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Effect of PCU Estimation Methods on Capacity of Two-Lane Rural Roads in India: A Case Study

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Abstract

The majority of roads in India are two lane undivided in nature with a supreme heterogeneity in traffic composition. As there is a large variation in dynamic profile of each vehicle, a single unit is essential to estimate the roadway capacity. The Passenger Car Unit (PCU) values of different vehicle categories have significant impact on the estimated roadway capacity. To study this effect, Kolkata-Basanti highway and Howrah-Amta Road, two state highways in the eastern part of India having two lanes each, were selected. Kolkata-Basanti highway connects the rural regions of Sundarban with Kolkata whereas Howrah-Amta Road connects the Amta region with Kona Expressway in the district of Howrah. It has a considerable heterogeneity in traffic with large speed differentials among the vehicles. Greenshield's linear model is applied to estimate the Capacity where the PCU values are determined by three different methods. These include the static PCU value from IRC 64 (1990), the concept of Dynamic PCU values as proposed by S. Chandra (2004) and the method suggested in Indo-HCM (2017). The analysis shows that there is a significant difference in the roadway capacity estimated using static PCU values from

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the other two methods. This may be attributed to the fact that the dynamism of the vehicles in the PCU value determination is not considered in the static PCU values listed in IRC 64 (1990).

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*Keywords:*Two Lane Road; Heterogeneous Traffic; Static PCU; Dynamic PCU; Traffic Flow; Capacity

1. Introduction

In most of the developing countries including India, the prevailing traffic is heterogeneous in nature. It comprises of a wide range of vehicle category which are different from each other in terms of static and dynamic behaviour. As they share the same road space, the mobility of one vehicle is greatly influenced by the presence of the other. The interaction between different categories of vehicle is more intense in case of intermediate or two-lane roads rather than multilane highways. As about three-fourths of National highways (NH) and most of the State highways (SH) in India are either two-lane, intermediate or single lane road, heterogeneity and speed differential plays a significant role in influencing capacity. Hence, to nullify the impact of the heterogeneity of the vehicles, the vehicles are converted to an equivalent unit i.e., Passenger Car Unit (PCU).There are multiple ways by which the PCU values are determined which have a significant impact on the estimation of a roadway capacity. The primary objective of the study is to comprehend the impact of different PCU values of the same vehicle on the roadway capacity. The secondary objectives are to estimate the PCU values of the different vehicle categories using three different well established methods, to establish the Speed-Flow-Density Relationship by Greenshield's Linear Model thereby estimating the roadway capacity and finally compare these capacity values with the capacity obtained at base condition.

Many researches have been done already to find out the most suitable PCU value of a vehicle category. Out of the many research, the most important concept of dynamic PCU has been invented by Chandra and Sinha(2001). They incorporated the dynamic characteristics of a vehicle in determining the PCU value of a vehicle. To determine PCU values, they used the concept that PCU is directly proportional to the ratio of clearing speed and inversely proportional to the space occupancy ratio with respect to standard design vehicle. After the invention of this concept there have been a numerous researches in India as well as in other countries related to capacity estimation using the dynamic PCU, such as Dey et. al. (2008), Mehar et. al. (2013), Mondal et. al. (2017) to name a few. Saha et. al. (2017) used the static PCU concept to estimate the capacity of two-lane roads under mixed traffic condition. But they suggested that introducing the concept of dynamic passenger car unit would reduce the deficiency of the current implication on capacity standards of two-lane roads under mixed traffic. In countries other than India, Al-Kaisy et al. (2005) considered Queue Discharge Flow (QDF) capacity as the equivalency criterion in developing the PCE factors. Zhang et al. (2006) proposed vehicle moving space as a measure to derive PCEs. They estimated PCE under different roadway and level of service conditions. In India, Basu et al. (2006) considered stream speed as a measure of equivalence for modelling Passenger Car Equivalent (PCE). They used Neural Network (NN) approach to capture the non-linear effects of traffic volume and its composition on stream speed. Satyanarayana et al. (2012) worked on development of PCU factors and capacity norms at mid blocks of rural highways in Visakhapatnam. Dhamaniya and Chandra (2013) also proposed an innovative methodology to convert heterogeneous traffic volume in vehicle per hour to homogeneous PCU per hour without determining PCU factors for each and every individual vehicles type by making use of stream equivalency factors. This concept was later used by Nokandek et al. (2016). Theyfound that PCU factors are very sensitive to any change in the traffic volume or traffic composition. They used the concept of stream equivalency factor to convert heterogeneous traffic into a homogeneous stream of passenger cars and proposed that the stream equivalency factor follows a linear relationship with proportion of different vehicle category. The concept of stream equivalency factor was later used as a part of capacity estimation in the Indo-HCM manual (2017) as well. In this study, the static PCU values, dynamic PCU values and the PCU value proposed in the Indo-HCM (2017) is used to estimate the capacity and are compared.

2. Methodology

Several macroscopic models proposed by different researchers are available to find out speed, flow and density relationship. In the present study, the speed, flow and density relationship is established using the traditional speed-density model, i.e., Greenshield's Linear Model. The speed–density relation is a straight line, having maximum speed when traffic flow is low and zero speed when vehicles are in jam condition. The speed volume relationship is parabolic having maximum volume at a density equal to half the jam density. The relationship between flow and density is given by

$$Q = K * V \quad (1)$$

Where,
Q=Traffic flow in PCU/h
K=Density in PCU/Km
V =Space mean speed in Km/h

Speed and density are inversely proportional to each other and their relationship is linear in nature having the generalised linear form as follows

$$V = a - b * K \quad (2)$$

Where, 'a' and 'b' are constants representing free flow speed and ratio of free flow speed to jam density respectively.

