

METHODS OF ESTIMATION OF PASSENGER CAR UNIT AT UNSIGNALIZED INTERSECTION A REVIEW

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Abstract : Passenger Car Unit (PCU) can also be termed as passenger Car Equivalent (PCE). PCU is a unit used in Transportation Engineering. To study the rate of traffic flow on any intersection or road we must have studied PCU value of various categories of vehicles. Passenger Car Equivalent of any type of vehicle is the effect of vehicle on traffic variable as compared with a Standard Passenger Car. Transportation plays an important role in the growth of any country. In developing country like India, Road Transportation plays very crucial role in the development. Nature of the traffic on developing countries like India is heterogeneous in nature. As we all know, India has second largest network in the world. Roads are the most common and used mode of transportation. Various categories of vehicles which differ in dimension are available on the roads. So any set of values of PCU is not suitable for that particular location or condition. This means that we cannot simply depend upon the static PCU values provided in the manuals, we need to calculate dynamic values of PCU varying with respect to location or condition.

Two Methods are used for determining the PCU values at unsignalized intersections. In first method the PCUs are estimated as per Highway Capacity Manual considered at unsignalized intersections. In HCM the PCU values are calculated using occupancy time method. In second method, the method proposed by Chandra & Kumar for estimation of PCUs is used. It is most popular method used for estimation of PCUs which is used in various countries of the world. Data was collected at unsignalized intersections. There was not obstruction in observation of traffic due to roadside construction, bus stop, market etc. There was no signalized intersection in the range of 3 km. roadway length. Traffic volume was collected in peak hours and in both directions. Speeds of various types of vehicles were also measured. The results obtained from the above methods were compared with the values given in Highway Capacity Manual and it shows there is difference in values of PCU, which is given in HCM. This suggests that we need to take dynamic value of PCU depending upon the characteristics of location and other variable for traffic volume study or analysis. Further study or research can be carried out for estimating the dynamic values of PCUs at Expressways, National Highways etc.

Index Terms – Highway Capacity Manual, PCU, PCE, Unsignalized.

1. INTRODUCTION

Transportation is of economic growth and development of country. In developing countries like India, Road transportation plays an important role in the development with road network second largest in the world after America, traffic study is very much important. In India, various types of vehicles with different dimension are present on roads and highways. With huge length of road, then also traffic congestion exist in India. To know the traffic capacity at any section or intersection, Passenger Car Unit is used. The traffic nature in India is heterogeneous fast moving vehicle and slow moving vehicle are present in same road which causes congestion To qualify the situation, all vehicle are converted into equal number of standard cars. That conversion is known as passenger car unit.

2. PROBLEM STATEMENT

In the present time, PCU values used in India are comparatively older, 55 years ago, road surface was not as improved as today and their maintenance was also not done as accurately in previous time as compared by recent times. The characteristics and dimension of vehicle in India were different from modern day's vehicles. Modern day vehicle on the roads of India is totally different from the vehicles which were present on that time when PCU values were calculated. The behaviour of driver is also different from the past as compared with present time. Modern day's driver always tries to take advantage of loose discipline or laws on the roads.

So, this is the time to calculate the Dynamic values of PCU of various categories of vehicles, otherwise the real capacity of any road or highway will not be used in Traffic Volume Study. PCU value of any vehicle changes with respect to condition so, we need to calculate the PCU values as per existing condition and compare the PCU values with the values given in Highway Capacity Manual (HCM).

3. OBJECTIVE OF THE STUDY

- To check the accuracy of PCU values calculated in Highway Capacity Manual.
- To Study the static and dynamic nature of PCU Values.
- Compare the static and dynamic PCU values.
- Calculation of PCU values at unsignalized Intersections.

4. RESEARCH METHODOLOGY

The above objective can be achieved by following steps

Step 1. Categorisation of Different Types of Vehicles on the Roads of India.

Step 2. Determination of dimension (average) of different category of vehicle.

Step 3. Determination of velocity (average) of different category of vehicle.

