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DRIVING BEHAVIOR MODELLING ON NATIONAL HIGHWAYS

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ABSTRACT

Car following models are critical components of microscopic simulation and are valuable for applications like as accident analysis and communication network analysis in traffic highway scenarios. Driving behavior is the description of intentional and unintentional characteristics and actions a driver performs while operating a motor vehicle. ManyStudies indicates that driving behavior is considered as a major safety problem. Drivers' car following behavior can be considered as one of the main factors that causes road accidents. The main research of this study was to examine the Weidman 99 car-following behavior model (CC0-CC9) parameters using safe following distance adopted by drivers on highways at various operating speeds. Field data collected on various locations of four-lane, six- lane divided highways are used to study the traffic flow behavior and estimate driver behavior model on highways. Microscopic traffic behavior related to speed and acceleration characteristics of individual vehicle type is studied on four-lane highway to incorporate them into a traffic simulation program. The study area was modeled using VISSIM microscopic simulation. The applicability of VISSIM in mixed traffic conditions of the type prevailing on Indian Roads has been examined in the present study and some of the driver behavior model parameters are calibrated to truly reflect these traffic conditions. The results indicate that the drivers exhibit different behaviors depending upon the vehicle Delay and vehicle travel time measurements which can imply an increase in aggression at particular speeds. According to the findings, traffic flow was more unsteady with aggressive drivers. One of the reasons for aggressive drivers changing lanes frequently and so generating less stable traffic was disruption in the flow of traffic, such as speed reduction.

Key words: *Driving behavior, National highways, simulation, calibration, VISSIM, Homogeneous, car-following*

1. INTRODUCTION

A country's economic, trade, and social development are all dependent on its road network. The strength of the highway system is its network, which allows for the easy transport of both passengers and commodities across the country. India, like many other developing countries, is heavily investing in expanding their road networks in order to improve their transportation and logistics systems. India has a massive road network with a total length of 4.69 million kilo meters, which is distributed across the country in a variety of road, traffic, and weather conditions. The Indian government has designated the years 2011 through 2021 as the "Decade of Innovation. "Roads are categorized in India as National Highways (NH), state Highways (SH), Major district roads (MDR), rural roads and urban roads. The total length of road network constitutes 76,818km of NH; 1,63,898 km of SH ; 10,05,327 km of MDR:27,49,805 km of Rural roads and 4,11, 840km of urban roads. Comparatively, length of rural roads has increased significantly in recent years and presently accounts for 59% part of total road network. The national highway network in India is managed by the ministry of Road and

Transport and Highways and National highway Authority of India (NHAI) which is responsible for overall development and maintenance of these highways. Other categories of roads are looked by the state and local government bodies. The National Highways (NH) are the arterials for inter-state movements of passengers and goods. These highways have one of the busiest network in the world that constitutes less than 2 percent of overall road but it handling network but handling 40 percent of total road traffic. The highways need more attention for studying traffic flow behavior and their capacity. The logics of car- following and lane changing behavior derived for homogeneous traffic condition in developed countries are not directly applicable to mixed traffic conditions. The frequent lane- changing and overtaking of vehicles and speed of individual vehicles affect the capacity of a highway section. Most of the studies are reported in literature on capacity of highways and driving behavior on highways. IRC guidelines for rural roads (IRC: 64, 1990) were framed in 1990. The static and dynamic characteristics of all vehicles in general and in particular, have changed considerably during last two decades. Traffic simulation is found as a powerful tool for circumventing such problems. The simulation represents a mirror or projection of actual traffic behavior which is difficult to observe in real-world situations. Present research uses a microscopic traffic simulation model to generate the mixed traffic flow after calibrating its influencing model parameters affecting longitudinal behavior of a driver /vehicle. Driver modeling is the simplification of the human driver with logical graphic and can represent the basic characteristics of human driving general, the driver model's purpose is to accurately imitate the driver while performing the prescribed tasks, which are divided into two parts: longitudinal control (e.g., speed) and lateral control (e.g., steering) (e.g., steering angle). The steering wheel angle/torque, acceleration or braking pedal position/pressure, and gear shift position are commonly the output characteristics of driver models. Microscopic traffic simulation systems rely on driving behavior models to describe these interactions. Microscopic traffic simulation models are widely used in traffic engineering and transportation planning research. Microscopic traffic simulation models are thought to have a significant time and cost advantage. The vast applications of simulation have been observed in literature on traffic flow behaviors and highways' operations in various developed countries under homogeneous traffic conditions, and few studies make efforts to apply this model even under heterogeneous and non-lane based traffic flow conditions. Simulation has the ability to display and visualize the complex traffic flow operations in a graphical manner with the degree of precision. The model utilizes every time step to identify an opportunity for each vehicle /driver unit within a network system (Weidman and Refeiter, 1991). The motivation behind adapting the microscopic traffic simulation model in VISSIM in the present study to analyze the effect of traffic composition on four-lane divided highway under traffic condition.

