Vissim as a Simulation Tool for AnalyzingOver-Saturated Signalized Urban Intersections with Heterogenous Traffic

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ABSTRACT: Simulation of heterogenous traffic is a modern approach to intersection analysis. In this process, the various modes of vehicles are directly input into the analysis without utilizing any conversion factors, thereby reducing the scope for errors significantly. Further, this process is a visual simulation, wherein the analyst can review the output in video format and calibrate the simulation model to replicate field conditions, thereby increasing the accuracy of the simulation significantly. In this study, Vissim software was utilized for heterogenous traffic at urban signalized intersections with over-saturated conditions. Various lane configurations and modes of vehicles were simulated in Vissim. The simulation software was further tested for sensitivity to various factors such as vehicle dimensions and speed of vehicles. It was determined that Vissim has some limitations, which may be overcome through software coding. Further, it was determined that irrespective of such limitations, Vissim is highly suitable for heterogenous traffic analysis.

KEYWORDS–*Vissim, Simulation, Signalized Intersections, Heterogenous Traffic*

1. Introduction

The traditional method of analyzing urban signalized intersections with heterogenous traffic includes the process of converting all the modes of the traffic into equivalent car units, i.e., Passenger Car Units (PCU). For this purpose, each mode of vehicle is assigned a PCU factor. For example, a 2-wheeler is usually assigned a PCU factor of 0.5, i.e., two 2-wheelers would be equivalent to one car. Further, the process requires determination of several other factors such as Capacity and Saturation flow. Such conversion factors are prone to error and may be significantly varying depending on several other conditions. Considering that the traditional methods are several decades old, it can be stated that the conclusions of the traditional methods are commendable. However, with the advent of new technology, it is time to revisit the situation and pursue new methods for resolving the problems.

Visual simulation is one such a new technology for heterogenous traffic. Utilizing simulation as a tool for heterogenous traffic eliminates the need to convert the traffic into any other mode. All the modes of the traffic could be directly entered as input into the simulation software, which greatly reduces any assumptions related to PCU. Further, a visual simulation software provides the output in a video format, which allows an analyst to review the simulated conditions and the field conditions, and thereafter calibrate the simulation software to replicate the real-life conditions. Such a calibration is easier to justify and can also be visually reviewed. Further, such calibration of the software improves the model accuracy significantly.

Vissim software was extensively used for several projects in India over the last five years. However, most of the studies are not related to intersections. Further, the few studies that are related to intersections do not explore the depths of the software and its capability for specific aspects related to the intersection saturation flow or capacity. Another interesting aspect to be noted is that most of these studies converted the input into PCU and then utilized the simulation software, thereby, reducing the benefits of the software.

This study reviews Vissim software in detail for the purpose of urban signalized intersection saturation flow and capacity for heterogenous traffic conditions with over-saturated traffic volumes. The study explores the behavior of the software to various modes of traffic individually for situations such as 2-wheelers only lanes, trucks only lanes, etc. Then, the study explores the software for collective modes of the traffic to review the heterogenous traffic behavior. Numerous combinations and permutations were explored in this study which comprised of the lane configurations, lane widths, speeds, signal timing, etc. Further, the software was subjected to sensitivity analysis to review the potential applications to other studies, locations and time periods, with regard to the changes to the vehicles dimensions also. This study elaborates the methodology and the results achieved in these aspects

2. Vissim as a Simulation Tool

As stated earlier, the traditional method of intersection analysis includes utilizing PCU factors. However, the PCU factors vary significantly, as shown in Table 1 [1 and 2].

