

Traffic Flow Simulation using VISSIM Software

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Abstract—In the present study demonstrate applicability of the PTV VISSIM 11.00-02 software to estimation of capacity of highway (NH-19) from Delhi to Agra (150.70-151.10) Km. The concept of area occupancy applied as the traffic has no lane discipline under mixed traffic condition in developing nations like India. There is no perfect lane – discipline. Traffic data on a section of six- lane divided highway are used to develop the fundamental relationship based on the 5 min speed, flow, and area-occupancy using the validated simulation model for a heterogeneous flow , considering traffic compositions and roadway conditions, simulation capacity value for different combination of standard car and one of the remaining four types of vehicle in the traffic stream , the result finally combine to proposed the generalized equation to determine mixed flow capacity, The present study was to carry out sensitivity analysis to characterize the effect of variation in percentage of Two wheeler and car in traffic stream on its capacity values, stream average speed and area occupancy value. To emphasize the dynamic nature of Passenger car unit (PCU) values for different categories of vehicles under heterogeneous traffic conditions at eight different volume-capacity (V/C) ratios. Thresholds the level of service based on volume to capacity ratio are established by using cluster analysis approach, and also for the counting effort to prepare an Indian Highway capacity

Keywords: VISSIM, capacity, mixed traffic area-occupancy, LoS, PCU, highway.

1. INTRODUCTION

The vehicle traffic on highways has increased substantially due to rapid growth in industrialization, population and economical activities in developed and developing countries. Increasing traffic demand is requiring for efficient traffic flow operation on highway facilities. Many developing nations are facing different levels of difficulties for provide efficient due to mixed nature of traffic. The vehicle operation characteristics vary from location to location with varying significant composition. several Four lane national highways in India is widened into Six lane or may me exceed multilane highway project are in progress so as to meet the requirement of higher traffic due to increasing the commercial vehicle on these highway. We should be more attention with traffic flow and capacity analysis on multi lane highway.

Rapid increase in mixed nature of traffic, poor lane discipline and traffic volume, prevailing highway, need a good considerate of data interpretation and traffic flow analysis. The roadway structure and operational analysis significantly depends on availability of traffic flow data from field. The period of time over which a traffic count data is recorded is an important consideration in assess in terms of traffic flow rate. Estimation of roadway capacity for different levels of problems under mixed traffic and poor lane discipline of drivers. Unrestricted mixing of various classes of vehicles makes the capacity, density analysis more complex as compared to homogeneous flow condition. Simulation of traffic flow has been a very effective tool for such problems. Field data in such situation are generally not suitable to study the variation of traffic volume and vehicle composition on stream speed and capacity.

Various traffic simulation programmes have been developed based on homogeneous traffic conditions in various countries. One such microscopic traffic simulation model is VISSIM software which was developed in Germany based on the continuous work of Wiedemann -99 on car following behaviour It has default values of standstill distance time headway and Following Variation evaluated for the type of traffic existing field condition in India and other developed countries. Traffic simulation models use stochastic processes to model traffic conditions given a set of geometry, traffic demand, vehicle routing, and driver behavior inputs. Examples of adjustable model parameters include driver lane changing aggressiveness, car following behavior, lane change gap acceptance, route choice, vehicle speed distributions, and vehicle acceleration distributions. A key component of simulation modeling is the calibration and validation stage of the model building process. Calibration is defined as the adjustment of computer simulation model parameters to accurately reflect prevailing conditions of the roadway network.

2. THE SIMULATION MODEL

Simulation technique is one of the renowned techniques to study traffic flow and its characteristics. Simulation gives us the advantage of being able to study how the created model behaves dynamically over time or after a certain span of time. A traffic characteristic on roads as a system varies with time and with a considerable amount of randomness and simultaneous interactions. The simulation model, followed in the present study is shown in the form of a flow chart in Figure 1. Data in the form of videos collected from the study site was analyzed and this information is used for building the simulation model in the software VISSIM. Then, the model was calibrated and validated for rendering it suitable for replicating the conditions at site. The validated simulation model then was used to simulate traffic over a wider range of traffic volume and traffic composition to estimate roadway capacity, level of service and to carry out sensitivity analysis for fulfilling the objectives of the present study. The validated base model can also be used to develop a simulated scenario which is desired to be known. The base model development involves the following steps:

- Study Stretch & Data Collection
- Defining Model Parameters
- Model calibration and validation

2.1 Study Stretch

The Delhi to Agra National highway No-19 is a 6-lane divided facility. A longitudinal section of 30 m length was made on the National highway (in one direction of traffic movement) using video recording of the section was done for 6 hours on a typical weekday on October 20, 2018. The study stretch was selected after conducted a reconnaissance survey to satisfy the following condition: (1) the stretch should be quite straight; (2) width of roadway should be uniform, the stretch is a three-lane divided road with 3.50 m wide central median. The main width of carriageway, with bituminous surfacing, for each of the two directions of traffic flow, is 10.5m. The overall roadway condition has also been depicted in the form of Google map in figure 2.

