International Journal of Computing and Digital Systems
ISSN (2210-142X)
Int. J. Com. Dig. Sys.8, No.5 (Sep-2019)
http://dx.doi.org/10.12785/ijcds/080509

Calibrating Traffic Microsimulation Model for Bahrain and Estimating Traffic Impacts of a Mall on Road Network

Uneb Gazder[1], Mahmoud Hamed Mahmoud Saleh[1], Yazan Mohammad Al Zoubi[1], Omar Mohammed[1] and Khalid Abdul Nasser Alhalabi[1]

[1] Department of Civil Engineering, University of Bahrain, Isa Town, Bahrain

Received 29 Nov. 2018, Revised 23 Apr. 2019, Accepted 29 Aug. 2019, Published 1 Sep. 2019

Abstract: Traffic simulation programs such as VISSIM are frequently used worldwide as a tool, for analyzing transportation problems, with minimum cost. Traffic simulation is an effective approach for finding out the benefits and limitations of different alternatives. Advancements in computer technology have led to the development of high-quality microscopic simulation models. The calibration of a simulation model is the main step for obtaining any representative results from the analysis. Therefore, objectives of this study include; to calibrate a microscopic simulation model using VISSIM for Bahrain and to estimate the effects of construction of a new mall using the calibrated microscopic simulation model. The study location was Avenue 27, Saar, Kingdom of Bahrain. Traffic data from two intersections of this avenue, which were in the vicinity of a new mall (El Marcado), was collected for the period before and after the construction of the mall. The road segment between the intersections had a length of 600m. The posted speed of the road is 50Km/hr. Ministry of Works provided the data for straight movement on this segment and proportion of turning movements were estimated from a dataset collected by the research team for a shorter time period in AM and PM peak hours. A microsimulation model was calibrated on the studied segment using the dataset collected by the research team. Default values for several parameters such as volume, average travel time and average travel speed were modified to replicate field conditions. The results with the modified values showed no significant discrepancy between the model simulation and the field observed values. The simulation model was run on the data provided by the ministry for the periods before and after construction of the mall. The simulation results showed a clear deterioration in traffic conditions on the overall network and more specifically for turning movements towards the mall. Increase in traffic, due to the mall, reduced Level of Service (LOS) on the intersections and doubled the queue length and delay on them. The environmental estimation method in VISSIM was not found to be effective in accurate simulation of emissions and fuel consumption.

Keywords: VISSIM, Bahrain, Microscopic Simulation, Mall Construction, Traffic Impacts

1. Introduction

The expanding power of computer technologies, the advancement of software engineering and the intelligent transport systems has made traffic simulation to be one of the most utilized approaches for traffic analysis [1]. The capability of traffic simulation, to copy the time variability of traffic phenomena, makes it a special tool for capturing the complexity of traffic systems.

Traffic simulation is considered as a mathematical model of transportation systems. These systems may include, freeway junctions, roundabouts and arterial routes, etc. Traffic simulation programs allow us to plan, design and operate transportation systems in an accurate manner [2]. Traffic simulation started over forty years ago, and presently considered to be an important discipline in transportation planning and traffic engineering [3]. Traffic simulation can help to study the models which are too complicated for analytical or numerical treatment. Moreover, it can be used for experimental studies to study the detailed relations that could be lost in analytical or numerical treatment. It can also produce appealing visual demonstrations of present and future scenarios.

Microsimulation is basically considered as a class of computerized analytical tools that is used to find a detailed analysis of activities such as; traffic flows through a highway/intersection(s). Microsimulation modeling of traffic flows is based on the description of the motion of each single vehicle which is part of the traffic stream. It is becoming the most used standard for the development and evaluation of road traffic management and control systems worldwide [4]. Moreover, microsimulation can simulate the movement

E-mail address: unebgazdar@gmail.com, mahmood95.uob@hotmail.com, ymz-95@hotmail.com, om.alazawi97@gmail.com, kalhalabi38@gmail.com

and interaction of existing structures. Also, it continuously predicts the state of each single vehicle and primarily focuses on individual vehicle locations and speeds. Therefore, it can be said that any innovative solution, designed to solve traffic problems, can be evaluated from many aspects using a traffic simulation model.

