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Determination of Dynamic PCU values at Signalized Intersection on Urban Corridor of Ahmedabad City

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Abstract — *PCU values of different types of vehicles are varying with composition of vehicles, time, situation, location and their interaction. Static PCU values suggested by IRC for the signalized intersection is generally overestimate the saturation flow rate. Dynamic PCU value for mid- block section in the Indian traffic scenario has been found by the several researchers, but very few researchers have attempted to find the dynamic PCU on signalized intersections. Dynamic PCU can be co-related with projected area of car and vehicle category as well as with departure flow rate (saturation flow rate), speed, headway, travel-time etc. The actual travel-time to cross the signalized intersection includes most of the factors like acceleration, deceleration, stop-delay, maneuverability etc. Hence, in this proposed study relative project area and actual travel-time of the vehicle category are considered to decide the dynamic PCU of vehicle category. In this proposed study comparison of static pcu values at signalized intersections suggested by IRC and Justo & Tuladhar with dynamic pcu values. It seems that dynamic pcu value of 2W and 3W are quite lower than suggested static pcu values.*

Keywords- *Dynamic PCU, static PCU, mixed traffic, projected area, travel-time.*

I. INTRODUCTION

In Indian road traffic, the heterogeneity is of high degree with vehicles of widely varying static and dynamic characteristics. Under this condition, it becomes difficult to make the vehicles to follow traffic lanes. Consequently, the vehicles tend to choose any advantageous lateral position on the road based on space availability. Under the said traffic conditions expressing traffic volume as number of vehicles passing a given section of road per unit time will be inappropriate and some other suitable base needs to be adopted for the purpose. The problem of measuring volume of such heterogeneous traffic has been addressed by converting the different types of vehicles into equivalent passenger cars and expressing the volume in terms of Passenger Car Unit (PCU) per hour. The PCU is the universally adopted unit of measurement of traffic volume, derived by taking the passenger car as the 'standard vehicle'.

This paper focuses on the determination of dynamic PCU values for different category of vehicles at signalized intersections under mixed traffic conditions by adopting directly proportional to the ratio of travel time of vehicle, and inversely proportional to the space occupancy ratio of vehicle with respect to the standard area of vehicle, i.e. a car.

II. AIM OF THE STUDY

The main aim of the study is to determine the dynamic PCU value at signalized intersection for heterogeneous traffic condition.

III. OBJECTIVES OF THE STUDY

The objectives of the works are,

- To determine dynamic PCU values for varying traffic composition at signalized intersections in the city,
- To compare the static PCU values with dynamic PCU values at signalized intersections.

IV. SCOPE OF THE STUDY

- The relationship between the dynamic and static PCU value can be utilized for the same situation at other sites.
- The scope of this study is limited to four legged signalized intersections.

V. REVIEW OF LITERATURE

Indian Roads Congress Special Publication (IRC SP-41-1994) had recommended PCU values for two wheelers as 0.5, three wheelers as 1 and bus/lorry as 3 at signalized intersection for conversion of different types of vehicles into equivalent PCU.

Dynamic PCU model concept developed by Chandra and Sikdar (1993) considered the intersection clearing speed of each category of vehicles. Chandra and Kumar (2003) have proposed a concept to estimate the PCU factor for a mode in a mixed traffic environment utilizing area concept. It was found that the PCU for a vehicle type increases

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linearly with the width of carriageway. This was attributed to the greater freedom of movement on wider roads and therefore a greater speed differential between a car and a vehicle type.

Arasan and Jagadeesh (1995) estimated the PCU for different categories of vehicles using the multiple linear regression procedure, where the saturated green time was regressed against the number of each category of vehicles crossing the stop line, during the green time, assuming a linear relationship between the variables. PCU values obtained were for bus in the range of 2.11 to 2.83, for two-wheeler 0.30 to 0.38 and for three-wheeler 0.58 to 0.64.

Vien et al. (2003) have developed a statistical approach of headway ratio method for finding the PCU values of different vehicles at signalized intersections with respect to Malaysian traffic conditions.

Rahman et al. (2004) presented a procedure for estimating PCE of rickshaws and auto rickshaws at signalized intersections and suggested that the PCE values for rickshaws and auto rickshaws varies from 0.75 to 1.0 and 0.35 to 1.0 respectively depending on the proportion of vehicles in mixed traffic flow.

Patil et al. (2007) studied the influence of area type in the PCU values and estimated that the PCU for two wheeler ranges from 0.09 to 1.23, three-wheeler from 0.23 to 6.14 and that of bus from 1.02 to 3.78.

