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PCU ESTIMATION FOR TWO LANE UNDIVIDED STATE HIGHWAY(SH-57)

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Abstract - There are two types of traffic conditions homogeneous traffic and heterogeneous traffic. Homogeneous traffic has similar categories of vehicles. In developing countries like India, heterogeneous traffic exists, which has different categories of vehicle 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 but also depends on the dynamic nature of the vehicles like speed of vehicle, occupancy time of the vehicle, headway, lateral clearance and geometry of the roads. In this study the stretch of road having the mixed traffic condition of Abbalagere to Savalanga road is selected. For determination of the dynamic PCU values of categories of the vehicles Chandra's method and IRC method are used.

***Key Words*: Heterogeneous traffic, PCU, Mean Speed, Two lane, State Highway, Traffic condition, Volume**

1.INTRODUCTION

The Traffic condition has been in the form of two types i.e. homogeneous traffic and heterogeneous traffic. Homogeneous traffic consists of similar categories of vehicles. In most of developing countries including in India existing traffic is heterogeneous in nature. It includes a wide range of vehicles category which are different form each and every one other in terms of static and dynamic behavior. As every vehicle share the same road and their mobility of each one is greatly influenced by the presence of other, the vehicle categories like cars, bus, truck, LCV, cycle, tractor etc. with different speed, accelerating, ability, dimensions and weight. Heterogeneous traffic is more complicated than homogeneous due to its heavy traffic stream and road space is shared among many traffic modes with different physical dimension. Movement between different categories of vehicle is extremely more in case of intermediate or two-lane roads rather than multilane highways. As about 3/4th of national highway and most of state highway in India is either two-lane, intermediate or single lane road, mixed type of vehicles, their speed plays a major role in influencing capacity. The I.R.C as made certain guidelines for the capacity analysis of road passing through rural areas, they have been recommended certain design, service volume of various type of road as single lane, multilane, two and four lane. The difference between homogeneous and mixed traffic is to negate the impact of mixed vehicle and their vehicles are converted into an equivalent unit i.e. PASSENGER CAR UNIT (P C U).

1.1 What is PCU?

There are several types of vehicles in heterogeneous traffic flow like car, bike, auto, bus ,truck etc. their effect of flow in traffic may varies due to their size, dimension, speed, capacity. It's quite difficult to consider one type of vehicle as the standard vehicle for designing and planning point of view, hence the standard vehicle considered is known as PASSENGER CAR UNIT (PCU).

1.2 DETERMINATION OF PCU

Traffic in many part of the country has been heterogeneous in nature, the pavement of road in split into a different types of flow with different static and dynamic parameter. Some of the methods for determining the passenger car unit are mentioned below

- Modified Density method
- Method based on relative delay
- Headway method
- Simulation method
- Chandra's method
- Time Occupancy method

1.2.1 CHANDRA'S METHOD

This method is very popular to estimate the PCU value and it's quite often this method is used.
This method uses 2 factors namely;
Velocity of vehicle type and its projected rectangular area to calculate PCU value.
(PCU)I = (Vc/Vi)/(Ac/Ai)
Where Vc and VI are mean speed of car and vehicles of type I respectively and Ac and Ai are the respective projected rectangular area

1.3 Importance of determining PCU

In mixed traffic condition it is quite difficult to determine the flow volume of traffic on the roadway. Therefore we need to assign the equivalency factor for different class of vehicles. Commonly we consider the passenger car as the standard vehicle to convert the different class of vehicles. So this traffic volume is used for further design and upgradation of existing road to know its traffic trends, pattern for geometrical and structural design of roads

1.4 OBJECTIVE

Objective of this study consists of
Determining the PCU values of mixed traffic condition at two lane state highway of shimoga district based on dynamic characteristics of vehicle by using IRC and Chandra's method.

2. LITERATURE REVIEW

For the comparison of methods for determination of dynamic PCU values for different categories of vehicles at two lane state highway in shivamogga district. Many literatures are utilized for this study. Some of them are selected among those and referred in this study are listed as below,

[1.] Debraj pal, Sapatarshi Sen, Sandip Chakraboty: conducted study on "EFFECT OF PCU ESTIMATION METHOD ON CAPACITY ON 2-LANE RURAL ROADS IN INDIA".In this paper, the authors address the analysis of PCU estimation of different vehicle categories which impact on capacity of roadway. The green shield's linear model is applied to estimate the capacity where PCU values are determined by different method.

