Queue Dissipation at Signalized Intersection under Mixed Traffic Conditions

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Abstract

The complexity in discharge pattern through the intersection in developing countries is mainly due to its mixed properties of traffic stream where both motorized and non-motorized vehicles are traveling in the same stretch without any lane discipline. In a mixed traffic stream, no single vehicle dominates the traffic stream consequently prediction of saturation flow is more sensitive for that mixed traffic. Therefore, it is essential to convert all categories of vehicles into a single unit to integrate their effects on traffic stream called passenger car unit (PCU).

Moreover, vehicles headway is one of primary microscopic parameter, which contributes major impacts on discharge rate estimation for a signalized intersection. It is the time gap between two consecutive vehicles with some reference line during the queue dissipation in green time, called discharge headway.

The methodology for data collection is being adopted as per the guidelines of Highway Capacity Manual (2010). Initially, five four legged signalized intersections from the city of Delhi, Chandigarh and Allahabad were selected for the data collection purpose. All the selected intersections are free from pedestrian activities with a pre timed signal characteristics. Video graphic technique was used to capture the vehicular movement through the intersection. The camera was installed and focused to a particular approach to capture its discharge pattern during the green time. The recording was done during the morning (9 am to 12 pm) and evening (4 pm to 7 pm) peak hours.

An optimization approach is used to find out discharge rate of vehicles during queue dissipation. Dynamic PCUs are estimated through reducing the Theil's coefficient. The obtained flow value is compared with the ideal flow profile provided by HCM 2010.

The discharge pattern of vehicles during the queue dissipation is analyzed using the graphical representation of departure headway with queue position. It shows a generalized trend where departure headway decreases with increase in vehicle position in the queue with a saturation headway of 2.05 sec/veh.

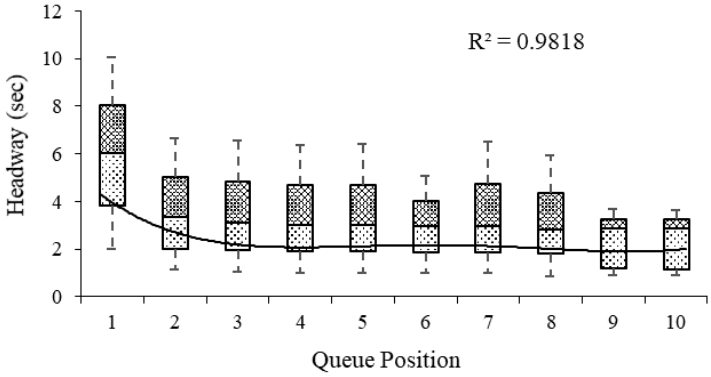

Fig. 1: Departure headway pattern of vehicles

Several distribution models are tested to find out the distribution of departure headway. The hypothesis result obtained by Kolmogorov-Smirnov (K-S) test shows that the departure headways follow a particular log-normal distribution for each vehicle position in a queue.

