ANALYSIS OF SATURATION FLOW AT SIGNALIZED INTERSECTIONS IN URBAN AREA

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ABSTRACT

This project deals with the analysis of saturation flow at signalized intersections in urban areas. At-grade intersections are one of the most important elements that control the performance of road network. For efficient and safe movement majority of the intersections are signalized and large volumes of traffic on city road network. The capacity, the design and operation of a signalized intersection critically depend on passenger car unit (PCU) and saturation flow. Operation and Performance of signalized intersections is influenced by the operating parameters, traffic condition, roadway parameters and environmental conditions along with user's behavioral characteristics which significantly differ among locations. The intersections on urban roads in India cater to heterogeneous motorized traffic along with slow-moving traffic including pedestrians. Therefore, it is necessary to consider saturation flow for mixed traffic conditions and passenger car unit (PCU) to evaluate the overall operation of signalized intersections.

KEYWORDS: Passenger Car Unit (PCU), Signalized Intersection, Saturation Flow and Mixed Traffic.

I. Introduction

India could be a developing country and its cities are undergoing fast urbanization and modernization as a result there is increase in the road traffic growth. Traffic movement in Bharat is terribly advanced due to the heterogeneous traffic stream sharing the same carriage way. Additionally despite having lane markings, most of the times lane discipline is not followed particularly at intersections. Highway capability manual and other works assume homogeneous and lane primarily 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 throughout saturated half of inexperienced part. Due to these fundamental variations, the customary western relationships for predicting the values of saturation flows and PCU factors aren't applicable for developing countries like INDIA.

In the gift study, actual classified vehicle traffic flow during saturated inexperienced intervals of the in experienced phases angular distances been measured in the field at completely different approaches of four intersections to calculate the saturation flow. PCU values for various vehicles are calculable based on space and clearance time magnitude relation of different vehicles as compared with that of the customary automobile as obtained from field data. Saturation flow obtained in terms of variety of various vehicles are reborn into PCU by applying IRC price obtained from the sector with exploitation the PCU factors as per IRC-SP-41. Models have additionally been developed

for estimation of saturation flow for different approach widths and different proportion of two wheelers and cars at signalized intersection for non-lane primarily based mixed traffic conditions of Hyderabad. The paper further compares the results of saturation flow as obtained from the derived model and actual field saturation flow obtained exploitation field calculable. PCU values there up on obtained exploitation the U.K model and PCU factors as per IRC-SP-41. It's found from the analysis that the derived model provides better results.

1.1 AUDIENCE FOR THIS GUIDE

This guide is meant for planners, designers, and operations analysts United Nations agency perform, or wish to perform, one or additional of the subsequent functions as they pertain to signalized intersections Evaluate substantive safety performance tough by users of the system. Evaluate operational performance tough by users of the system. Identify treatments that might address a selected operational or safety deficiency. Understand elementary user wants, signal temporal arrangement or geometric style components and traffic style components. Understand the impacts and tradeoffs of a selected intersection treatment. It is visualized that this guide are going to be utilized by planners, engineers and decision makers who are attached the look, design and operation of signalized intersections, notably those with high volumes. Are attached the identification of potential treatments. Make selections relating to the implementation of treatments at those intersections.

1.2 INTERSECTION

Intersection is a vicinity shared by two or additional roads. This space is selected for the vehicles to show to totally different directions to achieve their desired destinations. Its main operate is to guide vehicles to their individual directions. Traffic intersections square measure advanced locations on any road. This is often as a result of vehicles occupation totally different direction wan to occupy same area at a similar time. Additionally, the pedestrians conjointly get same area for crossing. Drivers need to build blink of call at an intersection by considering his route, intersection pure mathematics, speed and direction of alternative vehicles etc.

1.2.1 Conflicts at associate degree intersection

Conflicts at associate degree intersection square measure totally different for various kinds of intersection. Think about a typical four-legged intersection as shown in figure. The quantity of conflicts for competitor through movements square measure four, where as competitor right flip and thru movements square measure eight. The conflicts between rights flip traffics square measure four, and between left flip and merging traffic is four. The conflicts created by pedestrians are eight taking into consideration all the four approaches. Diverging traffic conjointly produces concerning four conflicts. Therefore, a typical four leg like intersection has concerning 32 different types of conflicts.

