TRAFFIC DISTRIBUTION ON MULTILANE HIGHWAYS IN JAKARTA AND ITS EFFECT ON VEHICLE DISTRIBUTION COEFFICENT ON THE INDONESIAN FLEXIBLE PAVEMENT DESIGN MANUAL

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ABSTRACT
Vehicle traffic on multilane highway is distributed across its lanes. Due to the Indonesian traffic regulation, heavy or low speed vehicles tend to use the kerb lane, whilst high speed vehicles tend to use the median lane. A study on this could be used to revise the vehicle distribution coefficient in Indonesian flexible pavement design manual. In this paper only a highway link faraway from major conflict points will be discussed in order to focus on the impact of vehicle composition on traffic distributions. Vehicle composition is a function of time period, highway type, highway location, environmental condition, etc. In this paper the effect of time period on traffic distribution across the lanes of a multilane highway will be discussed. The data was collected on a working day, in a 24 hours video observation of a 6 lanes 2 ways divided road in Jakarta.

KEYWORDS
vehicle, distribution, multilane, highway, Jakarta

INTRODUCTION

Vehicle traffic on multilane highway is distributed across its lanes. In a highway link faraway from any conflict points, the distribution across the lanes is usually caused by vehicle composition. In Indonesia, heavy vehicles or low speed vehicles tend to use the kerb lane, whilst high speed vehicles tend to use the median lane. The middle lane is usually used by the rest of the vehicle. This is quite logical, considering the traffic regulation in Indonesia. A study on this area could be used to revise the vehicle distribution coefficient (*C*) in Indonesian flexible pavement design manual. This coefficient is required in order to obtain the cumulative axle loads in the design lane. In this paper only a highway link faraway from major conflict points will be discussed. Therefore a focus on the impact of vehicle composition on traffic distribution across the lanes of a multilane highway can be maintained. Vehicle composition itself is a function of time period, highway type, highway location, environmental condition, etc. In this paper only the effect of time period (and consequently volume to capacity ratio) on traffic distribution across the lanes of a multilane highway will be discussed. More complete paper written not in English was published in a proceeding of a conference in Indonesia (1) but with some errors in the presentation a major table and the interpretation of the table. In this present paper the error is corrected, notes on further studies are added and only major results are presented due to limited number of pages allowed .

LITERATURE REVIEW

According to the Indonesian flexible pavement design manual (2), vehicle distribution coefficient (*C*) is determined by vehicle type and number of lanes (**Table 1)** Number of lanes is determined by the effective width of the highway (**Table 2)**

Table 1 Vehicle Distribution Coefficients (*C*)

Number of Lanes	Light Vehicle		Heavy Vehicle	
	1 Way	2 Ways	1 Way	2 Ways
1	1.000	-	1.000	-
2	0.600	0.500	0.700	0.500
3	0.400	0.400	0.500	0.475
4	-	0.300	-	0.450
5	-	0.250	-	0.425
6	-	0.200	-	0.400

Table 2 Number of Lanes based on Effective Width of the Highway

Effective Width of the Highway (*L*) in Meter	Number of Lanes
$L < 5.50$	1
$5.50 \le L < 8.25$	2
$8.25 \le L < 11.25$	3
$11.25 \le L < 15.00$	4
$15.00 \le L < 18.75$	5
$18.75 \le L < 22.00$	6

Light vehicles are motorized vehicles weigh less than 5 tons including passenger car, pick-up, etc. Heavy vehicles are motorized vehicles weigh at least 5 tons including bus, truck, tractor, semi-trailer and trailer. The *C* coefficients in **Table 1** show the percentage of vehicle using the design lane.

According to the manual the design lane is the lane carrying the heaviest traffic load. However, the manual does not specify which lane should be considered as the design lane. In general, for practical reason Indonesia engineers were used to assume the kerb lane as the design lane. Since the value of *C* will affect average equivalent axle load, the thickness and the quality of the pavement material to be used will be sensitive to the accuracy of the value Moreover, in road construction practice, the pavement thickness for the other lanes will refer to the thickness of the design lane. Considering that typical pavement thickness and material quality will be applied for several kilometers, accuracy of every single design component will be important to optimize the use of resources.

METHODOLOGY

Traffic count survey was conducted for 24 hours from Tuesday, 24 April 2007 (10:30 a.m.) to Wednesday, 25 April 2007 (10:30 a.m.) at a 6 lanes-2 ways arterial road (S. Parman Road in West Jakarta). The observation was recorded by 2 VHS video cameras 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 lane and for each direction. Furthermore the vehicles were classified into four categories, i.e. light vehicle (LV), heavy vehicle (HV), motorcycle (MC) and non-motorized vehicle (NMV). Counting for NMV was conducted only for side friction class indication. Side friction is one of adjustment factor used in Indonesian Highway Capacity Manual (3). Capacity calculation was conducted only for volume to capacity ratio analysis. Correlation between the volume to capacity ratio and the percentage of each type of vehicle at each lane will be analyzed. However, the main part of the result will be based on simple comparison analysis between the value of *C* in the manual and the value of *C* calculated from the field data observation.

