DRIVER BEHAVIOUR IN A SIGNALIZED INTERSECTION IN BEKASI, WEST JAVA, INDONESIA

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ABSTRACT

The objective of this study is to understand the driver behaviour in a signalized intersection in Bekasi, a city in Indonesia. This paper provides characteristics of traffic rule violation in a very busy signalized intersection. Additionally an analysis of traffic conflict in the same intersection is provided. The traffic conflict is the combined effect of both traffic rule violation and opposed signal phasing. The data collection was conducted for about 2 hours in each observation period, i.e. morning peak, mid day off peak and afternoon peak in a normal working day. The selected intersection is located at the heart of Central Business District in Bekasi. Types of observed vehicles were light vehicle, heavy vehicle and motorcycle. The observed traffic rule violation includes vehicle waiting for green beyond stop line, conducting left or right turn without turning on the turn signal, conducting left or right turn in incorrect lane and red light running. The observation was carried out by counting the occurence of each type of violation for each type of motorized vehicle per approach per signal cycle. For traffic conflict analysis, every conflict that potentially causing an accident was recorded. The observation include distance to potential accident, speed, type of conflict, type of movement and type of driver reaction. The % of occurance of different type of violation was affected by type of vehicle. Right turn conflicts (between straight through and right turn vehicle) were dominant. All pairs of driver/ rider reactions involved slowing down. The findings suggest that safety awareness campaign is required to improve driver behaviour in signalized intersection especially regarding conducting right turn/ left turn movement without turning on the sign. In such a busy intersection, opposed signal phasing should not be used as this will potentially lead to dangerous conflicts between straight through and righ turn vehicles.

Keywords: driver behaviour, signalized intersection, Indonesia

INTRODUCTION

The objective of this study is to understand the driver behaviour in a signalized intersection in Bekasi, a city in Indonesia. Bekasi is located in greater Jakarta (the capital city of Indonesia) and therefore still represent metropolitan characteristic. Commuter Traffic from Bekasi to Jakarta is verry congested and the highest compare to the other sub urban areas of Jakarta, i.e. Tangerang in the West and Depok/ Bogor in the South (Figure 1). This affects driver behaviour. Desperate drivers trapped in severe congestion tend to disobey traffic rule.

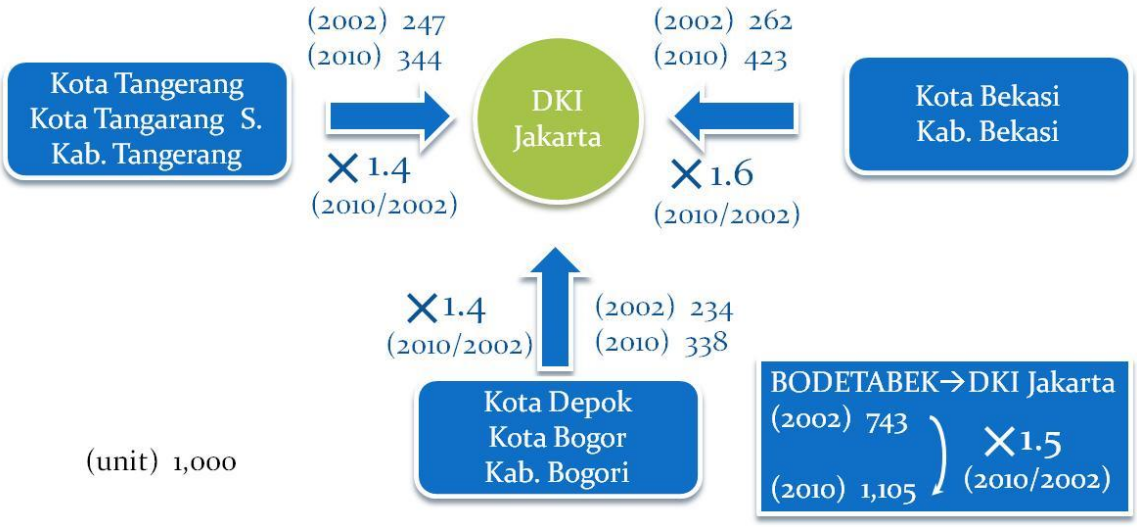

Figure 1 – High Commuter Traffic from/to Bekasi (Source: JUTPI)

This paper provides characteristics of traffic rule violation in a very busy signalized intersection. Additionally an analysis of traffic conflict in the same intersection is provided. The traffic conflict is the combined effect of both traffic rule violation and opposed signal phasing. The data collection was originally carried out for the purpose of a doctoral dissertation research. The selected intersection is located at the heart of Central Business District in Bekasi and directly connecting a toll road access with several major arterials.

