POTENTIAL APPLICATIONS OF VISSIM FOR MODELING HETEROGENEOUS TRAFFIC FLOW- A REVIEW

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Abstract : Due to heavy rate of migration from rural areas to nearby cities there is a rapid population growth there by leading to overcrowding of routes especially at junctions of road. The congestion of roads are occurring due to the increase in motor vehicles usage day by day. Especially in India the heterogeneous traffic condition is seen where the motor vehicle move with less lane discipline. So, this traffic congestion can be reduced in a systematic way by means of current technology available. One such alternative of existing technology is use of microsimulation softwares such as VISSIM, AIMSUN, and SIDRA etc. The present paper reviews the previous research investigations on modeling, calibration and validation of the traffic condition in heterogeneous traffic flows using VISSIM. It also reviews the relative performance of VISSIM software in comparison to other microsimulation softwares as well as the previous case studies in Indian traffic scenario which focuses on minimizing traffic congestions and delay at signalized intersections.

IndexTerms **- VISSIM, Microsimulation, Calibration, Validation, Driver behaviour parameters, Traffic delay.**

I. INTRODUCTION

1.1 Broad Classification of Traffic Simulation Models

Simulation of real-time traffic operations has become necessary for traffic engineers and transport planners, for making the traffic flow without congestion and delays as well as for optimizing the traffic flows in case of public and private transport. Basically modeling of traffic using software can be done logically in three ways namely macroscopic, mesoscopic and microscopic. Macroscopic models are used to view the flow as a larger part which measures, roadway capacity, average travel time and average speed etc. While microscopic model will give attention to individual vehicles and their characteristics of flow [20, 43], microscopic simulation is a powerful tool as it provides fast, in expensive and risk less environment [34]. The mesoscopic model will fall between these macro and microscopic model. Where the traffic simulation is a tool for modeling operations of dynamic traffic systems [18]. There are many number of micro simulation softwares available in the market where the VISSIM software has got importance in recent years. Various softwares which are used at present for modelling the traffic environments at micro, macro and mesoscopic scales are listed in Figure 1.

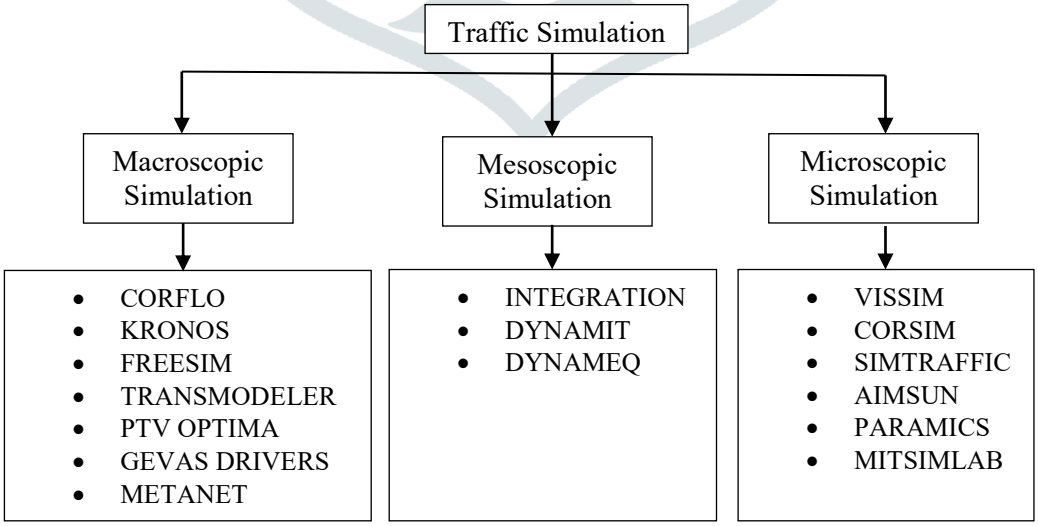

Figure 1: Classification of Traffic Simulation Models

However in this paper the focus is towards the microsimulation softwares and hence a brief description of the related softwares is presented below.

