

# Analysis of Saturation Flow at Signalized Intersection in Urban Area: Surat

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## Abstract

Observations of Traffic Flow at certain urban centres are indicating variation in actual Traffic handling Capacity on links and at intersections which may be due to change in Density and subsequent change in Approach Velocity at intersection and Acceleration pattern. For safe and efficient movement of large volumes of traffic on city road network, majority of the intersections are usually signalized. The design, the capacity and operation of a signalized intersection critically depend on and passenger car unit (PCU) and saturation flow. The intersections on urban roads in India cater to heterogeneous motorized traffic along with slow-moving traffic including pedestrians. It is therefore necessary to consider passenger car unit (PCU) and saturation flow for mixed traffic conditions to evaluate the overall operation of signalized intersections. This paper presents the results of the study on analyses of saturation flow rate conducted at signalized intersections with mixed traffic condition in Surat. Traffic volume and speed data collected on urban road of Surat city by using Videographic Technique are analyzed to determine the saturation flow. Observations of traffic flow at certain urban centers are indicating variation in actual traffic handling capacity on links and at intersections, which may be due to change in density and saturation flow. Such situation needs to be evaluated to correctly predict the saturation flow as it is critical for designing signal cycle time and determining actual capacity of the road.

**Keywords:** Signalized Intersection, Saturation Flow, Mixed Traffic, Passenger Car Unit (PCU)

## I. INTRODUCTION

In developing countries like India, road traffic in general and urban roads traffic in particular, is highly heterogeneous comprising vehicles of widely varying static and dynamic characteristics and the vehicles share the same road space without any segregation. Also despite having lane markings, most of the times lane discipline is not followed particularly at intersections. Highway Capacity Manual and other works assume homogeneous and lane based traffic for analysis, which exists in developed countries. There is notable lateral movement at intersections and vehicles tend to use lateral gaps to reach the head of the queue and overtake even during saturated part of green phase. Due to these fundamental differences, the standard western relationships for predicting the values of saturation flows and PCU factors are not appropriate for developing countries like India. The most significant parameter that influences the design of signalized intersection and its signal plan is the "saturation flow". Saturation flow is a key factor determining the capacity and level of Service (LOS) of a signalized intersection. If the saturation flow rate can be computed to the reasonable accuracy, the capacity of the signalized intersection can be evaluated. In the present study, actual classified vehicular traffic flow during saturated green intervals of the green phases has been measured in the field to calculate the saturation flow. The observed saturation flow is then compared with the IRC recommended formula.

### A. Saturation flow rate:

Saturation flow rate (S) is 'The maximum rate of flow of vehicles that can pass through the intersection per unit time of effective green expressed in PCU/hr or PCU/sec'.

As recommended by IRC-41, Saturation flow(s) expressed in terms of Passenger Car Units (PCUs) per hr. and with no parked vehicles present is given by

$$S = 525 (w) \text{ PCUs per hr.}$$

where  $w$  = width of approach road in m.

This expression is valid for widths from 5.5 m to 18 m. For a lesser width the values may be obtained from the table

Width $w$ in metre	3.0	3.5	4.0	4.5	5.0	5.5
Saturation flow(s) in (PCUs)/hr.	1850	1890	1950	2250	2550	2990

## II. OBJECTIVE

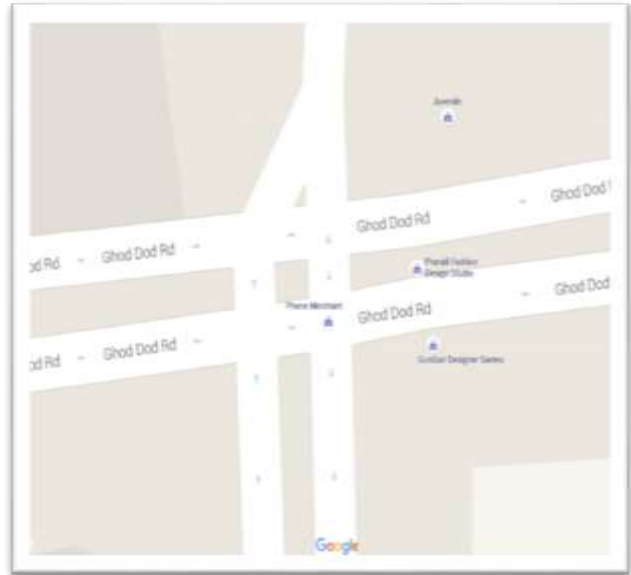
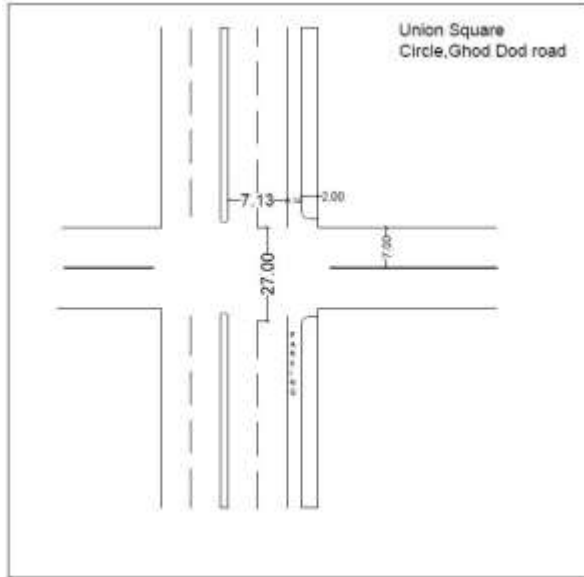
Comparative study of saturation flow with base saturation flow as per IRC

