Lane Changing Behaviour in Six Lanes-Two Ways Divided Freeway in Jakarta

Leksmono Suryo PUTRANTO
Senior Lecturer
Department of Civil Engineering
Tarumanagara University
Jl. Let. Jen. S. Parman No. 1,
Jakarta 11440, Indonesia
Fax: +62-21-566-3277
E-mail: lexy@tarumanagara.ac.id

Dedy Setio INTAN
Alumni
Department of Civil Engineering
Tarumanagara University
Jl. Let. Jen. S. Parman No. 1,
Jakarta 11440, Indonesia
Fax: +62-21-566-3277
E-mail: dedy_togar@hotmail.com

Abstract: Driver behaviour affects traffic safety. One of important driver behaviour is lane changing behaviour. In a multi lanes-two ways divided road, lane changing behaviour is more important than overtaking behaviour. This is due to the availability of sufficient number of lanes in each direction to change lane without the need to return to the original lane. Research on this area in Indonesia was still very limited. Therefore in this paper the lane changing behaviour on a six lanes-two ways divided urban freeway will be discussed. A 24 hours observation was carried out in urban freeway segment adjacent Let. Jen. S. Parman arterial road, in front of the West Jakarta Courthouse. A video camera was installed in a nearby pedestrian crossing bridge to record 24 hours traffic movement in the Grogol-Slipi direction of the freeway. Desk observation was then carried out by playing back the video in the computer. For each type of vehicle, i.e. light vehicle and heavy vehicle, the number of several movements were recorded every 15 minutes period. These movements include lane changing to the left, lane changing to the right, overtaking from the left and overtaking from the right. The percentages of each type of movement relative to the number of vehicle for each vehicle type for every 15 minutes period were then be calculated. The Pearson correlations between these percentages and volume to capacity ratio (V/C) were calculated.

Key Words:

1. INTRODUCTION

Driving behaviour is affecting traffic safety significantly. Driver who violates traffic regulation, drives without valid driving license, drives improper vehicle will potentially endangers his/ her own safety as well as the safety of his/ her passengers and other vehicles. One of dangerous driver behaviour is unsafe overtaking, such as overtaking from the left, double overtaking and overtaking on limited available gap, etc. However overtaking behaviour is more important to be observed in undivided roads, especially in two lanes-two ways undivided roads. In a multi lanes-two ways divided road, lane changing behaviour is more important than overtaking behaviour. This is due to the availability of sufficient number of lanes in each direction to change lane without the need to return to the original lane. Research on this area in Indonesia was still very limited. Therefore in this paper the lane changing behaviour on a six lanes-two ways divided urban freeway will be discussed.

2. OBJECTIVE

The objective of this research is to know the relationship between rate of occurrence of various type of lane changing and overtaking movements and volume to capacity ratio (V/C).

These movements include lane changing to the left, lane changing to the right, overtaking from the left and overtaking from the right.

3. SCOPE AND LIMITATIONS

The observation was only carried out in 6 lanes-2ways divided urban freeway segment adjacent Let. Jen. S. Parman arterial road, in front of the West Jakarta Courthouse in Grogol-Slipi direction. The observation was only conducted for 24 hours in a normal working day.

4. LITERATURE REVIEW

Previous studies specifically on lane changing behaviour were hard to find. However, there were some research on overtaking behaviours that can be referred here. The probability to overtake a slow moving vehicle was affected by overtaking sight distance (HCM, 2000), vehicle type (Troutbeck, 1982), road condition (Kallberg, 1980) and overtaking time (Kallberg, 1980). The number of overtaking movement on low traffic flow was affected by the traffic density and the speed of overtaking vehicle (Troutbeck, 1981).

