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# A MODIFIED APPROACH FOR ESTIMATION OF PASSENGER CAR UNITS ON INTERCITY DIVIDED MULTILANE HIGHWAYS

**Seelam Srikanth[1], Arpan Mehar[2]**

[1,2] Transportation Division, Department of Civil Engineering, National Institute of Technology, Warangal, Telangana, India

[1] e-mail: ssseelamsrikanth@gmail.com
[2] e-mail: arpanmehr400@gmail.com

***Abstract:*** *The accuracy of measured traffic flow on a roadway is highly depends on correctness of PCUs used for converting traffic volume. Field data for the present study was collected from the mid-block road sections of different divided multilane highways in India. Video graphic method was used for collecting the field data. PCUs are estimated from the available methods as given in the literature by using traffic flow data observed in the field. Present study describes a modified methodology for estimation of PCU value of subject vehicles that includes the time headway as influencing parameter. The approach used in the present study is inspired from the method of dynamic PCU estimation where a PCU is expressed as the ratio of speed ratio and area ratio of standard cars to the subject vehicle type. Unlike dynamic PCU method, this method includes time headway factor for PCU estimation. The method found more realistic and logical as it provides relatively higher values of PCUs than those obtained from dynamic PCU method. Simulation of traffic flow was also performed through microscopic simulation model VISSIM for generating congestion and for comparing estimated PCU values at the level of maximum traffic volume. The methodology adopted in this study will be extended for development of comprehensive PCU model by including more numbers of influencing factors under varying traffic and roadway conditions.*

***Key words:*** *PCU, traffic volume, headway, speed, VISSIM.*

## 1. Introduction

The term Passenger Car Unit (PCU) or Passenger Car Equivalency (PCE) was first introduced in HCM (1965) to account for the effect of trucks and buses in the traffic stream. Subsequently, PCU value of vehicle type and its estimation has been subject of interest over the world. The accuracy of measured traffic flow on a roadway is highly depends on correctness of PCUs used for converting traffic volume counts of observed vehicle category. With the extensive growth in roadway network, increase in numbers of vehicles plying on the Indian highways has been observed significantly. Substantial increase in traffic volume and speed levels on highways is warranted much safer and secured traffic flow operational system. Traffic on Indian roads is of heterogeneous nature that incorporates wide variation in vehicles physical and operational characteristics. Any one type of vehicle considered to be different in compare to any other vehicle types. PCU of a vehicle type is used as a volume count adjustment factor to account for the non-uniformity in traffic flow stream. This problem of non-uniform traffic is resolved by converting volume count of different types of vehicle into a common unit i.e., PCU (passenger car unit) and thereby to express traffic volume in terms of PCU/hr. The appropriate measurement of traffic volume is the most vital inputs for the traffic system design and assessment of roadway capacity. Hence, the proper estimation of PCU values of different types of vehicle becomes essential for planning and design of traffic operational facilities. The most recent addition of the US HCM (2000) provides different sets of PCE values of trucks and recreational vehicles, for different types of terrain and highway facilities.

In developing countries, several methods were developed for determining PCU homogenization coefficient, method based on relative delay, walker's method, headway method, simultaneous equations, multiple linear regression method, simulation method etc. Most of these methods are commonly used under homogeneous traffic conditions but failed in converting volumes under heterogeneous traffic conditions. Methods developed for PCU estimation under mixed traffic conditions are also not unerring in all the aspects of degrees or levels of heterogeneity as the estimated PCUs are also tend to vary with the change in traffic and roadway factor. Since, PCU is expected to be different for different vehicle types therefore, it is considered as very complex parameters in the measurement of traffic flow. Due to arising complexities in volume measurement, selection of appropriate parameters and methods for determining PCU values need a better and comparative study. By considering various influencing parameters and available methodologies, a modified approach for finding PCU values is proposed in the present study. Present study describes a modified methodology for estimation of PCU value of subject vehicles that includes the time headway as influencing parameter. The approach used in the present study is inspired from the method of dynamic PCU estimation where a PCU is expressed as the ratio of speed ratio and area ratio of standard cars to the subject vehicle type. Unlike dynamic PCU method, this method includes time headway factor for PCU estimation.