1.2.2 Levels of intersection management

The management of associate degree intersection may be exercised at totally different levels. They'll be passive management, active management or semi control. In passive management, there's no express management on the driving force. In semi management, some amount of management on the driving force is there from the traffic agency. Active management means that the movement of the traffic is totally controlled by the traffic agency and therefore the drivers cannot merely man oeuvre the intersection according to his choice.

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II. LITERATURE REVIEW

The analysis allotted earlier within the fields relating to this study is reviewed during this chapter. Although a number of the areas of analysis cited don't seem to be directly related to this work, the results of the works reviewed have a substantial bearing on the abstract framework of this study. Stress is placed on the research on saturation rate estimation, PCU issue development and back research on saturation rate estimation, PCU issue development and back propagation primarily based neural network modeling. The methodology advised by route capacity manual (2000) is mentioned intricately to review the quality of the application of this procedure to Indian urban traffic conditions and to counsel appropriate modifications.

2.1 Webster's Analysis:

The pioneering study relating to the signalized intersections is reported by Webster (1958). The fundamental ideas projected by Webster are still being followed and the signal style supported his theory is taken into rate as associate indicator of the capability of the approach to a signalized account as a regular procedure in several countries. Webster has treated the saturation intersection and supported in depth analysis, he has proposed associate equation for the estimation of saturation rate. In step with Webster, saturation rate in PCU/hour, S is given by S=525w, wherever 'w' is that the approach dimension offered for the movement in m. so as to require into thought the different kinds of vehicles Webster has additionally advised a group of PCU factors to be adopted at a signalized intersection. His work deals extensively with the corrections and modifications to saturation rate underneath totally different section patterns Webster observed that for given traffic and road factors, the typical delay to a vehicle depends on the cycle length, If the cycle is just too short, the delay are terribly high and if the cycle is just too long, then additionally the delay are extremely high. Webster has suggested that for given conditions, there'll be a cycle time wherever the delays are minimum and he referred to as it because the optimum cycle time. Saturation rate plays a serious role in influencing the optimum cycle time. Webster has additionally studied the transport delays at signalized intersections and he has suggested associate equation for the delay estimation supported simulation of traffic.

Studies on Mixed Traffic Equivalency Factors Nagaraja, Saint George and John (1990) have conducted studies on lateral and linear placements of vehicles below mixed traffic state of affairs. Their analysis is predicted on the observations of traffic in mid-blocks of Calicut ton through videographer. They have proposed mixed traffic equivalents for various modes supported the influence space of a mode. They need rumoured that in mixed traffic state of affairs the flow admire capacity condition will have wide variable values relying upon the degree of freedom enjoyed by vehicles. It's conjointly rumoured that the PCU values developed within the study are considerably completely different from the values planned by earlier works due tohigh proportion of Auto-Rickshaws within the traffic stream. The lateral and linear spacing's of vehicles in mixed traffic are studied by Anjaneyulu, Phani Kumar and Nagaraja (1998) victimization neural networks.

Justo and tuladhar (1984) have planned the construct of influence space of a vehicle that extends on the far side the static dimension of a vehicle and supported the influence exerted by a specific mode the PCU factors are planned for varied modes. The probabilistic pavement occupancy construct is planned by Agarwal, Jainand Khanna (1994) in their study on mixed traffic behavior at 3 legs like intersections. The study determined that the effective traffic will increase because the vehicles approach the intersection and supported the pavement occupancy of the vehicles at the intersection the researchers have planned railway car Equivalents for the mixed traffic conditions. Satish, Virendra Kumar and Sikdar (1990, 1993 and 1995) have proposed that the PCU issue for a mode in a very mixed traffic surroundings doesn't depend solely on the static dimensions and therefore the operational characteristics of the vehicles and it's a dynamic issue. Supported their observations of traffic within the field they need suggested completely different sets of PCU factors that may facilitate within the capability estimation of the intersections. Bhattacharya and mandal (1980) investigated the traffic at the uncontrolled intersections of Calcutta town and railway car equivalents were planned for different modes supported their observations. Tamizharasan etal (1993, 1995 and 1999) have used the saturated inexperienced time for the event of PCU factors and therefore the saturation flow rates supported these factors

are planned for the signalized intersection approaches below heterogeneous traffic conditions. Tamizharasan observed from his study that the saturation rate for a lane of three.5 m works dead set be over 1800 PCU/hr, a price planned by the HCM.