2. LITERATURE REVEIW

In this project, we present a literature review found on driver behavior modelling, driving behavior parameters, we sum up the state of the art of analysis methods adopted in studies that

Focused on analyzing driver behavior. From referred papers, it is identified that a Driver Behavior Modelling (DBM) prepared by Reason et al, 1990 is used for all the studies. Here, the analysis of the behavior of drivers during driving and also their socio-demographic characteristics has to be taken into consideration for the purpose of enhancing road safety.

Bawan Mahmood and Jalil Kianfar(**2019**)[1]In this paper VISSIM, it is necessary to give different driver behavior parameters for multi axle and passenger vehicles. **Hassan M. Al-Ahmadi, Arshad Jamal, Imran Reza, Khaled J.Assi and Syed AneesAhmed**(***May*** **2019**)[2]**:**This paper explains how to use VISSIM, a micro-simulation software, to calculate the driving behavior parameter. Parameters was optimized. Unless the optimized performance metrics, such as travel speed, queue length, and trip time, were achieved, the settings were modified through a given number of iterations within the specified range.**Narayana Raju, Shriniwas Arkatkar and Gaurang Joshi** (**2019**)[3]In this research, high-quality vehicular trajectories were used to calibrate driving behavior characteristics. The research of driver behavior in the identification of leader-follower pairs in various traffic conditions was a significant component of this. The Weidman 99 model is a car-following model in which the following behavior is described by ten parameters, each with its own significance.**Hen, Hao Liu and Xiaoming Liu** (**2019**)[4]The impacts of weather on traffic flow parameters were measured using a mix of traffic simulation and driving simulator in this work. **D.C. Dey, S. Roy and M.A. Uddin December**(**2019**)[5]**:** This work describes the calibration and validation of a microscopic model of a congested junction in detail. Driving behavior parameters were updated with the help of the PTV VISSIM model to create a virtual environment that replicates traffic scenarios and optimizes the problem while visualizing the output that is required to meet current and future difficulties. **Matthias Richterband Jan Paszkowski**(**2018**)[6]**:**The primary goal of this study was to look at driving behavior parameters in order to build a way for enhancing micro-simulation traffic models that focus on traffic solutions. **Athul Suresh and Pabitra Rajbongsh** (**2016**)[7]This research discusses the effectiveness of VISSIM software in simulating traffic conditions at an Assam rotary intersection. VISSIM is a microscopic traffic simulation programme that aids in the creation of realistic diverse field conditions. **Zheng yang Lu, Ting FU; Lipping Fu, Sajad Shiravi, Chaozhe Jiang** (**2016**)[8] The goal of this research was to create a reliable and practical approach for calibrating car-following parameters in the VISSIM micro simulation software. **Palak Maheshwarya, kinjal Bhattacharyya, Bhargab Maitra, and Manfred Boltze (July 2016**)[9] The mechanism for calibrating vehicle class driver behavior is demonstrated in this paper at a Kolkata intersection. VISSIM microscopic simulation was used to duplicate the data from the study area. The sensitive characteristics that influence driving behavior have been discovered. **EmilieFransson** (**2016**)[10]The major goal of this study was to use a micro simulation model to evaluate how complex driving behavior on ramps and merging regions was. Field observations and a simulation study were conducted. **Higgs, Abbas, and Medina** (**2014**)[11]The Weidman automobile following model is examined in this work utilizing car following periods that occur at varying speeds.**Wenwen Liu, Yong Qin, Honghui Dong and Yanfang Yang** (**2014**)[12]Three sensitivity analysis approaches are used in this paper: poor analysis line chart method, sensitivity coefficients method, and sensitivity coefficients method. The trend between the dependent and independent variables is represented by a line chart. By examining the association between the evaluation and the parameters, sensitive parameters can be found. In each level, range analysis shows the difference between the maximum and least values.**Filmon G. Habte Michael and Luis de pica do Santos (July 2013**)[13] paper describes the quantitative evaluation for the impact parameters through sensitivity analysis for total 21 driving behavior. Two base models were developed for different geometric layouts. Sensitivity analysis for VISSIM car-following and lane-changing model on safety for simulated vehicles were conducted through setting a realistic maximum and minimum value for each and every parameter. Habte Michael& Santos, July 2013.