**A. Selected Study Area:**

Surat city is located 284 km south of the state capital, Gandhinagar, on the south of Tapti River (Tapi), the center being around 22 km from the river's mouth. Surat had a population of 4.6 million at the 2011 census, making it the second largest city in the state of Gujarat, after Ahmedabad. It is the eighth largest city and ninth largest metropolitan area of India. Surat has a Bus Rapid Transit System (BRTS). The major highways passing through Surat are the Udhana-Mumbai Highway also known as Udhana-Navsari Highway, Surat-Ahmedabad Highway also known as Varachha Main Road. The Golden Quadrilateral highway system passes through Surat. The city is connected to the National Highway 8 through a 16 km connector highway.

1) Intersection of surat city are selected as study area:

Selected intersettion is Union Square Intersection, Ghod dod road, Surat.



As part of roadway conditions data measurement of all approach widths at stop line, length and widths of taper, width of median, width of left slip roads, sidewalks etc. were taken manually on site by measuring tape. The number of lanes for turning traffic in each direction viz. straight/ through (TH) and right (RT) and left (LT) were also noted. The signal timing for each 4 phase of each approach was noted manually for all the intersections.

**B. Data collection:**

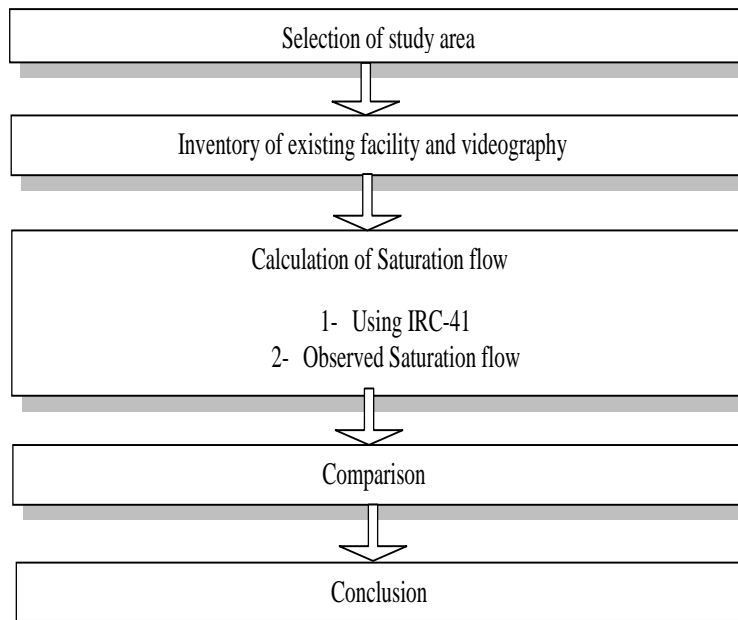
A video based photographic technique was used for data collection. The technique has the advantage of lesser requirement of manpower. The data collection does not interfere with the traffic movement and the storage of data is permanent.

In this study, traffic turning movement data of the subject approaches of the intersections was recorded by using a portable digital video camera mounted on the height at the corner of the intersection to cover all, three/two or one of the approaches of the intersection so that it clearly capture view of approach road from exit line (line joining ends of Channelizing islands) of both the through (TH) and right (RT) movements. Continuous pictures of the traffic flow were recorded with the video camera for peak morning period of 30 minutes on normal week days. Simultaneously data on signal timing i.e. cycle length, number of phases and phase length was collected manually.

Junction Name	Existing Cycle Length (sec)	Approach Name	Green Time + Amber Time (sec)	Movement	Approach Width (m)
Union Square Intersection	2:45	Athwa road approach	42+3=45	Straight, Right, Left	7.13

**III. STUDY METHODOLOGY**

In the present study attempt has been made to measure saturation flow in the field by actually measuring the flow at the stop line during saturated green phase and to study the impact of various influencing parameters such as road widths, traffic composition etc. based on actual field studies/experiments of the typical Indian traffic conditions. The systematic flow chart of methodology of this research work is depicted in Figure 1.



#### IV. DATA ANALYSIS

Data was collected during the morning peak between 10:00 to 12:00 AM. For data extraction an observation point is selected by playing a video clip recorded for the particular approach of the intersection. The observation point is normally the stop line. Start of the green is noted down from the video camera timer. A conventional stop watch timer is used to measure time in seconds. The video clip is paused at the moment the signal turns green, and the stop watch is set to zero. The video is played to count the vehicles crossed the stop line. This procedure continued until the signal turns red.

