ESTIMATION OF EQUIVALENCY UNITS OF DIFFERENT VEHICLE TYPE UNDER MIXED TRAFFIC CONDITIONS

Seelam Srikanth[1], S. Eswar[2], Syed Omar Ballari[3], Anil Modinpuroju[4] and Chunchu Balarama Krishna[5]

[1,5]School of Civil Engineering, REVA University, Bangalore, India
[2]Department of Civil Engineering, Gudlavalleru Engineering College, Gudlavalleru, Andhra Pradesh, India
[3]Dept of Civil Engineering, Guru Nanak Institutions Technical Campus, Ibrahimpatnam, Telangana, India
[4]Department of Civil Engineering, Kamala institute of Technology and Science, Telangana, India

ABSTRACT

PUC is equivalency unit and acts converting factor that is used to convert different vehicle type in traffic stream into equivalent vehicle type exclusively in terms of passenger cars. There are several methods of estimating the PCU values . This study carried out estimating of PCU using few of method as mentioned in literature only based on data collected from field and it mainly concentrate on the on static characteristics of vehicle .This paper discuss the accuracy of methodology used in studies.

Keywords: *PCU, Equivalency Units*

Introduction

In developing country traffic flow is generally heterogenous in nature, however implementing degree of heterogeneity varies. Heterogenous traffic shows complication in implementing traffic operations and designing roads. Measuring traffic volume as veh/hr. is inappropriate because of heterogenous traffic comprising different types of vehicles with different static and dynamic characteristics .due to this heterogeneity traffic studies becomes critical. PCU or PCE is a common approach used to convert the heterogenous traffic into equivalent homogenous units. In analyzing the traffic facilities and controlling and managing the traffic PCU estimation plays crucial role .

The highway research board in 1965 highway capacity manual first defined PCU as "the number of passenger cars displaced in traffic flow by a truck or a bus under prevailing roadway and traffic conditions". Later its redefined by Transportation Research Broad in 2010 as "the number of passenger car which will result in the same operational condition as a single heavy traffic vehicle of a particular section of road under particular traffic type under specified roadway, traffic and controlled conditions. Many different methods came to existence in this mean period of time . This led to confusion between user in terms of accuracy of PCU

Use of appropriate PCU for different vehicle categories will lead to correct volume of heterogenous traffic in mixed traffic conditions holding the desired level of services .In present studies ,videography is used to collect data and different method like dynamic PCU method , modified approach to dynamic method and multiple non- linear approach method are used and estimated the equivalency units .this paper also compare and discuss accuracy of results obtained from each method

Methodology

1.1 Dynamic Method

According to this method, PCU is directly proportional to speed ratio and inversely proportional to the projected area ratio with respect to the standard vehicle

$$PCU=(V_c/V_i)/ (A_c/A_i)$$

where V_i and V_c = mean speeds of vehicle type 'i' and car respectively; A_i and A_c = respective projected rectangular areas of vehicle type 'i' and car; on the road.

1.2 Modified Approach Method

This method is modification of dynamic method where headway is extra factor which is used to estimate PCU.In this method speed factor, area factor, headway is considered. the product of speed factor, area factor, and

headway factor gives PCU values and calculation of each factor is as shown.

1.2.1 Speed factor (F_v): Its ratio of speed of standard car i.e., small car to that of speed of subject vehicle. Let's consider two-wheeler as subject vehicle.

1.2.2 Area factor (F_a): It is a ratio of area of subject vehicle to that of area of standard car.

Then $F_a = \frac{Ai}{Ac}$

Where: F_a- Area factor of subject vehicle.

A_i- area of subject vehicle.

A_c-area of standard car.

1.2.3 Headway factor F_t:

Its ratio of headway of subject vehicle to that of headway of standard car.

Then $F_t = \frac{Ti}{Tc}$

Where: F_t- headway factor of subject vehicle

T_i- mean time headway of subject vehicle

T_c-mean time headway of standard car

1.2.4 PCU of subject vehicle (TW):

The product of speed factor, area factor, and headway factor gives the PCU of subject vehicle.as shown below.

$PCU_i = F_v * F_a * F_t$

Where:PCU_i-PCU of subject vehicle

F_v- speed factor of subject vehicle

F_a- area factor of subject vehicle

F_t- time headway factor of subject vehicle

1.3 Multiple non-linear method

To estimate PCU speed model are developed using independent variable in non-linear regression method. It considers the variable like proportion of all type of vehicle ,an average speed of vehicle types other than standard cars(CS),where CS is considered as standard vehicle and area ratio of CS to all other vehicle types. The product of the area ratio of CS to subject vehicle type ,proportion share of subject vehicle type and average speed of subject vehicles type are used as multiplicative component and proportional of car is used as additive component. This model is developed to predict the sped of standard vehicle type whose co-efficient are estimated as equivalency units of all subject vehicle type.

