

Forecasting of Traffic Simulation Model Under Heterogeneous Traffic Condition

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Abstract- Road Transport in India is an extremely extensive system, it involves different categories of vehicles like motorize and non-motorized vehicles, animal or human powered vehicles. India has 159.5 million vehicles at present and 16.7 million vehicles added every year. Traffic volume on Indian road increase at a Compound Annual Growth Rate of 10.5% per annum. This paper focuses on traffic forecasting on a multilane highway in India and development of simulation model to study the speed-flow relationship. For this purpose, a strip based approach method is used. A section of 50-meter length was marked as study stretch on National highway-06 (Nagpur to Amravati). A video recording of this study stretch was done for morning and evening normal weekdays. Traffic volume, space mean speed, vehicle category, vehicle frequency etc were extracted from the video. A speed-flow relation established to evaluate capacity. All the traffic data obtain from the field are put in the simulation model VISSIM. The simulated speed-flow curve is then correlated with the field speed-flow curve. It was found that simulated capacity 3688 PCU/hr/dir and field capacity 3733 PCU/hr/dir. A general equation is established for prediction of traffic volume at National Highway-06 by using previous traffic data. Also, a relationship between capacity and width of the carriageway is obtained follow the second-degree curve.

Key Words: Simulation Model, Forecasting, Capacity, Heterogeneous Traffic, Traffic volume, Speed-Flow Equations.

1.INTRODUCTION

The rapid growth of urban area results in an increase in road transportation. The interconnection between two

cities is carried out by the multilane highway on which the vehicle population is increasing day by day. Due to increase in vehicle population, the congestion is also increasing near the vicinity of the city area. The increase in traffic demand wishes a proficient traffic flow and highway facilities. To avoid congestion we required a proper and channelized traffic. This can be achieved by developing a microscopic model by using various computer programming. The computer program will analyze the data and simulate the traffic whenever required. Computer simulation model is superior favorable to analyze and study the several traffic characteristics in traffic stream (Partha Pritam Dey,2008). They are much economic, efficient, and flexible in the traffic stream. The observation, analysis, measure, and probe which are impossible in the field they can also be performed by using simulation model for the roadway. In recent years due to substantial growth rate, the traffic volume is increased and it will more increase in future, due to that, mix traffic congestion occurs on a highway in the countries. Mix traffic is one of the major problem facing the developing countries and they are unable to provide efficient vehicular traffic operations on the highway. India has mix traffic condition where motorize and non-motorized traffic ply on the highway. Traffic in India is extremely heterogeneous having a wide variety of vehicles of various physical dimension, weight, and dynamic characteristics. The vehicle class in India are categories as Car, Bus, Two-wheeler, Three-wheeler, Light Commercial Vehicle (LCV), Multi-Axle Vehicle (MAV), Truck, Bicycle, Tri-Cycle, Auto rickshaw, Animal cart (Tamtam, Pithu, Bullock-Cart), Human powered vehicles etc. All these classes of vehicle share the same road while traveling. The speed of the different vehicles varies from 10km/h to 110 km/h. As the speed varies and physical dimension varies, it becomes too difficult for the vehicle to follow the traffic lane or travel in the same lane. Whenever they get the space in traffic stream they tend to take that place along the width of the carriageway. In

such traffic condition, it is difficult to measure actual traffic on the road. The issue of measuring traffic volume in such condition is overcome by converting the traffic as passenger car unit. For measuring the traffic volume, the above mention unit is used. The passenger car unit value is derived by selecting the passenger car as standard vehicles. There are several highway manual in which guideline for highway capacity is given. But in these manual capacity estimation given are on the basis of fixed and regular PCU values of different vehicles type and these estimations are belongs to level road. However even on a level road the PCU values of vehicles changes (V.Thamizh Arasan,2010). Hence, estimation of passenger car unit values of various vehicle class in traffic stream at highway is immensely necessary for design, analysis, planning, operation, regulation and control of traffic on the highway. The road transport system in India is a lack of lane discipline and absence of operation and management experience. Lane discipline plays an important role in roadway capacity. To calculate the roadway capacity of any highway is the biggest censorious issue in highway planning and management. Developing countries like India, the traffic stream has diversity and a wide range of varies traffic. Also, the rapid increase in commercial vehicles and cars on Indian highway, a plenty of two-lane highways have been widening into a four-lane highway. Under National Highway Authority of India, to fulfill the wish of better and free-flow of traffic. Traffic forecasting is the approach of reckoning the no of vehicle or people which are likely to use various transportation amenity in future. For example, a forecast may predict the number of vehicles on highway or bridges, number of ridership on a metro line or railway, number of a passenger arriving and leaving at an airport or it may predict the expected future traffic level for the nation. The forecast is extremely needed in all the areas where the development has to be done. For planning, implementation and development of any transportation system, it is extremely important to know the future traffic flow as they also help in operation, management, and control of traffic. Structure design and geometric design of highway or bridge are principally based on forecast traffic volume and equivalent single axle load. In the present study, the main aim is to forecast the traffic by using previous traffic data and develop a relationship between speed-flow curve.

2. LITERATURE SURVEY

It has been perceiving that simulation modeling is an immensely suitable tool for the design and improvement of the urban freeway system. Before implementation of the simulation model, it facilitates the engineer to vaticinate the outcome of an intent change to the freeway or highway system and asspraise the attribute

