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Operation Performance of Police Control at U-turn

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Abstract

There are a lot of u-turn facilities at the midblock median opening in the developing countries. U-turn maneuver is risky and causes traffic interruption. The u-turn operation is sometimes controlled by police, especially during peak periods. The performance of the traffic police control at u-turn is still in doubt. This research investigated the operational effect of police control on u-turn movement. The u-turn continuous movement when the conflicting traffic stopped, with and without police control, was compared in terms of discharge headway and flow rate. The data were collected at four u-turn locations on an urban arterial in Bangkok, Thailand. Those sites have different median widths. With police control, the queue discharge characteristic was similar to the queue discharge movement at a signalized intersection. The minimum discharge headway was not reached until the eighth position of the queuing vehicles. The results showed that the u-turning vehicles moved with smaller headway when police controlled the junction at all sites. The differences between the discharge headway of u-turn movement in both control conditions (with and without police) might be caused by the drivers' hesitation. The police control could increase the u-turn discharge flow rate by approximately 10%. The effect of median width was also investigated. On condition that the median width was comfortably sufficient for u-turn maneuver, the wider median leaded to the larger value of discharge headway. Consequently, the u-turn discharge flow rate decreased as the median width increased. However, too narrow median caused uncomfortable u-turn maneuver and might decrease the u-turn discharge flow rate. Moreover, the efficiency of police control was diminished at the site with too narrow median.

Keywords: u-turn; police control; discharge headway

1. Introduction

The u-turn movement at uncontrolled midblock median opening is based on the gap acceptance process. When the vehicle arrives at the median opening, its driver faces the gaps of the conflicting through traffic, waits for an acceptable gap, and then makes a u-turn.

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However, when the conflicting traffic volume is high, it is very difficult to find a large enough gap for the u-turn movement. The police will present and control the u-turn junctions. When the u-turn traffic has long queue, the policeman stops the conflicting through traffic and lets the u-turn traffic move. This is to facilitate the u-turn traffic movement, avoid through traffic blockage by u-turn queue, and prevent unsafe forcing u-turn behavior.

This research evaluates the performance of police control at u-turn on its discharge flow, comparing to the normal traffic operation when there is no police control. To conduct a fair comparison, the effect of conflicting traffic volume was neglected. The discharge flow rate is calculated by inversing the discharge headway. In case of no police control, the headway of u-turn traffic was measured in the situation that conflicting traffic stopped for u-turn or no conflicting traffic. The objectives of this study can be listed as follows:

(i) to study the departure headway characteristics of continuous u-turn movement;

(ii) to evaluate the performance of police control on u-turn queue discharge flow;

(iii) to investigate the effect of median width on u-turn queue discharge flow and u-turn maneuver.

The u-turning vehicles in this research focused only on passenger car, which included all kinds of vehicle with passenger car equivalent (PCE) of 1.

2. Literature Review

This research focused on the u-turn at midblock. Although it is not signalized, the movement, when it is controlled by police, is similar to the movement at a signalized intersection. The HCM indicates that the saturation flow rate is reached after the fourth to sixth queuing passenger car crosses the stop line when the signal turns green [1]. However, a study of discharge headway model shows that the minimum headway is not achieved until the eighth or higher queue positions [2]. In addition, another study discovers that queue discharge headways tend to undergo compression for a considerable time as more vehicles in the queue are discharged. The discharge rates keep rising even after the 15th queued vehicle entering the junction [3]. A study on signalized u-turn movements in Kunming, China, indicates that the saturation headways can be measured from the eighth queuing vehicle [4]. The current research investigated the discharge headway characteristics of continuous u-turn movement.

In developing countries, traffic police are often utilized to control the traffic operation during peak periods. There is a study evaluating the efficiency of a police controlled roundabout comparing to a pre-timed traffic signal controlled intersection, in term of dynamic delay. The police is necessary to be provided to control the roundabout during peak periods. This gives better chances for mass crossings of traffic and better control on queue length. The relationship between delay and queue length as the vehicle joins the queue has been developed. It shows that the roundabout cause less delay when the queue length less than 80 m and cause greater delay as the 80 m queue length criterion is exceeded [5].

The provision of midblock median openings for u-turn between intersections can reduce the number of turning maneuvers at the adjacent intersections. Since the conflict points are less, the accident rates at midblock median openings are lower than at three- or four-leg median openings [6]. However, the u-turning vehicles may delay full-speed conflicting through traffic. In addition, narrow medians may not provide enough space for larger vehicles to negotiate a u-turn maneuver. To accommodate the u-turn maneuver at median opening, the width of median nose (refer to median at u-turn location) and receiving driveway should be wide enough. For the design vehicle P (passenger car, 5.7 m length), AASHTO recommends the median nose width of 9 m, 5 m, and 2 m for the u-turn maneuver from inner lane to inner lane, to outer lane, and to shoulder lane, respectively, for 4-lane divided highway [7].