This study mainly focuses on the effect of PCU estimation on the highway capacity. So, the PCU values which are used in the capacity estimation are determined by three methods: (i) Static PCU method, as per Indian Roads Congress (IRC-64: 1990), (ii) Dynamic PCU as proposed by S.Chandra (2004) and (iii) Indian Highway Capacity Manual (Indo-HCM) (2017) method. The methods to determine the PCU are described.

Static PCU Values

IRC-64 (1990) provides tentative equivalency factors for conversion of different types of vehicles into equivalent passenger car units based on their relative interference value. IRC-64 provides a table of equivalency (Refer to Table 1) factors for different categories of vehicle in rural roads which are used in estimating the roadway capacity.

Table 1: Static PCU as per IRC-64 (1990)

Vehicle Type	Equivalency Factor
Motor Cycle or Scooter	0.5
Passenger Car or Auto Rickshaw	1
LCV	1.5
Truck or Bus	3
Truck-trailer, Agricultural-trailer	4.5
Cycle	0.5
Cycle-rickshaw	2
Hand Cart	3
Horse-drawn Vehicle	4
Bullock Cart	8

Determination of Dynamic PCU Values

Dynamic PCU values are calculated using the methodology as proposed by Chandra and Sinha (2001). The basic proposed concept to estimate the PCU is that it is directly proportional to the ratio of clearing speed and inversely proportional to the space occupancy ratio with respect to the standard design vehicle, a car.

PCU_i = Speed ratio of the car to the i-th vehicle ÷ Space ratio of the car to the i-th vehicle

$$PCU_i = \frac{V_c / V_i}{A_c / A_i} \quad (3)$$

Where,

PCU_i = PCU for the vehicle type i.

V_c is mean speed of car (kmph).

$V_i$is mean speed i-th type vehicle (kmph).

A_c is projected rectangular area of passenger car (m^2)

A_i is projected rectangular area of vehicle type i on the road (m^2).

The PCU values determined by this method are used in this study to estimate the roadway capacity.

Determination of PCU As Per Indo-HCM (2017)

According to Indo-HCM (2017) PCU values for a vehicle type depends on its proportion in the traffic stream and total volume on the road. Except motorised 2W, for all vehicle-types, the PCU has been found to be increasing with their increasing proportions in the traffic stream. In case of 2W PCU values reduces with increasing proportion of 2W. The ranges of proportions of different vehicle types and limits of PCU values are given in Table2 for two-lane road. For any intermediate proportion of a vehicle type PCU values are obtained by interpolating in a linear manner from the PCU ranges. These PCU values are used to estimate the roadway capacity.

Table 2: Range of PCU and Traffic Proportion for Two-lane or Intermediate-lane

Vehicle Type	PCU Value		Composition Of Vehicle	
	Lower Limit	Higher Limit	Lower Range	Higher Range
SC	1	1	6	30
BC	1.13	2.5	5	16
2W	0.2	0.5	17	64
Auto Rickshaw(3W & 4W)	1.1	2	5	19
BUS	2.8	4.8	5	10
LCV	2	5	2	18
HCV (Two or Three Axle Truck)	3	5.5	5	20
MAV (Multi Axle Truck)	4.6	11.6	2	11
TRACTOR	5	8	2	5
BICYCLES	0.4	0.4	2	5
CYCLE RICKSHAW	2.5	2.5	2	5
ANIMAL DRAWN VEHICLE	11.5	11.6	0	5

Determination of PCU As Per Indo-HCM (2017)

According to Indo-HCM (2017), “Capacity is influenced by the road conditions and drivers’ behaviour. A linear relationship exists between operating speeds of standard cars and capacity of a road section”. The operating speed (V_{OS})can be defined as the 85^{th} percentile of free flow speeds of standard cars. The linear relationship of Base capacity of a two-lane road with the operating speed is given by the following equation

$$C = 394 + 34 * V_{OS} \quad (4)$$

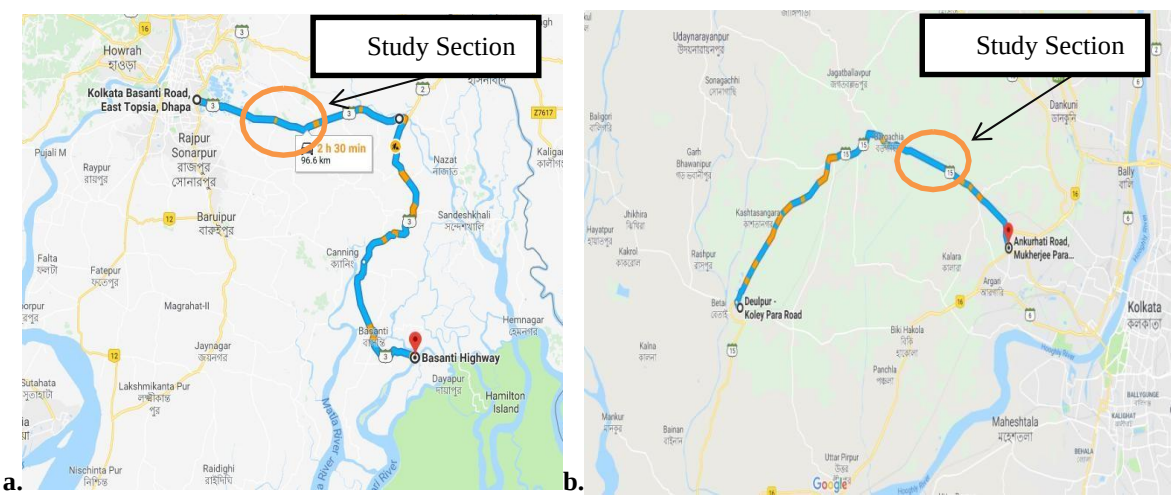
A roadway section to be considered as the base section, some important criteria must be checked as mentioned in the Indo-HCM (2017). The criteria are listed below:

- The carriageway width should be 7.0mwith a minimum of 1.0 m soft shoulder to facilitate two-way traffic movement in the case of two lane bidirectional roads.
- The section should be straight and level.
- The section should not be influenced by interruptions such as intersections, steep gradients and curvatures as well as any other adjoining roads.
- There must not be any physical barrier on at least 500 m section such as speed breakers, rumble strips, as it may affect the traffic stream.
- Section should be free from any form of road side activities.
- Section should be free from any form of work activity for at least 1 km on either side.
- No incidents or crashes at the time of observation for at least 1 km on either side.

The capacity obtained using this equation is considered as the standard capacity of the roadway. The capacity estimated using the static PCU, dynamic PCU and Indo-HCM proposed PCU will be compared in this study.

3. Study Section

Kolkata and Howrah are two of the oldest city in the eastern part of India in the state of West Bengal state. Both of the cities are densely populated and are connected with the rural areas in the South Bengal region. These rural areas are mostly connected by State Highways, most of which are intermediate or two lane road with substantial heterogeneity in vehicle composition. The Kolkata-Basanti Highway is one such two-way, two-lane, undivided road connecting Kolkata with Taki and Sunderban areas. The study section selected at Chainage 17 is located between Bhojerhat & Ghatakpukur. On the other hand, the Howrah-Amta road is another two-way, two-lane, undivided highway which connects Amta region with the Kona Expressway near Salap in the Howrah district. The selected section is located at Madhya Santoshpur (Near Jagat Ballavpur), Domjur. Both the state highways have a carriageway width of 7 meter. The vehicles plying through these corridors consist of Standard Car (SC), Big Car (BC), Light Commercial Vehicle (LCV), Heavy Commercial Vehicle (HCV), Multi Axle Vehicle (MAV), Three Wheeler (3W), Two Wheeler (2W), Four Wheeled Auto (4W) and Bus. Both the sections are located on level terrain and there is no no-passing zone. Unlike the Howrah-Amta Road, the traffic at Kolkata-Basanti Highway is not affected by side friction or road side activity. Moreover, these sections fulfil all the criteria of base conditions as mentioned in the Indo-HCM (2017). Figure 1 shows the locations of the study sections.



a. **b.**

Figure 1: Map showing the study sections: (a) Kolkata-Basanti Highway; (b) Howrah-Amta Road
Source: Google Map

4. Data Collection and Extraction

Data for the proposed study has been collected on the road sections by video photographic technique. The process of traffic data collection and its extraction processes are described.

Collection of Traffic Data

A trap length of 60 meter was physically marked on the road with the help of white paint and traffic cones. A video camera was installed with the help of tripod stand at the edge of the pavement. The camera was positioned at a height of 6m above the shoulder and projected 1.5m into the carriageway. And the camera was adjusted in such a way that the entire segment of 60m span was clearly visible to enable decoding of the traffic volumes and space mean speed of different vehicle types. Video photographic data were collected on typical week days and weather condition is sunny. Survey is conducted for morning 4 hours(08:00 am to 12:00 noon) and evening 4 hours (04:00 pm to 08:00 pm).

Data Extraction

Video files are played on monitor and following steps are followed during data extraction process. Each hour was divided into twelve five minutes intervals. Playing the video, traffic volume is obtained by manual counting for each five minutes interval considering each type of vehicle separately. Entry and exit time of vehicles into the segment were noted down with an accuracy of 1/25 second. Space Mean Speed (SMS) was calculated by dividing the segment length with this time span.

5. Results

Static PCU Values

The static PCU values used in this study are suggested by IRC 64 (1990). These values are mentioned in Table 1. These PCU values are used to establish the Speed-Flow-Density relationship and ultimately the highway capacity.

Dynamic PCU Values

The dynamic PCU values for the selected two study sections are calculated as per method proposed by Chandra and Sinha (2001) using equation 3. The method is described in the methodology section. The table 3 and Table 4 shows the dynamic PCU values for the vehicles plying along Kolkata-Basanti Highway and Howrah-Amta Road respectively.