[2.] Ballari Syed Omar, PranabKar, Mallikarjuna chunchu: conducted study on "PASSENGER CAR EQUIVALENT ESTIMATION FOR RURAL HIGHWAY". Here the LOS determination is find out over here which being include only passenger car in the traffic flow. They found a proper use of simulation model and selecting exact performance to define LOS as two major factor that influence PCE estimation process.

[3.] Nabanita Roy, Rupali Roy, Hitesh, Talukdar, PritamSaha: conducted study on "EFFECT ON MIXED TRAFFIC ON CAPACITY OF 2-LANE ROADS: CASE STUDY ON INDIAN HIGHWAY". This study they have clearly focused on mixed traffic and made it clear that capacity reduces if amount of slow vehicles increases in traffic stream. Therefore it explicates need of introducing the concept of dynamic passenger car unit, they have taken the speed data at free flow and analyzed and compared to speed flow model free flow and there would have the current conclusion on capacity standard of different 2-lane roads under mixed traffic condition.

[4.] D.N.D Jayarante, H.R Parindu: conducted study on "EMPHERICAL STUDY ON CAPACITY EVALUATION OF URBAN MULTI-LANE ROADS UNDER HETEROGENEOUS TRAFFIC CONDITION". This paper represents the study in progress to development for guideline for silence. Its applicability of HCM local condition and looking out the aspherical evidence. They knew that it's not applicable of HCM guideline to certain local situation for the less traffic area speed. And consider the greenshield;s linear model to calculate the capacity later these values are taken and compared with HCM guideline's by varying of capacity.

[5.] Hitakshi Barve, Sunil Sagandhi and Vinay deulkar: conducted study on "ESTIMATION OF CAPACITY AND PCU VALUE FOR HETERGENEOUS TRAFFIC STREAM. "This paper mainly deals with study of PCU value of vehicles in a mixed traffic flow at congested highway. Here they have collected the data from 5 main highway around Khandwa city using videography method and they extract the traffic volume and speed for every 5 min time gap covering both peak and non-peak hours then PCU values is been calculated by Chandra's method to give a realistic result.

[6.] Ashutosh Arun,Senathipathi Velumurugan,Madhu Errampalli : conducted study on "METHODOLOGICAL FRAMEWORK TOWARDS ROADWAY CAPCITY ESTIMATION FOR INDIAN MULTI-LANE HIGHWAY".This paper discuss the capacity estimated developed in India as well as abroad under the suitable for the mixed traffic condition as observed in Indian roads. In HCM method developed in US is not applicable around the world due to mixed traffic arising. Here a gap is identified and efforts were taken by CSIR to develop HCM.They conclude by saying that estimating capacity for Indian 2-lane highway, here they enable Indo-HCM to get the accurate capacity estimation.

[7.] Gauri.S.Biraje, Prof A.S Thorbole: conducted study on "CAPACITY ASSESSMENT ON TWO LANE ROAD ON STATE HIGHWAY".Here the study is to find out the cause traffic congestion in a Maharashtra area for the case study and followed the capacity assessment of 2-lane road by indo-highway capacity manual. The which they have selected area its capacity is reduced and find out that there was a traffic congestion is more during peak hours so that capacity is to increase for the particular area.

[8.] Manish.P.Jain, Ajinkya Mane, Shriniwas.S.Arkatkar, Gaurang.J.Joshi :conducted on "CAPACITY ESTIMATION ON 2-LANE HILLY ROADS UNDER HETEROGENEOUS TRAFFIC CONDITION IN INDIA. "The present study is made on the estimating capacity on hilly road under heterogeneous traffic. Here they develop a relationship between capacity v/s operating speed of car, capacity v/s gradient magnitude. Finally they conclude by saying that undivided hilly road decrease with increase in magnitude gradient. Its maximum capacity. This result of capacity estimation can be used to prioritize the upgradation of the highway under study.