**Siddharth S M P, Gitakrishnan Ramadurai** (**2013**)[14]The techniques and results of sensitivity analysis and automatic calibration of VISSIM models using data collected from one of Chennai's intersections are described in this study. Sensitivity analysis was used to generate parameters that affect driving behavior in Indian diverse situations. **Arpan Mehar, Satish Chandra and S. Velmurugan** (**2013**)[15]The goal of this study was to see if VISSIM could be used in mixed traffic situations and, if so, to calibrate the model's driving behavior parameters to fit the situation. Data on traffic volume was gathered and utilized to create a speed and flow curve. The same set of data is utilized in simulation to construct the speed flow curve, which is then compared to the field curve. Driver behavior parameters were first established for homogeneous traffic conditions with any one of the vehicle types in the flow, and then the findings were aggregated to obtain the values for a mixed traffic stream. (Mehar, et al., 2013).**Praveen Edara & Indrajit Chatterjee** (**2013**)[16]Multivariate regression models were used to express the link between the VISSIM model's essential driving behavior characteristics, truck percentages, work zone capacity, and work zone lane arrangement in this article.**Michaa Niezgoda, Mikoaaj Kruszewski** (**2012**)[17] This paper discusses the many ways for assessing driver behavior and objective behavioral indicators such as lane deviations, time to collision, time headway, post encroachment-time, deceleration rate, gap acceptance, red-light infractions, and other traffic safety measures. Furthermore, there were no universally accepted standards forthese indications, and their cutoff values ranged from one to a few seconds. Furthermore, safety was always defined by a set of parametersand single indicators, each with its ownset ofconstraints. (Niezgoda and colleagues, 2012)**Jian Rong, Kejun Mao, and Jianming Ma**(**2011**)[18]The implications of individual differences on traffic flow features and driving behavior are discussed in this research. Driving behavior was considered a significant strategy in developing ways to reduce roadway traffic crashes, enhance vehicle designs, develop in-car safety systems, and increase the level of service provided by a route. The motorists were divided into three groups: aggressive, moderate, and conservative. The data acquired from the driving simulator was used to calibrate driving behavior parameters for these three groups of drivers. **Craig D. yannes and Nicholas E. Lowness** (**2010**)[19]:The important parameters of the VISSIM driver behavior model utilized in pair combination evaluation are described in this study. The interactive studies were carried out in order to discover correlations between the pairs of driver behavior factors and roadway capacity. Each parameter, with the exception of headway acceleration, was found to have a significant effect on roadway capacity. Because it has the ability to interact with the other elements that determine capacity, headway acceleration is included in the combinations. CC1: Headway Time, CC2: Following Variation, CC3: Threshold for Entering Following, CC4 and CC5: Following Threshold were the combinations. CC6: Speed Dependent Oscillations, CC7: Oscillation Acceleration, CC8: Stopped Condition Acceleration, CC9: 80 km/h Acceleration The goal of this study was to enable simulation modeler better understand how changing driver behavior factors affects calibration. Yannes&Lowness, 2010).**Viti, Francesco, and Hoogendoorn Serge, Arem Bart van** (**2010**)[20] This paper explains how microscopic data was obtained and processed using image processing or clustering approaches. They used the data to provide the first results of a study of driving behavior at signalized intersections. **Vincenzo Galleli and Rosolino vaiana** (**2008**)[21] :This paper consists of the results of a wide range survey conducted on roundabout with different scenarios through the use of simulation software called VISSIM. Because it's difficult to set the geometric and user behavioral characteristics for roundabout traffic simulations, they often result in a lot of complications. **Christopher S. Russo** (**2007**)[22]The goal of this study was to create and calibrate two very different micro simulation models. SHAKER, a deterministic queuing model for cars using toll collection facilities, and VISSIM, a driving behavior analysis model, were the two models used. The findings revealed that each simulation model had advantages over the others in terms of setup time, analysis reporting time, results practicality, and ability to adjust to variance.**Varun Ramanujam**(**2007**)[23] This paper focused on studying driver behavior models and developing improved lane shifting models. **Nicholas E. Lowness and Randy B. Machemehl** (**2006**)[24]This paper describes the sensitivity analysis of VISSIM’s simulation capacity on output under different values of driving behavior parameters.

