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ANALYSIS OF SATURATION FLOW AT SIGNALIZED INTERSECTIONS

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Abstract - *This project deals with the saturation flow at signalized intersection in urban area. It help in evaluating the efficiency and effectiveness of the control devices like signal system ,the remedial measures for accidents etc. The design, the capacity and operations of a signalized intersection depends on the passenger car unit (PCU) and saturation flow. In India the traffic movement is complex due to heterogeneous traffic stream along with slow moving traffic including pedestrians. Therefore, it is necessary to consider saturation flow and PCU to evaluate the overall operation of signalized intersection.*

Key Words: Passenger Car Unit (PCU), Saturation Flow, Signalized Intersection, Heterogeneous Traffic

1. 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 the 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 ".It 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.

2. METHODOLOGY

2.1 Study Area

A four armed pre- timed signalized intersections were selected for the present study having different approach widths ranging from 7.5m to 9.75m.Intersections selected for this study have level gradient on all approaches and least interference to entry or exit traffic due to pedestrians, bus stops, parked vehicles, etc. All the approaches of the intersections reach saturated stage for whole or majority of the green interval during almost each phase during peak hour as traffic flow is very heavy. Two selected signalized intersections are :

1. Cheranalloor intersectiion
2. Vytilla intersection

2.2 Data Collection

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 a stand to cover all approaches of the intersection so that it clearly capture view of approach roads. Continuous pictures of the traffic flow were recorded with the video camera for peak morning period of two to three hours between 9:00 am to 12:00 noon and evening period of 4:00 pm to 6:00 pm on monday and friday.

Simultaneously data on signal timing i.e. cycle length and clearance time of different vehicles at each phase of the signal at each phase of the signal at different approaches of the signalized intersections was collected manually.

Table -1: Geometric And Operational Details Of Signalized intersection

Intersection	Approach From	Width(m)	Cycle Time (s)	Green Time	Amber Time	Red Time
Cheranalloor	Edapally	9.75	121	25	3	90
	Aluva	7.5	121	25	3	90
	Paravur	9.75	121	25	3	90
	Ernakulam	7.5	121	25	3	90
Vytilla	Ernakulam	7.5	151	47	2	100
	Edapally	7.5	151	47	2	100
	Muvattupuzha	7.5	151	47	2	100
	Aroor	7.5	151	47	2	100

2.3 Estimation Of PCU Values

The PCU may be considered as a relative measure of the relative space requirement of a vehicle class compared to that of a passenger car under specified set of roadway, traffic and other conditions. If the addition of one vehicle of a particular class in the traffic stream produces the same effect as that due to the adddition of one passenger car, then the vehicle class is considered equivalent to the passenger car with a PCU value equal to 1.0. The PCU value of particular vehicle class may be considered as the ratio of the capacity of roadway when there are passenger cars only to the capacity of the same roadway when there are vehicles of that class only. PCU values for different classes of vehicles were estimated for saturated flow condition using equation

$$PCU_i = \frac{A_i \times t_i}{A_c \times t_c}$$

Where,

PCU_i = Passenger Car Unit of vehicle type i

Ai = Area of i^{th} vehicle

Ac = Area of passenger car

t_c = Average clearing time of car in sec

t_i = Average clearing time of vehicle type i in sec

Table -2: PCU Value Of Each Vehicle Type

Type Of Vehicle	Cheranalloor	Vytilla
4 Wheelers	1.57	1.77
3 Wheelers	0.932	1.06
2 Wheelers	0.193	0.26
Heavy Vehicle	5.121	6.27
Non Motorised Vehicle	0.132	0.132

2.4 Estimation Of 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 in PCU/hr or PCU/sec.

Saturation flow was calculated for each approach by using formula given below:

$$S = \frac{Total\ number\ of\ vehicles\ (PCU)}{Saturated\ Green\ Time\ in\ sec} \times 3600$$

Where,

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

Table-3: PCU And Saturation Values At Cheranalloor And Vytilla Signalised Intersection

Intersection	Approach From	PCU (veh/hr)	Satiration Flow (PCU/hr)
Cheranalloor	Edapally	807	7281
	Aluva	1077	9720
	Paravur	1447	13036
	Ernakulam	1489	13428
Vytilla	Edapally	1967	8564
	Ernakulam	1413	6776
	Muvattupuzha	1668	7992
	Aroor	1677	8040

2.4 AS PER IRC SP-41

Guideliness for the design of at grade intersections for rural and urban area, has defined saturation flow as

S = 525*W

Where,

S –Saturation flow in PCU/h

W – Width of road in metre

This equation is applicable for roads having a width above 5.5m .However, it does not specify any characters of LOS for signalized intersection.

Table-4: Saturation Flow As Per IRC:41

Intersection	Approach Road	Width	Saturation Flow
Cheranalloor	Edapally	7.5	3938
	Aluva	7.5	3938
	Paravur	7.5	3938
	Ernakulam	7.5	3938
Vytilla	Ernakulam	9.75	5119
	Edapally	7.5	3938
	Muvattupuzha	9.75	5119
	Aroor	7.5	3938

2.5 COMPARISON CHART

From the comparison with IRC SP-41 and field studies, the saturation flow rate obtained through field studies is higher than the saturation flow ratre obtained by generalised formula as per IRC SP-41 as mentioned above.

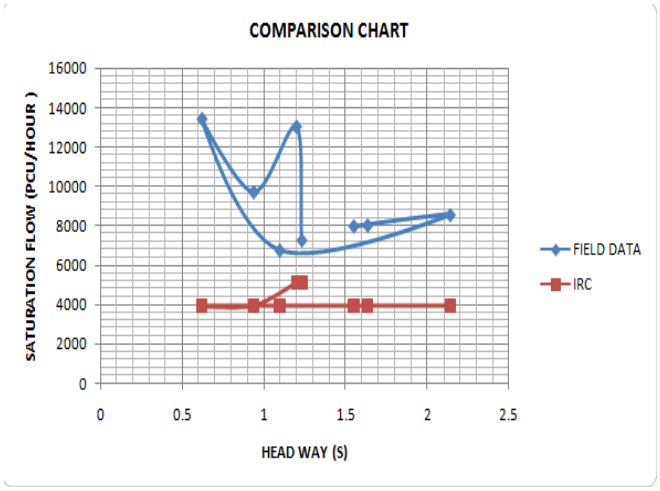

Figure-1: Comparison Chart Of Saturation Flow Vs Headway

3. CONCLUSION

Field study saturation flow obtained is higher than saturation flow obtained from generalized formula of IRC SP-41. Saturation flow analized for the intersection shows that it does not depend only on the width of approach. Therefore the empirical formula suggested as per IRC SP-41-1994 of indian road congress is inappropriate for obtaining saturation flow. Saturation flow were affecting due to higher traffic composition of two wheelers and four wheelers. Hence with the increasing proportion of two wheelers saturation flow per meter width tends to increase due to heterogeneity and filling gaos of two wheelers. Vicen versa with increase in proportion of four wheelers saturation flow tends to decrease due to more homogeneity.

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