LITERATURE REVIEW

Malkhamah (2005) stated that in developing country city such as Yogyakarta, Indonesia, the driver behaviour affects capacity of roundabout weaving section capacity. The effect of high proportion of motorcycles in the general traffic on intersection capacity was underlined by Munawar (2006) based on the observation in Banjarmasin and Yogyakarta, Indonesia. Hadiuzzaman (2008) stated that lack of lane discipline in the intersection Dakha, Bangladesh caused reduction in intersection capacity. Considering lack of lane discipline of especially motorcycle riders in Indonesia, Idris (2009) from Indonesian Road and Bridge Research Center, Ministry of Public Work conducted research in an Exclusive Stopping Space (in Indonesian

term called *Ruang Henti Khusus*, abbreviated as RHK). This design can be seen in Figure 2. The main improvements due to this kind of intersection design were reduction of traffic conflict and increase of discharge rate. Putranto and Sucipto (2007) found that there were two types of red light violation, i.e. (1) at the beginning of red and (2) at the end of red. The type 1 was dominant during the early morning observation, whilst type 2 was dominant during the other three observations. The analysis shows that the higher the degree of saturations (Q/C) the higher the rate of type 1 violation and the lower the Q/C the higher the rate of the type 2 violation.

Figure 2 – Exclusive Stopping Space in Bandung, Indonesia (Source: Idris, 2009)

Hyden (1987) developed Swedish Traffic Conflic Techniques (STCT). He defined traffic confict as an event involving two or more road users in which one of the road users actions was evasive action to avoid collision. Evasive action oftenly taken is slowing down. However, it also can be in the form of speeding up, sudden change in steering direction or combination of these two actions. The time when evasive action was started is called time to action. Time to accident is time left after evasive action started until the time of potential collision (if no action such as slow down/ speed up or change vehicle direction). Figure 3 shows schematic proportion of undisturbed passages, potential conflicts, conflicts and accidents.

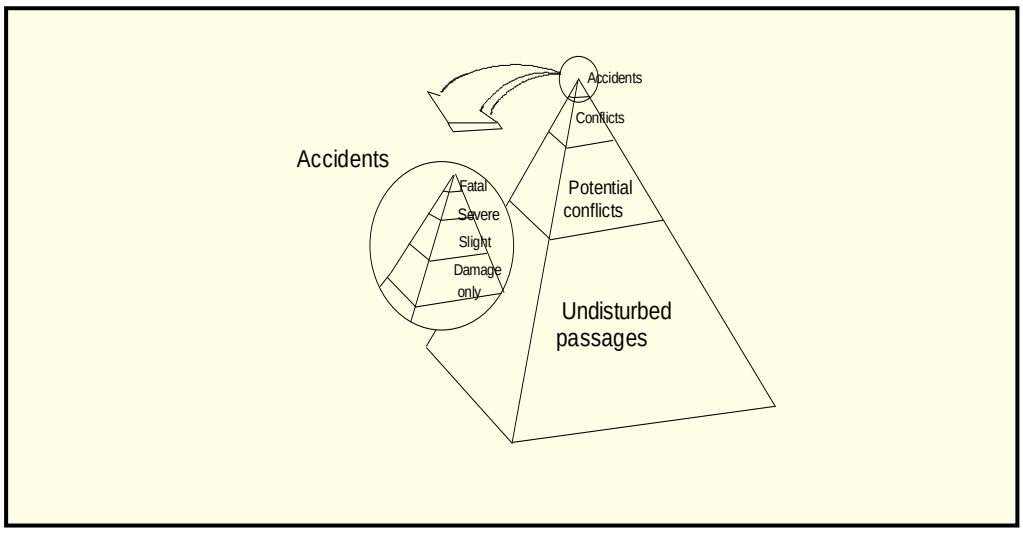

Figure 3 – Degree of Conflicts

A conflict can be categorized as seroius conflict or non-serious conflict (slight conflict) based on the entering speed and time to accident. This can be senn in Figure 4.