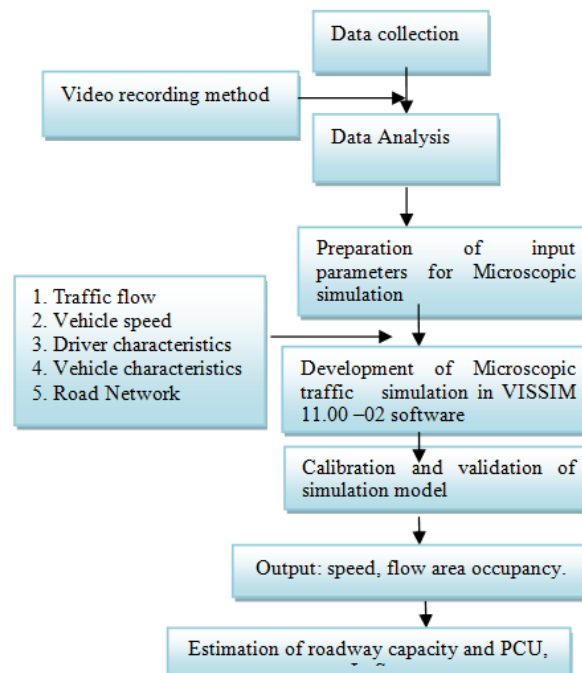


Figure 1. Simulation model methodology



Figure 2: Google image of a study- section on Delhi- Agra National Highway no. 19

2.2 Data Collection

The free flow speeds were asserted by observing one- hour vehicles in different categories of evening period. The traffic flow on the road was observed for one hours in the evening peak period from 4:15 to 5:15 h. this data was then used for the purpose for model calibration and validation. The video film was later replayed on a wide screen monitor in laboratory. A snapshot of the video-captured data is depicted in figure 3. The video was then analysed at the speed one- eighth of actual speed to enable recording and measurement data. The speed of a vehicle was determined by noting the time taken by the vehicle to cross the longitudinal trap of 30 m using a stop watch of 0.01 s accuracy. Speeds of individual categories of vehicles were analysed and the distribution profiles were created. The parameters such as mean, standard deviation and percentile Limits as estimated from the field data are given in Table 2. Speed of all vehicles included in the 5-min count was averaged to get the stream speed, and traffic volumes were converted into equivalent number of CS by making use of PCU values. Chandra and Kumar (2003) suggested using Equation -1 to calculate the PCU factor of a vehicle type

$$PCU_i = \frac{V_c/V_i}{A_c/A_i} \dots\dots\dots\text{Equation (1)}$$

Where, PCU_i = the PCU for the vehicle type i; V_c and V_i speed of standard car and i types vehicle respectively, A_c and A_i area of standard car and i types vehicle respectively. The traffic flow observed was 2031 veh/hr in peak hr. Observed traffic composition and dimensions based on the different categories of vehicle is shown in table 1.

Heterogeneous traffic condition on highway is more complex to traffic density. Use the area occupancy to analyze such characteristics of heterogeneous traffic, when the occupancy concept is applied to heterogeneous traffic, it is necessary to consider the area (length and width) of the detection zone and the area of vehicles as the bases. Hence, formulation (Equation -2) developed by Arasan and Dhivya (2010) was used for the purpose of estimating a surrogate measure, namely area occupancy in place of density of traffic

$$\text{Area occupancy} = \frac{a_i \sum_{t=0}^n (t_i)_{AO}}{AT} \dots\dots\dots\text{Equation. (2)}$$

Where: (t_i)_{AO} time during which the detection zone is occupied by vehicle i in s and the subscript AO stands for area occupancy, a_i is the area of the detection zone occupied by vehicle I during time t_i in square meters, A is the area of the whole of the road stretch in square meters, and T is the total observation period in s. the values of area occupancy were estimated using the travel times, individual vehicle category areas and total area of the detection zone along with the total time under consideration.

2.3 Defining model parameters

2.3.1 Vehicle model.

Vehicle model deals with defining the dimensions



Figure 3: A snapshot of the video-captured data is depicted

Table 1. Vehicle dimension and their proportion in traffic

Vehicle types	Length (m)	Width (m)	Projected area(m ²)	Proportion in traffic (%)
HV	10.5	2.5	26.5	18
CS	3.95	1.72	6.75	14
CB	4.8	1.85	8.88	10
3W	2.5	1.3	3.25	11
2W	1.8	0.8	1.08	47

Table 2. Speed parameters from field data

Vehicle types	Seed Parameters (Km/h)				Percentile Seed(Km/h)	
	Max.	Min.	Avg.	St. D	15 th	85 th
HV	74.2	27.51	48.32	12.72	33.85	65.3
CS	85.37	33.14	51.79	14.9	39.66	67.5
CB	94.32	37.11	54.14	14.74	41.02	74.8
3W	53.73	23.97	36.54	8.11	28.1	47
2W	78.54	25.2	46.15	11.82	34.4	56.4

(Length and width as shown in table 1.1), acceleration, lateral clearance value of each vehicle type is considered for the present simulation model as per the description given in (Table 1. and table 3.).