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3. METHODOLOGY

This study's methodology involves a literature review, the development of models, and the development of objectives. Following the development of the objective, the study location was chosen in order to collect the necessary data, such as traffic volume, flow, and speed. The data was gathered by a video-graphic survey, which was then analyzed. The data has been extracted and summarized in Excel for further analysis.

The methodology adopted for the present study is represented in the form of flow chart.

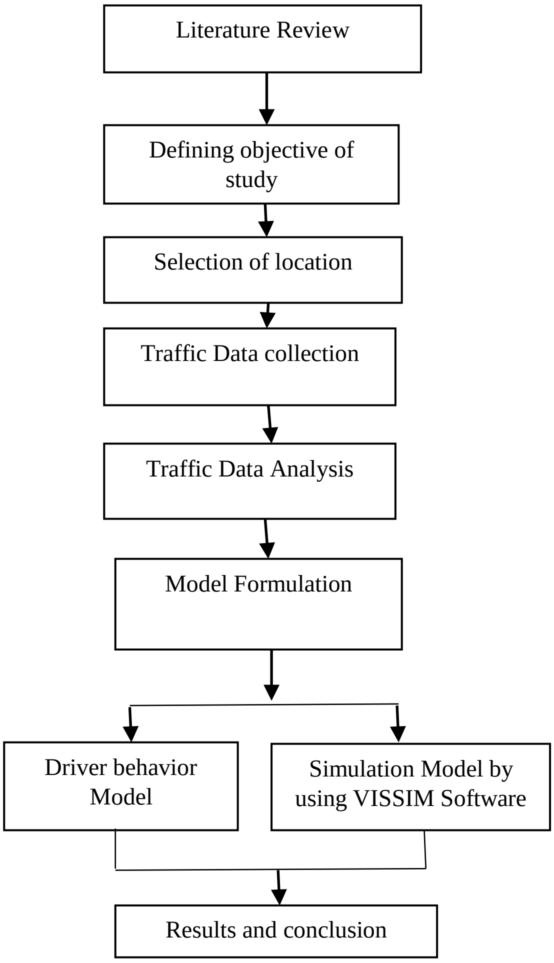

Figure1: Flow chart of Methodology

3.1 STUDY AREA SECTION

The study area was chosen based on national roadway difficulties. The areas of Ghatkesar, Shamshabad, and HKR Roadways were chosen in this study for examining traffic data on national highways since they are suffering driver behavior model concerns. Driver behavior modelling (DBM) was developed to predict driving movements, driver purpose, and driver state, as well as environmental condition, in order to improve transportation safety and the overall driving experience.

