Modeling the Impact of On-Street Parking on Main Parameters on Vehicular Traffic

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Abstract: The management of on-street park is one of main parameters in traffic management. The lack of concentrated parking results in increased on-street parking and disturbance in traffic system. Approximation of traffic variants in precise analysis of movement management trend has an important role. The behavioral pattern of on-street park have direct relation with land use around high ways as well as quantity and quality of traffic variants such as: speed, delay time, flow rate and volume to capacity rate which are effective in movement analysis. The recognition of relational model between dependent and independent variables as well as knowledge of all effective conditions in this model and it's application in analysis of movement management are of these research aims.
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1. Introduction

The rapid growth of population and increased utilization of private vehicle bead to increased density in transportation network. In great cities, the problem of park shortage in especial, in central regions is clear. The stop time of vehicles is more than their traffic time. Thus, the anticipation of suitable space of parking for cars, in especial in dense regions, cause to saving in loss time in finding park space, saving in fuel use decreased density of astray vehicles on finding parking space and subsequently, decreased delay time in network. On the other hand, the on-street park causes to decreased capacity, low movement speed, decreased safety level in highways. (Chick, 1996) The utilization of movement management systems is created special position to resolve civil problems. This subject is more and cost effective than methods such as physical development. The behavioral pattern of on-street park is one of main subjects which have had special position is movement management system.(Di Renzo, 1981) The transportation system management is an effective element of transportation planning process which indicates that correction solutions of transportation system pass thorough different paths and necessary management operations any of transportation systems parts. With regard to progressively demand, the optimum utilization of available possibilities, traffic flowing, best use of capacity, decreased travel time, partial speed increase, service level increase, safety increase, pollution decrease and costs are of such management solutions. (Ellis, 1987)

2. Problem Statement

The on-street park management is of subjects that have been posed among transportation experts in movement and control management section since past decades. It could be referred to traffic pattern studies and traffic management which their analytical base is on applied variants such as lines number, movement times of vehicles in on-street park and subsequently, providing effect coefficients of on-street park on capacity.(Meyer, 1983) Although there are lack of movement management process and lack of behavioral pattern of on-street park influence on variants such as speed, delay time, flow rate. By creating identity for on-street parks and description of relations between on-street park and traffic variants and showing these park's influence on main elements of movement such as speed, delay time, flow rate, obtaining coefficients, relations between speed - park percent, the volume capacity rate, delay time, flow rate in different highways and description of changes in relations between elements in different situations and their practical use by managers and planning of transportation in terms of movement management is utilized.(Al-Masaeid, 1999)

3. Solution Method

The movement management process is a broad trend which has been categorized in proposed methodology into three input, process and output processes. The input of such processes include of supply model, demand molded, control methods and environmental conditions. Fig1 shows proposed process:

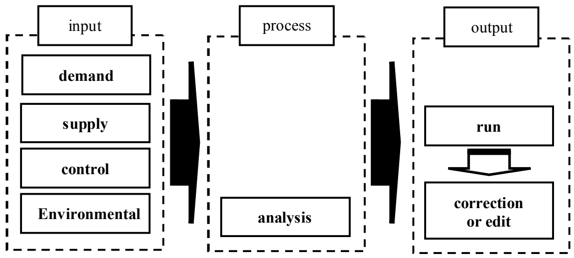

Figure 1. Movement management process in proposed methodology

3.1. Traffic Variables

With average velocity ($\bar{v}$), average delay time ($\bar{t}_d$), flow rate ($\overline{V}$) in P=0 percent and influence coefficients of on-street park for any variable in various Ps percent, could be obtained adjustment values in relations 1,2,3 in effect of different Ps percent. (U.S. Dot, 1981)

$$v = f_{VP}.\bar{v} \tag{1}$$

$$t_d = f_{t_d P}.\bar{t}_d \tag{2}$$

$$V = f_{VP}.\overline{V} \tag{3}$$

Where:

f_{VP}: Average speed $(0 < f_{VP} < 1)$.

