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Estimation of PCU Values for Mid Block Section and Rounabout

Swapnil Gorwadkar, Piyush Gurav, Chintan Shah, VIneet Ranka
Civil Engineering, Universal College of Engineering
Mumbai, India
sgorwadkar@yahoo.in, piyushpravingurav@gmail.com, chintanshah345@gmail.com, akvineet@gmail.com

Asir Khan
Civil Engineering
Universal College of Engineering
Mumbai, India
Asir.khan@universal.edu.in

***Abstract*—** Traffic in developing countries like India is highly heterogeneous in nature, which is characterized by the presence of vehicles of different categories having varying physical and operational characteristics over a wider range. Due to heterogeneity, it is difficult to define various traffic parameters. Hence in such cases, traffic volume is expressed in terms of Passenger Car unit (PCU). In the present study, various methods to determine PCU is studied also the variation in PCU values has been determined at different geometric condition keeping the drivers characteristic, vehicular characteristic and other parameters constant with only variation was in geometrics of road. This was achieved by studding the flow characteristic of same sample vehicle at different location. However at intersection, the values may change as the parameters vary at intersection as compared to a mid block section hence the PCU values at rotary intersection is found using the occupancy approach.

Keywords- *Ocupancy time, PCU, Roundabouts*

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I. INTRODUCTION

Traffic in developing countries like India is highly heterogeneous in nature, which is characterized by the presence of vehicles of different categories having varying physical and operational characteristics over a wider range. The exponentially rising population in the country, augmentation in the urban road network and a advancement in motorization affects the level of service on the road network in general and deteriorates safety specifically at road intersections.

Under moderate traffic conditions (traffic volume prevailing in the range of 3000 to 5000 vehicles/h), a roundabout may reduce delay and provide safer movement in comparison with un-signalized intersections. Recent studies have also shown that the damage incurred in roundabout crashes was considerably less as compared to other types of intersections. Similarly, while comparing number of conflict points, a roundabout may reduce conflicts significantly over conventional intersection. Because of lower number of conflict points there may be less potential for accidents, since traffic flow merges and diverges at small angles, at lower speeds.

One way to represent heterogeneous traffic flow is to express each vehicle category in terms of the interference it causes to the flow in terms of a standard vehicle category such as standard car. Such a measure is called the Passenger Car Unit (PCU) as known in India or Passenger Car Equivalent (PCE) world-wide. In general, heterogeneous flows are expressed as PCU per hour taking the whole width of the carriageway into account. PCU values formulated in developed countries are not suitable for Indian heterogeneous traffic conditions, where traffic was more diverse in nature, and driver do not follow any lane-discipline. Hence, developing a suitable method, which incorporates various mixed traffic flow parameters, for the estimation of PCU value at roundabout, may be helpful for capacity estimation. Chandra and Kumar (2003) suggested a methodology for the estimation dynamic PCU value as: it is directly proportional to the ratio of clearing speed ratio of standard car and subject vehicle category, and inversely proportional to the space occupancy ratio of standard car and subject vehicle category

II. OBJECTIVE

- To study various method to determine PCU.
- To study the effect of geometrics on PCU values.
- To find the PCU value at midblock and rotary intersection.

III. ESTIMATION OF PCU VALUE AT MID BLOCK SECTION

a) Field study :

Study was carried out at Chinchoti- AnjurPhata Rd, in the state of connecting the city of Bhiwandi with western express way. The road is also a connecting link for the warehouses situated at the southern end of Bhiwandi with the western expressway and hence major traffic found over here is of heavily loaded trucks. The traffic flow is found high in the morning towards Bhiwandi and it is Vice versa in the evening hours. Further the locations selected for study was such that there was minimum

loss of vehicles within the stretch as it had only 2 exit points 1 for the small habitant and other for few industry.

