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Investigating Network Efficiency Improvement Measures Using Simulation Technique in Mirpur Area

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Abstract Traffic engineers and planners need information about traffic for planning and designing purpose. Traffic survey are the means of obtaining various data. Survey aims to capture data that accurately reflects the real-world traffic situation in a particular area. It includes determination of volume of traffic, peak hour congestion, traffic composition. It also depicts a complete traffic scenario of a certain area of interest. A traffic study was conducted in the Mirpur cantonment area of Dhaka city to analyze the scenario of the prevailing traffic condition. The traffic is heterogeneous and comprises of vehicles including cars, trucks, buses and non-motorized vehicles (NMV). Inside the Mirpur Cantonment area, flow is relatively lower than any other typical area of Dhaka. This study generates simulation done by microsimulation software-VISSIM using the field data. After calibration, the evaluation parameters are determined. The paper also depicts the future traffic scenario of the studied area simulated by VISSIM. Eventually, the study suggests few measures so that the increased traffic can be efficiently managed and circulated.

Keywords Traffic study, Traffic simulation, Network efficiency, Improvement measures

1. Introduction

Increasing traffic congestion is an inescapable condition in growing metropolitan areas across the world. Peak-hour traffic congestion is an inherent result of the urbanization. One of the main reasons why there is more congestion is due to more private cars and NMVs on the road. Bangladesh is a densely populated country where traffic congestion is a common phenomenon. Dhaka is a mega city and capital of Bangladesh. More than twelve million people live in Dhaka [1]. In recent years, rapid increase in travel demand and the number of vehicles on roadways have resulted in serious congestion problem here (Figure 1).

The traffic congestions do not only cause tremendous time and monetary losses but also reduce road safety and increase air pollution. The study area 'Mirpur Cantonment' is situated in the western part of Dhaka City. It is a restricted area where traffic studies had not been conducted extensively in the past. Here traffic flow is relatively low compared to outside region. This research focuses on analysing the traffic scenario in this area. Mirpur Cantonment is an education hub for Bangladesh Military Forces. The study area comprises various educational Institutions and thus it can be stated as a vibrant area for people of various educational interest (Figure 2). It composes of Mirpur Cantonment Public School and College, Military Institute of Science & Technology (MIST), National Defense College (NDC), Bangladesh University of Professionals (BUP) and Defense Services College & Staff College (DSCSC). Mirpur DOHS and Alubdi are situated just adjacent to Mirpur Cantonment. A large of number of traffic is generated due to both academic and administrative purpose in NDC, MIST, BUP and DSCSC. The traffic volume is quite high especially during the rush hours in the morning. This study emphasizes on studying the traffic in this area during the peak hour when there is possibility of delay due to intense flow of traffic.

Figure 1. Traffic Congestion in Dhaka Mega City
(*Source: www.google.com*)

The most widely used strategy to mitigate the congestion problem is to increase roadway capacity and managing the increasing demand. However, the growing demand issue

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cannot be mitigated by only expanding road infrastructure due to financial and other constraints. Rather, more efficient use of the existing traffic network through better operation and management can be a conducive measure against the congestion problem.

Active Traffic Management involves the use of appropriate traffic flow models to accurately simulate and predict traffic state variables in real-time and then apply proper control strategy. In the developed countries, it has been successfully practiced for decades as a highly effective tool for mitigating traffic congestion and improving safety.

Figure 2. Mirpur Cantonment area, Dhaka

1.1. Objectives of the Study and Problem Identification

The Mirpur Cantonment area faces congestion in the morning peak hour due to the presence of various educational institutions. Among them, MIST and BUP are expanding their curriculum day by day. As a result, the number of students are increasing who rush in the morning to attend the classes. This causes a congestion in the morning that comprises a wide variety of vehicles. Prime target of this research work is to study this traffic scenario. The maximum traffic congestion in the study area occurs in the morning between 0730-0830 hours. This is considered as the 'Peak Hour', while the maximum traffic flow generates. Another aim is to model existing traffic condition and calibrate the model with micro simulation technique so that it mimics the real situation. Evaluation parameters need to be determined for this base model. The research also focuses on estimating the rise in future traffic volume with a growth rate of 5%. Thus, the traffic scenario after 5 years is anticipated by micro simulation with VISSIM. The model for future traffic is assessed and measures are provided with the help of evaluation features of VISSIM. This will enable obtaining the best appropriate outputs from the analysis. Therefore, the possible outcome of the study includes a depiction of the existing and future traffic scenario in Mirpur Cantonment and evaluating the measures that will ensure efficient traffic flow through the studied network in future.

