International Journal of Advance Research in Science and Engineering
Vol. No.5, Issue No. 10 , October 2016
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

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. For correct these parameters ought to be calculable primarily based on the native prevailing traffic conditions and hence requires a completely different approach of analysis.

There are no correct pointers obtainable to estimate saturation flow for non-lane based heterogeneous traffic conditions. Impact of lack of lane discipline on capacity analysis must be thought of. The most vital parameter that influences the look of signalised intersection and its signal arrange is that the "saturation flow". Saturation flow could be a key issue determining the capability and level of Service (LOS) of a signalized intersection. The

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

saturation flow rate will be computed to the cheap accuracy, the capability of the signalized intersection will be evaluated.

1.1 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. A little error in judgement will cause severe accidents. It conjointly causes delay and it depends on kind, geometry, and sort of management. Overall traffic flow depends on the performance of the intersections. It conjointly affects the capability of the road. Therefore, each form the accident perspective and therefore the capacity perspective, the study of intersections important for the traffic engineers particularly within the case of urban situation.

1.2 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 right 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. This is often shown in fig. The essence of the intersection management is to resolve these conflicts at the intersection for the safe and economical movement of each traffic and pedestrians. Two strategies of intersection controls square measure there: sharing and area sharing. The sort of intersection management that must be adopted depends on the traffic volume, value concerned, road geometry, importance of the road etc.

1.3 Levels Of Intersection Management

The management of associate degree intersection may be exercised at totally different levels. They'll be either 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 maneuver the intersection according to his choice.

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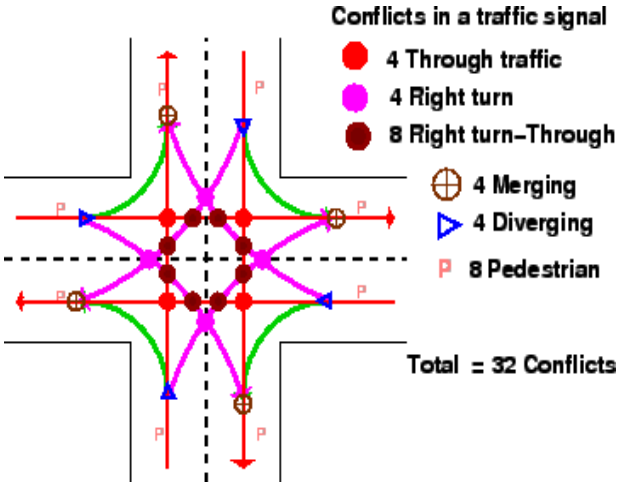

CONFLICTS AT AN INTERSECTION

As we tend to mentioned earlier, grade-separated intersections are provided to separate the traffic within the vertical grade. But the traffic needn't be those bearing on road solely. Once a railway line crosses a road, then also grade separators are used. Differing types of grade-separators are flyovers and interchange. Flyovers itself are subdivided into bridge and subway. Once two roads cross at some extent, if the road having major traffic is elevated to a better grade for any movement of traffic, then such structures are referred to as bridge. Otherwise, if the key road is depressed to a lower level to cross associate other by means that of an below bridge or tunnel, it is called under-pass. Interchange could be a system wherever traffic between two or additional roadways flows at completely different levels within the grade separated junctions. Common forms of interchange embrace trumpet interchange, diamond interchange and cloverleaf interchange.

1. Trumpet interchange: Trumpet interchange could be a well-liked sort of 3 leg interchange. If one amongst the legs of the interchange meets a road at some angle however doesn't cross it, then the interchange is termed trumpet interchange.
2. Diamond interchange: Diamond interchange could be a well-liked sort of four-leg interchange found within the urban locations wherever major and minor roads crosses. The vital feature of this interchange is that it are often designed albeit the key road is comparatively slender.
3. Clover leaf interchange: its additionally a four leg interchange and is employed once two highways of high volume and speed see one another with significant turning movements. The most advantage of interchange intersection is that it provides complete separation of traffic. Additionally, high speed at intersections can be achieved. However, the disadvantage is that enormous space of land is needed. Therefore, cloverleaf interchanges are provided primarily in rural areas.