Table 3: Dynamic PCU values for the vehicles plying along Kolkata-Basanti Highway

Vehicle Class	2W	3W	SC	BC	LCV	HCV	BUS	4W-AUTO
Average Speed (Kmph)	42.94	28.2	57.8	56.92	49.06	48.56	57.58	47.17
V_c/V_i	1.35	2.05	1	1.02	1.18	1.19	1	1.23
A_c/A_i	4.48	1.2	1	0.66	0.42	0.3	0.22	0.94
PCU	**0.3**	**1.71**	**1**	**1.54**	**2.82**	**3.92**	**4.6**	**1.3**

Table 4: Dynamic PCU values for the vehicles plying along Howrah-Amta Road

Vehicle Class	2W	3W	SC	BC	LCV	HCV	BUS	4W-AUTO
Average Speed (Kmph)	43.99	34.46	49.52	49.89	41.25	41.25	46.64	40.32
V_c/V_i	1.13	1.44	1.00	0.99	1.20	1.26	1.06	1.23
A_c/A_i	4.47	1.20	1.00	0.66	0.42	0.30	0.22	0.94
PCU	**0.25**	**1.20**	**1**	**1.50**	**2.87**	**4.14**	**4.90**	**1.30**

PCU Values As Per Indo-HCM (2017)

The PCU values for the selected two study sections are calculated as per method suggested in the Indo-HCM (2017). This method considers the proportion of vehicles on the roadway while determining the PCU values (Table 2). The method is described in the methodology section. The Table 5 and Table 6 show the PCU values for the vehicles plying along Kolkata-Basanti Highway and Howrah-Amta Road respectively.

Table 5: PCU values for the vehicles plying along Kolkata-Basanti Highway

Vehicle Class	2W	3W	SC	BC	LCV	HCV	BUS	4W-AUTO
Percentage Composition of Vehicles	37.07	19.74	8.33	8.79	10.30	4.98	6.42	4.37
PCU	**0.37**	**2**	**1**	**1.6**	**3.56**	**3**	**3.37**	**2**

Table 6: PCU values for the vehicles plying along Howrah-Amta Road

Vehicle Class	2W	3W	SC	BC	LCV	HCV	BUS	4W-AUTO
Percentage Composition of Vehicles	57.9	8.8	7.2	5.0	4.3	1.2	3.2	12.4
PCU	**0.27**	**1.96**	**1**	**1.13**	**2.36**	**3**	**2.8**	**1.96**

Speed-Flow-Density Relation using Static PCU Values

The static PCU values (Refer to Table 1) are used in the Greenshield's Linear Model to establish the relation among speed, flow and density. The graphical representation of the speed density relation, speed flow relation and flow density relation for both the study sections are presented in Figure 2, Figure 3 and Figure 4.

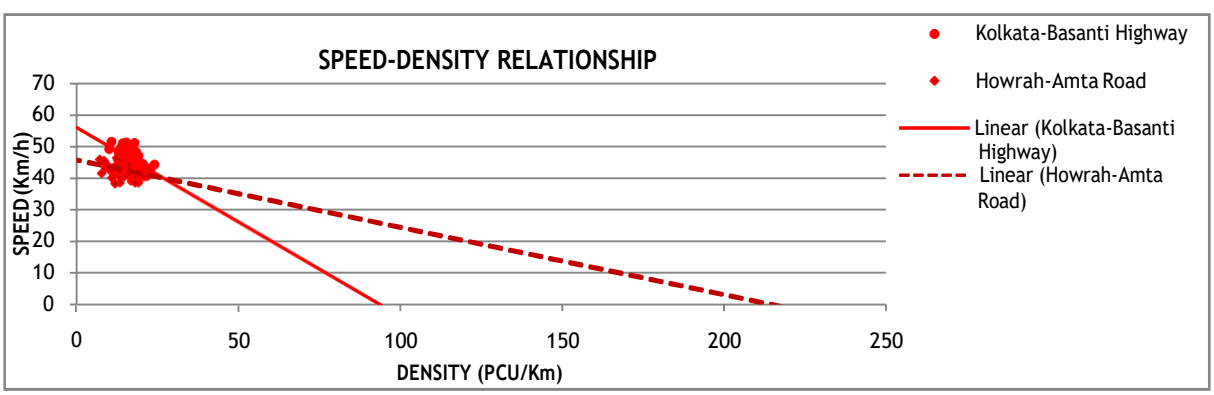


Figure 2: Speed-Density Relationship using Static PCU Values for Kolkata-Basanti Highway and Howrah-Amta Road

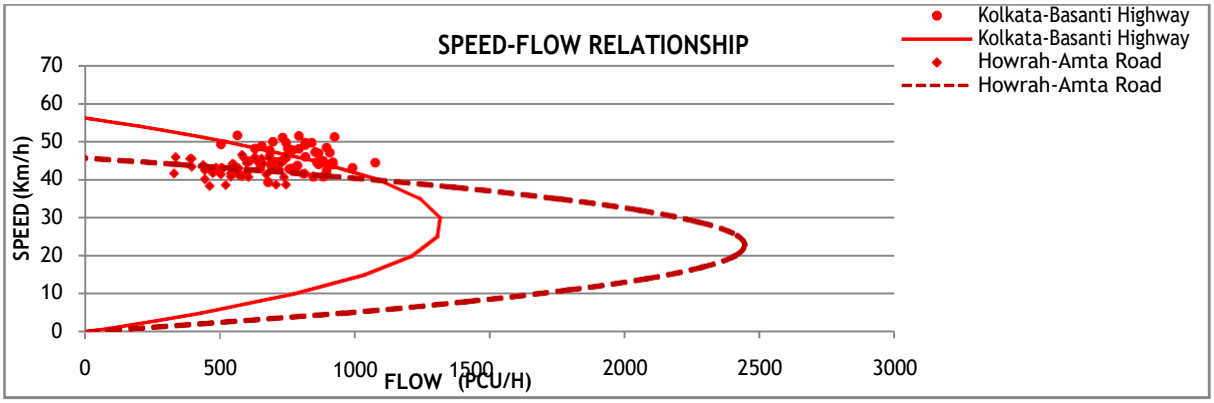


Figure 3: Speed-Flow Relationship using Static PCU Values for Kolkata-Basanti Highway and Howrah-Amta Road