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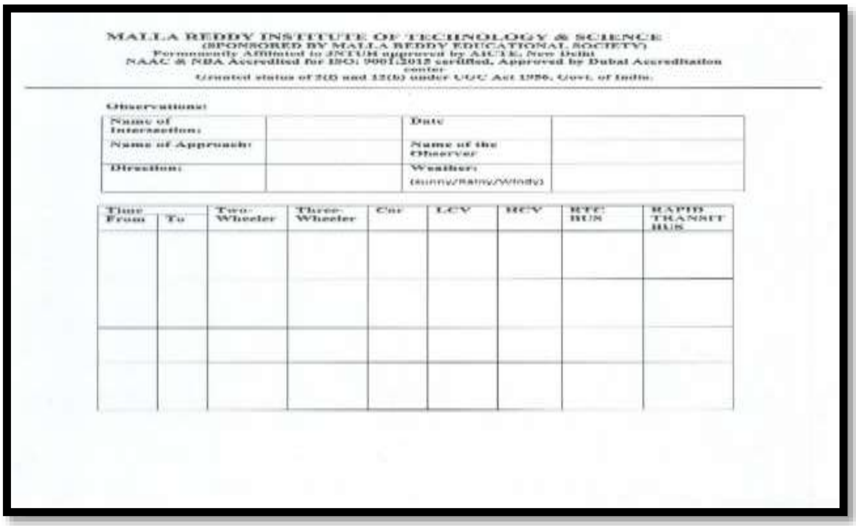
3.2 DATA COLLECTION

The traffic data was extracted from the collected video and VISSIM software and SPSS software is also used. At the intersections, data can be manually collected or video-graphed for a period of time. The Video-graphic mode takes data in a continuous, non-interrupted manner. From 9 a.m. to 10 a.m., video–graphic data was collected for a one-hour traffic count. For data extraction, we use a manual process. Indirect manual method was used to acquire and retrieve video-graphic data. In this indirect method, we play the video frame by frame for 15 minutes at a time interval, and the data is recorded in a template as shown in Figure 2 below.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NAAC & NBA Accredited for ISO: 9001:2015 certified, Approved by Dubai Accreditation center
Granted status of 2(f) and 12(b) under UGC Act 1956, Govt. of India.

Observations:

Name of Intersection:		Date	
Name of Approach:		Name of the Observer	
Direction:		Weather: (Sunny/Rainy/Windy)	

Time From	To	Two-Wheeler	Three-Wheeler	Car	LCV	HCV	RTC BUS	RAPID TRANSIT BUS

Figure 2: Shows the Data template

4. DATA ANALYSIS

The major road network connecting state capitals, major ports, large industrial areas and tourist centers as well as notified by Ministry of Road Transport and Highways (MORTH), Government of India (GoI) are classified as the National Highways. There are no divergences, traffic signals, severe curves, or railroad crossings, and all cars drive in one direction without stopping. As a result, driving on a motorway differs from driving on a regular street or road. The purposeful and unintentional features and activities that a driver conducts while operating a motor vehicle are referred to as driver behavior. Individual vehicle attributes and driver behavior are affected by congested traffic circumstances.

4.1 DATA PRE-PROCESSING

The video-graphic data is the Real –time data, it has to be processed and analyze the development of Driver behavior model. The data is analyzed using the steps below.

- Data pre-processing
- These data were observed at 15-min intervals. The observations were taken in a table with video-graphic survey to collect the field data.
- Video- recordings are then played back in the laboratory to process the collected data as required.

4.2 GHATKESAR STRETCH

The video-graphic data obtained from the site location is evaluated by playing the video for 15-minute intervals of data from the field on the data sheet, as illustrated in Figure: 3 for a selected area of the Ghatkesar stretch. This table shows the proportions of highway vehicles (veh/hr.) and through vehicles (veh/hr.) for 2-wheelers, 3-wheelers, 4-wheelers, Heavy commercial vehicles (HCV), light commercial vehicles (LCV), and buses.

Table 1: Data collected at Ghatkesar stretch of volume count.