Field data for the present study was collected from the mid-block road sections of three different divided multilane highways in India. Field data for present study includes; speed, time headway and projected area of vehicle type observed on study sections. Simulation of traffic flow was also performed through microscopic simulation model VISSIM for generating congestion and verification of estimated PCU values at level of maximum traffic volume.

## 2. Literature review

Various studies have been reviewed in connection of estimation of PCU values under different traffic and roadway conditions around the world. The literature review also covers the discussion on various methods available for PCU estimation with their merits and demerits.

Homogenization coefficient method is the earliest method of PCU estimation and is based on the methodology that PCU value of a vehicle is calculated by the ratio of the theoretical maximum capacity of the subject vehicle type to only passenger car. Basically this method compares the traffic stream which contains all vehicles as passenger cars and all vehicles as other than passenger car. The PCU is given by equation (1).

$$PCU_i = \frac{V_c / V_i}{L_c / L_i} \quad (1)$$

Where L and V are the length (meters) and speed (Kmph) of vehicle, suffice i indicates vehicle type and c indicates the car. PCU values were obtained by CRRI in the Road User Cost study (1982) and Chandra et al., (1997) by using this method, based on the observed mean free flow speed data under the different road condition were found quite realistic as compared to other methods.

The principle behind Walker's method is based on the number of overtaking that would be performed per kilometer length of highway if each vehicle continued at its normal speed. The method pointed the difference in operating capabilities between the heavy vehicles and the passenger cars. The passenger car unit is calculated as the ratio of the number of overtaking when traffic has one slow moving vehicle per hour to the number of overtaking when there are passenger car of equal volume. Normal speed distribution of interacted vehicle found that at high speed obtained PCUs of different vehicle tend to unity because of low speed differential and few chances of overtaking (Chandra et al., 1997). There is practically no difference between the speed of a truck and a two-wheeler. Therefore, Walker's method becomes unrealistic under high volume and mix traffic conditions.

Headways have been used in some of the most popular methods of PCU estimation to account for the primary effect of heavy vehicles in the traffic stream that they take more space than a single passenger car. The equation (2) is given for estimation of PCU by headway method.

$$PCU = [(\frac{h_m}{h_c}) - c] / t \quad (2)$$

Where $h_m$, and $h_c$ are the time headway of mixed vehicle and passenger cars; $c$ is the proportion of cars in the traffic stream; $t$ is the proportion of commercial vehicles in traffic stream.

Werner and Morrrall (1976) used this method for low speed truck and the conventional speed method of the HCM (1965) for the higher speed trucks. They suggested that head way method is best suited to determine PCEs on level grade and at low level of service. According to Chandra et al. (1997) the method demands grouping of all vehicles into commercial and non-commercial vehicle category. This method is suitable for high density condition but in mix traffic adaptation of method is very limited.

PCU of a vehicle can be calculated by solving simultaneous equations by using the concept of headway. In this approach the equivalency factor of a subject vehicle is the ratio between the headways maintained by the subject vehicle to the standard vehicle. Volume of car traffic and volume of mixed traffic is calculated from the average headways of the car traffic and mixed traffic. Chandra et al. (1997) used headway values with proportional composition to set simultaneous equation for seven vehicle categories. Further Gauss-Sidel elimination method was applied to solve non-linear equations to get PCU for each vehicle type.

In statistics, regression analysis is a technique for modeling and analyzing variables. It focuses on relationships between a dependent variable and one or more independent variables. Regression analysis is divided into two categories, one is asynchronous regression and other one is synchronous regression. The speed of the car is regress against volume of different types of vehicles where speed is considered as dependent variable. The generalized form of multiple linear regression equation (3) is given as:

$$V_1 = A_0 + A_1Q_1 + A_2Q_2 + A_3Q_3 + ... + A_nQ_n \quad (3)$$

where:
$V_1$ and $Q_1$ are the speed and the volume of cars;
$Q_2$, $Q_3$,…,$Q_n$ the volume of vehicle type 2, 3 … n;
$A_1$ and $A_2$ are the regression coefficient;
$A_0$ is a constant.