Fig. 1- Location of Traffic Survey

Six different sections were selected on the stretch having different road conditions the first section was near Kaman Station having rising gradient just followed by falling gradient near Jain temple. The next section was right hand curve with deflection of 25°, followed by straight section having 7 m wide, two lane roads on each side. The left hand curve was having deflection of 20°.

a) **Data Collection:**

The data was collected manually on the selected six sections of the road. The trap length selected on each section is 30m. The study was conducted in the evening peak hour for the vehicles towards western expressway on mid of the week to get the actual traffic condition. Classified volume count and speed data were collected. The vehicles were identified by the registration number at the first section and the same vehicle was then observed by different observers at l the remaining 5 sections.

Coordinators in each section points were connected to each other with 'WhatsApp' to give information about the registration number and class of the selected vehicle. This info is then passed on saying "2W Red Pulsar 526", which is helpful for other station to look for the vehicle.

Ensure that sufficient time is available to collect enough data points within the allotted time period. Plan to spend at least two hours for setup, calibration and removal of the equipment. With measuring tapes 30m length is marked already.

Students were divided into 6 different groups for each section. Each group had 10 members. The works were divided among the members of all groups as follows:

- 2 members were Coordinating with other groups through WhatsApp for the registration number of selected vehicles.
- 2 members noting the time taken by those selected members for traversing the trap length at their section.
- 3 members were carrying out the inventory survey at the section. Also were estimating the gradient, curves if any.
- 3 members were manually noting the classified volume count.

b) Data Retrieval **:**

CVC count and Speed of categorized vehicle was obtained from field survey for one peak hour flow of traafic and further evaluation was done to get the speed profiles at all friction points.

c) DATA EXTRACTION :

CLASSIFIED VOLUME COUNT -

Classified volume count was carried out for the full duration so as to know the traffic composition. It was carried out manually by group of 3 students at all the section for interval of 5 minutes. It was simultaneously carried at all the students so as to understand the loss of vehicle in between if any.

Following figure shows the composition of vehicles in the section.

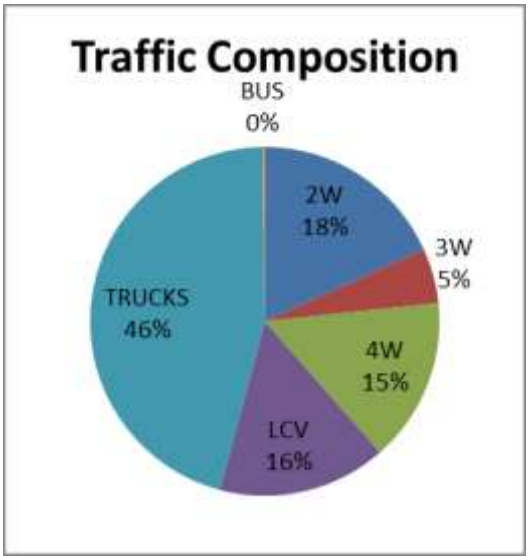

Fig 2- Pie chart representing traffic composition

From traffic composition, it can be clearly understood that the majority of the vehicles in the stream is trucks and LCV (about 60%) since the stretch selected connects the warehouse of Bhiwandi with the western expressway. It is then followed by cars and two wheelers. The percentage of bus is almost zero since only few state transport busses plying between Vasai-Virar and Bhiwandi use the stretch.

A. Speed Measurement-

Speed estimation was completed to cover the same chose vehicle of all class at all the segments. For this the gatherings of facilitators were associated with each other through

WhatsApp and the enlistment number of chose vehicle was passed on to all the gatherings. The stretch was set apart out and about for trap length of 30 meters and the time required by the subject vehicles to navigate. The normal pace of those vehicles were then evaluated for every area and these velocities at various street condition was contrasted and the rate got at the straight extend to examine the impact of that specific condition on the vehicle speed. Taking after figure demonstrates the normal velocity of every classification of vehicles at various areas.