Compared to the moving car observation (Sucahyo, 1994), the stationer observation (Mahdi, 1994) which will be used with some adjustments in the present research, had several advantages as follows:

a. All of overtaking movement at various overtaken vehicle speeds could be recorded.
b. Only camera with standard recording technology was required.
c. The behaviour of other vehicles was not affected

Chakroborty et al (2004) stated that microscopic modelling of driver behaviour consisted of all scenarios of traffic conditions ranging from free flow traffic to forced flow traffic, including traffic condition which could lead to overtaking movement. Most of the previous studies considered only car following situation, i.e. when a driver is forced to drive his/ her car behind another vehicle travelling with a speed below the acceptable speed by the driver behind his/ her car (Kikuchi dan Chakroborty, 1992; Fritzche, 1994; Aycin dan Benekohal, 1998; Chakroborty dan Kikuchi, 1999).

5. METHODOLOGY OF DATA COLLECTION AND ANALYSIS

Traffic count survey was conducted for 24 hours from 4 September 2007 (8:00 a.m.) to 5 September 2007 (8:00 a.m.) at a 6 lanes-2 ways freeway (adjacent to S. Parman arterial road in West Jakarta). Although the recording was carried out in two directions, only Grogol-Slipi direction data was used in this present research. This was due the lane changing and overtaking movement could only be observed properly in Grogol-Slipi direction. It should be noted that the video observation was originally carried out for lane distribution research (Putranto and Intan, 2008) which had different requirements of video observation compared with this present research. The observation for a Grogol-Slipi direction was recorded by a VHS video camera from a pedestrian crossing bridge so that the counting can be conducted later. This was required in order to accommodate the need to classify the counting in 15 minutes observation for each type of movement and each type of vehicle. The vehicles were classified into two categories, i.e. light vehicle (LV) and, heavy vehicle (HV). Capacity

calculation was conducted based on Indonesian Highway Capacity Manual (1997) only for the purpose of volume to capacity ratio (V/C) analysis. A Pearson correlation analysis was then conducted between V/C and the percentage of each type of lane changing and overtaking movements. These movements include lane changing to the left (type 1), lane changing to the right (type 2), overtaking from the left (type 3) and overtaking from the right (type 4). A significance level of 0.05 was used.\

Figure 1 The observed freeway

6. DATA ANALYSIS RESULTS

Table 1 and Table 2 summarize V/C, percentage of each type of lane changing and overtaking movements for each 15 minutes observation period for light vehicle (LV) and heavy vehicle (HV) respectively. It can be seen that as predicted before, percentages of overtaking movements were clearly less than percentages of lane changing movements. From a total of 54,061 light vehicle 24 hours flow, only 9,612 (17.8%) of them were observed to either change lane or overtake other vehicle. This consists of 8.6% lane changing to the left, 8.4% lane changing to the right, 0.5% overtaking from the left and 0.3% overtaking from the right. From a total of 9,388 heavy vehicle 24 hours flow, 3,015 (32.1%) of them were observed to either change lane or overtake other vehicle. This consists of 15.0% lane changing to the left, 14.9% lane changing to the right, 0.4% overtaking from the left and 1.8% overtaking from the right. Although number of light vehicles carried out 4 types of movement was higher than number of heavy vehicle carried out 4 types of movement, in percentage the results were the other way around.

Information from Table 1 and Table 2 was then used to calculate the Pearson correlation coefficients as stated in the previous chapter. The summary of the correlation coefficients were tabulated in Table 3. It can be seen that in general relationship between V/C and percentages of each types of movement were significantly found only in heavy vehicle. Except for overtaking from the right, the higher the V/C the higher the percentage of each type of movement of heavy vehicle (lane changing to the left, lane changing to the right and overtaking from the left). This implies that on higher V/C, heavy vehicles tend to move from their original lanes possibly because the speed of the leading vehicles were not acceptable (too slow). On the contrary for light vehicle only relationship between percentage of overtaking light vehicle from the right was significantly correlated with V/C. The correlation coefficient was negative, meaning that the higher the V/C the lower the percentage of overtaking vehicle from the right. This implies that on higher V/C overtaking movement of light vehicle become more difficult to be carried out.