Table 3: Acceleration deceleration rate and lateral clearance of vehicle assigned to VISSIM

Vehicle Types	Acceleration (m/s ²)		Deceleration (m/s ²)		Lat. clear. share (m)	
	Max	Des.	Max.	Des.	Min.	Max.
HV	2.2	1.6	1.5	0.5	0.4	0.6
CS	2.7	1.3	1.8	1.2	0.3	0.4
CB	2.1	1.5	1.6	1	0.4	0.6
3W	1.1	0.9	1.1	0.8	0.3	0.4
2W	2.5	1.5	1.7	1.2	0.1	0.3

2.3.2 Desired speed distribution.

The desired speed distribution for each vehicle category was given as input for the simulation model in VISSIM. The max, mini, 15th & 85th %tile values of the speeds and distribution between these values were defined in the model for all types of vehicle. Curve for any vehicle category is generally an ‘S’ shaped curve

2.3.3 Vehicle composition and Vehicle Flow.

Vehicle composition and vehicle flow based on field observations is given as an input to simulation model for the given time interval.

2.3.4 Look-ahead distance

The minimum look-ahead distance for model calibration and validation, which defines the distance a vehicle can see forward in order to react to vehicles in front/to the side of it set to a value of 127 m, was found to be appropriate for the present situation. This value of 127 m was taken by Mathew and Radhakrishnan (2010).

2.3.5 Driving behaviour characteristics.

The driving behaviour characteristics mainly include these two features viz. car following behaviour and lateral distance. The psycho-physical driver behaviour based Wiedermann-99 Car-following model has been used for simulating the vehicle following behaviour. The car-following behaviour contains ten different driver related parameters ranging from CC0 to CC9 with their default values. The values of these parameters have been investigated in different scenarios by researchers and checked the sensitivity of these parameters on simulated results. The literature suggests that simulated results are highly sensitive to parameters namely, CC0 and CC1, CC2 (PTV VISSIM manual). The parameters of this car-following model including safety distance during standstill, minimum time headway and Following Variation CC2(Lownes and machemehl 2006) are given in table 4. For defining the lateral distance between the vehicles the location of the vehicle on a lane, minimum and maximum lateral distance for vehicle composition (puvvala et.al type is 2013) are shown in above table 3.

Table 4: Wiedermann- 99 cars- following model parameters

homogeneous vehicle types	Driving behaviour parameter			lat. clear shear (m)	
	CC0	CC1	CC2	Min	Max
HV	2.4	2	6.84	0.4	0.6
CB	1.5	0.9	6.84	0.4	0.6
CS	1.2	0.9	6.84	0.3	0.4
3W	1.5	0.9	4.42	0.3	0.4
2W	0.3	0.5	4.42	0.1	0.3

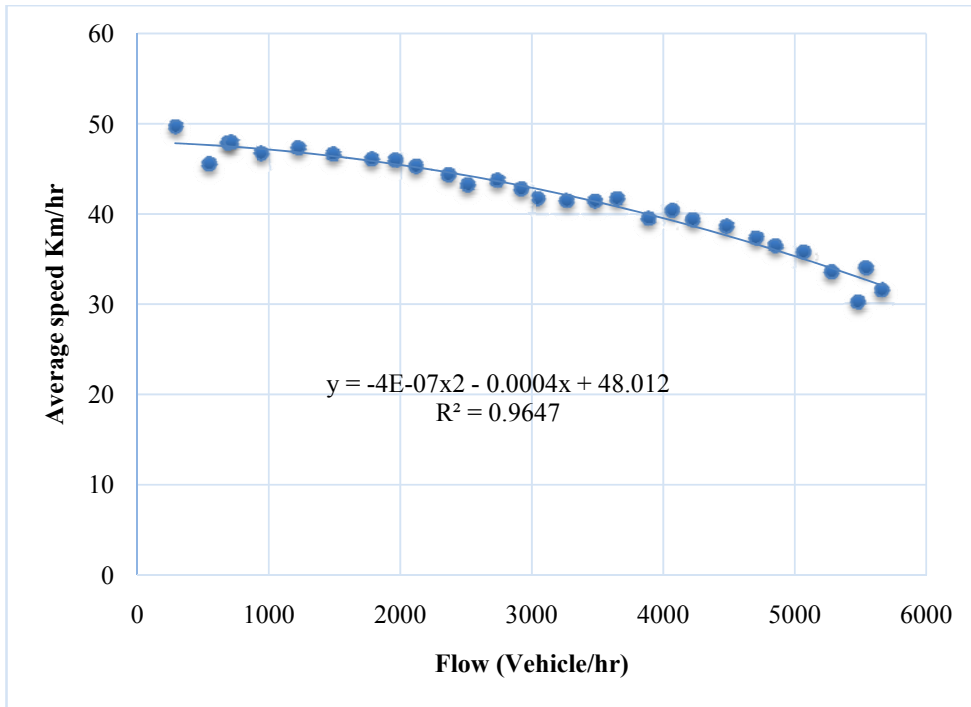
2.4 Model calibration and validation

The comparison of the model to reality is carried out by tests that require data on the system’s behaviour and the corresponding data produced by the model. The input data required for the above-mentioned heterogeneous traffic-flow model are related to four aspects, namely road geometrics, traffic characteristics, driver reaction time, and vehicle performance. The power of simulation as a tool for the study of traffic flow lies in ability of the model to include the effect of the random nature of traffic. Hence, the random variables associated with traffic flow such as free-flow speed distribution, are expressed as frequency distributions and input into the simulation model. These data, pertaining to one direction of traffic flow, were collected at a selected stretch of National Highway for model calibration and validation purposes.