$f_{t_d P}$: delay time $(f_{t_d P} \geq 1)$.

f_{VP}: flow rate $(0 < f_{VP} < 1)$, effect on-street park in various V/Cs and adjustment variables.

v: average vacuity (km/h).

t_d : average delay time

V: flow rate (veh/hr)

Based on proposed methodology, the calculation and evaluation process is described based on Figure 2.

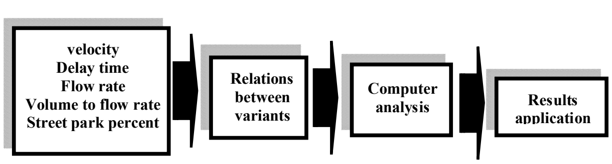

Figure 2. Calculation and evaluation process of on-street park effect on movement flow elements

4. Data collection and resorting

The research methodology has been conducted as case study in Tehran. In order to collect primary data, the data of Tehran transport broad studies firm and traffic police research center has been utilized. The studied high wags have been categorized into four general groups: highways, residential arterials, business arterials and local streets. The secondary effective factors on traffic flow variants such as the secondary effective factors on movement rate variants (speed, delay time and flow rate) include of volume of vehicles in opposite street, movement of passers, physical position of street condition, being of cross and it is effect on flow variables, climate situation of calculation time and width of street lines has been considered. Also, field estimate P percent, has been taken by video shutting for various V/Cs situations, 0, 25, 50, 75 percent, and 100 percent. In order to review different streets in uses of high way, Basij high way the deride between Mahalati to Zamzam line (north to south path) and in residential main street region, Davood Abad line the divide between 10 Farvarding to Jafar Nejad line (west to east path) and commercial main street region of Molavi line between Vahdat Isalmi line to Mohammadieh Square (west to east path) has been selected and calculated.

5. Analysis

The With regard to importance of subject and posed problems, from main factors which are effective in decree quantity and quality of street traffic, the effects of on-street parks on average movement velocity and average delay time and movement flow rate on capacity of path has been calculated.

5.1. Average movement velocity

With regard to essential reviews and based on categorization of streets as well as on conducted assortment for various V/Cs, P percent for velocity and different coefficients in table (1), it could be observed that by increasing %P in any of streets in certain V/Cs, the value of speed decreases. In evaluation process of velocity equations that are as third-grade descent, the allocation of one line of street to on-street park causes to decreased capacity of street and increased density of passing traffic and consequently, decreased velocity of vehicle. Friction and maneuvers of park lead to disturbance in flow situation and decrease average velocity.

Table 1. Average movement velocity and its adjustment coefficient, in streets situations V/C various %P

Street type	*V/C*	average movement velocity					Influence coefficient at on-street park on average movement velocity				
		%P on-street park percent					*%P on-street park percent*				
		%0	%25	%50	%75	%100	%0	%25	%50	%75	%100
Highway	%25	78	74	72	69	64	1.00	0.95	0.92	0.88	0.82
	%50	76	70	68	65	56	1.00	0.92	0.89	0.86	0.74
	%75	57	49	45	43	38	1.00	0.86	0.79	0.75	0.67
	%100	34	19	11	6	-	1.00	0.56	0.32	0.18	-
Residential Arterial	%25	61	59	57	54	50	1.00	0.97	0.93	0.89	0.82
	%50	56	53	49	46	41	1.00	0.95	0.88	0.82	0.73
	%75	37	32	25	21	15	1.00	0.86	0.68	0.75	0.41
	%100	19	14	6	-	-	1.00	0.74	0.32	-	-
Business Arterial	%25	56	53	51	54	43	1.00	0.95	0.91	0.86	0.77
	%50	49	45	41	46	31	1.00	0.92	0.84	0.78	0.63
	%75	35	28	24	21	9	1.00	0.80	0.69	0.51	0.26
	%100	15	13	5	-	-	1.00	0.76	0.29	-	-
Local street	%25	39	34	32	48	20	1.00	0.87	0.82	0.72	0.51
	%50	37	32	28	38	15	1.00	0.86	0.76	0.62	0.41
	%75	29	21	15	18	-	1.00	0.72	0.52	0.34	-
	%100	18	13	-	-	-	1.00	0.72	-	-	-