2.2 Studies on Performance analysis of Signalized Intersections:

Kara and raheel (2000) analyzed the impacts of various light-weight duty trucks (LTDs) on the capability of signalized intersections. Multivariate analysis generated estimates of headways related to varied classes of LDTs in addition as passenger automobiles and calculated railway car equivalents. It had been instructed that the impacts of LDTs were to be special thought once analyzing the capability of signalized intersections. Bradon associate degreed nagui (2002) summarized the results of an empirical study of lane volume information associate degreed provided an analysis of six lane choice strategies won too estimate lane flows. The lane choice ways were used as half of the subgroup approach for estimating saturation flows. The analysis indicated that the choice strategy supported equal back of queue or cycle average queue provides the most effective prediction of lane volumes and these results indicated three international capability guides victimization associate degree equal flow magnitude relation or degree of saturation strategy for estimating lane flow would like an outsized information effort to verify the results.

Satish Chandra and Upendra Kumar (2003) have planned a thought to estimate the PCU issue for a mode in a very mixed traffic surroundings utilizing space concept. It had been found that the PCU for a vehicle kind will increase linearly with the dimension of roadway. This was attributed to the bigger freedom of movement on wider roads and thus a bigger speed differential between a automobile and a vehicle kind. The capacity of a two lane road conjointly will increase with total dimension of the roadway and therefore the relationship between 2 follows a second degree curve and this relationship was used to derive the adjustment factors for substandard lane widths.

Ibrahim, zeinab and reza (2004)planned a simulation model for transport dynamics victimization probabilistic cellular automata and evaluated the delay old by the traffic for specified time intervals and a few traffic responsive indication algorithms were proposed for optimum indication of traffic lights supported the construct of cut-off queue length and cut-off density.

Huang and jianping (2004) studied the bicycler behaviour resembling crossing speeds, crossing gap/lag acceptance and cluster riding behaviour at a symbol controlled intersection and applied mathematics information analysis was conducted to work out the across group behaviour of cyclists helpful for understanding the performance of mixed traffic at signalized intersections and to create microscopic simulation models. Li, Yuen and Wong (2004) studied a grey system theory- primarily based technique for the quantitative evaluation and ranking of the operational safety performance of signalized intersections in urban areas below mixed traffic conditions. 5 index parameters, the degree of saturation, the typical stopped delay, queue length, the conflict magnitude relation and separation magnitude relation are planned within the technique and therefore the results showed that the tactic can be wont to comprehensive performance analysis and ranking of signalized intersections with urban road network systems.

III. METHODOLOGY

3.1 GEOMETRIC DESIGN

This chapter presents geometric style pointers for signalized intersections supported a review of technical literature and current style policy within the use. Geometric style of a signalized intersection involves the practical layout of travel lanes, curb ramps, crosswalks, bike lanes, and transit stops in each the horizontal and vertical dimensions. Geometric style contains a profound influence on road safety; it shapes road user expectations and defines a way to proceed through an intersection wherever several conflicts exist. In addition to safety, geometric style influences the operational performance for all road users. Minimizing impedances, eliminating the necessity for lane changes and merge manoeuvres, and minimizing the specified to traverse an intersection all facilitate improve the

operational potency of an intersection. The needs of all potential road users should be thought of to realize best safety and operational levels at an intersection. At times, style objectives could conflict between road user groups; the professional person should rigorously examine the requirements of every user, establish the tradeoffs related to every part of geometric style, and create selections with all road user teams in mind.

This addresses the subsequent topics:

- Principles of channelization.
- Range of intersection approaches.
- Intersection angle.
- Horizontal and vertical alignment.
- Corner radius and curb ramp style
- Detectable warnings.
- Access management.
- Sight distance.
- Pedestrian facilities.
- Bicycle facilities.

3.2 TRAFFIC DESIGN AND ILLUMINATION

The stoplight hardware and code the infrastructure that controls the assignment of conveyance and pedestrian right-of-way at locations wherever conflicts or dangerous conditions exist. The right application and style of stoplight could be a key element in up the protection and potency of the intersection. This chapter presents an outline of the elemental principles of traffic style and illumination as they apply to signalized intersections. The topics mentioned include:

1. Stop (or) traffic signal management sort.
2. Traffic signal phasing.
3. Vehicle and pedestrian detection.
4. Traffic signal pole layout.
5. Traffic signal controllers
6. Basic signal temporal order parameters.
7. Signing and pavement marking.
8. Illumination.