of attempt designs (Adolf May 2004). Satish Chandra,(2004) introduce a systematic procedure for evaluation of the capacity of the road under heterogeneous condition based on adjustment factor of lane width, shoulder width, gradient, traffic composition, slow moving vehicles, directional split, pavement surface condition etc. He found that the upgrade gradient decreases the capacity by 2.62 percent and downward gradient increases the capacity by 3.08 percent. In the case of lane width and carriageway width the capacity of road increase with an increase in carriageway width. For slow moving vehicles, the capacity increases with a decrease in the percentage of slow moving vehicles. when the shoulder is in bad condition the capacity automatically reduce. And also, the free-flow speed and capacity decrease with increase in road roughness. Satish Chandra et. al,(2003) gave a new concept for evaluation of pcu values of various vehicles for heterogeneous traffic condition. In this concept, the PCU values find out by using the speed of the vehicles and projected area of vehicles in the traffic stream. He observed that the PCU values of vehicles and capacity increases with increase in width of the carriageway and their relationship are obtained a second-degree curve. Partha Pritam Dey et. al, (2008) studies the impact of the vehicle on the capacity of road and speed. For this, he collected traffic data at the various location of two-lane road in India. He concludes that the capacity decrease when the percentage of heavy vehicles, 3-wheeler, and an increase in the traffic stream. However the capacity increase with an increase in the proportion of two-wheeler. V.Thamizh Arasan et. al, (2010) has done an extensive research on evaluation of passenger car unit value for various vehicles in mix traffic condition and no lane discipline on Indian road using microscopic simulation. In his extensive research study, he found that the PCU values of vehicles differ with differing in traffic volume and width of the road. Errampalli Madhu et. al,(2011) develop a simulation model using PARAMICS simulation computer software in order to study the speed-flow equation of different vehicles on the eight-lane expressway. And from his study he observed that the capacity of eight-lane expressway under no virtual lane condition reduced by 15 per cent. Modeling of traffic flow is currently of great interest in too many transportation professionals due to a rapid increase in vehicle population at the highway. Manraj Singh Bains et. al,(2012) model the traffic flow on Indian expressway to estimate the capacity of the expressway also, observe the consequences of the configuration of traffic on passenger car unit. Pan Liu et. al,(2012) gave a procedure for model U-turn movement at unsignalized intersection by using VISSIM simulation software. For calibration and validation of the model, a genetic algorithm was purposed by him. Calibration is the process in which the

parameters of the simulation model are so adjusted so that the simulation model response same with the measured field condition. Siddharth S.MP et. al,(2013) present a method for sensitive analysis and automatic calibration of VISSIM by using traffic data. ANOVA and elementary method are used for sensitive analysis. There are different studies in which many authors compare the performance of VISSIM software with another computer program and VISSIM is recognize as the best result among them. Arpan Mehar et. al,(2013) presented the applicability of simulation software VISSIM for determination of the capacity of highway under heterogeneous traffic condition. And he observed that VISSIM overestimates the capacity and speed of highway in its original form. But after modification of driver behavior parameters CCO and CC1 the simulated capacity and field capacity almost same. Yadav Anamika et. al,(2014) estimates the capacity of multilane interurban highway in India. He also develops a speed-flow relationship of different vehicle category in order to estimate the capacity of the roadway.

3. DESCRIPTION OF SITE AND GEOMETRIC INFORMATION

The test site for the study is four-lane divided National Highway (Nagpur-Amravati NH-06) in India is selected. A longitudinal stretch of 50 meters is marked on the carriageway of the highway. A video recording of this section is done for morning, evening, and off-peak hour of normal weekdays. Traffic data is then extracted from the video for 5-minute interval and composition. All the vehicles are classified into seven categories namely Car, Bus, Two-Wheeler, Three-Wheeler, LCV, MAV, Truck. Physical dimensions of vehicles and their proportion at highway is shown in table-A-1. The speed of the vehicles in traffic stream is determined by using speed-distance formula at the highway and also, using a stop watch having accuracy 0.01 second. The speed of the different vehicles is shown in table-A-2. Vehicle characteristics at different carriageway shown in table A-3. The PCU values of a vehicles change from vehicle to vehicle and it affects the capacity of the road. In order to know the effect of lane width or carriageway width on the capacity of the road, the capacity of a two-lane road with different carriageway are collected shown in Table.A-4. and Table.A-5. The capacity of road and carriageway are plotted shown in Fig.1.0. From the graph it was found that the relationship between width

of the carriageway and capacity of road is followed by second-degree curve, given bellows:-

$$C = -843.4w^2 + 1526w - 61926 \dots\dots(A)$$

$$R^2 = 0.996$$

Relation (A) can be used to find out the capacity of the roadway. Vehicle composition obtains from the field are shown in Fig.1.1

Table.A-1. Physical dimensions of vehicles and their percentage

Traffic Category	Length of vehicle s (m)	Width of Vehicle s (m)	Projected area of Vehicles(m 2)	Percentage of Various Traffic in Traffic Stream.
Car	3.6	1.4	5.04	33.08%
2-Wheeler	1.8	0.6	1.2	7.81%
3-Wheeler	3.2	1.4	4.4	3.59%
Bus	11.4	2.5	28.5	13.26%
LCV	6	1.9	11.4	13.32%
MAV	13.7	2.5	34.25	12.15%
TRUCK	13.6	2.42	32.91	19.83%

Table.A-4. Detail of Carriageway width at a different section.

Section	Highway	Width of the Carriageway (m)	Type of Shoulder (m)	
			Paved Shoulder(m)	Earthen Shoulder(m)
1	NH-06	7.2	0.5	1.5
2	NH-07	7	0.5	1.5
3	MSH-260	7.8	0.5	1.2
4	MSH-255	6.8	0.5	1.2

Table.A-5. Capacity of various road with different carriageway.

Highway	Carriageway width (m)	Capacity(Pcu/h)
MSH-260	7.8	5821
NH-06	7.2	4182
NH-07	7	3688
MSH-255	6.8	2826

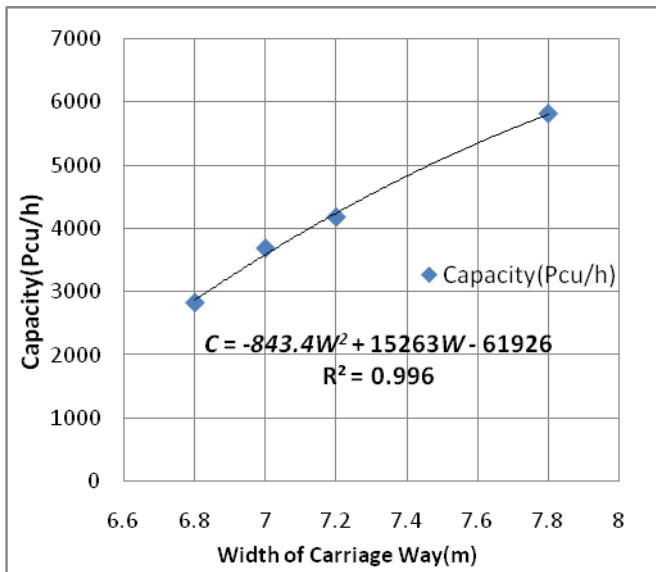


Fig 1.0 Variation of Capacity of the road with respect to the width of the carriageway

