"PCU Estimation on Two-lane Undivided National Highway"

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Abstract - *There are two types of traffic conditions homogeneous and heterogeneous traffic. Homogeneous traffic has similar categories of vehicles. In developing countries like India has heterogeneous traffic, it has the different categories of vehicles class like two wheelers, three wheelers, car, LCV, bus, trucks, cycle etc., having the different speed, acceleration ability, dimensions and weight will share the same lanes of the road. The PCU values of the different type of vehicles are varying with the composition of vehicles, time, situation, location and their interaction. Because of the heterogeneity in nature of the traffic the PCU values are not only depends on the static nature of the vehicles like dimensions and weight, also depends on the dynamic nature of the vehicles like speed of the vehicles, occupancy time of the vehicle, headway, lateral clearance and geometry of the roads. In this study the two lanes NH having mixed traffic condition is selected. For determination of the dynamic PCU values of various categories of the vehicles the Chandra's method and the IRC method are used.*

*Key Words***: *PCU, Chandra's method, IRC method.*

1. INTRODUCTION

Transportation plays a vital role in the development of the country. Also it plays an important role in socio-economic growth of the country. Transport is important because it enables trade between people which is essential for development of civilization.

India has the second largest road network in the world (3.3 million km). Current affair of the Indian highways total length is 55,000 km in that which 66% of roads are two lane facilities with varying lane width but still India is facing enormous difficulties in providing better vehicular traffic flow and operations. The main source of transportation in India is by road. Rapid and continuous increase population is major problem for highway engineers.

There are two types of traffic conditions homogeneous traffic and heterogeneous traffic. Homogeneous traffic has similar categories of vehicles. In developing countries like India has heterogeneous traffic, it has different categories of vehicles like two wheelers, three wheelers, car, LCV, bus, truck, cycles, tractor, animal drawn etc., with different speed, accelerating ability, dimensions and weight, will share the same lanes of road. Heterogeneous traffic is more complicated than the homogeneous traffic and it acts completely different compare to homogeneous traffic.

1.1 Passenger Car Unit

There are several classes of vehicles in heterogeneous traffic conditions like car, bike, auto, bus, truck etc., their impact on the traffic flow will also varies due to variation in size, shape, acceleration, capacity, speed. It is difficult to consider one category of vehicles as the standard vehicle for the planning and designing point of view. Hence, a standard vehicular type has been considered known as Passenger Car Unit (PCU). In other words Passenger Car Unit is the factors which will convert a vehicle type into standardised car units. For example if the truck has the PCU values of 3 which means that a single truck is equivalent to the 3 standardised car units. The PCU values of a particular vehicle class may be considered as the ratio of the capacity of a roadway when there are passenger cars only to the capacity of the same roadway when there are vehicles of that class only. Factors which affect the PCU are

- Static parameters of the vehicles like width and length.
- Dynamic characteristics of the vehicles like speed, power, acceleration and occupancy time.
- Transvers and longitudinal gap/space between two moving vehicles.
- Traffic stream characteristics like different vehicle composition, mean speed.
- Road geometrics.
- Environmental and climatic condition.

As mentioned in the factors of PCU value not only depends on the static parameters like vehicular dimensions but also depends on the dynamic characteristics of the vehicles like speed of the vehicle, occupancy time of the vehicle. And also depends on the longitudinal and transverse gap between two moving vehicles which depends on speed of the vehicles, driver characteristics and vehicle class.

1.2 Objective
Objective of the research is
• Determining PCU values of mixed traffic condition at selected NH based on the dynamic characteristics of the vehicles by using Chandra's method and IRC method.

2. LITERATURE REVIEW

[1] "Dynamic PCU & Estimation of Capacity of Urban Roads" by Satish Chandra, Kumar, P.K.Sikdar.

In this paper, the authors are found the PCU factors for Indian roads because which consists heterogeneous traffic through concept of Dynamic passenger car unit (Dynamic PCU) which is more appropriate. And also the speed-flow relationships and estimation of road capacities also discussed.

[2.] "Capacity Estimation procedure for two lane roads under mixed traffic conditions" by Satish Chandra.