Field surveys were exhausted order to gather the subsequent parameters:

- Roadway/Approach conditions and operational parameters
- Traffic conditions

As a part of route conditions information activity of all approach widths at stop line, length and widths of taper, breadth of median, breadth of left slip roads, size of channelizing, sidewalks etc were taken manually on site by measurement tape and measurement wheel. The amount of lanes for turning traffic in every direction viz straight through (TH) and right (RT) were additionally noted. The signal temporal order for every colony of each approach was noted manually for all the intersection. Roadway condition and operational data for various approaches for all the selected intersections are given below table:

Geometric and operational details of the intersections:

INTERSECTIONS	TRAFFIC APPROACH FROM	WIDTH (M)	CYCLE TIME (SEC)	GREEN TIME (SEC)	AMBER TIME (SEC)	RED TIME (SEC)
Uppal ring road	Uppal bus stop (NB)	9.0	128	30	3	90
	Ramanathapura-m (SB)	10.3	128	20	3	100
	Survey of India (EB)	11	128	30	3	90
	Nagole (WB)	12	128	30	3	90
Tarnaka	Uppal ring road (NB)	10	160	45	3	120
	Habsiguda (SB)	12.5	160	45	3	120
	Lalapet (EB)	10	160	45	3	120
	Osmania university (WB)	11	160	45	3	120
Ecil	Kushiguda (NB)	9.4	140	60	3	140
	Moula ali (SB)	12	140	60	3	140
	Radhika (EB)	14	140	60	3	140
	NTPC (WB)	10	140	60	3	140
Alkapuri	Nagole (NB)	14	120	60	3	100
	L.B.Nagar (SB)	14	120	60	3	100

NB=NORTH BOUND; SB= SOUTH BOUND; EB= EAST BOUND; WB=WEST BOUND

Traffic condition information deals with the sphere traffic flow patterns (traffic volume) of various turning movements, traffic composition, clearance/speed time of various vehicles at every section of the signal at completely different approaches of the signalized intersections during this study, traffic turning movement information of the subject approaches of the intersections was recorded by employing a transportable digital video camera mounted on the 6m (20ft) high stand at the median or alternatives island or at a viewpoint at the corner of

the intersection to hide all, one or two or three in all the approaches of the intersection in order that it clearly capture read of approach road from exit line (line connection ends of channelizing islands) of each the through (TH) and right (RT) movements up to regarding 10m within the stop line on the top approach. Continuous footage of the traffic flow were recorded with video camera for peak morning amount of two or three hours between 9:00 am to 12:00 afternoon on traditional week days. Simultaneously information on signal temporal order i.e. cycle length, range of sections and phase length was collected manually.

These values saturation flow were calculable in PCU per hour for every approach as shown in below table:

$$PCU_i = (V_c \times A_i) / (V_i \times A_c)$$

$$= (A_i \times t_i) / (A_c \times t_c)$$

PCU_i = railcar Unit of car kind i
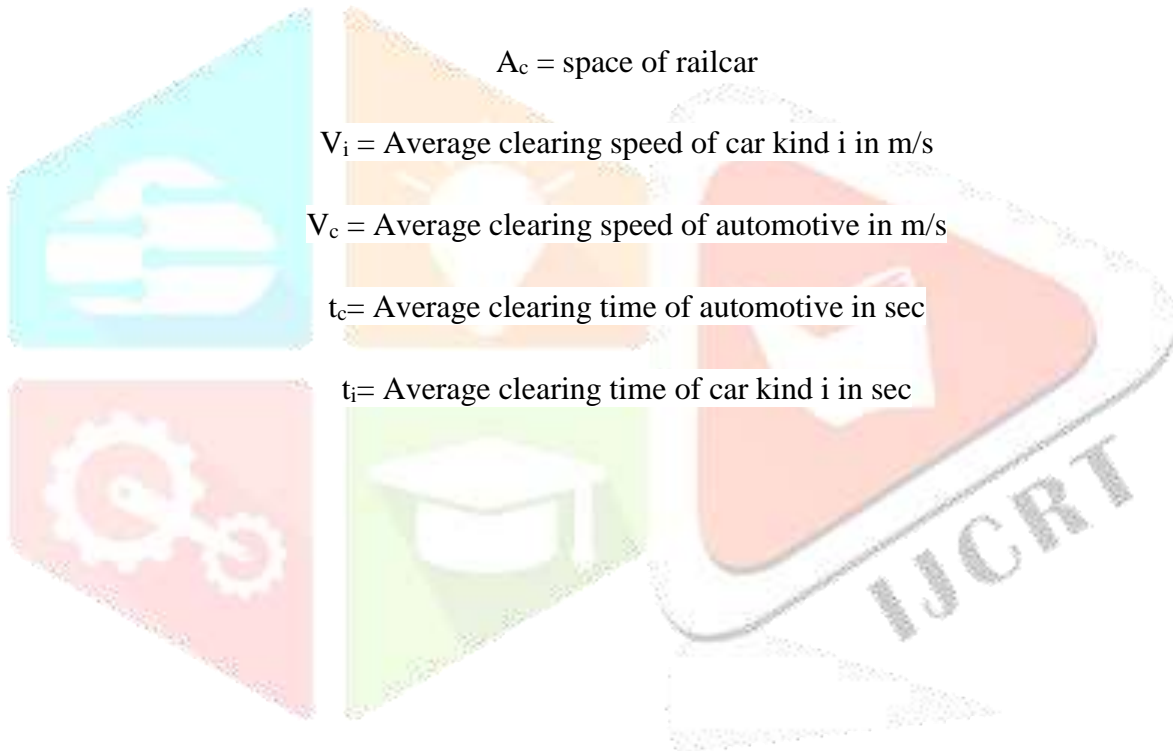
A_i = space of ith vehicle

