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Determination of Dynamic PCU values at the signalized intersection for mixed traffic conditions

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***Abstract*—Traffic conditions in India and many of the developing countries differ from the western country mainly in the composition and lane discipline. Under such conditions, vehicles widely varying in their size, accelerating abilities, and performance capabilities are to share same lanes of the road, which is highly heterogeneous in nature. Especially at signalized intersections. Hence, Passenger Car Unit (PCU) values of several vehicles do not remain static. Recent research works show that the PCU of any type of vehicle can be different at different traffic composition and volume level which points towards the importance of the concept of dynamic PCU. Objective of the present study is to estimate dynamic PCU values of different vehicle categories at signalised intersection under mixed traffic condition by Area Occupancy Method. Effect of traffic characteristics on the dynamic PCU value is also analysed. With the use of estimated dynamic PCU by Area occupancy method, mathematical model is developed for estimation of dynamic PCU using regression technique. From the study it was observed that with the increase in vehicle composition dynamic PCU value also increased and the increase in lane width, dynamic PCU value of two wheelers decreased. The lane width and dynamic PCU values of two wheelers is found to have a negative correlation. Mathematical model was developed for the estimation of dynamic PCU of various categories of vehicles using regression by in cooperating the effect of traffic composition and lane width and cycle time.**

***Keywords*— Signalized intersection, Area occupancy, Dynamic PCU**

1. INTRODUCTION

Traffic conditions in India, having several vehicles with wide variation in their size, accelerating abilities and performance capabilities share same lanes of the road, which is highly heterogeneous in nature. Heterogeneous traffic behaves differently compared to the homogeneous traffic condition. Moving vehicles of heterogeneous traffic condition, may occupy any suitable lateral position on the road. Due to the mixed traffic flow, intersections are take into account as more critical compared to straight road from safety point of view, which have different vehicles with static and dynamic vehicular characteristics. Therefore, to make an intersection secure is challenging part for traffic engineers. Hence for effective planning, design, operation and management of given intersection, the study of traffic operations and traffic characteristics at intersections is of topmost importance.

The non-uniformity in the static and dynamic characteristics of the vehicles is normally taken into account by converting all vehicles in terms of a common unit known as Passenger Car Unit (PCU). The PCU is the universally adopted unit of measurement of traffic volume, derived by taking the passenger car as the standard vehicle. The interaction between moving vehicles in a traffic stream is highly complex and is influenced by a number of roadway and traffic factors. The accurate estimation of the magnitude of vehicular interaction for different roadway and traffic condition is the prerequisite for better operation and management of roadway facilities in their prevailing conditions. Most of the existing analytical approaches based on the field data have the limitation of an underlying assumption of homogeneity, which is a long way from the high variations of driver vehicle characteristics in mixed traffic condition. Stimulation models on the other hand, follow the dynamics of the traffic system, and give a continuous view of the state of the traffic system over time. Hence, PCU values of several vehicles does not remain static due to the heterogeneous condition.

This project focuses on model for determining the DPCU value of various categories of vehicles at signalised intersection in heterogeneous traffic condition by adopting concept of Area Occupancy Method. Also, to find the effect of traffic characteristics on the Dynamic PCU value and to develop a

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model on the obtained DPCU value by regression technique using Excel Software. Model for determining the DPCU value of various categories of vehicles at signalised intersection in heterogeneous traffic condition.

2. EASE OF USE

2.1 Objectives

- To determine the Dynamic PCU value at 4-legged signalised intersection.
- To determine the effect of Traffic characteristics on the Dynamic PCU value.
- To develop a model for determining the DPCU value for the various categories of vehicle at signalised intersection in heterogeneous traffic condition.

2.2 Scope Of Study

Limited to gradient change. Gradient of the road surface is taken as homogeneous. Flow rate of vehicle is assumed to be relatively same on each traffic intersections. Study is based only on Four legged signalized intersection. DPCU Value is obtained based on Area Occupancy Method, its value may change with other methods.