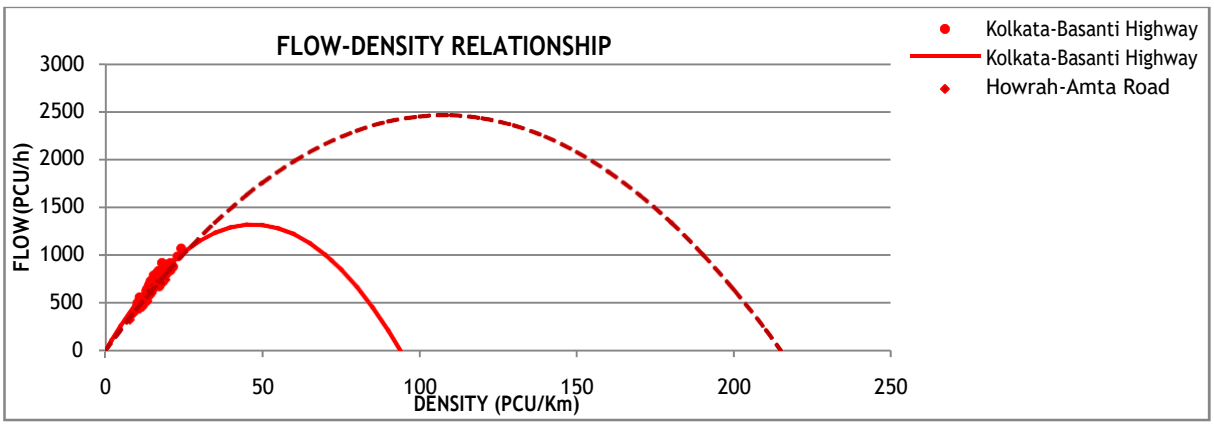


Figure 4: Flow-Density Relationship using Static PCU Values for Kolkata-Basanti Highway and Howrah-Amta Road

Speed-Flow-Density Relation using Dynamic PCU Values

The dynamic PCU values for both the roads (Refer to Table 3 and Table 4) are used in the Greenshield's Linear Model to establish the relation among speed, flow and density. The graphical representation of the speed density relation, speed flow relation and flow density relation for both the study sections are presented in Figure 5, Figure 6 and Figure 7.

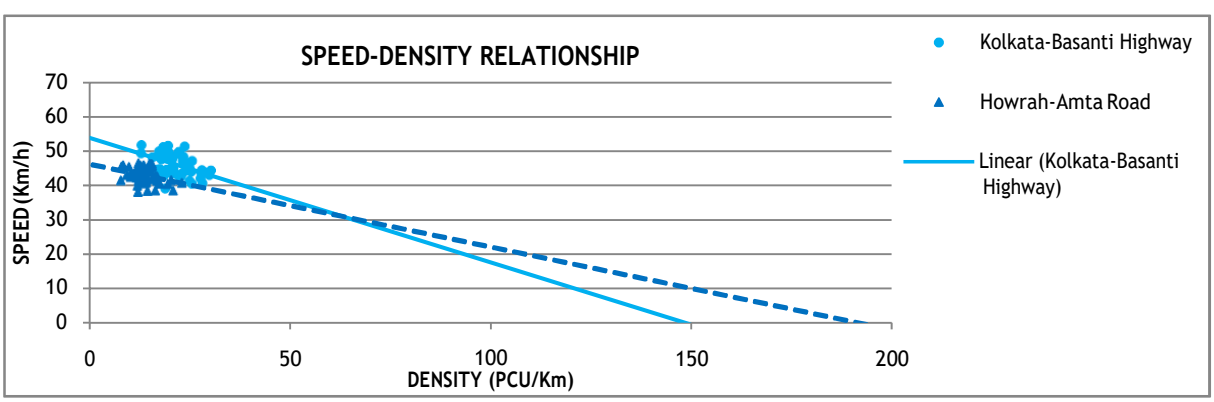


Figure 5:Speed-Density Relationship using Dynamic PCU Values for Kolkata-Basanti Highway and Howrah-Amta Road