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IJARSE
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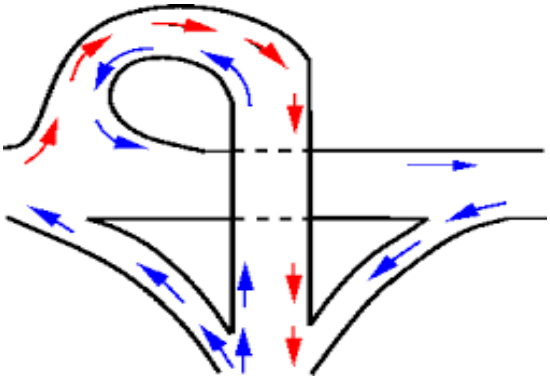
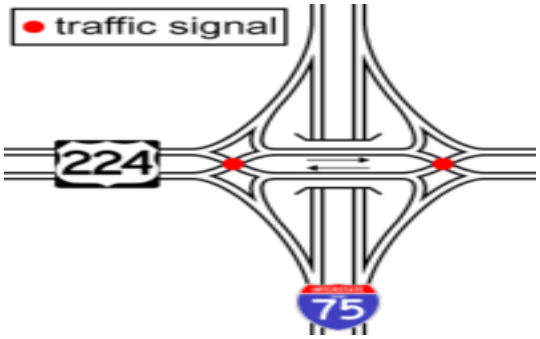
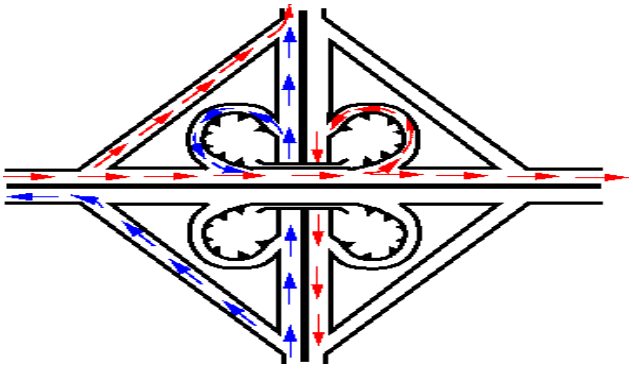


TRUMPET INTERCHANGE



DIAMOND INTERCHANGE



CLOVER LEAF INTERCHANGE

1.4 Channelized Intersection

Vehicles approaching associate intersection are directed to definite methods by islands, marking etc. and this methodology of management is termed direction. Channelized intersection provides a lot of safety and potency. It reduces the number of potential conflicts by reducing the realm of conflicts out there within the roadway. If no channelizing is provided the driving force can have less tendency to scale back the speed whereas getting into the intersection from the carriage way. The presence of traffic islands, marking etc. forces the driving force to scale back the speed and becomes more cautious where as manoeuvring the intersection. A channelizing island additionally is a refuge for pedestrians and makes crossing safer. Direction of traffic through a legged intersection.

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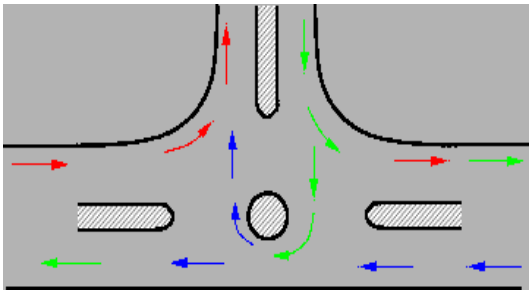
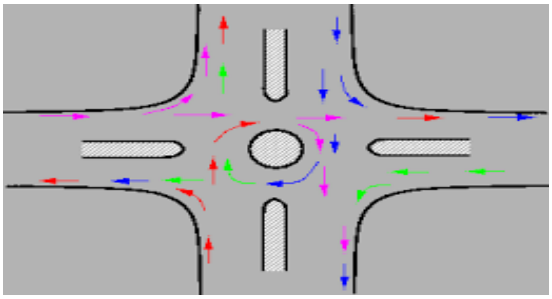
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346



CHANNELIZATION OF TRAFFIC THROUGH A THREE-LEGGED INTERSECTION



CHANNELIZATION OF TRAFFIC THROUGH A FOUR-LEGGED INTERSECTION

II. LITERATURE REVIEW

2.1 Studies On Performance Analysis Of Signalized Intersections

2.1.1 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.