Therefore PCU value of vehicle type n is given by:

$$PCU_n = \frac{A_n}{A_1} \quad (4)$$

Kimber et al. (1985) stated asynchronous regression gives lower estimates for medium and heavy goods vehicles and buses than the other existing methods. The ratio of mean headways is of fundamental significance and PCU values depend upon the method of derivation also. Chandra et al. (1997) has reported that the PCU values obtained from linear regression method can be negative also. Therefore this method is not acceptable in all traffic scenarios.

In general, simulation is defined as dynamic representation of some part of real world achieved by building a computer model and moving it through time. The use of computer simulation started when Gerlough published his dissertation: "Simulation of freeway traffic on a general-purpose discrete variable computer" at university of California. Thereafter, methods of simulation become popular for various kinds of traffic related analysis and estimations. Method of simulation is an alternative approach with various input parameters in design and analysis. Arasan and Arkatkar (2010) used micro-simulation model HETEROSIM to observe the effect of variation in roadway and traffic conditions on PCU values of vehicles in heterogeneous conditions. Mehar et al. (2013) estimated PCU values for vehicle types on interurban multi-lane highways at different LOS and traffic composition. Authors used the traffic simulation model VISSIM for generating data under controlled traffic conditions. Finally, PCU values for different vehicle types were suggested at different LOS on 4-lane and 6-lane divided highways.

Chandra et al. (1995) proposed a method for estimation of PCU value for different vehicles under mixed traffic situation. The basic concept used in this method is that the PCU value is directly proportional to the speed ratio and inversely proportional to the area ratio with respect to the standard car. Chandra and Kumar (2003) estimated the PCU values by using this method and studied the effect of lane width on PCU values. Authors found that the PCU for a vehicle type increases linearly with the width of carriageway. The equation (5) is given for estimation of PCU by dynamic PCU method.

$$PCU_i = \frac{V_c / V_i}{A_c / A_i} \quad (5)$$

where:
$PCU_i$ = Passenger car unit value of the $i^{th}$ vehicle,

$V_c/V_i$ = Speed ratio of the car to the i$^{th}$ vehicle and $Ac/A_i$ = Space ratio of the car to the i$^{th}$ vehicle.

Giuffre et al. (2015) applied Aimsum micro-simulation to isolate traffic conditions difficult to capture on field and used traffic density as equivalency criteria for the estimation of passenger car equivalents for heavy vehicles. Authors stated that PCEs were increasing with increasing of traffic flow rates of heavy vehicles for upgrades as well as downgrades. Nokandeh et al. (2016) are formulated simultaneous equations to calculate the speeds of different types of vehicles for a given traffic composition and traffic volume on the road and the concept of a stream equivalency factor was suggested to convert a heterogeneous traffic stream into a homogeneous stream consisting of passenger cars. Biswas et al. (2017) used kriging based approach for estimation of vehicular speed and passenger car units on an urban Arterial and also proposed novel algorithm for selecting the optimal correlation function in kriging approach.

## 3. Study methodology

PCU of a vehicle type depends on vehicular characteristics, stream characteristics, roadway characteristics, environmental factors, climate conditions and control conditions (Anand et al. 1999). The factors considered in present study are mean speed, mean time headway and mean rectangular projected area of vehicle types. Present study estimates the PCU value of subject vehicle types by taking the product of speed factor, headway factor and area factor. The factors calculation and development of PCU equation is discussed in detail in the following paragraphs.

### 3.1. Speed factor (Fv)

Time spent by the vehicle in the traffic stream will decrease by increase in mean speed of vehicle. When other factors remain constant, PCU is inversely proportional to mean speed of vehicle. Speed factor is ratio of mean speed of standard car ($V_c$) to mean speed of subject vehicle type ($V_i$).

$$F_v = \frac{V_c}{V_i} \tag{6}$$

where:
$F_v$ = speed factor of subject vehicle type,
$V_c$ = mean speed of standard car,
$V_i$ = mean speed of subject vehicle type.