Step 4. Calculation of Passenger Car Unit values by following methods

- Chandra and Kumar method.
- Occupancy time Method

Step 5. Comparison of PCU values with the values given in Highway Capacity Manual.

Step 6. Analysis of Result.

Step 7. Conclusion and Recommendation.

5. FACTORS AFFECTING THE PCU VALUES

PCU values are very sensitive such that any change in traffic data or dimension of vehicle changes the PCU values dynamically. As per HCM the factors affecting PCU values are as follows

Feature of Vehicles

Feature of vehicle is categorized into two categories i.e. Physical and mechanical. Physical feature includes such as length, width & height of the vehicle. Mechanical feature include power, accelerations, deceleration and braking characteristics of the vehicles. Many methods to calculate the PCU values mainly focus on projected area of vehicle on the road so any change in dimension of any category of vehicle changes its PCU values. Mechanical properties are also an important factor while deciding the PCU values.

Characteristics of Traffic stream

Any change in traffic data changes the PCU values of vehicles. Various traffic parameter which can affect the PCU values is a) Mean speed of the traffic. b) Lateral or transverse gap of vehicle at different speeds of traffic flow. c) Longitudinal gap of vehicles at different speeds of traffic flow. d) Composition of Traffic Stream i.e. Percentage distribution of different category of vehicles. e) Volume to capacity ratio of the traffic. f) Flow nature.

Characteristics of Road

Various properties of roads can affect the PCU values. Location of the road also plays an important part whether rural, urban or semi urban areas. The place where we are calculating the values such as signalized intersections, unsignalized intersections, mid block or rotary also affects the PCU values. The value of longitudinal and lateral friction of the surface also plays an important part in deciding the PCU values. Regulation of traffic flows also plays an important part in estimation of PCU values, whether the road is one-way, two-way, divided or undivided roads. Total number of lanes also affects the PCU values.

Characteristics of Environment

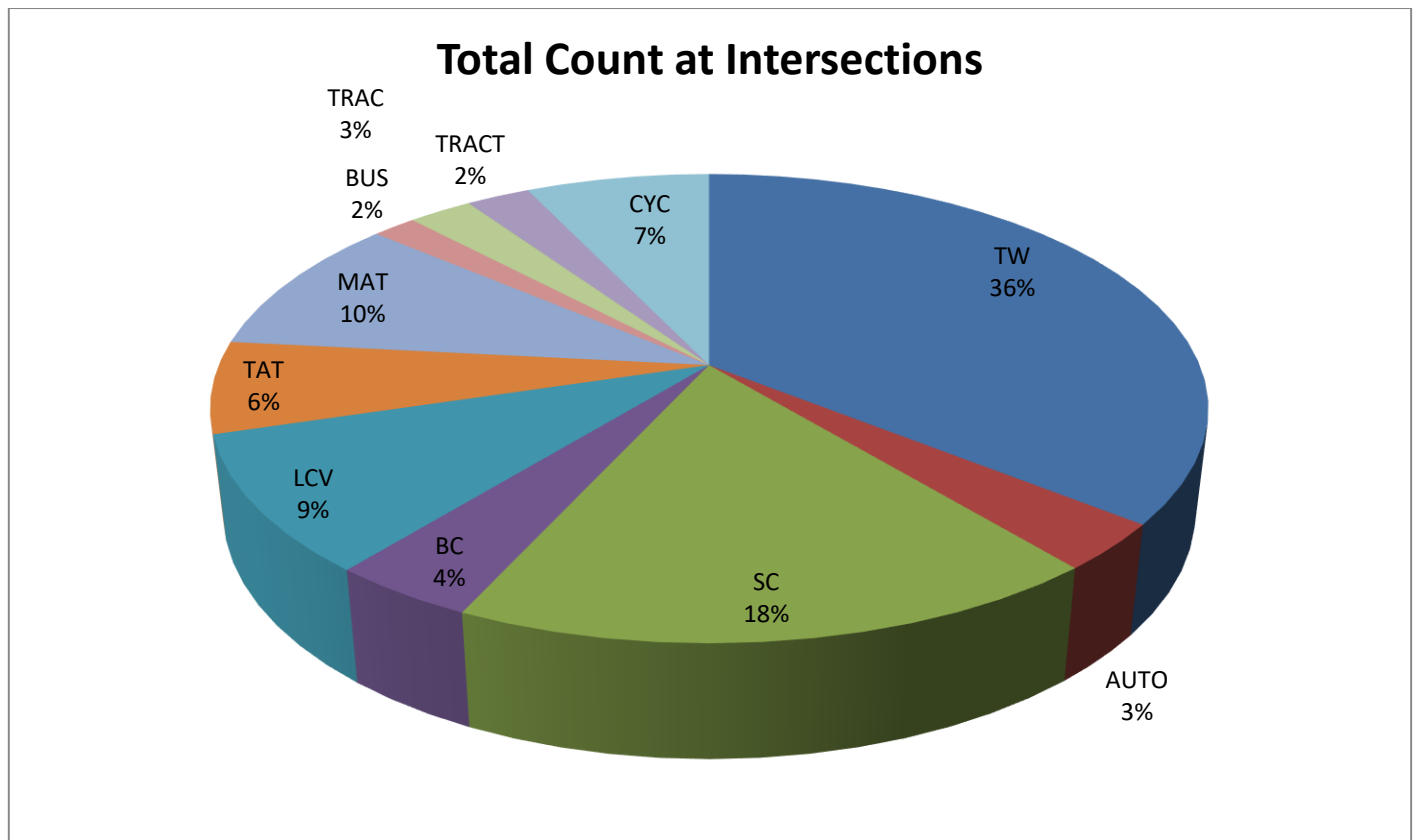
The terrain condition of road or highway can affect the PCU values of vehicles, whether road is in plain, rolling, hilly or mountainous areas. Local Factors can also affect the PCU values.