2. Literature Review

Traffic engineers and planners require intensive information to design and manage road traffic system. They use the data for planning and designing traffic facilities, selecting geometric standards, economic analysis, justify warrant of traffic control devices and determination of priorities. They also employ this information to study the effectiveness of introduced schemes, diagnosing given situations and finding appropriate solutions, forecasting the effects of projected strategies, calibrating and validating traffic models. The main purpose of traffic survey are traffic monitoring, control and management, enforcement, forecasting, model calibration etc. Traffic studies include inventory of road traffic physical features, traffic stream characteristics studies, capacity studies, travel time and delay studies, O-D survey, supply & demand studies, accidents studies, environmental impact studies etc. [2]. The traffic engineer must acquire general knowledge of traffic volume characteristics. The total number of vehicles that pass over a given point or section of a lane or roadway during a given time interval is referred as volume or flow. Average Annual Daily Traffic (AADT) is the average 24-hr volume at a given location over a full 365 days year, estimated as the number of vehicles passing a site in a year divided by 365 days.

Hourly, daily, and monthly expansion factors can be determined using data obtained at continuous count stations. Hourly Expansion Factors (HEFs) are determined by the ratio of total volume for 24-hour period and volume for particular hour. Daily Expansion Factors (DEFs) are computed as the ratio of average total volume for week and average volume for particular day. Monthly Expansion Factors (MEFs) are computed as AADT divided by ADT for particular month. The AADT for a given year may be obtained from the ADT for a given month by multiplying this volume by the MEF [3]. Different types of traffic counts are carried out, depending on the anticipated use of the data to be collected. Intersection counts are taken to determine vehicle classifications and turning movements at intersections. These data are utilized mainly to determine phase lengths and cycle times for signalized intersections, in the design of channelization at intersections and in the general design of improvements to intersections [4]. In order to obtain certain traffic volume data, such as AADT, it is necessary to obtain data continuously.

However, it is not feasible to collect continuous data on all roads because of the cost and time involved. Different types of periodic counts, with count durations ranging from 15 minutes to continuous are conducted. There are two major methods (manual and automatic counting method) for volume survey. There are two methods of manual counting: direct method and indirect method (Figure 3). Data is counted by using hand tally and manual counters in the direct method. Data can be used immediately after collection. Nevertheless, this method is not practicable for long duration count and when flow is high. While in the indirect method, data is collected using video camera. Video is captured for long time and data is collected later by rewinding. Data can be crosschecked and quality can be ensured. This method is applicable when volume is high. It is suitable for non-lane based traffic operation. Although a suitable elevated place is required for filming operation. However, this process is time consuming. Because of limitation of capacity of film, it is not suitable for long duration counts. Quality of video recorded on film is also dependent on intensity of light and this method is not suitable in inclement weather conditions.

Figure 3. Manual method of vehicle count

On the other hand, in the automatic counting method vehicles are counted automatically. It can be done by contact system or contactless system (e.g. magnetic/inductive loop, infrared system). This method is suitable for long duration count. It does not need work force and free from human error. Data is needed to be extracted to usable format. Count is not affected by bad weather condition. Disadvantages of this method are the requirement of strict lane discipline and tough to detect non-motorized vehicles [4]. Duration of count depends on the objective of data collection. For traffic control and management or operational studies short duration count at peak period is conducted. For planning and design purpose, long duration count is conducted. Another basic parameters of traffic stream, speed, is the rate of movement of a vehicle. Radar speed gun is a convenient way for measuring spot speed of individual vehicles (Figure 4). The effective measuring distance for radar meters ranges from 200 feet up to 2 miles [5]. A radar meter requires line-of-sight to measure speed accurately. Effective ranges may be up to 2 miles. The more the distance, the more error prone it becomes [6].

