

ESTIMATION OF DYNAMIC PCUS OF DIFFERENT TYPES OF VEHICLES ON URBAN ROADS UNDER HETEROGENEOUS TRAFFIC CONDITIONS

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Abstract: This paper presents a concept of Dynamic passenger car unit, appropriate for the mixed traffic on Indian roads, and shows that the PCU factor for different types of vehicles is not a static factor as is generally assumed. Speed and Volume data are collected at two urban roads of Vadodara city by video camera technique on midblock section during morning and evening peak hour. Dynamic PCUs are estimated based on speed and size of vehicle type in the traffic stream with respect to standard car. The result show that PCU value for different types of vehicles varies with traffic volume and composition on both the roads.

Keywords – Passenger car unit, Traffic volume, Mixed Traffic, Speed

I. INTRODUCTION

The mixed traffic stream consists of wide range of vehicle types with varying dynamic characteristics. Vehicles occupy different spaces on the road, travel at different speeds, and start at different accelerations. Without any physical segregation the operating condition on roads become more complex when all these vehicles of different sizes travel on the same road space. It also become very difficult to study the different traffic characteristics and to estimate parameters like highway capacity, LOS, density etc. hence traffic volumes containing a mix of vehicle types are converted into an equivalent flow of passenger cars using passenger car unit. The second edition of the Highway Capacity Manual of the United States (HCM 1965) introduced the concept of the passenger car unit (PCU) as a measure to convert all types of vehicles in a traffic stream into an equivalent number of passenger cars.

The guidelines provided by Indian roads congress in respect of PCU of different types of vehicles are more or less based on static characteristics of the vehicles whereas the dynamic characteristics have been not taken into account during the formulation. This paper present a concept of dynamic passenger car unit, suitable for the heterogeneous traffic on urban roads, and shows that the passenger car unit factor for a vehicle type is not a static factor as is generally assumed.

Table 1.1: Recommended PCU factors for various types of vehicles on urban roads as per IRC 106-1990

SR. NO.	Vehicle Type	Equivalent PCU factors	
		Percentage composition of vehicle type in traffic stream	
	Fast vehicles	5%	10% and above
1	Two wheelers –motor cycle, scooter, etc.	0.5	0.75
2	Passenger car, pick-up van	1.0	1.0
3	Auto-rickshaw	1.2	2.0
4	Light commercial vehicle	1.4	2.0
5	Truck or Bus	2.2	3.7
6	Agricultural Tractor –trailer	4.0	5.0
	Slow vehicles		
7	Pedal cycle	0.4	0.5
8	Cycle rickshaw	1.5	2.0
9	Tonga (Horse drawn vehicle)	1.5	2.0
10	Hand cart	2.0	3.0

Table: 1.1 shows the equivalent PCU factors for fast moving vehicles and slow moving vehicles at 5% and 10% of vehicle composition on urban roads. It can be said that in fast moving vehicles the PCU factors are maximum for agricultural tractor or trailer and minimum for 2-wheelers. Other side the equivalent PCU factors are maximum for hand cart and minimum for cycle in slow moving vehicles.

II. LITERATURE REVIEW

Chandra and P.K sikdar (2000) have studied the dynamic nature of PCU. The variation of PCU with traffic and geometric variables is explained graphically. They develop computer program to estimate the PCU value for a vehicle type under given condition of composition and traffic volume per lane width. It is applicable to all traffic situations with a maximum number of five vehicle categories in the stream. And it is suitable for other cities also having similar conditions of traffic.

Chandra and Kumar (2003) have presented a new concept to estimate the passenger car unit of different types of vehicles under mixed traffic conditions. Data were collected at ten sections of two-lane in different parts of India. The video recording technique was used to collect the data. All vehicles were divided into nine different categories and their PCU's were estimated at each road section. It was found that the PCU for a vehicle type increases linearly with the width of carriageway.