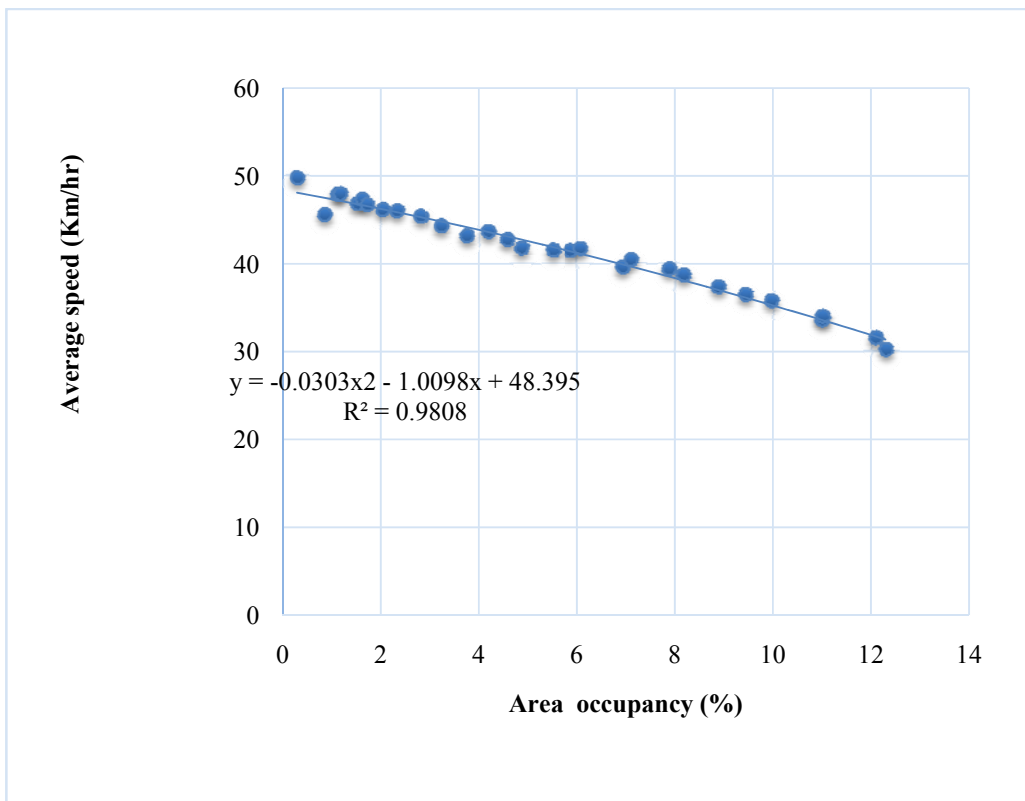
3. RESULTS AND DISCUSSIONS

3.1 Relationships between Speed-flow-Area Occupancy and generalised mixed flow capacity Equation.

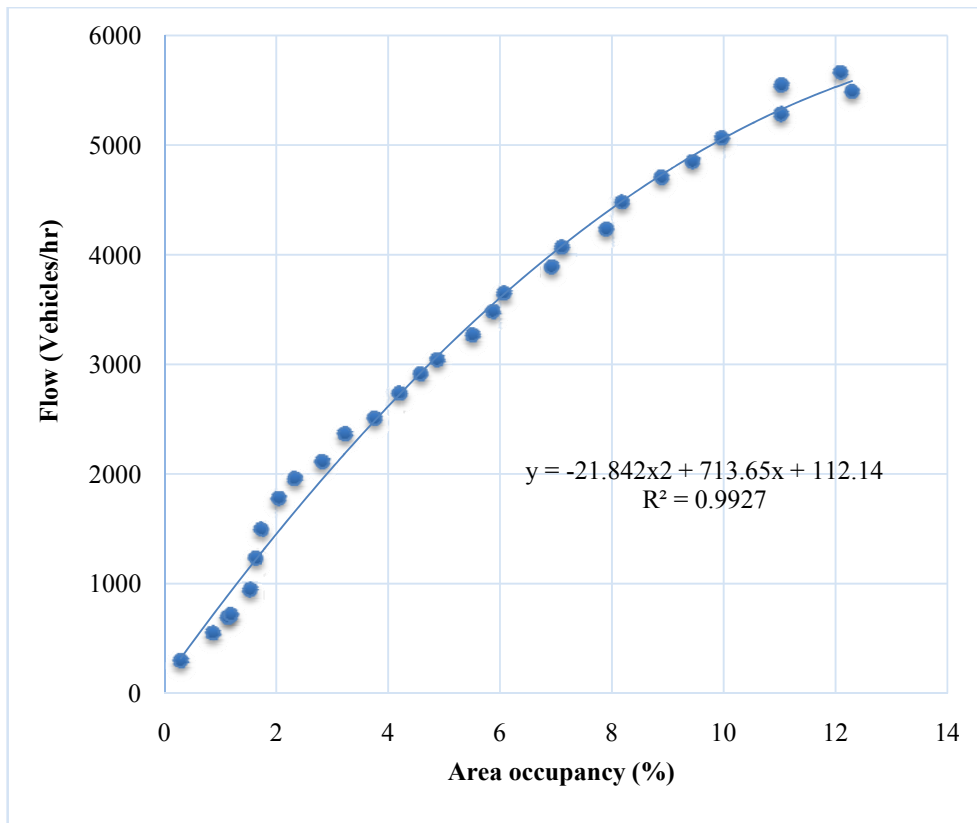
Fundamental relationships and capacity one of the basic studies in traffic-flow research is to examine the relationships between speed– flow–area-occupancy relationships were developed using the validated simulation model for a heterogeneous flow, as shown in figure 4.