In this study, PTV VISSIM was used as the tool for microsimulation. The name “VISSIM” is derived from the German words “Verkehr In Städten SIMulationsmodell” which means “Traffic in cities - simulation model”. VISSIM was developed by PTV (“Planung Transport Verkehr”), Karlsruhe, Germany [5].

Despite the useful features of VISSIM, there is no study found for its calibration in Bahrain. Moreover, its use for traffic impact assessment is rarely found. The studies found thus far [6,7] are either focusing on emissions modeling, which is not found to be a strong feature of VISSIM in this study, or they are using other simulation programs. Hence, this study is focused on fulfilling these gaps in the present literature.

The objectives of this study are as follows: calibrating a microscopic traffic simulation model for Bahrain using VISSIM and using the model to evaluate the traffic impacts of a new mall in the study area. The study area was an avenue with two intersections in Bahrain.

A student version of the PTV VISSIM program was used in this study to perform microsimulation. This version contains a number of restrictions which are listed below:

- Size 1 x 1 km
- 10 signal controllers
- No pedestrians
- Max. 600 simulation seconds

1. Literarure Review

Several well-known simulation models, such as VISSIM, CORSIM, Paramics, SimTraffic and Synchro, are currently used in the world. The proceeding sections give brief description about traffic simulation and discuss the advantages of VISSIM software. Some examples are also provided related to the use of VISSIM in previous traffic simulation studies. Lastly, previous work related to use of VISSIM for environmental emissions has been presented.

A. Traffic Simulation and Its Development

Traffic simulation has become popular over the last few decades. It is a very effective and popular tool, used for analyzing the problems which occur in transportation and require complex analytical computations. Using simulation, transportation specialists can study the dissipation and formation of blockage on roadways, evaluate the impacts of control strategies, compare alternative geometric configurations and evaluate impacts on land use developments [8].

Traffic simulation models attempt to imitate a population of drivers in a theoretical highway network. Over the past three decades, a considerable variety of complicated computer models, that can simulate various traffic operations, have been created. Traffic simulation models can be categorized as static or dynamic, and microscopic or macroscopic [1]. Each simulation model has its own logic and limitations, which determines its application for specific components of a transportation system.

B. Microscopic Simulation

The classification of traffic simulation models is based on the level of accumulation. Microscopic models consider the behavior of each single vehicle, and its interactions with other vehicles in the traffic stream. Therefore, they can simulate traffic operations in detail but usually need detailed inputs and longer execution times. Analytical procedures are incorporated in these models to evaluate existing conditions and to predict performance under different design and control scenarios [9].

Microscopic traffic simulation models include physical components, such as the roadway network, traffic control systems, and driver-vehicle units. They also include behavioral models such as driving behavior models and route choice models. These components and models have complicated data requirements and need a large number of model parameters. Microscopic simulation modeling combines queuing analysis, shock-wave analysis, and other analytical techniques [9].

C. Calibration and Validation

The viability of a traffic simulation model in evaluating traffic management strategies lies in its ability to accurately replicate actual traffic conditions. This requires proper calibration of its parameters which may differ from the default values. Calibration is the process in which the parameters of the simulation model are determined to a point which makes it possible to obtain a close match between the simulated and the actual traffic measurements. The traffic parameters primarily include speed, occupancy and volume. In other words, calibration is an iterative process which allows the engineer to modify the simulation model parameters until the results produced by the model is the same as those from the field measurements. Comparing the outcomes of the simulation with field data, which has not been used in the calibration, is referred to as validation [10].

D. Microscopic Simulation Programs

Some of the existing microscopic traffic simulation programs include; VISSIM, CORSIM, Paramics, SimTraffic, Synchro, AIMSUN, INTEGRATION, TEXAS (Traffic EXperimental Analysis Simulation). For a long period of time, CORSIM was the industry standard and most commonly used software for microscopic traffic simulation. Recently, VISSIM has gained popularity and now competes with CORSIM as one of the most widely used microscopic traffic simulation software in the world. Other commonly used models include SimTraffic, Paramics and Synchro.

