

# Review on Effect of User's Violation on Saturation Flow Rate at Signalized Intersection

<sup>1</sup>Jay Rachchh,<sup>2</sup>V. R. Patel,

<sup>1</sup>PG Student, L.D. College of Engineering, Ahmedabad, India,

<sup>2</sup>Associate Professor, Department of Civil Engineering, L.D. College of Engineering, Ahmedabad, India

**Abstract:** Intersections are the points where two or more roads converge at same or different elevations which plays key role in quality of transportation system. Signals are provided at intersections for safe movement of large volume of vehicles. For the estimation of performance of intersection, users' behaviour plays important role as conflict between users leads to decrease in green phase time which ultimately leads to reduction in capacity of intersection. Saturation flow rate and PCU are important to consider for capacity, design and operation of signalized intersection as India have heterogeneous traffic conditions. Saturation flow rate depends on geometric conditions, traffic characteristics, operating conditions and environmental and user's behaviour. Violations by users are the problematic traffic behaviours at signalized intersections which lead to reduction in saturation flow rate and capacity and increased delay. This paper attempts to review on effect of road user's infringement on saturation flow rate at signal controlled intersection. Under heterogeneous traffic condition, violations by different kinds of users have noteworthy negative effect on saturation flow rate and should be considered in development of saturation flow rate model and estimation of capacity.

**Index Terms:** Intersection Capacity, Road User's Violation, Saturation Flow Rate, Traffic Behaviour

## I. INTRODUCTION

An intersection is a spot where different roads from different directions cross each other at same or different elevation. In India intersection at the same grade is normal as grade separated intersection is very expensive but provide least delay and more safety and relatively. At such a location, different traffic streams compete with one another for the use of that common space at the intersection. To avoid conflict and to control traffic movements signals are provided at intersections.

To assess the performance of intersection user's behaviour plays vital role because conflict between different users leads to decrease in intersection capacity. For assessment, intersection clearing speed and capacity of approach lane are required to determine which are also important to plan, to design, to operate and to manage the transportation system. At present, the methods available for the capacity estimation of signal controlled intersections are dependent on the saturation flow rate concept.

Saturation flow is the number of passenger car units (PCU) such that there is a dense traffic flow for a definite intersection approach. In a heterogeneous traffic state, the interface between different classes of vehicles causes trouble to the engineers because of the wide variation in their substantial and effective characteristics. Hence, different class of vehicles are required to convert in PCU. Therefore to design and to operate a signal controlled intersection and to estimate capacity of intersection, Saturation Flow and PCU are needed to take into consideration.

Saturation flow is the maximum vehicular volume which can cross the stop line for the duration of the saturated green time. HCM 2010 defines saturation flow as: under existing traffic condition queued vehicles can cross the intersection at maximum hourly flow rate. In this definition it is assumed that vehicles do not experience any losses and green time is available all the time. The capacity and LOS of an intersection can be accessed from Saturation Flow. HCM 2010 assumes that the vehicles follow lane discipline. However, in India, lane discipline is not properly followed due to heterogeneous condition. Because of primary difference in traffic condition and road user behaviour, the models for developed countries for saturation flow estimation were not appropriate for developing countries like India. Saturation flow rate depends on a variety of factors such as flow characteristics, geometric characteristics, traffic behaviour and type of movement.

## II. LITERATURE REVIEW

**PeimanMohseniMelerdiet.al.(2018)** carried out study on the impact of motorcyclist's and pedestrian's violations and lane changes of vehicles on estimation of saturation flow rate at signal controlled intersections through regression models. They found that if there is unit increment in motorcyclist's violation in one hour and unit increment in pedestrian's violation at entrance crosswalk in one hour then it leads to decrease in saturation flow rate by 0.66 unit and 0.43 unit respectively.

The percentage of motorcycle in the traffic flow has arising impact on the saturation flow rate because of lesser headway of it in comparison with further vehicles hence if there is unit increment in the proportion of motorcyclists then it leads to 7 unit increment in the saturation flow rate. The proportion of buses coefficient is -17, which shows the noteworthy decrease in the saturation flow rate due to slow speeding up and huge size of buses. It has also been concluded that the impact of violating pedestrians at the entrance crosswalk is far larger than exit crosswalk.

**Yao Wu et.al.(2018)** investigates factors that significantly contribute to pedestrians violation at signalized intersections. A random parameters logistic regression was developed to discover the potential unnoticed heterogeneous effects across observations. Results showed that age, gender, group size, cell phone use, pedestrian signal type, pedestrian volume were statistically considerable in the model. Gender and age were found to notably affect red light running violations. It was found from study that red light violations in male pedestrians were 1.411 times more than female pedestrians. As for age, it was found that red light violation in young and middle-aged pedestrians were 1.654 and 1.253 times more than older pedestrians. It was due to the reason that risk taking behaviour of youngsters is greater as compared with older ones. Violation increases as the pedestrian volume increased. Cell phone use could extensively increase the pedestrian violations probability.

**Arpita Saha et. al. (2017)** computed the saturation flow considering right turning vehicles proportion, width of road, the traffic composition in the approach. The proposed formula represents saturation flow in vehicles/hr of green/lane to evade the monotonous job of computing PCU for different types of vehicle at signalized intersections. For heterogeneous traffic condition, developed saturation flow rate model can be effectively used at signal controlled intersections.

**Apoorv Jain et. al. (2016)** studied the concept of saturation flow at signal controlled intersections via taking into account the factors like turning movement, width of approach and traffic composition. It was observed that the proportions of 2-wheelers were showing increasing impact on saturation flow rate. Saturation flow of any approach decreases with the percentage of heavy vehicles in the traffic flow which is discharging from that approach. Saturation flow increases linearly with its approach width. Impact of Right Turning movements was studied and it was accomplished that with decrease in Right Turning vehicles proportion of the traffic flow saturation flow rate increases.