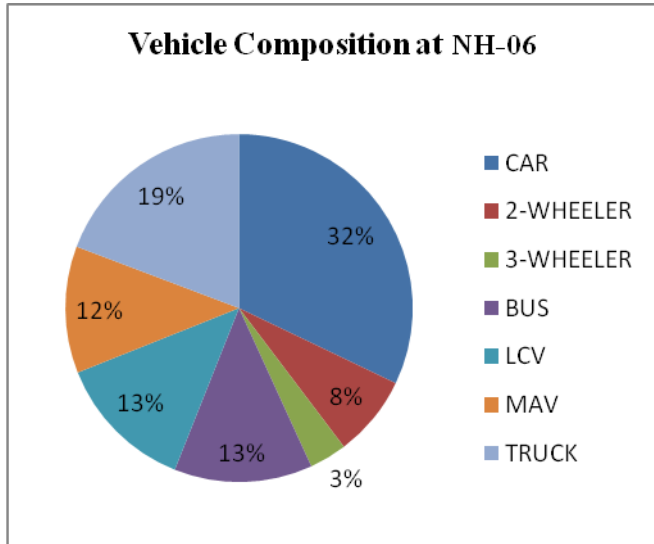


Fig 1.1 Vehicle Composition at NH-06.

4. DEVELOPMENT OF SPEED-FLOW RELATION.

Traffic data are extracted from the video for a 5-minute interval of each vehicle. As we know the capacity and flow are generally measure in terms of passenger car per

hour. Therefore, obtain a number of vehicles are converted into passenger car unit. There are many methods for estimation of passenger car unit of vehicles but all these methods do not use dynamic PCU (Chandra et.al 1997). There are many highway manuals in which guideline for highway capacity is given. But in these manual capacity estimation given are on the basis of fixed PCU values of different vehicles type and these estimations are belongs to level road. However even on a level road the PCU values of vehicles changes (V.Thamizh Arasan,2010). Satish Chandra and Upendra Kumar (2003) gave an equation for estimation of passenger car unit (PCU) of different vehicles and the same equation is used in the present study to find out the Passenger car unit values.

$$PCU_i = \frac{V_c}{V_i} \frac{A_c}{A_i} \dots (B)$$

The curve obtains from the field is shown in Fig. 1.2 The field capacity is 3688 pcu/hr/dir or 1844 pcu/hr/lane.

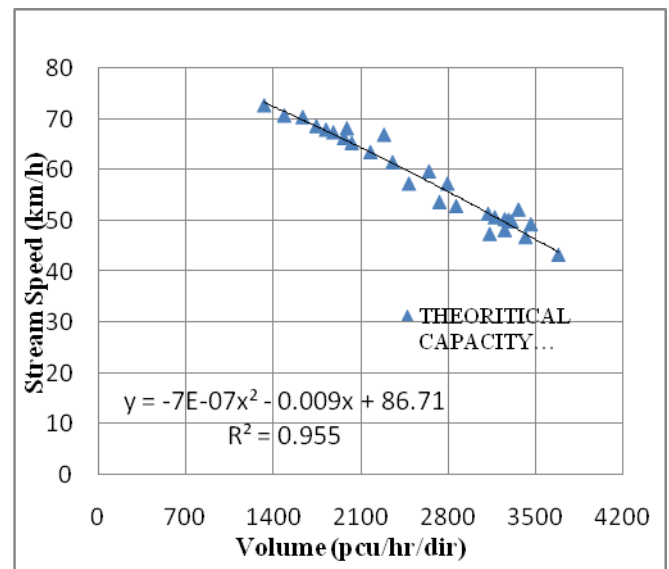


Fig1.2 Speed-Flow curve obtains from field data.

5. SIMULATION MODEL DEVELOPMENT USING VISSIM

Vissim is the microscopic traffic simulation software based on driver behavior for modeling of traffic. It has defaults values of some assertive parameter. It works on

driver behavior characteristics There are ten different drivers related parameter CC0 to CC9. Out of which CC0 and CC1 are the highly sensitive parameter and other parameter and CC2 to CC9 have a negligible impact on the capacity of the road (Gomes et. al,2004). Table.A-6. Shows the calibrated values for different driver behavior. Filed data are simulated by using the simulation model which is prepared in computer simulation software vissim 7.0 after modification of some parameter in order to behave heterogeneous traffic. The procedure for model preparation is given in Fig.1.3.

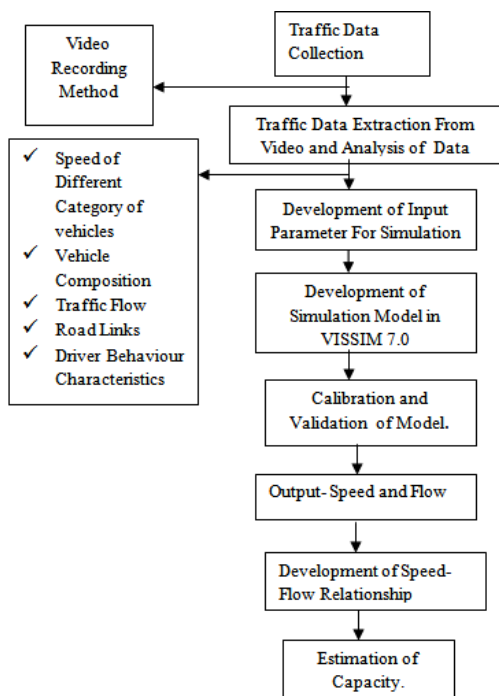


Fig.1.3 Methodology for simulation model preparation

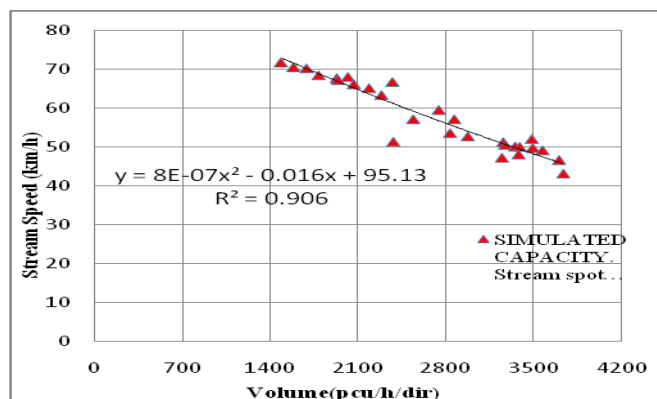


Fig 1.4. Simulated speed-flow curve after calibration.