VISSIM is a microscopic, time step, and behavior-based traffic simulation computer program. It can model public transit operations and urban traffic and can analyze traffic (cars, trucks, pedestrians) and transit (buses, trains, trams) operations under restrictions such as traffic composition, lane configurations, transit stops, traffic signals etc. This program can be used for freeway operation studies to simulate interchange configurations, merging, weaving movements and ramp [5].

VISSIM has a graphical user interface, which allows the user to add traffic and signal data to existing base maps of intersections and road layouts. This unique feature reduces the workload required for data input, and it also improves the quality of animation of traffic and transit operations. In contrast to other simulation models, VISSIM's complicated vehicle simulation model allows the user to precisely analyze traffic/transit interactions such as curbside bus stops [11].

Researchers and academicians have been favoring VISSIM for multiple applications. Kaseko [12] has mentioned the following reasons for this trend: multimodality, maximum accuracy to detail, virtual testing of autonomous vehicles, ease of use and productivity, 2D and 3D visualization, and strong customer service.

Related to the studies done in the middle eastern countries, a study was found in which a microscopic simulation model was calibrated and validated for Saudi Arabia using VISSIM. The researchers calibrated the VISSIM model for the traffic conditions in Al-Khobar, Saudi Arabia by modifying the default values of the number of observed vehicles, additive and multiplicative parts of desired safety distance, amber signal decision, and distance required in changing lanes. VISSIM has also been used to successfully develop a microsimulation model for Dammam, Saudi Arabia [13].

E. Traffic Related Impacts of Commercial Development

Traffic impact studies are often required by the state authorities for commercial projects including shopping malls. In most of the cases, these studies are limited to estimating the extra trips generated by the development on the adjoining network. These trips are often calculated using pre-defined rates such as those given by Institute of Transport Engineers (ITE) or other local agencies [14]. However, these rates do not take in to account other impacts such as; changes in driver behavior, environmental emissions and fuel consumption [15].

Traffic simulation programs, especially VISSIM, have been used to evaluate the impacts of fuel consumption and emissions due to different traffic management strategies [16]. In addition to the inherent estimation model of VISSIM, other emission models have also been integrated with success by some researchers. One of such models was Passenger Car and Heavy Vehicles Emission Model (PHEM) [17]. However, emission model used by VISSIM is known as EnViVer [16]. It is a statistical model which calculates the CO_2, NOx and PM_{10} emissions using the speed-time profile of vehicles [19]. This model has been proved to perform well in comparison to other estimation methods such as COPERT IV [20]. However, other studies have also recommended to calibrate the simulation model effectively before applying the emission estimation model [21].

Presently, the authors could not find any studies in which VISSIM has been used to evaluate the traffic and environmental impacts of commercial project.

TABLE I. VALIDATION CRITERIA [4]

Parameters	**Description**	**Validation criteria**
Average travel time	The difference in values between the average travel time measured by the floating car technique (provided by the ministry of works) and that from the simulation model	$\pm$ 1 standard deviation
Average travel speed	The difference in values between the average travel speed measured by the floating car technique (provided by the ministry of works) and that from the simulation model	$\pm$ 1 standard deviation

2. RESULTS AND DISCUSSION

Table II presents the summary of volume count data for each lane in the AM and PM peak hours. Preliminary values, calculated from the volume data, are also shown. These values included heavy vehicle factor (HVF) as a percentage and peak hour factor (PHF). HVF was the proportion of heavy vehicles (trucks and buses) from the total volume. PHF is the ratio between peak hour volume and peak flow rate in that hour.

It can be observed from table II that volume is generally higher in the AM peak hours as compared to PM peak hours. There is no notable difference in the PHF in different directions or hours. However, the proportion of HVF was significantly higher for the AM peak as compared to the PM peak hours for both directions.

Table III shows the roadway geometry data which was measured by the researchers in the field. The lane widths were found very close to the standard values of 3.6 m. The gradient of the road was mild, so it could be considered as a level terrain. Width of node 1 was higher as it was connecting to a major highway.