Here the author has selected more than 40 sections on two lane road in different parts of country for analysis. On those selected sections he studied the effect of different parameters like gradient, lane width, shoulder width, traffic composition, directional split, slow moving vehicles and pavement surface conditions on capacity is evaluated and a suggested a systematic procedure for evaluation of heterogeneous traffic under Two-lane road.

[3] "Impact of lane width of road on PCU & Capacity under mix traffic condition in cities on congested highways" by A.R.Khanorkar, S.D.Ghodmare, Dr.B.V.Khode.

This study is done to determine the pcu value under mixed traffic condition on congested highways. This study is done in Nagpur highway where 5 locations selected and data is collected through digital video recorder. The main aim of the study is do find out the PCU value for different class of vehicle there by increasing the width of shoulder so that the area will increase which is useful in linearly movement of vehicles. He also suggested that the capacity of highway will increase in increasing in shoulder area.

[4] "Highway capacity research on inter-urban highways in India" by Satish Chandra.

This paper represents the overview for the researches that took place from last four decades. The capacities of Indian highways like one lane, intermediate lane, two lanes, multilane and inter urban highways, expressways and freeways are studied. It helps the designer for developing the capacity manual for Indian conditions, since due to the heterogeneous traffic conditions because of there is no lane disciple is maintained in Indian highways.

[5] "Estimation of PCU for heterogeneous traffic in Visakhapatnam" by Dadi. Vasavi Shwetha.

This paper mainly deals with study of PCU variation in static and dynamic characteristics for different traffic stream. In this paper we study three different methods for PCU heterogeneous traffic those are Modified density method, Homogenization coefficient method and Time head way method.

[6] "Comparative study of methods used for a capacity estimation of road" by Pratik U.Mankar, Dr.B.V.khode.

This paper discuss and review the Capacity estimation of roads under heterogeneous traffic condition by various authors and the factors influencing the capacity of roads and parameters affect the capacity of roads is reviewed and studied. This Paper can be used for analyzing different methods used for Capacity analysis of roads to improve the roadway and traffic condition.

[7] "Capacity estimation of urban roads under mixed traffic conditions" by Pratik U.Mankar, Dr.B.V.Khode.

The intension of this work is to analyze capacity for urban roads in heterogeneous condition and it is relatively tough to estimate traffic volume on the road. The problem of measuring flow may addressed by using Dynamic PCU values. The Capacity of urban roads is find out by green shield model and the results are compared with Microscopic simulation model. The sudden increase in width of lane on the road is checked and result shows that with the increase in road width Capacity of road also increases.

[8] "Capacity estimation for two lane undivided carriageway – A case study for national highway 63" by Hemanth M.Kamplimath.

Roadway capacity estimation involves traffic volume counts and analysis, origin and destination studies, analysis of socio-economic variables, estimation of traffic growth rate, traffic forecasts and finally capacity estimation. In this present paper, the complete process of Capacity Estimation for National Highway-63 has been expressed through a case study. The results obtained from capacity estimation suggests the year at which the road may reach its maximum capacity. This result of capacity estimation can be used to prioritize the up gradation of the highway under study.

[9] "Effect of mixed traffic on capacity of two lane roads: A case study on Indian Highways" by Nabanita Roy, Rupali Roy, Hitesh Talukdar, Pritam Saha.

This paper focuses on effects of mixed traffic on capacity of two-lane roads. On the basis of field data collected on Indian highways, the present paper makes it clear that capacity reduces if the proportion of slower vehicles increases in the traffic stream. Since such vehicles are responsible for the formation of platoons, their increasing proportion in traffic would accordingly increase the equivalency factor of vehicles, thereby, resulting in variation in capacity. The present study therefore explicates the need of introducing the concept of dynamic passenger car unit and anticipates that this would alleviate the current implication on capacity standards of such roads under mixed traffic

3. METHODOLOGY

The present work is going to have a three phases. The first phase involves determining the study area next road inventory, vehicle count and speed studies. Later in second phase we have calculation part and that involves in which PCU is determined by using Chandra's method and Modified density method. Later in the final phase it includes a comparison between these above mentioned methods under the section of results.

3.1. Data Collection

The data collection is the important step which is very necessary to carry out the project. The traffic data is collected for a period of 12hours from morning 7.00am to evening 7.00pm for three days on a selected stretch of national highway, also the speed of vehicles are noted.