a-Speed –flow (5min interval)



b-Speed- Area occupancy (5-min interval)



c-Flow- Area occupancy (5-min interval)

Figure 4. Plots for fundamental relationship for observed traffic composition

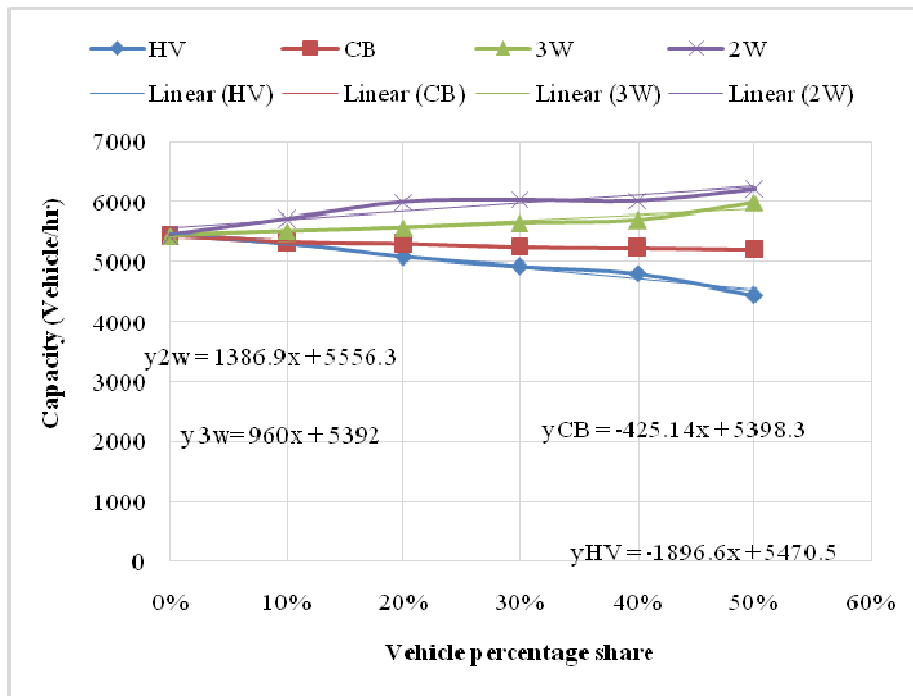


Figure 5. Capacity of Six-Lane Highway with varying two vehicle category proportion

Combined the generate linear equation to find out to generate the mixed traffic capacity equation of the highway for a situation when all the five categories of vehicles are present simultaneously. It is given by Eq. (3).

$$C_{mix} = 5436 + 1387P_{2W} + 960P_{3W} - 425P_{CB} - 1897P_{HV}$$

.....Equation (3)

3.2 Level of service

Based on speed flow data points, the threshold values for different Level of service (LoS) With respect to are derived using the K- mean clustering techniques.

