Research Paper on Estimation of Saturation Flow And PCU at Intersection with Platoon Dispersion Model

Prof. Shrinath Karli  
Department of Civil Engineering  
Hasmukh Goswami College of Engineering, Vehlal, India

Prof. Vishal Vadhel  
Department of Civil Engineering  
Hasmukh Goswami College of Engineering, Vehlal, India

Prof. Pinakin Patel  
Department of Civil Engineering  
Hasmukh Goswami College of Engineering, Vehlal, India

Prof. Vrundani Vaidhya  
Department of Civil Engineering  
Hasmukh Goswami College of Engineering, Vehlal, India

Devangi G. Hattimare  
PG Student  
Department of Civil Engineering  
Hasmukh Goswami College of Engineering, Vehlal, India

Abstract

This study will analyse the effect the road traffic and travel situation is highly aggravated in metropolitan cities of developing country like India because of significant growth in traffic and addition of more and more numbers of vehicles year by year in to the stream with wide ranging static and dynamic characteristics. Signalisation is a traffic control strategy to ease the competition by providing right of way in a cyclic manner to conflicting traffic at intersections. Saturation flow is a major component in the design of signals, and is influenced by a variety of factors like vehicle composition, intersection geometry and driver’s behaviour. Two-wheelers (2W) constitute a major proportion of urban traffic and therefore their effect on the saturation flow could be substantial. The highway capacity manual (HCM)000 has recommended a saturation flow model primarily for homogeneous conditions, with limited ability to address heterogeneity. But the traffic in India is highly heterogeneous and hence, defining a unified saturation flow concept is a challenging task. The variability in vehicle types necessitates the use of passenger car units (PCUs). Mixed traffic behaviour on saturation flow rate at the signalised intersections. Traffic data will be collected at signalised intersections located in urban area of different cities of Gujarat with different geometric configurations and approach width. Micro level discharge rate studies will be carried out by observing different traffic attributes. The passenger car units (PCUs) values will be derived for different types of vehicles in the traffic stream by different approaches. Mixed traffic discharge flow models will be developed using regression method by relating the various parameters. Also an effect of platoon dispersion on discharge rate will be carried out under this study.

Keywords: heterogeneous traffic; passenger car unit; saturation flow

I. INTRODUCTION

A. Saturation Flow and PCU:

The term saturation flow is defined as the maximum rate of flow that can pass through a given road space (width), under prevailing roadway and traffic conditions, during the effective green time in a signal phase. Saturation flow is an important input parameter in the design of cycle time for traffic signals. India is a developing country and its cities are undergoing rapid urbanization and modernization as a result there is rapid growth in the road traffic. Traffic movement in India is very complex due to the heterogeneous traffic stream sharing the same carriageway. Signalized intersections play a critical role in the smooth operation of both arterial and urban streets, where traffic movement in different directions meets together.

The authors classified some patterns, which were different relative positions of motorcycle to passenger car, then used regression analysis to estimate how different among these patterns were in terms of headway and start-up lost time. However, that method is quite difficult from practical use.

The goal of this paper is to investigate the stochastic nature of queue discharge headways, which may provide better information, and, so, to develop a new saturation flow rate estimation method. To fulfil the objective, a literature review, data collection and data analysis, and model development were conducted.
B. What Is Platoon?

“Platoon of road traffic can be defined as a set of vehicles or pedestrians travelling together as a group, either voluntarily or involuntarily, because of signal control, road geometry or other factors”. In the Highway Capacity Manual (HCM), a vehicle platoon is defined as a group of vehicles travelling together.

C. Objectives of Study:

1) To collect traffic data and study the traffic flow characteristics at selected signalized intersections of Gujarat in different cities.
2) To Estimate the passenger car equivalent unit values of different categories of vehicles at signalized intersections.
3) To study effect of mixed traffic on queue discharge characteristics at signalised intersections.
4) To study the effect of platoon dispersion on queue discharge at signalized intersections.

D. Need of Study:

1) To Estimate Saturation Flow
2) To Estimate Passenger Car Unit (PCU)
3) To Study Platoon Dispersion Effect for Mixed Traffic Flow

E. Statement of Problem:

Saturation flow is a major component in the design of signals, and is influenced by a variety of factors like vehicle composition, intersection geometry and driver’s behaviour, so the analysis of saturation flow is must require in India. Two-wheelers (2W) constitute a major proportion of urban traffic and therefore their effect on the saturation flow could be substantial.