Arasan and Krishnamurthy (2008) conducted a study on the effect of traffic volume and road width on PCU values of vehicles using microscopic simulation at mid-block sections of urban roads. The results showed that the PCU value of a vehicle significantly changes with change in traffic volume.

Arasan and Dhivya (2008) incorporated the concept of area occupancy and showed the appropriateness of the concept in heterogeneous traffic condition for urban roads.

Arasan and Arkatkar (2010) used the simulation model, HETEROSIM, to derive the PCU values for different types of vehicles in urban roads. The results showed that the PCU value of a vehicle significantly changes with change in traffic volume and width of roadway.

Radhakrishnan and Mathew (2011) in their study have proposed an optimization technique for the computation of dynamic PCU values. PCU values obtained were 0.34 for two wheelers, 1.88 for three wheelers and 3.90 for heavy vehicles considering eight intersection approaches and 0.24 for two wheelers, 0.6 for three wheelers and 2.26 for heavy vehicles considering eleven intersection approaches.

VI. METHODOLOGY

To study the deference between static pcu value and dynamic pcu value the data collected with the help of videography on selected intersection during peak period.

6.1 Field Videography

The traffic characteristic at the intersection involves study of traffic volume along with the vehicle composition and discharge rate. Video camera can be used to collect data on the field. Video based technique overcomes many of the difficulties of collecting traffic information. The video camera takes continuous picture of the traffic and pictures are recorded on the videotape.

The video recording approach has number of advantages as under:

- It requires small labor power
- It produces permanent, complete record of the traffic scene
- Recording may be reanalyzed at any stage

Major disadvantage of video technique is that the large amount of time and efforts are needed for data extraction.

6.2 Methods for Dynamic PCU at Signalized Intersection

In this research work the method adopted for the signalized intersection in this study to estimate the dynamic PCU values is that it is directly proportional to the ratio of travel time of vehicle, and inversely proportional to the space occupancy ratio of vehicle with respect to the standard area of vehicle, i.e. a car.

$$Dy.PCU = \frac{T.Ti}{T.Tc} \times \frac{Ai}{Ac}$$

Where,

PCU = passenger car unit value of ith type vehicle

T.T.i = travel time of i^{th} category of vehicle (sec)

T.T.c = travel time of car (sec)

Ac = static area of a car (m^2)

Ai = static area of i^{th} category of vehicle (m^2)

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From the above equation of the dynamic PCU value, if the area of the i^{th} category of vehicle and travel time of the i^{th} category of vehicle is increased, then the value of the dynamic PCU also increases. The travel-time of each category of vehicle is different in particular cycle, thus average travel time is considered. The area of each category of vehicle is same for the all cycle.

6.3 Cycle time of two intersections

Cycle time of two intersections was calculated from the videography in morning peak hours 11:00:00 a.m. to 12:00:00 noon from the videography.

Table 5.1: Cycle time Girish Coldrinks (A) and Bodyline intersection (B)

Junction name	Approach Name	Existing cycle length (sec)	Green time (sec)	Amber time (sec)
Girish Coldrinks	From Swastik	105	23	3
	From S.V. Desai		21	3
	From Bodyline		20	3
	From Mithakhali Circle		29	3
Bodyline	From Girish	111	19	3
	From Kokilaben Vyas Marg		30	3
	From Travel Infocity		25	3
	From Samartheswar Mahadev Road		25	3

6.4 Data Analysis

From the videos different vehicles were tracked at different intersections A and B. In analyse the data vehicles were tracked in three different directions i.e. straight, right and left.

From the data travel time of a particular vehicle was calculated in each direction in each cycle. Similarly, at those cycles classified volume count of the vehicles were also taken out.

Table 1: Average t.t of different vehicle of Girish Coldrinks Intersection

Vehicle category	Direction	Approach			
		Swastik	S. V. Desai	Bodyline	Mithakhali
2W	S	4.8	4.4545	3.6667	4.96
	R	6	3	5	3.8333
	L	0	0	0	2.3333
3W	S	4.4286	4	6.3333	5.4
	R	0	3	5	4.5
	L	0	0	0	6
Car	S	5.2	4.4545	4.625	6
	R	5	2.5	4.8	5.5
	L	0	0	0	0
LCV	S	0	0	0	0
	R	0	0	0	0
	L	0	0	0	0
Bus/ Truck	S	0	0	0	0
	R	0	0	0	0
	L	0	0	0	0
NM	S	10.5	0	0	0
	R	6	5	0	0
	L	0	0	0	0

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Table 2: Dynamic PCU Calculation