3. Methodology

This research intends to compare the continuous u-turn movement between when there is a police control and no police control. For comparison purpose, the discharge headways of u-turn movement in both situations are determined. In case of police control, it is the headway of the u-turn movement when the police blocks the conflicting traffic and allows for u-turn. In case of no police control, it could be measured in the situation that the conflicting traffic stop and allow the u-turning vehicles to make u-turn continuously. The discharge flow rate of this u-turn movement is determined by inversing the discharge headway; $S = 3600/h$, where S is the discharge flow rate (veh/hr) and h is the discharge headway (s).

The analysis of headway data determines the discharge headway. The data screening is required in order to rule out the undesirable driver behaviors, such as too quick or too slow movements. In addition, to avoid the possible error from the inconsistent driver behavior, outliers are also excluded. In this study, the outlier is any data point that is at least 1.5 times interquartile ranges (IQR) less than the lower quartile (Q1) or greater than the upper quartile (Q3). In other words, the headway data points used in statistical analysis are between Q1-1.5*IQR and Q3+1.5*IQR.

In this study, the discharge headway and flow rate of u-turn movement are compared between control strategies at each site. In addition, the comparisons of the results from all sites are conducted to check the potential effects of median width.

4. Data Collection

To fulfill the research objectives, the selected u-turn sites should be operated for both with and without police control. In addition, the sites should feature the situation that the major through traffic stops to allow u-turn. The site locations should be in the same area to get the similar driver behavior, i.e. same driver population. Four midblock median openings were selected for data collection, as shown in Fig.1. Those sites are located on Phetkasem road, a six-lane divided street in the western Bangkok, Thailand. The lane arrangement at u-turn section at all sites are similar; one u-turn lane and three through lanes in each direction. The width of median nose and receiving roadway is sufficient for u-turn maneuver at all sites.

Site	Data Collection Date
1	14 Dec 10, 4 Jan 11
2	16 Dec 10, 6 Jan 11
3	21 Dec 10, 7 Jan 11
4	22 Dec 10, 12 Jan 11

Fig. 1. Location and traffic condition at the u-turn sites

A video camera was set on the nearby pedestrian bridge at each site to record the traffic movement during morning peak (7:00-9:00), afternoon peak (16:00-18:00), and off-peak (11:00-13:00) periods on the dates as shown in Fig.1. The video data were reviewed to collect information in the laboratory. The first step was to identify the periods that the u-turning vehicles can move continuously. After that, the time headway data of u-turn movement were collected for all eligible periods.

5. Results and Discussions

5.1. Discharge headway characteristics

From the collected headway data, the average headway for each queue position of the u-turn queue is illustrated in Fig. 2, for the movement without and with police control. The headway data started from the second queue position, i.e. the departure time difference between the first and second vehicles. The discharge headway patterns in case of no police control were dispersed. On the contrary, the stable headway could be noticed in case of police control. The result showed that the police control acted in the similar way as a signal control does. Some leading vehicles face the start-up lost time, causing the larger headway in the beginning of the queue. Then, the moving queue with stable headway can be found. The minimum discharge headway could be reached from the seventh or eighth queue position.

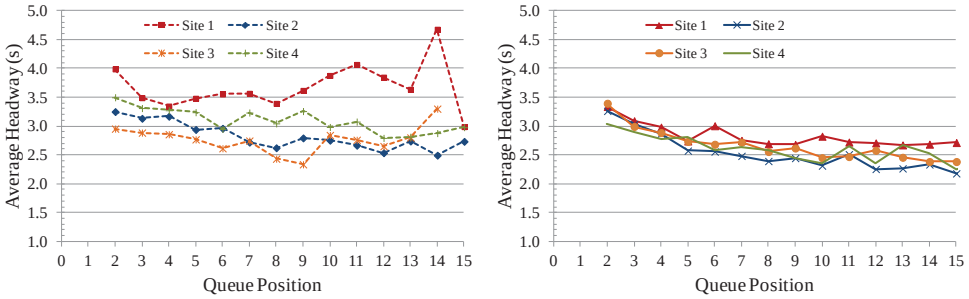

Fig. 2. Discharge headway pattern (a) no police; (b) with police

After data screening and excluding the outliers, the descriptive statistics of discharge headway at each site with each control condition were determined as shown in Table 1.