Time	2-wheeler	3-Wheeler	4-Wheeler	Heavy commercial vehicles (HCV)	Bus	LCV
9:00 am to 9:15 am	126	8	127	7	16	34
9:15 am to 9:30 am	130	11	120	12	12	40
9:30 am to 9:45 am	120	9	119	20	9	43
9:45 am to 10:00 am	98	10	133	8	14	37
TOTAL	474	38	499	47	51	124

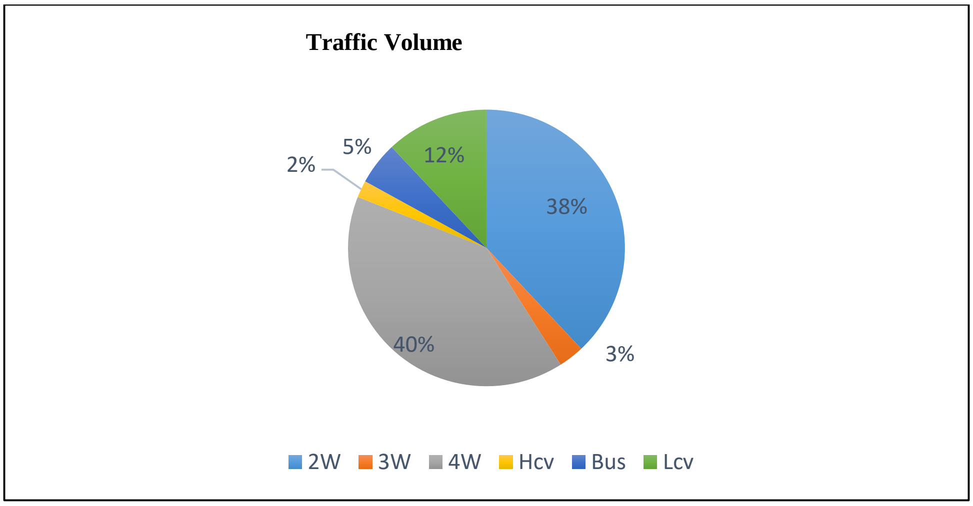

Figure 3: Vehicle composition of National highway at Ghatkesar stretch

In Fig 3: the vehicle composition is shown, with the four-wheeler having the highest share of 40% when compared to other vehicles. When compared to other vehicles, the bus has a 38 percent share. At the Ghatkesar area, the remaining 3-wheelers make up HCV make up 2%, and LCV is make up 12% of the roadway.

4.3 BASIC INPUT DATA AND NETWORK CODING

The basic input data required for Microscopic multimodal includes microscopic characteristics of traffic flow parameters, roadway and, traffic conditions to be simulated. These data include, roadway geometry and elements, type of vehicles and class, static and dynamic characteristics of vehicle type, vehicle composition, traffic volume, free and operating speeds. The functions and distributions of parameters (acceleration, deceleration, average speed, weight and power etc.,) in Microscopic simulation the base data have default values or profiles for each type of vehicle (car, HGV, Bus, Bike etc. Available 2D and 3D default vehicle models in simulation errors are checked and modified conforming to field data. Present study is in tented to generate the mixed traffic flow in simulation using field data collected on Highways and to analyze capacity under varying traffic and roadway conditions. The link coding in simulation for the highway network was performed by assigning the attributes such as, link length, number of lane and lane width, behavior type whether rural or urban, lane closure etc. The assigning input data to simulation is mainly based on the traffic conditions and the stream flow parameters as observed in the field that provide idea about the development of model and its calibration. The default values of parameters in available car-following, lane –change and lateral behavioral models are basically the outcome of the calibration studies performed in Germany under controlled sets of traffic conditions. The driving in India is fairly different from other developed countries. The calibration of model parameters will be performed the next chapter for determination of highway capacity by simulating the mixed traffic flow using the field data. The identification, collection and preparation of data very important before providing base data are very important before providing base data into Micro simulation. Wherever possible the base data should be modified as per field conditions.

4.4 LINK PROPERTIES AND LINK BEHAVIOR TYPE

The most basic component of a VISSIM network is the 'Link,' which represents a single or multiple-lane roadway segment with a single flow direction. Therefore, a two –way road section can be constructed using two links with opposite direction of flow. Assigning the link attributes is an important task for specifying roadway and geometric conditions to simulation. The properties about the link such as name, number of lanes, lane width, link length etc., can be given to the created link. The link behavior type is required to depict the nature of a link on which the traffic is to be generated. Moreover, for the particular type of link behavior, specific driver behavior models and parameters can be chosen. Micro simulation also provides some default link behavior types for simulating different traffic flow situations such as urban (motorized), freeway, pedestrian area and bicycle truck. In the present study, custom link behavior type has been created and named as Indian condition which comprises the driving behavior signifying the Indian mixed traffic condition. The link behavior type for Indian condition is shown in Figure 4 below