Table 1 V/C and % of each type of lane changing and overtaking movement of LV

15' Period	Total Light Vehicle Flow	Percentage of Light Vehicle				V/C
		Changing Lane to the Left	Changing Lane to the Right	Overtaking from the Left	Overtking from the Right	
08.00 - 08.15	1,104	9.7	10.1	0.0	0.0	0.74
08.15 - 08.30	1,153	9.0	8.3	0.1	0.1	0.74
08.30 - 08.45	1,054	9.6	11.2	0.3	0.2	0.68
08.45 - 09.00	1,311	8.8	7.9	0.2	0.0	0.87
09.00 - 09.15	987	7.8	9.4	0.3	0.2	0.65
09.15 - 09.30	958	7.5	9.9	0.2	0.0	0.62
09.30 - 09.45	919	8.9	8.3	0.1	0.1	0.60
09.45 - 10.00	925	8.9	8.9	0.2	0.2	0.58
10.00 - 10.15	872	7.2	7.7	0.0	0.0	0.55
10.15 - 10.30	996	12.1	5.4	0.1	0.4	0.62
10.30 - 10.45	1,045	8.8	9.4	0.8	0.2	0.65
10.45 - 11.00	1,010	7.8	11.1	0.1	0.1	0.62
11.00 - 11.15	1,006	10.0	6.3	0.1	0.0	0.63
11.15 - 11.30	1,037	8.6	7.2	0.2	0.0	0.63
11.30 - 11.45	949	11.5	10.1	0.3	0.2	0.60
11.45 - 12.00	1,244	7.1	7.2	0.1	0.1	0.78
12.00 - 12.15	1,289	6.0	5.6	0.2	0.1	0.82
12.15 - 12.30	1,326	6.9	8.0	0.5	0.1	0.85
12.30 - 12.45	1,089	8.7	7.3	0.5	0.0	0.71
12.45 - 13.00	1,036	8.6	6.7	0.8	0.3	0.66
13.00 - 13.15	812	7.6	7.9	0.6	0.1	0.53
13.15 - 13.30	863	7.9	8.3	0.6	0.5	0.56
13.30 - 13.45	796	9.7	10.6	0.6	0.6	0.50
13.45 - 14.00	766	9.5	10.7	0.3	0.4	0.49
14.00 - 14.15	813	9.3	8.4	0.6	0.1	0.54
14.15 - 14.30	1,071	6.1	6.7	0.8	0.2	0.65
14.30 - 14.45	1,114	6.9	6.2	0.3	0.4	0.71
14.45 - 15.00	1,132	5.6	6.1	0.3	0.1	0.72
15.00 - 15.15	1,117	7.6	5.0	0.5	0.1	0.74
15.15 - 15.30	1,015	8.7	8.1	0.3	0.1	0.67
15.30 - 15.45	1,033	9.6	7.6	0.7	0.2	0.67
15.45 - 16.00	914	7.1	7.1	1.0	0.0	0.57
16.00 - 16.15	793	9.8	7.3	1.0	0.8	0.49
16.15 - 16.30	704	8.8	7.8	0.6	0.0	0.48
16.30 - 16.45	547	12.1	12.1	1.6	1.1	0.36
16.45 - 17.00	529	13.8	11.5	0.8	0.2	0.38
17.00 - 17.15	625	9.0	12.5	1.3	0.2	0.45
17.15 - 17.30	561	10.3	10.0	1.1	0.5	0.42
17.30 - 17.45	529	10.6	11.2	0.6	0.4	0.40
17.45 - 18.00	630	8.4	6.5	0.5	0.0	0.48
18.00 - 18.15	568	9.5	8.6	0.4	0.0	0.41
18.15 - 18.30	499	6.2	7.0	1.0	0.0	0.35
18.30 - 18.45	288	10.4	14.9	2.1	0.0	0.22
18.45 - 19.00	284	10.2	9.5	1.1	0.7	0.22
19.00 - 19.15	593	5.9	4.7	0.8	0.5	0.44
19.15 - 19.30	450	10.9	6.4	1.3	0.2	0.36
19.30 - 19.45	406	8.1	7.1	1.0	0.0	0.31
19.45 - 20.00	373	5.4	7.5	1.3	0.0	0.26

