Civil and Environmental Research www.iiste.org
ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online)
Vol.8, No.7, 2016

Operational Performance Evaluation of Post Office – Teaching Hospital Road, Ile – Ife, Nigeria

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Abstract
Traffic demand is significantly on the increase in our urban centres without a commensurate increase in the rate of road infrastructure development, resulting in traffic congestion. The need to periodically evaluate the operational performance of these roads with a view to addressing this problem becomes imperative, hence this study. Speed and traffic flow data were collected for morning and evening peaks for seven days for two segments of the selected urban road in Ile-Ife, using normal procedure. Traffic flow parameters, such as, travel speed, traffic volume and capacity were computed and operational performance evaluation determined. The study showed that, motorcycles were the predominant means of transport (50 %), and followed by buses (25 %), cars (23 %) and trucks (2 %), while the average travel speed was 41 km / h. The average traffic capacity of 1306 pc/hr/ln was also obtained. The results revealed that the operating speed and capacity of the road were short of the required values of 1500 pc/hr/ln and 50 – 60 km / h, respectively, for an urban two-way two-lane highway. The road is therefore prone to congestion.
Keywords: key words, Traffic Demand, Road Infrastructure, Operational performance

1. Introduction

Cities and traffic have developed hand-in-hand since the earliest large settlements. The same forces that draw inhabitants to congregate in large urban areas also lead to sometimes intolerable levels of traffic congestion on urban streets and thoroughfares. Road traffic congestion poses a challenge to all large and growing urban areas (ECMT, 2007).

Aderamo (2012) noted that, urban transport problems remain one of the most nagging problems in urban transportations today. All over the world, attempts have been made to tackle the problems, yet the situation seems to get worse. Cities are centres of economic, social, cultural and intellectual activities. These activities result in the drift of the population from rural to urban centres and these congregations have caused cities to expand without control in many areas, causing congestion, environmental and social problems.

Various approaches have been taken to combat urban transport problems. In ancient Rome for example, Julius Caesar once prohibited the movement of cars during day light to relieve traffic congestion on roads (Bruton, 1975). Congestion was also common place in seventeenth century London and nineteenth century New York. In the United States, various studies were carried out in cities with traffic problems with the aim of reducing urban traffic congestion problems. In 1973, the Organization for Economic Cooperation and Development Report discussed the wide spread uses of Restraint of Road traffic techniques in the developed countries as a means of reducing heavy urban traffic problems (OECD, 1973). In Nigeria, many scholars have also carried out studies on urban transport problems all aimed at proffering solutions. These include Adedamila (1977); Adenle (1977); Ogunsaya (1984) and Aderamo (1998). Many of these scholars who worked on urban transport problems in Nigeria have identified congestion as the most serious (Aderamo, 2012).

In developing countries, rapid urban growth is overstepping the capacity of most cities to provide adequate services for their citizens (Cohen, 2004). Furthermore, lack of infrastructure and weak maintenance put extra stress on growing traffic flows, resulting in congestion, pollution and a low road safety level. (Rust *et a*l., 2008, Cohen, 2004, Gakenheimet, 1999 and Gwillian, 2003). Urban mobility problems in Nigeria had been on the increase since independence. This is due to rapid increase in population in urban areas, which is not matched with growth in transport facilities such as road network, transport complimentary facilities, transport services and traffic management techniques (Ogunbodede, 2008).

Improved mobility in urban areas in developing countries is possible by building new infrastructure. However, this is a long term solution and expensive. A short term solution is to improve the traffic management to rationalize the use of existing infrastructure (Gakenheimer, 1999).

Rothenberg (1985) defined urban congestion as “a condition in which the number of vehicles attempting to use a roadway at any given time exceeds the ability of the roadway to carry the load at generally acceptable level of service”. There are two types of congestion: recurring and non-recurring. Typically, recurring congestion occurs during the morning and afternoon rush hours as commuters travel to and from work. Non-recurring congestion is caused by random incidents, most often by disabled vehicles and accidents. Recurring congestion is most easily identified as the characteristics of rush hour traffic are well documented. Incidents are random events, and traffic patterns and characteristics are not well defined (Arnold, 1985).

Traffic congestion is a hardy and annoying urban perennial problem. If Glaeser and Kahn (2004) had argued that, cities are the absence of space between people, then traffic is the inevitable friction that keeps them apart. Understanding, measuring and dealing with transportation problems are key challenges for city and national leaders (Corpright, 2010).