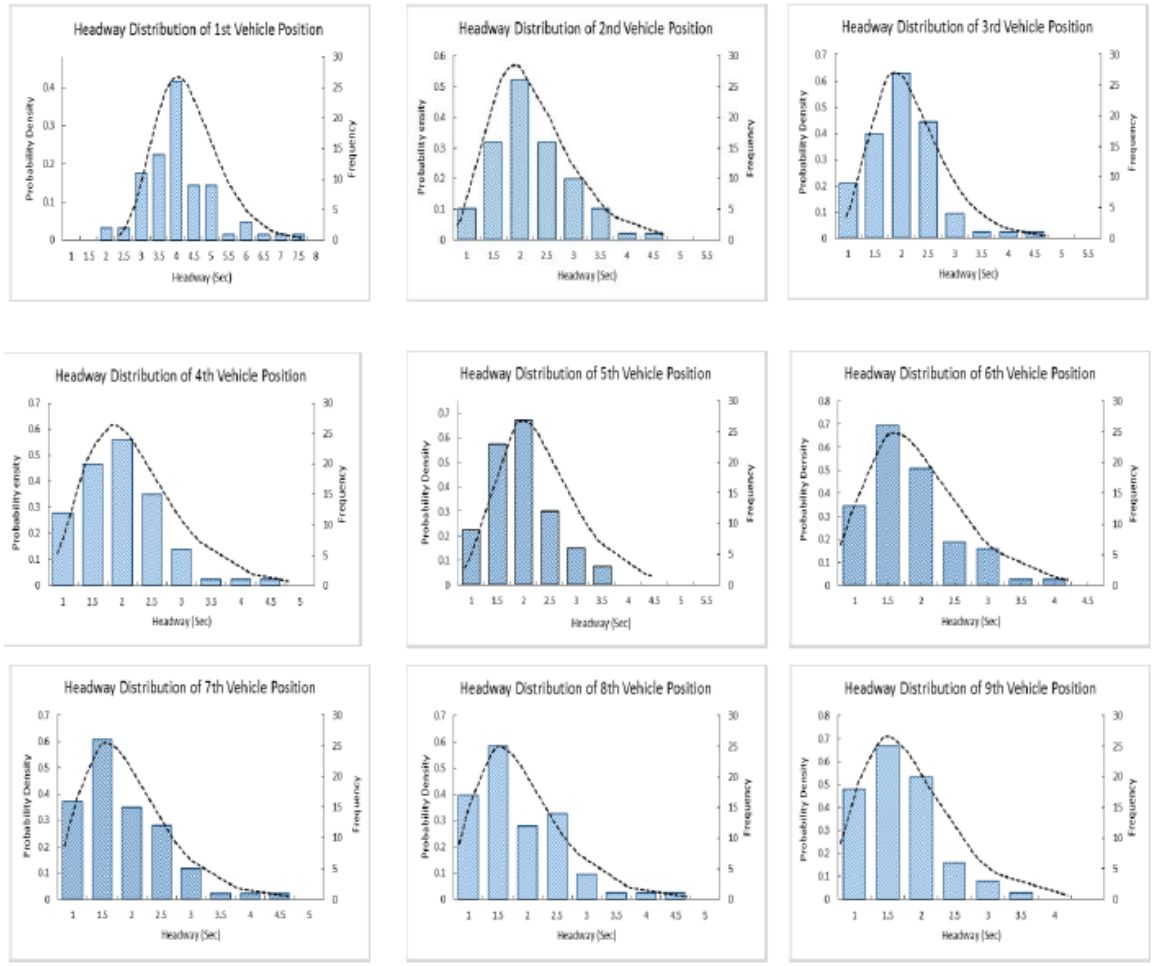

Fig. 2: Histogram of the empirical departure headway for each vehicle position

The optimization technique is applied during the saturated green period, obtained by one way ANOVA for each successive pair of green slices. The dynamic PCUs of vehicles are estimated through minimizing the Theil's coefficient value by taking the PCUs as decision variable with several constraints of PCUs.

$$Z_{\min} = \frac{\sqrt{1/N\sum_{i=1}^{N}(S_b - S_i)^2}}{\sqrt{1/N\sum_{i=1}^{N}(S_b)^2} + \sqrt{1/N\sum_{i=1}^{N}(S_i)^2}}$$

$$S_i = \sum_{j=1}^{m} n_j P_j \ , \ P_j \geq P_{j\min}$$

The primary function of the optimization is to minimize the difference between the observed and ideal flow profile provided by HCM 2000. The DPCUs are used to estimate the discharge rate.

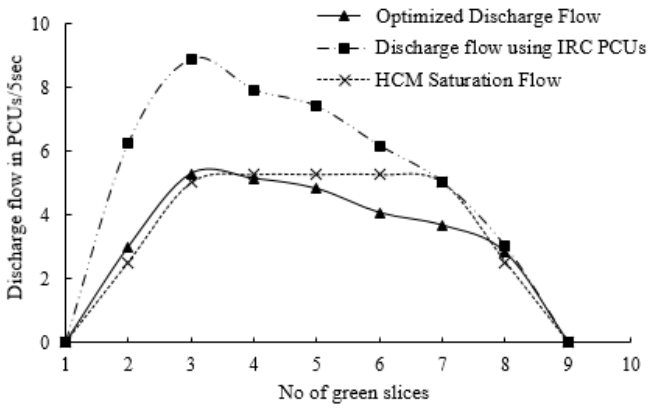

Fig. 3: Discharge profile using optimized PCUs

Result gives a flow value of 1908 PCU/hr/lane which is almost near to the ideal profile proposed by the Highway Capacity Manual 2000. Therefore, the current methodology can effectively be used to evaluate the dynamic PCUs and discharge value for a non-lane based mixed traffic stream.

Key words: Departure headway, Discharge rate, Mixed traffic, Passenger car unit, Signalized intersection

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