Table 1 (Cont') V/C and % of each type of lane changing and overtaking movement of LV

15' Period	Total Light Vehicle Flow	Percentage of Light Vehicle				V/C
		Changing Lane to the Left	Changing Lane to the Right	Overtaking from the Left	Overtking from the Right	
20.00 - 20.15	375	7.7	9.6	0.5	0.8	0.32
20.15 - 20.30	335	10.7	11.9	0.3	0.9	0.29
20.30 - 20.45	320	6.6	9.7	0.0	0.9	0.30
20.45 - 21.00	270	10.0	9.6	0.0	0.4	0.25
21.00 - 21.15	219	8.7	7.8	2.3	0.9	0.21
21.15 - 21.30	203	6.9	8.9	0.5	1.0	0.20
21.30 - 21.45	180	2.2	9.4	0.0	1.1	0.19
21.45 - 22.00	202	6.4	6.9	0.5	2.0	0.21
22.00 - 22.15	200	9.5	9.0	2.5	1.0	0.22
22.15 - 22.30	186	11.8	11.8	0.5	0.5	0.17
22.30 - 22.45	222	11.7	11.7	1.4	0.5	0.22
22.45 - 23.00	241	6.2	7.1	1.2	2.5	0.26
23.00 - 23.15	265	6.8	4.9	0.4	0.0	0.25
23.15 - 23.30	211	6.6	8.1	2.4	0.5	0.21
23.30 - 23.45	191	5.8	5.2	0.0	0.0	0.20
23.45 - 24.00	182	3.3	10.4	0.5	1.1	0.19
00.00 - 00.15	176	11.4	9.1	0.0	1.1	0.19
00.15 - 00.30	142	4.9	8.5	0.7	0.0	0.16
00.30 - 00.45	116	11.2	17.2	0.0	0.9	0.14
00.45 - 01.00	110	8.2	17.3	0.0	0.9	0.13
01.00 - 01.15	106	6.6	5.7	0.0	0.9	0.13
01.15 - 01.30	74	16.2	10.8	0.0	1.4	0.09
01.30 - 01.45	63	7.9	7.9	0.0	1.6	0.09
01.45 - 02.00	74	8.1	2.7	0.0	0.0	0.10
02.00 - 02.15	67	6.0	11.9	0.0	0.0	0.08
02.15 - 02.30	64	7.8	7.8	0.0	0.0	0.10
02.30 - 02.45	61	6.6	6.6	0.0	0.0	0.08
02.45 - 03.00	54	5.6	5.6	0.0	0.0	0.10
03.00 - 03.15	47	8.5	10.6	0.0	0.0	0.09
03.15 - 03.30	42	9.5	4.8	0.0	0.0	0.08
03.30 - 03.45	41	12.2	7.3	0.0	0.0	0.07
03.45 - 04.00	54	3.7	11.1	1.9	0.0	0.10
04.10 - 04.15	55	5.5	3.6	0.0	0.0	0.09
04.15 - 04.30	81	9.9	6.2	0.0	0.0	0.12
04.30 - 04.45	114	6.1	3.5	0.9	0.0	0.14
04.45 - 05.00	129	4.7	2.3	0.0	0.8	0.15
05.00 - 05.15	160	6.9	5.0	0.0	0.0	0.16
05.15 - 05.30	202	3.5	1.0	0.0	1.0	0.20
05.30 - 05.45	260	5.0	5.0	0.0	1.2	0.24
05.45 - 06.00	316	7.3	7.6	0.3	0.9	0.28
06.00 - 06.15	516	7.9	7.0	0.4	0.6	0.42
06.15 - 06.30	609	7.4	7.1	1.1	1.0	0.47
06.30 - 06.45	789	10.0	6.0	0.8	0.4	0.54
06.45 - 07.00	888	10.5	10.0	1.2	0.6	0.59
07.00 - 07.15	909	10.6	10.1	0.6	0.6	0.60
07.15 - 07.30	927	6.8	5.9	0.5	0.2	0.61
07.30 - 07.45	935	14.9	13.6	0.2	1.0	0.62
07.45 - 08.00	943	11.6	15.1	0.5	0.6	0.63