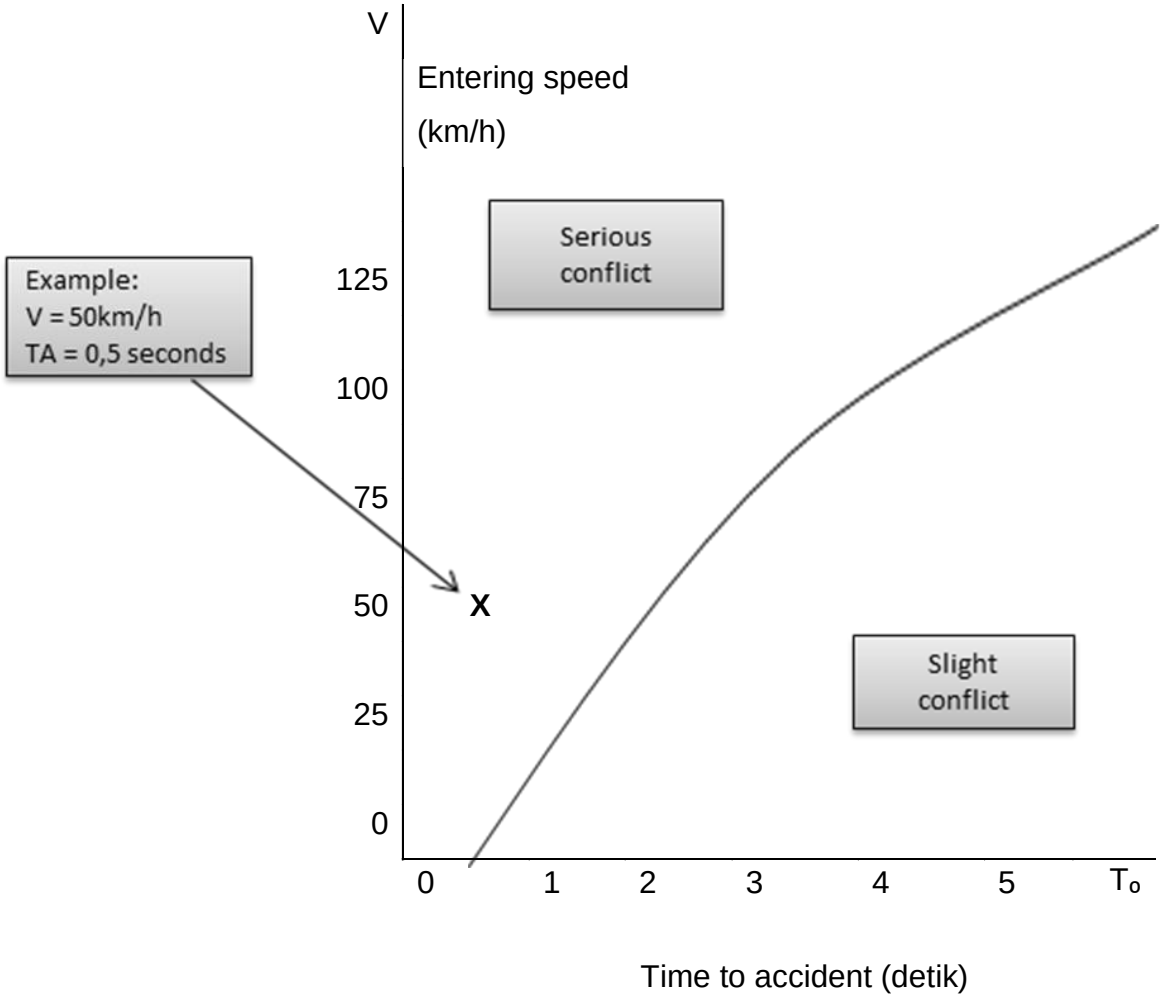

Figure 4 – Serious Conflict vs Slight Conflict

METHODOLOGY

The data collection was conducted for an hour per observation period, during 3 observation periods, i.e. a morning peak, mid day off- peak and afternoon peak on a working day. The data was aggregated per signal cycle. Traffic violation survey was conducted for 45 cycles and traffic conflict survey was conducted for 25 cycles.

The selected intersection is located at the heart of Central Business District in Bekasi and directly connecting a toll road access with several major arterials (Figure 5). The intersection consists of 4 legs, i.e.:

1. Jalan Kiyai Haji Noer Ali (West)
2. Jalan Ahmad Yani (North)

3. Jalan Madmuin Hasibuan (East)
4. Jalan Ahmad Yani (South)

Figure 5 – Location Map of the Obseved Intersection

As in Indonesian roads mixed traffic can be found in any level of road hierarchy, in the observed intersection, all type of vehicles, i.e. light vehicle, heavy vehicle, motorcycle and unmotorized vehicle were passing (however the unmotorized vehicle was not included in the observation). The observed traffic rule violation includes:

1. vehicle waiting for green beyond stop line;
2. vehicle conducting left or right turn without turning on the turn signal;
3. vehicle conducting left or right turn from incorrect lane and;
4. vehicle engaging in red light running.