### 3.2. Headway factor (Ft)

Moving space available for vehicle in traffic stream is increases with the increase in the meantime headway maintained by the vehicle. Hence, PCU is directly proportional to mean time headway. Headway factor based on the mean time headway of different vehicle type is calculated by dividing the mean lower time headway of subject vehicle type ($T_i$) by the mean lower time headway of standard car ($T_c$).

$$F_t = \frac{T_i}{T_c} \tag{7}$$

where:
$F_t$ = Headway factor of subject vehicle type,
$T_c$ = mean lower time headway of standard car,
$T_i$ = mean lower time headway of subject vehicle type.

### 3.3. Area factor (Fa)

PCU of a vehicle type depends on vehicular dimensions. PCU is inversely proportional to area of vehicle. Area factor is the ratio of rectangular projected area of standard car ($A_c$) to the area of subject vehicle type ($A_i$).

$$F_a = \frac{A_i}{A_c} \tag{8}$$

where:
$F_a$ = Headway factor of subject vehicle type
$A_c$ = rectangular projected area of standard car
$A_i$ = rectangular projected area of subject vehicle type

### 3.4. PCU of subject vehicle type

PCU value of subject vehicle is calculated by product of speed factor, headway factor and area factor of corresponding subject vehicle.

$$PCU_i = F_v \cdot F_t \cdot F_a \tag{9}$$

where:
$PCU_i$ = PCU value of subject vehicle type,
$F_v$ = Speed factor of subject vehicle type,
$F_t$ = Headway factor of subject vehicle type,
$F_a$ = Area factor of subject vehicle type.

## 4. Field data collection and analysis

For the selection of study locations, different National Highways were identified. Three different sections of multilane divided highways were selected to perform traffic survey. Details of study locations are given in Table 1. After selection of study locations traffic survey was conducted. Video graphic method was used for collecting the field data. Video recording of traffic operation was done on clear weather condition for 3-4 hours on weekdays. A trap length of 50 meters was marked on each section of highway to estimate the speed of vehicles. Vehicle type survey was also conducted to obtain the clear dimensions of different vehicle types. The dimensions of each vehicle type are shown in Table 2.

The traffic composition, average speed and mean lower time headway data of each vehicle type were extracted from the field data survey conducted at different highway sections. Correlation analysis was carried out between speed and headway data obtained from the three sections and statistically weak correlation was found between speed and headway data.

## 5. Estimation of PCU

### 5.1. Estimation of PCU using available methods

Field data collected at study section on NH202 is used for estimation of PCU from most popular methods given in the literature. PCU values of subject vehicle types were determined by different methods at every five minute interval. The PCU values obtained by different methods are given in Table 4.

Table 1. Study locations details

| Section | Highway No. | Name | Type of highway | Type of shoulder | Properties |
|---|---|---|---|---|---|
| **Section-I** | NH 58 | Meerut-Delhi | 4 lane divided | Un-paved | CW: 7.0 m |
| **Section-II** | NH 202 | Madikonda | 4 lane divided | paved | CW:7.0m SW: 1.5m |
| **Section-III** | NH 16 | Vijaywada-Guntur | 6 lane divided | paved | CW:10.5m SW: 1.8m |

* CW= Carriageway width, SW= Shoulder width

Table 2. Dimensions of vehicles

| Vehicle Type | Length(m) | Width(m) | Area($m^2$) |
|---|---|---|---|
| **Standard Car(CS)** | 3.6 | 1.6 | 6.12 |
| **Big Car(CB)** | 4.6 | 1.7 | 7.82 |
| **Light Commercial Vehicles(LCV)** | 4.3 | 1.56 | 6.71 |
| **High Commercial Vehicles(HCV)** | 6.7 | 2.3 | 15.41 |
| **Multi Axle Vehicles(MAV)** | 11.5 | 2.42 | 27.83 |
| **Two-Wheeler(TW)** | 1.97 | 0.74 | 1.46 |
| **Three Wheeler(3W)** | 3.2 | 1.3 | 4.16 |
| **Bus(B)** | 10.6 | 2.4 | 25.44 |