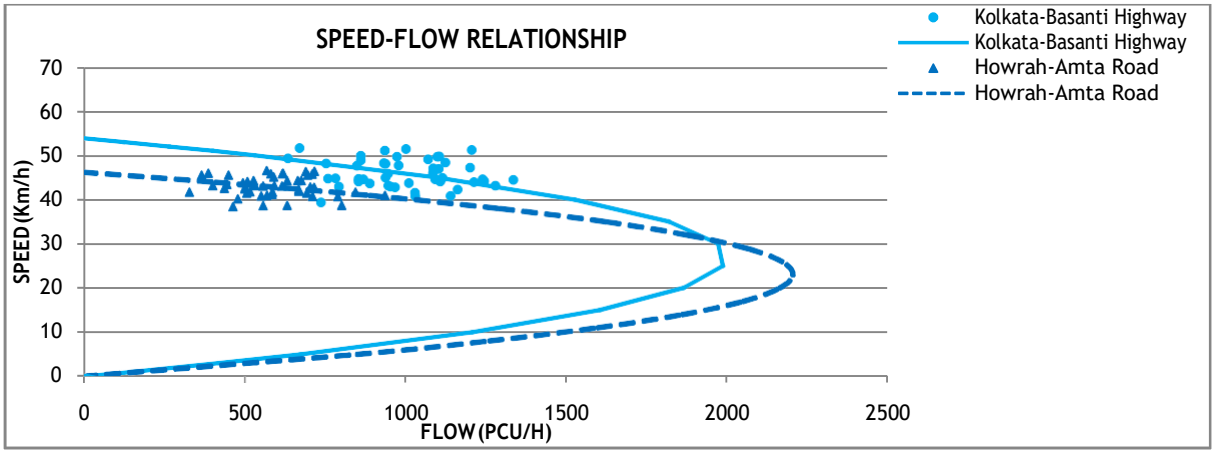


Figure 6:Speed-Flow Relationship using Dynamic PCU Values for Kolkata-Basanti Highway and Howrah-Amta Road

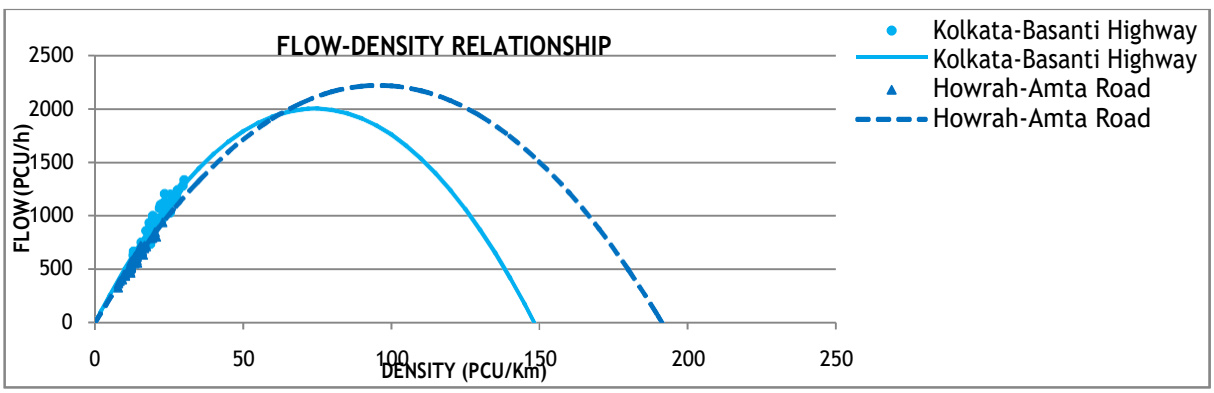


Figure 7: Flow-Density Relationship using Dynamic PCU Values for Kolkata-Basanti Highway and Howrah-Amta Road

Speed-Flow-Density Relation using Indo-HCM proposed PCU Values

The PCU values as obtained by the method suggested in Indo-HCM (2017) (Refer to Table 5 and Table 6) are used in the Greenshield's Linear Model to establish the relation among speed, flow and density. The graphical representation of the speed density relation, speed flow relation and flow density relation for both the study sections are presented in Figure 8, Figure 9 and Figure 10.

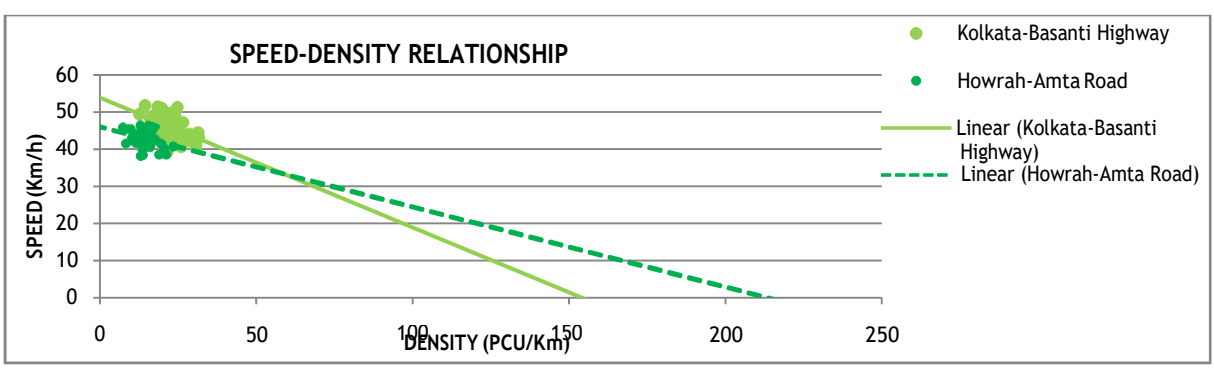


Figure 8: Speed-Density Relationship using PCU Values proposed in Indo-HCM for Kolkata-Basanti Highway and Howrah-Amta Road