II. BRIEF NOTE ON MICROSIMULATION SOFTWARES

2.1 CORISM

CORISM is one of the traffic simulation software developed by the McTrans Center, University of Florida which was designed for analysis of highway systems, urban streets etc., as the name CORSIM represents the corridor simulation in which two microscopic models characterize the traffic environment. FRESIM and NETSIM are the two judging models in CORSIM software in which FRESIM is used for modeling highway systems and NETSIM for urban streets. CORISM is capable of simulating different traffic condition and maintained by Federal Highway Administration. The model was execution through the windows based interface with the help of Traffic Software Integrated System. The output results such as animation is achieved by the TRAFVU processor which allows the user to view an edit the network [24]. The latest stable version was TSIS-CORSIM 6.3 released in the year 2012.

2.2 SIM-TRAFFIC

Sim-Traffic is a micro simulation software which can model signalized and un-signalized intersections in an easy manner that can simulate cars, buses, pedestrians etc., the advantage of this simulation is that it displays the animated visual while simulating [30]. For simulating the traffic model in Sim-Traffic it uses SYNCHRO program [27].

2.3 AIMSUN

AIMSUN is a microscopic simulation software which was developed in Spain which can simulate individual vehicles in detailed, where the word AIMSUN represents Advanced Interactive Microscopic Simulator for Urban and Non-Urban Networks. This simulation software is very helpful in simulating the new traffic systems and even the application of Intelligent Transport Systems is done [26]. The latest stable version Aimsun Live was released in the year 2012.

2.4 PARAMICS

PARAMICS is a microscopic simulation software used for analysing individual vehicles and their behaviour on road network. It was developed in early 1990's by UK department of transport. With the help of PARAMICS software different types of vehicular movements, Pedestrian movements, public transport vehicles can be modelled [28].

2.5 PTV VISSIM

Various stages in the development of PTV (Planung Transport Verkehr AG) VISSIM software are mentioned as follows. In 1974 Wiedemann proposed psycho-physical car-following model described the vehicular movement on single lane with no exists. Extensive research at the University of Karlsruhe in the period of 1978-1983, focusing on the aspect of lane changes on two lane motorway, traffic flow at gradients and lane changing maneuvers on three-lane motor ways. . In the year 1983 Hubschneider has done Ph.D. thesis on simulation model of vehicles on signalized and non-signalized at multi-lanes, this model is named as MISSION. The application of this model is to calculate the noise and emissions. In the year 1994 first commercial VISSIM software has been released in Germany which was implemented in C programing on MS Windows 3.1. In the year 1998, the features of the software has been increased by graphical enhancement of 3D visualization. Dynamic assignment routing is introduced in order to address the larger scale application in the year 2000. In the year 2003 the COM interface provided allowed the user to operate the software externally with VISSIM in background. Even the pedestrian modeling has been implemented in the VISSIM based on the Helbing and Molnar model [16]. The stable release of PTV VISSIM is VISSIM 10 released in the year 2017. The ongoing development version is VISSIM 11.

VISSIM is a Multi modal simulation i.e. which can simulate more than one type of traffic such as vehicles including cars, buses, trucks, public transport, cycles rickshaw, auto and pedestrians. To run the traffic flow models in the VISSIM software mathematical models are included. It can simulate all types of roads such as freeways, arterials in different conditions. Heterogeneous traffic flows are very common in developing countries like India, Bangladesh etc. Heterogeneous mix condition comprises of motorized and non-motorized vehicles with no lane discipline [1, 19, 39] and the level of service experienced by different types of vehicles on the same road will be different in heterogeneous traffic conditions [38]. Microsimulation softwares are one of the best options for modeling of heterogeneous traffic flow scenarios due to its advantage in terms of safety, faster implementation, validation, as well as it is least expensive [2]. At present there are many microsimulation softwares available in the market. Among those VISSIM has got the flexibility to use because of its easy coding of road network, supporting GIS system and having wireless sensors which makes the software to perform more efficiently [3]. VISSIM is a behavior-based, time step-oriented and microscopic simulation software program for modeling diversified modes of transport operations such as rail and road-based public transportation in an accurate and realistic manner considering every aspect in detail. In addition to the vehicle simulation, VISSIM can also perform a simulation of the pedestrian base on the Wiedemann model [21].