Conditions of the Climate

Presence of Fog, mist on highway can affect the PCU values. Rainy season or dry season can also affect the PCU values of Vehicles.

Controlling condition

Speed Limit, no access of heavy vehicles these types of controlling condition can also affects the PCU values.

6.Survey Data**Graph 1 Representation of Percentage of Different Category of Vehicles****Table 1 Average Velocity of Different Categories of Vehicles at Intersection**

S.N	Category of Vehicle	Average Velocity at Kotma Road(kmph)	Average Velocity at Dola Road(kmph)	Average Velocity at Bijuri Road(kmph)	Average Velocity at Intersections(kmph)
1	TW	49.36	50.74	44.47	48.19
2	AUTO	32.59	38.57	32.76	34.64
3	SC	63.08	67.3	53.29	61.22
4	BC	46.82	49.53	42.02	46.12
5	LCV	45.82	46.31	37.47	43.20
6	TAT	62.47	64.44	43.83	56.91
7	MAT	70.45	73.91	49.23	64.53
8	BUS	71.33	69.89	48.75	63.32
9	TRAC	40.28	44.97	44.44	43.23
10	TRACT	40.28	44.88	44.44	43.20
11	CYC	15.29	14.77	11.41	13.82

Estimation of PCU values of Different Categories of Vehicles at Intersection by Chandra Method

As per Chandra method PCU is calculated by following equation

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

Where, V_c = Avg. velocity of standard passenger car (kmph), V_i = Avg. velocity of vehicle type 'i' (kmph), A_c = Project area of standard passenger car (m^2), A_i = Project area of vehicle type 'i' (m^2)

Table 2 Calculation of PCU values for Different Categories of Vehicles

S.N	Type of Vehicle	Notations	Avg.Area (m ²)	Velocity (kmph)	Vc/Vi	Ac/Ai	Estimated PCU	HCM PCU VALUES
1	Two Wheelers	TW	1.46	48.19	1.27	3.84	0.33	0.4
2	Motorized Auto rickshaws	Auto	3.63	34.64	1.77	1.55	1.14	0.98
3	Small /Standard Cars	SC	5.61	61.22	1.00	1.00	1.00	1
4	Big Cars and Vans	BC	8.82	46.12	1.33	0.64	2.09	1.29
5	Light Commercial Vehicles	LCV	7.19	43.20	1.42	0.78	1.82	1.7
6	Two / Three Axle Trucks	TAT	13.16	56.91	1.08	0.43	2.52	2.38
7	Multi Axle Trucks	MAT	20.52	64.53	0.95	0.27	3.47	3.06
8	Buses	Bus	23.92	63.52	0.96	0.23	4.11	2.29
9	Tractors	TRAC	5.87	43.23	1.42	0.96	1.48	1.62
10	Tractor with Trailers	TRACT	15.13	43.20	1.42	0.37	3.82	3.13
11	Cycles	CY	0.87	13.82	4.43	6.45	0.69	0.42