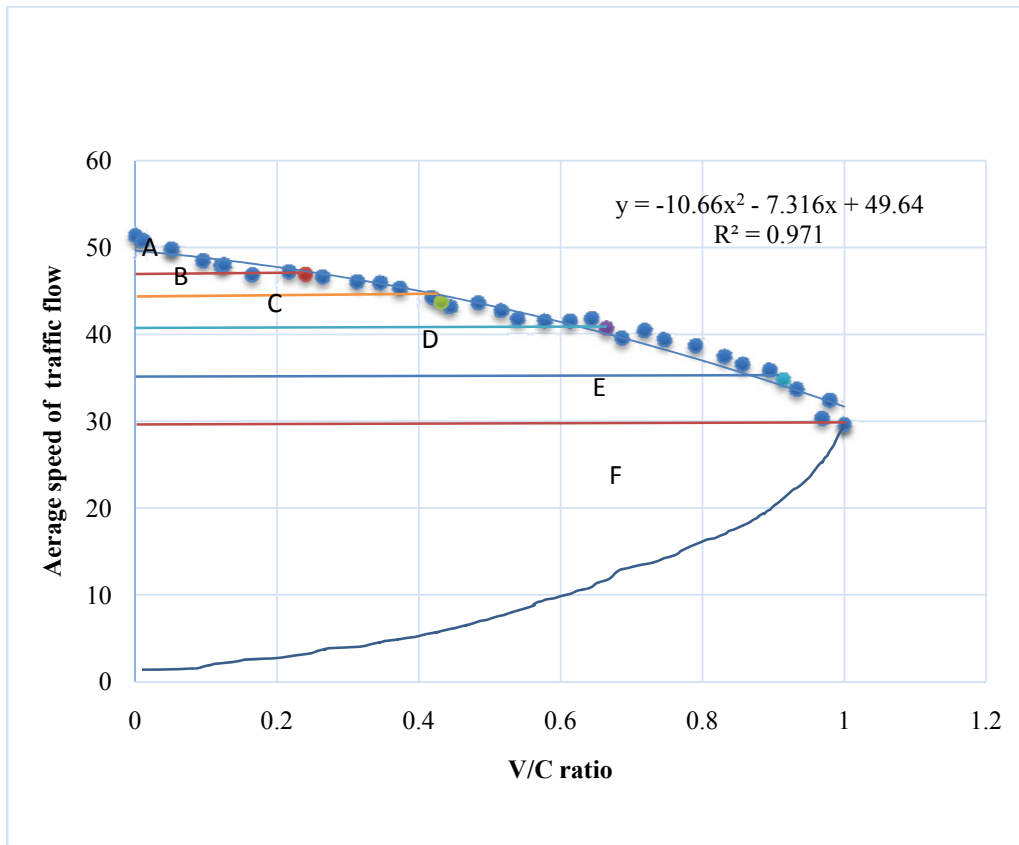


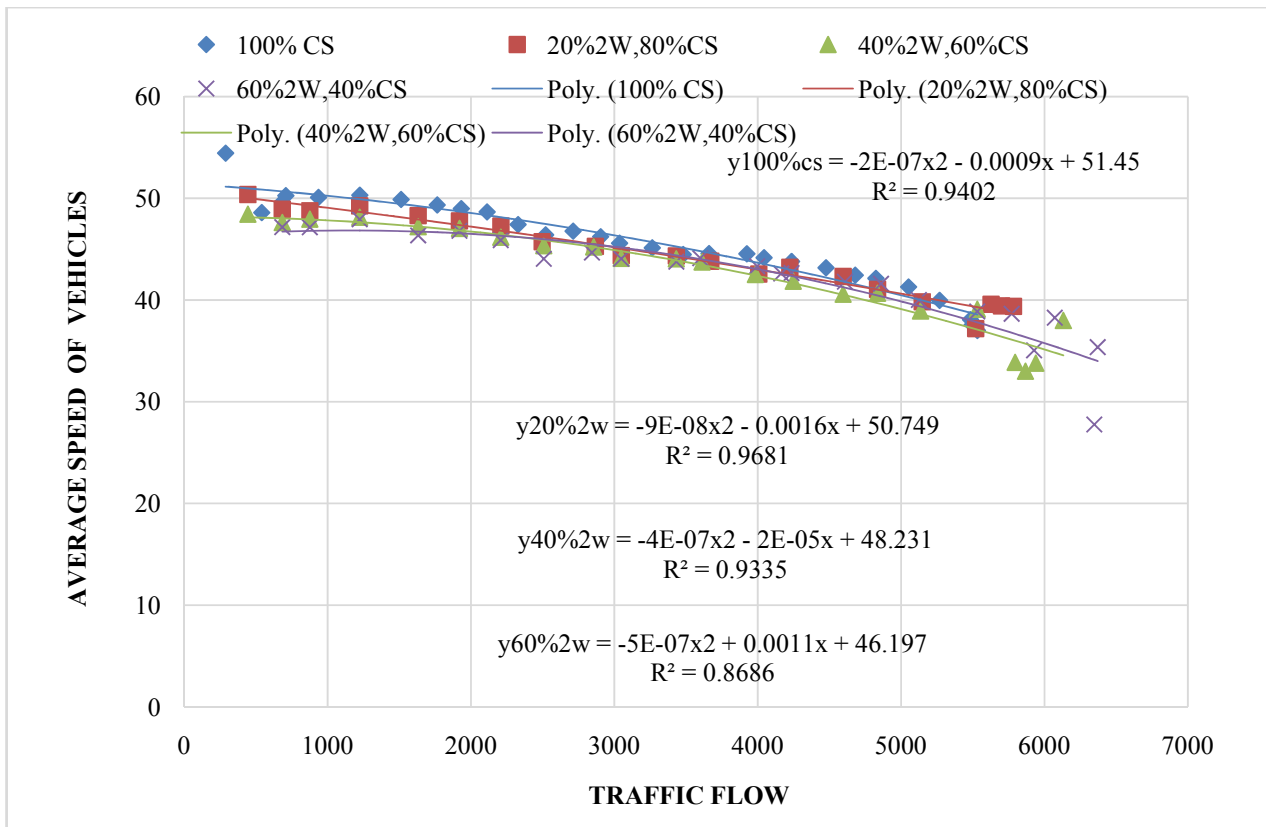
Figure 6. Level of Service Threshold values based on V/C