The detailed vehicle to vehicle interactions and driver behavior are simulated in the VISSIM to create real field situations [6]. The advantage in the VISSIM when compared with other simulation softwares is that it can estimate desired as well as the unobservable quantities such as fuel consumption rates, toll revenues and vehicles pollutant emissions [2]. In VISSIM modelling of road network can be possible where in vehicles can move on any side of the road without any lane restrictions. The geometric features of the road with varying width can also be modelled in VISSIM. All these features enabling the model to represent the heterogeneous condition [1]. VISSIM offers user friendly GUI (Graphical user Interface) [37] environment allows the user to add vehicles and signal data to the existing base map. Usage of this tool further enhances the quality of animation in relation to traffic and transit operations [4]. In order to represent the traffic conditions of the signalized or un-signalized junctions in case of homogeneous or heterogeneous traffic flows the driver behavior parameters need to be selected and calibrated in a way that is simulating the actual field conditions. Where VISSIM has got different parameters to represent the real field conditions [32]. Later the validation of model can be achieved by testing the model with new set of inputs and by minimizing the error in the desired output. The previous experimental studies in relation to the adjustment and calibration of driver parameters as well as the validation of the model is summarized below.

III. REVIEW OF LITERATURE ON CALIBRATION AND VALIDATION OF MODEL

3.1 Driver Behavior Parameters

In VISSIM user can incorporate the driving behavior parameter to represent the same field condition in the simulation model. The behavior parameters such as, lateral behavior, the following behavior, car following model and lane change behavior etc. are considered in the model, among them the important parameter is a car following model which was implemented in VISSIM by Wiedemann 74 or Wiedemann 99.

The car following characteristics such as headway, safety distance, and standstill distance is considered in this study. Where the driver behavior parameters of Wiedemann 74 and Wiedemann 99 the default values are changed such that to incorporated the new values in the model in order to match the same field conditions in the simulated model. With the help of video graphic data, the lateral distance between the cars, two-wheelers and heavy vehicles are investigated [5]. The sensitivity analysis has been considered to find out the driver behavior parameters in which seven driving behaviors and four desired accelerations parameters are considered. Only these eleven parameters are considered because of their importance in judging the calibration values to represent the same field condition with minimum error [1]. When the model runs with default parameters it fails to reproduce the real values that are obtained from the field. So, the sensitivity analysis is done by choosing the correct parameters.

As the microsimulation models contains large number of parameters that are to be calibrated before the model that is used for prediction [17]. Mainly Wiedemann's traffic flow model assumes that the driver will be following one of four driving modes they are free driving, Approaching, Following and Braking [35]. The VISSIM incorporating the psychophysical perception model which was developed by Wiedemann (1974) [36, 42]. These Driver behavior parameters are developed to represent real-world situations as close as possible. The Wiedemann 74 model is suggested to use in the urban conditions where the Wiedemann 99 is proposed to use in inter-urban motorway or freeway.

3.2 Calibration and Validation

The term Calibration in VISSIM explains about the traffic model calibration which is a process of considering a set of parameters for making the actual representation of field conditions in the simulation model in VISSIM [31, 40, 44]. After the model calibration, the validation is done in which the new data conditions are given as inputs such as volumes, vehicle compositions etc. The error between the calibrated model delay and delay occurred at the field is measured. The model which is having an error with in the limit will be preferred [1, 9].