Measuring congestion is a necessary step in order to deliver better congestion outcomes. Good indicators can be based on a wide network of roadway sensors but simple indicators based on less elaborate monitoring can sometimes adequately guide policy. What is important is to select metrics that are relevant to both road managers (e.g. speed, and flow, queue length and duration, etc) and road users (e.g. predictability of travel times, sustain reliability etc) (ECMT, 2007).

Transportation performance measures based on travel time quantities satisfy a range of mobility purposes. They show the effect of many transportation and land use solutions and they are relatively easy to communicate to a range of audiences. A variety of different measures can be created to show the effect of mobility problems and solutions on individuals, regions, businesses and the economy. There are also several ways to calculate or estimate the travel time measures including roadway inventory and traffic files; travel speed datasets from system monitoring devices or companies, computerized transportation demand models and simulations of traffic flow. Each of the measures and data sources has their strengths and weaknesses, and each is better suited for some applications (Lomax and Schrank, 2010).

The basis of travel time measure is rooted in the interests of travellers and urban residents. Travel time indices are good measures of the effects of congestion; they rely on an estimate of the speed that travellers choose to travel if there is no congestion (in this case, 90 km/h (60 mph) for freeways and 45 km/h (30 mph) on streets (Lomax and Schrank, 2010).

Lindley (1986) noted that, if the volume over capacity ratio (v/c) is greater than or equal to 0.77, then there is congestion.

Operational performance evaluation indices for road networks could therefore, give policy guide to improve existing road infrastructure and ensuring better traffic management.

2. MATERIALS AND METHODS

The study road is the Post Office – Teaching Hospital road, at Ile-Ife, Osun State, Nigeria. Figure 1 shows the map of Osun State, while Figure 2 shows the study route. Speed and traffic flow data were collected for morning and evening periods for seven days for two segments of the road using standard procedure (Mathew, 2014 and Gresham *et al*., 2002). The traffic characteristic was determined from the traffic flow data by proportioning, while the traffic volume was obtained using passenger car equivalent factors (HDM, 2007). The average travel speed was computed using equation 1

$$t_a = \frac{\sum_1^n t_i}{n}, \text{ hour} \qquad (1)$$

Where t_i = travel time for every i_{th} vehicle observed in 15 minutes
n= total number of observed vehicles
i = 1, 2, 3, 4, -- n

The traffic flow rate in passenger car unit per hour per lane (pcu/hr/ln) was computed using equation 2

$$Q = \frac{\sum_1^n (Q_a)_i}{n} \qquad (2)$$

Where Q = average traffic flow rate
Qa = average traffic flow rate for every 15 minute increment per day
i= 1, 2, 3, 4---------------------- n
n = number of days of counting

The traffic density (k) was therefore determined using equation 3

$$K = \frac{Q}{Usa} \text{ pcu/km/h} \qquad (3)$$

Where
Q – average flow rate
U_{sa} = average speed.

A linear regression equation representing the speed-density model was developed, using Table 1. The free flow speed (U_f) and jam density (K_j) were determined by comparing the speed-density model with the speed-density equation postulated by Greenshields (1935).

Having determined U_f and K_j, the optimum speed (U_o) and optimum density (K_o) were computed respectively using equations 4 and 5.

$$U_o = \frac{U_f}{2} \qquad (4)$$

$$K_o = \frac{K_j}{2} \qquad (5)$$

The road capacity was thereafter determined using equation 6.

$$Q_m = K_o \times U_o \qquad (6)$$

3.RESULTS AND DISCUSSION

The traffic stream was composed of 23, 25, 2 and 50 % for cars, buses, trucks and motor cycles respectively (Figure 3). The large percentage for motor cycles is typical of urban passenger transport system (Ogunbodede, 2008). Khan and Maini (1999) reported that composition of traffic in developing countries is mixed, with a variety of vehicle motorised and non-motorised. They pointed out that, the motorized or fast moving vehicles include, passenger cars, buses, trucks, auto rickshaws, scooters and motorcycles. The composition of the traffic on this route is classified as heterogeneous. Mohan and Tiwari (2000) reported that heterogeneous traffic flow consists of modes of varying dynamic and static characteristics sharing the road space.