Paul and Sarkar (2013) have done the study on four urban roads of Delhi city. They collected classified volume, speed, lateral clearance, and headway data on 30m trap length by video camera technique for three hours during peak hours. Calculation of PCU value is ratio of any type of vehicle to the space requirement of the vehicle with respect to the car. The result obtain from this study is shows that PCU value of two wheeler increase with increase in percentage of heavy motor vehicles and decrease in percentage of non-motor traffic. There is no significant relationship was observed between PCU value of auto and change in percentage of HMV and NMT. As the speed of stream decrease the PCU value of bus is increase. The PCU value of three wheeler and cycle also decrease with decrease in speed.

Ashish Dhamaniya and Satish Chandra (2013) have presents a methodology to convert a mixed traffic stream into a homogeneous equivalent without making use of PCU factors. Traffic volume and speed data collected on different six-lane urban arterial roads in India are analyzed to determine PCU values of five different categories of vehicles found on these roads. These PCU values are used to convert heterogeneous traffic volume in vehicles per hour to homogeneous volume in PCU per hour. A new term stream equivalency factor (SEF) is introduced in this study and denoted by K. It is the ratio of traffic volume in PCU per hour and volume in vehicles per hour. Proposed method is simple to use and expected to eliminate the problem of estimation of PCU factors required in many studies.

Muhammad Adnan (2014) has found the PCE factors for heterogeneous traffic environment in urban arterials of Karachi city, Pakistan. He had used four methods of estimation of PCE factors and compared them with each other and those which are currently used in different traffic studies of Karachi. His analysis showed that significant differences are found among the values of PCE factors from each method and what followed in Karachi.

Ankit Mahidadiya and Jayesh Juremalani (2016) reviewed on the PCU reveals that there are several methods used for calculating PCU values. And the PCU values depends upon the current road traffic condition. They demonstrated that it is also needs to revised PCU value in India. Because many cities of India undergoes rapid urbanization its result change in traffic condition, varying road width, and traffic composition. It been also seen that PCU values of vehicles considering all effects of factors such as grade, shoulder condition, roughness, percentage of vehicle, percentage of slow moving vehicles has not been calculated universally.

R. srinivasa Rao et al. (2017) reviewed on the different methods to estimate PCU value in homogeneous and heterogeneous traffic flow reveals that there are several methods available for calculating PCU values for mixed and homogeneous traffic flow. And each method has its own factors like density, headway, speed, delay, projected rectangular area etc. They demonstrated that India having mixed traffic condition hence there is a much need for considering all the factors such as geometric elements of road, traffic conditions, vehicle compositions, vehicle conditions etc. to develop model for deriving the most appropriate PCE values that can be adopted throughout the world.

Subhadip Biswas et al. (2017) have demonstrated the effects of traffic volume and its composition on individual speed and PCE in the context of urban mixed traffic. Traffic data on classified traffic volume and speed were collected at six-lane divided arterial mid-block road sections in New Delhi, India. A Computer system model was adopted to develop a volume-based speed prediction model for individual vehicle category. Validation results displayed a great deal of agreement between the predicted and the observed speeds. Then, the sensitivity investigation was performed utilizing the model developed in order to observe the effects of traffic volume and its composition on individual speed and corresponding PCE.

III. DATA COLLECTION

In this study, traffic volume and speed data collected at road sections of four lane road and six lane road of Vadodara city to determine PCU factors for the different categories of the vehicles. The detail of the selected sections are given in table 3.1

Table 3.1: Details of the study sections

Sites	VIP road		Gotri road	
	Towards lion circle	Towards amitnagar circle	Towards harinagar	Towards gotri cross road
ROAD TYPE	3-Lane Road in one direction	3-Lane Road in one direction	2-Lane Road in one direction	2-Lane Road in one direction
CARRIAGEWAY WIDTH	15.5 M	15.5 M	12.74 M	12.74 M
WIDTH OF MEDIAN	1.9 M	1.9 M	1 M	1 M
ROAD SEGMENT	30 M	30 M	30 M	30 M

Videography method was used for data collection. A trap of 30m was made on the road using white spray. Data on volume and speed of vehicles were recorded at section. To avoid distraction to the drivers by the video camera, it was placed in an obscured place such as under a tree or a roadside building with reasonable distance from the pavement. All vehicles are divided in seven categories based on their physical size and operating conditions table 3.2 displays various vehicle categories and their projected rectangular area.