6. COMPARISON OF THEORETICAL AND SIMULATED SPEED-FLOW CURVE

A link of 1km stretch and two lanes of 3.5m width was created in Vissim. A travel time section of 50 m was marked at a distance of about 650 m from the vehicle input. Field input was assign to the link. The lateral and overtaking of driver behavior are modifies in order to behave same as in fields. Fig 1.5 Shows the Comparison of Theoretical and Simulated Speed-Flow Curve.

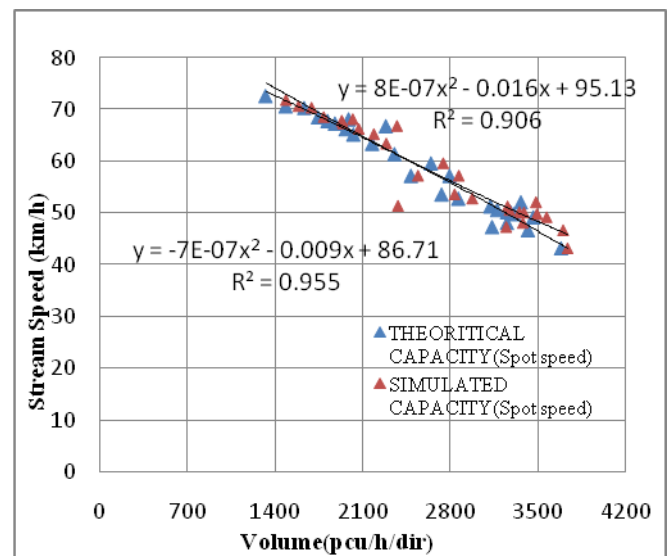


Fig.1.5. Comparison of Theoretical and Simulated Speed-Flow Curve

7. FORECASTING OF TRAFFIC DEMAND AT NH-06

Traffic forecasting is the approach of reckoning the no of vehicle or people which are likely to use various transportation amenity in future. Previous five-year traffic data are collected for NH-06 (Nagpur-Amravati) from National Highway Authority of India. And each category of vehicles is plotted against year, to examine the growth rate of the vehicle per year. Fig.1.5 to 1.9 shows the variation of the vehicle at NH-06. An equation is generated for each category of vehicles in order to find out the total number of vehicles increasing each year. And it was found that the relationship between years and number of vehicles follows the second-degree curve shown in Fig 1.5 to Fig 1.9.

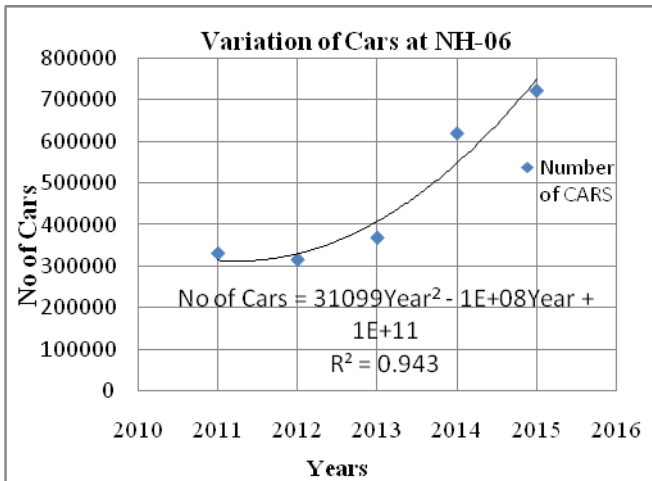


Fig.1.5. Shows the Variation of Total Number of Cars at NH-06

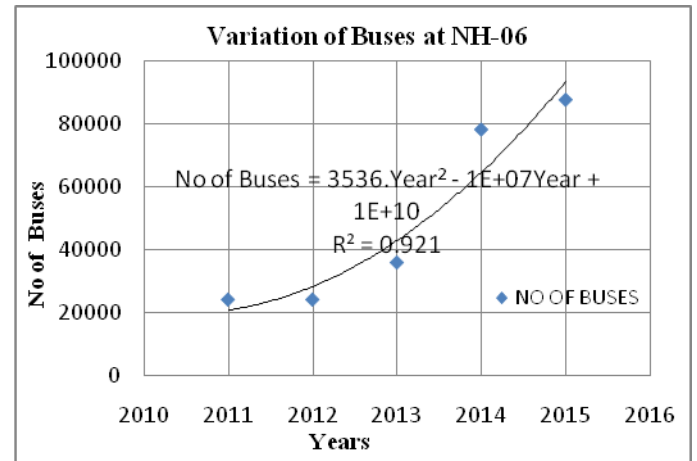


Fig.1.7. Shows the Variation of Total Number of buses at NH-06.