The speed pattern on the route is typical of movement trends of traffic in urban centres. High speeds at the early part of the morning (6.30 – 7.00 am) and dropped in the later part (8.16 and 8.30 am), when most commuters were on their way to work. The speed picked up thereafter and dropped again at 4.15 – 4.30 pm, when commuters once again made their way back home (Figure 4). The periods of speed drop observed were morning and afternoon rush hours as commuters travel to and from work which also corresponded to periods of high traffic flow (Figure 5). This Arnold (1985) termed recurring congestion. Cortright (2010) pointed out that, relationship between traffic and speed depends on traffic volume at specific times.

Traffic streams are not uniform, but vary over both space and time (FHRT, 2016). Typical traffic time variation pattern are as displayed in Figures 5 and 6. The typical morning and evening peak periods are evident, as usual for urban commuters (HCM, 2000). As envisaged, "peaky" flow with the highest traffic in peak periods and lower traffic in off-peak periods (Orthongthed *et al*., 2013).

The linear regression expression $U_s = -0.324K + 41.13$ was derived as the speed-density model for the road (Figure 7). With an R^2 value of 0.61 and an F-test result of F (0.08) < $F_{critical}$ (0.76), the model is significant at 0.05. A free flow speed (U_f) and a jam density (K_j) of 41.13 km/h and of 127 pcu/km/ln, were obtained respectively. The road operating capacity (Q_m) value was therefore, 1306 pcu/h/ln.

These values, 41 km/h and 1306 pcu/h.ln. for speed and operating capacity respectively, were short of the specifications for an urban a two-way, two-lane road (HDM, 2007).

4. Conclusion

Operational performance evaluation of Post Office – Teaching Hospital Rroad, Ile –Ife, Nigeria was carried out. The results revealed that the capacity and operating speed of the road are short of the required values of 1500 pc/hr/ln and 50 – 60 km / h respectively for an urban two-way two-lane highway. The road is therefore prone to congestion..

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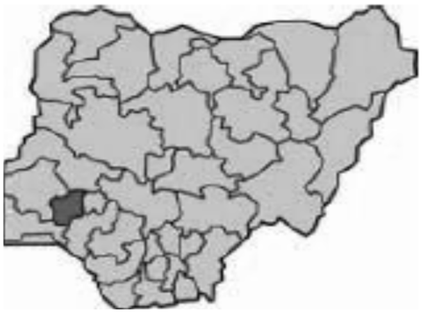

Source: http://www.ngex.com/nigeria/places/states/osun.htm
Figure 1: Map of Nigeria Showing Osun State