Table 2. Average movement velocity Equations and its adjustment coefficient, in streets situations V/C various %P

Street Type	V/C	Movement average velocity		Application of coefficient on movement average velocity	
		Equations	R^2	Equations	R^2
Highway	%25	$Y= 0.0333X^3 + 2.7857 X^2 - 9.881 X + 85.4$	0.999	$Y= 0.0033 X^3 + 0.279 X^2 – 0.01088 X + 1.084$	0.999
	%50	$Y= 0.8322X^3 + 7 X^2 – 21.67 X + 91$	1.000	$Y= 0.0117X^3 + 0.0993 X^2 – 0.299 X + 1.212$	0.999
	%75	$Y= 0.5833X^3 + 5.821 X^2 – 21.595 X + 73.4$	0.999	$Y= 0.0082 X^3 + 0.0932 X^2 – 0.3576 X + 1.274$	0.999
	%100	$Y= 0.6667X^3 + 7.5 X^2 + 32.833 X + 60$	1.000	$Y= 0.6667 X^3 + 7.5 X^2 + 32.833 X + 60$	1.000
Residential Arterial	%25	$Y= 0.0833X^3 – 0.2876 X^2 – 0.8881 X + 3.68$	0.998	$Y= 0.0017 X^3 + 0.0.0093 X^2 – 0.049 X + 1.042$	0.999
	%50	$Y= 0.833X^3 - 0.2876 X^2 – 0.8881 X + 3.68$	0.997	$Y= 0.0008X^3 + 0.0025 X^2 – 0.0567 X + 1.056$	0.998
	%75	$Y= 0.0714X^3 - 0.2876 X^2 – 0.8881 X + 3.68$	0.995	$Y= 0.0008 X^3 + 0.0096 X^2 – 0.1795 X + 1.174$	0.996
	%100	$Y= 1.5 X^2 + 0.05 X + 21.68$	1.000	$Y= 0.08 X^2 – 0.002 X + 1.1$	1.000
Business Arterial	%25	$Y= 0.25X^3 + 1.8929 X^2 – 6.8571 X + 61.2$	0.999	$Y= 0.0042 X^3 + 0.0311 X^2 – 0.1148 X + 1.088$	1.000
	%50	$Y= 0.3333X^3 + 2.642 X^2 – 10.024 X + 56.8$	0.997	$Y= 0.0075X^3 + 0.0589 X^2 – 0.2136 X + 1.164$	0.997
	%75	$Y= 0.5X^3 + 4.0714 X^2 – 15.429 X + 46.8$	0.999	$Y= 0.0133 X^3 + 0.0107 X^2 – 0.4188 X + 1.32$	0.998
	%100	$Y= 2.0 X^2 – 2.0 X + 17$	1.000	$Y= 0.115 X^2 – 0.105 X + 1.01$	1.000
Local street	%25	$Y= 0.5833 X^3 + 4.6786 X^2 – 14.738 X + 49.6$	0.999	$Y= 0.0158 X^3 + 0.1275 X^2 – 0.3967 X + 1.284$	0.999
	%50	$Y= 0.0092X^3 + 0.0696 X^2 – 0.2812 X + 1.22$	0.999	$Y= 0.0092X^3 + 0.0696 X^2 – 0.2812 X + 1.22$	0.999
	%75	$Y= 0.1667 X^3 + 2.0 X^2 – 12.833 X + 40$	1.000	$Y= 0.01 X^3 + 0.01 X^2 – 0.051 X + 1.22$	1.000
	%100	$Y= 5.0 X + 23$	1.000	$Y= 0.25 X + 1.28$	1.000