Table 1: PCU Factors for Intersections

Vehicle Mode	IRC:SP:41 (1994)	Indo-HCM (Chapter-6)	Other Studies
Two-wheelers	0.5	0.2 - 0.75	0.05 - 1.06
Three-wheelers	1.0	0.3 - 1.0	0.34 - 0.96
Cars	1.0	1.0 - 1.5	0.98 - 1.03
Light Trucks	1.5	1.0 - 2.0	1.10 - 3.10
Mini Bus / Tempos	1.0	-	1.17 - 2.68
Bus	3.0	1.5 - 4.0	1.79 - 6.10
Heavy Trucks	4.5	1.5 - 4.0	1.89 - 6.10
Pedal Cycles	0.5	0.2 - 0.5	0.14 - 0.24
Cycle Rickshaws	1.5	1.5 - 4.0	1.80
Hand Carts	3.0	4.0 - 8.0	4.00
Horse Drawn Carts	4.0	4.0 - 8.0	-
Bullock Carts	8.0	4.0 - 8.0	-

From these PCU factors, it can be observed that the PCU factors varies in some cases by more than 3 times. This variance could result in huge errors, some times more than 50% also, depending upon the traffic composition. Hence, the traditional method of intersection analysis has certain limitations. However, with the advent of new technologies, such as visual simulation tools for heterogenous traffic, it is possible to overcome such limitations and errors.

For this study, Vissim software version 10.00-10 was used. PTV Vissim is a leading software being used extensively for various traffic scenarios. The software has several options such as various modes of traffic, lane distribution, vehicle composition, traffic signal timing, speed of vehicles, acceleration & deceleration rates, lateral distance, gap between vehicles, decision making distance, etc. Thus, the software is suitable for micro level simulation also.

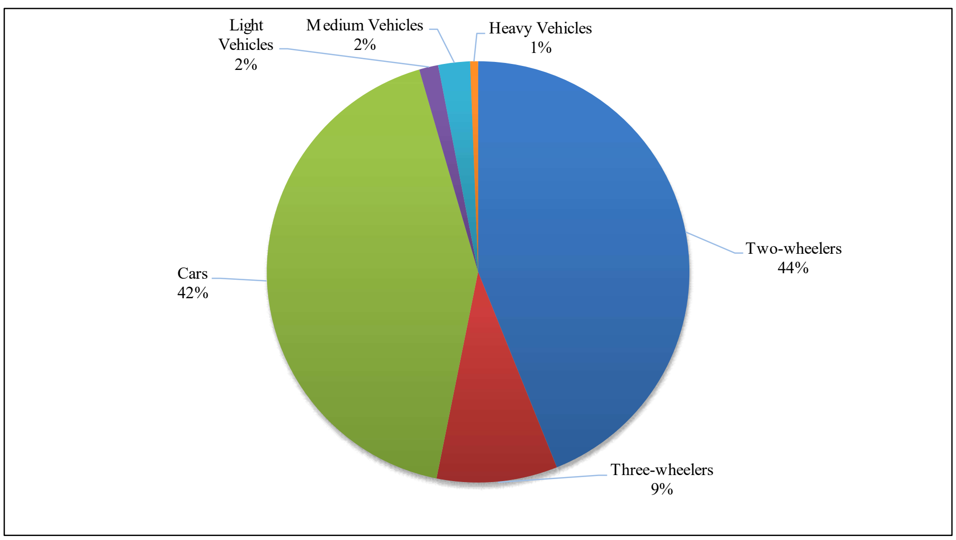
The study was based on the field conditions in Hyderabad, Telangana, India. For this study, several default parameters of Vissim were customized to replicate local field conditions. The dimensions of each mode of vehicles maintained the same, i.e., each mode of the vehicle was provided with the same dimension. It should be noted that Vissim has an option to input numerous cars, with various dimensions. However, based on detailed analysis, the vehicles modes and their dimensions were standardized as noted in Table 2.

Table 2: Modes and Dimensions of Standard Vehicles

Sl. No.	Mode	Length (m.)	Width (m.)
1	Two-wheelers	2.063	0.778
2	Three-wheelers	3.018	1.422
3	Cars	4.402	1.797
4	Light Vehicles	4.206	1.737
5	Medium Vehicles	6.844	2.245
6	Heavy Vehicles	10.619	2.488

Some of the other parameters included modification of the vehicle parameters such as acceleration & deceleration rates, gaps between vehicles, lateral spacing, decision making distance, etc., which were based on field observations, trial runs, literature review, vehicles manufacturer specifications, etc. The network speed was restricted to 40 kmph to meet the local field conditions. Further, based on numerous traffic volume counts in the area, the vehicle composition was determined as noted in Figure 1.