2.3 Need For Study

Effect of Passenger car unit is important for traffic capacity analysis, level of service measures, signal design and coordination. Due to this wide application accuracy of PCU Values is considered to have signinficant influence on traffic flow analysis. In developed countries various methods are devised for PCU Value determination. From the studies conducted it is clear that these methods are not completely applicable to mixed traffic because of the presence of wide variety of vehicles, non-lane discipline and intra class variability of vehicles. Hence this study aims to determine the Dynamic PCU values on four, four legged signalised intersections of Kerala of mixed traffic conditions and to develop a model of DPCU and define the effects of traffic characteristics on DPCU, which will help the traffic engineers while planning and designing an intersection. From the literatures we studied we understood that Area Occupancy . Method is best suited for this study to determine the DPCU values of different category vehicles.

3. LITERATURE SURVEY

Nikhilkumar P. Parmar, P. N. Patel, Dr. L.B. Zala (2018) Their study illustrates the comparison of different dynamic PCU (DPCU) estimation methods (Time occupancy method, Area occupancy method, Time headway method, and Regression method) which shows that Time occupancy and Area occupancy method are suitable to estimate PCU of vehicles in mixed traffic condition.

Sheela Alex, Kuncheria P. Isaac. (2015) This paper clearly explained the significance of PCU values, and has been proved that the PCU values are highly sensitive to the given traffic and geometric condition such as approach width, stream speed, traffic composition as well as traffic volume. The dynamic PCU value for all categories of vehicles has got a negative correlation with the stream speed except in the case of PCU of car and that of bus, in saturated condition. It was also observed that PCU values of two-wheeler, three-wheeler, car and bus decreases with increase in stream speed, during non-saturation stage.

J. Mavani , D. R. Sisodiya , D. K. Kadiya (2016) In this study they found that composition of two wheelers is quite high (60%-70%).It is also seen that dynamic PCU value of 2W and 3W are quite lower than suggested static PCU values. They concluded that increase in 2W composition reduces the maneuverability of the vehicles.

Megha Bhatt ,Priyesh Patel (2017) By this study they concluded that at all intersections composite of two wheelers is quite high . Three wheelers composite varies between (11%-19%). Car composite varies between (14%25%).Light Commercial Vehicle composite varies between (0%-1%). The proportion of 2W,3W and Car is more as compared to LCV ,Bus/Truck and Non motor vehicles.

4. METHODOLOGY

Surveys were conducted systematically on each intersection by video recording method. Data collection was done at peak hours of each junctions. Data's were divided into 20 cycles and DPCU value of different category vehicles at each junction was determined. DPCU value was determined by Area Occupancy Method. Effects of Traffic characteristics were found out and relation graphs were plotted. A model on DPCU was formulated by regression technique using Excel Software.

4.1 DPCU by Area Occupancy Method

Area occupancy is the proportion of the time set of observed vehicles occupy the chosen stretch. It is non-dimensional parameter and its value ranges from 0 to 1. Area occupancy of an individual vehicle category is the sum of the area occupancy of that category vehicles during the observed time.

$$AO = \Sigma i\ (AO)i \quad (1)$$

$$AOi = {}^{ai\,\Sigma}\underline{nti}\ /TA \quad (2)$$

Where,

AOi= the area occupancy of "i" category vehicle.

a_i= horizontal projected area of "i" category vehicle.

t_i= time occupancy of "i" category vehicle. T= observed period in seconds.

A= area of study stretches.

Let$(A_{eq})_i$ be total standard car horizontal projected area equivalent to "i" category vehicle clearing the observation area during observed green time and be the average occupancy time of the all vehicles passing the stop line during the observation green time in the intersection area. So that equivalent standard car occupancy corresponding to the observed area occupancy is $(A^{eq})i t^s\ /TA$. Total occupancy of a vehicle category "i" can be converted to standard car area occupancy as shown in Equations (3) and (4).

$$AO_i = {}^{ai\Sigma nti}/TA = {}^{(Aeq)its}/TA \quad (3)$$

$$(A_{eq})_i = {}^{ai\Sigma nti}\ /\ ts \quad (4)$$

Let $N(cs)_i$ is the equivalent number of standard car spaces corresponding to "i" category vehicle, present in the intersection area during observed green time can be determined using Equation (5).

