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Modelling follow up time at a single-lane roundabout

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Abstract: The follow up time is an important parameter for estimating the entry capacity of roundabouts. However, its variability and contributing factors have long been ignored in the literatures. In this study, 171 follow up samples and contributing factors (traffic volume, vehicle position, waiting vehicles behind, vehicle type, and drivers' gender) are collected at a roundabout in Pacific Pines, Australia. It is found that the follow up time is indeed significantly affected by traffic volume, waiting vehicles behind, vehicle type, and drivers' gender. In order to establish the relationship between the follow up time and its contributing factors, an inverse Gaussian regression model is further developed. This relationship could be applied to estimate the entry capacities by taking into account the variability of follow up samples. According to the model, the traffic volume and vehicle types are the most important contributing factors.

Key words: roundabout capacity; critical gap; follow up time

1 Introduction

Urban roads are becoming more and more congested due to the increase of car ownership. A number of management tools, such as pricing, signal control, dedicated lanes have been applied to alleviate road congestion (Liu and Meng 2014; Liu et al. 2013a; Liu et al. 2014; Meng and Liu 2011; Meng et al. 2012; Wang et al. 2013). At the same time, there are some roads that are less controlled such as unsignalized intersections. A roundabout is a type of circular intersection or junction in which road traffic is slowed and flows almost continuously in one direction around a central island to several exits onto the various intersecting roads (Tenekeci et al. 2010; Xu and Tian 2008; Qu et al. 2014). As pointed out by Bie et al. (2008), unlike a signalized intersection, wherein traffic streams are controlled by the traffic signal, vehicles must follow the give way rules to enter a roundabout. The direction of traffic flow is either clockwise for left-side driving or anticlockwise for right-side driving. Since all vehicles are regulated to travel

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along with the same direction, number of conflicting points is significantly reduced (Wong et al. 2012). Further, the drivers usually slow down the vehicles' speed thanks to the impact of "give way" rules and the roundabout curves (Al-Masaeid 1999). The roundabout is therefore considered as a safer intersection type compared to signalized intersections, in terms of both frequency and severity of accidents (Vasconcelos et al. 2012). A roundabout can also reduce the delay (for low traffic conditions) and thus decrease pollutant emissions (Hoglund 1994). Accordingly, the roundabout becomes an increasingly popular intersection type, especially for suburbia with relatively low traffic volume.

The entry capacity of a roundabout is usually estimated on the basis of gap acceptance theory. The fundamental parameters for this theory are the critical gap and follow up time. The critical gap is the minimum time gap between successive circulating conflicting traffics that allow vehicles queued in an approach to enter the roundabout. The follow up time is defined as the time difference between two vehicles queued in an approach entering the roundabout during the same gap in the circulating traffic (Özuysal et al. 2009). It has been well recognized that both parameters are highly affected by drivers' behaviours, traffic conditions, geometric parameters, and vehicle types. The variability of critical gap and its affecting factors have been well analyzed in the literatures (e. g. Bottom and Ashworth 1978; Polus et al. 2003; Tian et al. 1999). By contrast, the other important contributing factor, follow up time, has been unfortunately out of the focus in the literatures. Akcelik (2005) mentioned that the follow-up time was reduced with increasing circulating traffic. Dahl and Lee (2012) pointed out that the follow up time varies with the vehicle types of the two entering vehicles in a queue. The above-mentioned two articles are, to the best of our knowledge, the only references that analyze the contributing factors of follow up time. In reality, according to the Highway Capacity Manual (HCM) models (TRB 2000; 2010), the variability of follow up time might have higher impact on entry capacities than that of critical gap, especially during the light traffic conditions. Therefore, it is of great importance to analyze the variability of follow up time and its contributing factors.

In this study, traffic videos are recorded during distinct time periods (8×30 minutes each) at a roundabout in Pacific Pines of Queensland, Australia. 171 samples of follow up times and the contributing factors (including vehicle type, waiting position in a queue, queuing vehicles behind, traffic volume, and driver's gender) are measured and/or identified from the videos. Then, one way analysis of variance (ANOVA) is applied to examine whether a contributing factor has a statistically significant impact on follow up time. Finally, a generalized linear regression model is developed to establish the relationship between follow up time and its contributing factors.

The contributions of this study are two-fold. On one hand, this paper analyses the impact of various contributing factors (including vehicle position in a queue, number of waiting vehicles behind, and driver's gender) on follow up time using real data. More importantly, this is the first attempt to establish the relationship between follow up time and its contributing factors using a generalized linear nature. This result could be applied to estimate the roundabout capacity by incorporating the impact of these contributing factors.

2 Data description

The field data analyzed in this paper was collected from a roundabout at the junction of Smith Street and Pitcairn Way, Pacific Pines, Queensland (Fig. 1). Traffic videos were recorded during distinct time period (8×30 minutes each; a combination of peak and off-peak hours during day time). The speed limit for Smith Street and Pitcairn Way are 70 and 60 km/hour, respectively. As the Smith Street is the most important corridor connecting Pacific Pines to Gold Coast, the traffic volume of this roundabout during peak hours is relatively high. The radius of the central island is 24 meters. In sum, 171 follow up samples and the contributing factors are measured and/or identified from the videos. The mean and standard deviation of the samples are 2.76 seconds and 0.62 seconds, respectively. The contributing factors to follow up times are vehicle type, waiting position in a queue, queuing