Table 3. Headway, speed and traffic composition at study sections

| Vehicle Type | NH-16 | | | NH-202 | | | NH-58 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Average headway (sec) | Composition (%) | Average speed (Kmph) | Average Headway (sec) | Composition (%) | Average speed (Kmph) | Average headway (sec) | Composition (%) | Average speed (Kmph) |
| CS | 2.689 | 22 | 75.1 | 3.962 | 20 | 64.5 | 1.828 | 40 | 68.4 |
| CB | 2.721 | 10 | 83.3 | 4.044 | 6 | 67 | 1.731 | 9 | 71.4 |
| LCV | 2.784 | 4 | 60.1 | 4.098 | 7 | 47.6 | 1.828 | 3 | 58.2 |
| HCV | 2.762 | 4 | 51.9 | 4.157 | 4 | 42.1 | 2.167 | 5 | 54.9 |
| MAV | 2.767 | 4 | 50.9 | 4.655 | 3 | 39.1 | 3.625 | 1 | 47.8 |
| TW | 2.68 | 49 | 56.5 | 4.482 | 45 | 45.1 | 2.065 | 35 | 57.3 |
| 3W | 2.757 | 2 | 49.4 | 4.428 | 12 | 40.8 | 1.638 | 3 | 46.9 |
| B | 2.72 | 5 | 66.1 | 4.582 | 3 | 45.2 | 2.643 | 5 | 65.2 |

Table 4. PCU values estimated from different methods

| Methods | Passenger Car Unit(PCU) | | | | | | |
|---|---|---|---|---|---|---|---|
| | CB | 3W | HCV | MAV | LCV | TW | B |
| Homogenisation Coefficient Method | 1.24 | 1.39 | 2.92 | 5.74 | 1.63 | 0.77 | 4.31 |
| Headway Method | 1 | 1 | 11.05 | 11.05 | 1 | 1 | 11.05 |
| Simultaneous Equation Method | 4.02 | 6.03 | -5.03 | 2.02 | 6.27 | -0.04 | -8.11 |
| Multiple Linear Regression Method | -10.19 | 13.7 | 34.67 | -12.95 | 30.72 | 21.91 | 34.72 |
| Dynamic PCU Method | 1.26 | 1.05 | 3.87 | 7.53 | 1.49 | 0.34 | 5.97 |

After analysing the estimated PCU values given in above Table, it can be concluded that the PCU values obtained from the headway method, simultaneous equations and multiple linear regression methods are inaccurate. Only the results of homogenisation coefficient method and dynamic PCU method are giving better results than other methods. However, the PCU obtained from dynamic method are better as it gives relatively higher values than the homogenisation coefficient method. The dynamic PCU values of each vehicle type were estimated on NH 58 and NH 16and are given in Table 5.

Table 5. Dynamic PCU values of different vehicles on NH 16 and NH 58

| Vehicle Type | PCU | |
|---|---|---|
| | NH 16 | NH 58 |
| CB | 1.44 | 1.24 |
| LCV | 1.52 | 1.29 |
| HCV | 4.04 | 3.14 |
| MAV | 7.45 | 6.53 |
| TW | 0.35 | 0.29 |
| 3W | 1.12 | 0.97 |
| B | 5.26 | 4.39 |

Dynamic PCU method considers the speed ratio and area ratio of vehicle types but ignores the effect of time headway maintained by vehicle types. Present study uses the time headway as influencing factor and provides a modified approach for PCU estimation of subject vehicle types. The estimation procedure and results are described in the following sections.

### 5.2. Estimation of PCU using modified approach

The PCU values of different vehicles are estimated as the product of speed factor, headway factor and area factor. PCU values of different types of vehicles on mid-block section of divided highways are estimated by using modified approach and are shown in Table 6, Table 7 and Table 8 respectively. The PCU value of each vehicle type estimated by using the modified approach is found to be realistic and logical.