$$V_{CS} = \sum_{j=1}^{k} a_j \left(\frac{Acs}{Aj} * n_j * V_j \right) + a_i * n_{cs}$$

Where $V_{CS\,i}$=average speed of small car

a_j&a_i = regression co-efficient

V_j = average speed of vehicle type j

n_j = proportion of vehicle type j

n_{cs}= proportion of standard car

A_j= projected area of subject vehicle type j

A_{cs}= projected area of standard car

Field Data Collection and Analysis

To carry out of studies two different section of NH 16 is selected as site. section I is near Vijayawada and Guntur and second section is at Ongle. Data is collected by varying the time as peak and non -peak hours are considered. 3-4 hours of videography is collected from both sections. A stretch of 50 m is marked and video is recorded . From videography recorded entry and exit time of each vehicle in between stretches noted. Based on this volume of traffic, speed and time headway are collected and even observed traffic capacity and speed parameters like low median and design speed are extracted.

Table 1 Dimension of Vehicle Type

Vehicle type	Length in m	Width in m	Area in m^2
TW	1.97	0.74	1.46
LCV	4.3	1.56	6.71
CB	4.6	1.7	7.82
HCV	6.7	2.3	15.41
A	3.2	1.3	4.16
MAV	11.5	2.42	27.83
BUS	10.6	2.4	25.44
CS	3.6	1.6	6.12

Table 2 Average Speed and Average Headway of Different Vehicle Type at Both Sections

Section	I		II	
Vehicle Type	Average Speed in km/hr.	Average Headway in sec	Average Speed in km/hr.	Average Headway in Sec
TW	54.92	2.54	51.80	4.25
LCV	58.15	2.34	58.63	3.99
CS	84.19	2.68	76.46	4.08
CB	80.32	2.79	84.28	3.80
HCV	52.7	2.88	48.56	4.48
A	50.13	2.58	45.32	3.85
MAV	46.82	2.87	43.95	5.09
BUS	63	2.85	57.54	4.62

Table 3 Speed Parameters and Composition of Vehicle at Different Sections

Section	Vehicle Type	Maximum Speed in km/hr.	Minimum Speed in km/hr.	SD	V 15	V50	V85	Compositions of Vehicle in %
I	TW	90	22.5	14.95	45	60	60	50.10
	LCV	90	30	14	45	60	60	6.76
	CS	90	36	26.44	60	90	90	23.21
	CB	90	30	21.34	60	90	90	7.03
	HCV	90	30	15.83	36	45	60	3.82
	A	60	36	10.07	45	45	60	2.12
	MAV	60	30	10.07	36	45	60	2.59
	BUS	90	35	14.03	45	60	90	4.10
II	TW	90	25	13.29	36	45	60	32.29
	LCV	60	22.5	19.03	36	60	90	6.69
	CS	90	30	17.06	60	90	90	18.70
	CB	90	45	14.38	60	90	90	5.19
	HCV	90	25.8	15.75	36	45	60	4.98
	A	60	22.5	9.23	36	45	60	2.25
	MAV	90	28	10.13	36	45	60	6.69
	BUS	90	45	11.02	45	60	60	4.16
Section	**Vehicle Type**	**Maximum Speed in km/hr.**	**Minimum Speed in km/hr.**	**SD**	**V 15**	**V50**	**V85**	**Compositions of Vehicle in %**
I	TW	90	22.5	14.95	45	60	60	50.10
	LCV	90	30	14	45	60	60	6.76
	CS	90	36	26.44	60	90	90	23.21
	CB	90	30	21.34	60	90	90	7.03
	HCV	90	30	15.83	36	45	60	3.82
	A	60	36	10.07	45	45	60	2.12
	MAV	60	30	10.07	36	45	60	2.59
	BUS	90	35	14.03	45	60	90	4.10
II	TW	90	25	13.29	36	45	60	32.29
	LCV	60	22.5	19.03	36	60	90	6.69
	CS	90	30	17.06	60	90	90	18.70
	CB	90	45	14.38	60	90	90	5.19
	HCV	90	25.8	15.75	36	45	60	4.98
	A	60	22.5	9.23	36	45	60	2.25
	MAV	90	28	10.13	36	45	60	6.69
	BUS	90	45	11.02	45	60	60	4.16

Estimation of PCU Using the different method mentioned in literature review, the process of estimation of equivalency units is carried out.