Table 3.Comparison of estimated PCU values with the HCM values

S.N	Type of Vehicle	Notations	Estimated PCU	HCM PCU VALUES
1	Two Wheelers	TW	0.33	0.4
2	Motorized Auto rickshaws	Auto	1.14	0.98
3	Small /Standard Cars	SC	1.00	1
4	Big Cars and Vans	BC	2.09	1.29
5	Light Commercial Vehicles	LCV	1.82	1.7
6	Two / Three Axle Trucks	TAT	2.52	2.38
7	Multi Axle Trucks	MAT	3.47	3.06
8	Buses	Bus	4.11	2.29
9	Tractors	TRAC	1.48	1.62
10	Tractor with Trailers	TRACT	3.82	3.13
11	Cycles	CY	0.69	0.42

Estimation of PCU values of Different Categories of Vehicle at Intersection by HCM Method

As per Highway Capacity Manual the PCU is calculated by following equation

$$PCU_i = (OT_i / OT_{sc}) * (W_i / W_{sc})$$

Where PCU_i=PCU value of vehicle type 'i', OT_i=Occupancy Time of Vehicle type 'i' in seconds, OT_{sc}=Occupancy Time of standard Passenger Car in seconds, W_i=Width of Vehicle type 'I' in m, W_{sc}=Width of standard passenger car in m.

Table 4. Calculation of PCU values by HCM Method

S.N	Type of Vehicle	Notations	Avg. Width(m)	Occupancy Time(s)	Wi/Wsc	OTi/OT _{sc}	Estimated PCU
1	Two Wheelers	TW	0.73	2.90	0.46	0.94	0.43
2	Motorized Auto rickshaws	Auto	1.32	4.75	0.84	1.53	1.29
3	Small /Standard Cars	SC	1.57	3.10	1.00	1.00	1.00
4	Big Cars and Vans	BC	1.86	3.99	1.18	1.29	1.52
5	Light Commercial Vehicles	LCV	1.61	4.30	1.03	1.39	1.42
6	Two / Three Axle Trucks	TAT	2.11	4.90	1.34	1.58	2.12
7	Multi Axle Trucks	MAT	2.39	5.92	1.52	1.91	2.91
8	Buses	Bus	2.42	4.95	1.54	1.60	2.46
9	Tractors	TRAC	1.71	5.26	1.09	1.70	1.85
10	Tractor with Trailers	TRACT	2.13	6.16	1.36	1.99	2.70
11	Cycles	CY	0.47	12.87	0.30	4.15	1.24

Table 5. Comparison of estimated PCU values with the HCM values

S.N	Type of Vehicle	Notations	Estimated PCU	HCM PCU VALUES
1	Two Wheelers	TW	0.43	0.34-0.48
2	Motorized Auto rickshaws	Auto	1.29	0.98
3	Small /Standard Cars	SC	1.00	1
4	Big Cars and Vans	BC	1.52	1.29
5	Light Commercial Vehicles	LCV	1.42	1.7
6	Two / Three Axle Trucks	TAT	2.12	2.38
7	Multi Axle Trucks	MAT	2.91	3.06
8	Buses	Bus	2.46	2.29
9	Tractors	TRAC	1.85	1.62
10	Tractor with Trailers	TRACT	2.70	3.13
11	Cycles	CY	1.24	0.42

8. Conclusion

The main outcome of the study is to obtain a set of values which can be used for calculation of traffic capacity. This paper demonstrates the dynamic value of PCU on two-lane highways with heterogeneous nature of the traffic. With the help of PCU values we can predict the impact of any vehicle on traffic stream. PCU values are calculated on the basis of average speed of a vehicle type on the road with respect to a standard passenger car. PCU values are calculated by two methods i.e. Chandra & Kumar Method & HCM method. The study shows that PCU values vary with traffic composition and total traffic count. The aim of the study was to explain the dynamic nature of PCU values.