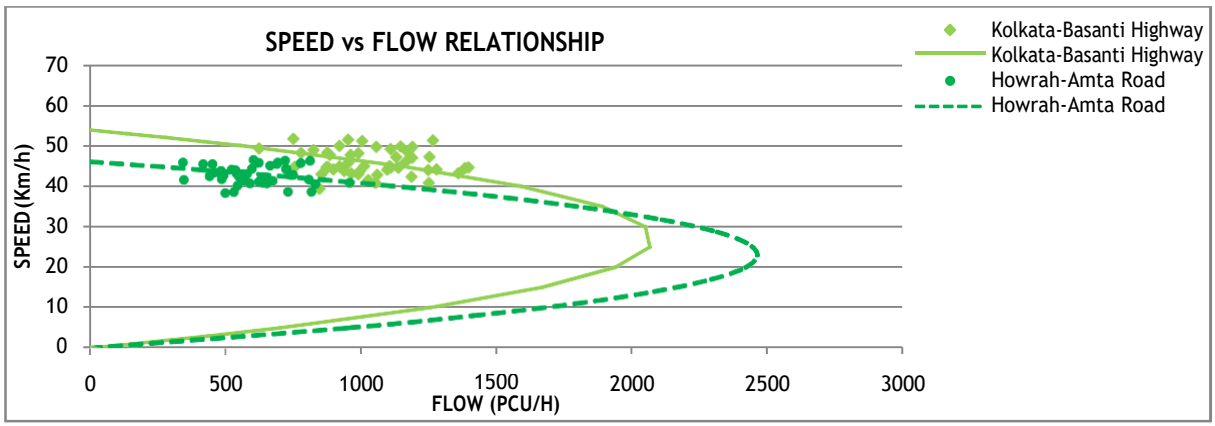


Figure 9: Speed-Flow Relationship using PCU Values proposed in Indo-HCM for Kolkata-Basanti Highway and Howrah-Amta Road

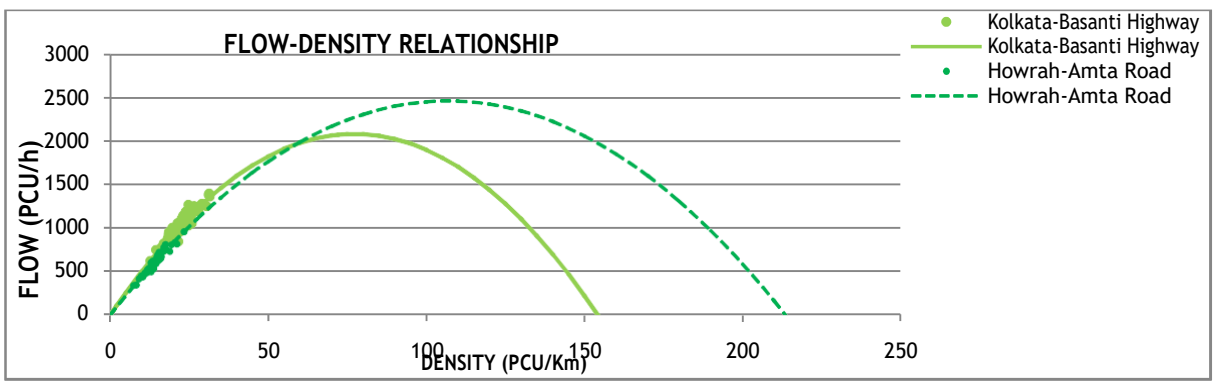


Figure 10: Flow-Density Relationship using PCU Values proposed in Indo-HCM for Kolkata-Basanti Highway and Howrah-Amta Road

Estimated Capacity

The traffic stream characteristics for the two study sections along with the roadway capacity obtained from the Greenshield's Linear Model is presented in Table 7.

Table 7: Estimated Capacity for the two study sections using different PCU values

Traffic Stream Characteristics	Kolkata-Basanti Highway			Howrah-Amta Road		
	PCU Type			PCU Type		
	Static PCU	Dynamic PCU	Indo-HCM PCU	Static PCU	Dynamic PCU	Indo-HCM PCU
Free Flow Speed (kmph)	56.22	53.86	53.88	45.77	46.25	45.97
Jam Density (PCU/Km)	94	148	154	215	191	214
Capacity (PCU/hr)	1321	1998	2078	2454	2213	2455

It shows that the Free Flow Speed for Kolkata-Basanti Highway is higher than that of the Howrah-Amta Road. There is no significant difference for the different PCU estimation methods. The jam density estimated is higher for Howrah-Amta Road and there is a significant difference in the jam density obtained by using the different PCU

values with the Static PCU values giving the lowest Jam Density for Kolkata-Basanti Highway whereas, it is giving the highest Jam Density for Howrah-Amta Road. Similar pattern is observed in the capacity as well. The capacity value is considerably low in the Kolkata-Basanti Highway using Static PCU values whereas, no such difference is observed in the Howrah-Amta Road. Since, 2-wheelers has a static PCU value of 0.5 but has low dynamic PCU value and Indo-HCM proposed PCU value (Refer to Table 8), the capacity of Howrah-Amta road using the different PCU values is not following the trend observed in the Kolkata-Basanti Highway.

Estimation of Capacity at Base Condition

The capacity at base condition for both the road section under study is estimated using the equation 4 The capacity obtained by the analysis from the Greenshield's Model is compared with this capacity.