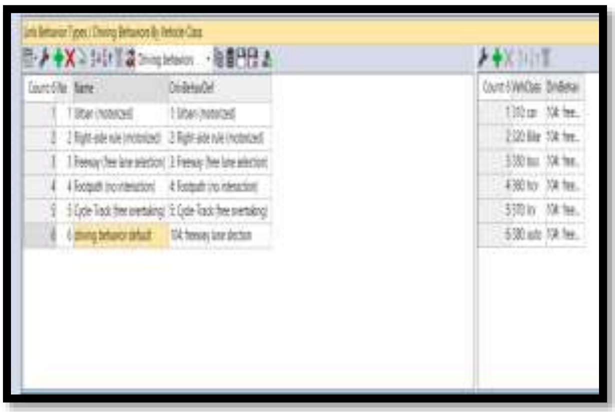

Figure4: Link behavior type assigned to Microsimulation

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4.5 LONGITUDINAL ACCELERTATION FUNCTIONS

The acceleration or deceleration characteristics of vehicles are needed as basic inputs to Microscopic simulation. Acceleration and deceleration functions of vehicles assigned to each vehicle type selected in simulation. The acceleration or deceleration functions depend upon the speed of the vehicle moving through the link. For each vehicle type, two accelerations and two deceleration profiles are assigned as maximum and desired acceleration profiles. For present study, new maximum and desired values for acceleration and deceleration profiles were created for vehicle type's standard car, heavy vehicle, car, motorized two-wheelers, and motorized three wheeler. Typical acceleration profiles for standard car and heavy vehicle as assigned to VISSIM are shown in Figure 5: below

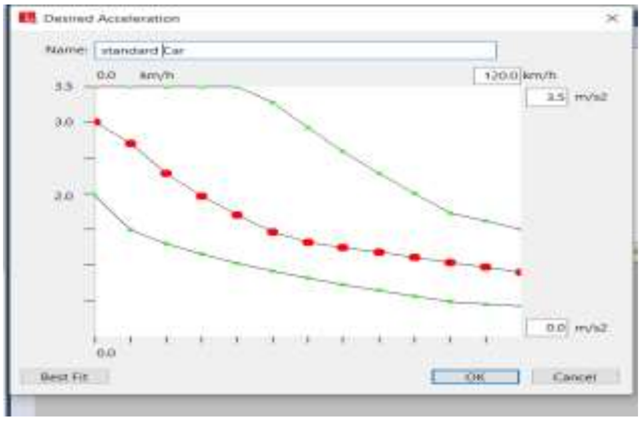

Figure 5: Acceleration profiles created for CS and HV

4.6 AVERAGE COMPOSITION OF TRAFFIC VOLUME COUNT AT DIFFERENT SECTIONS OF SITE LOCATIONS

The information gathered from the video-graphic data survey is sufficient for the analysis and building of a driver behavior model utilizing a linear regression model and SPSS Statistics. The procedure of extracting more data from the traffic data graph is described in the data analysis chapter, and the traffic volume numbers derived from SPSSsheets are listed below.

Table 1: Average Composition of Traffic Volume count at different sections

Location	Proportions of vehicles veh/hr.	Composition of vehicles Veh/hr.					
		2w	3w	4w	HCV	Bus	LCV
Hyderabad-Karimnagar Road	1314	507	42	507	50	51	157
Ghatkesar	1247	484	40	499	47	53	124
Shamshabad	1272	474	38	504	49	54	156

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4.7 CAR-FOLLOWING PARAMETER SET

Parameters CCO (standstill distance), CC1 (Headway time), CC2 (Following Variation), CC3 (Threshold for entering following), CC4 is (Negative following threshold) CC5 is (Positive following threshold), CC6 (speed dependency), CC7 (oscillation acceleration), CC8 (standstill acceleration), CC9 (Acceleration at 80 km/h) are predicted for vehicles like 2W, 3W, Car/LCV, Bus/HCV in Table as shown below.