Fig 1. Google Earth image of location

Fig 2. Vehicle movements in Location

3.2 Study Area

The study is carried at a village called M.C Halli in between Bhadravathi and Tarikere on National Highway-206 which connects Tumkuru to Shivamogga.

Lane width – 7.20m

Pavement material – Bituminous

Shoulder width – 2.00m

3.3 Traffic Survey

The traffic survey is most important in designing the road characteristics. One of the most important characteristics of a stream of traffic is its 'flow' i.e., the number of vehicles which pass a fixed point in unit time. This is commonly referred as 'volume'. Its direct measurement by counting vehicles is there fundamental to any systematic approach.

3.4 Types of Traffic Surveys

Some techniques that are used to count traffic are

1. Manual surveys
2. Automatic traffic counts (ATCs)
3. Video surveys

3.5 Classified Traffic Volume Count Survey

For the present study manual count method has been adopted and the side traffic counts are taken for selected stretch. 12 hour traffic data collected for 3 different days a week.

3.6 Speed Studies

Speed is one of the most important characteristics of traffic and its measurement is a frequent necessity in traffic engineering studies. Speed is the rate of movement of traffic or of specified components of traffic and is expressed in metric units in kilometer hour (kph).

3.7 Types of Speed

1. Spot Speed

Spot speed is the instantaneous speed of a vehicle at a specified location.

It is given by

Spot Speed = Distance covered / Time taken

2. Running Speed

It is the average speed maintained by vehicle over a given course while the vehicle is in motion. It is significant to note the clause 'while the vehicle is in motion' i.e., by the running time which excludes that part of the journey time when the vehicle suffers delay. Thus,

Running speed = (Length of course) / (Running time)

= (Length of course) / (Journey time - Delay)

3. Journey Speed

It is also known as overall travel speed, is the effective speed of vehicle between two points and is the distance between two points and divided by the total time taken by vehicle to complete the journey, including all delays incurred en route. It is given by

Journey speed = Distance / Total journey time

3.8 Methods of Measuring Spot Speeds

The methods which are used for measuring the spot speed are

1. Stopwatch Method that requires observations of the time taken by a vehicle to cover a known distance.
2. Radar meter method, which automatically records the instantaneous speed.
3. Photographic method.
4. Moving observer method.

Table 1. Average spot speed from Bhadravathi to Tarikere direction

Vehicle Type	Speed	
	m/s	Km/h
Bike	19.70	70.91
Car/Jeep	18.07	65.04
Bus	16.64	59.92
Truck	15.21	54.76
MAV	13.54	48.76
Tractor	11.47	41.30
Goods Auto	10.64	38.32

Table 2. Average spot speed from Tarikere to Bhadravathi direction

Vehicle Type	Speed	
	m/s	Km/h
Bike	20.01	72.04
Car/Jeep	18.40	66.24
Bus	17.44	62.78
Truck	15.65	56.34
MAV	13.90	50.04
Tractor	11.79	42.44
Goods Auto	10.90	39.24

4. ANALYSIS

4.1 Determination of PCU

Traffic in many parts of the world is heterogeneous, where road space is shared among many traffic modes with different physical dimensions. Loose lane discipline prevails, car following is not the norm this complicates computing of PCU. Some of the methods for determining passenger car units (PCU) are follows.

- Modified Density Method
- Chandra's Method
- Method Based on Relative Delay
- Headway Method
- Multiple Linear Regression Method
- Simulation Method

4.2 CHANDRA'S METHOD

The PCU of a particular vehicle category can be expressed as the amount of interaction of that vehicle type to the traffic stream with respect to passenger car. This interaction gets changed with both traffic volume & proportion composition of traffic stream. It will vary with the length & weight to horsepower ratio of the vehicle. There interactions are reflected in speed of a vehicle type therefore speed is considered as one of the basic parameter for estimation of PCU factors.