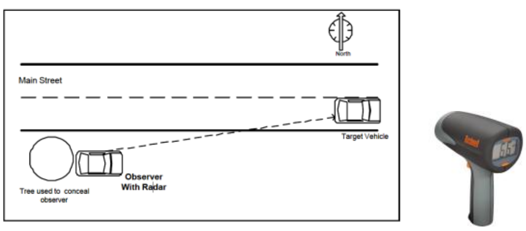


Figure 4. Radar speed gun for spot speed measurement

Traffic micro-simulation models are widely used to evaluate the benefits and limitations of traffic operation alternatives. Simulation models are mainly classified as microscopic and macroscopic. Models that simulate individual vehicles at minor intervals are termed as microscopic. To evaluate the existing situation and predicting the future scenario at individual vehicle level, microscopic simulation is very significant. VISSIM is a microscopic, time step and behavior-based simulation model. The program can analyze traffic operations thus making it a useful tool for the evaluation of various alternatives based on transportation engineering and planning measure. Accordingly, also pedestrian flows can be modelled either exclusively or combined with traffic. VISSIM can be applied as a useful tool in a variety of transportation problem settings [7].

Earlier, researchers informally calibrated simulation models and often used default parameters resulting in large errors [8]. Bruce R. Hellinga (1998) pointed out the requirements for the calibration of traffic simulation models [9]. Fellendorf and Vortisch (2001) presented the possibilities of validating the microscopic simulation model [10]. Park and Won (2006) outlined the calibration procedure for the parameters controlling human and vehicle characteristics for VISSIM where genetic algorithm was used to optimize calibration parameters [11]. Bastian et al. (2014) presented calibration and validation results for modeling interchanges in a micro-simulation environment [12]. Biagio and Azevedo (2014) proposed a multistep sensitivity analysis approach for model calibration [13]. Some studies were also performed to heterogeneous traffic conditions. Hossain (2004) calibrated the heterogeneous traffic model in VISSIM to match saturation flows at an intersection in the city of Dhaka [14]. Mathew and Radhakrishnan (2010) made a study on calibration of VISSIM with respect to heterogeneous traffic in the context of three signalized intersections in India [15].

Pruthvi et al. (2013) presented the identification and observation of unique features of mixed traffic and techniques to incorporate them in VISSIM [16]. For Indian heterogeneous conditions, a sensitivity analysis was done to find the parameters, which affect VISSIM models [17]. Arpan et al. (2013) demonstrated applicability of VISSIM software to determine capacity of multilane highways under mixed traffic flow conditions [18]. A methodology for simulating heterogeneous traffic on expressways in developing countries was proposed by Shriniwas et al. (2015) [19]. Orvin et al. (2018) investigated the performance evaluation of a signalized junction using VISSIM [20]. Keller and Saklas (1984) developed a procedure to estimate Passenger Car Equivalent (PCE) values using simulation model [21]. Hossain (2001) used micro simulation technique to model traffic operations at signalized intersections [22]. Arasan and Koshy (2005) developed a simulation model for urban roads [23].

Arasan and Krishnamurthy (2008) also conducted a study on the effect of traffic volume and road width on PCU values of vehicles using Microscopic simulation [24]. Arasan and Vedagiri (2006) applied the simulation model to estimate the saturation flow rate of heterogeneous traffic [25]. Gowri and Sivanandan (2008) developed a simulation model and examined the effects of left turn channelization on vehicle waiting times [26]. Radhakrishnan and Mathew (2011) developed a traffic simulation model integrating the concepts of cellular automata [27]. Thus, microscopic simulation models has been used in recent times for numerous purposes. This study contribute to replicate the present traffic condition in Mirpur cantonment area and evaluate the future scenario. Modifications of the future model is also justified by evaluation results of microscopic simulation. Wiseman (2017) proposed a real time digital imaging approach to identify congestion intensity of road segments that can help drivers to know whether the road is congested or not [28]. However, this is beyond the scope of our study, but the existing congestion scenario in our studied site can be reproduced using this technique and results can be compared to the actual scenario to better understand the congestion situation in the site.