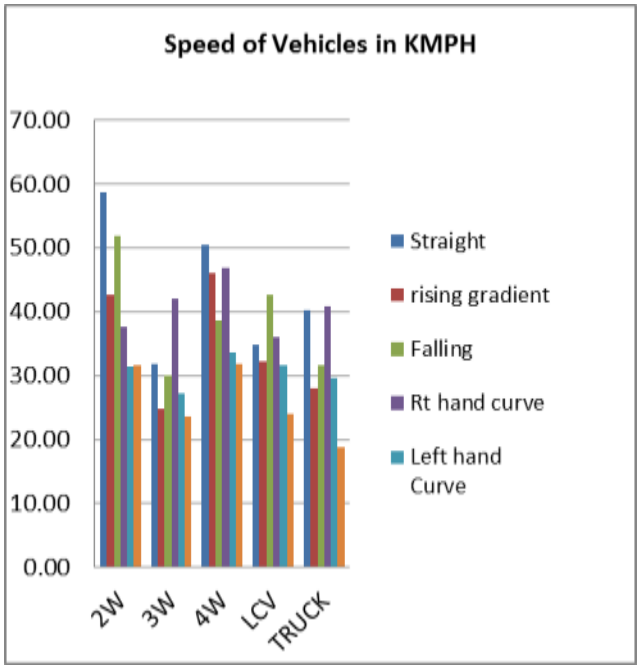

Fig 3 – Bar chart representing speed at six different sections

It is watched that the rate decrease in rate is comparable for 2W, 3W and 4W at left hand bend area and at segment close to the home. Trucks and LCV have high scope of diminishment close to the methodology area. In any case, 3W, LCV and Truck have higher velocity at right hand bend when contrasted with rate at straight segment with 3W having speed just about 30% higher at RHC. Comparable perception is ruined the LCV at area with falling angle with rate 22% higher at falling slope then the velocity at straight segment. The pace is found to most astounding at the straight segment for bikes and four wheelers. Three wheelers and trucks pick up the most elevated rate on right hand bend however the pace of truck at right hand bend is marginally more than the rate at straight area. Though, LCV demonstrates most elevated velocity at an area with falling angle. The pace by all vehicle classes is observed to be least at methodology area close residence and it is trailed by velocity at left hand bend.

B. Estimation of Passenger Car Units :

Traffic composition of India is basically heterogeneous. Traffic volume of heterogeneous traffic is expressed as Passenger Car Unit (PCU) by converting the different types of vehicles into equivalent passenger cars. PCU values at the study section were found using Homogenization method where the length and speed of various vehicle categories is compared with that of passenger car. General formula used for the same is as follows:

$$Li/Vi / Lc/Vc \quad \ldots\ldots\ldots\ldots (1)$$

Where L and V are the length and speed of vehicles

Suffix i and c refers to the vehicle category and car respectively

Standard values of vehicles in India were used for the length of each vehicle category.

Table 1. Dimensions of vehicles

Vehicle Type	Overall Dimension (m)		Area (m^2)
	Length	Width	
2W	1.87	0.64	1.2
3W	2.6	1.4	3.64
Car	3.72	1.44	5.36
Big Car	4.58	1.77	8.11
Buses	10.3	2.5	25.75
LCV	5	1.9	9.5
Truck	7.2	2.5	18

The PCU values obtained by homogenization method were obtained. Usually the PCU values are estimated for straight road section. However since the PCU value is found to be dynamic and changes with the change in speed and Speed is found to Vary with roadway condition. Hence PCU values will vary with the roadway condition. Therefore the variation in PCU values at different section was compared. The following table shows PCU values for different vehicle categories at different sections.