Table 2 V/C and % of each type of lane changing and overtaking movement of HV

15' Period	Total Heavy Vehicle Flow	Percentage of Heavy Vehicle				V/C
		Changing Lane to the Left	Changing Lane to the Right	Overtaking from the Left	Overtking from the Right	
08.00 - 08.15	139	5.0	5.0	0.0	0.0	0.74
08.15 - 08.30	104	7.7	4.8	0.0	1.0	0.74
08.30 - 08.45	104	7.7	11.5	0.0	0.0	0.68
08.45 - 09.00	164	8.5	5.5	0.0	1.2	0.87
09.00 - 09.15	107	15.9	20.6	0.0	1.9	0.65
09.15 - 09.30	87	27.6	21.8	0.0	1.1	0.62
09.30 - 09.45	95	29.5	23.2	0.0	1.1	0.60
09.45 - 10.00	64	43.8	56.3	0.0	4.7	0.58
10.00 - 10.15	62	37.1	32.3	1.6	3.2	0.55
10.15 - 10.30	66	28.8	19.7	0.0	1.5	0.62
10.30 - 10.45	57	45.6	49.1	0.0	1.8	0.65
10.45 - 11.00	46	76.1	60.9	0.0	0.0	0.62
11.00 - 11.15	61	68.9	49.2	1.6	1.6	0.63
11.15 - 11.30	46	58.7	52.2	4.3	0.0	0.63
11.30 - 11.45	72	37.5	50.0	2.8	1.4	0.60
11.45 - 12.00	84	46.4	42.9	1.2	1.2	0.78
12.00 - 12.15	105	17.1	28.6	0.0	1.0	0.82
12.15 - 12.30	116	19.0	31.9	3.4	1.7	0.85
12.30 - 12.45	113	17.7	31.0	2.7	0.9	0.71
12.45 - 13.00	84	25.0	34.5	1.2	1.2	0.66
13.00 - 13.15	85	28.2	32.9	1.2	3.5	0.53
13.15 - 13.30	90	24.4	31.1	0.0	0.0	0.56
13.30 - 13.45	60	21.7	51.7	0.0	10.0	0.50
13.45 - 14.00	64	39.1	50.0	0.0	6.3	0.49
14.00 - 14.15	92	18.5	19.6	0.0	3.3	0.54
14.15 - 14.30	43	86.0	55.8	4.7	4.7	0.65
14.30 - 14.45	89	28.1	34.8	2.2	5.6	0.71
14.45 - 15.00	95	22.1	20.0	0.0	3.2	0.72
15.00 - 15.15	127	20.5	16.5	0.0	0.8	0.74
15.15 - 15.30	121	19.8	23.1	0.0	0.8	0.67
15.30 - 15.45	108	17.6	14.8	1.9	0.0	0.67
15.45 - 16.00	52	55.8	51.9	1.9	1.9	0.57
16.00 - 16.15	46	54.3	32.6	0.0	6.5	0.49
16.15 - 16.30	97	16.5	21.6	0.0	2.1	0.48
16.30 - 16.45	59	37.3	28.8	0.0	0.0	0.36
16.45 - 17.00	100	24.0	25.0	0.0	3.0	0.38
17.00 - 17.15	120	16.7	20.0	0.8	2.5	0.45
17.15 - 17.30	128	11.7	10.2	0.0	0.0	0.42
17.30 - 17.45	130	12.3	9.2	0.0	0.8	0.40
17.45 - 18.00	149	7.4	6.0	0.0	1.3	0.48
18.00 - 18.15	101	8.9	10.9	0.0	1.0	0.41
18.15 - 18.30	77	13.0	14.3	0.0	2.6	0.35
18.30 - 18.45	67	16.4	23.9	0.0	0.0	0.22
18.45 - 19.00	71	7.0	14.1	0.0	1.4	0.22
19.00 - 19.15	132	9.1	9.1	0.8	0.0	0.44
19.15 - 19.30	130	8.5	10.8	0.0	1.5	0.36
19.30 - 19.45	95	10.5	17.9	0.0	0.0	0.31
19.45 - 20.00	59	16.9	18.6	0.0	3.4	0.26