$(A^{eq})^i$

$$N(cs)_i = (A_{eq})_i\ /a_{sc} \quad (5)$$

Where,

a_{sc}= the horizontal projected area of standard car in m^2.

The number of standard car spaces obtained through Equation (5) can be considered as the equivalent number of passenger cars to the total number of "i" category.

Take be the number of vehicles in the "i" category then the dynamic PCU value of "i" category vehicle can be calculated out using following Equation (6).

PCUi = $N(CS)_i / n_i$ (6)

Where, n_i is number of vehicles of "i" category whose time occupancy are used for the calculation of PCU

Here put the value of $N(cs)_i$from Equation (5)

PCUi = $(A_{eq})_i / asC \times n_i$ (7)

DPCU Values were found out by dividing the green phase into saturated flow time, time of last queued vehicles and Free flow vehicles.

5. ANALYSIS OF DATA

Data collection was done on Perumbavoor M.C. Road traffic signal, Thodupuzha Vengalloor junction, Medical Trust Junction and Jos Junction during the peak hours. Camera was set in such location from that whole clearance area of intersection and up to 10 m from the stop line approach would be visible so that clearance time of straight and right moving vehicles can be counted. Traffic flow is recorded using the above video camera set up. Datas collected were divided into 20 cycles. Dpcu of each category vehicle with percentage volume during the saturated green time, last queued vehicles and free flow vehicles were calculated.

Table.1 Horizontal Projected Area

Vehicle type	Physical dimension (m)		Area (m2)
	Length	Width	
Two Wheeler	1.87	0.64	1.20
ThreeWheeler	2.6	1.4	3.64
Small car (CS)	3.72	1.44	5.36
Big car (CB)	4.58	1.77	8.11
LCV	5.0	1.9	9.50
Buses and HCV	10.3	2.5	25.75

Fig.5.1 Four legged signalised intersection at Perumbavoor

Fig 5.2 Four legged signalised intersection at Thodupuzha

Fig 5.3 Four legged signalised intersection at Jos Junction

Fig 5.4 Four legged signalised intersection at Medical trust junction

6. RESULTS AND DISCUSSION

6.1 Dynamic PCU Model

By developing a mathematical model based on regression analysis, easy and quick estimation of PCU values for the prevailing geometric and traffic stream condition are enabled. To develop DPCU model, data extracted from 3 signalised intersections were taken. Using the traffic stream condition and the obtained DPCU value, regression based model is developed using Excel Software. Data from the balance junction is then used as a check against the obtained DPCU model.

Dpcu Regression model was formulated using the Excel Software. The Regression is given below :

$$PCU_i = a_0 + a_{2W}P_{2W} + a_{3W}P_{3W} + a_{BUS}P_{BUS} + a_{HV}P_{HV} + a_{GT}GT + a_C C + a_W W$$

Where,

PCUi is the PCU of "i" category vehicle;
a_0, a_{2W}, a_{3W}, a_{BUS}, a_{HV}, a_{GT}, a_C, a_W are the regression coefficients;
P_{2W}, P_{3W}, P_{BUS} and, P_{HV} are the percentage of the 2W, 3W, bus and, heavy vehicle;
GT is green signal time in seconds;
C is the cycle length in seconds and;
W is the width of the approach in meter.

Regression Model of Dynamic PCU in Saturation flow :

$PCU_{2W} = 0.181 + 0.0005P_{2W} - 0.0003P_{3W} + 0.0001P_{BUS} - 0.0002P_{HV} - 0.0002GT + 0.006W$ $R^2 = 0.809$

$PCU_{LCV} = -0.732 - 0.002P_{2W} + 0.006P_{LCV} + 0.005P_{BUS} - 0.001P_{HV} + 0.006GT + 0.133W$ $R^2 = 0.560$

$PCU_{BUS} = -18.445 + 0.095P_{2W} + 0.089P_{LCV} + 0.750P_{BUS} + 0.013P_{HV} + 0.047GT + 1.120W$ $R^2 = 0.894$

$PCU_{HV} = 51.670 - 0.495P_{2W} - 0.487P_{LCV} - 0.497P_{BUS} - 0.012P_{HV} + 0.004GT + 0.242W$ $R^2 = 0.857$

Regression Model of Dynamic PCU in Last queued :