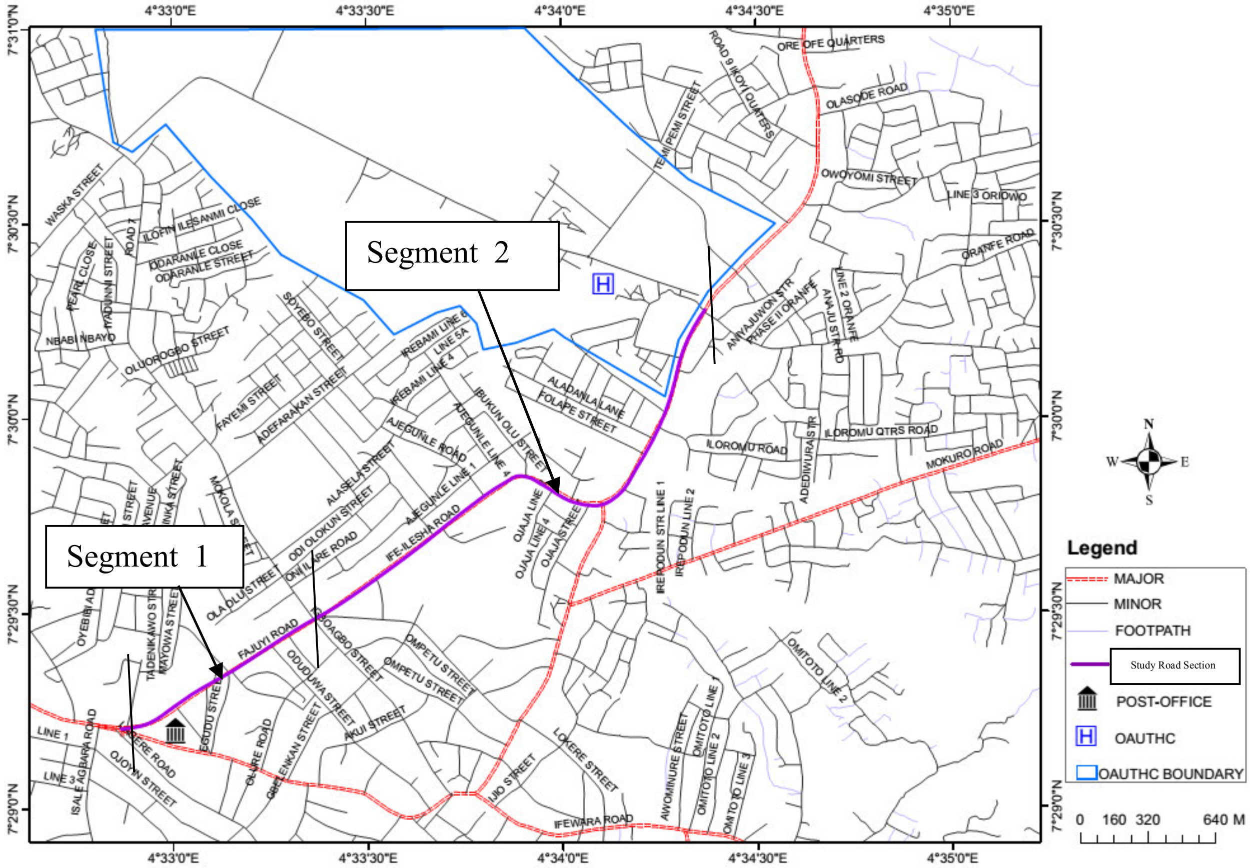

Figure 2: Location of the study route

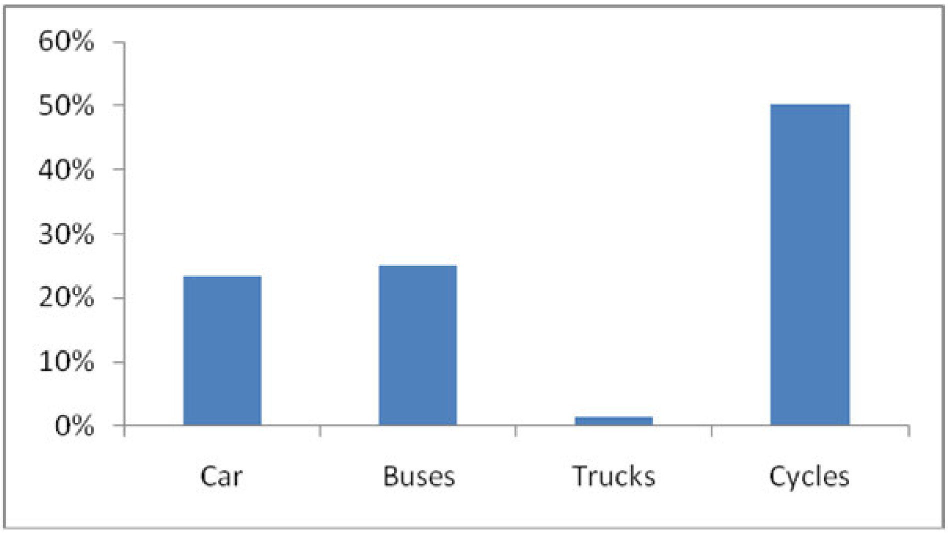

Figure 3: Traffic composition

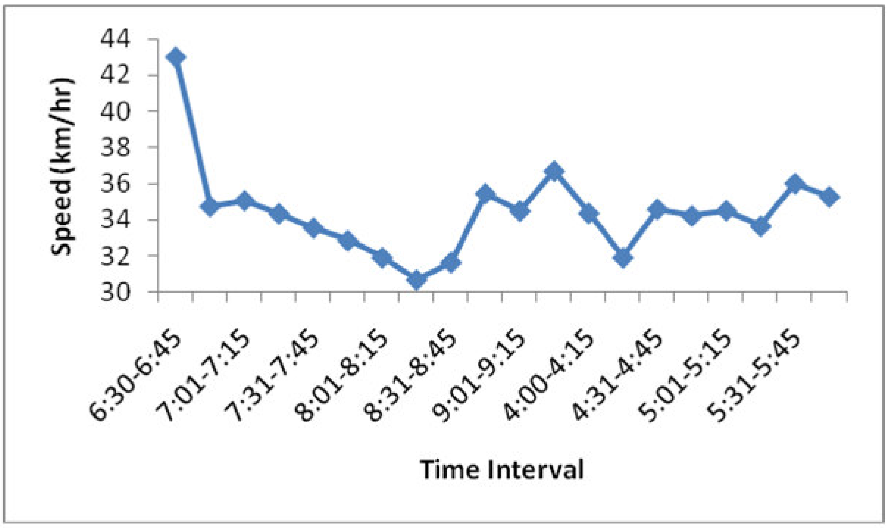

Figure 4: Speed vs Time

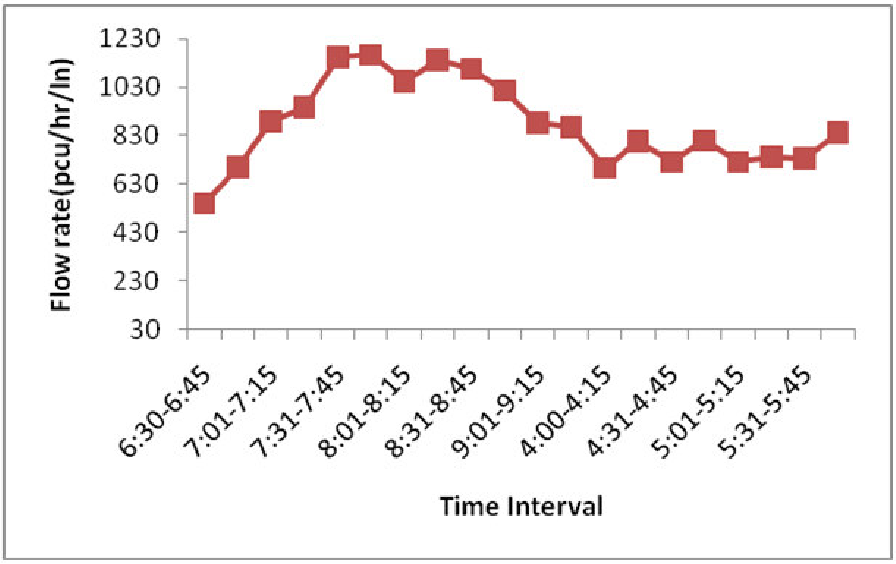

Figure 5: Flow rate vs Time

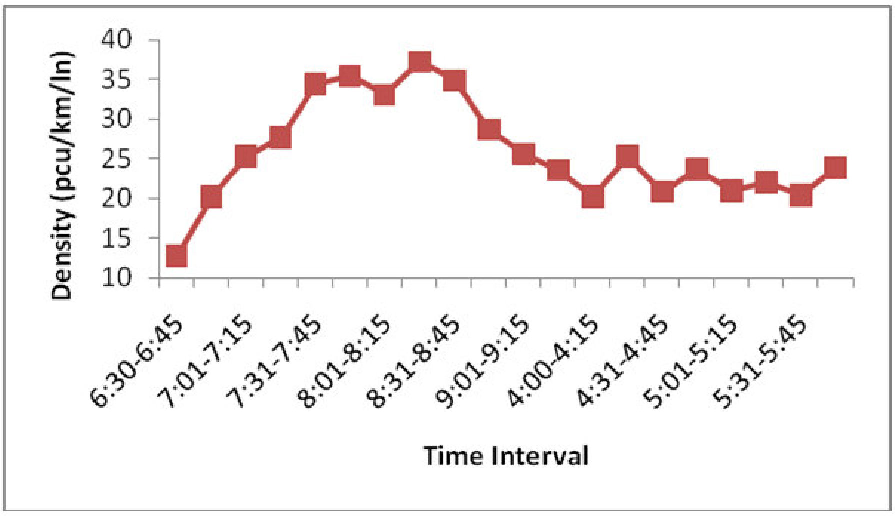

Figure 6: Density vs Time

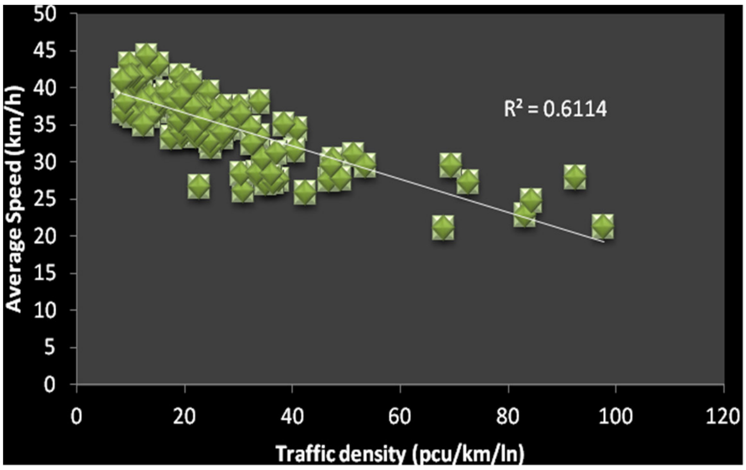

Figure 7: Speed-Density model

Table 1: Average speed (km/h)and average traffic density (K pcu/km/ln)

Day	Interval	Qagg (pcu/h/ln)	Us (km/h)	K = Qagg/Us
Day 1	6:30-6:45	655	33.43	19.60
	6:46-7:00	606	26.64	22.73
	7:01-7:15	1100	25.88	42.51
	7:16-7:30	1440	30.29	47.53
	7:31-7:45	1983	27.32	72.57
	7:46-8:00	2576	27.84	92.53
	8:01-8:15	1905	22.89	83.22
	8:16-8:30	2072	21.21	97.68
	8:31-8:45	2091	24.79	84.35
	8:46-9:00	2046	29.46	69.42
	9:01-9:15	1019	28.13	36.21
	9:16-9:30	1034	27.65	37.39
	4:00-4:15	944	28.33	33.31
	4:16-4:30	1432	21.01	68.13
	4:31-4:45	812	26.22	30.96