THE DATA

In general from one period of 15 minutes traffic observation to another period of 15 minutes traffic observation, the percentage of HV and the percentage of MC were relatively more fluctuative than the percentage of LV in both directions. This indicates that LV tend to follow lane discipline consistently without any influence of traffic condition changes.

In 40% of the 15 minutes observation periods, the volume to capacity of the road were more than 0.8. This indicates that the traffic performance of the road was relatively not satisfactory. A stop and go traffic operation was potentially happened from the morning period to the afternoon period.

ANALYSIS

Table 3 shows the number and the percentage of each type of vehicles for each lane during 24 hours for Grogol to Slipi direction. **Table 4** shows the same for the opposite direction.

Table 3 The Number and the Percentage of Each Vehicle Type and Each Lane (Grogol-Slipi)

Vehicle Type	Number of Vehicles				Percentage of Vehicles			
	Left	Middle	Right	Total	Left	Middle	Right	Total
HV	1,836	1,624	2,446	5,906	31.1	27.5	41.4	100.0
LV	5,718	19,642	24,148	49,508	11.5	39.7	48.8	100.0
MC	22,002	22,956	7,675	52,633	41.8	43.6	14.6	100.0
Total of Motorized Vehicles	**29,556**	**44,222**	**34,269**	**108,047**	**27.4**	**40.9**	**31.7**	**100.0**
NMV	277	0	0	277	100.0	0.0	0.0	100.0

Table 4 The Number and the Percentage of Each Vehicle Type and Each Lane (Slipi-Grogol)

Vehicle Type	Number of Vehicles				Percentage of Vehicles			
	Left	Middle	Right	Total	Left	Middle	Right	Total
HV	1,232	1,924	2,086	5,242	23.5	36.7	39.8	100.0
LV	5,248	17,642	24,088	46,978	11.2	37.6	51.3	100.0
MC	29,287	19,743	6,119	55,149	53.1	35.8	11.1	100.0
Total of Motorized Vehicles	**35,767**	**39,309**	**32,293**	**107,369**	**33.3**	**35.5**	**30.1**	**100.0**
NMV	329	0	0	329	100.0	0.0	0.0	100.0

It can be seen that the numbers of motorized vehicles in both directions were about the same both in total and for each type of vehicle. However the traffic distribution in each lane was clearly more uniform in Slipi-Grogol direction. In the Grogol-Slipi direction the total percentage of vehicles in the left lane was relatively low. This could be the effect of the use of the left lane for parking during certain periods of working hours.

Other interesting finding was that most of LV and HV were not in the left lane, but were in the right lane. Considering this finding, the right lane might be more appropriate to be the design lane. Therefore, based on the result, the percentage of HV in the design lane was about 40%, whilst the percentage of LV in the design lane was about 50%. **Table 5** shows the comparison between the analysis result and the value of *C* in the manual.

Table 5 Comparison between the Analysis Result and the Value of C in the Manual

Number of Lanes	*C* in the Manual				*C* from Analysis Result			
	LV		HV		LV		HV	
	1 Way	2 Ways	1 Way	2 Ways	1 Way	2 Ways	1 Way	2 Ways
3	0.400	0.400	0.500	0.475	0.500	-	0.400	-
6	-	0.200	-	0.400	-	0.250	-	0.200

Although in the manual there is *C* for 3 lanes-2ways road, but in practice such road configuration is hardly exist. Moreover the conducted observation was not in this type of road. Therefore no comparison was made in the *C* for this road type. In the observed road, 6 lanes-2 ways road is assumed to be same with 3 lanes-1 way road (because each direction of the arterial road was seperated each other with another 6 lanes-2 ways toll road in the middle). Therefore the *C* from the analysis result for 6 lanes-2 way road was simply the half of the analysis result for 3 lanes-1 way road. *C* for the LV for 3 lanes-1 way road and 6 lanes-2 ways toad from the analysis result (0.500 and 0.250) was higher than the *C* from the manual (0.400 and 0.200). *C* for the HV for 3 lanes-1 way road and 6 lanes-2 ways road from the analysis result (0.400 and 0.200) was lower than the *C* from the manual (0.500 and 0.400). It should be noted that the *C* from the manual for the HV in 6 lanes-2 ways road is questionable (far beyond the half of the value for 3 lanes-1 way road).

There were 3 groups of correlation analysis between volume to capacity ratio and percentage of each vehicle type in each lane, i.e. for total of both directions (**Table 6**), Grogol-Slipi direction (**Table 7**) and Slipi-Grogol direction (**Table 8**). In general, almost all of correlation coefficients were significant at α=0.05. This indicates that in general there was a relationship between volume to capacity ration with the percentage of each vehicle type in each lane.