A. Calibration and Validation

The speed and travel time data provided by the ministry of works, in addition to the above-mentioned data collected in this study, was used for calibration.

Speeds and travel times were calculated to validate the results using the validation criteria table I.

10 vehicles were chosen randomly from the simulation and their speeds and travel times were calculated for each peak hour in each lane. It is an approach used by Nyame-Baafi et al. [22] for unsignalized intersections which was also present at avenue 27. A comparison was made between the introduced speeds and the speeds provided by the ministry of works using the validation criteria given in table I. Table IV presents the results of this comparison. Wherein ASTS is average simulated travel speed, SSTS is standard deviation for simulated travel speed, ATSM is average travel speed from ministry, ASTT is average simulated travel time, SSTT is standard deviation of simulated travel time and ATTM is average travel time from ministry. It can be observed from table IV that the validation criteria were satisfied in 3, out of 4, trials. Hence, the accuracy of simulation model can be considered reasonable at default values and further calibration was not required.

TABLE II. SUMMARY OF VOLUME DATA FOR CALIBRATION

Lane 1 (AM peak hour)	
Peak hour	6:40-7:40
Peak hour volume for lane 1	883
Volume in this hour for lane 2	692
Total Volume	1575
HVF (%)	9.2
PHF	0.802
Lane 2 (AM peak hour)	
Peak hour	6:45-7:45
Volume in this hour for lane 1	881
Peak hour volume hour for lane 2	696
Total Volume	1577
HVF (%)	9.1
PHF	0.803
Lane 1 (PM peak hour)	
Peak hour	14:10-15:10
Peak hour volume for lane 1	1280
Volume in this hour for lane 2	228
Total Volume	1508
HVF (%)	1.9
PHF	0.782
Lane 2 (PM peak hour)	
Peak hour	14:50-15:50
Volume in this hour for lane 1	897
Peak hour volume for lane 2	308
Total Volume	1205
HVF (%)	1.7
PHF	0.756

TABLE III. ROAD GEOMETRY

Parameter	**Value**
Length of the road	600 m
Lane width	3.5 m
Width of intersection 1	7 m
Width of intersection 2	9 m
Gradient	0.36%

B. Before and After Analysis

Volume provided by the ministry for each link is given in table V. The data was run in the calibrated simulation model of VISSIM and the traffic and environmental parameters were calculated. Due to the limitation of student version of the software, the simulation could only be run for 10 minutes. But this period can be considered sufficient to observe the difference in traffic and environmental factors due to mall construction.

It can be noted from table V that the volumes to and from the main highway (links 6 and 11) has the highest movement in all cases. Furthermore, the number in the parenthesis show the % increase in volume of each link. For e.g., the increase in volume on link 11 in PM peak hour was 14.64%. In the PM peak hour, the traffic on the links joining the Shaikh Salman highway (6) showed higher growth. This could be partly due to increase in residential population in the same area from which people would travel towards offices and school/college in the morning.

TABLE IV. VALIDATION RESULTS

	Lane 1 (AM peak)	**Lane 2 (AM peak)**	**Lane 1 (PM peak)**	**Lane 2 (PM peak)**
ASTS	37.86 km/h	36.76 km/h	44.13 km/h	48.81 km/h
SSTS	6.36 km/h	5.87 km/h	7.58 km/h	3.97 km/h
ATSM	30.00 km/h	42.40 km/h	40.50 km/h	51.60 km/h
Valid.	(30.00-37.86)>6.36	(42.4-36.76)<5.87	(44.13-40.5)<7.58	(51.60-48.81)< 3.97
ASTT	58.45 s	59.93 s	50.46 s	44.52 s
SSTT	9.31 s	10.53 s	9.83 s	3.61 s
ATTM	71.43 s	50.54 s	52.9 s	41.50 s
Valid.	(71.43-58.45)>9.31	(50.54-59.93)<10.53	(52.9-50.46)<9.83	(44.52-41.50)< 3.6

TABLE V. COMPARATIVE VOLUMES

Link	2016 PM	2016 AM	2017 PM	2017 AM
11	833	270	955 (14.64)*	340 (25.93)*
3	28	29	34 (21.43)*	40 (37.93)*
9	88	39	101 (14.77)*	36 (-7.69)*
2	24	33	29 (20.83)*	34 (3.03)*
6	899	1229	1074 (19.47)*	1278 (3.99)*

* % increase in traffic volume

The results obtained from the calibrated VISSIM model, after running the simulation for each case, are shown in tables VI – IX.