3. Methodology

3.1. Data Collection Procedure

A team of MIST students collected data from the field. The studied area is modelled with micro simulation software ‘VISSIM’ version 5.40. Extensive data were required since micro simulation encounters with individual track of vehicles. It uses distance and time headway, lane changing and car following behaviour to generate model. Basic data that are required such as geometry of the links and intersections, number of lanes, lane width, median width, traffic volume, directional count, traffic composition, queue length, travel time, speed of vehicles, delay time etc. The traditionally simplest approach for counting vehicle is to record each observed vehicle with a tick mark in a tally sheet which is used in this study. Indirect method of manual counting, video camera was also utilized for verifying the collected data. For speed study, radar speed gun was used. Sample size was taken as at least ten vehicles of a particular vehicle class.

3.2. VISSIM Model Generation

Using the various data collected from the field, the model is generated in VISSIM. The network generation process includes importing and scaling overlay image after fixing units, determining driver behavior parameters, fixing individual link behavior, link and connector generation, determination of vehicle types and classes, vehicle composition selection, vehicle input in all the arrival points of the network, routing for various links, conflict areas and priority implementation. No traffic signal program is installed in the field. Data collection points, travel time sections and queue counters are established where necessary for evaluation purpose. After the network design, simulation is initiated with random seed value. If the random seed varies, the stochastic functions in VISSIM are assigned a different value sequence and the traffic flow changes. This allows stochastic variations of vehicle arrivals in the network. To attain meaningful results, arithmetic mean for at least five runs with different random seed settings were selected for evaluation.

3.3. Model Calibration and Validation

Calibration of the generated model was executed to check whether it replicate the existing situation or not. Calibration is defined as the process of adjusting the parameters used in the model to ensure that it accurately reflects input data [20]. Traffic at the studied portion is heterogeneous. Since it is in cantonment area, vehicles partially maintain lane discipline. During the calibration process, sensitivity analysis was initiated to identify the key driving behavior parameters. Thus, the driving behaviour parameters were modified so that the model replicates the field condition. Two sets of observed data were required during the model development process. One was used to calibrate the model by adjusting the parameters and latter was used to verify that the aspects of the performance of the calibrated model are in agreement to the set of observed data [29]. It is very significant that the output found for particular traffic parameters combinations are within the calibration target range (Table 1).

Table 1. Calibration Target

Criteria and measures	Acceptability targets
Hourly flows, model vs observed	
Individual link flows : Within 100 vph for Flow < 700 vph	>85% cases
Total link flows : Within 5%	All accepting links
GEH statistic- Individual link flows : GEH < 5	>85% cases
GEH statistic- Total link flows : GEH < 4	All accepting links
Visual audits	To analyst’s satisfaction
Individual link speeds : Visually acceptable speed-flow relationship	To analyst’s satisfaction
Bottlenecks : Visually acceptable queuing	To analyst’s satisfaction

Source: (FHWA Freeway Model Calibration Criteria, Dion et al., 2012)

3.4. Model Evaluation

After the calibration and validation of a model, evaluation criteria were determined. Due to construction work of BUP and new faculty towers of MIST, there will be vast increase in traffic in future. Therefore, the model evaluation is also done for future expansion of traffic. The probable traffic volume of the next five years is estimated with a growth rate of 5%. The effect of this increased traffic is discussed and measures are tested based on the evaluation result in VISSIM.

4. Data Collection

4.1. Study Area

Certain portion of Mirpur cantonment was the concerned study area. With a view to conducting the volume study of the studied area, the data collection points were selected first. There are one four legged and two three leg junctions as illustrated in Figure 5. The study required vehicle input data for Osmany hall to Junction 1, MP Check Post to Junction 1 and DSCSC to Junction 1 link road respectively. Due to a military controlled area, there are several links where public access is restricted. The blue marks on the Figure 5 indicate the roads accessible by mass people. There is a right turn restriction at Junction 1 for the approaching vehicles from DSCSC. These vehicles makes a U-turn at MP Check Post.

