716	213

The unbalance situation of parking demand and supply shown in table8,at block 5,17,19,23,25,and 11-2.

5. CONCLUSION

From the discussion above, we see that parking demand in peak hour changes greatly in each building for the character of building and link road. If parking behavior is not properly guided in some key sections, like block 5,7,19 and the like, the parking-searching and queuing phenomenon would appear. How to avoid the parking congestion phenomenon? What measures to take in the management? From the three layer information on parking supply and its utilization status, the number of parking spaces and their location, time restrictions on use of parking spaces and the type of parking facility, we propose the parking information guidance management.

Furthermore, here gives two ways to solve the demand-supply unbalance status:

1. to use the aisle public parking resource;
2. to form an open-union parking link-network.

The steps to take in The manage policy and information displaying aspects are:

- Acquiring the real time information of parking lots, such as the left space etc;
- Using the parking price policy to reduce the searching time and to form a better arrangement on parking flow;
- Using variable message signs to provide parking guidance information on the availability of parking place ,especially the underground traffic aisle;
- Constructing the short links between traffic aisle and destination building to reduce walking time.

In conclusion, parking behavior is an important part of the transportation system. The fact has indicated that cruising is the main reason of the inefficiency of the parking and the congestion on streets. These analysis give a way to solve the parking problem from three aspects, namely, suitable parking price, the limitation of the parking time, and the parking guidance.

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