Vehicle Category	S	R	L
2W	= (4.8/5.2) *(1.295/5.475)	= (6/5) *(1.295/5.475)	= (0/0) *(1.295/5.475)
	= **0.2183**	= **0.2838**	= **0**
3W	= (4.4286/5.2) *(3.25/5.475)	= (0/5) *(3.25/5.475)	= (0/0) *(3.25/5.475)
	= **0.5055**	= **0**	= **0**
Car	= (5.2/5.2) *(5.475/5.475)	= (5/5) *(5.475/5.475)	= (0/0) *(5.475/5.475)
	= **1**	= **1**	= **0**
L.C.V.	= (0/5.2) *(12.81/5.475)	= (0/5) *(12.81/5.475)	= (0/0) *(12.81/5.475)
	= **0**	= **0**	= **0**
Bus/Truck	= (0/5.2) *(24.745/5.475)	= (0/5) *(24.745/5.475)	= (0/0) *(24.745/5.475)
	= **0**	= **0**	= **0**
N.M	= (10.5/5.2) *(0.75/5.475)	= (6/5) *(0.75/5.475)	= (0/0) *(0.75/5.475)
	= **0.2766**	= **0.1644**	= **0**

As per above calculation dynamic pcu of different cycle were calculated.

6.5 Total Vehicle Composition at Intersection

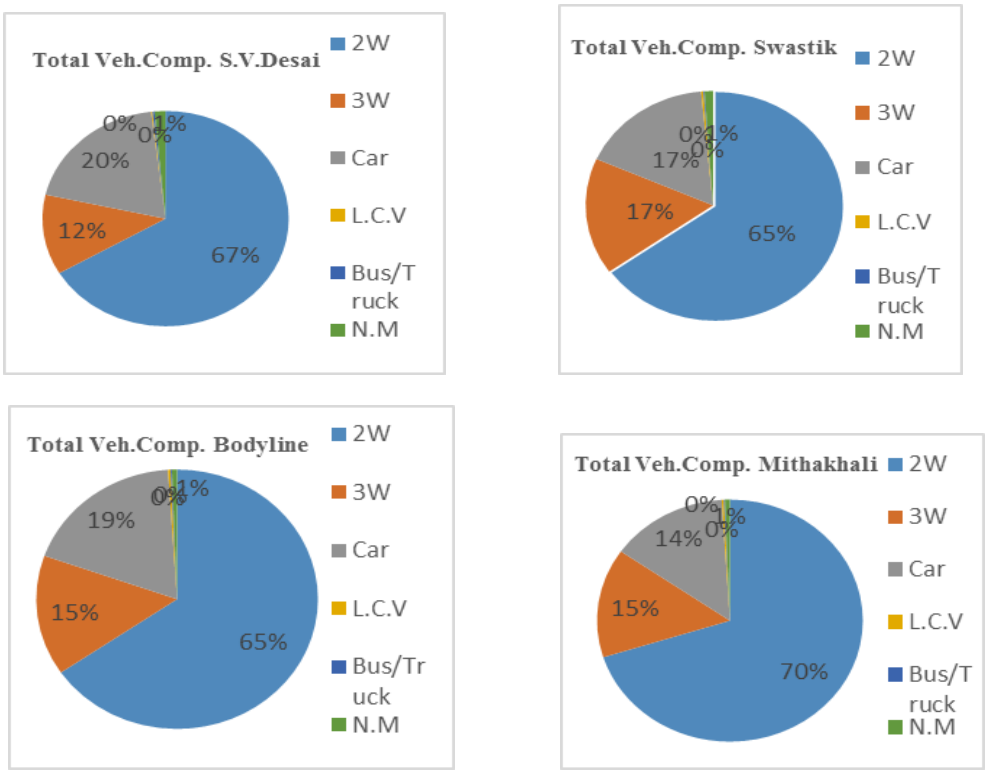

Figure 1: Vehicle Composition at Girish Coldrinks Intersection

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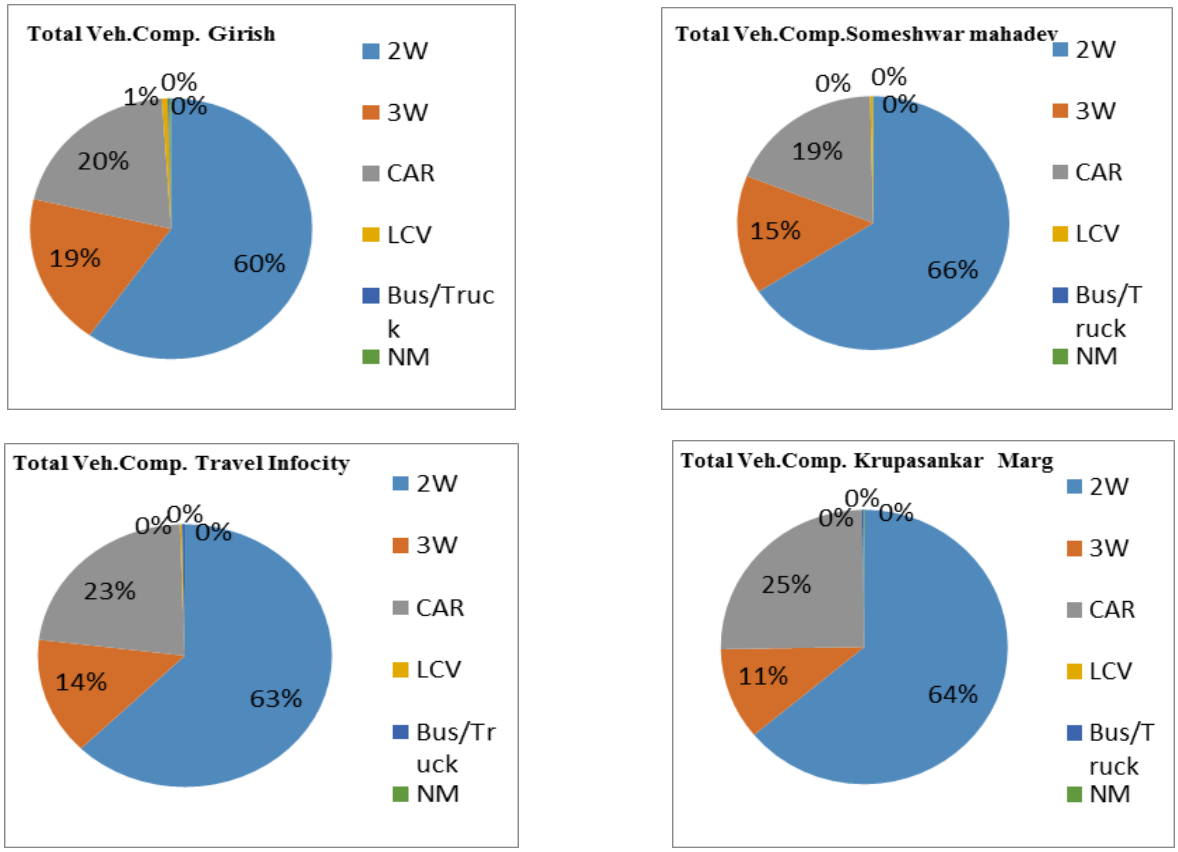

Figure 2: Vehicle Composition at Bodyline Intersection

6.6 Comparison of Static PCU values and Dynamic PCU values

Table 3 shows comparison of static pcu values at signalized intersections suggested by IRC and Justo & Tuladhar with dynamic pcu values obtained in this proposed study.

Table 3: Comparison of Static PCU values and Dynamic PCU values at Intersections

Vehicle Type	PCU values					
	As per IRC SP-41-1994	As per Justo & Tuladhar (1984)	Girish Coldrinks Intersection		Bodyline Intersection	
			Straight	Right	Straight	Right
2W	0.5	0.3	0.2384	0.2271	0.2411	0.2413
3W	1.0	0.4	0.6272	0.6089	0.6197	0.6778