Table 3.2: vehicle categories with corresponding average dimensions (Source: M. Mardani N 2015)

Vehicle Category	Vehicles Included	Average Projected Rectangular Area	Area Ratio to Passenger Car to Vehicle Type
Small Car	Standard Car	5.36	1.0
Big Car	Jeep, Mini Vans	8.06	0.6650
Two Wheeler	Scooter, Motor Cycle	1.48	3.62
Three Wheeler	3 Wheeler Auto	4.48	1.1964
LCV	Mini Trucks, chhota hathi	12.81	0.4184
Bus	Buses, Mini Buses	25.73	0.2083
Bicycle	Non-motorized	0.86	6.2325

Traffic volume count were carried out at every five minute interval on both the road sections. Table 3.3 below displays the traffic composition at study sections. Speed of each type of vehicles included in every five minute count were estimated by measuring the time taken by the vehicle to cover the 30m trap on the road using stop watch.

Table 3.3: Traffic composition on both roads

Name of road	Traffic composition						
	2w	3w	4w sml	4w big	Bus	LCV	cycle
VIP	60.21	9.82	20.3775	4.6675	1.82	1.43	1.665
Gotri	60	15.515	15.0275	3.71	0.53	1.0425	4.16

IV. RESULTS AND DISCUSSION

4.1 Estimation of PCUs

Different types of vehicles operating on the same road without any physical segregation therefore the traffic on Indian roads are heterogeneous. Passenger car units (PCU) of different types of vehicles are required to convert a mixed traffic stream into a homogeneous Equivalent, and thereby to express the mixed traffic flow in terms of equivalent number of passenger cars. Table 4.1 displays PCU values for different categories of vehicles and roads.

Table 4.1: PCU values for different categories of vehicles and roads

PCU VALUE							
Name of road	2W	3W	4WSML	4WBIG	BUS	LCV	CYCLE
VIP ROAD	0.276045	1.0075	1	1.565	5.6675	2.6875	0.47
GOTRI ROAD	0.3125	1.0375	1	1.5325	5.6325	2.6675	0.495

Many scholars have recognized methods to estimate PCU for the vehicle type. For the present study the PCU values were estimated by using the equation 1 which was introduced by Chandra and Kumar (2003).

$$(PCU)_i = \frac{(V_c/V_i)}{(A_c/A_i)} \dots \dots \dots (1)$$

Where,
 Vc and Vi are mean speeds of car and vehicle of type i respectively and
 Ac and Ai are their respective projected rectangular area (length x width) on the road.

4.2 Variation in PCUs

The PCU value is the amount of interaction caused by a vehicle type to the traffic stream of passenger cars. This interaction will be different at different traffic volume levels. It will change with composition of the traffic stream as well. Figures 1, 2 and 3 show the PCU values and variation for different types of vehicles on four lane and six lane roads. Fig 1 and Fig 2 gives the PCU values for vip road traffic composition and Gotri road traffic composition. It can be seen that from fig. 3. PCU values on six lane divided road for big car, bus and LCV are maximum than that on four lane divided roads.