2.1.2 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 wont to estimate lane flows. The lane choice ways were used as half of the sub group 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 victimisation associate degree equal flow magnitude relation or degree of saturation strategy for estimating lane flow would like an outsized information assortment effort to verify the results.

2.1.3 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 two follows a second degree curve and this relationship was used to derive the adjustment factors for substandard lane widths.

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ISSN (O) 2319 - 8354
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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.

The result of heterogeneousness of traffic on saturation flow and performance and capability analysis of signalized intersections. Road capability manual (or) highway capacity manual (HCM) provides basis for the capability analysis supported estimation of saturation flow based mostly on headway measurements at stop line throughout saturated flow condition for ideal base conditions of uniform traffic and lane etymologizing and applying adjustment factors to account for various influencing parameters. This approach is being wide employed in most of the developed countries because it represents their traffic conditions. Within the gift study try has been created to live saturation flow within the field by actually measurement the flow at the stop line throughout saturated inexperienced part and to check the impact of various influencing parameters like traffic composition and road widths etc supported actual field studies/experiments of the standard Indian traffic conditions. The systematic flow chart of this analysis work is represented in below flow chart.

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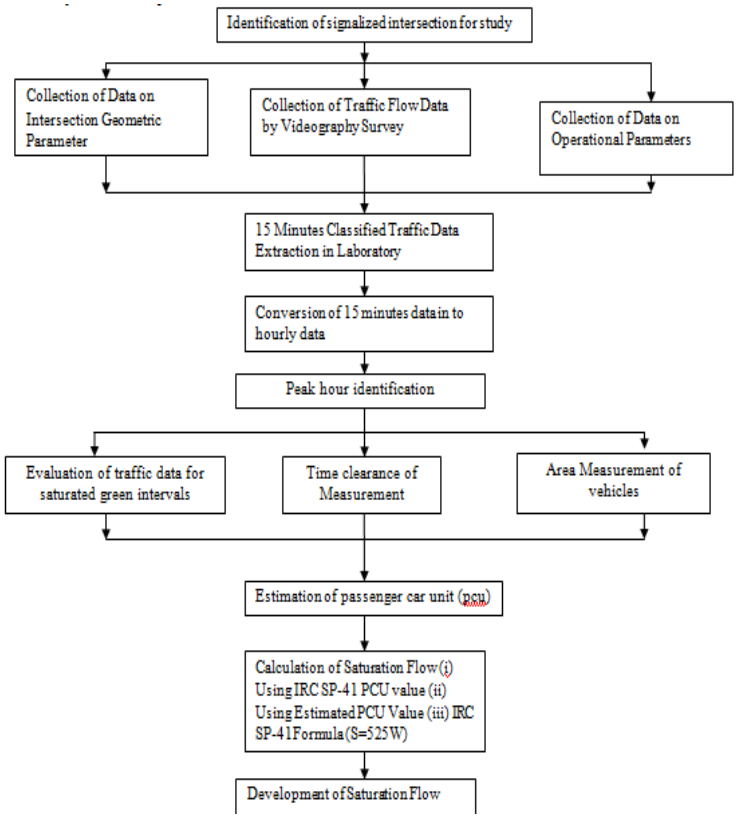

Field surveys were exhausted order to gather the subsequent parameters:

- 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, side walks 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	9
	Ramanathapuram-m(SB)	10.3	128	20	3	100
	Survey of India (EB)	11	128	30	3	90

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

	Nagole (WB)	12	128	30	3	90
Nagole (WB)	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.