$PCU_{2W} = -1.871 + 0.002P_{2W} + 0.00036P_{LCV} + 0.0003P_{BUS} + 0.000012P_{HV} + 0.008GT + 0161W$ $R^2 = 0.950$

$PCU_{LCV} = -10.624 - 0.002P_{2W} + 0.011P_{LCV} - 0.001P_{BUS} + 0.005P_{HV} + 0.047GT + 0.944W$ $R^2 = 0.789$

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PCU_{BUS} = -18.445+0.095P_{2W} + 0.089P_{LCV} + 0.750P_{BUS} +0.013P_{HV} + 0.047GT +1.120W R^2 = 0.894

PCU_{HV} = -12.252 – 0.001P_{2W} – 0.002P_{LCV} + 0.034P_{BUS} + 0.158P_{HV} + 0.074GT + 1.481W R^2 = 0.857

6.2 Validation of DPCU Model

Jos Junction is selected for the model validation. DPCU values of 2 Wheeler , LCV, Bus, Heavy vehicle was calculated using DPCU regression model. Equation is validated using MAPE(Mean Absolute Percentage Error) . the obtained MAPE values for DPCU model of 2 Wheeler , LCV , Bus and Heavy Vehicles in saturation flow condition, 2 wheeler and LCV in last queued and free flow conditions is less than 10%, hence the model is excellent. For Bus , Heavy Vehicle in last queued and free flow conditions the MAPE value is less than 20%, hence the DPCU model is good. This reveals that the model can estimate PCU values with reasonable accuracy and it can be used for the estimation of saturation flow, free flow, last queued flow under heterogeneous traffic conditions.

6.3 Variation in DPCU value with Vehicular volume

In mixed traffic condition at intersections vehicle of several category cross the stop line with varying compositions during green saturated time. Hence, the effect of considerable changes can be observed on DPCU value with the changes in the vehicles compositions, Flow rate, Approach width, and Right turning percentage. To show the effect of some of the above traffic characteristics average PCUs of straight moving vehicle of green phase are used. Here effect of percentage of vehicle on its own PCU value are described considering the composition on different approaches.