From **Table 6** for total of both directions, it can be seen that in the left lane, the higher the volume to capacity ratio the higher the percentage of the HV. The opposite was true for the middle and right lanes. This indicates that at low volume to capacity ratio, the HV were distributed randomly across the lanes and at high volume to capacity ratio the HV were tended to shift to the left lane. In the middle lane, the higher the volume to capacity ratio, the lower the percentage of the LV. The opposite was true for the right lane. This indicates that at low volume to capacity ratio the LV were tended to choose "neutral" lane, i.e. middle lane and along with the increase of the volume to capacity ratio, the LV were tended to distribute to the other lanes, especially the middle lane. In the left and right lanes, the higher the volume to capacity ratio, the lower the percentage of the MC. The opposite was true for the middle lane. This indicates that at low vehicle to capacity ratio, the MC were tended to choose "neutral" lane, i.e. the middle lane and along with the increase of the volume to capacity ratio will, the MC were tended to distribute to the other lanes, especially the right lane.

Table 6 Correlation between Volume to Capacity Ratio to the Percentage of Each Vehicle Type in Each Lane (Total of Both Directions)

Vehicle Type	Lane Position	Correlation Coefficient	α	Significant at α=0.05?
HV	left	0.729	<0.001	yes
	middle	-0.317	<0.001	yes
	right	-0.607	<0.001	yes
LV	left	-0.069	0.172	no
	middle	-0.663	<0.001	yes
	right	0.550	<0.001	yes
MC	left	0.138	0.028	yes
	middle	-0.470	<0.001	yes
	right	0.675	<0.001	yes

Table 7 Correlation between Volume to Capacity Ratio to the Percentage of Each Vehicle Type in Each Lane (Grogol-Slipi)

Vehicle Type	Lane Position	Correlation Coefficient	α	Significant at α=0.05?
HV	left	0.772	<0.001	yes
	middle	-0.584	<0.001	yes
	right	-0.390	<0.001	yes
LV	left	-0.489	<0.001	yes
	middle	-0.767	<0.001	yes
	right	0.770	<0.001	yes
MC	left	-0.226	0.014	yes
	middle	-0.300	<0.001	yes
	right	0.797	<0.001	yes

From **Table 7** for total of Grogol-Slipi direction, it can be seen that in the left lane, the higher the volume to capacity ratio the higher the percentage of the HV. The opposite was true for the middle and right lanes. This indicates that at low volume to capacity ratio, the HV were distributed randomly across the lanes and at high volume to capacity ratio the HV were tended to shift to the left lane. In the middle lane, the higher the volume to capacity ratio, the lower the percentage of the LV. The opposite was true for the right lane. This indicates that at low volume to capacity ratio the LV were tended to choose "neutral" lane, i.e. middle lane and along with the increase of the volume to capacity ratio, the LV were tended to distribute to the other lanes, especially the middle lane. In the left and middle lanes, the higher the volume to capacity ratio, the lower the percentage of the MC. The opposite was true for the right lane. This indicates that at low vehicle to capacity ratio, the MC were distributed randomly across the lanes and along with the increase of the volume to capacity ratio will, the MC were tended to shift to the right lane.

From **Table 8** for total of Slipi-Grogol direction, it can be seen that in the left lane, the higher the volume to capacity ratio the higher the percentage of the HV. The opposite was true for the right lane. This indicates that at low volume to capacity ratio, the HV were distributed randomly across the lanes and at high volume to capacity ratio the HV were tended to shift to the left lane. In the left and right lanes, the higher the volume to capacity ratio, the higher the percentage of the LV and the MC. The opposite was true for the middle lane. This indicates that at low volume to capacity ratio the LV and the MC were tended to choose "neutral" lane, i.e. middle lane and along with the increase of the volume to capacity ratio, the LV and the MC were tended to distribute to the other lanes.

Table 8 Correlation between Volume to Capacity Ratio to the Percentage of Each Vehicle Type in Each Lane (Slipi-Grogol)

Vehicle Type	Lane Position	Correlation Coefficient	α	Significant at α=0.05?
HV	left	0.739	<0.001	yes
	middle	-0.069	0.252	no
	right	-0.801	<0.001	yes
LV	left	0.219	<0.001	yes
	middle	-0.577	<0.001	yes
	right	0.338	<0.001	yes
MC	left	0.429	<0.001	yes
	middle	-0.610	<0.001	yes
	right	0.549	<0.001	yes

CONLUSIONS AND FURTHER STUDIES

(1) The Indonesian flexible pavement design manual are recommended to be revised. The required revision is not only in terms of the *C* values but also in the definition of the design lane.
(2) In general, the volume to capacity ratio is correlated significantly with the percentage of each type of vehicle in each lane. At low volume to capacity ratio, in general vehicles choose the lane freely according to their speeds and travel directions, although they tend to avoid to flow in the left lane with potential disturbance of stopping vehicles, parking vehicles or in/out vehicles (from road side activities). On the contrary at high volume to capacity ratio the percentage of the motorized vehicles in the left lane was increased since in other lanes the available space for traffic was decreased.
(3) At the time of the preparation of this paper, similar study is conducted in the 6 lanes-2 ways toll road. The main difference of the expected results are due to the different vehicle classification (only LV and HV are allowed to use the toll road), the existence of a wide paved shoulders, etc.

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