Table 5: LoS threshold using K-mean clustering technique

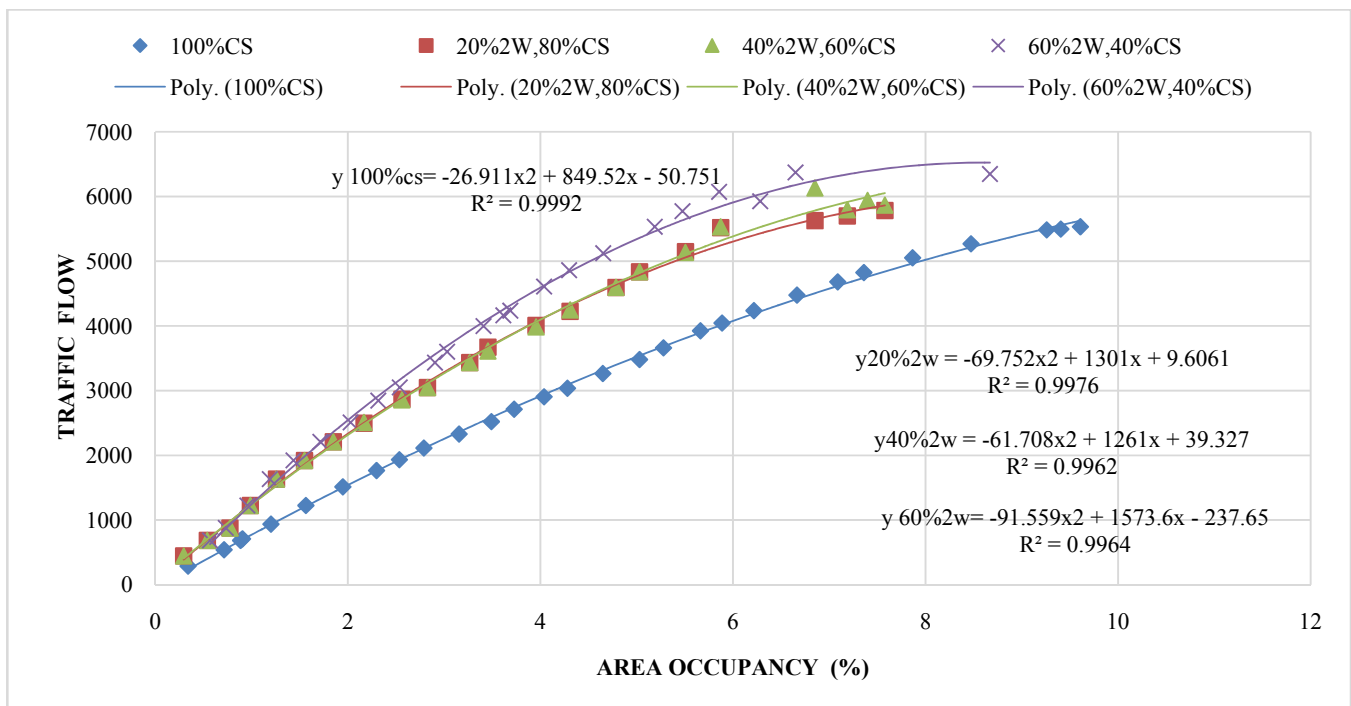
Level of service	range of V/C ratio
A	<0.239
B	0.239-0.430
C	0.430-0.665
D	0.665-0.913
E	0.913-1.000
F	>1