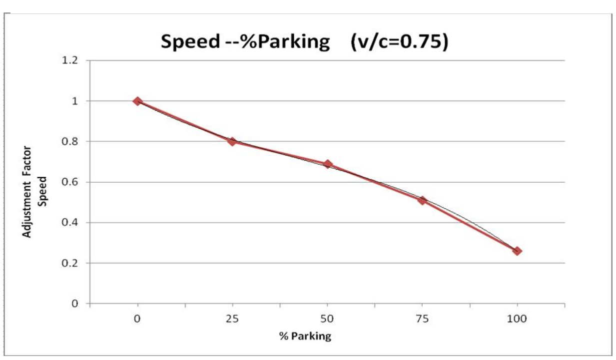

Figure 3. Effect *coefficient* of On-street park on average flow velocity in second-grade Main Street with trade usage

5.2. Average delay time

The evaluation of average coefficient of delay time given in table (3) shows that by increasing P percent in any of streets and in certain V/C, the delay time increases. The evaluation of delay time equations with regard to table4, the equations are as third grade ascending ones. These equations, firstly, by increasing P percent from O percent to 25 percent because of converse relation with velocity, are highly ascending, then by increasing P percent from 25 percent to 50 percent and in some of cases up to 75 percent up to 100 percent are along with ascending rate.

Table 3. Average movement delay time and its adjustment coefficient, in different V/C various %P percent, street conditions

Street type	V/C	average delay time					Influence coefficient at on-street park on average movement delay time				
		%P on-street park percent					%P on-street park percent				
		%0	%25	%50	%75	%100	%0	%25	%50	%75	%100
Highway	%25	4.60	4.90	5.00	5.20	5.60	1.00	1.07	10.09	1.13	1.22
	%50	4.70	5.10	5.30	5.50	6.40	1.00	1.09	1.13	1.17	1.36
	%75	6.40	7.50	8.30	8.80	9.80	1.00	1.17	1.30	1.38	1.53
	%100	10.6	19.00	33.00	60.00	-	1.00	1.79	3.11	5.66	-
Residential Arterial	%25	5.90	6.10	6.30	6.70	7.20	1.00	1.03	1.07	1.14	1.22
	%50	6.40	6.80	7.30	7.80	8.80	1.00	1.06	1.14	1.22	1.38
	%75	9.70	11.20	14.40	17.00	24.00	1.00	1.15	1.48	1.75	2.47
	%100	18.90	25.70	60.00	-	-	1.00	1.35	3.17	-	-
Business Arterial	%25	6.40	6.80	7.10	7.50	8.40	1.00	1.06	1.11	1.17	1.31
	%50	7.30	8.00	8.80	9.50	11.60	1.00	1.10	1.21	1.30	1.59
	%75	10.30	12.5	15.00	18.00	40.00	1.00	1.21	1.46	1.75	3.88
	%100	21.00	27.70	72.00	-	-	1.00	1.32	3.43	-	-
Local street	%25	7.40	8.50	9.00	10.30	14.4	1.00	1.15	1.22	1.39	1.95
	%50	7.80	9.00	10.30	12.50	19.00	1.00	1.15	1.32	1.60	2.44
	%75	9.90	13.70	19.20	28.90	-	1.00	1.38	1.94	2.92	-
	%100	19.00	22.20	-	-	-	1.00	1.39	-	-	-

Table 4. Average movement delay time and its adjustment coefficient, in different V/C %P percent, streets conditions