Where the system level calibration parameters include traffic compositions, traffic inputs, and vehicle route choice etc. it also requires operational calibration level parameters which includes safety distance, standstill distance, headway etc. [5]. In VISSIM the measures of effectiveness are used to calibrate delay, entry flow, queue length, and maximum queue length. For matching the field conditions in the traffic model the parameters within the model are adjusted which includes headway, speed, minimum gap time etc. [6]. Where as in VISSIM different variables are used in order to calibrate and validate the model. So, some of the major variables used in the VISSIM were Speed, Level of service, Lane configurations, signal timing, Vehicle composition, Gap-acceptance and rejection, Desired speed, Acceleration and Deceleration, Braking rate, Standing distance, Flow, Headway, Signal phase etc. As the input parameters will be varying depending upon the field conditions that to be represented in the model for validation [7].

For calibrating the VISSIM in the heterogeneous traffic condition such as in India the calibrating parameters that are modified are driver behavior parameters, acceleration or deceleration and desired speed distributions. The manual calibration to represent the actual field condition in the simulated model would take more time to eliminate the errors. So in order to minimize the error percentage, COM interface by mean of code facilitates the quick simulation of the VISSIM model. The COM interface got direct access to change only three Wiedemann parameters. By accessing IN0 file other parameters can be modified. With this COM interface, the parameter set is run through the optimization technique randomly until the least mean absolute percentage error (MAPE) obtained between the simulated value and actual field value. By this COM interface, the VISSIM can be operated by external tools such as python, C++, Java, Mat lab, Visual Basic etc. [1].

The advantage in VISSIM is that it can model any traffic condition such as public transit, private transit, and pedestrian etc. where the calibration is done to the public transit such that the separate routing is given for buses for bus stops and lay by. The volume calibration is calculated with the help of Geoffrey E. Havers formula [8]. The use of a genetic algorithm in the optimization of the parameters to minimize the error between the field and the simulated model. The genetic algorithm has a formula called global calibration which has been used to optimize the parameters of the model [9]. The genetic algorithm has been widely used in the process of calibration and validation of microscopic simulation model [41].

3.3 Advantages of VISSIM

In comparison to other microsimulation softwares VISSIM has specific features which makes its use more user friendly and adoptable, these advantages are outlined below.

- Every individual link can be edited separately for modeling driving behaviour parameters.
- The ready data available from the excel sheet can be copied and can directly pasted in VISSIM.
- With COM interface the external coding is possible which makes VISSIM work more easily.
- VISSIM has got vehicle routing decision a powerful tool that can access the high amount of turning movement's data [29].

IV. STEP BY STEP PROCEDURE FOR CALIBRATING AND VALIDATING OF TRAFFIC MODEL IN VISSIM

The basic step by step procedure of creating a traffic model in VISSIM is explained in detailed in the following flow chart (Figure. 2)