Table 2. Calculated PCU values at different sections

	Straight	Rising gradient	Falling Gradient	Right hand curve	Left hand Curve	Approach
2W	0.43	0.54	0.37	0.63	0.54	0.5
3W	1.11	1.29	0.9	0.78	0.86	0.94
4W	1	1	1	1	1	1
LCV	1.95	1.92	1.22	1.75	1.43	1.77
TRUCK	2.43	3.18	2.37	2.22	2.2	3.27

PCU value can be observed to be higher than straight section at sections with curve except for LCV and Trucks where they are decreasing. Also the values are greater at rising gradient and lower for falling gradient. The values near the approach of habitation are found to be greater for 2W and Truck and are lower for 3W and LCV.

Since the corridor mainly consist of heavy vehicle and hence truck is a dominating vehicle in the stream. Hence for design of facilities at this corridor, trucks should be considered

as subject vehicle. Therefore the equivalency factor for other vehicle category is found using the following equation:

$$Li/Vi / Lt/Vt \quad \ldots\ldots. \quad (2)$$

Where L and V are the length and speed of vehicles

Suffix i and t refers to the vehicle category and truck respectively

Equivalent values for other vehicle categories with truck as reference vehicle are tabulated as below.

Table 3. Truck Equivalency Factor

	Straight	Rising gradient	Falling	Right hand curve	Left hand Curve	Approach
2W	0.18	0.17	0.16	0.28	0.24	0.15
3W	0.46	0.41	0.38	0.35	0.39	0.29
4W	0.41	0.31	0.42	0.45	0.45	0.31
LCV	0.8	0.6	0.52	0.79	0.65	0.54
TRUCK	1	1	1	1	1	1

Similar pattern of variation is found with the truck as reference vehicle and PCU values. However using these values seems to be more logical for such corridors where truck is the dominating vehicle.

C. Estimation of traffic volume

Conventionally for various purposes, the traffic volume is found in terms of PCU per hour using the PCU values either suggested by IRC or through values obtained through various models. In case if there is different roadways resulting in variation in PCU values, the estimated volume may be erroneous.

The volume at different sections obtained is shown in the following table

Table 4. Compared PCU values

	Straight	Rising gradient	Falling Gradient	Right hand curve	Left hand Curve	Approach
Vehicles per hour	492	492	492	492	492	492
PCU per hour (IRC suggested Values)	788	788	788	788	788	788
PCU per hour (Calculated PCU values)	838	1020	757	786	749	1015
In terms of Trucks per hour	345	321	320	354	341	311

It can be seen that the PCU varies from 788 to about 1000 PCU per hour hence the decision for the selection of value of volume should be carried out carefully

IV. ESTIMATION OF PCU VALUE AT ROUNDABOUT

a) Field study :

For the present study video realistic review is more appropriate on account of its capacity to gather information of all the movement stream qualities all the while and encourage information extraction at both infinitesimal and additionally perceptible levels. This additionally gathers exact information for more length. An average four-legged roundabouts having distance across in the scope of 20 to 25 m have been viewed as situated in Chandigarh (Northern piece of India). Four methodologies are having distinctive dimensional components and it is self-controlled amid the off-crest hours. To embrace this study, typical movement stream was kept unregulated for seven hours. Width of the circuitous is measured as 19.82m.

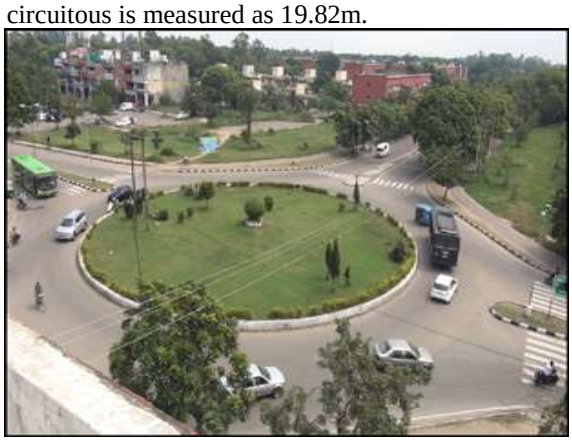

Figure 4:.Snapshot of study location

b) Data Collection :

