

Determination of Dynamic PCUS of Different Types of Passenger Vehicles on urban Road: A Case Study of Rajkot City

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Abstract— This study represents a concept of "dynamic passenger car unit" (DPCU), appropriate for the heterogeneous traffic on Indian roads, and shows that the PCU factor for a vehicle type is not a static factor as it is usually assumed. Various relationships will be developed between speed-flow. By using three different methods of estimating PCU, PCU value of different category of vehicles should be found. This PCU factor is the ratio of the projected rectangular area of the vehicle type to the speed of the vehicle type, with respect to car. Factors influencing PCU value are classified volume of vehicles and Average speed .PCU values of different types of vehicles is determined on Rajkot Urban Road by different methods and suggest the reliable method.

Key words: Dynamic PCU, Heterogeneous Traffic, classified volume

I. INTRODUCTION

In India, the hasty tempo of urbanization has impacted various sectors of the country amongst which the transportation sector is in the spotlight due to urban vehicular growth and this effect is felt in terms of traffic congestion, delays, road safety, pollution, and transport efficiency. When compared to the rural areas the extent and nature of traffic problems of urban areas are poles apart. Therefore urban areas are always lying at the core of the research sphere of traffic engineering with all its concepts linked to the traffic characteristics. Knowledge of roadway capacity is of supreme importance for the proper understanding of traffic characteristics. Traffic carrying capacity can be a benchmark for representing the amount of utilisation of the existing roads which in turn can be used for determining present requirements as well as predict future requirements of the road improvement based on the traffic. Traffic in India is exceedingly heterogeneous comprising of vehicles having wide range of static characteristics as length, width, etc., and dynamic characteristics as speed, acceleration, etc., apart from these the driver behaviour of the different vehicle classes is also found to vary considerably. Therefore the heterogeneous traffic flow characteristics are very much complex when compared to homogeneous traffic consisting of passenger cars only. Now to overcome this difficulty it is mandatory to bring all vehicle classes to a common unit called passenger car unit. The concept of passenger car unit has been used in several countries abroad including United Kingdom, United States of America, Belgium, etc., as car contributes to a major share of the traffic flow. The idea of considering car as the basic vehicle on urban roads is followed in the Indian context so as to account for the influence of varying vehicle types. Existing practice in India is to use different PCU values based on the composition of various vehicle types in the traffic stream accounting for 5 % and 10 % of any

subject vehicle type. These values are termed as Static PCUs as they remain constant across varying conditions of traffic volume irrespective of variation in other parameters of traffic stream. But the roads located in different cities of the country exhibit varying operating and vehicular characteristics. Considering this, it is prudent to estimate the PCU values based on the varying characteristics of vehicles by associating dynamism to it.

II. LITERATURE REVIEW

A. *Probhat Kr Paul and P.K Sarkar "Determination Of Dynamic Pcus Of Different Types Of Passenger Vehicles On Urban Road: A Case Study, Delhi Urban Area"*

They done the study on urban arterial road of Delhi city and they considered four road of Delhi city. Select stretch of 30 m from the fixed object and collect classified traffic volume, speed, lateral clearance and headway by video camera for 3 hours on single road during peak hours. Calculation of PCU is ratio of speed of any type of vehicle to the space requirement of the vehicle with respect to the car. From estimated PCU value the develop the relation between influence area and volume, speed and composition. The analysis of PCU value done in statistics program. The result obtained from this study the PCU of 2- wheeler increase with increase in percentage of heavy motor vehicles and decrease in percentage of non-motor traffic. No significant relationship was observed between PCU of Auto rickshaw and change in percentage of HMV and NMT.As the speed of the stream decrease the PCU of bus increase. This shows that buses experience a more freedom of space with higher speed as compared to other type of vehicles. The PCU of 3-wheeler and cycle also decrease with decrease in speed.

B. *A.R.Khanorkar, S.D.Ghodmare , Dr.B.V.Khode "Impact Of Lane Width Of Road On Passenger Car Unit Capacity Under Mix Traffic Condition In Cities On Congested Highways"*

They have studied of Nagpur city and considered six section of two lane highways around city. They were determine the impact of lane width and shoulder's condition on capacity of two lane highway. Collect the different types of traffic volume and use of video camera to cover the full length of road section. stop watches were used to record the time of all the vehicles passing through the travelling section and speed can be determined. They were also collect the width of all the section. Find out the value of PCU by chandra and kumar method and speed and volume relationship graph. The result obtained from this study was new PCU value obtained from this study were quite different from the value given in IRC code. Also found that PCU value for motor cycle , auto rickshaw were 0.35 and 1.14 for SH 225 smaller than the value given in IRC code and value for truck , trailer , and L.C.V found 5.51 , 6.29 , 3.1 higher than value

given in IRC 64-1990. Also found that PCU for a vehicle type increase with increasing lane width. The capacity of a 7.2 m wide road is PCU values is estimate 3348.48 PCU/h which is higher than the value 3200 PCU/h suggested in HCM 2000.