Figure 5. Study area

4.2. Traffic Study

All the data were collected for one hour in each input. For the data collection, peak hour (0730-0830 hour) was selected. The traffic demand is maximum during this period. Typical volume and composition data for DSCSC to Junction 1 road is illustrated in Table 2. It is observed that number of bus for carrying students is very less. Therefore, there are significant amount of NMV plying in the study area. In addition, it was found that 35% of the students travel by bus, 21% by private car and 44% use NMV. It was also revealed that 71% are not pleased with the number of buses operating in this area. Design speed is 45 km/hour, which is corresponding to 98th percentile speed.

Traffic is forecasted for the next 5 years with a growth rate of 5%. For this purpose, AADT is calculated using the expansion factors. According to Idaho Transportation Department, USA, AADT for future forecasted year is determined by the following formula:

$$E_{(t+n)} = E_t*(1+g)^n \quad (1)$$

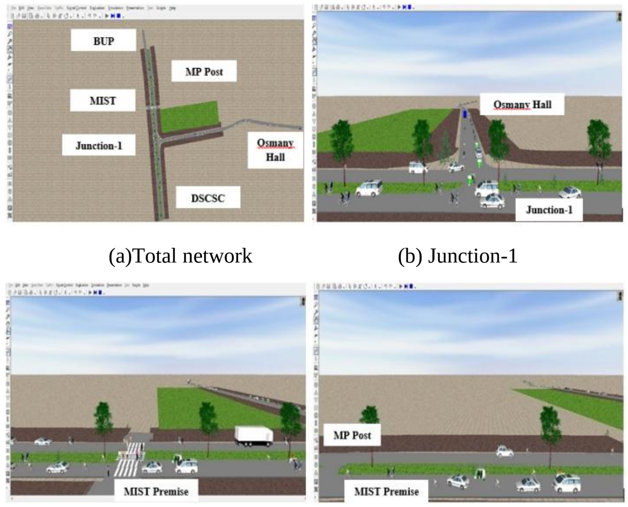
Where, $E_{(t+n)}$ = AADT value of t year, forecasted n years in the future, E_t = base year AADT value and g = growth rate [30]. Number of pedestrians were found 502 persons/hour to MIST premise and 119 persons/hour from MIST premise in the base year during the peak hour.

Table 2. Typical Volume Data for DSCSC to Junction 1

Link	Vehicle	Number	%	Left	Through	Right
DSCSC to Junction 1 (AADT = 20758 vehicles)	Bus	8	2.19	-	5	3
	Car/Micro	153	41.8	-	84	69
	Rickshaw	98	26.78	-	54	44
	CNG	25	6.83	-	14	11
	Bike	46	12.56	-	25	21
	Cycle	36	9.84	-	20	16
	Total =	366 vehicles/hour		-	202	164

5. Model Generation in VISSIM

The traffic flow model in VISSIM is a discrete, stochastic, time step based where driver-vehicle-units as single entities. Car following and lane changing behavior is incorporated in VISSIM. Generally, vehicles follow partial lane discipline, as there is military enforcement. The existing situation is generated as per the field data. The model shown in Figure 6(a) mimics the field condition and it is the 'Base Model'. Link roads from DSCSC to BUP and MP Post to DSCSC have two lanes in one direction. There is prohibition of right turn from DSCSC to Junction-1 (Figure 6b).



(a)Total network (b) Junction-1

(c) Pedestrian crossing at MIST (d) On-street Parking at MIST

Figure 6. VISSIM 3-D model

At MIST premise there is a pedestrian crossing that creates slow movement of traffic (Figure 6c). In addition, after the crossing there is an on-street parking for few moments to drop off students at MIST premise (Figure 6d). Then these vehicles make a U-turn at MP Post. The vehicle composition consists of car, bus, CNG, rickshaw, truck, motorcycle and cycle in all roads. Vehicle routing was done as per the field data. No traffic signal implementation is present in the field condition.