3. METHODOLOGY

The present work is going to have three phases. In that the first phase involves determining the study area next road

inventory, vehicle count, and speed studies. Later in second phase we conduct calculation part and that involves in which PCU is determined by using Chandra's method and IRC method. Later the final phase includes a comparison between these above mentioned methods under the section of results

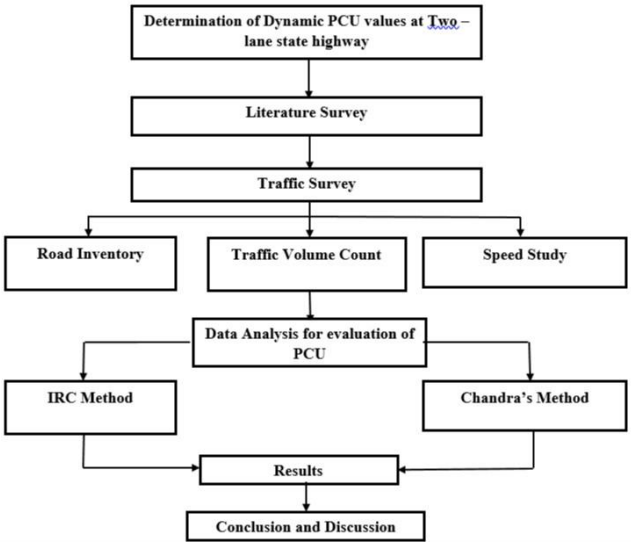

Fig -1: Flow chart of Methodology

3.1 Study area : Abbalagere to Savalanga

For the present study, we have chosen a two- lane state Highway i.e., Abbalagere (SH-57). Abbalagere is a village of Shivamogga taluk. It connects the cities Nyamthi, Shikaripura, Soraba, Honnalli through Two- lane roads under State Highway SH-57. The width of the road is 7.35m. The aerial View of Abbalagere to Savalanga is shown below

Fig -2: Aerial View of Abbalagere to Savalanga (SH-57)

3.2 Surveys conducted:

To know the present scenario of traffic condition, we have undergone the following survey at above mentioned State Highway.

*Road Inventory
*Vehicle Count
*Speed Study

These surveys are conducted manually and collected traffic volume data for 3 days

3.2.1 Road Inventory

This survey is conducted to study the profile of roads in the area of study, features like road/pavement width etc. Abbalagere to Savalanga:

*Terrain: plain
*Carriageway Width : 7.3m
*Type of Carriageway : Flexible pavement
*Shoulder width : 1.5m on Both sides
*Type of Shoulder : The road having Paved shoulder

3.2.2 Traffic Volume Count :

For the present study manual count method has been used for the entire stretch and traffic counts are taken on both sides. For each direction, separate volume counts have been done. We considered 11 hours data for 3 days.

3.2.3 Data Collection :

It is a basic step required for the project with respect to the objectives of the study. The required data were collected in 5 stages as follows:

*Study stretch selection
*Surveying to obtain required sections
*Classified traffic volume count
*Observation and collection of speed of traffic
*Dimension of different class of vehicles

Table -1: Classified volume count survey from Abbalagere to Savlanga

DATE AND DAY OF THE WEEK :			05/04/2021 MONDAY				ROAD CLASSIFICATION :		SH
DIRECTION OF TRFFIC :			FROM Abbalagere TO Savalanga				DISTANCE :		100 mts
							ROUTE NUMBER :		SH57
							DISTRICT :		SHIVAMOGGA
TIME	MOTAR CYCLE	CARS, JEEPS	BUS	TRUCK			GOODS AUTO	TRACTOR	TOTAL Veh/Hr
				2 AXLE	3 AXLE	MAV			
7:00-8:00AM	122	66	6	25	16	7	9	5	256
8:00-9:00AM,	134	59	8	13	4	2	12	3	235
9:00-10:00AM	95	42	7	16	6	1	9	1	177
10:00-11:00AM	200	90	14	21	17	2	19	2	365
11:00-12:00PM	185	98	12	23	18	1	14	2	353
12:00-1:00PM	164	97	11	25	14	1	16	3	331
1:00-2:00PM	97	89	11	26	14	3	14	4	258
2:00-3:00PM	103	85	16	26	16	2	12	2	262
3:00-4:00PM	115	117	14	15	6	1	11	2	281
4:00-5:00PM	153	136	19	15	5	1	11	6	346
5:00-6:00PM	198	149	13	21	18	5	19	9	432
TOTAL	1566	1028	131	226	134	26	146	39	3257