	4:46-5:00	947	27.08	34.98
	5:01-5:15	994	27.32	36.36
	5:16-5:30	864	28.33	30.49
	5:31-5:45	958	28.57	33.52
	5:46-6:00	1024	28.33	36.15
Day 2	6:30-6:45	584	33.33	17.51
	6:46-7:00	902	33.33	27.05
	7:01-7:15	1405	34.38	40.88
	7:16-7:30	1046	30.39	34.40
	7:31-7:45	1588	30.97	51.26
	7:46-8:00	1286	27.50	46.75
	8:01-8:15	1354	27.69	48.89
	8:16-8:30	1578	29.48	53.53
	8:31-8:45	1396	29.55	47.25
	8:46-9:00	1271	31.52	40.33
	9:01-9:15	1348	35.08	38.43
	9:16-9:30	1289	38.04	33.87
	4:00-4:15	856	36.54	23.41
	4:16-4:30	851	34.62	24.57
	4:31-4:45	882	33.93	25.98
	4:46-5:00	812	36.54	22.22
	5:01-5:15	774	34.62	22.37
	5:16-5:30	978	37.00	26.43
	5:31-5:45	964	35.58	27.08
	5:46-6:00	921	35.58	25.87

Table 1: Average speed (km/h)and average traffic density (K pcu/km/ln) (contd.)

Day	Interval	Qagg (pcu/h/ln)	Us (km/h)	K = Qagg/Us
	6:30-6:45	552	38.08	14.5
	6:46-7:00	718	39.29	18.28
	7:01-7:15	820	38.08	21.52
	7:16-7:30	874	38.08	22.95
	7:31-7:45	937	39.29	23.84