C. A. Mehar, S.Chandra And S.Velmurugan "Passenger Car Units At Different Levels Of Service For Capacity Analysis Of Multilane Interurban Highways In India"

They have studied on two section of interurban highways, one with four lane and other with six lane divided roadway. They were selected 100 m straight portion of the highway having no influence of any access point or intersection. Traffic volume and speed data were collected for 6 hours during morning peak hours, non-peak hours and in evening for 2 hours by using video recording methods. Classified volume count at every 5 min of intervals. Then value of PCU determined from Chandra and kumar eq. Capacity of four lane and six lane divided highway was estimated as 4950 PCU/h and 6700 PCU/h in each direction of traffic movement. They were used VISSIM model to know the effect of traffic composition on capacity and develop speed – flow curve for different combination of traffic composition. The input parameters for VISSIM are roadway geometry, vehicle dimension, vehicles acceleration characteristics and speed distribution and output from VISSIM is very sensitive to the driver behaviour parameter. Then calibration of VISSIM model is done and then validation of PCU values was carried out. The result obtained from study were value of PCU decrease with decrease in level of services from A to E. This study demonstrates the effects of congestion level on PCU of different type of vehicles on multilane interurban highways.

D. Prema Somanatham Praveen, Venkatachalam Thamizh Arasan "Influence Of Traffic Mix On PCU Value Of Vehicles Under Heterogeneous Traffic Conditions"

They have studied application of micro- simulation technique to derive equivalency value on purely homogeneous traffic stream as well as on heterogeneous traffic stream for different types of vehicles over a wide range of traffic flow and composition on four lanes divided urban road in India. They were collected data on divided urban road in India and also find out the influence of change in traffic volume and composition and volume on PCU of the vehicles. They were used HETEROSIM software to determine the PCU value. It was found that complex nature of interaction between vehicles under the mix traffic condition, at low volume levels, the PCU value of vehicles increase with increase in traffic volume, whereas under higher volume condition, the PCU value decrease with increase in traffic volume, for any given composition. It was found that the effect of traffic composition on PCU values is higher at lower value and the effect of traffic composition on PCU value decrease with increase in the composition of subject vehicles.

E. Ashish Dhamaniya and Satish Chandra "Midblock Capacity Of Urban Arterial Roads In India"

They have studied 12 urban arterial road in four city of India; New Delhi, Jaipur, Bengaluru and Chandigarh. Eight sections were selected on six lane divided road and four section on four lane divided road. The selected section was

free from effects of intersection, bus stop, parked vehicles, curvature, gradient, pedestrian movement and other side friction. Traffic volume collected from 6 am to 6 pm by using video camera and average dimension and speed of all the vehicles were collected. PCU value determine by ratio of speed of any type of vehicle to the space requirement of the vehicle with respect to the car. Also calculated by regression methods solved in MS-Excel. Then plot the graph between PCU value and traffic composition by keeping traffic volume constant. Also plot the graph between PCU value and traffic volume by keeping traffic composition constant. The results obtained from this study were PCU for a vehicles increase with its own proportion in the traffic stream. Also observed that PCU of vehicles type is higher at 10% proportion than that of 5%. The capacity value obtained from this study were 1500 puc/h/lane to 2100 puc/h/lane for six lanes and 1556 to 2043 puc/h/lane for four lanes.

F. Gaurang Joshi And Dinesh Vagadia, "Dynamic Vehicle Equivalent Factors For Characterisation Of Mixed Traffic For Multilane Metropolitan Arterials IN INDIA"

In this paper Dynamic vehicles equivalent factors (DVEF) called as Dynamic car unit and Dynamic Two wheeler unit (DTU) were derived by using homogenization coefficient approach. Traffic data collected on seven cities of India, lucknow, kanpur, jaipur, patna, surat, pune and Thiruvananthapuram. Traffic volume counted manually for 1 min time interval and spot speed calculated by using stop watch. Mathematically, DVEF considering 'x' reference vehicles is the ratio of speed to area of vehicles. Find out DVEF for all the cities and comparison of DVEF values with the existing guideline. They observed that study was based on real world observations and result may not exactly match simulation results. Driver behaviour and local condition lead to higher deviation in result. effect of driver behaviour reduce with increase in traffic flow. Loading condition also affect DCU/DTU values for LCV, truck and pedal rickshaw reflecting on speed variation.