Figure 1: Traffic Composition for Simulation



Numerous scenarios were tested in the simulation software. Such scenarios included different geometric configurations, different modes of traffic independently, heterogenous traffic, lane configurations, etc. To replicate real-life conditions, the model was allowed to run initially for 30 minutes to allow for queue build-up (i.e., seeding the model). The results after such queue build-up were considered. The Saturation flow and the Capacity was identified independently for each mode of the traffic. Then, the model was reviewed for heterogenous traffic wherein all the six modes of the vehicles were input. The interaction of the heterogenous traffic exhibited certain inconsistencies with the field observations. Then, the input parameters were suitably modified and all the models were re-run again. This process of iterative runs was continued until all the modes individually (i.e., homogenous condition) and collectively (i.e., heterogenous conditions) replicated real life observations. Such observations were also compared with earlier studies through literature review and were found to be acceptable. The model parameters were subjected to sensitivity analysis with various changes to the vehicle dimensions also. All the obtained results were validated for errors, accuracy and precision by comparing the results with field observations and against earlier studies. For consistency and comparison, all the simulation runs were made with the same parameters.

From the various runs, the following observations were made:

- The output volume in Vissim was limited and was not able to replicate very high traffic volumes. Such high volumes are not possible under homogenous traffic conditions, similar to developed countries. But, for heterogenous traffic, in certain locations, such high traffic volumes were observed in the field.

- Under heterogenous traffic conditions, when the intersection was provided with a continuous green signal for one-hour (i.e., 3600 seconds) to replicate the saturation flow, then the results were found to be similar to a mid-block scenario. But, when the signal was provided a red phase, it allowed the vehicles to queue up, wherein the high maneuverable vehicles were observed to occupy the gaps and spaces between large vehicles, and therefore exhibited higher output traffic volume. This behavior of occupying the gaps was similar to the field conditions.

- For short link lengths, due to the queue, certain vehicles were not generated into the model, but high maneuverable vehicles were observed to be generated. Further, even for the conditions with long road links, it was observed that certain vehicles were blocking each other and reducing the capacity drastically.

- When a "single lane" (i.e., a lane without any lane discipline, say one lane of 10.5 m wide) was considered, against "multiple lanes" with the same total width (say 3 lanes each with 3.5 m wide), then, the model exhibited significantly higher output under the "multiple lanes" condition due to the "stream lined" traffic behavior. From field observations it was noticed that even though the intersections did not have marked lanes, the traffic indeed behaved similar to marked lanes to a large extent, similar to the model results.

- The model with multiple lanes exhibited lower capacity per lane, which was similar to several literature review.

- An interesting aspect of the Vissim software was that vehicles could move in lanes narrower than the vehicle dimension, which is not practically possible. However, when multiple lanes were provided, the lateral spacing between the vehicles did not allow such movements.

- A few other minor limitations were observed with the software. But it was noted that with software coding most of such limitations and some of the above noted observations may be overcome.

- The ideal lane width was also identified for each mode of the vehicle as noted in the Table below.

Table 3: Ideal Lane Width for various modes of Vehicles

Sl. No.	Type of Vehicle	Ideal Lane Width (m)
1	Two-wheelers	1.0
2	Three-wheelers	1.6
3	Cars	2.1
4	Light Vehicles	2.1
5	Medium Vehicles	2.7
6	Heavy Vehicles	2.8

3. Results and Discussion

More than 600 runs were made in this study. However, the selected results with heterogenous traffic conditions are noted in the Table below.