To achieve high credibility for a simulation model, calibration and validation are of utmost importance [31]. The studied model conforms the calibration targets as shown in Table 1, where the limits are within the specified range. The heterogeneity of flow was incorporated by modeling all the vehicle classes. The pedestrians were also simulated in the model. Non-lane based flow stands in sharp contrast to microsimulation. Here, vehicle's desired position at free flow is at middle of the link due to military enforcement. Though other driving behavior parameters are modified since traffic flow is heterogeneous and not properly lane based. The parameter's sensitivity analysis is performed as well. Finally using trial and error method, the calibrated parameters set is found that mimics the field result in terms of flow. The parameter combination is displayed in Table 3. Comparison of real data observed in the field and simulated data from VISSIM is illustrated in Table 4. The calibrated model is validated for data collected from another working day.

Table 3. Calibrated and Modified Parameters Combination

Parameter	Default Value	Modified Value
Significant Driving Behavior Parameters:		
Look ahead distance	Max: 250 m	30
Look back distance	Max: 150 m	30
Smooth close-up Behavior	unchecked	checked
Average standstill distance	2 m	2.95 m
Additive part of safety distance	2 m	1.90 m
Multiple part of safety distance	3 m	2.88 m
Maximum speed difference	10.8 km/hour	15.8 km/hour
Maximum collision time	10 s	15 s
Minimum headway (front/rear)	1 m	1.25 m
Desired position at free flow	Middle of lane	As it is
Keep lateral distance	unchecked	checked
Diamond shaped queuing	unchecked	checked
Consider next turning direction	unchecked	checked
Collision time gain	2 s	1.26 s
Minimum longitudinal speed	3.6 km/hour	1.51 km/hour
Overtake on same lane	unchecked	All checked
Minimum lateral distance	1.0	0.90

Table 4. Observed Data in Field v/s Data from Simulation

Direction	Vehicle	Individual link flow		Diff.	GEH	Remarks
		Field	Model			
DSCSC to Junction-1	All	366	335	31	1.66	Difference within 100 veh/hr, for Flow < 700 veh/hr for more than 85% of the cases. GEH Statistic <5 for Individual Link Flows for more than 85% of the cases Sum of All Link Flows within 5% of sum of all link counts
	Bus	8	4	4	1.63	
	Car	153	140	13	1.07	
	CNG	25	23	2	0.41	
	Motorcycle	46	34	12	1.90	
	Cycle	36	34	2	0.34	
	Truck	0	0	0	-	
	Rickshaw	98	100	2	0.20	
MP Post to Junction-1	All	158	146	12	0.97	
	Bus	3	2	1	0.63	
	Car	53	45	8	1.14	
	CNG	14	8	6	1.81	
	Motorcycle	18	17	1	0.24	
	Cycle	26	33	7	1.29	
	Truck	2	1	1	0.82	
	Rickshaw	42	40	2	0.31	
Osmany Hall to Junction-1	All	386	400	14	0.71	
	Bus	4	2	2	1.15	
	Car	110	105	5	0.48	
	CNG	35	38	3	0.50	
	Motorcycle	20	16	4	0.94	
	Cycle	43	50	7	1.03	
	Truck	2	1	1	0.82	
	Rickshaw	172	188	16	1.19	
Total		910	881	(3.19%)		

The calibrated and validated model is evaluated for travel time, delay time, queue forming, network performance etc. Then the model is tested for two conditions. Firstly, the future traffic generation using 5% growth factor (Modified Model-I) where no geometric or operational change is done. Secondly, modification of Model-I with prohibited right turn from Osmany Hall to MIST/BUP rather U-turn at DSCSC as displayed in Figure 7 (Modified Model-II). There is sufficient space available to increase capacity. So, one lane is incremented from Osmany Hall to Junction-1 and from DSCSC to MIST otherwise traffic became stagnant and it created significant delay due to lack of capacity for future traffic flow. Both these modified models were calibrated by matching the flow as shown in Table-4. After calibration, these two models are evaluated for the same parameters as mentioned for the base model. For evaluation purpose, five random seed were selected and average value were taken as final results. Warming up period for the base model and modified models was 900 seconds and 500 seconds respectively. Finally, the comparison of result is done and effectiveness of the measures are discussed.