Table 2 (Cont') V/C and % of each type of lane changing and overtaking movement of HV

15' Period	Total Heavy Vehicle Flow	Percentage of Heavy Vehicle				V/C
		Changing Lane to the Left	Changing Lane to the Right	Overtaking from the Left	Overtking from the Right	
20.00 - 20.15	135	13.3	7.4	0.7	0.0	0.32
20.15 - 20.30	126	19.0	15.9	0.8	5.6	0.29
20.30 - 20.45	148	10.1	4.1	0.0	2.0	0.30
20.45 - 21.00	121	9.9	5.8	0.0	0.0	0.25
21.00 - 21.15	115	6.1	9.6	0.0	0.0	0.21
21.15 - 21.30	108	12.0	6.5	0.0	0.0	0.20
21.30 - 21.45	113	4.4	9.7	0.0	2.7	0.19
21.45 - 22.00	119	10.9	10.1	0.0	1.7	0.21
22.00 - 22.15	137	4.4	7.3	0.7	0.0	0.22
22.15 - 22.30	78	19.2	10.3	1.3	15.4	0.17
22.30 - 22.45	118	18.6	12.7	0.8	11.9	0.22
22.45 - 23.00	166	14.5	4.8	0.6	1.2	0.26
23.00 - 23.15	126	5.6	4.8	0.0	0.0	0.25
23.15 - 23.30	113	3.5	8.0	0.0	0.0	0.21
23.30 - 23.45	115	7.0	5.2	0.0	0.0	0.20
23.45 - 24.00	118	3.4	12.7	0.0	0.8	0.19
00.00 - 00.15	113	11.5	8.0	0.0	2.7	0.19
00.15 - 00.30	102	6.9	3.9	0.0	1.0	0.16
00.30 - 00.45	95	6.3	12.6	1.1	0.0	0.14
00.45 - 01.00	85	4.7	11.8	0.0	0.0	0.13
01.00 - 01.15	89	12.4	3.4	1.1	1.1	0.13
01.15 - 01.30	67	9.0	7.5	0.0	0.0	0.09
01.30 - 01.45	69	8.7	11.6	0.0	0.0	0.09
01.45 - 02.00	72	8.3	2.8	0.0	4.2	0.10
02.00 - 02.15	50	18.0	6.0	0.0	0.0	0.08
02.15 - 02.30	79	13.9	3.8	0.0	3.8	0.10
02.30 - 02.45	65	15.4	7.7	0.0	1.5	0.08
02.45 - 03.00	85	5.9	11.8	0.0	0.0	0.10
03.00 - 03.15	82	9.8	4.9	1.2	0.0	0.09
03.15 - 03.30	72	6.9	8.3	0.0	11.1	0.08
03.30 - 03.45	65	4.6	7.7	0.0	3.1	0.07
03.45 - 04.00	88	8.0	4.5	0.0	1.1	0.10
04.10 - 04.15	78	1.3	1.3	0.0	1.3	0.09
04.15 - 04.30	93	7.5	4.3	0.0	3.2	0.12
04.30 - 04.45	95	12.6	3.2	0.0	1.1	0.14
04.45 - 05.00	94	6.4	3.2	0.0	0.0	0.15
05.00 - 05.15	87	8.0	3.4	0.0	0.0	0.16
05.15 - 05.30	110	7.3	7.3	0.0	2.7	0.20
05.30 - 05.45	116	9.5	11.2	0.0	0.9	0.24
05.45 - 06.00	129	14.7	14.0	0.0	3.1	0.28
06.00 - 06.15	154	9.1	7.1	0.0	4.5	0.42
06.15 - 06.30	150	7.3	7.3	0.0	4.0	0.47
06.30 - 06.45	123	8.1	13.0	0.0	2.4	0.54
06.45 - 07.00	103	10.7	12.6	0.0	0.0	0.59
07.00 - 07.15	111	7.2	4.5	0.0	2.7	0.60
07.15 - 07.30	109	1.8	1.8	0.0	0.0	0.61
07.30 - 07.45	116	2.6	4.3	0.0	0.0	0.62
07.45 - 08.00	123	4.1	7.3	0.0	0.0	0.63