Table 4: Saturation Flow for various Lane Configurations and Scenarios

Scenario 1 (Multiple Lanes)		Scenario 2 (Single Lane)	
Lane Configuration	**Veh. / Hour / Lane**	**Lane Configuration**	**Veh. / Hour / Lane**
Through Movement			
2.1 m X 1 Lane	3,206	2.1 m X 1 Lane	3,206
2.1 m X 2 Lane	2,489	4.2 m X 1 Lane	2,065
2.1 m X 3 Lane	2,049	6.3 m X 1 Lane	1,880
2.1 m X 4 Lane	1,905	8.4 m X 1 Lane	1,714
Left Movement			
2.1 m X 1 Lane	3,911	2.1 m X 1 Lane	3,911
2.1 m X 2 Lane	3,012	4.2 m X 1 Lane	2,457
2.1 m X 3 Lane	2,469	6.3 m X 1 Lane	2,219
2.1 m X 4 Lane	2,266	8.4 m X 1 Lane	2,040
Right Movement			
2.1 m X 1 Lane	2,885	2.1 m X 1 Lane	2,885
2.1 m X 2 Lane	2,203	4.2 m X 1 Lane	1,817
2.1 m X 3 Lane	1,762	6.3 m X 1 Lane	1,626
2.1 m X 4 Lane	1,659	8.4 m X 1 Lane	1,521
Scenario 3 (Multiple Lanes)		**Scenario 4 (Single Lane)**	
Lane Configuration	**Veh. / Hour / Lane**	**Lane Configuration**	**Veh. / Hour / Lane**
Through Movement			
3.5 m X 1 Lane	3,864	3.5 m X 1 Lane	3,864
3.5 m X 2 Lane	2,279	7.0 m X 1 Lane	1,824
3.5 m X 3 Lane	1,898	10.5 m X 1 Lane	1,693
3.5 m X 4 Lane	1,810	14.0 m X 1 Lane	1,588
Left Movement			
3.5 m X 1 Lane	4,694	3.5 m X 1 Lane	4,694
3.5 m X 2 Lane	2,846	7.0 m X 1 Lane	2,211
3.5 m X 3 Lane	2,277	10.5 m X 1 Lane	2,008
3.5 m X 4 Lane	2,154	14.0 m X 1 Lane	1,987
Right Movement			
3.5 m X 1 Lane	3,404	3.5 m X 1 Lane	3,404
3.5 m X 2 Lane	2,039	7.0 m X 1 Lane	1,614
3.5 m X 3 Lane	1,642	10.5 m X 1 Lane	1,459
3.5 m X 4 Lane	1,546	14.0 m X 1 Lane	1,356

It was observed that the traditional design values such as a lane with 3.5 m. wide are not required for urban conditions. A lane width of 2.1 m, was suitable for more than 97% of the vehicles in urban conditions. Further, the remaining few vehicles, when present, would occupy more width than the lane, but due to human behavior, such conditions provided higher traffic output. This observation is similar to the field conditions.

It was also noted that the vehicles could be directly input into the model without any need for converting into PCU. Such conditions provided for high accuracy results. It is probably time for the traditional analysis based on PCU to be set aside and to conduct the analysis based on vehicles.

Further, under the sensitivity analysis, it was noticed that the speeds and lengths of the vehicles affected the saturation flow as per expectations. However, when the widths of the vehicles were increased, the model saturation flow reduced drastically, which is attributed to the ideal lane widths. Hence, if the design vehicle widths are increased, the ideal lane widths should also be modified.

4. Conclusions

The Vissim software is suitable for most of the traffic conditions in India, which includes heterogenous traffic. Certain modifications to the model default parameters are required before utilizing the model directly for Indian conditions. Lane markings are highly recommended for achieving higher output at signalized intersections. The model identified the capacity of exclusive lanes such as 2-wheeler only lanes, 3-wheeler only lanes, truck-only lanes, etc., which would be useful for special road designs.The design standards may be modified based on the results of this study so that the roads are not widened unnecessarily thereby saving huge amounts of money, including the need for land acquisition. This study does not review the road safety aspects related to the reduced lane widths, and hence, caution is recommended before modifying the design standards.

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