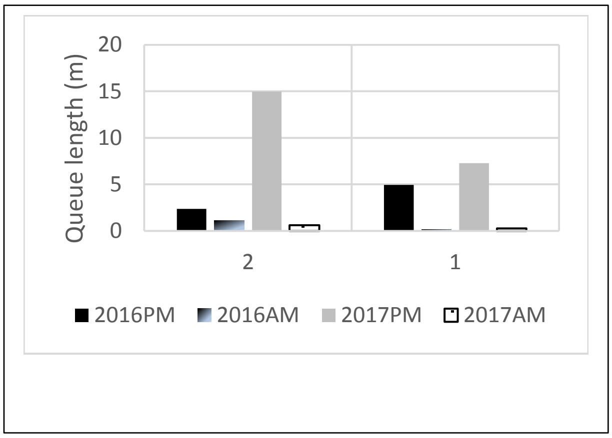

Figure 1. Comparison of Queue Lengths at Nodes

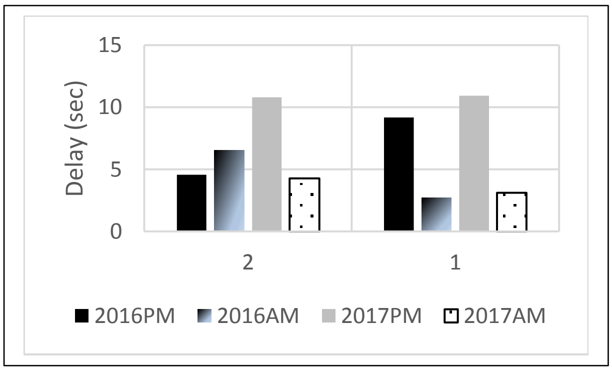

Figure 2. Comparison of Delay at Nodes

The queue lengths, shown in tables VI to IX, are generally higher for turning movements (4-8, 3-6 and 3-11) which could be attributed to the higher volumes on through movements providing less opportunity for the turning movements. The queue length was also higher for through movement 6-6 which can be due to the fact that this link has 2 lanes which are merged in to one lane after node 1. The differences, between 2016 and 2017, in increase of queue length and delay for AM peak hours have generally been lower than PM peak hours. On node 1, highest delays were observed for movement from minor road at node 1 towards avenue 27 (3-6) in all cases. This could be attributed to the fact that it is a minor road which is merging in to the direction avenue which contains highest volume (see table V) in the study network. The construction of mall has resulted in degrading the LOS of both nodes from A to B.

The main impact of the mall can be observed in the PM peak hour for movement 4-8 which is a left turn for the travelers coming from Shaikh Salman highway. the increase in queue length was 15m and that for delay was 15 sec for this movement, as compared to PM peak hour of 2016. This could mean that shoppers are coming towards the mall from areas outside Saar which are connected by this highway. Another movement towards the mall is 11-8 which has not shown any significant impact in terms of queue length or delay in the PM peak hours. This trend could be indicative of the above-mentioned fact.

With regards to the environmental factors, simulated model did not show any significant difference between 2016 and 2017 for any case. Moreover, there was no consistency shown between higher queue lengths and delay and environmental parameters. Table V also shows that links 6 and 11 have highest volumes in 2016 as well as 2017. Hence, emissions and fuel consumption are higher for through movements. Therefore, it could be said that VISSIM model was not effective in calculating environmental factors, more specifically, for turning movements. Further improvements in estimating these factors, especially for turning movements, could be achieved by more rigorous calibration or perhaps employment of a different environmental estimation model. This trend would also justify the use of environmental estimation models employed in previous studies [17,20].