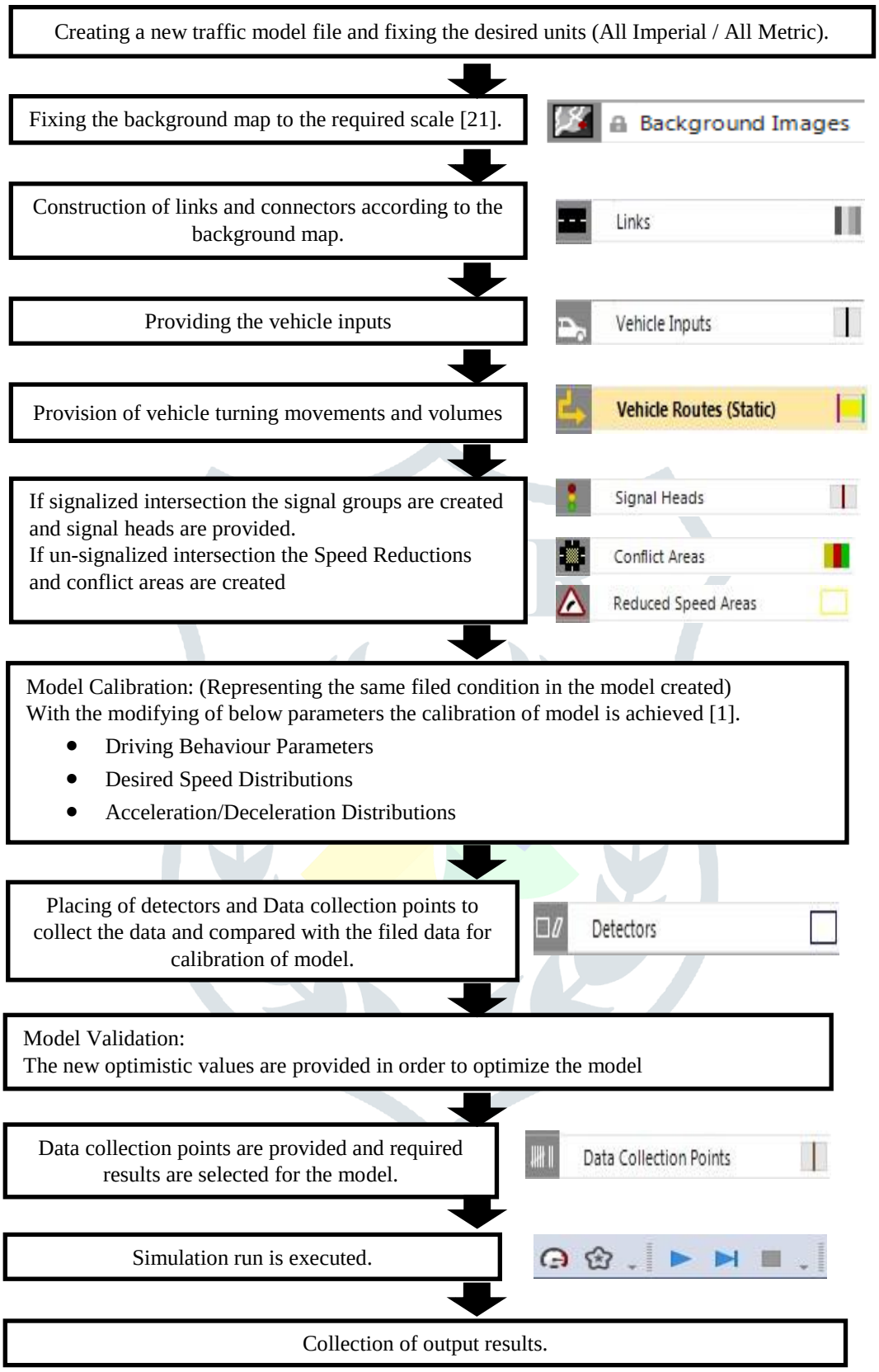

Figure 2: Step by step procedure of creating VISSIM Traffic Model

V. COMPARISON STUDY OF VISSIM WITH OTHER MICROSIMULATION SOFTWARES

With the rapid growth of vehicular volumes now a days making intersections more congestion and oversaturated. These conditions are to be minimized with the proper methods and techniques where the traffic simulation softwares are very help full in solving this type of conditions in an effective manner. At the present time there are many number of traffic simulation softwares

available in the market all around the world. Some of them are VISSIM, SIDRA, CORSIM, Advanced Interactive Microscopic Simulator for Urban and Non-Urban Networks (AIMSUN), SYNCHRO etc.

VISSIM and SIDRA simulation software results are compared by considering the actuality traffic data at West Wenhua Road and Changchun Road signalized intersection of Xianyang City. The main objective of this paper is to compare the simulation softwares by output error and the operation performance. Where the input factors such as road network construction is simple in SIDRA compared to VISSIM because it has got intersections which are already loaded in it thus the values are edited to get the required intersections where in VISSIM the road network is constructed according to the base map by fixing the scale and by providing driver routes etc. even the provision of signal timing, vehicle composition, and flow input is simple in SIDRA when compared with the VISSIM.

In the output factors both softwares will provide best results where the output speed is faster in SIDRA and the output error is very less in VISSIM compared to SIDRA. By considering all this factors the simulation was done for the signalized intersection by this the VISSIM has shown accurate vehicular delays in the output compared with the SIDRA [22].