Table -2: Classified volume count survey from Savlanga to Abbalagere

DATE AND DAY OF THE WEEK :		05/04/2021 Monday					ROAD CLASSIFICATION :	SH	
DIRECTION OF TRFFIC :	FROM Savalanga TO Abbalagere						DISTANCE :	100 mts	
							ROUTE NUMBER :	SH57	
							DISTRICT :	SHIVAMOGGA	
TIME	MOTAR CYCLE	CARS, JEEPS	BUS	TRUCK			GOODS AUTO	TRACTOR	TOTAL Veh/Hr
				2 AXLE	3 AXLE	MAV			
7:00-8:00AM	149	169	16	23	29	3	21	5	415
8:00-9:00AM,	230	154	27	21	25	1	16	3	477
9:00-10:00AM	120	142	19	19	17	0	17	4	338
10:00-11:00AM	270	152	23	22	27	1	22	6	523
11:00-12:00PM	130	157	17	20	15	1	20	6	366
12:00-1:00PM	123	146	14	17	19	2	20	7	348
1:00-2:00PM	114	138	15	21	17	2	14	8	329
2:00-3:00PM	136	122	16	21	15	4	16	5	335
3:00-4:00PM	167	167	23	16	13	2	23	4	415
4:00-5:00PM	185	182	25	18	19	1	25	3	458
5:00-6:00PM	288	206	18	26	23	5	24	5	595
TOTAL	1912	1735	213	224	219	22	218	56	4543

3.3 Speed studies

The term speed is one of the important characteristics of traffic and its measurements is a frequent necessity in traffic engineering. As speed defines the distance travelled by user in a given time under a different traffic movement. Here the speed may vary as per the traffic flow of a particular stretch due to change in traffic volume, traffic condition at that time

3.3.1 Spot speed studies

When we measure any limitation over a short distance we generally measure the spot speed. A spot speed is measured by taking each individual category of vehicle speed sample which passes in a given spot on a street or a highway

3.3.2 Methods of measuring Spot speed

a) Stop watch method
b) RADAR meter method
c) Photographic method
d) Moving observer method

In this study, we used the stop watch method for data collection. This method requires observation of time taken by a vehicle to cover the known distance. Using this method, we estimate different vehicle category speed

Table -3: Spot speed studies from Abbalagere To Savlanga

Abbalagere to Savalanga						
Vehicle Category		Sl No.	Distance (m)	Travel time	Running speed	
					KmpH	Mps
Two Wheeler		1	100	3.45	40	11.11
		2	100	3.83	51	14.17
		3	100	3.37	36	10
		4	100	2.82	45	12.5
		5	100	2.47	51	14.14
Three Wheeler		1	100	4.23	45	12.5
		2	100	3.74	60	16.67
		3	100	4.55	36	10
		4	100	4.39	30	8.34
		5	100	3.98	32	8.89
Car		1	100	2.84	60	16.67
		2	100	2.74	90	25
		3	100	2.54	51	14.17
		4	100	2.92	72	20
		5	100	2.97	60	16.67
LCV		1	100	2.93	45	12.5
		2	100	2.61	51	14.17
		3	100	2.45	60	16.67
		4	100	2.35	45	12.5
		5	100	2.72	60	16.67
Std Bus		1	100	3.22	36	10
		2	100	3.74	30	8.34
		3	100	3.23	40	11.12
		4	100	2.55	45	12.5
		5	100	3.47	60	16.67
Truck	Two axle	1	100	4.46	30	8.34
		2	100	3.63	32	8.89
		3	100	3.98	36	10
		4	100	4.06	45	12.5
		5	100	4.42	40	11.12
	Three Axle	1	100	4.87	45	12.5
		2	100	4.65	60	16.67
		3	100	4.49	51	14.17
		4	100	4.57	60	16.67
		5	100	4.23	46	12.78
	Multi Axle	1	100	3.82	60	16.67
		2	100	3.65	51	14.17
		3	100	3.46	36	10
		4	100	3.69	32	8.89
		5	100	3.45	51	14.17