Due to the above-mentioned issues with environmental factors, comparison for nodes were only made for traffic parameters in figures 3 and 4. It could be observed that node 2 has higher values for AM and PM peak hours in both years. The highest queue length and delay was observed for node 2 in PM peak hour of 2017. The increase in queue length was almost 10m higher for this case than any other time of 2016 or 2017. Consequently, the delay was increased by 2 times or more compared to any other case for node 2. Queue length and delay was also higher for node 1 in 2017 PM peak hour. This is clearly indicative of the impact of mall construction.

TABLE VI. SIMULATION RESULTS FOR 2016 PM PEAK HOUR

Movement	Qlenth (m)	LOS	Delay (sec)	CO	NOx	VOC	Fuel (L)
2-7	0.00	A	0.00	1.51	0.29	0.35	0.02
3-6	1.14		20.72	3.39	0.66	0.78	0.05
3-11	0.86		47.03	1.26	0.25	0.29	0.02
6-6	12.06		6.16	64.54	12.56	14.95	0.92
11-11	0.00		1.89	35.83	6.97	8.30	0.51
12-7	0.10		6.52	2.06	0.40	0.47	0.03
Node 2	2.36		4.57	109.10	21.23	25.28	1.56
4-8	27.96	A	34.58	62.57	12.17	14.50	0.89
6-6	0.00		7.00	45.86	8.92	10.63	0.66
9-6	1.65		22.29	8.64	1.68	2.00	0.12
9-11	0.00		0.83	0.30	0.06	0.07	0.01
11-8	0.09		0.79	1.94	0.378	0.45	0.03
11-11	0.00		1.42	29.78	5.79	6.90	0.42
Node 1	4.95		9.17	150.10	29.20	34.79	2.15

TABLE VII. SIMULATION RESULTS FOR 2017 PM PEAK HOUR

Movement	Qlenth (m)	LOS	Delay (sec)	CO	NOx	VOC	Fuel (L)
2-7	0.00	B	0.00	1.51	0.29	0.35	0.02
3-6	2.32		67.66	11.05	2.15	2.56	0.16
3-11	3.56		0.00	0.00	0.00	0.00	0.00
6-6	83.88		17.35	91.73	17.85	21.26	1.31
11-11	0.00		2.55	41.15	8.01	9.54	0.59
12-7	0.08		5.77	2.02	0.39	0.47	0.03
Node 2	14.97		10.79	147.43	28.69	34.17	2.11
4-8	42.46	B	50.91	62.66	12.19	14.52	0.90
6-6	0.00		8.26	45.48	8.85	10.54	0.65
9-6	1.14		15.63	7.87	1.53	1.82	0.11
9-11	0.03		0.50	0.30	0.06	0.07	0.00
11-8	0.00		1.17	2.47	0.48	0.57	0.04
11-11	0.00		1.95	35.60	6.93	8.25	0.51
Node 1	7.27		10.93	153.99	29.96	35.69	2.20

TABLE VIII. SIMULATION RESULTS FOR 2017 AM PEAK HOUR

Movement	Qlenth (m)	LOS	Delay (sec)	CO	NOx	VOC	Fuel (L)
2-7	0.00	LOS_A	0.00	1.51	0.29	0.35	0.02
3-6	2.04		32.11	3.57	0.70	0.83	0.05
3-11	1.66		23.93	2.33	0.45	0.54	0.03
6-6	0.00		4.46	68.55	13.34	15.89	0.98
11-11	0.00		0.44	13.31	2.59	3.08	0.19
12-7	0.06		5.93	1.02	0.20	0.24	0.01
Node 2	0.63		4.27	90.28	17.56	20.92	1.29
4-8	1.42	LOS_A	4.95	31.44	6.12	7.29	0.45
6-6	0.00		3.24	44.05	8.57	10.21	0.63
9-6	0.10		5.67	2.43	0.47	0.56	0.03
9-11	0.00		0.00	0.00	0.00	0.00	0.00
11-8	0.04		4.43	1.13	0.22	0.26	0.02
11-11	0.00		0.19	11.89	2.31	2.76	0.17
Node 1	0.26		3.12	90.86	17.68	21.06	1.30