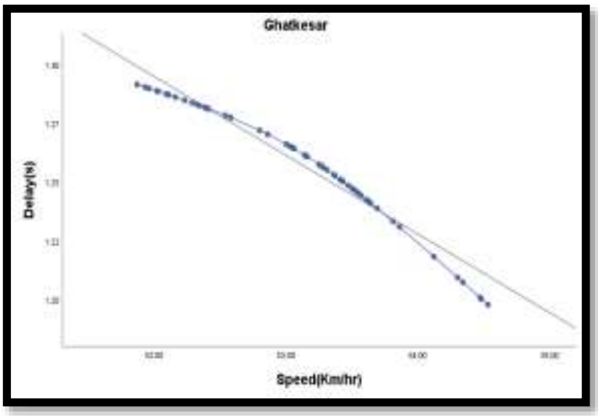
Table 2: Predicted parameter set

Parameter	Default	2W	3w	Car/LCV	BUS/HCV
CC0	1.50	0.47	1.00	1.20	2.00
CC1	0.90	0.43	1.2	0.81	0.94
CC2	4.00	4.42	4.42	6.84	6.84
CC3	-8.00	-8.00	-8.00	-8.00	-8.00
CC4	-0.35	-0.35	-0.35	-0.35	-0.35
CC5	0.35	0.35	0.35	0.35	0.35
CC6	-11.44	-11.44	-11.44	-11.44	-11.44
CC7	0.25	0.20	0.20	0.77	0.77
CC8	3.50	2.30	2.30	2.30	2.30
CC9	1.50	1.50	1.50	1.50	1.50

REGRESSION STATISTICS

	Mean	Standard deviation	N
Delay	1.2583	.1595	60
Speed	53.0905	1.71826	60

Table 3: Descriptive statistics of Delay and speed at Ghatkesar stretch



$R^2 = 0.961$

D=3.040-0.34*s

Figure: 6 Relation between Delay(s) and Speed (km/hr) Ghatkesar stretch

From the above graph it is observed that the relationship travel time and speed (km/hr).

The equation is obtained is

$$\boldsymbol{D = 3.040 - 0.34 * s}$$

Where,

D = delay (s)

S= speed (km/hr)

Model of Delay & speed at Ghatkesar stretch. The summary of the model is shown in above Table 3

S=.1595, R^2=0. 961

and R. square (adjusted) =0.960

Summary of the Model

R square of the model is 0.961 which is greater than R square (adjusted) which shows the model fits fairly.

5. RESULTS AND CONCLUSION

Based on the Results of this study, the following points were concluded below:

1. Delay and Travel time models for National highways were found to be significant.
2. For Ghatkesar stretch, Delay and speed hasR^2 value is 0.961 i.e. it explains when speed increases delay decreases. As speed increases travel time decreases.
3. Delay and speed for Shamshabad, relation is obtained Delay and speed and R^2 value is 0.896.
4. For HKR stretch, Delay and speed has R^2 value is 0.872
5. At Ghatkesar stretch, Travel time and speed has R^2 value is 0.892
6. For Shamshabad stretch, Travel time and speed has R^2 value is 0.897
7. At HKR stretch, Travel time and speed has R^2 value is 0.997
8. In this study it is found that how car following model and lane change model in driving behavior at different locations can affect the traffic stream and create congestion and delays.
9. Installation of speed breakers at the beginning of merging section at an ramp to the main line can help to increase safety and decrease delay travel time.
10. In this study, the calibrated parameter values indicated that drivers in India are more aggressiveness in lane changing and car following compared with default values in VISSIM run analysis under congested conditions.

6. FUTURE SCOPE

The present study has considered field data with respect to volume, speed and acceleration of different types of vehicles for calibration of Micro simulation software. The lane-changing and lateral behaviors are not considered in the present research. These characteristics may have some influence on capacity of highway and needed to be studied in future research.

In future, we plan to utilize this model as a base model to evaluate different Traffic Incident Management strategies to provide the most effective strategy in different situations. This may help decision makers in long-term and sustainable development.

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