The modeling of two lane and three lane roundabouts are considered in a city of Dohaby and compared their performances in two simulation softwares VISSIM and Sim-Traffic. Where the study illustrated that in case of higher traffic volumes the average delay showing better results in VISSIM compared with the Sim-Traffic and observed the similar output results in case of low traffic volumes. The delay studies were compared for both the softwares and it was shown that the results are strongly related with each other [25].

A study conducted at the four road urban signalized intersection (city of Surrey, Canada) three different parameters namely car-following model and safety-related parameters, the conflict spatial distributions, the relationship between the field measured and simulated conflicts, were analyzed using VISSIM and PARAMICS. The results showed that with proper calibration a good correlation was obtained between the simulated and field measured data [23].

The two microsimulation softwares VISSIM and Corridor Simulation (CORSIM) are the regularly used softwares to study traffic data because of their real approaches for different scenario [33]. These two simulation softwares ae compared in a study conducted at downtown Seattle, south of Central Business District considering the throughput and LOS. These two simulation models provides detailed output, animated graphics etc. in an effective manner. The comparison was done for the driver behaviour and vehicular behaviour etc. number of investigations were done on these two models on throughput and LOS. The similar results were shown in both simulating softwares at intersection level. The variabilities of the model has shown larger difference in both the softwares that can be possibly be eliminate by multiple simulation runs [24].

VI. MODELING OF VEHICLE EMISSIONS AND FUEL CONSUMPTIONS IN VISSIM

The rapid growth of vehicular traffic now a days making consumption of large amount of fuel and making emission of greenhouse gases into the environment causing problems to the public, environment and even to the economy [47]. So due to the emission of greenhouse gases into the environment the Global warming is caused more over the larger share of greenhouse gases are emitted from transportation that is from vehicular exhausts [45]. With the help of microscopic simulation models the vehicle emissions and fuel consumptions can be modelled. Also it is possible to calculate and predict future emissions in order to reduce the emission the greenhouse gases using individual vehicle speeds, acceleration of every single vehicle. Other alternative available simulating softwares for modeling the emissions of vehicle such as Sim-Traffic, AIMSUN2, WATSim, CORSIM, MicroSim, PARAMICS, MITSIM, PADSIM, and VISSIM [47]. VISSIM has got a separate add on EnViVer [49], which can analyse different types of emissions such as carbon dioxide, nitrogen oxide and particulate matter etc.

According to the Intergovernmental Panel on Climate Change (IPCC) the carbon dioxide emissions will be increasing from 40% to 110% within the time period of 2000 to 2030. Some of the pollutants that are considered from transportation are carbon dioxide, particulate matter etc. The model developed by the U.S MOVES has got the capacity to estimate the emission for every second that help to model to simulate in VISSIM software. This study has considered a 10 miles stretch considering four different approaches and estimated the emissions on road by manual calculation using speeds and volume counts. Then after the advanced tools of VISSIM or MOVES are used to develop a model and to analysis the stretch in different approaches. The results has provided more accurately on the simulating software by analyzing second to second emission values [46]. The study conducted at Florida considers optimal design in the microscopic model for highways in estimating CO2 emissions with MOVES or VISSIM which can estimate the emissions of vehicles for second to second. The study shows with the maintenance of 90% capacity in the freeways of speeds 55 to 60 mph it has been observed reduction of CO2 emissions and stated that speed has substantial importance in CO2 emissions when the acceleration, deceleration of vehicles operations are considered [48].

With the optimization of signal timings the fuel consumption and emissions of vehicles can be minimized, basically with the signal optimization the delays at junctions are reduced. This study has linked VISSIM, CMEM, and VISGAOST for minimizing the CO2 emissions and consumption of fuel. The study is considered at park city and signal optimization is done for different functions to find the lowest fuel consumption and emissions. The study stated that with CMEM function 1.5% fuel saving is achieved while the other functions were shown ineffective [50].

VII. CASE STUDY UNDER HETEROGENEOUS TRAFFIC CONDITION

Countries like India with heterogeneous traffic condition, non-lane based condition is most commonly observed. Under these traffic situations, the signal optimization can be achieved with the help of VISSIM by minimizing, the traffic delay and congestion.