3. Conclusions

The main objective of the study was to develop a microscopic simulation mode for Avenue 27 with two intersections in Bahrain by using PTV VISSIM software. The subsequent objective was to use the calibrated model for determining the traffic impacts of a new mall near avenue 27. The goal was achieved by validating the simulation model results with the real data at default values. The criteria for validating the simulation results was based upon the variation in the simulation data, shown by its standard deviation. Traffic volume data shows that the road segment had high percentage of heavy vehicles in the morning peak hours as compared to the evening peak hours.

Based on this study, it is found that VISSIM is a useful tool which can be used for traffic management and operations in Bahrain without requiring considerable efforts for calibration and validation. Hence, it could be considered as an effective tool to identify and analyze smart solutions for traffic issues in Bahrain.

Therefore, further study was done to analyze the traffic and environmental impacts of a shopping mall on the nearby road and intersections. It was found that the construction of mall resulted in reducing the LOS on both adjoining intersections. The movement towards the mall had highest impact in terms of queue length and delay. Further degradation in the traffic conditions can be expected in the study area with normal growth rate of traffic at that location. The simulation model was not useful in estimating the environmental parameters especially for turning movements. This could be solved by, doing rigorous calibration with additional parameters for turning movements, or using other available methods for environmental factor estimation.

Acknowledgment

The authors acknowledge the cooperation from Ministry of Works for providing us with the required data and special thanks to Eng. Hari who was coordinating with us from the ministry.

References

[1] Dimitrakopoulos, G., & P. Demestichas, "Intelligent transportation systems", IEEE Vehicular Technology Magazine, 5(1), 77-84, (2010).

[2] Barceló, J. "Fundamentals of traffic simulation", Vol. 145, New York: Springer, (2010).

[3] Brockfeld, E., R. D. Ku ̈hne, & P. Wagner, "Calibration and validation of microscopic traffic flow models," Transportation Research Record, Albany, California, (2004)

[4] Ahmed, S. A. "Calibration of VISSIM to the Traffic Conditions of Khobar and Dammam,", M.S. Thesis, King Fahd University of Petroleum and Minerals (K.F.U.P.M), Dhahran, (2005).

[5] "Vissim user manual - V.3.70", Karlsruhe, Germany, April, 2013.

[6] Aditjandra, P. T., F. Galatioto, M. C. Bell, & T. H. Zunder, "Evaluating the impacts of urban freight traffic: application of micro-simulation at a large establishment", Eur J Transp Infrastruct Res, 16(1), 4-22, (2016).

[7] Chen, K., & L. Yu, "Microscopic traffic-emission simulation and case study for evaluation of traffic control strategies", Journal of Transportation Systems Engineering and Information Technology, 7(1), 93-99, (2007).

[8] Taylor, N. B. "The CONTRAM dynamic traffic assignment model", Networks and Spatial Economics, 3(3), 297-322, (2003).

[9] Park, B., & J. Schneeberger, "Microscopic simulation model calibration and validation: case study of VISSIM simulation model for a coordinated actuated signal system", Transportation Research Record: Journal of the Transportation Research Board, (1856), 185-192, (2003).

[10] Fellendorf, M., & Vortisch, P. "Validation of the microscopic traffic flow model VISSIM in different real-world situations", 80th Meeting of the Transportation Research Board, Washington, D.C., (2015)

[11] Fellendorf, M., & P. Vortisch, "Microscopic traffic flow simulator VISSIM", In Fundamentals of traffic simulation (pp. 63-93). Springer New York, (2010).

[12] Kaseko, M.S. "Comparative evaluation of simulation software for traffic operations (No. RDT 03-032)", (2002), https://www.nevadadot.com/home/showdocument?id=4010 Accessed November 17, 2017.

[13] Ratrout, N. T., & S. M. Rahman, "A comparative analysis of currently used microscopic and macroscopic traffic simulation software", The Arabian Journal for Science and Engineering, 34(1B), 121-133, (2009).