Table 1. Descriptive statistics of discharge headway data

Site	Median Width (m)	Case	No. of Sample	Mean (s)	Standard Error (s)	Standard Deviation (s)	Min. (s)	Max. (s)
1	5.8	No Police	544	2.84	0.02	0.43	1.5	3.7
		With Police	823	2.59	0.02	0.44	1.5	3.6
2	3.2	No Police	553	2.64	0.02	0.45	1.4	3.7
		With Police	373	2.39	0.02	0.39	1.4	3.3
3	2.7	No Police	389	2.64	0.02	0.47	1.5	3.8
		With Police	334	2.49	0.02	0.42	1.3	3.7
4	3.8	No Police	830	2.67	0.01	0.38	1.5	3.7
		With Police	569	2.41	0.02	0.40	1.2	3.3

5.2. Effect of police control

From the statistical analysis results, the comparison of average discharge headway at different median widths on different control strategies is illustrated in Fig. 3. The mean headway values of u-turn movement in case of police control were significantly lower than those in case of no police control at all sites. This could indicate that the police control at u-turn could increase the u-turn discharge flow, even comparing with the same situation that the conflicting through traffic stopped. When the u-turn junction was controlled by police, the drivers were more confident to make u-turn quickly. Based on the field observation, the policeman who controlled the junction sometimes rushed the u-turn movement by his hand sign as well. On the contrary, when the through traffic stopped without police, the u-turn drivers still concerned on the conflicting traffic's action, whether to let u-turn go or not.

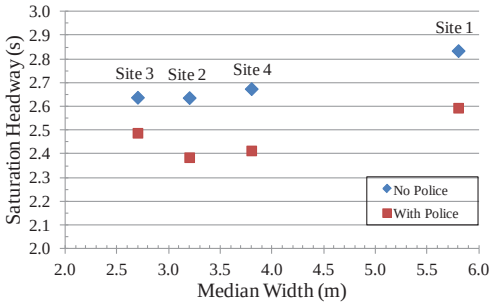

Fig. 3. Effect of police control and median width

The amount of discharge flow rate increase due to police control is summarized in Table 2. The discharge flow rate was increased by approximately 10% at all sites except the site with the narrowest median (2.7 m), which the flow rate increase was only 6%. The median width might affect the discharge flow rate since the u-turn maneuver requires a large driving space.

Table 2. Discharge flow increase by police control

Median Nose Width	Case	Discharge Flow Rate (veh/hr)	% Increase by Police Control
2.7 m	No Police	1,365	6%
	With Police	1,447	
3.2 m	No Police	1,365	11%
	With Police	1,509	
3.8 m	No Police	1,346	11%
	With Police	1,491	
5.8 m	No Police	1,270	9%
	With Police	1,388	

5.3. Effect of median width

The effect of median width on discharge headway can also be seen in Fig. 3. Except the narrowest median of 2.7 m, the wider median nose leaded to the greater headway, and consequently the lower discharge flow rate of u-turn movement. The raised median might be considered as an obstacle for u-turning vehicle. The drivers have to carefully control their

vehicles when making a u-turn at a wide median. Therefore, the wider median nose at u-turn, the larger headway to follow the leading vehicle. Since the width of roadway is sufficient for u-turn maneuver, there is no limitation of space for u-turn maneuver.

In case of normal gap acceptance u-turn, on the contrary, the u-turning vehicle prefers the wide median to the narrow median. Since the u-turn maneuver needs large space to turn back, the wide median can compensate the required space. The u-turning vehicle can turn into the inner lane (close to median). The conflicting traffic is only the through vehicles on that lane. Therefore, the lesser conflicting traffic, the easier u-turn movement and the higher u-turn capacity. For narrow median, the u-turning vehicle conflicts with through traffic on two or more lanes, making it more difficult to complete the u-turn maneuver.

The median nose width of 2.7 m seemed too narrow for comfortable u-turn maneuver. The drivers had to turn steering wheel tightly. So, the contribution of police control was less at the site with uncomfortably narrow median.

6. Conclusions

This research evaluated the effect of police control by collecting the discharge headway at different sites. The conclusions could be listed as follows:

- police control could stabilize u-turn movement and acted similar to the traffic signal;
- discharge headway was less when police controlled the traffic operation at u-turn;
- police control could increase the discharge flow rate by about 10%;
- discharge flow rate was less at the sites with the wider median;
- median width at u-turn should be wider than a critical minimum width for comfortable u-turn maneuver; and
- with too narrow median, the discharge flow rate was less and so was the efficiency of police control.

For design purpose, if a u-turn at midblock median opening is designed to be fully controlled by traffic signal, the median width should be minimal but still provide a comfortable u-turn maneuver. On the contrary, for uncontrolled u-turn junction, the median should be as wide as possible to give more chances for gap acceptance u-turn due to the less interference with the conflicting traffic stream.

The comparison between police-controlled and signal-controlled u-turn movement could also be studied in future. In addition, the swept path analysis should be conducted to get better understanding of the u-turn maneuver in traffic engineering point of view.

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