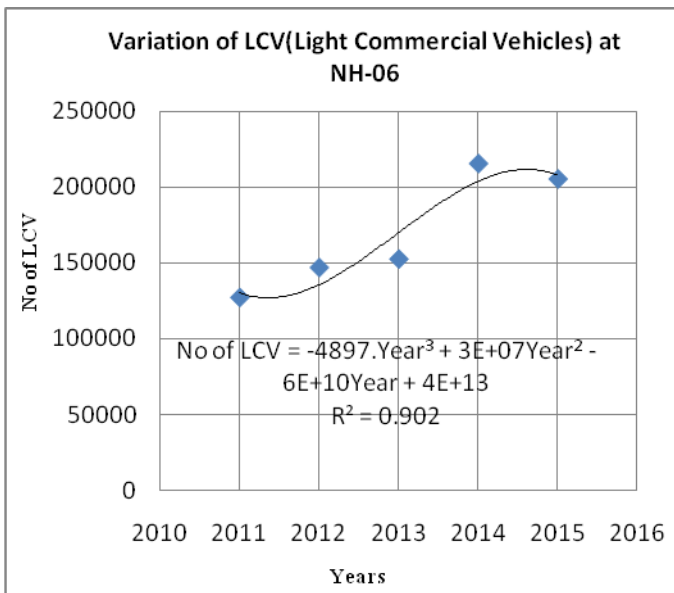


Fig.1.6. Shows the Variation of Total Number of LCV at NH-06.

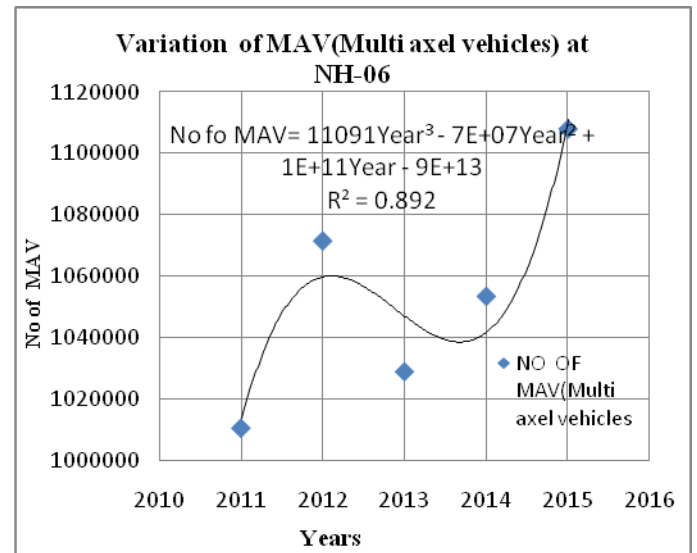


Fig.1.8. Shows the Variation of Total Number of MAV at NH-06.

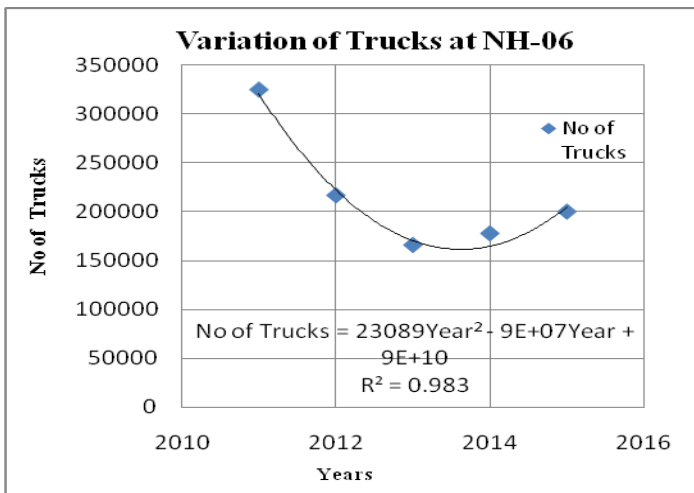


Fig.1.9. Shows the Variation of Total Number of Truck at NH-06.

After plotting each category of vehicles, it was found that the number of Cars, LCV, and Buses are increasing with respect to a year while a number of Trucks and MAV, there is sudden decrease and then increase. They do not linearly vary due to traffic condition. So in order to find out the total percentage of traffic growth on NH-06 (Nagpur-Amravati), we need to plot all vehicles in one graph against years. Fig.10. Shows the Variation of Total Number of Vehicles at NH-06 during 2011-2015. A general equation is established from the relationship of no of vehicles and years (Fig.10.) for prediction of future traffic at NH-06. By using this relation, a total number of vehicles till 2030 is carried out which is shown in Fig.10.1.

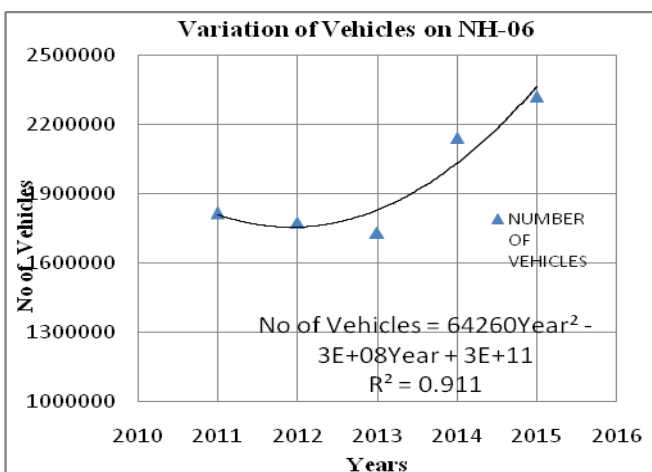


Fig.10. Shows the Variation of Total Number of Vehicles at NH-06 during 2011-2015.

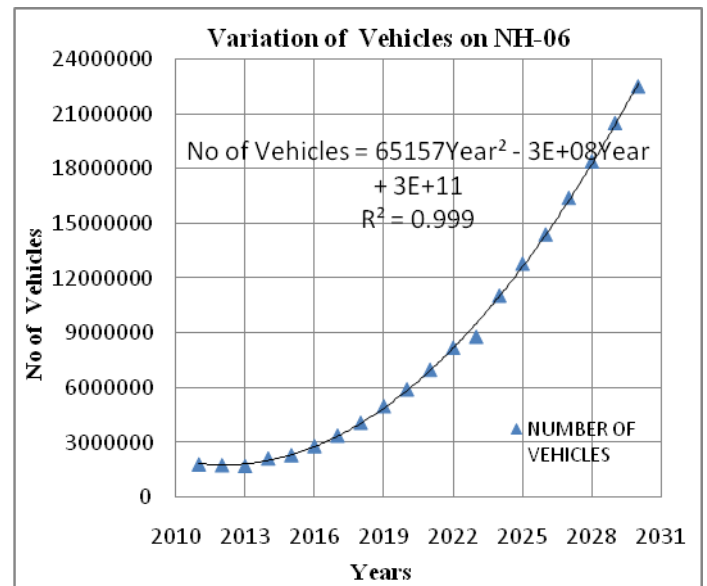


Fig.10.1 Shows the Total Number of Vehicles at NH-06 till 2030.