Table 6. PCU values of different vehicle types by modified method on NH 58

| Vehicle Type | Speed factor | Headway factor | Area factor | PCU |
|---|---|---|---|---|
| CS | 1 | 1 | 1 | 1 |
| CB | 0.958 | 0.947 | 1.299 | 1.18 |
| LCV | 1.174 | 1.000 | 1.100 | 1.29 |
| HCV | 1.244 | 1.185 | 2.525 | 3.72 |
| MAV | 1.130 | 1.443 | 4.566 | 7.95 |
| TW | 1.192 | 1.130 | 0.239 | 0.32 |
| 3W | 1.458 | 0.896 | 0.667 | 0.87 |
| B | 1.048 | 1.446 | 4.184 | 6.34 |

Table 7. PCU values of different vehicle types by modified method on NH 202

| Vehicle Type | Speed factor | Headway factor | Area factor | PCU |
|---|---|---|---|---|
| CS | 1 | 1 | 1 | 1 |
| CB | 0.963 | 1.021 | 1.299 | 1.28 |
| LCV | 1.355 | 1.034 | 1.100 | 1.54 |
| HCV | 1.532 | 1.049 | 2.525 | 4.06 |
| MAV | 1.650 | 1.175 | 4.566 | 8.85 |
| TW | 1.430 | 1.131 | 0.239 | 0.39 |
| 3W | 1.581 | 1.118 | 0.667 | 1.18 |
| B | 1.427 | 1.156 | 4.184 | 6.90 |

Table 8. PCU values of different vehicle types by modified method on NH 16

| Vehicle Type | Speed factor | Headway factor | Area factor | PCU |
|---|---|---|---|---|
| CS | 1 | 1 | 1 | 1 |
| CB | 1.107 | 1.012 | 1.299 | 1.45 |
| LCV | 1.383 | 1.035 | 1.100 | 1.57 |
| HCV | 1.601 | 1.027 | 2.525 | 4.15 |
| MAV | 1.633 | 1.029 | 4.566 | 7.67 |
| TW | 1.471 | 0.997 | 0.239 | 0.35 |
| 3W | 1.682 | 1.025 | 0.667 | 1.15 |
| B | 1.257 | 1.012 | 4.184 | 5.32 |

### 5.3. Comparison of modified PCUs with dynamic PCU values

The PCU values as estimated on NH 202 and NH 16 highways sections based on proposed approach are further compared with PCUs determined by dynamic PCU method. The estimated mean PCU values estimated from both the methods are given in the Table 9. It may be seen that the mean PCUs estimated from modified approach for all the vehicle types are relatively higher than the Dynamic PCU values. However, the difference is only found statistically significant in case of large size vehicle type such as HCV, MAV and BUS.

Table 9. PCU estimated using modified method and dynamic method for subject vehicle types

| Vehicle Type | NH-202 | | NH-16 | |
|---|---|---|---|---|
| | Modified method | Dynamic PCU method | Modified method | Dynamic PCU method |
| CB | 1.28 | 1.25 | 1.45 | 1.44 |
| LCV | 1.54 | 1.49 | 1.57 | 1.52 |
| HCV | 4.06 | 3.87 | 4.15 | 4.04 |
| MAV | 8.85 | 7.53 | 7.67 | 7.45 |
| TW | 0.39 | 0.34 | 0.35 | 0.35 |
| 3W | 1.18 | 1.05 | 1.15 | 1.12 |
| B | 6.90 | 5.97 | 5.32 | 5.26 |

## 6. Verification of PCUs through traffic flow simulation

The PCUs of vehicle types estimated from the proposed method are based on lower to medium traffic volume levels. The comparison of PCUs may also be better if it could have been performed with higher traffic volumes. To overcome such difficulties, microscopic traffic flow simulation model VISSIM was used to generate the congestion and to estimate PCU values of vehicle type at maximum flow level. The field data collected from the highway section NH 202 was used as input to the VISSIM and base link network was created.

### 6.1. Preparation of Base link network

A straight link of more than 1000 meters was created in VISSIM and inputs were assigned as per field data. A travel time section of 50 m was assigned at the 600 m away from the point of vehicle input that allowed vehicles to get warm up before reaching the travel time section. Vehicle type data such as length and width was assigned as per field data. The desired speed distribution profile of vehicle types was also modified based on mean and standard deviation of individual vehicle type speed data. The new traffic composition was created in VISSIM by assigning proportional share and desired speed profile of each vehicle types. The behavior of simulating vehicles is generally influenced by the driving behavior model parameters sets as given in VISSIM. The driving behavior models are generally control the car following behavior of vehicles and affect overall performance of the traffic stream. Two car following models are given in VISSIM and each model consists of default values of different parameters.