[14] Gonzalez-Feliu, J., & C. Peris-Pla, "Impacts of retailing attractiveness on freight and shopping trip attraction rates", Research in Transportation Business & Management, 24, 49-58, (2017).

[15] Millard-Ball, A. "Phantom trips: Overestimating the traffic impacts of new development", Journal of Transport and Land Use, 8(1), 31-49, (2015).

[16] Stevanovic, A., J. Stevanovic, K. Zhang, & S. Batterman, "Optimizing traffic control to reduce fuel consumption and vehicular emissions: Integrated approach with VISSIM, CMEM, and VISGAOST", Transportation Research Record: Journal of the transportation research board, (2128), 105-113, (2009).

[17] Hirschmann, K., M. Zallinger, M. Fellendorf, & S. Hausberger, "A new method to calculate emissions with simulated traffic conditions. In Intelligent Transportation Systems (ITSC)", 2010 13th International IEEE Conference on (pp. 33-38). IEEE, (2010, September).

[18] Csikós, A., & I. Varga, "Real-time modeling and control objective analysis of motorway emissions", Procedia-Social and Behavioral Sciences, 54, 1027-1036, (2012).

[19] Vreeswijk, J. D., M. K. M. Mahmod, & B. van Arem, "Energy efficient traffic management and control-the eCoMove approach and expected benefits", In Intelligent Transportation Systems (ITSC), 2010 13th International IEEE Conference on (pp. 955-961). IEEE, (2010, September).

[20] Quaassdorff, C., R. Borge, D. de la Paz, J. Pérez, J. M. de Andrés, & J. Lumbreras, "High resolution emission estimation in a heavily trafficked urban area in Madrid (Spain)", 1-16, available at http://tecnaire-cm.org/wp-content/uploads/2016/03/2016AirQualityMicrosimulation.pdf, accessed on 11th February 2019, (2016).

[21] Dias, H. L. F., B. V. Bertoncini, M. L. M. D. Oliveira, F. S. A. Cavalcante, & E. P. Lima, "Analysis of emission models integrated with traffic models for freight transportation study in urban areas", International Journal of Environmental Technology and Management, 20(1-2), 60-77, (2017).

[22] Nyame-Baafi, E., C. A. Adams, & K. K. Osei, "Volume warrants for major and minor roads left-turning traffic lanes at unsignalized T-intersections: A case study using VISSIM modelling", Journal of Traffic and Transportation Engineering (English Edition), 5(5), 417-428, (2018).

Dr. Uneb Gazder He is an assistant professor in the department of Civil Engineering at University of Bahrain. He completed his PhD from King Fahd University of Petroleum and Minerals in 2014. His areas of research include; transportation planning, artificial neural networks, traffic simulation and safety.

Yazan Mohammad Al Zoubi A fresh graduate from University of Bahrain with B.Sc. in Civil Engineering and a cumulative

GPA of (3.23). Excellent problem-solving, teamwork, time-management and communication skills. Moreover, studying MSc. in Construction Management in University of Leeds in the United Kingdom

Mahmoud Hamed Mahmoud Saleh A fresh graduate from University of Bahrain with B.Sc. in Civil Engineering with a cumulative

GPA of (3.26). I am a member in Institution of Civil Engineers (ICE) since 2015. I am more focused on Traffic Engineering, especially traffic simulation. I have a basic experience in using VISSIM software. I am willing to pursue my Masters degree around the same domain.

Omar Mohammed Omar Mohammed is a civil engineering student at the University of Bahrain. He is in the fourth year of his studies. He took some courses such as Autocad and Vissm, also did some site visits for different construction sites. He is presently working on his senior project which is in the field of traffic simulation after which he will focus on preparing for masters degree.

Khalid Abdul Nasser Alhalabi. He has graduated from Al Noor International School after completing his IGCSE's and ALevels. He is currently completing a Bachelor's degree in Civil Engineering at University of Bahrain. He is experienced in using softwares such as Microsoft Visual Basic, ArcGIS and AutoCAD**.**