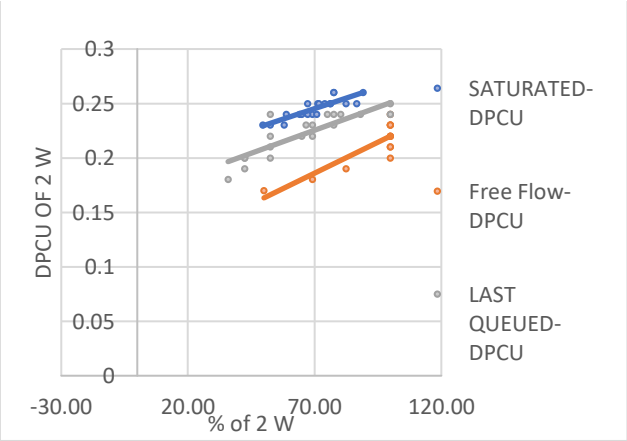

Fig 6.1 Variation in DPCU of Two wheeler with vehicular volume

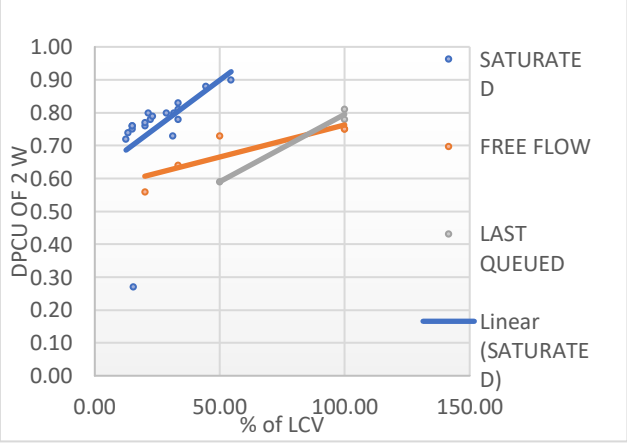

Fig 6.2 Variation in DPCU of LCV with vehicular volume

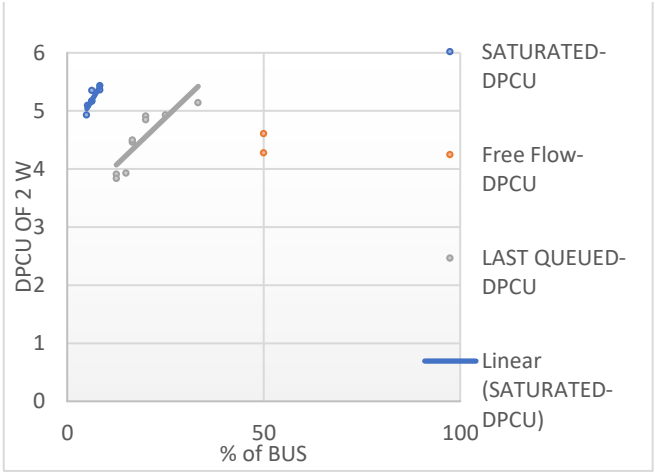

Fig 6.3 Variation in DPCU of Bus with vehicular volume

6.4 Variation in DPCU with approach width

Lane widths of different junctions were found to be 7m,7.5m,9m and 9m for Perumbavoor, Thodupuzha, Medical trust junction and Jos junction respectively.

It was found that with the increase in lane width Dpcu value of 2 wheelers decreased. Thus lane width and Dpcu value of 2 wheelers were found to have a negative correlation. For LCV, Bus and Heavy Vehicle , Dpcu and lane width has a positive correlation.