Table -4: Spot speed studies from Savlanga To Abbalagere

Savalaga to Abbalagere						
Vehicle Category		Sl No.	Distance (m)	Travel time	Running speed KmpH	Mps
Two Wheeler		1	100	2.13	40	11.11
		2	100	2.5	51	14.17
		3	100	2.12	36	10
		4	100	1.85	45	12.5
		5	100	2.77	51	14.14
Three Wheeler		1	100	3.05	45	12.5
		2	100	2.85	60	16.67
		3	100	2.74	36	10
		4	100	2.95	30	8.34
		5	100	3.13	32	8.89
Car		1	100	1.92	60	16.67
		2	100	2.1	90	25
		3	100	1.99	51	14.17
		4	100	1.21	72	20
		5	100	1.24	60	16.67
LCV		1	100	1.79	45	12.5
		2	100	3.08	51	14.17
		3	100	2.66	60	16.67
		4	100	1.86	45	12.5
		5	100	2.84	60	16.67
Std Bus		1	100	2.41	36	10
		2	100	3.2	30	8.34
		3	100	3.46	40	11.12
		4	100	3.33	45	12.5
		5	100	2.72	60	16.67
Truck	Two axle	1	100	3.3	8.34	8.34
		2	100	3.32	8.89	8.89
		3	100	3.36	10	10
		4	100	3.45	12.5	12.5
		5	100	3.4	11.12	11.12
	Three Axle	1	100	3.45	12.5	12.5
		2	100	3.6	16.67	16.67
		3	100	3.51	14.17	14.17
		4	100	3.6	16.67	16.67
		5	100	3.46	12.78	12.78
	Multi Axle	1	100	3.6	16.67	16.67
		2	100	3.51	14.17	14.17
		3	100	3.36	10	10
		4	100	3.32	8.89	8.89
		5	100	3.51	14.17	14.17

4. Results

The data collected are analyzed and results are obtained then they are represented in the form of tables.

4.1 Determination of PCU values

Here in the study the PCU value at two lane state highway i.e. Savalanga to Abbalagere is calculated for the comparison between static PCU values and dynamic PCU values. Hence the dynamic PCU values are determined by using Chandra's method and IRC method.

4.1.1 Chandra's method

The PCU for a specific category of vehicle is to be expressed in the amount of interaction between the vehicle type to the traffic with respect to the passenger car interaction gets switch to both for volume of traffic & composition of traffic. Here it varies with dimension and weight of the vehicle. The speed of the vehicle is considered as the basic parameter for the estimation of PCU factors.

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

$PCU_i = (Vc/Vi)/(Ac/Ai)$

Where, V_c & V_i = mean speed of car & vehicle type i respectively

A_c & A_i = Projected rectangular length or width on the road of car & i type of vehicle

Table -5: PCU values of different category of vehicle from Savlanga to Abbalagere

SAVALANGA TO ABBALAGERE

Vehicle Type	Vc (m/s)	Vi (m/s)	Ac (m2)	Ai (m2)	PCU Value
Bike	18.40	20.01	5.36	1.20	0.21
Car/Jeep	18.40	18.40	5.36	5.36	1.00
Bus	18.40	17.44	5.36	24.54	4.83
Truck	18.40	15.65	5.36	17.63	3.87
MAV	18.40	13.90	5.36	37.19	9.19
Tractor	18.40	11.79	5.36	16.28	4.74
Goods Auto	18.40	10.90	5.36	4.48	1.41

Table -6: PCU values of different category of vehicle from abbalagere to savalanga

ABBALAGERE TO SAVALANGA

Vehicle Type	Vc (m/s)	Vi (m/s)	Ac (m2)	Ai (m2)	PCU Value
Bike	18.50	12.39	5.36	1.20	0.33
Car/Jeep	18.50	18.50	5.36	5.36	1.00
Bus	18.50	11.72	5.36	24.54	7.23
Truck	18.50	14.03	5.36	17.63	4.34
MAV	18.50	12.78	5.36	37.19	10.05
Tractor	18.50	11.47	5.36	16.28	4.90
Goods Auto	18.50	14.50	5.36	4.48	1.07

Table -7: Average PCU of different category of vehicle

Vehicle Type	PCU value range	AVG PCU VALUE
Bike	0.21-0.33	0.27
Car/Jeep	1	1.00
Bus	4.83-7.23	6.03
Truck	3.87-4.34	4.10
MAV	9.19-10.05	9.62
Tractor	4.74-4.90	4.82
Goods Auto	1.07-1.41	1.24

