Effects of Different Pavement Design and Different Phase of Green Signal Time on Aggressiveness of Left Turn Driver towards Pedestrian

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Left turn vehicles (left hand traffic system) are allowed to do their turning manoeuvres with pedestrian at signalized intersection for traffic operational efficiency. For pedestrian safety left turn vehicle drivers have to yield pedestrian first , when they interact with pedestrian on pedestrian crossing. But accident data reveals that Pedestrians has danger with left tuning vehicles at pededestrian crossings. Aggressive drivers tend to show more non-yielding behavior towards pedestrian. In this study we tried to evaluate how intersection pavement design and different part of traffic green signal phase influeneced the aggressive behavior of left turn vehicle's driver. This paper uses data from an observational study, conducted at three signalized intersection with different pavement design. The behaviors selected for observation were those that are denoted as "aggressive driving" and they consisted of forcing pedestrian to slow down, accelerating to accept small gap and sudden braking. The results showed that red color and brick in pavement reduce aggressiveness of driver. Considering signal time it is found that driver at intersection with no design has more time pressure at later part of signal than red colored and brick pavement designed intersection.

Key Words : *Aggressive driving, Left turning vehicle, Pedestrian safety, traffic signaling time, Entrance design*

1. INTRODUCTION

Traffic signal is operated to control competing flows of traffic. For traffic operation efficiency it is not always possible to separate signal phase for all type of road users. Separate traffic signal for pedestrian is operated only if conflicting road user volume is heavy on pedestrian crossing. For moderate traffic volume Pedestrians have to share the same signal phase with through vehicle in the same approach of road. Usually they are not conflicting road user as their running path is seperated. But usually at signalized intersection left turn vehicle (left hand traffic system) are allowed to do their turning manoeuvres with pedestrian . As left turn vehicle has to use the pedestrian crossing pedestrian-left turn vehicle conflict is very common phenomenon at signalized intersection. At crosswalk pedestrians are given prior-

itized right of way. It means that left turn vehicle has to yield pedestrian first when they interact with pedestrian at crosswalk. . But accident data reveals that Pedestrians has danger with left tuning vehicles at pededestrian crossings. One of the main reason of this type of accidents is the aggressiveness of left turn drivers. If a driver is aggressive he tends to show more non-yelding behabior towards pedestrians.

Now a days aggressive driving is considered as a significant problem for traffic safety[1]. It is important to find out the factors which influence driver's aggressive behavior. Some previous study had been done between aggressive driver and some factors: gender[2,3,4] , age[5] , Presence of passengers[6,7] , congestions related delay[8,9] .

Since this study based on observational data it was impossible to assess driver characteristics in depth.In summary this study thought to evaluate how intersection entrance design and different part of traffic signal phase influeneced the aggressive behavior of left turn vehicle's driver. This study will be beneficial for entrance design at intersection between arterial and residential road.

2. RESEARCH OBJECTIVES

The objectives of this research is

- To find a safe intersection entrance pavement design which may recuce aggressiveness of left-turn driver on pedestrian crossing
- To assess the influence of different phase of green signal time on aggressiveness of left turn driver

3. METHODOLOGY

(1) Data collection

Data was collected from three sites near nishikawaguchi station, Japan. This three sites are situted along a major road one by one**(Fig. 1)**. Almost all characteristics exept pavement design are similar in these three intersections **(Table 1)** . Data were collected during December,2014- January,2015, during the day light from 9.00am to 4.00pm by video recording. The observations were conducted at three sites in the immediate proximity of an intersection where visual design is different.

Fig.1 Three site with different intersection approach design
Source: Google map.