G. Suhas Vijay Patil, P. R. Adavi, "Development Of Passenger Car Units (Pcu), Case Study- Nal Stop, Pune"

The work took into account the effect of mixing of traffic, speed and headway. A set of PCU values was then derived. Speed measurement, Time headway measurement, Width and lateral clearance were find out by manually count method. Data analysis done by Speed distribution :- $F_u = U_c/U_v$, Headway distribution :- $F_t = T_v/T_c$, Width and lateral clearance :- $F_w = W_v/W_c$, $PCU = F_w * F_v * F_t$. They conclude that PCU value of each vehicle was not a constant but varies with several factors such as proportion of other classes, level of service, volume to capacity.

III. DATA COLLECTION

For the purpose of this study Traffic flow data and Average speed of all vehicles is collected through videography technique at one minute interval on two road (kalwad road, 150ft ring road) in Rajkot for the duration ranging from 6 hours covering the morning and evening periods.

IV. METHODS FOR ESTIMATION OF DYNAMIC PASSENGER CAR UNIT (DPCU)

The dynamic passenger car unit of vehicles plying on the road stretches selected for this study are determined by employing four different methods viz.

- 1) Homogenization Coefficient Method
- 2) Chandra's Method

Amongst the methods stated above the later two methods take into account physical dimensions of vehicles for estimation of dynamic passenger car unit. The dimensions of the vehicles considered for this study are stated in Table

Type of vehicle	Length (m)	Width (m)	Area (sq . m)
2 W	1.87	0.64	1.20
3 W	3.20	1.40	4.48
Small car	3.72	1.44	5.36
Big car	5.0	1.80	9.0
Mini Bus	6.0	2.20	13.2
Bus	12	2.60	31.2
LCV	5.17	2.0	10.34
Truck	7.50	2.50	18.75
MAV	12	2.50	30.0
Bicycle	1.90	0.45	0.86
Cycle Rickshaw	2.84	1.22	3.46

Table 1:

A. Homogenization Coefficient Method

This method is mainly adopted by developed countries where homogeneous traffic conditions persist and lane discipline is followed. The DPCU value is determined by using equation

$$PCU = L_i V_i \div L_c V_c$$

Where, L and V are the length and speed of a vehicle; suffix i indicates a vehicle type and c indicates the car.

Using this method the DPCUs for various for different cities are computed. The DPCU ranges for Rajkot is shown in the table

	At Kalawad Road	At 150 ft ring road
Two Wheeler	0.58	0.51
Three Wheeler	1.14	1.15
Light commercial vehicles	1.97	1.76
Car	1.00	1.00
Bus	5.04	4.56
Truck	2.64	2.76
MAV	4.85	5.19

Table 2:

The high variation of DPCUs may be due to these vehicles are travelling at less speeds and taking more time on trap as a result these vehicles hinder the traffic stream poorly and thus bear high values of passenger car unit.

B. Chandra's Method

This method is the modification of homogenization coefficient method in which the length of vehicle is considered for the PCU calculation while in here the length of vehicle is replaced by the projected area of the vehicle. The PCU value is determined by using following equation:

$$PCU = V_c V_i \div A_c A_i$$

Where, Vc and Vi are speeds of car and vehicle i respectively and Ac and Ai are their projected rectangular

area. The dynamic passenger car unit ranges for Rajkot are computed and presented in Table

C. Comparison between Homogenization Coefficient

	At Kalawad Road	At 150 ft ring road
Two Wheeler	0.23	0.23
Three Wheeler	1.07	1.12
Light commercial vehicles	2.42	2.29
Car	1.00	1.00
Bus	8.06	8.22
Truck	4.75	5.64
MAV	8.35	9.00

Table 3: Comparison Between Homogenization Coefficient

D. Method and Chandra's Method

In Homogenization Coefficient Method and Chandra's Method the PCU value is directly proportional to the speed ratio. The difference between these methods is that the PCU value in the former method is inversely proportional to the length ratio and in the later method the PCU value is inversely proportional to the projected area ratio.

Vehicle Type	Composition (%)	DPCU Value
Two Wheeler	40-60	0.23
	60-70	0.23
	70-80	0.22
Three Wheeler	5-10	1.07
	10-15	1.07
	15-20	1.06
	>20	1.09
Light commercial vehicles	<5	2.44
	>5	2.35
Bus	<5	8.11
	>5	6.26
Truck	<5	4.83
MAV	<5	8.55

Table 4: DPCU Values for Varying Traffic Composition of two wheeler

V. CONCLUSION

Homogenization Coefficient Method gives higher PCU values for smaller vehicles as 2W, 3W compared to Chandra's Method.

Chandra's Method gives higher PCU values for larger vehicles as Bus, LCV, Truck, MAV compared to homogenization coefficient method

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A. IRC Code

- IRC-64-1990 Guideline for capacity of Roads in Rural Area.
- IRC-106-1990 Guideline for capacity of urban road in plain area.
- HCM 2000.