PCU value depends on the factors such as vehicle characteristics, roadway characteristics, climatic conditions, control conditions etc. The selected values are shown in the Table

In order to estimate the saturated green time, all vehicles passing an approach are counted for every interval. They are converted into passenger car unit as per values selected and shown in Table

PCU values used for calculation are mentioned below:

Serial Number	Class of Vehicle	PCU as per IRC SP-41-1994
1	Two Wheeler	0.5
2	Three Wheeler	1.0
3	Four Wheeler	1.0
4	Bus	3.0
5	Cycle	0.5

The different types of motor vehicles observed on the road stretch were divided in five categories as following:

- 1) Two-Wheelers (2W), which includes Motorcycles, Scooters and Mopeds,
- 2) Three-Wheelers (3W.), which includes Auto-Rickshaws and three wheeled goods vehicles,
- 3) Four wheelers (4W),
- 4) Buses, Trucks, Tempo (B/T),
- 5) Bicycles and Tricycles (Cycle)

Data collection and analysis for the following stretches during Peak hour are given:

Interval	Total PCU Unit	Avg. time headway (m/s)	Saturation Flow (PCU/h)	Saturation Flow As per IRC : 41 (PCU/h)
45 sec	103	0.62069	5800	3743.25
45 sec	54.5	1.525424	2360	3743.25
45 sec	57.5	1.232877	2920	3743.25
45 sec	63	1.2	3000	3743.25
45 sec	62.5	1.097561	3280	3743.25
45 sec	77.5	0.918367	3920	3743.25
45 sec	61	1.636364	2200	3743.25
45 sec	85.5	0.825688	4360	3743.25
45 sec	57	2.142857	1680	3743.25
45 sec	55	1.551724	2320	3743.25
45 sec	75.5	0.9375	3840	3743.25
45 sec	57.5	1.428571	2520	3743.25

(Value show in red is the maximum value which r observed on the field as compared IRC-41)

**A. Observed Saturation flow:**

The saturation flow rate on field measurements is done by measuring time headway.

However, due to the complexity of the traffic and road conditions, the base saturation flow rate cannot be observed directly and only can be estimated by using the field data collected on the conditions which are close to the base conditions.

The saturation flow rates are computed using the following equations:

$$\text{Saturation flow (S)} = 3600/\text{Average time headway (h)}$$

**B. As per IRC -4:**

A generalized formula is given in IRC SP-41 for direct calculation of saturation flow on the basis of road width i.e.  $S=525*W$  in absence of realistic saturation flow value. Using this formula the saturation flow for different approaches was also estimated for comparison purpose only.

$$S=525*(7.13) = 3743.25$$

**C. Comparison chart:**

It is also found that average saturation flow obtained through field studies is higher than the saturation flow obtained by generalized formula  $S=525*W$  of IRC SP-41.

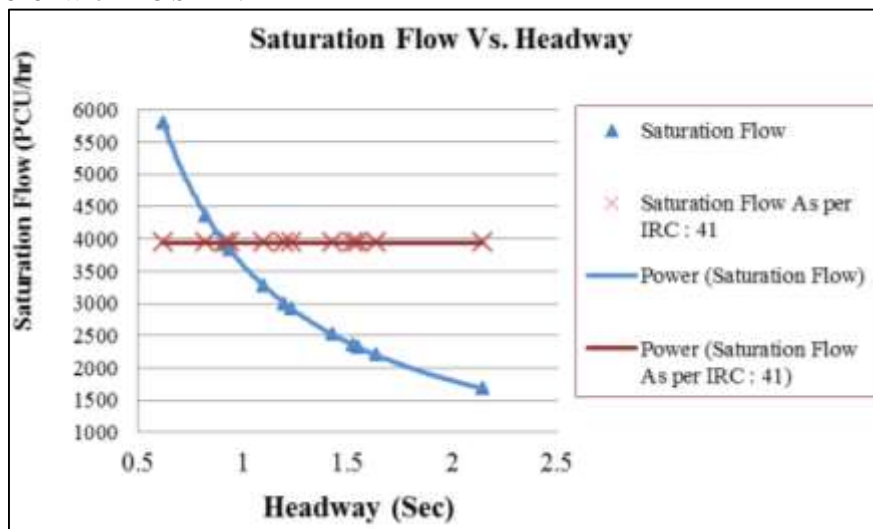


Fig. 1: Saturation Flow vs. Headway

Approach name	Width (m)	Observed Max Saturation flow (PCU/h)	Saturation flow as per IRC-41 formula $525*w$ (PCU/h)
Union Square Intersection, Athwa road approach, Surat	7.13	5800	3743.25

**V. CONCLUSION**

It is found that the Saturation flow obtained through field studies is higher than the saturation flow obtained by generalized formula  $S=525*W$  of IRC SP-41.

It is found that with increasing proportion of two wheeler, saturation flow per meter width also tends to increase due to heterogeneity and filling of gaps by two wheelers, while with increase in proportion of cars the saturation flow tend to decrease due to more homogeneity.

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