Street type	V/C	average movement delay time		Application of coefficient on average movement delay time	
		Equations	R^2	Equations	R^2
Highway	%25	$Y= 0.0333 X^3 - 0.2876 X^2 + 0.8881 X + 3.68$	0.999	$Y= 0.0083 X^3 - 2.0707 X^2 – 0.221 X + 0.842$	0.999
	%50	$Y= 0.075X^3 - 0.6036 X^2 + 1.7214 X + 3.5$	0.998	$Y= 0.0167 X^3 - 0.1357 X^2 + 0.3876 X + 0.73$	0.998
	%75	$Y= 0.0667 X^3 - 0.6357 X^2 + 2.597 X + 4.36$	0.999	$Y= 0.0092 X^3 – 0.0889 X^2 – 0.3819 X + 0.696$	0.998
	%100	$Y= 1.2333 X^3 – 4.6 X^2 + 13.567 X + 0.4$	1.000	$Y= 0.44 X^2 – 0.67 X – 1.265$	0.998
Residential Arterial	%25	$Y= 0.0083 X^3 - 0.0179 X^2 + 0.1738 X + 5.74$	0.998	$Y= 0.0093 X^2 – 0.0007 X – 0.992$	0.999
	%50	$Y= 0.0333X^3 - 0.2143 X^2 + 0.8524 X + 5.72$	0.998	$Y= 0.0143 X^2 – 0.0063 X – 0.984$	0.994
	%75	$Y= 0.225 X^3 – 1.2821 X^2 - 4.2929 X + 6.36$	0.994	$Y= 0.225 X^3 – 1.1254 X^2 + 0.4221 X + 0.67$	0.994
	%100	$Y= 13.75 X^2 - 34.45 X + 39.6$	1.000	$Y= 0.725 X^2 – 1.815 X – 2.09$	1.000
Business Arterial	%25	$Y= 0.05 X^3 - 0.3714 X^2 + 1.0176 X + 5.54$	0.999	$Y= 0.0075 X^3 – 0.0554 X^2 + 0.1771 X + 0.87$	0.999
	%50	$Y= 0.1083X^3 - 0.0782 X^2 + 2.4095 X + 5.54$	0.996	$Y= 0.0157 X^3 – 0.1168 X^2 + 0.3574 X + 0.74$	0.995
	%75	$Y= 1.5583 X^3 + 11.161 X^2 – 26.081 X - 6.11$	0.992	$Y= 0.15 X^3 – 1.0729 X^2 + 2.5041 X - 0.61$	0.991
	%100	$Y= 18.8 X^2 – 0.49 X + 51.9$	1.000	$Y= 0.895 X^2 – 2.365 X + 2.47$	1.000
Local street	%25	$Y= 0.2833 X^3 - 2.0643 X^2 + 5.3524 X + 3.82$	0.999	$Y= 0.0392 X^3 – 0.2868 X^2 + 0.744 X + 0.502$	0.999
	%50	$Y= 0.35 X^3 - 2.3286 X^2 + 5.9214 X + 3.82$	0.998	$Y= 0.045 X^3 – 0.2986 X^2 + 0.7564 X + 0.462$	0.998
	%75	$Y= 0.4167 X^3 – 1.65 X^2 + 5.8333 X + 5.3$	1.000	$Y= 0.15 X^2 + 0.118 X + 0.98$	0.998
	%100	$Y= 6.2 X + 9.8$	1.000	$Y= 1.36 X^2 – 3.69 X + 3.33$	1.000

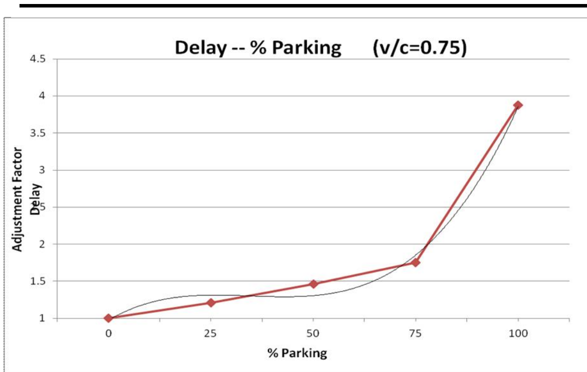

Figure 4. Influence coefficient of on-street park on average flow delay in main second grade street with trade use

5.3. Flow current rate

The evaluation of flow rate coefficients in table (5) shows maximum flow rate based on streets classification and different %P. As absorbed in table, by increasing P percent, the maximum flow rate decreases. The evaluation of flow rate equations with regard to table (6) shows that in flounce coefficient of on-street park on maximum flow rate is as third-grad descending equations. In these equations, by increasing P percent from O percent up to 25 percent, firstly, is observed that it decreases and then by increasing P percent from 25 percent up to 75 percent, the rate of descending of equations decreases.