Wiedemann 99 Car following model was considered in the present study. The default values of the model parameters CC0 and CC1 are 1.5 m and 0.9m. Default values are average for entire stream and do not replicate field condition. For the present study, calibrated values of driver behaviour parameters of Wiedemann 99 car following model such as Standstill Distance (CC0) and Time Headway (CC1) are employed from the study performed by Mehar et al. (2015). Authors simulated the four-lane divided highway under homogeneous traffic stream of vehicles with single category such as CS, CB, HV, 3W and 2W and identified appropriate values of CC0 and CC1 parameters. The calibrated values of CC1, CC0 parameter is given in Table 10. Calibrated values of CC1, CC0 vehicle type HV is used for the vehicle types HCV, MAV and B.

Table 10. Calibrated Parameters values for vehicle type (Mehar et al., 2015)

| Homogeneous vehicle type | Driving behaviour parameters | |
|---|---|---|
| | **CC0 (m)** | **CC1 (s)** |
| CS | 1.2 | 1 |
| CB | 1.5 | 1.4 |
| HV | 2.4 | 1.7 |
| 3W | 1.5 | 0.9 |
| 2W | 0.3 | 0.3 |

The above driver behaviour parameters (CC0 and CC1) for each vehicle type were used for the base model to replicate the mixed traffic behaviour. CC0 and CC1 parameters are most influence parameters to estimate the capacity using VISSIM.The traffic regulations were chosen as "left-side traffic" to replicate the Indian traffic conditions.The lateral behaviour of each vehicle type was also adjusted such that their desired position at free flow is on any lane. A new link behaviour type "Mixed traffic" was created in which each vehicle type class and its driving behaviour was added in this category. This behaviour type was selected in Link data for the created link. Field volumes were given as input from lower (100 veh/hr) to higher (7000 veh/hr) levels along with composition of vehicle types as observed in the field. The simulation was run for about 10800 simulation seconds. For evaluation files related to vehicle record, travel time and vehicle inputs were chosen to get the required output.

The travel time of each vehicle type over the trap length obtained from the simulation was used to calculate the speed of each vehicle type. The average speed of each vehicle type obtained from field data and simulated data were compared. The percent error calculated between average speeds of each vehicle type and is reported in Table 11. Fine tuning of VISSIM parameters was confirmed as speed values fall under acceptable limits of percentage error (5%). Hence VISSIM model may be used for further study.

Table 11. Estimated Percentage error between field and simulated average speeds

| Vehicle type | Simulation Average speed (kmph) | Field Average speed (kmph) | Percentage error |
|---|---|---|---|
| CS | 61 | 64 | 4.62 |
| CB | 63 | 67 | 6.41 |
| LCV | 48 | 48 | 0.03 |
| HV | 41 | 42 | 3.47 |
| MAV | 39 | 39 | 0.67 |
| TW | 45 | 45 | 0.31 |
| 3W | 39 | 41 | 3.53 |
| B | 47 | 45 | 2.94 |

### 6.2. Estimation of capacity

The speed - flow curve was developed by using simulated data for estimation of capacity. The speed-flow curve for mixed traffic is shown in Figure 1.