A_c = space of railcar

V_i = Average clearing speed of car kind i in m/s

V_c = Average clearing speed of automotive in m/s

t_c= Average clearing time of automotive in sec

t_i= Average clearing time of car kind i in sec

Estimated PCU values at different vehicles at different approaches

Approach road	Approach width	Jeeps/ cars/ van/ taxi BIG AND SMALL	THREE WHEELERS (AUTO-RICKSHAWS)	TWO WHEELERS (MOTOR CYCLES/ SCOOTERS)	NON-MOTORIZED TRAFFIC (NMT) BICYCLES AND CYCLE RICKSHAWS
Uppal bus stop (NB)	9.0	1.56	0.84	0.15	0.76
Ramanthapurm (SB)	10.3	1.54	0.86	0.16	0.74
Survey of India (EB)	11	1.32	0.87	0.14	0.72
Nagole (WB)	12	1.64	0.85	0.12	0.80
Nagole (NB)	14	1.58	0.9	0.26	0.68
L.B.Nagar (SB)	14	1.48	0.8	0.28	0.82
Average	11.72	1.52	0.85	0.19	0.75

Saturation flow was calculated for every approach by exploitation formula given below:

S = (total number of vehicle (PCU) / saturated green time in sec)x 3600

S= Saturation Flow in vehicle/h OR (PCU/h)

Comparison of measured saturation flow (pcu/h) of different approaches calculated using different pcu factors/ methods:

INTERSECTION	APPROACH NAME	WIDTH (M)	SATURATION FLOW (PCU/h)		
			Field estimated S S=525xW	As per IRC SP-41	pcu as per IRC SP 41
Uppal ring road	Uppal bus stop (NB)	9.0	6567	6910	4725
	Ramanathapuram (SB)	10.3	5450	5550	5407
	Survey of India (EB)	11	7820	6180	5775
	Nagole (WB)	12	7900	6358	6300
Tarnaka	Uppal ring road (NB)	10	8050	7998	5250
	Habsiguda (SB)	12.5	10,100	9500	6563
	Lalapet (EB)	10	7600	7755	5250
	Osmania university (WB)	11	7769	8050	5775
Alkapuri	Nagole (NB)	14	7800	8050	7350
	L.B.Nagar (SB)	14	7000	5780	7350

IV.CONCLUSION

The project clearly emphasize the requirement for estimation of PCU values supported actual field studies at the signalized intersections for his or her analysis and performance as these area unit found to vary significantly as compared to IRC PCU values. Estimated PCU worth's area unit determined to offer higher however consistent value of saturation flow for various approach widths as compared to IRC-PCU values. Calculable PCU values offer consistent worth of saturation flow per meter dimension of approach for all the approaches. However calculable values of PCU fail to elucidate the variation of saturated flow throughout totally different saturated in experienced phases of same approach which can be attributed its sensitivity to composition and also the variable composition of traffic throughout different inexperienced phases of signal. It affirms that PCU values at signalized intersections area unit extremely dynamic and more emphasizes the requirement of estimation of PCU values supported totally different comprehensive approach.

It's found that with increasing proportion of two wheeler, saturation flow per meter dimension additionally tends to extend because of non-uniformity and filling of gaps by two wheelers, while with increase in proportion of cars the saturation flow tend to decrease because of a lot of homogeneity.

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