After getting the total number of vehicles at NH-06 (Nagpur-Amravati), now for finding traffic volume and capacity we need to convert the number of the vehicle into PCU values because flow and capacity of the road are always measured in pcu/hr. The average speed of vehicles is assumed for the future model. All these filed values are used as an input for the development of simulation model. Fig10.2. Shows the simulated traffic volume at NH-06. simulated capacity obtains from a speed-flow relationship is 6237 PCU/h/Lane.

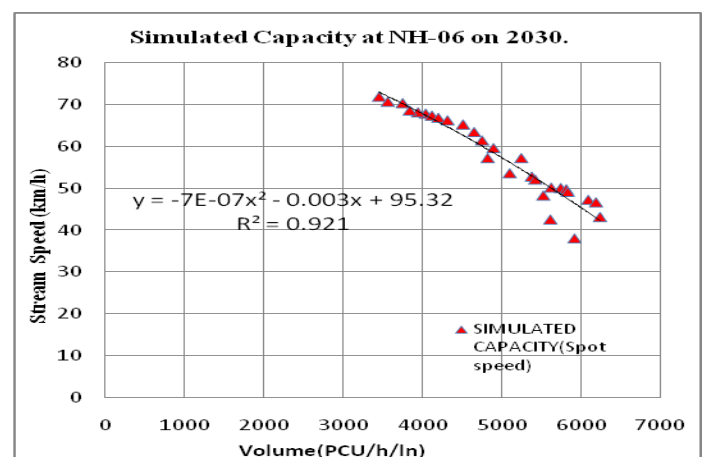


Fig10.2. Shows the simulated traffic volume at NH-06.

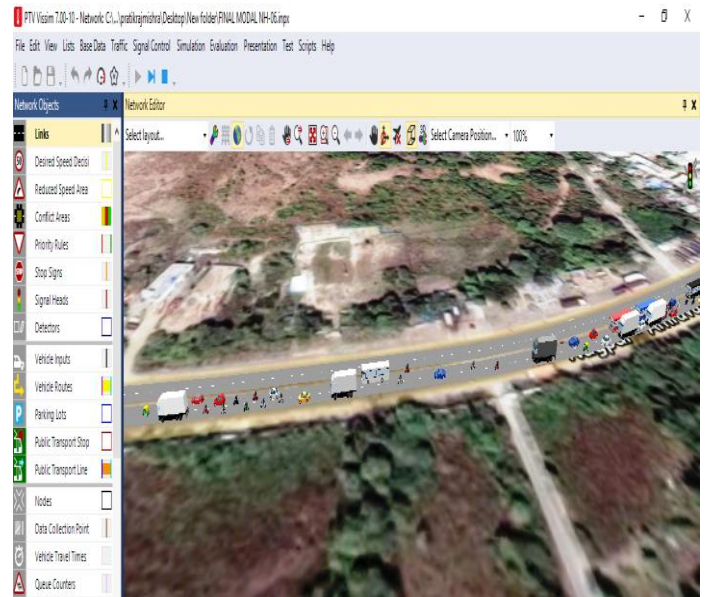
8. CALIBRATION AND VALIDATION OF VISSIM MODEL

Calibration is the process in which the parameters of the simulation model are so adjusted so that the simulation model response same with the measured field condition. The adjustment parameter is desire speed distribution, vehicles classes, and composition, acceleration, and deceleration of different vehicles, minimum lateral distance, minimum safety distance, driver behavior characteristics (car following behavior and lateral distance) etc. For the development of simulation model in vissim 7.0 Wiedeman 99 cars following model is used. Also, as mention earlier CC0 and CC1 are the highly sensitive parameter and CC2 to CC9 have a negligible impact on the capacity of the road (Gomes et. al,2004). Calibrated values for different driving behavior (CC0 and CC1) are shown in Table.A-6. With these calibrated values, the simulation program was run for 3600 seconds. Before starting the simulation, the model was run for 600 seconds for warm up the simulation program in order to get an accurate result.

Table.A-6. Calibrated Values for different driving behavior

Driving Behaviour in VISSIM	Assigned Vehicles Class	Calibrated values (Mehtar,2013)	
		CC0(m)	CC1(s)
Car	Car	1.5	1.0
Two-Wheeler	Two-Wheeler	0.3	0.3
Three-Wheeler	Three-Wheeler	1.5	0.9
Heavy Vehicles(HV)	LCV, HCV, MAV ,BUS, Tractor.	2.4	1.4

Validation is the process of checking output receive from the calibrated simulation model in term of simulated values against the field values (Manraj Singh Bains et.al, 2012). Vehicle Composition, Speed and Traffic Volume is assigned to the simulation model and simulation run was performed for 3600 seconds excluding 600 seconds for warm-up the model in order to get accurate results. Fig.(2a). Shows the snap short of a simulation model of four-lane divided highway.



(2a). Shows the snap short of simulation model of four-lane divided Highway

The output of simulation model (speed-flow) is used to develop a speed-flow curve for evaluation of the capacity of the highway. Developed simulation curve and obtain field curve are shown in Fig.1.4. Simulation Capacity of National Highway-06 is 3733 PCU/h/dr or 1866 PCU/h/Lane and Field capacity is 3688 PCU/h/dr or 1844 PCU/h/Lane. The difference between them is approx 1.5 percent. It prove, calibrated values of the model is suitable for simulation of heterogeneous traffic in India. The simulated values and field values are also compared with the other researcher which shows in Fig.(2b), (2c). Fig.(3a) Shows the value of the field and simulated are between plus minus 5-percent Fig.(3b) Shows the observer simulated stream speed and field simulated stream speed are between plus minus 5-percent.