Figure 7. Modified Model-II

6. Result and Discussion

After studying, it is observed that at field condition there is considerable amount of delay in Junction-1. There also exists slow movement of traffic due to right turn at Junction-1 from Osmany Hall, lack of overtaking lane for speedy vehicles generated from Osmany hall, pedestrian crossing and on street parking for drop off students at MIST premise. To achieve better performance in the study area, various road-traffic parameters, characteristics and measures need to be experimented. In this study existing condition (Base Model) is compared with future traffic generation for 5% growth rate (Modified Model-I) and Modifying Model I with lane increment from DSCSC to MIST and right turn ban from Osmany Hall to Junction-1 (Modified Model-II). Wiseman (2018) thinks expansion of roadway is an efficient solution for traffic delay mitigation. However, due to obstacles, land restraints or other practical reasons there is little scope for lane increment in most practical cases [32]. As the studied site is in cantonment area and military controlled, there is significant amount of unused lands around the existing site. Therefore, we considered lane increment as an important factor for delay minimization for the future traffic. Eventually, the Modified Model II is evaluated in terms of efficiency.

It is obvious that traffic volume will increase in future days, as the study area is an education hub for Bangladesh Military Forces and the dimension of the military units are expanding day by day. From Osmany Hall to Osmany Hall via MIST, DSCSC to Osmany hall and DSCSC to DSCSC via MIST, it is observed that the average travel time of the vehicles are moderately high for field condition. It is to be mentioned that VISSIM evaluation results of travel time is the average travel time (including waiting or dwell times) determined as the time required by vehicles between crossing the first and crossing the second cross sections [7].

It is noticed that due to traffic growth in future, the travel time for all links considered except links from BUP, significantly increased in comparison to existing condition (Table 5). If the model with future traffic is modified as discussed, the travel time decreases largely. For instance, for Osmany Hall to Osmany Hall via MIST route, the travel time is decreased to 14.32% compared to base model and 24.06% compared to Modified Model-I.

Table 5. Typical Comparison of travel Time for the Generated Models

O-D	Distance in meter	Travel Time in sec		
		Base Model	Modified Model-I	Modified Model-II
DSCSC to BUP	481.1	485.0	664.1	321.0
DSCSC to Osmany hall	1040.8	862.3	1023.4	758.6
DSCSC to DSCSC via MIST	757.9	514.8	794.6	411.6
BUP to Osmany Hall	712.4	505.7	496.3	512.7
BUP to DSCSC	432.2	205.9	167.3	153.5
Osmany Hall to BUP	770.0	786	909.3	620.7
Osmany Hall to DSCSC	673.5	539.2	681.6	321.9
Osmany Hall to Osmany Hall via MIST	1329.5	1126.8	1271.3	965.4

*Travel time refers to the average travel time (including waiting or dwell times)

From simulation, average total delay per vehicle, average standstill time per vehicle and average number of stops per vehicle can also be computed. The total delay is calculated for every vehicle completing the travel time section by subtracting the theoretical (ideal) travel time from the real travel time. The theoretical travel time is the time that would be reached if there were no other vehicles and no signal controls or other stops in the network. The delay result is illustrated in Table 6. The more traffic will increase, the more delay will occur in future. For, DSCSC to Osmany hall route, the existing delay in field is found 554.9 sec and it rises to 614.9 sec for future traffic generation after 5 years. If the Modified Model II is considered, this delay minimized to 381.7 sec.

Table 6. Typical Comparison of Delay for the Generated Model

Direction	Base Model	Modified Model-I	Modified Model-II
DSCSC to BUP	301.2	490.3	154.2
DSCSC to Osmany hall	554.9	614.9	381.7
DSCSC to DSCSC via MIST	301.8	503.4	157.4
BUP to Osmany Hall	205.8	263.5	249.7
BUP to DSCSC	20	22.4	14.8
Osmany Hall to BUP	353	489.4	138.9
Osmany Hall to DSCSC	193.4	312.6	13.6
Osmany Hall to Osmany Hall via MIST	507.2	690.7	387.3

*Delay is the average total delay per vehicle in sec, Stopd is the average standstill time per vehicle in sec and Stops is the average number of stops per vehicle.