II. LITERATURE REVIEW

Li and Prevedouros applied three methodologies to analyze the saturation headway based on the field data. It was revealed that when long queues are present, the typical field measurement of saturation flow rate based on the first 12 vehicles is an overestimate of saturation flow rate for through vehicles and an underestimate of saturation flow rate for protected left-turning vehicles. Lee et al. (2010) employed the flow rate method to estimate motorcycle PCU values, with the help of a recently developed agent-based simulation model, which was capable of representing the characteristic movement patterns of motorcyclists. Road traffic platoon dispersal pattern has been studied, using simulation technique, by several researchers (e.g., Seddon; Castle and Bonniville and Benekohal and Treiterer). The continued research attempts on simulating road traffic have helped to refine the simulation models to its present status of a universally accepted analytical tool for traffic flow modeling. Robertson (1969) developed an empirical platoon dispersion model using a discrete iterative technique. Because of the simplicity in applying the model, it gained popularity and became a virtual standard platoon dispersion model. Lighthill and Witham (1955) used the kinetic wave theory to study the dispersion. Pacey (1956) used the diffusion theory to characterize dispersion, where he assumed that if the stream speeds are normally distributed, the dispersion in the corresponding platoons can be described by the dispersion in speeds.

III. STUDY AREA AND METHODOLOGY

A. Study Selection

The signalized junction of Pallav char rasta with A.E.C and Ghatlodiya, in the shastrynagar area of Gujarat City in India, was selected for the study. The straight-on stream of traffic on A.E.C to Akhabarnagr and for other signalized junction of NOIDA (NEW OKHLA INDUSTRIAL DEVELOPMENT AUTHORITY) with stadium chowk in Delhi, India.

Table - 3.1

<table>
<thead>
<tr>
<th>Sr no</th>
<th>Location</th>
<th>GPS coordinate</th>
<th>Time of video-graphic survey</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pallav char rasta (A.E.C), Ahmedabad Pallav char rasta (Ghatlodiya)</td>
<td>23°3’42”N 72°33’9”E</td>
<td>10.00 am to 11.30 am 5.00pm to 8.00pm</td>
<td>1 hours and 30 minutes (morning) 3 hours (evening)</td>
</tr>
<tr>
<td>2</td>
<td>Stadium Chock Noida, Delhi</td>
<td>28°34’48.00” N 77°19’48.00” E</td>
<td>10.00am to 1.30pm</td>
<td>3 hours and 30 minutes (morning)</td>
</tr>
</tbody>
</table>
Fig. 3.1: Ahmedabad-Pallav Cross Road Intersection Google Image

Fig. 3.2: Ahmedabad-Pallav Cross Road Cam-1 Provided At Shivalik Yash And Abhushan Complex
### B. Data Retrieval Process:

The recorded traffic flow video was replayed on a computer and data related to entry capacity, and occupancy time was extracted manually and recorded for further analysis. The vehicles are classified into seven categories, namely, motorized two-wheeler, motorized three-wheeler, small car, big car, LCV, bus and truck. The data related to time occupied by each vehicle originated from each of the entry points, for straight movement and right turn movement was separately extracted and recorded for estimating PCU values for different vehicle categories.
C. Measurement techniques for PCU:

1) Headway Method
2) Area Occupancy Method
3) Time Occupancy Method
D. Methodology for Platoon Growth

Vehicles travel in groups i.e., in platoons on urban roads. The speed of a vehicle is influenced by the lead gap available in the front and the variation in the lead gap is the crucial factor for acceleration or deceleration. That is, the headway between vehicles influences the vehicular speed. If the vehicles travel in platoon with the intra vehicular headway less than the free flow state and their speed are largely influenced by the presence of the vehicles in the front. If the headway is greater than minimum free flow headway, the speed of the vehicles depends on the driver and vehicular characteristics.

For ease of estimation, the flow rate is computed taking fixed intervals i.e., 1 minute or 5 minutes, or 10 minutes or 15 minutes. Large time intervals, like 5 minutes or 15 minutes, are usually adopted to estimate the flow rate. Considering fixed time intervals to compute the flow rate is likely to include periods of no flow.

The speed-density flow rate and stream speed plots was analyzed for the data aggregated for fixed time intervals and platoon flow period.

![Fig. 3.7: Illustration of Flow as Platoons on Urban Roads](image-url)

Consider three sections of urban road as shown in figure 2. In each section, the time intervals taken for the flow to leave the section is marked as t. In section I, the number of vehicles, n1=5 Section II n2=9 and section III n3= 5. The number of vehicles moving as platoon was determined as those vehicles with headway less than minimum free headway.

![Fig. 3.8: Group Of Vehicles at Pallav Char Rasta,Ahmedabad (Platoons)](image-url)

The advantage of this proposed methodology is demonstrated in this study by plotting headway against average speed of the traffic stream aggregated for fixed time intervals.
IV. Conclusion

In this semester I have collected data and videos from Ahmedabad (pallav char rasta), and Delhi (Noida) for methodology and during next semester I have collected data videos from Surat and worked on estimation saturation flow and pcu data calculations and also check the effects on platoons.

Acknowledgement

First and foremost, I would like to thank God, The Almighty, for blessing me with the opportunity and ability to complete this work.

I would like to express my sincerest appreciation, solemn gratitude, and heartiest thanks to my guide Professor Srinath Karli and prof. Pinakin Patel for his thoughtful guidance, unparalleled support, constant encouragement also thanks to my head of department prof. Vrundani Vaidhya.

I am very thankful to Prof. V.A. Vadhel who has given me such great guideline regarding my project work and also he has given me benefits of his deep knowledge.

References