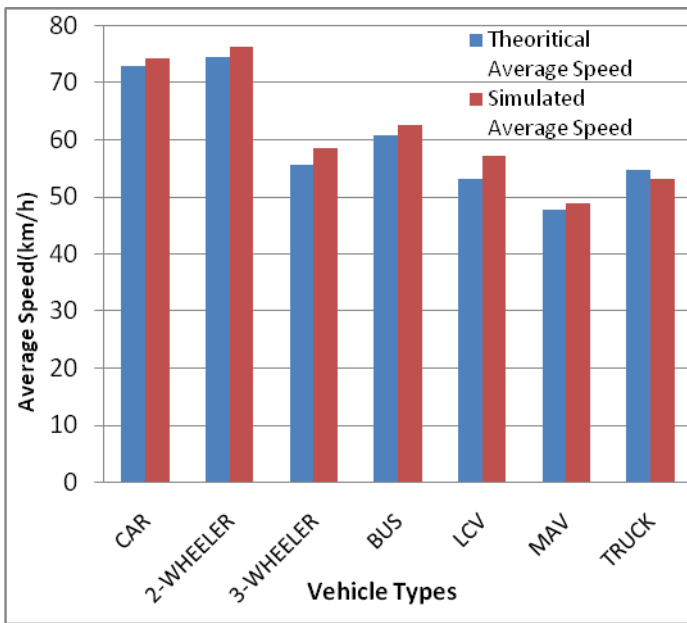


Fig 3.0 Shows the comparison of Theoretical and Simulated Average Speed.

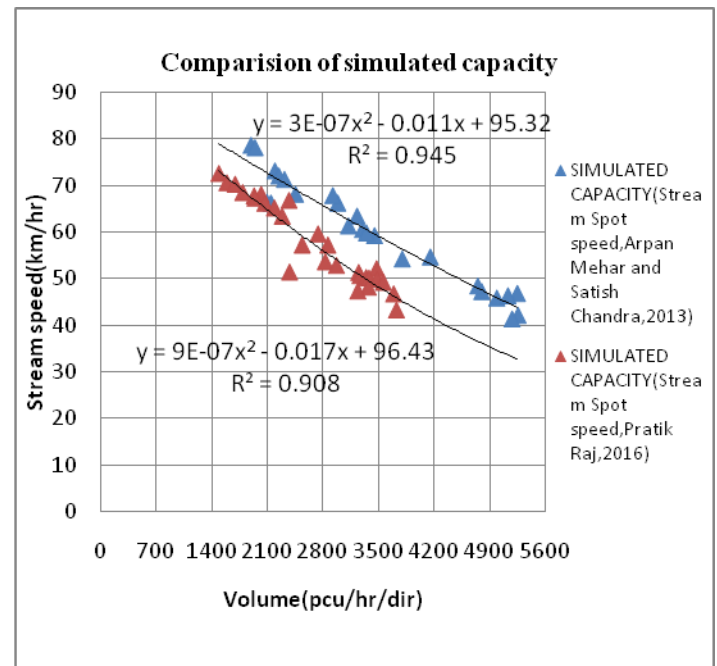


Fig 2c Shows the comparison of simulated capacity with the other researchers.

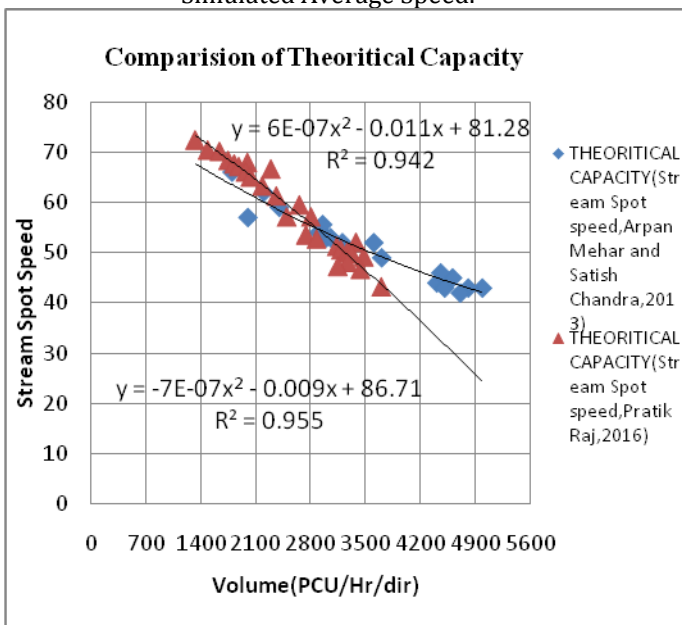


Fig 2b Shows the comparison of Theoretical capacity with other researchers.

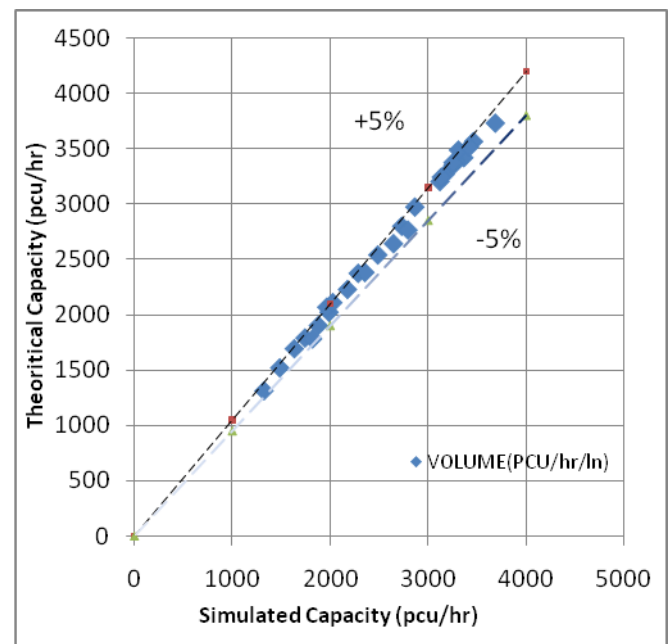


Fig.(3a) Shows the variation of capacity using Manual Calculation and microscopic simulation tools VISSIM.