INVENTORY SURVEY AND PRELIMINARY OBSERVATIONS:

Inventory survey was carried out for the selected study roundabouts to gather details on geometry such as, diameter of Central Island, entry width, approach width, departure width, weaving width, weaving length, etc. The inventory data was collected using a measurement tape. Geometric details of both the roundabouts are shown in subsequent sections

Leg	Entry width (m)	Exit width(m)
A	10.5	9.5
B	8.72	8.72
C	8.3	8.3
D	9.3	9.3

Table 5: Primary observations

For the present study field surveys were carried out on the selected locations using high resolution SONY video camera mounted at vantage locations on nearby high-rise buildings. The arrangement done for video graphic data collection is as below.

Fig5: Data collection through videography

c) Data Retrieval :

Time occupancy**:** Information extraction is the Whole review information was accumulated to get the movement information in wanted configuration. The recorded activity stream video was replayed on a PC and information identified with volume, creation, and inhabitancy time, progress in the coursing stream, acknowledged hole, rejected hole and catch up time was removed physically and recorded for further examination. Procedure of recovering information from obscure or inadequately organized information hotspots for further information preparing, stockpiling and investigation. Various minute and plainly visible level components can be removed from a database like movement video. In the present study the recorded movement stream video was replayed on a substantial screen PC to separate the information identified with passage limit, circulatory stream and inhabitance time, progress, acknowledged and dismisses holes, follow-up time by manual number and recorded for further examination. The vehicles are ordered into seven classifications, in particular, mechanized bike, mechanized three-wheeler, little auto, enormous auto, LCV, transport and truck. The Avidemux-2.6 programming is utilized with the end goal of information extraction as it is a helpful instrument to concentrate activity information in milliseconds. The time distinction in milliseconds will give exactness in investigation and in the meantime keep up the accuracy moreover.

Fig 6 : Snap of avidemux

d) Data Analysis :

The field survey has been carried out for mixed traffic flow data on the selected roundabout located at Chandigarh. Data was extracted for all the individual vehicles for the selected hours for obtaining traffic flow parameters, like entry flow and circulating flow. The entire width of the road was considered for data collection and analysis purpose.

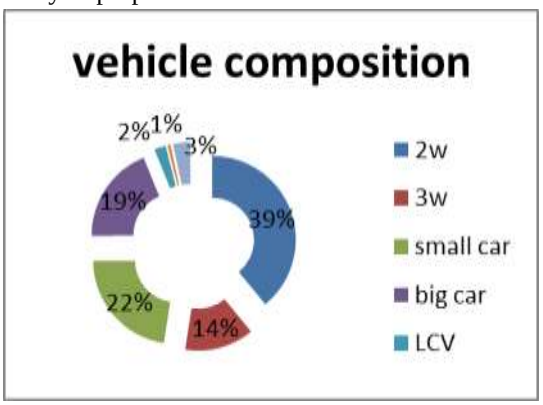

Fig 7 : Pie Chart Showing Vehicle Composition

A. ESTIMATION OF PCU VALUES BY OCCUPANCY TIME :

For the estimation of PCU in roundabout, it is logical to consider the total occupancy time of a vehicle in the roundabout area.A vehicle which occupies lesser time in the roundabout area will create less impedance to the circulating flow, therefore PCU will be different from the vehicle occupies more time to clear the roundabout area. It may be noted that by using this approach, important parameter for performance evaluation at intersections, delay is also incorporated in the clearing time. For example, higher clearing (occupancy) time for heavy vehicles in comparison with standard car implies higher value of delay and hence higher values of PCU. Whereas, lower clearing (occupancy) time or clearing time for small vehicles in comparison with standard carimplies lower

value of delay and hence lower values of PCU.