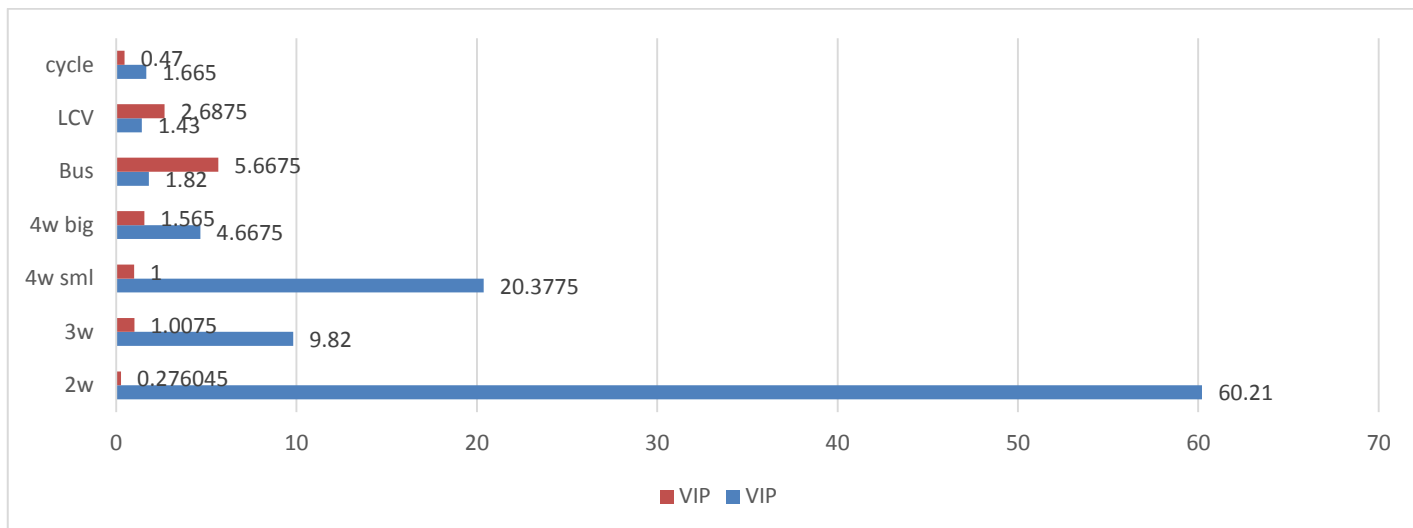


Fig.1 variation in PCU on VIP road traffic composition

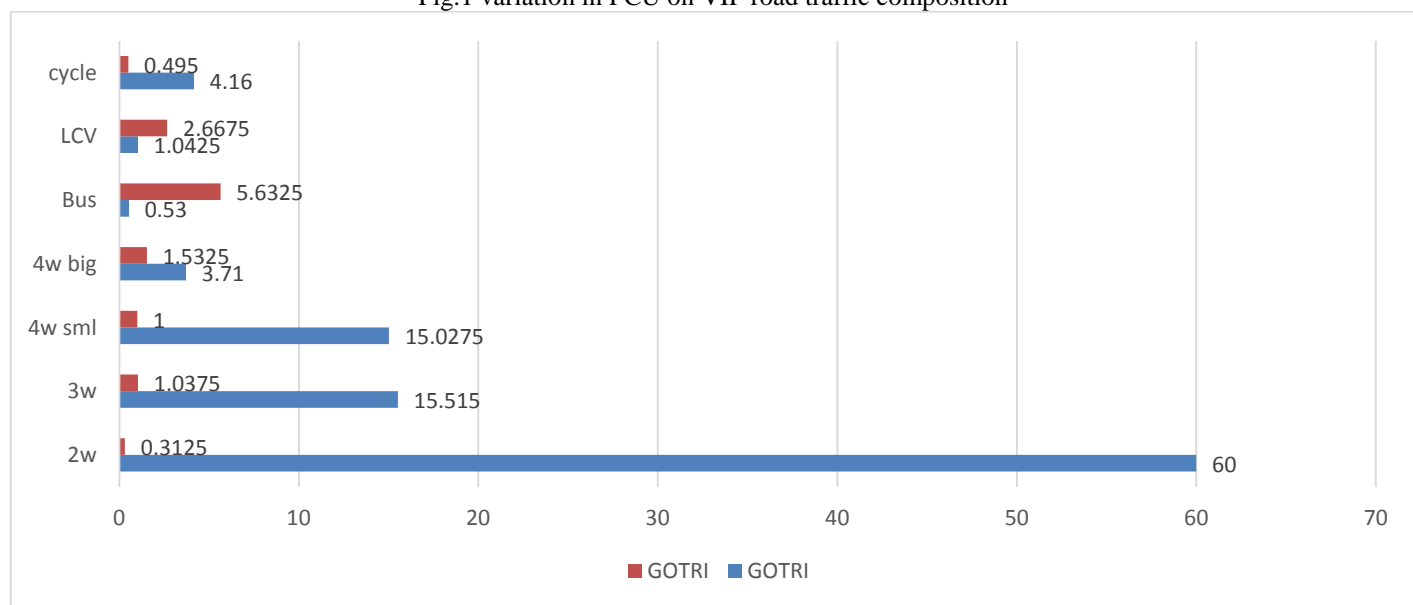


Fig.2 variation in PCU on Gotri road traffic composition

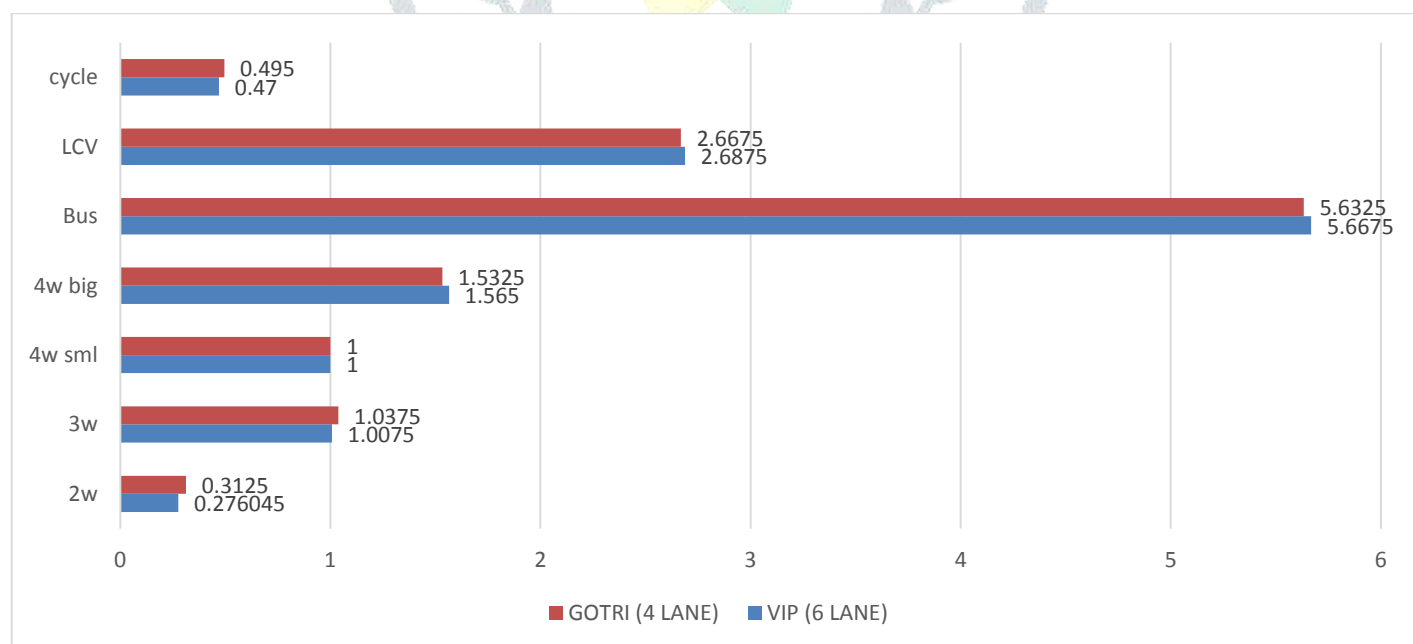


Fig.3 variation in PCU on different roads

V. CONCLUSIONS

The present study demonstrates the dynamic value of PCU factors on two different roads under highly heterogeneous traffic conditions. The PCU values are calculated using Chandra’s method on both the roads. The PCU factors on both roads are found to be very sensitive to any changes in the traffic stream either in terms of traffic composition or in terms of traffic volume. It is also affected by the type of roads also. Chandra’s method for determining dynamic passenger car units is takes into account longitudinal and lateral dimensions representing

the vehicles as a box so the projected rectangular area of vehicle can be considered as an influencing parameter to passenger car unit which is satisfactory consideration for developing countries like India where transverse movements of vehicles are very frequent.

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A. IRC Code:

- IRC-106-1990 Guideline for capacity of urban road in plain area