The observation was carried out by counting the occurence of each type of violation for each type of motorized vehicle per approach per signal cycle.

For traffic conflict analysis, every conflict that potentially causing an accident was also recorded per cycle. The observation includes (the first two points of observation will not be extensively analyzed in this paper):

1. distance to potential accident;
2. speed;
3. type of conflict;
4. type of movement and;
5. type of driver reaction.

The collected data were then analyzed descriptively to understand following characteristics:

1. the percentage of motorized vehicles violating traffic rules
2. the percentage of motorized vehicles involves in conflict
3. the percentage of each type of motorized vehicle in each traffic rule violation type
4. the percentage of each traffic rule violation type in each type of motorized vehicle
5. the percentage of each driver reaction type in each type of motorized vehicle

6. the percentage of each conflict type in each type of motorized vehicle
7. the percentage of pair of driver/ rider reactions in each conflict type
8. the percentage of conflict type in pair of driver/ rider reaction

RESULTS

During the observation periods in each legs of the intersection the vehicle composition was mainly consist of motorcyles (47% to 81%), followed by light vehicles (18% to 47%) and heavy vehicles (0 to 7%). Very high exposure of motorcycle in the general taffic explains high percentage of any traffic rule violation type, traffic conflict type and driver reaction type involving motorcycles. 44.1% of 94,465 vehicles involved in a type of traffic rule violation (74.2% motorcycles, 22.5% light vehicles and 3.3% heavy vehicles). 23.5% of 37,242 vehicles involved in a type of conflict (66 % motorcycles, 31% light vehicles and 3% heavy vehicles). The total number of vehicles for traffic conflict observation was less then total number of vehicles for traffic rule violation observation because only in 2 of the 4 approaches traffic conflict existed and difference in number of cycles observed as deseribed in the methodology. There was no significant different in traffic violation and traffic conflict pattern between morning, mid-day and afternoon observation periods. Therefore, for analysis the data was aggregated for the whole day. Table 1 shows that percentage of motorcycle engaged in each type of violation was higher than proportion of motorcycles in the traffic. Therefore, motorcycles tend to wait beyond stop line, turn right or left without turning on signal and engaged in red light running more than other type of vehicles. In terms of vehicle turning from incorrect lane the percentages of each type of vehicles in this type of violation were within the range of vehicle composition of the traffic. Therefore none of the vehicle type (compare to each other) was dominant in this type of violation. This is confirmed in Table 2 in which it was obvious that the highest percentage of violation was vehicle turning from incorrect lane for all types of vehicles. In Table 2, it is clear that the most dangerous violation (red light running) was the least frequent.

Table 1-Percentage of Each Type of Vehicle Engaged in Each Type of Violation

Type of Violation	Frequency (%)			
	MC	LV	HV	Total
Waiting beyond Stop Line	95.7	3.4	0.9	100
Turning without Turn on Signal	71.1	26.9	2.0	100
Turn from Incorrect Lane	63,2	31.7	5.1	100
Red Light Running	94.7	5.1	0.1	100

Table 3 shows the percentage of pair of conflicting vehicle types in each pair of driver/ rider reactions. The pattern follows pattern of vehicle composition. Conflicting vehicles involving motorcycle were dominant both in slowing down-avoding reaction and slowing down-speeding up reaction, followed by conflicting vehicles involving light vehicle and conflicting vehicles involving heavy vehicle. Table 4 shows the percentage of pair of driver/ rider

reaction in each pair of conlicting vehicle types. Slowing down-speeding up reactions were more dominant than slowing down-avoiding reactions in all pair of conflicting vehicle types.