**LI Jieet. al.(2016)** compared the driver behaviour and saturation flow between China and the Netherlands. They found that the lanes utilization at signal controlled intersections in China was 20 to 30% poorer as compared to The Netherlands and also poorer as compared to standard saturation flow considered in accordance with the HCM on account of lack of traffic discipline. The reason behind different driving behaviour in Chinese cities from the Dutch cities were irregular and larger gaps in saturated traffic flows moreover, drivers have a tendency to alter lanes abruptly before and after the stop line in Chinese cities. In the first 10 sec the time headways were longer than those in the subsequent period during a green phase in the Chinese intersections due to the start lag which was not seen in the surveyed intersections in the Netherlands. The reason behind different start lag was due to the fact that reaction time of the drivers of The Netherlands to the alteration of the traffic signal is short. At the last part of the green time the time headways is likely to be converted into larger in china which is not seen in case of intersections in The Netherlands. The reason behind larger headway at the last part of green phase is long cycle time of signal.

**Yixin Chen et.al.(2015)** investigates impact of pedestrian flow characteristics on left turn lane group saturation flow rate. Data collection has been carried out through videography from which vehicular and pedestrian flow characteristics such as spatial location and speed have been extracted. To evaluate impact of pedestrians, average operation speed at Saturation Flow with and without pedestrian traffic was used. They found that the distance between the vehicle and pedestrians and position of pedestrian in the crosswalk significantly affect the saturation flow rate. But if the distance is less than four meter then only impact was significant beyond that limit impact can be neglected. They have divided impact between vehicle and pedestrians in four levels. They found that the Saturation Flow at best level is 15.7% higher as compared to worst level, which shows importance of consideration of pedestrian crossing behaviour. Effective traffic control and enforcement methods are required improve pedestrian crossing behaviour at signal controlled intersections.

**Chauhan Vishal &N. G. Raval (2015)** developed the saturation flow model for urban arterial road intersection based on width of approach, traffic compositions and gradient criteria. The developed models of saturation flow gave the accurate value of saturation flow. These developed models were calibrated & validated with field observed data. It has been observed that in estimation of Saturation Flow bus and auto rickshaw are most affected parameter. Observed saturation flow is more than the suggested by the IRC. Hence it is necessary to revise the saturation flow as per the field condition. Proportion of two wheelers is also significant factor affecting on the saturation flow due to higher composition.

**Subhaskumar C. Singh & N. G. Raval (2014)** had carried out study on development of saturation flow model for mixed traffic on urban arterial roads, intersection in Ahmedabad city. They have selected four intersections for concerned research work. Using linear regression analysis, they developed two regression models for saturation flow with based on gradient of an approach in percentage, width of an approach, proportion of all category vehicles. The results showed that the saturation flow rates methodology recommended by HCM can also be used in India. They concluded that models provide suitable results nearer to field observations.

**Chang-qiao SHAO et. al. (2011)** carried out study on the saturation flow rate with its influencing factors at signal controlled Chinese intersections. They have developed saturation flow rate model considering influencing factors such as approach grade, and left-turn radius, traffic composition and lane width. For selected left-turning lane and the through lanes base conditions at signal controlled intersections were suggested and base saturation flow of 1800 PC/hr/lane has been estimated which is not reliable with the HCM. With the purpose to improve exactness of model altered passenger car equivalent was used for different vehicle movement such as through movement and left-turning movement and Saturation Flow estimated accordingly. In case of

exclusive lane, the width of lane and turning-radius has noteworthy impact on the operation of the signal controlled intersection. They found that Saturation Flow resembles to base value when radius increases additionally, the lane no. also had significant impact on the saturation. Therefore, it was recommended that the selected LT have to be considered independently.

Nan JIANG et. al.(2011)carried out investigation of crossing behaviors of pedestrian at signal controlled crosswalk in Singapore and Beijing on usual workdays on dissimilar periods such as , i.e. regular periods, lunch periods, and peak periods. They had carried out correlation and hierarchical regression analysis through SPSS16.0. They found that as lane number increases pedestrian violation rate decreases.The intersection type had noteworthy impact on pedestrian violation as the violation rate at T-intersection was drastically lesser as compared to Cross-intersection. The result showed that for narrow road violation rate was higher. Unlawful group crossing was more noticeable in Beijing as compared to Singapore but in case of individual vulnerable pedestrians such as lame, women, old men violation rate was noticeable in Singapore as compared to Beijing. In both cities, they found that if there were less number of vehicles; violation rate increases as most pedestrians seen at the approaching vehiclesin preference to the traffic lights.

### III. CONCLUSION

In developed countries various saturation flow rate model is suggested which is based on homogeneous traffic condition where traffic flow follows lane discipline. However, in India, lane regulation is not properly followed because of heterogeneous traffic condition. Researchers have shown that saturation flow depends on geometry, traffic and control factors. Impact of these factors is mainly dependent on the driving culture, which is diverse in different countries. In developed and developing countries, violating pedestrian behaviour is a major factor of many traffic crashes but comparatively violating pedestrian behaviour is higher in developing countries than developed countries. Violating Pedestrians behaviour violation depends on various factors, such as individual characteristics, road and traffic conditions and environment factors. Demographic characteristics have been found to be imperative factors to pedestrian violating behaviours. The negative impact of vehicle's violation was greater than negative impact of pedestrian's violation. From past work it has been observed that gender and age significantly affect the pedestrian violating behaviour. The intersection type had noteworthy impact on pedestrian violation as the violation rate at T-intersection was drastically lesser as compared to Cross-intersection. The road width also affects pedestrian violation as the road width decreases, violating behaviour increases.

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