Table 8: Capacity at Base Condition for the two study sections

Road Name	Operating Speed (kmph)	Capacity at Base Condition (PCU/h)
Kolkata-Basanti	73	2875
Howrah-Amta	66	2636

The table 8 shows that the capacity at base condition for Kolkata-Basanti Highway and Howrah-Amta Road is 2875 PCU/hr and 2636 PCU/hr respectively. The capacity estimated for Kolkata-Basanti Highway is considerably less than the capacity at base condition whereas there is not much deviation in the capacity estimated for Howrah-Amta Road. This difference is due to the high percentage of slow moving vehicle (about 20% of total traffic) (Refer to Table 5) plying along this highway in the form of motorised three wheeler load carrying van (Maximum load carrying capacity: 1 to 1.2 tonne) having poor dynamic characteristics with an average speed of 28 km/h (58% of that of the other vehicles in the traffic stream). The effect is more prominent in the capacity estimated using the static PCU values. This is because the static PCU values of these motorized 3-wheeler load carrying vans are considered equivalent to that of an LCV i.e., 1.5 (Refer to Table 1). Whereas, in the other two PCU value estimating methods, these vans have higher PCU values which makes the capacity estimation more accurate and are comparable with the capacity at the base condition. On the other hand, these vans are not present in Howrah-Amta Road. Thus, there is no significant difference in the capacity estimated by the Greenshield's Linear Model and the capacity estimated at the base condition.

6. Discussion

In this study, the effect of PCU estimating methods on roadway capacity determination is observed for two lane rural roads. The case study sections considered here are Kolkata-Basanti Highway and Howrah-Amta Road. Both the road sections are a part of two lane two way state highways near the city of Kolkata and Howrah. Three PCU estimating methods were adopted to determine the PCU values of the vehicles travelling along the case study sections viz. Static PCU values from IRC 64 (1990), Dynamic PCU concept by Chandra and Sinha (2001) and the method suggested in Indo-HCM (2017). The PCU values determined by the dynamic PCU concept are dependent on the dynamic characteristics of a vehicle and its area (Table 3 and Table 4). The PCU values determined by the method proposed in Indo-HCM consider both the dynamism and also the percentage composition of that vehicle category plying along the roadway (Table 5 and Table 6). These PCU values are then used to establish the Speed-Flow-Density relationship (Figure 2 through Figure 10) for both the road sections using the Greenshield's Linear Model. Ultimately, the capacity of the two highways was estimated with different PCU values obtained from different PCU value estimating methods. The capacity values are found to be considerably low in the Kolkata-Basanti Highway using Static PCU values whereas, no such difference is observed in the Howrah-Amta Road. Since, 2-wheelers has a static PCU value of 0.5 but has low dynamic PCU value and Indo-HCM proposed PCU value (Refer to Table 4 and Table 6), the capacity of Howrah-Amta road using the different PCU values is not following the trend observed in the Kolkata-Basanti Highway. The capacity at base condition, which has a linear relationship with the operating speed, were found out to be 2875 PCU/hr and 2636 PCU/hr respectively for Kolkata-Basanti Highway and Howrah-Amta Road. The capacity estimated for Kolkata-Basanti Highway is considerably

less than the capacity at base condition whereas there is not much deviation in the capacity estimated for Howrah-Amta Road. This difference is due to the high percentage of motorised three wheeler load carrying van (about 20% of total traffic) (Refer to Table 5) plying along this highway (Maximum load carrying capacity: 1 to 1.2 tonne) having poor dynamic characteristics with an average speed of 28 km/h (58% of that of the other vehicles in the traffic stream). The effect is more prominent in the capacity estimated using the static PCU values because the static PCU values of these 3-wheelers are considered equivalent to that of an LCV i.e., 1.5 (Refer to Table 1). Whereas, in the other two PCU value estimating methods, these vans have higher PCU values which makes the capacity estimation more accurate and are comparable with the capacity at the base condition. On the other hand, these vans are not present in Howrah-Amta Road. Thus, there is no significant difference in the capacity estimated by the Greenshield's Linear Model and the capacity estimated at the base condition. Whereas, the percent share of 2-wheelers in Howran-Amta Road is more than 50% which is influencing the capacity estimated using the Indo-HCM proposed PCU values.

Thus, it is evident from the present study that the concept of dynamic PCU as well as the concept proposed in the Indo-HCM (2017) is providing more realistic results in terms of capacity estimation, unlike the Static PCU values. The development of this concept has been a great development in the field of traffic engineering. Further modifications in these concepts by considering the day and night effect and the weather effect on the PCU values can open up another dimension in this regard in providing more accurate result.

7. Limitations of the Study

The most important limitations of the present study are as follows.

- The data points of the lower region of the speed-flow domain are not considered to plot speed flow curve. If speed-density or speed-flow data points are collected from field for all flow conditions i.e. starting from free flow condition to jamming condition and corresponding graph is plotted, comprehensive analysis can be obtained.
- Data collection for the present study was done in fair weather condition in day time. The effect of time dependency i.e. changing environmental factors such as daylight and darkness or weather conditions can be considered for further study.
- In the present study, the analysis is done only for four selected sections using limited hours of traffic data. More number of sections and traffic data for entire day can be considered for further study.

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