Table 3 Summary of correlation coefficients

Vehicle Type	Correlation Coefficients Between V/C Type of Movement			
	Type 1: Lane Changing to the Left	Type 2: Lane Changing to the Right	Type 3: Overtaking from the Left	Type 4: Overtaking from the Right
Light Vehicle	0.140 (0.173)	0.010 (0.921)	-0.030 (0.771)	-0.285 (0.005)
Heavy Vehicle	0.444 (<0.001)	0.538 (<0.001)	0.338 (0.001)	-0.055 (0.600)

*The numbers between the brackets show significant levels

7. CONCLUSIONS

From the results, several conclusions can be made, i.e.:

- Percentages of overtaking movements were less than percentages of lane changing movements for both light vehicles and heavy vehicles.
- Although number of light vehicles carried out 4 types of movement was higher than number of heavy vehicle carried out 4 types of movement, in percentage the results were the other way around.
- Except for overtaking from the right, the higher the V/C the higher the percentage of each type of movement of heavy vehicle.
- The higher the V/C the lower the percentage of overtaking vehicle from the right. This im

REFERENCES

_____. (1997). **Indonesian Highway Capacity Manual**. Jakarta: Directorate General of Highway, Ministry of Public Works, Republic of Indonesia.

_____. (2000). **Highway Capacity Manual**. Washington D.C.: Transport Research Board

Aycin, M.F., Benekohal, R.F. (1998). Linear Acceleration Car-Following Model Development and Validation. **Transportation Research Record 1644**. Washington D.C.: Transportation Research Board.

Chakroborty, P., Agrawal, S., Vasishth, K. (2004). Microscopic Modelling of Driver Behavior in Uninterrupted Traffic Flow. **Journal of Transportation Engineering, July/August 2004**, 438-451.

Chakroborty, P., Kikuchi, S. (1999). Evaluation of the General Motors Based on Car Following Models and a Proposed Fuzzy Inference Model. **Transportation Research Part C: Emerging Technology, Volume 7**, 209-235.

Fritzche, H.T. (1994). A Model for Traffic Simualtion. **Traffic Engineering Control, May 1994**, 317-321.

Kallberg H. (1980). **Overtaking Platoons on Two-Lane Rural Road**. Technical Research Centre of Finlad.

Kikuchi, S., Chakroborty, P. (1992). Car-following Model Based on Fuzzy Inference System. **Transportation Research Record 1365**. Washington D.C.: Transportation Research Board.

Mahdi, T.A. (1994). **Overtaking Behaviour on Single Carriageway Roads**. Cardiff: Div. Of Civil Engineering, University of Wales, College of Cardiff (tidak diterbitkan).

Putranto, L.S., Intan, Intan, D.S. (2008). Distribusi Arus Lalu-Lintas pada Lajur-Lajur Jalan Bebas Hambatan Dalam Kota 6 Lajur 2 Arah. **Jurnal Transportasi Volume 8 Edisi Khusus No.3, Oktober 2008**, 259-272.

Sucahyo, S.H. (1994). **Overtaking Manouvre on Two-Lane Two-Way Rural Roads**. Master Thesis. Sistem dan Teknik Jalan Raya ITB, Bandung.

Troutbeck, R.J. (1978). **The Effect of Long Vehicles in The Traffic Stream**. ARRB Internal Report. Victoria.

Troutbeck, R.J. (1981). **Overtaking Behaviour on Narrow Two-Lane Rural Highways**. Victoria: ARRB.

Troutbeck, R.J. (1982). **Overtaking Behaviour on Australian Two-Lane Two-Way Rural Roads**. ARRB Special Report, Victoria.