	7:46-8:00	842	37.36	22.54
	8:01-8:15	875	35.06	24.94
	8:16-8:30	898	38.87	23.1
	8:31-8:45	1048	36.71	28.53
Day 3	8:46-9:00	958	36.71	26.08
	9:01-9:15	943	34.36	27.43
	9:16-9:30	909	38.08	23.87
	4:00-4:15	751	35.06	21.42
	4:16-4:30	651	34.47	18.88
	4:31-4:45	666	35.06	18.98
	4:46-5:00	984	34.54	28.47
	5:01-5:15	711	35.06	20.26
	5:16-5:30	795	32.00	24.84
	5:31-5:45	740	33.43	22.12
	5:46-6:00	984	35.71	27.54
	6:30-6:45	540	36.71	14.71
	6:46-7:00	797	35.06	22.72
	7:01-7:15	803	36.11	22.24
	7:16-7:30	875	35.58	24.59
	7:31-7:45	1154	31.19	37.01
	7:46-8:00	1012	36.12	28.02
	8:01-8:15	1025	35.58	28.80
	8:16-8:30	1134	33.42	33.94
	8:31-8:45	1117	34.62	32.25
	8:46-9:00	904	38.64	23.4
	9:01-9:15	913	33.93	26.91
Day 4	9:16-9:30	967	39.29	24.6
	4:00-4:15	655	33.93	19.31
	4:16-4:30	835	35.71	23.37
	4:31-4:45	909	37.22	24.42
	4:46-5:00	919	35.58	25.82
	5:01-5:15	709	36.12	19.63
	5:16-5:30	813	32.75	24.81
	5:31-5:45	736	37.50	19.63
	5:46-6:00	1128	37.36	30.18