In VISSIM, queues are counted from the location of the queue counter on the link or connector upstream to the final vehicle that is in queue condition. Typical Comparison of queue length for the models are shown in Table 7. For all the links, queue length increased due to more traffic generation in future. If the model with future traffic is modified as Modified Model II, queue lengths are decreased for most of the cases. Although maximum queue length did not improve much for few instances. As an example, for Junction-1 to MIST link, queue length is reduced to 258 m from 339 m. Although maximum queue length is ascended to 1.82%. From Osmany Hall to Junction-1 the maximum queue length was lessened from 477 m to 155 m due to the consideration of extra lane for future traffic.

Table 7. Typical Comparison of Queue Length for the Generated Model

Direction	Base Model		Modified Model-I		Modified Model-II	
	Queue length	Max queue length	Queue length	Max. queue length	Queue length	Max. queue length
DSCSC to Junction-1	78	210	164	209	112	217
Junction-1 to MIST	249	385	339	385	258	392
MP Post to Junction-1	72	196	97	223	108	209
Osmany Hall to Junction-1	160	414	439	477	27	155
Junction-1 to DSCSC	6	80	7	122	7	79
Junction-1 to Osmany Hall	29	193	46	309	63	445

*Queue length is the average queue length and queue length is output in units of length not in number of cars

The models are also evaluated as a whole network. Average delay time per vehicle, average speed, average stopped delay per vehicle, total delay time, total stopped delay and total travel time are determined (Table 8). All these parameters climbed up when future traffic for the five years are considered. However, the modifications that are incorporated for future traffic model, served very well. For instance, average speed increases to 5.629 km/hr from 3.251 km/hr and total delay time reduces to 50.251 hours from 121.094 hours.

Table 8. Comparison of Network Performance for the Generated Models

Term	Base Model	Modified Model-I	Modified Model-II
Average delay time per vehicle [s]	306.935	424.065	160.517
Average speed [km/h]	4.058	3.251	5.629
Average stopped delay per vehicle [s]	91.804	158.179	23.551
Total delay time [h]	84.237	121.094	50.251
Total stopped delay [h]	25.195	45.169	7.373
Total travel time [h]	163.269	194.589	142.536

It is obvious that to accommodate future traffic conveniently and keep mobility up to the mark, the model need to be tuned up. Both the extra lane consideration and right turn prohibition techniques are deliberated. Existing condition will deteriorate a lot due to future expansion of traffic and it will worsen the prevailing condition. The Modified Model II will be more effective in elevating the performance of the studied area.

7. Summary and Conclusions

This research focuses on the study of the major part of the Mirpur cantonment Area. The existing situation is generated and simulated with the help of detailed data input. To investigate the prevailing condition, simulation tool VISSIM 5.30 is applied. All the vehicle types are modeled to induce heterogeneity. The real field condition is simulated by modifying the default driving behavior characteristics of VISSIM. The model is calibrated and evaluation parameters are ascertained. At present, the network is not overloaded though there are few delay points such as Junction-1, pedestrian crossing and on-street parking. Then another model is generated for future traffic propagation for five years with 5% growth rate without changing other parameters. This model is also calibrated and evaluated. The results suggest overall deterioration of existing condition. So, the future traffic model is modified and few treatments are provided such as right turn prohibition and lane increment. This model improves the evaluation parameters a lot and proves that measures will be effective. To achieve better efficiency at Junction-1 and DSCSC, signal system can be experimented which is beyond this study. Signal system may effectively manage conflict points and add more efficiency to the network. Pedestrian crossing signal and on-street parking bay for dropping off students can also be implemented and tested. The existing congestion situation can also be compared using digital image processing modern technique used by Wiseman (2017) [28]. Moreover, more percentage of bus and reduced number of NMV will improve the condition significantly. Overall, it is obvious that improvement measures will be necessary in future. Lane increment and right turn prohibition rather U-turn incorporation will prove to be effective for the studied area for future traffic.

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