Table 1 Geometric and traffic characteristics at observational sites

Intersection	*Average left turning car (veh/hr)*	*Average pedestrian /cyclist*		*Intersection corner angle*	*Width of Major road (m)*	*Width of Minor road (m)*
		Ped.	Cyc.			
No pavement design	6	12	17	90°	6	6
Red colored pavement	8	9	13	90°	6	6
Brick pavement	5	7	13	90°	6	6

Table 2 Traffic signaling time at observational sites

Intersection	*Survey time*	*Green time sec*	*All red sec*	*Red time sec*	*All red sec*	*Total Cycle sec*
No pavement design	9.00 am to 4.00pm	50	2	26	2	80
Red colored pavement	9.00 am to 4.00pm	45	2	31	2	80
Brick pavement	9.00 am to 4.00pm	46	2	30	2	80

(2) Measures of aggressive driving

Total 30hrs video was observed from all three intersections. From all three intersections total 109 interactions between left turn vehicle and pedestrian or cycist was observed. Out of which 13 meneuvers

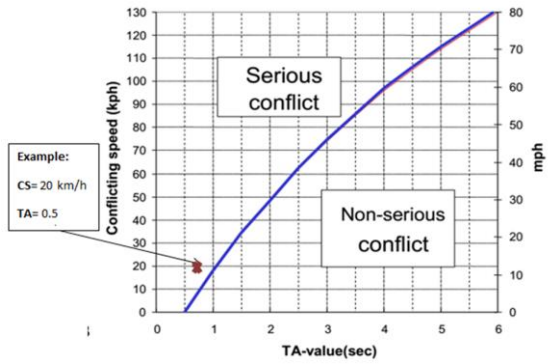

Fig.2: severity of Swedishtraffic conflict technique[10]

Table 3 Categories by splitting time in green signal phase

Category	*No pavement design*	*Red colored pavement*	*Brick pavement*
1	0≤t<12.5 sec	0≤t<11.25 sec	0≤t<11.5 sec
2	12.5≤t<25 sec	11.25≤t<22.5 sec	11.5≤t<23 sec
3	25≤t<37.5 sec	22.5≤t<33.75 sec	23≤t<34.5 sec
4	37.5<t≤50 sec	33.75<t≤45 sec	34.5<t≤46 sec

Table 4 Percentage and frequencies of Aggressive behavior

Intersection	*Interaction between left turn car and pedestrian*	*No. of Aggressive behavior*	*percentage*
No pavement design	36	9 (SB= 4 PS = 5)*	25.00
Red colored pavement	44	4 (SB = 4)	9.09
Brick pavement	30	1(PS = 1)	3.33

*SB = Sudden Braking; PS = Pedestrian Slow

were denoted as "aggressive". In this respect, a maneuver was considered aggressive if it forces pedestrian to slow down and makes sudden brake to avoid collision with pedestrian.

Sometimes driver comes with a very low velocity and if he found any pedestrian or cyclist on the crosswalk he make a sudden brake, which may not be so dangerous. To select the most severe situations created by sudden brake, the approach of the Swedish Traffic Conflict Technique is used[8)] . This technique is developed at Lund University. In Swedish traffic conflict study they use TA-CS graph (**Fig. 2**) to show the severity of each sudden brake event.

TA is the time that remains from one of the road users have started an evasive action, until a collision would have occurred if the road users had continued with unchanged speeds and directions.

The TA value can be calculated based on the estimates of distances d and conflicting speed CS.

$$TA\ value = \frac{Distance\ to\ collision\ point\ (d)}{Conflicting\ speed\ (CS)} \quad (1)$$

Where, d = Distance to collision point = is the remaining distance between the point where car takes evasive action (sudden brake) and the potential point of collision. The conflicting speed (CS) is the speed of the involved road user at the moment when the evasive action (sudden brake) starts.

(3) Different phase of green signal time

All intersections are operated by traffic signal for controlling vehicle movement from different direction. Information of signaling time is shown in **Table 2**. As driver has to finish his maneuver in a specific time duration, so drivers feel some time pressure. The purpose of this study is to assess the effect of the different phase of green signaling time on left turn driver's aggressive behavior. For this reason Time duration in green signal phase in one direction has been splitted into 4 categories (**Table 3).**

(4) Data Extraction

All interaction are observed from video. Required data like speed of vehicle, time duration, distance are extracted from video by using video analyzing software KINOVEA.