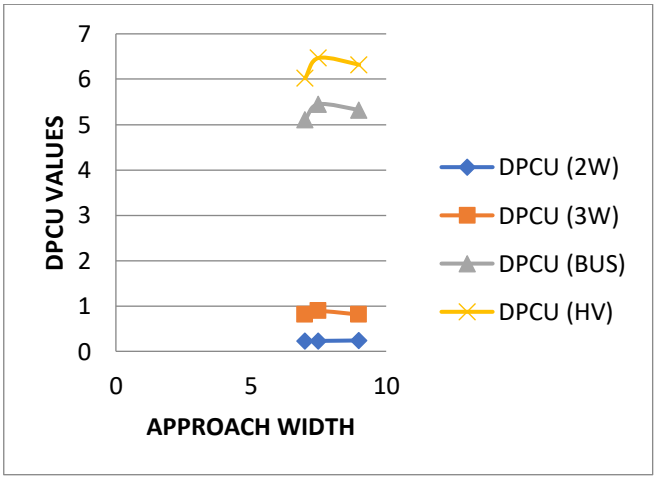

Fig 6.4 Variation in DPCU values of Saturated time flow With approach width

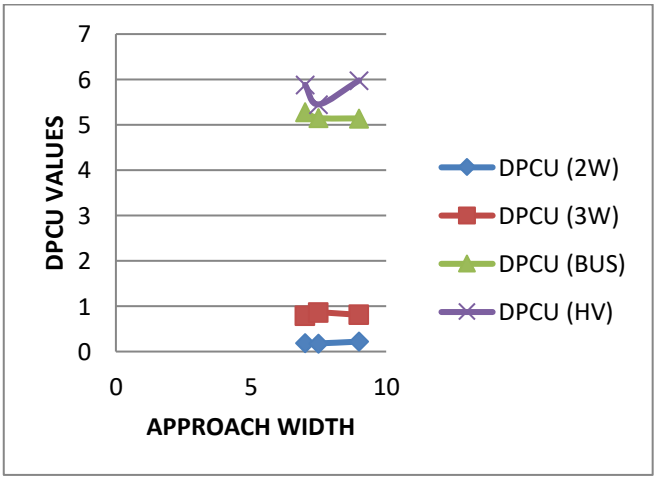

Fig 6.5 Variation in DPCU values of Free flow with approach width

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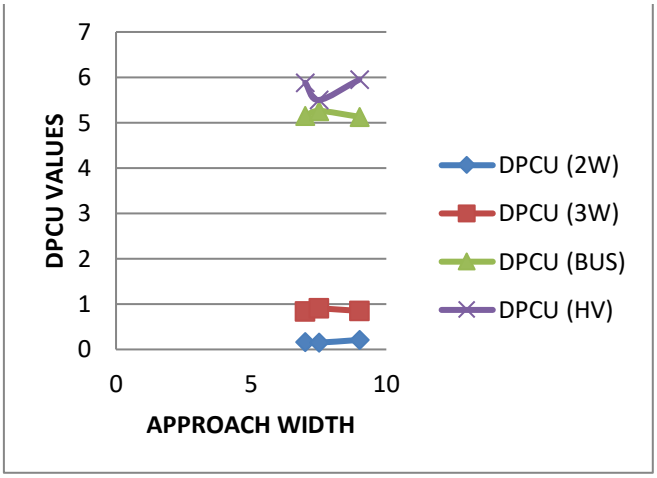

Fig 6.6 Variation in DPCU values of Last queued with approach width

7. CONCLUSION

This study determines the Dynamic PCU values of 4, four legged signalised intersections in mixed traffic flow in Kerala, which helps the traffic engineers for better study of the intersection and analysed the effect of traffic flow characteristics on the DPCU value. Correlation of several traffic parameters with the DPCU are illustrated with the graphs. Mathematical model was developed for estimation of DPCU of various category vehicles using regression technique by Excel Software. Mathematical model enable the easy and quick estimation of D PCU values for the prevailing geometric and traffic stream condition. The model is created using the values found out at Perumbavoor junction, Thodupuzha Vengallor Junction and Medical trust junction and is checked using the values from Jos junction. .In addition, following results are concluded for the selected approaches:

- Dpcu value range for 2 wheelers at Perumbavoor junction is maximum during saturated green time and decreases in last queued to free flow vehicles. This behaviour is same for other category vehicles also.
- Dpcu value range increases from Free flow vehicles to Last Queued vehicles to saturated flow vehicles for different vehicle categories at other junctions also.
- Dpcu values for 2 wheelers, LCV, Buses and Heavy vehicles have a positive correlation with its own proportion at every junction taken.
- With the increase in vehicle composition, Dpcu value also increases.
- It is found that with the increase in lane width Dpcu value of 2 wheelers decreased. Thus lane width and Dpcu value of 2 wheelers is found to have a negative correlation.
- For LCV, Bus and Heavy Vehicle, Dpcu and lane width has a positive correlation.

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REFERENCES

[1] **Nikhilkumar P. Parmar, P. N. Patel & Dr. L.B. Zala,** "Effect of Traffic Characteristics on the Dynamic PCU under Mixed Traffic Condition at Urban Signalized Intersection", International Research Journal of Engineering & Technology(IRJET), Volume:05 Issue 05, May 2018.

[2] **Sheela Alex & Kuncheria Isaac**, "Dynamic PCU Values at Signalised Intersections in India For Mixed Traffic", International Journal for Traffic and Transport Engineering, 2015, 5(2):197-209.

[3] **J. Mavani , D. R. Sisodiya , D. K. Kadiya , P. M. Shah & Dr. H. R. Varia,** "Dynamic PCU values at Signalized Intersection on Urban Corridor of Ahmedabad City", International Journal of Advance Engineering & Research Development, Volume 3, Issue 5, May-2016.

[4] **Megha Bhatt & Priyesh Patel**, "Determination of dynamic PCU in Ahmedabad city", IJARIIE-ISSN(O)-2395-4396, Volume-3 Issue 2- 2017.

[5] **Fadly Arirja Gani & Toshio Yoshii**, "Estimation of Dynamic value of Passenger Car Unit in the Mixed Traffic", Journal of the Eastern Asia Society for Transportation Studies, Vol. 12, 2017.

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