In the present study the PCU of a particular vehicle category 'i' is estimated by using equation,

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

Where,
V_c = Speed of passenger car (m/s)
V_i = Speed of vehicle type i (m/s)
A_c = Projected rectangular area of car (m2)
A_i = Projected rectangular area of vehicle type i on the road (m2)

Table 3. Rectangular area of Vehicles

Category	Vehicle	Length h(m)	Width (m)	Area (m2)
Standard car	Passenger car, taxi	3.72	1.44	5.36
Two wheeler	Scooter, motor cycle	1.87	0.64	1.20
Three wheeler	Auto rickshaw	3.20	1.40	4.48
LCV	Mini bus, van, mini truck	6.10	2.10	12.81
Bus	Bus	10.10	2.43	24.54
Truck	2 & 3 axle	7.50	2.35	17.63
HCV	Multi axle vehicle	15.24	2.44	37.19
Tractor trailer	Tractor with trolley	7.40	2.20	16.28
Cycle	Bicycle	1.90	0.45	0.86

Table 4. Dynamic pcu values for Bhadravathi to Tarikere direction

Vehicle type	PCU values
Bike	0.21
Car / jeep	1.00
Bus	4.83
Truck	3.87
MAV	9.19
Tractor	4.74
Goods auto	1.41

Table 5. Dynamic pcu values for Tarikere to Bhadravathi direction

Vehicle type	PCU values
Bike	0.20
Car / jeep	1.00
Bus	4.97
Truck	3.91
MAV	9.26
Tractor	4.79
Goods auto	1.42

Table 6. Calculated ADT values from Chandra's method

Direction	ADT
Bhadravathi to Tarikere	6651pcu/12hrs
Tarikere to Bhadravathi	6698pcu/12hrs

4.3 PCU CALCULATION BY USING IRC STANDARDS

When the traffic is composed of a number of vehicles, the flow will be converts into passenger car unit (PCUs) by using specified equivalency factors (IRC 86) for each type of vehicles. The flow is then expressed as PCU for urban area as per IRC 86:1983 geometric design standards for urban roads in plain.

Table 7. PCU factors from IRC 86:1983

Sl No.	VEHICLE TYPE	PCU EQUIVALENCY FACTOR
1.	Motorcycle, Scooter and Cycle	0.5
2.	Passenger Car, Tempo, Auto Rickshaw, Jeep, Van or Agricultural Tractor	1.0
3.	Cycle Rickshaw	1.5
4.	Truck, Bus or Agricultural Tractor Trailer	3.0
5.	Horse drawn vehicle	4.0
6.	Hand Cart	6.0
7.	Bullock Cart	8.0

These are the equivalent PCU factors based on composition as given in Table 3 of "IRC 86:1983 Geometric design standards for urban roads in plains" is been used to convert vehicle counts to PCUs.

Table 8. Calculated ADT values from IRC method

Direction	ADT
Bhadravathi to Tarikere	5509pcu/12hrs
Tarikere to Bhadravathi	5489pcu/12hrs

5. RESULT

Table 9. Dynamic PCU Values comparison

Vehicle Type	PCU Value	
	Chandra's Method	IRC Method
Bike	0.20-0.21	0.5
Car/Jeep	1	1.0
Bus	4.83-4.97	3.0
Truck	3.87-3.91	3.0
MAV	9.19-9.26	4.5
Tractor	4.74-4.79	4.5
Goods Auto	1.41-1.42	1.0

Table 10. ADT values comparison

Direction	ADT	
	Chandra's method	IRC method
Bhadravathi to Tarikere	554 pcu/hr	459 pcu/hr
Tarikere to Bhadravathi	558 pcu/hr	457 pcu/hr

- From the above tables, we can clearly observe that there is difference in dynamic pcu factors as well as ADT values that are obtained from Chandra's method when comparing with IRC method.

6. CONCLUSIONS

From the above study we drawn to these conclusion

1. PCU values are dynamic in nature and depend on traffic volume and traffic composition on the road. It was observed that significant variation is created in PCU value of a vehicle under low and high volume levels as well as different proportion of the same or other vehicle categories in the traffic stream.

2. In Chandra's method the PCU values of the vehicles are inversely proportional to the speed of the vehicle.

5. In IRC 86-1983 the PCU values are given by considering all the relevant factors and the values are same for all the condition.

3. Since the PCU values in Chandra's method will change depending on speed so the considering of IRC values will be better for the design aspect.

7. REFERENCES

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