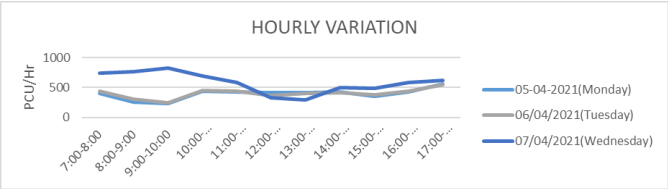

Fig -3: Hourly variation of PCU from abbalagere to savalanga by Chandra's method

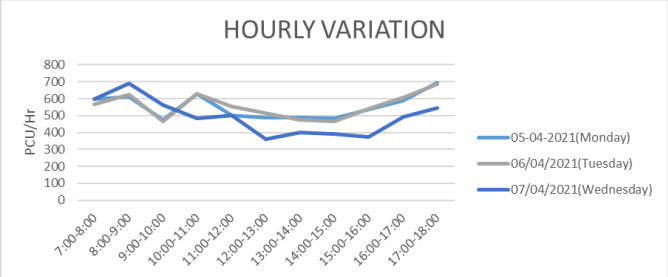

Fig -4: Hourly variation of PCU from savalanga to abbalagere by Chandra's method

4.1.1 IRC method

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: PCU factors from IRC 86:1983

Sl No.	VEHICLE TYPE	PCU EQUIVALENCY FACTOR
1	Motor Cycle, 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

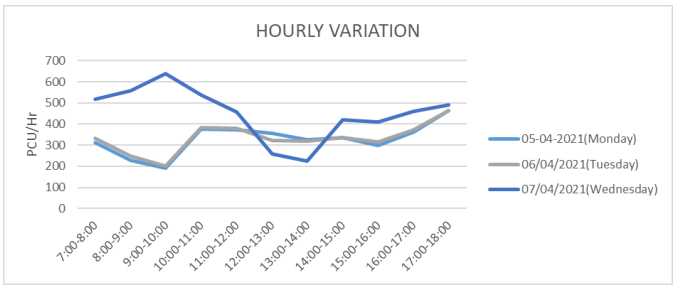

Fig -5: Hourly variation of PCU from Abbalagere to Savalanga by IRC method

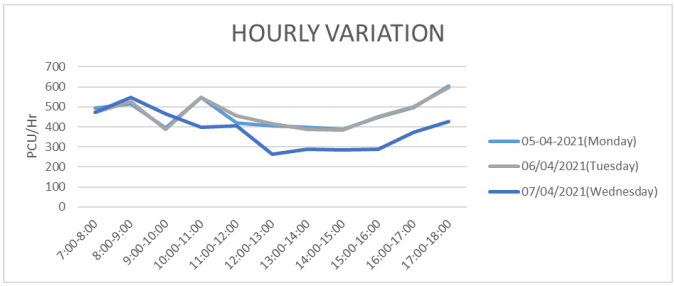

Fig -6: Hourly variation of PCU from Savalanga to Abbalagere by IRC method

5. CONCLUSIONS

The following major conclusion are obtained from this study are,

- The moving vehicle PCU is not only influenced by static parameters of vehicle, but also it is influenced by the dynamic characteristics of vehicle.

- **Table -9: Comparison of PCU values from both methods**

Vehicle Type	PCU Value	
	Chandra's Method	IRC Method
Bike	0.27	0.5
Car/Jeep	1.00	1.0
Bus	6.03	3.0
Truck	4.10	3.0
MAV	9.62	4.5
Tractor	4.82	4.5
Goods Auto	1.24	1.0

- The average daily traffic (ADT) for selected two lane state highway from Abbalagere to Savalanga SH-57
- Chandra's method :
  Average PCU/day= 5060
- IRC method :
  Average PCU/day= 4093
- The average daily traffic (ADT) for selected two lane state highway from Savalanga to Abbalagere SH-57
- Chandra's method:
  Average PCU/day= 5877
- IRC method :
  Average PCU/day= 4817
- It is noticed that the PCU values of the vehicles are inversely proportional to the speed of the vehicle in Chandra's method, whereas the PCU values are given considering all the relevant factors and values are same for all the conditions and speeds in IRC method. Therefore dynamic PCU values can be obtained by using Chandra's method.
- In current scenario IRC method is used to determine the PCU values and further capacity of the road in state highways. Our conclusion is that use of Chandra's method would be more appropriate as it calculates dynamic PCU values and predicts more realistic capacity of the road.

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