Table 1: Average speed (km/h)and average traffic density (K pcu/km/ln) (contd.)

Day	Interval	Q_{agg} (pcu/h/ln)	U_s (km/h)	K = Qagg/U_s
	6:30-6:45	580	37.50	15.46
	6:46-7:00	769	40.00	19.23
	7:01-7:15	798	41.56	19.21
	7:16-7:30	1008	37.36	26.98
	7:31-7:45	940	36.71	25.59
	7:46-8:00	1065	32.54	32.73
	8:01-8:15	1053	32.45	32.43
	8:16-8:30	1112	36.54	30.42
	8:31-8:45	904	34.19	26.43
	8:46-9:00	831	40.91	20.31
Day 5	9:01-9:15	797	39.29	20.27
	9:16-9:30	817	40.32	20.25
	4:00-4:15	609	38.04	16.01
	4:16-4:30	673	38.87	17.32
	4:31-4:45	600	42.65	14.07
	4:46-5:00	695	38.08	18.24
	5:01-5:15	688	36.71	18.73
	5:16-5:30	577	38.45	15.01
	5:31-5:45	652	43.06	15.14
	5:46-6:00	529	38.87	13.60
	6:30-6:45	350	38.08	9.19
	6:46-7:00	424	43.06	9.85
	7:01-7:15	510	41.56	12.27
	7:16-7:30	543	37.62	14.43
	7:31-7:45	661	39.29	16.82
	7:46-8:00	440	40.32	10.9
	8:01-8:15	428	41.56	10.29
	8:16-8:30	452	40.91	11.04
	8:31-8:45	431	41.56	10.37
Day 6	8:46-9:00	408	41.56	9.81
	9:01-9:15	475	37.36	12.7
	9:16-9:30	344	40.91	8.40
	4:00-4:15	386	36.12	10.68
	4:16-4:30	462	38.08	12.14
	4:31-4:45	447	36.12	12.36
	4:46-5:00	489	36.12	13.52
	5:01-5:15	363	36.43	9.97
	5:16-5:30	317	36.71	8.63
	5:31-5:45	341	38.08	8.94
	5:46-6:00	432	35.06	12.33

Table 1: Average speed (km/h)and average traffic density (K pcu/km/ln) (contd.)

Day	Interval	Qagg (pcu/h/ln)	Us (km/h)	K = Qagg/Us
	6:30-6:45	580	44.29	13.09
	6:46-7:00	695	35.00	19.85
	7:01-7:15	782	38.08	20.52
	7:16-7:30	857	37.36	22.94
	7:31-7:45	825	37.36	22.07
	7:46-8:00	923	33.93	27.19
	8:01-8:15	749	38.08	19.68
	8:16-8:30	756	33.64	22.47
	8:31-8:45	743	34.29	21.66
	8:46-9:00	691	38.08	18.13
Day 7	9:01-9:15	689	36.43	18.91
	9:16-9:30	695	38.10	18.24
	4:00-4:15	672	35.58	18.87
	4:16-4:30	745	36.71	20.30
	4:31-4:45	730	36.71	19.88
	4:46-5:00	823	36.71	22.40
	5:01-5:15	807	37.36	21.60
	5:16-5:30	838	35.71	23.45
	5:31-5:45	750	38.64	19.40
	5:46-6:00	868	40.60	21.37