PCU is estimated by dynamic method, modified method and multiple non-linear regression method at both section after extracting average speed and average time headway from data collected

Table No. 4 PCU Value of Different Vehicle types by Dynamic Method at Section I and II

Section	Vehicle Type	Speed Ratio	Area Ratio	Dynamic PCU
I	TW	1.53	4.192	0.33
	LCV	1.45	0.912	1.5
	CS	1.00	1.00	1.00
	CB	1.03	0.783	1.23
	HCV	1.59	0.397	4.02
	A	1.67	1.471	1.14
	MAV	1.79	0.220	8.17
	BUS	1.34	0.241	5.5
II	TW	1.47	4.19	0.35
	LCV	1.30	0.91	1.43
	CS	1.00	1.00	1.00
	CB	0.91	0.78	1.6
	HCV	1.57	0.39	3.95
	A	1.68	1.47	1.14
	MAV	1.71	0.22	7.91
	BUS	1.33	0.24	5.52

Table No 5 PCU Value of Different Vehicle types by Modified Approach Method At

Vehicle types	Speed Factor	Area Factor	Headway Factor	Modified PCU
TW	1.53	0.239	0.95	0.35
LCV	1.44	1.09	0.87	1.36
CS	1.00	1.00	1.00	1.00
CB	1.03	1.28	1.04	1.37
HCV	1.59	2.52	1.07	4.28
A	1.67	0.68	1.08	1.3
MAV	1.79	4.55	1.07	8.71
BUS	1.34	4.15	1.06	5.89

Table No 6 PCU Value of different Vehicle types by Modified Approach Method at Section II

Vehicle Types	Speed Factor	Area Factor	Headway Factor	Modified PCU
TW	1.47	0.239	1.04	0.36
LCV	1.31	1.09	0.99	1.41
CS	1.00	1.00	1.00	1.00
CB	0.91	1.28	0.98	1.13
HCV	1.57	2.52	1.09	4.29
A	1.68	0.68	1.06	1.21
MAV	1.74	4.55	1.07	8.47
BUS	1.32	4.15	1.13	6.19

For MNLR method: Initially vehicle count and proportion of each vehicle is calculated for 5 min of time intervals. The traffic composition and average speed of all vehicle types on all sections are given in Table 7. Field data collected at Section-I was used for the development of multiple non-linear regression (MNLR) speed models and Section-II data was used for the validation of the developed model.

Table No 7 Average Speed and Proportional Share of Vehicle at both Section I and II

Section	I		II	
Vehicle Type	Average Speed in km/hr.	Proportion Share	Average Speed in km/hr.	Average Headway in Sec
TW	45.1	0.45	56.5	0.48
LCV	47.6	0.07	60.1	0.04
CS	64.5	0.20	83.3	0.23
CB	67.0	0.06	75.1	0.10
HCV	42.0	0.07	51.9	0.08
A	40.8	0.12	49.4	0.018
BUS	45.2	0.03	66.1	0.05

PCU values of different vehicle are considered as regression coefficient in proposed equation of regression method. The average speed of accuracy of model in determining speed.

V_{cs}= a_1*ncs+a2*$\left(\frac{Acs}{Acb} * n_{CB} * V_{CB}\right)$+a3*$\left(\frac{Acs}{Alcv} * n_{LCV} * V_{LCV}\right)$+a4*$\left(\frac{Acs}{Ahcv} * n_{HCV} * V_{HCV}\right)$+a5*$\left(\frac{Acs}{Atw} * n_{TW} * V_{TW}\right)$+a6*$\left(\frac{Acs}{Aa} * n_A * V_A\right)$+a7*$\left(\frac{Acs}{Ab} * n_B * V_B\right)$

standard car (cs) is considered as initial co-efficient as a_1 .73 km/hr. is taken as a_1.R^2 value obtained is 0.77. R^2 indicates the

Table No 8

Vehicle Type	Co-Efficient	PCU Values
CB	a_2	1.56
LCV	a_3	2.69
HCV	a_4	3.83
TW	a_5	0.28
A	a_6	0.85
B	a_7	6.80

Comparison of Results

PCU is estimate dusing dynamic method, modified approach method at both Vijayawada - Guntur and Ongle sections is compared with their results .and it is observed that modified approach shows higher PCU values than dynamic method . These results compared with MNLR method it shows greater values of PCU than both methods for some vehicles.

Table No 9

Section	I		II	
Vehicle type	Dynamic PCU	Modified PCU	Dynamic PCU	Modified PCU
TW	0.33	0.35	0.35	0.36
LCV	1.5	1.36	1.43	1.41
CS	1.00	1.00	1.00	1.00
CB	1.23	1.37	1.6	1.13
HCV	4.02	4.28	3.95	4.29
A	1.14	1.3	1.14	1.21
MAV	8.17	8.71	7.91	8.47
BUS	5.5	5.89	5.52	6.19

Conclusion

- Different method mentioned in literature review used to estimate PCU are resulted realistic under mixed traffic condition .
- Modified approach method shows higher values of PCU when compared to dynamic method
- MNLR method is found to be more realistic and logical under heterogenous traffic and it is suitable for high heterogenous traffic conditions. Since MNLR method considered composition into consideration where other two method considered only relations of area and speed and headway.
- But the present studies have practical difficulties in collecting data under controlled conditions and the data has been collected at different section of same site , it would have improved if collected at different location and studies will be continued to observe variation of PCU with respect to different location and considering road characteristics for calculations of PCU

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