4. RESULTS AND DISCUSSIONS

The effect different design on pavement, analyzed by comparing the frequencies of the aggressive behavior. The frequencies and percentage of aggressive behavior sample are given in **Table 4.** In aggressive samples 9 out of 36 (25%) left turn driver commit aggressive behavior at intersection without any pavement design when they face pedestrian at crosswalk. In red-colored pavement designed intersection 9.09% driver shows aggressive behavior. Percentage of commiting aggressive behavior is less in brick pavement designed intersection (3.33%).

The frequencies and percentage of aggressive driving considering different pavement design and different phase of green signal time are presented in

Table 5 Percentage and frequencies of Aggressive behavior as a function of different pavement design and different phase of green signal time

Category	*No pavement design*		*Red colored pavement*		*Brick pavement*	
	No. of inter-teraction	No. of Aggressive behavior. (Percent)	No. of inter-teraction	No. of Aggressive behavior. (Percent)	No. of inter-teraction	No. of Aggressive behavior. (Percent)
1	11	1(9.09)	20	0	12	0
2	9	3(33.33)	9	3(33.33)	8	1(12.5)
3	9	2(22.22)	9	1(11.11)	6	0
4	7	3(42.86)	6	0	4	0

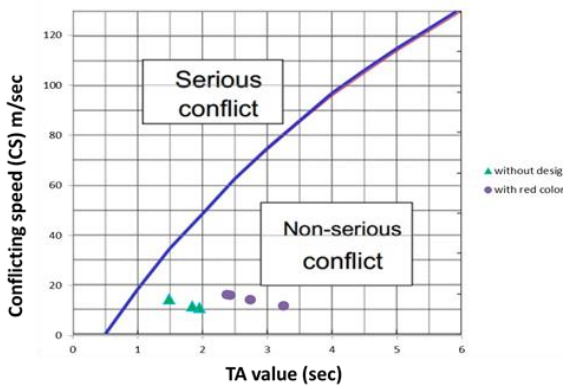

Fig.3 Seriousness of sudden brake using TA-CS graph[10]

Table 5 . Frequency of aggressive behavior is more at the 2nd part of green signal time for all type of intersections. 33.33% driver at intersection without pavement design, 33.33% driver at red colored intersection and 12.5% driver at brick pavement designed intersection are aggressive at the 2nd part of green signal time. At 4th part of green signal time is the more crucial time. because this is the last part of green signal. 42.86% drivers at intersection with no pavement design shows aggressive behavior in the 4th part of green signal time. Driver at red colored pavement and brick pabement designed intersection shows no aggressive behavior at this part of green time.

There are no sudden brake event was occurred at brick pavement designed intersection. In **Table 4** it is shown that there are 4 sudden brake event occurred at each intersection of red colored pavement intersection and no pavement designed intersection. To select the most severe situations created by sudden brake, the approach of the Swedish Traffic Conflict Technique is used[10]. This technique is developed at Lund University.

From **Fig.3** it is found that all conflicts are not so serious. But the level of seriousness of all sudden brake is low for intersection with red colored intersection. According to the definition of TA-CS graph the severity of conflict become low towards right bottom part of the graph.

5. CONCLUSIONS

The results of this study clearly shows that aggressive driving is influenced by different design on pavement and different phase of green signal time. In this study the intersections are very similar in all characteristics except pavement design. At intersection with red colored pavement and brick pavement aggressiveness of driver is much lower than that at normal intersection without any pavement design. When left driver reaches near the crosswalk he has to be more careful about pedestrian. He should yield pedestrian first. This study shows that red color and brick have visual effect on driver. In these intersections driver become more careful about pedestrian.
About signalling time it is found that drivers become more aggressive when they face pedestrian at later part of traffic signal. Later part of traffic signal is crucial time for driver. Because if he miss the signal than he has to wait for next green signal. At normal intersection without design drivers are aggressive at last part of signal time. But at red colored and brick pavement designed intersection driver did not commit any aggressive behavior. Because of design driver does not get any confidence to cross or show non yielding behavior to pedestrian. For pedestrian safety it is very important to yield them first. By forcing driver to reduce their aggressiveness is very important for traffic safety. The main purpose of this study is to find some design solution at intersection which can reduce the aggressiveness of driver when they make turning through the crosswalk. The results of this study imply that red color and brick has good safety effects on driver's behavior.

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