Considering the above concept, the dynamic PCU equation proposed by Chandra and Kumar (2003) is modified and the total occupancy time of a vehicle type is compared with the occupancy time of standard car for estimation of dynamic PCU. The modified equation is given as Equation 2.

$$PCU = \frac{Clearing\ time(occupancy)\ ratio\ of\ i^{th}\ vehicle\ to\ standard\ car}{Space\ ratio\ of\ car\ to\ the\ i\ th\ vehicle}$$

$$PCUi = \frac{Ti/Tc}{Ac/Ai} \cdots (2)$$

Where, PCUi is the PCU of the subject vehicle i; Tc = Average time occupancy of standard car in seconds for 5- min interval; Ti= Average time occupancy of subject vehicle in seconds for 5 min interval ; Ac= Projected rectangular area of a car as reference vehicle in m^2 and Ai= Projected rectangular area of the vehicle type 'i' in m^2.

For the purpose of this study, the projected rectangular area of the car, (Ac) (reference vehicle) was considered as the average value of the rectangular area of small cars. The physical dimensions for different vehicle categories used for the estimation of PCU value are given in the following Table.2.

Table 6: Physical dimensions for different various categories for PCU estimation

Vehicle Type	Overall Dimension (m)		Area (m^2)
	Length	Width	
Motorized Two-Wheelers	1.87	0.64	1.20
Motorized Three-Wheelers	2.60	1.40	3.64
Small Car	3.72	1.44	5.36
Big Car	4.58	1.77	8.11
Buses	10.3	2.5	25.75
Light Commercial Vehicles	5.00	1.9	9.50
Truck	7.20	2.5	18.0

B. Evaluated PCU values are for all 4 legs as below:

Approach 'A'

Vehicle Category	Left trurning	Straight	Right turning
2 w	0.178	0.174	0.15
Small Car	1	1	1
Big car	1.9	1.32	1.04
LCV	0	1.74	1.23
Truck	0	3.7	0
Bus	5	5.14	1.85
3 w	0.75	0.77	0.64

Approach 'B'

Vehicle Category	Left trurning	Straight	Right turning
2 w	0.17	0.21	0.21
Small Car	1	1	1
Big car	2.8	1.37	0.99
LCV	1.19	1.81	1.7
Truck	0	0	0
Bus	0	5.04	0
3 w	0.5	0.68	0.68

Approach 'C'

Vehicle Category	Left turning	Straight	Right turning
2 w	0.53	0.2	0.2
Small Car	1	1	1
Big car	1.22	1.54	2.25
LCV	1.26	1.53	2.5
Truck	3.33	2.89	0
Bus	6.82	4.18	0
3 w	0.54	0.58	0.77

Approach 'D'

Vehicle Category	Left turning	Straight	Right turning
2 w	0.2	0.18	0.15
Small Car	1	1	1
Big car	2.06	1.42	1.04
LCV	1.7	1.77	1.23
Truck	6.45	3.1	0
Bus	6.3	5.23	1.85
3 w	1.1	0.78	0.64

V. CONCLUSION

Chandra's Method is just technique that can be connected to the Indian state of heterogeneous movement that is described by free path discipline. The various strategies are basically in light of homogeneous activity conditions for the most part winning in created nations. The variety of the territory has impact on pace of vehicles and subsequently having impact on PCU values as noteworthy change in PCU qualities can be watched. This change might likewise influence the estimation of volume of activity stream henceforth the sort of landscape and its impact ought to be unmistakably dissected.

On account of indirect noteworthy change in PCU qualities is seen when contrasted with the qualities recommended by IRC at crossing point. Movement information investigation in the present study demonstrates that in activity organization, bike is having most astounding offer on both the roundabouts took after by little auto, enormous auto, three wheeler, LCV and transport. The PCU of a vehicle is alterable in nature and relies on upon the arrangement and movement volume in circuitous range. Both these element reflect in the inhabitance time of a vehicle sort in indirect zone. Subsequently the PCU qualities are resolved for various conceivable developments: left turn development, straight development and right turn development.

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