7.1 Use of VISSIM for Reducing the Traffic Queues

In a case study conducted in Pune at three signalized intersection, it was found that better results of signal time design can be attained with the microsimulation software than the traditional methods of signal optimization. Results showed that long queue

lengths and conflicts are eliminated [10]. A similar study conducted at the four road junction in Visakhapatnam it was reported that waiting time was reduced by simulating the traffic conditions in VISSIM software. The data required for this simulation was collected using video-based techniques [11].

A case study conducted in Chandigarh city, VISSIM software was employed for minimizing the delay at four roads signalized junction. The calibration of VISSIM is achieved by changing the default driver behavior parameters [12]. In the Bangalore city, a model has been developed for determining the saturation flow and delay for three selected signalized junctions with the help of VISSIM software. The calculated saturation flow and delay are validated with the Highway Capacity Manual. So with the help of VISSIM microsimulation model, the reduction in delay, travel time and queue length have been achieved [13].

7.2 Use of VISSIM for Increase in Efficiency of Signalized Intersection

The interaction of vehicles & pedestrians at the junction in Chandigarh was simulated using VISSIM. In this study, the efficiency of the junction is improved with VAP (Vehicle Actuated Programming) signals. For simulation add on module of Viswalk was used for simulating the pedestrians movements [14]. The analysis has been done on isolated signalized intersection to reduce the cost of traveling, by improving the traffic flow and to reduce air pollution at Dhaka City, Bangladesh. While four alternative models were recommended for solving the issues which are simulated in VISSIM software to get better output result in reducing traffic congestion mainly during peak hour period [15].

In this study, a new methodology has been proposed for calibrating the microsimulation software under heterogeneous traffic condition. Based on the similarity observed in geometry and traffic characteristics at three Signalized intersections of two cities in Indian namely Jaipur and Trivandrum were selected for the study. In this new methodology, the calibration parameters are identified with the help sensitivity analysis and the delay error between the field and simulated model is optimized by genetic algorithm. It was proposed that simulation models need to be modified so as to exactly represent the unique characteristics of heterogeneous traffic and driver behavior [9]. In a case study conducted at Mehdipatnam, Hyderabad the traffic congestion problem is rectified with the help of existing technology along with the traffic management measures. In the process, a microsimulation model is developed and calibrated in VISSIM. The calibrated model was evaluated using traffic management measures. Finally, travel time, queue length and delays have been minimized [8].

Using VISSIM a heavy traffic flow during peak hours at Chennai was modelled in this study the parameters which are affecting the driver behavior in Indian heterogeneous conditions are found through sensitivity analysis. Where calibration of VISSIM model was done with the help of C++ interface and the optimal combination of sensitivity analysis during calibration was achieved values with the help of a genetic algorithm. For the developed model the sensitivity and calibration was done in three different levels by considering discrete driver behavior parameters. This study revealed using VISSIM it possible to include all possible parameters during sensitivity analysis of heterogeneous traffic [1]. In a case study conducted traffic flow at the four-legged uncontrolled intersection in the state of Maharashtra, is modelled using VISSIM to determine the volume to capacity proportions of turning movements. The driver behavior parameters in this location were taken based on homogeneous movements. Based on the HCM 2010 procedures the gap acceptance capacity is calculated [5].

VIII. CONCLUSION

The microsimulation software VISSIM provides the signal optimization for traffic flows at intersections. Modification required in respect to driver behavior parameters for simulating heterogeneous traffic flow in VISSIM requires great attention compared to homogeneous traffic flows. The driver behavior parameters are chosen in such a way that the error between the actually observed and simulated values are minimized. In most of the cases the sensitivity analysis is done to choose the best parameter and also proposed new methodologies in such a way that the heterogeneous traffic conditions are represented as on field in VISSIM software. The case studies summarized herein explores the methodologies adopted in minimizing traffic queues and maximizing the efficiency of signalized intersections.

IX. ACKNOWLEDGEMENT

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