In India the static values of PCU is considered which is not reliable for the traffic data analysis. As we can see that the PCU values estimated is not same as given by Highway Capacity Manual. In modern times various types of vehicle are running on the roads of India which requires more category of vehicles in Highway Capacity manual. PCU values can change from one location to another location. In this study the accuracy of both methods is also compared and it is found that the Chandra method is more accurate as compared to occupancy time method.

9. Future Recommendations

The dynamic values estimated in this paper are useful for the estimation of traffic capacity. Whenever we have to analyze the traffic data we must conduct a survey for estimating the dynamic values of PCU. It will increase the accuracy of traffic analysis. Even in low traffic areas the larger PCU values of slow moving vehicles means that we need to provide a separate way for slow moving vehicles. This will increase the level of service of fast moving vehicles and the delay time will be decreased considerably. Static values of PCU are not reliable for the study because of the sensitiveness of PCU values.

References

1. Chandra, S., and Kumar, U. (2003). "Effect of lane width on capacity under mixed traffic conditions in India." J. Transp. Eng.
2. Chandra, S., and Sikdar, P. K. (2000). "Factors affecting PCU in mixed traffic situations on urban roads." Road Transp. Res.
3. CSIR – Central Road Research Institute (CRRRI) Highway capacity manual (2017) ,India
4. Prof. S.S. Goliya, Shivam Kushwaha (2015) Evaluation of Traffic Rotary & Design of Traffic Signal at Habibganj Naka Bhopal. IJSTE - International Journal of Science Technology & Engineering | Volume 5 | Issue 3 | September 2018 ISSN
5. Transportation Research Board. (1965). Highway capacity manual, Washington, DC.
6. Transportation Research Board. (2000). Highway capacity manual, 5th Ed., Washington, DC.
7. Transportation Research Board. (2010). Highway capacity manual, 5th Ed., Washington, DC.
8. Akhand Pratap Singh, Dr. S.S. Goliya, Dr. Rakesh Mehar (2018) "Road Accident Analysis for Evaluation of Safety at Different Location in Vidisha City." © 2018 JETIR July 2018, Volume 5, Issue 7
9. Chandra, S., Zala, L. B., and Kumar, V. (1997). "Comparing the methods of passenger car unit estimation." J. Institut. Eng., 78(CV-1), 13–16.
10. Arasan, T. V., and Shriniwas, S. (2008). "Simulating passenger car unit for vehicles in heterogeneous traffic." Traffic Eng. Control, 49(11), 436–444.
11. Bhattacharya, P. G., and Mandal, A. G. (1980). "Investigation of passenger car equivalents at controlled intersection in Calcutta." Highway Research Bulletin 14, Indian Roads Congress, New Delhi, India, 41–64.
12. Transportation Research Board. (1950). Highway capacity manual, Washington, DC.
13. Preethi, P., and Ashalatha, R. (2016). "Estimation of dynamic PCU using the area occupancy concept at signalised intersections." Int. Conf. On Transportation and Development 2016, ASCE, Reston, VA, 825–837.
14. Rahman, M., and Nakamura, F. (2005). "Measuring passenger car equivalents for non-motorized vehicle (rickshaws) at mid-block sections." J. East. Asia Soc. Transp. Stud., 6, 119–126.
15. Seguin, E., Crowley, K., and Zweig, W. (1982). "Passenger car equivalent on urban freeways." Rep. DTFH61-80-C-00106, FHWA, Washington, DC.
16. Dey PP, Chandra S, Gangopadhyay S. PCU factors for two-lane roads. Highway Research Bulletin, Indian Roads Congress, New Delhi 2007; 77, 111-119.