Table 5. Flow rate and its adjustment coefficient, in different V/C various %P percent, streets conditions

Street type	V/C	Flow current rate					Influence coefficient at on-street park on movement flow rate				
		%P on-street park percent					%P on-street park percent				
		%0	%25	%50	%75	%100	%0	%25	%50	%75	%100
highway	%25	93	74	81	79	74	1.00	0.89	0.86	0.84	0.79
Residential	%50	64	58	56	49	42	1.00	0.90	0.87	0.76	0.65
Business	%75	61	54	53	43	35	1.00	0.90	0.87	0.73	0.58
Local	%100	30	21	17	13	11	1.00	0.69	0.55	0.77	0.37

Table 6. Equations of flow rate and its adjustment coefficient, in different V/C %P percent, streets conditions

Street type	V/C	average movement velocity in study region		Application of coefficient on average movement velocity in study region	
		Equations	R^2	Equations	R^2
highway	%25	$Y= 0.0092 X^3 - 0.00918 X^2 - 0.319 X + 1.236$	0.999	$Y= 86 X^3 – 29.861 X^2 – 2994.7 X + 11607$	0.995
Residential	%50	$Y= 0.0057 X^3 + 0.0454 X^2 - 0.1788 X + 1.136$	0.989	$Y= 37.5 X^3 + 291.5 X^2 - 1151 X + 7327.8$	0.989
Business	%75	$Y= 0.0067 X^3 + 0.045 X^2 - 0.1683 X + 0.126$	0.989	$Y= 34.91 X^3 + 224.2 X^2 – 893.83 X + 6723.6$	0.986
Local	%100	$Y= 0.0108 X^3 + 0.1339 X^2 - 0.6252 X + 1.50$	0.998	$Y= 34 X^3 + 415.79 X^2 – 1920.20 X + 4562.8$	0.998

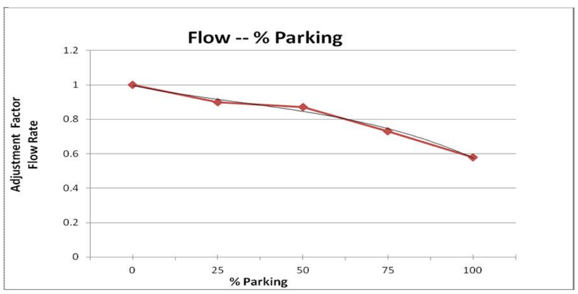

Figure 5. Influence coefficient of on-street park, magi mum flow density on main second-grade street use.

5.4. Evaluation of velocity- delay time in flow rate to different capacities rate

The comparison of on-street park effect on flow traffic variants on different streets in various V/Cs show than, one certain V/C. P percent given elements with regard to street type is different. The lines number of streets has direct relation with decreased capacity. The P percent between zero up to 65 percent causes to decreased capacity of street. The effect of street is different from one street to other street with regard to lines number and dominant situations on street type.

5.5. Evolution of on-street park effect on flow in streets

The review of velocity – delay time curve for different V/Cs and streets shows that decrease of velocity rate in any of given V/Cs along with increasing V/C rate causes to partial drop of flow velocity in P percent and leads to increased delay time.

On the other hand, in certain V/C, P percent causes to lower flow velocity rate and subsequently, increases delay time.

6. Conclusion

The knowledge of effective factors which decreases the contrast between estimated model and real model and imposes them in correction process of flow management is of the present research aims. The obtained results could be summarized as follows:

- Estimation of influence coefficient of on-street parking on velocity and flow moderate delay resultant of classification of streets and also product of different V/Cs, different on-street parking percent and average velocity improvement and flow moderate delay resulted from on-street parking.
- Estimation of influence coefficient of on-street parking on traffic volume resultant of classification of streets and different on-street parking percent and improvement of traffic volume resultant of on-street parking.
- Establishment of velocity behavioral pattern equations, delay time, traffic volume, second, third grade with equations accuracy ($0.9<R^2<1$).

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