Table 2- Percentage of Each Type of Violation in Each Type of Vehicle

Type of Violation	Frequency (%)		
	MC	LV	HV
Waiting beyond Stop Line	33.6	4.0	6.5
Turning without Turn on Signal	11.3	14.0	7.0
Turn from Incorrect Lane	49.2	81.0	86.4
Red Light Running	5.9	1.1	0.1
Total	100.0	100.0	100.0

Table 3-Percentage of Pair of Conflicting Vehicle Types in Each Pair of Driver/ Rider Reactions

Pair of Vehicle Types	%Slowing Down-Avoding	%Slowing Down-Speeding Up
Light Vehicle-Light Vehicle	11.8	10.7
Light Vehicle-Heavy Vehicle	1.8	1.5
Light Vehicle-Motorcycle	37.7	37.2
Heavy Vehicle-Heavy Vehicle	0.0	0.0
Heavy Vehicle-Motorcycle	4.5	4.4
Motorcycle-Motorcycle	44.1	46.3
Total	100.0	100.0

Table 4-Percentage of Pair of Driver/ Rider Reactions in Each Pair of Conflicting Vehicle Types

Pair of Vehicle Types	%Slowing Down-Avoding	%Slowing Down-Speeding Up	%Total
Light Vehicle-Light Vehicle	40.8	59.2	100
Light Vehicle-Heavy Vehicle	43.7	56.3	100
Light Vehicle-Motorcycle	38.6	61.4	100
Heavy Vehicle-Heavy Vehicle	0.0	0.0	100
Heavy Vehicle-Motorcycle	39.2	60.8	100
Motorcycle-Motorcycle	37.2	62.8	100

Table 5 shows the percentage of pair of conflicting vehicle types in each conflict type. The pattern follows pattern of vehicle composition. In general, conflicting vehicles involving motorcycle were dominant both in all conflict type, followed by conflicting vehicles involving light vehicle and conflicting vehicles involving heavy vehicle. Table 6 shows the percentage of conflict type in each pair of conlicting vehicle types. Right turn conflict was more dominant than rear end conflict and head on conflict in all pair of conflicting vehicle types.

Table 7 shows the percentage of pair of driver/ rider reactions in each conflict type. The pattern follows pattern of vehicle composition. Slowing down-speeding up reactions were more dominant than slowing down-avoiding reactions in all conflict type. Table 8 shows the percentage of conflict type in each pair of driver/ rider reactions. Right turn conflict was more dominant than rear end conflict and head on conflict in all pair of driver/ rider reactions.

Table 5-Percentage of Pair of Conflicting Vehicle Types in Each Conflict Type

Pair of Vehicle Types	%Right Turn	%Head On	%Rear End
Light Vehicle-Light Vehicle	10.9	11.4	12.4
Light Vehicle-Heavy Vehicle	1.6	2.1	1.3
Light Vehicle-Motorcycle	37.4	36.0	38.1
Heavy Vehicle-Heavy Vehicle	0.0	0.0	0.0
Heavy Vehicle-Motorcycle	4.3	4.8	4.9
Motorcycle-Motorcycle	45.9	42.6	43.3
Total	100.0	100.0	100.0

Table 6-Percentage of Conflict Type in Each Pair of Conflicting Vehicle Types

Pair of Vehicle Types	%Right Turn	%Head On	%Rear End	%Total
Light Vehicle-Light Vehicle	76.2	7.8	16.0	100
Light Vehicle-Heavy Vehicle	78.9	9.9	11.3	100
Light Vehicle-Motorcycle	78.1	7.3	14.6	100
Heavy Vehicle-Heavy Vehicle	0.0	0.0	0.0	0
Heavy Vehicle-Motorcycle	75.8	8.2	16.0	100
Motorcycle-Motorcycle	78.7	7.2	13.6	100

Table 7-Percentage of Pair of Driver/ Rider Reactions in Each Conflict Type

Pair of Driver/Rider Reactions	%Right Turn	%Head On	%Rear End
Slowing Down-Avoiding	39	36	36
Slowing Down-Speeding Up	61	64	64
Total	100	100	100

Table 8-Percentage of Conflict Type per Pair of Driver/ Rider Reactions

Pair of Driver/Rider Reactions	%Right Turn	%Head On	%Rear End	%Total
Slowing Down-Avoiding	79	7	14	100
Slowing Down-Speeding Up	77	8	15	100

It should be noted that as the intersection was very congested, the entering speeds were quite low. Therefore all conflicts were considered to be slight conflict.

CONCLUDING REMARKS

The findings suggest that safety awareness campaign is required to improve driver behaviour in signalized intersection especially regarding conducting right turn/ left turn movement without turning on the sign. In such a busy intersection, opposed signal phasing should not be used as this will potentially lead to dangerous conflicts between straight through and right turn vehicles.

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