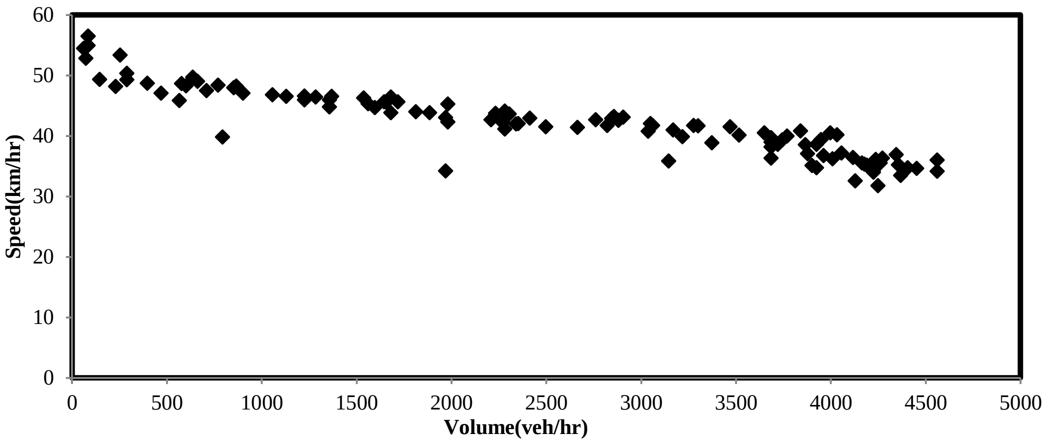


Fig. 1. Speed-flow curve for the mixed traffic flow on section II

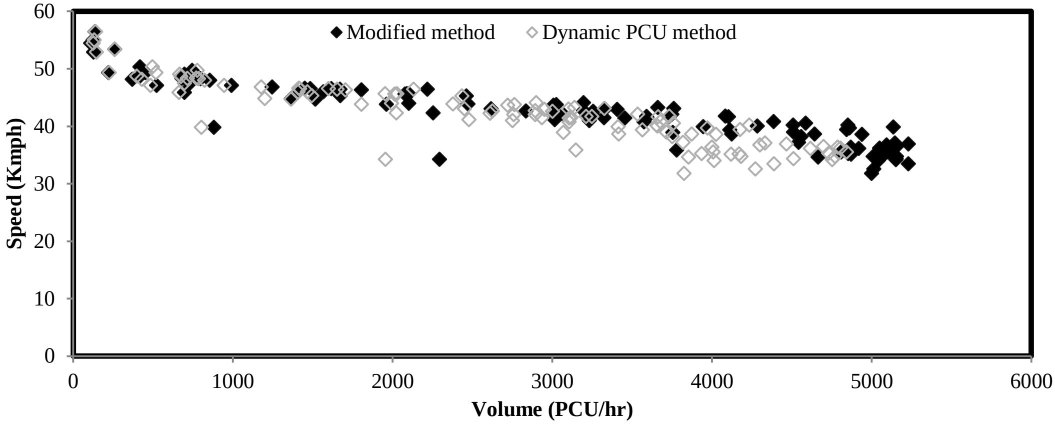


Fig. 2. Speed-flow curve for the mixed traffic flow converted into PCU/hr on section II

The capacity value obtained from speed-flow curve is 4560 veh/hr. Modified approach proposed in the present study is used to convert simulated heterogeneous traffic volume into passenger car units and developed speed –flow curve. The estimated capacity value is found as 5230 pcu/hr from speed-flow curve. Dynamic PCU method was also applied to convert simulated traffic volume into passenger car units and the capacity was obtained as 4840 pcu/hr. Speed-flow curve developed from both the methods is compared and shown in Figure 2. It can be observed that the capacity obtained by Dynamic PCU method is underestimated. Higher estimation of capacity is better than underestimation for planning, operation and analysis of highway. So, the values obtained by using modified method are more realistic.

## 7. Conclusions

- Different methods given in the literature used to calculate PCU value of vehicle types are not found realistic under traffic flow conditions observed in field data. However, homogenisation method and dynamic PCU method provides better results.
- Modification to Dynamic method was done by adding the time headway factor is found realistic and logical under heterogeneous traffic flow conditions.
- The modified approach used for PCU estimation in present study suggests relatively higher values than those obtained from dynamic PCU method.
- Simulation of traffic flow was also performed through microscopic simulation model VISSIM for generating congestion and for comparing estimated PCU values at the level of maximum traffic volume. The capacity obtained by using by modified PCU method is 5230 pcu/hr which is higher than capacity obtained by dynamic PCU method is 4840 pcu/hr.

## 8. Recommendation, limitations and future scope

- Higher estimation of capacity is better than underestimation for planning, operation and analysis of highway. So, use the modified dynamic method for estimation of PCU values of different vehicles types under heterogeneous traffic conditions.
- Present study was conducted under relatively lower to medium traffic flow level and no evidence is presented about PCUs under higher to maximum traffic flow level field conditions.
- The methodology adopted in this study will be extended for development of comprehensive PCU model by including more numbers of influencing factors under varying traffic and roadway conditions.

## References


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