Car	1.0	1.0	1.0	1.0	1.0	1.0
LCV	1.5	-	2.7037	3.1586	2.6495	2.7348
Bus/Truck	3.0	2.8	4.8997	5.7522	4.7954	6.7795
NM	0.5	0.4	0.2460	0.1920	0.1747	-

VII. CONCLUSION

Present study is carried out at three major signalized intersections of Ahmedabad city. Field data of vehicle and travel time are collected via videographic method for morning peak hours. Major findings of the study are briefed as under:

- Mix and composite traffic observed during study.
- At all intersections it is found that composition of two wheelers is quite high (60%-70%).
- Three wheelers composition varies between (11%-19%).
- Car composition varies between (14%-25%).
- Light Commercial Vehicle composition varies between (0%- 1%).
- Bus composition varies between (0% - 1%).
- Non-motorized composition varies between (0%- 1%).
- Maximum numbers of vehicles are observed at Bodyline intersection.
- The proportion of 2W, 3W and Car is more as compared to L.C.V, Bus/Truck and N.M.
- It is also seen that dynamic pcu value of 2W and 3W are quite lower than suggested static pcu values.

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- Percentage of Bus, LCV and N.M vehicles are very less hence their dynamic pcu values may not be considered for comparison.
- It is observed that dynamic pcu values of 2W and 3W are increased with the increase of 2W composition.
- It is also observed that dynamic pcu values of 3W are decreasing with the increasing composition of 3W and Car.
- It can be concluded that increase in 2W composition reduces the maneuverability of the vehicles.

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