3.3 Effect of composition on capacity and fundamental relationship

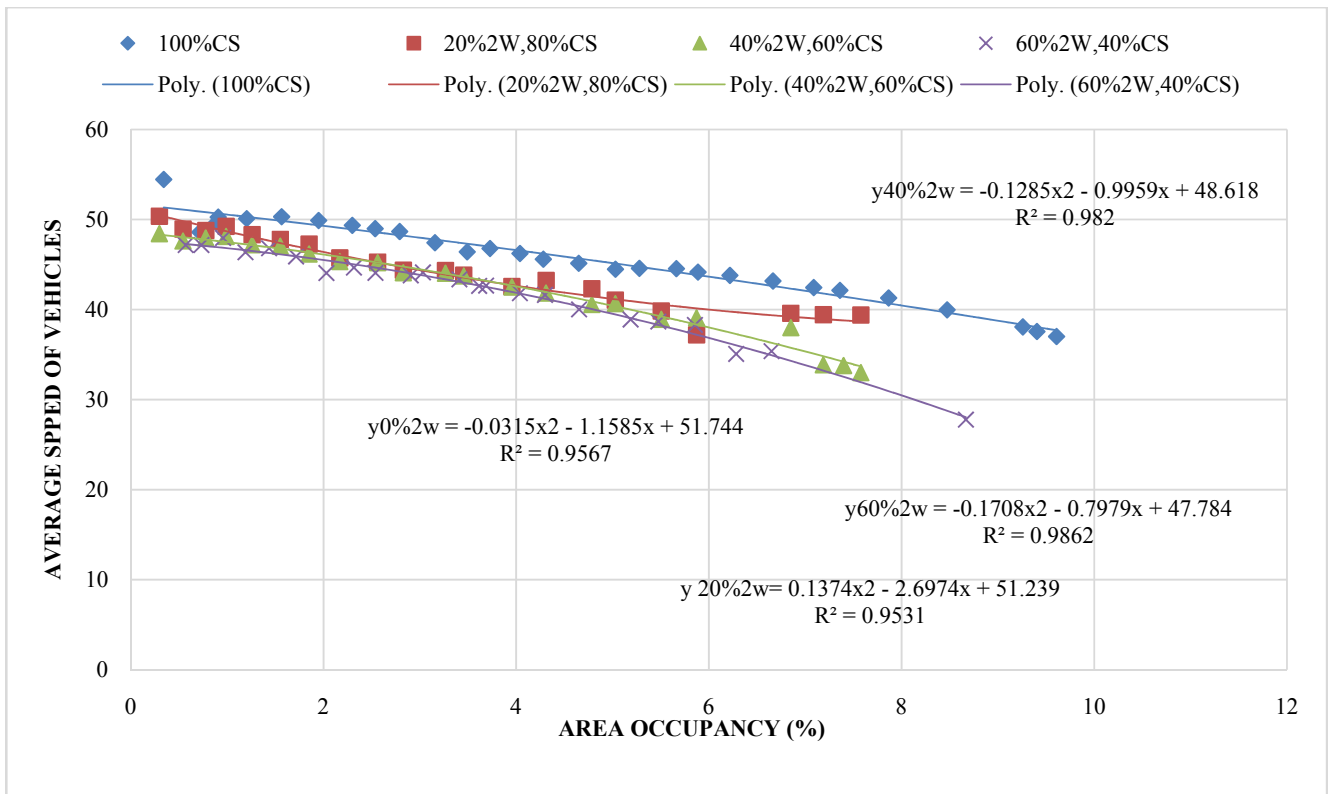
Proportional variation in the 2W and Cars on the highway capacity and generate the fundamental relationship are shown in figure 7



(a) Speed-Flow Relationship



(b) Flow- Area occupancy Relationship



(c) Speed- Area Occupancy relationship

Figure: 7. Effect of traffic composition on traffic- Flow Parameter

3.3 Effect of variation in V/C ratio on PCU values

PCU values for different categories of vehicles under heterogeneous traffic conditions at eight different volume-capacity (V/C) ratios viz. 0.125, 0.250, 0.375, 0.500, 0.625, 0.750, 0.875 and 1.000 were estimated using simulation as given in table 6.

Table 6. PCU Estimate of different vehicles at a different V/C ratio

V/C	HV	CB	2W	3W
0.125	4.275	1.222	0.185	0.687
0.25	4.23	1.202	0.182	0.681
0.375	4.145	1.195	0.177	0.647
0.5	4.186	1.183	0.176	0.638
0.625	4.083	1.173	0.17	0.611
0.75	4.02	1.166	0.167	0.568
0.875	4.019	1.156	0.16	0.546
1	3.965	1.147	0.166	0.505

4. CONCLUSIONS

Following conclusion can be drawn out of this paper:

The present study is focused on modeling of traffic flow using extracted traffic-flow video-captured data for two-peak hours on a basic section of national highway. It is further planned to collect more traffic data over a wider range of traffic flows and check the validity of the model. Although the results of the present study are applicable only for the basic sections of highway in India,

The results and overall methodology followed of modeling traffic flow on highway along with the capacity values for varying traffic compositions. From the speed-volume-area occupancy curve developed using the simulation model; it is found that, for the observed traffic composition, capacity of six-lane highway 5664veh/hr for one direction of traffic flow. These relationships may be quite useful for planning, design, and management of roadway facilities. In addition, these relationships may be quite useful keeping in view the absence of reasonably accurate roadway capacity values related guidelines for Highway.

The present study is focus on variation in traffic composition at any section of highway. We cannot measure traffic volume every time .generalised equation is very useful for to find out traffic capacity at heterogeneous flow

Under mixed traffic conditions, on Highways, the variation in % of 2W and car in the traffic composition of a stream, 2 W composition increase from 0 to 60 % , fundamental relationship are varying according to vehicle composition. So we can predict future traffic volume at any section of national highway the variation at traffics volume increase in (veh/hr) comprising only two vehicle categories: cars and 2W.

Under heterogeneous traffic conditions, the trend of variation of the PCU value, over traffic volume, indicates that the PCU value for the all vehicle category decreases as V/C ratio increases. As compared to CS are found to be relatively same under congested regime as compared to their PCU values near capacity.

Thresholds the level of service based on volume to capacity ratio are established by using cluster analysis approach, and also for the counting effort to prepare an Indian Highway capacity manual.

All the affordable results can be considered as an attempt toward a national level effort for carrying out studies in connection with continuing efforts of preparing Indian Highway Capacity Manual.

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