The recorded films were replayed within the laboratory on an oversized screen so as to retrieve the specified knowledge information for the study. Within the initial section 15 minute classified traffic turning movement knowledge were retrieved for entire period of survey for all the approaches so as to work out peak hour, peak issues, traffic composition, peak hour traffic volumes, share of turning traffic etc. for every approach, turning movement and intersection. Saturated inexperienced amount for the inexperienced time of the topic movement was taken from five seconds when the onset of the inexperienced section until the tip of dissipation of queue length. In order to retrieve the saturated inexperienced intervals for individual inexperienced phases throughout peak hour video records were replayed for individual inexperienced phases before really retrieving the classified movement knowledge for individual saturated inexperienced intervals of signal phases of the topic approaches. Throughout every saturated green interval of peak hour clearance time of various vehicles were conjointly retrieved on random sample bases in order to estimate PCU values throughout saturated flow. Clearance time was taken as time of auto occupying the intersection common space/area from finish of edge line at entry to

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

finish of edge line at exit (entry of front bumper at entry line to exit of rear bumper at exit line). PCU values were calculated victimization equation developed by Chandra and Kumar and victimization these values saturation flow was calculable in PCU per hour for every approach. Finally, saturation flow model is developed for non-lane based mostly mixed Indian traffic conditions

Data Analysis:

Data analysis of varied traffic characteristics like traffic volume, traffic composition, peak hour traffic volume, peak hour issue and traffic composition etc. was in serious trouble every turning movement, every approach and intersection as whole for every intersection. Classified traffic knowledge for saturate inexperienced intervals of all the phases of through (TH) and right turning (RT) movements were supplemental to calculate the typical saturation flow (number of vehicles per hour green) as there have been no quarantined lane for through (TH) and right turning (RT) movements of the various approaches. PCU factors for various categories of vehicles were calculable for saturated flow condition victimization equation developed by Chandra and Kumar and victimization. These values saturation flow were calculable in PCU per hour for every approach as shown in below table:

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
Ramanathapura (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 Saturation Flow Obtained exploitation calculable PCU, IRC SP-41 PCU and IRC SP-41Empirical Formula:

Classified saturation flow information of all the height hour cycles were accustomed get average saturation flow for every approach. The measured price of average Saturation Flow of various approaches of study intersections expressed in terms of PCU per hour exploitation calculable PCU values, IRC SP- forty one PCU

values [25] and

estimated as per equation S=525W as given by IRC SP-41as per UK technique has been conferred. The average saturation flow completely of various approaches is found to vary at different approaches. it's conjointly found that average saturation flow obtained through field studies is higher in both cases once expressed exploitation field calculable PCU values and IRC SP-41 PCU values than the saturation flow obtained by generalized formula S=525*W of IRC SP-41.

It is conjointly found that saturation flow measured within the field exploitation IRC SP-41 PCU values isn't consistent with the widths of approaches. The worth of saturation flow for approach breadth of 9.7 m is lower than that for 9.4 m approach breadth. Similarly the saturation flow for approach breadth 10.3 m and 11.7m are lower than that of approach widths of 10.0 m and 11.0 m severally and is contradicting. While the saturation flow obtained within the field exploitation estimated PCU values from (field data) area unit found to be consistent with approach widths and reflects have an effect on of tiny variation in widths logically.

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

INTERSECTIONS	TRAFFIC APPROACH FROM	WIDTH (M)	SATURATION FLOW (PCU/H)		
			FIELD ESTIMATE	AS PER IRC SP-41PCU	AS PER IRC SP-41 S=525XW
Uppal ring road	Uppal bus stop (NB)	9.0	6567	6910	4725
	Ramanathapuram-m(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	10100	9500	6563
	Lalapet (EB)	10	7600	7755	5250
	Osmania university (WB)	11	7769	8050	7350
Alkapuri	Nagole (NB)	14	7800	8050	7350
	L.B.Nagar (SB)	14	7000	6780	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

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

approaches. However calculable values of PCU fail to elucidate the variation of saturated flow throughout totally different saturated inexperienced phases of signal. It affirms that PCU values at signalized intersections are 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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