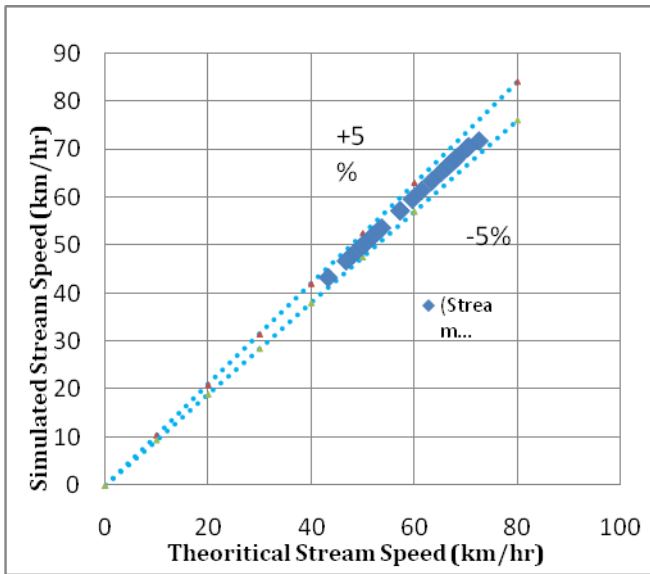


Fig.(3b) Shows the variation of stream speed using Manual Calculation and microscopic simulation tool VISSIM.

9. CONCLUSION

- ❖ Simulation Capacity of National Highway-06 is 3733 PCU/h/dr or 1866 PCU/h/Lane and Field capacity is 3688 PCU/h/dr or 1844 PCU/h/Lane. The difference between them is approx 1.5 percent. which prove that the Calibrated values for the model is suitable for simulation of heterogeneous traffic in India.
- ❖ A general equation is established for prediction of traffic volume at National Highway-06 by using previous traffic data of National Highway Authority of India which shows in Fig.10, 10.1.
- ❖ It has been observed from the studies, the PCU values of a various class of vehicles increases with increase in lane width due to the various physical dimension of vehicles share the same carriageway and heterogeneity of traffic on Indian Highway.
- ❖ A relationship is obtained from the traffic data between the capacity of roadway and width of the carriageway. it follows the second-degree curve shown in Fig.1.0

10. NOTATION

The following notation and symbol are used in this paper:-

PCU_i	=	Passenger Car Unit of i^{th} vehicle
V_c	=	Average speed of the Car.(km/h)
V_i	=	Average speed of the vehicle type i (km/hr)
A_c	=	Projected Area of Car in Traffic stream(m^2).
A_i	=	Projected Area of vehicles type i (m^2).
w	=	Total width of the Carriageway(m).
C	=	Capacity of the Highway(pcu/hr).
2-W	=	Two-wheeler vehicle.
3-W	=	Three-wheeler vehicle.
HV	=	Heavy vehicles.
LCV	=	Light Commercial vehicles
MAV	=	Multi Axle vehicles.

REFERENCES

- [1] Arpan Mehar et. al, "Highway Capacity Through Vissim Calibrated for Mixed Traffic Conditions" KSCE(Korean Society of Civil Engineers) Journal of Civil Engineering (2014) 18(2):639-645,2014
- [2] Errampalli Madhu et. al," Estimation of Roadway Capacity of Eight-lane Divided Urban Expressways under Heterogeneous Traffic Through Microscopic Simulation Models" International Journal of Science and Technology Education Research Vol. 1(6), pp. xxx - xxx, November (2011).
- [3] Gabriel Gomes et. al, "Congestion Freeway Model Microsimulation Model Using VISSIM" Transportation Research Board, (2004)
- [4] Ketan Kumar Varmora, " Use of Vissim in Heterogeneous Traffic Modelling-A Review" Indian Journal of Research Volume : 4 | Issue : 5 | May 2015 ISSN - 2250-1991,9 , (2015)
- [5] Manraj Singh Bains et. al, "Modelling of Traffic Flow on Indian Expressways using Simulation Technique" 8th International Conference on Traffic and Transportation Studies Changsha, China, ELSEVIER August 1-3,(2012)
- [6] Partha Pratim Dey et. at," Simulation of Mixed Traffic Flow on Two-Lane Roads" ASCE(2008).

- [7] P. Vedagiri et. al, " Estimation of Saturation flow of Heterogeneous Traffic Using Computer Simulation" 20th European Conference on Modelling and Simulation Wolfgang Borutzky, Alessandra Orsoni, Richard Zobel © ECMS, 2006 ISBN 0-9553018-0-7 / ISBN 0-9553018-1-5 (CD),(2006)
- [8] Pan Liu et. al, "Development of a VISSIM Simulation Model for U-Turns at Unsignalized Intersections" ASCE,(2012).
- [9] Satish Chandra et. al, "Effect of Lane Width on Capacity under Mixed Traffic Conditions in India" ASCE,(2003)
- [10] Satish Chandra et. al," capacity estimation procedure for two-lane roads under mixed traffic conditions "Indian Road Congress Paper No.498, (2004).
- [11] Siddharth et. al, "Calibration of VISSIM for Indian Heterogeneous Traffic Conditions" 2nd Conference of Transportation Research Group of India (2nd CTRG), ELSEVIER, (2013)
- [12] V. Thamizh Arasan et. al, " Microsimulation Study of Effect of Volume and Road Width on PCU of Vehicles under Heterogeneous Traffic". ASCE,(2010).
- [13] Velmurugan et. al, "Roadway Capacity Estimation for Multi-lane Interurban Highways in India" Colloquium on Transportation Systems Engineering and Management CTR, CED, NIT Calicut, India, Paper Id: 140 May 12-13,(2014).

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BIOGRAPHIES



Pratik Raj is a M.Tech scholar in Transportation Engineering Division, Department of Civil Engineering, G.H. Rasoni College of Engineering, Nagpur, Maharashtra, India. His research work is in the area of mixed traffic condition. He also completed research work in the bituminous mix. Mr. Pratik Raj obtains his