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INFLUENCE OF BUS BAY AND CURBSIDE BUS STOP IN AN URBAN ROAD

Saurav Barua
Department of Civil Engineering, Daffodil International University, Dhaka-1207, Bangladesh.
Email: saurav.ce@diu.edu.bd

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Abstract

Purpose of Study: The purpose of this study is to investigate the efficiency of bus bay compare to the curbside bus stop in a midblock road segment of Dhaka city.

Methodology: Vehicle composition and traffic volume were counted on-peak hours for the midblock of Azimpur road near the existing bus stop. Simulation models were developed in VISSIM, where Model 1 represented the existing road scenario with curbside bus stop and Model 2 represented the same road segment with a bus bay.

Main findings: The simulation result showed that Model 2 outperformed Model 1 due to the presence of bus bay. Comparing Model 1, travel time and delay reduced by varying 1.80% to 12.5% and 6.25% to 100% respectively in Model 2 during the simulation. Similarly, average speed increased by 1.39% and density decreased by 61.29% in model 2.

Application of this study: Curbside bus stops result in abrupt halt, disrupt traffic flow, and queuing of the small-sized vehicle behind buses. These bus stops caused traffic congestion and delays in urban roads which can be alleviated by alternatives, such as, bus bay.

The novelty of this study: The bus bay is a good alternative to the curbside bus stop, which can improve existing traffic conditions in urban roads.

Keywords: *Bus Bay, Curbside Bus Stop, Simulation, Travel time, Delay.*

INTRODUCTION

Bus bay is usually designed into the sidewalk or other pedestrian area, marked on the curbside of a road where buses pull out of the traffic flow to the board and alight passengers. The purpose of the bus bay is to not block traffic while the bus is stopped. A properly designed bus bay can reduce bus travel times and delays, as well as, maximized traffic capacity and improved safety (Rosinbum, T., Grote, W.U.L.F. and Jickling, D. (1991)). A field survey conducted by (Mushule, N.(2012)) found that bus bays reduced delays of the road network in the Dar Es Salaam city. Besides, (Luthy, N., Guler, S.I. and Menendez, M. (2016)) proposed an appropriately located bus bay instead of curbside bus stops to minimize delays of cars and buses. Dhaka, a densely populated metropolitan city where traffic congestion is a day-to-day major problem, bus bay may provide relief to some extent by saving travel time. The purpose of the study is to compare the performance, as well as, the feasibility of bus bay and curbside bus stop in a road segment of Dhaka city in terms of travel time, delay, average speed and density.

Curbside bus stops create congestion by halting on road, board and alight passengers occupying road space. Long dwell time and infrequent halting result in traffic congestion (Cohen, S. L. (1983)) in the downstream traffic of a curbside bus stop. Curbside bus stops affect traffic flow severely in an urban network by adding overburden congestion and delay in existing traffic (Nguyen-Phuoc, D.Q, et. al (2018)). Curbside bus stops are one of the sources of traffic congestion on the roads of Dhaka city.

The increasing number of buses has a negative impact on road capacity, result in the long queue and prolong delay at bus stops (Luo, Q., Zheng, T., Wu, W., Jia, H. and Li, J.(2018)). Xu, H., Tan, Z.X. and Yang, X.G. (2009) found significant effects of bus stops on the capacity of the adjacent lane under different traffic conditions. However, bus stops are marked as a tradeoff between public mobility and access coverage (Chen, J., Wang, S., Liu, Z. and Chen, X. (2018)). Guo, Z.H., Wang, W. and Lu, J.(2005) remarked buses are interrupted by other vehicles while boarding and alighting passengers. Bus bay could replace bus stops without blocking traffic severely (Nakamura, F., YABE, T. and Suzue, S.(2005), Koshy, R.Z. and Arasan, V.T.(2005)). Fitzpatrick, K., Hall, K., Finley, M. and Farnsworth, S. (2002) proposed bus bulbs similar to bus bay, a sidewalk extended from the curb of the parking lane, which improved vehicle and bus speed in the traffic of Seattle and Vancouver cities.

There are noticeable impacts of bus bay in the traffic of an urban road. Buses required more time to merge back into flowing traffic. Therefore, bus bays will usually need longer dwell times (Xia, Y.X. and Xue, Y. (2010)). Similarly, Hu, X., Xu, N. and Wan, Q. (2018) remarked that though the bus bay reduced the effect of bus stops on traffic flow, it increased interference to regular traffic flow while leaving the bus bay. Though there are some shortcomings, bus bay seems to be more feasible than curbside bus stops. The novelty of this study is, it investigated the performance of bus bay over curbside bus stop under heterogeneous traffic in the context of Dhaka city.

LITERATURE REVIEW

Several studies have been conducted on the effects of bus bay on the roadway traffic system. Luo, Q., Zheng, T., Wu, W., Jia, H. and Li, J.(2018) revealed that an increasing number of buses and bus lanes decrease the capacity of the roadway. Increasing delay and queuing time at bus bay have a negative effect on curbside roadway capacity. Bus bay can reduce fuel consumption of buses under high volume-capacity ratio and long-time bus boarding scenarios (Bachok, S., Osman, M. M., & Ponrahono, Z. (2014)). Bachok et al. Bachok, S., Osman, M. M., & Ponrahono, Z. (2014) found bus bay enhance the efficiency of public transport operation in terms of mobility and speed.

The dwelling of the bus at bus stop interrupt traffic flow and cause bottleneck (Wang, C., Ye, Z., Fricker, J. D., Zhang, Y., & Ukkusuri, S. V. (2018)). Wang, C., Ye, Z., Fricker, J. D., Zhang, Y., & Ukkusuri, S. V. (2018) developed a queuing model to observe the effect of bus dwell time and arrival rate on bus stop capacity. Because of extra dwell time, the bus stop reduces the mobility of traffic, create congestion in the road (Chen, J., Wang, S., Liu, Z. and Chen, X. (2018)). Weather conditions and location have an influence on bus service time and dwell time at the bus stop (Wang, C., Ye, Z., Wang, Y., Xu, Y., & Wang, W. (2016)). Chand, S., Chandra, S., & Dhamaniya, A. (2014) developed relationships among bus frequency, capacity drop and dwell time at the bus stop. Curbside bus stop increases collision probability, reduce vehicular speed under heterogeneous traffic condition (Chand, S., & Chandra, S. (2014), Hasnine, M. S. (2011)).

METHODOLOGY

The purpose of the study was to observe the comparative performance of a curbside bus stop and a bus bay in the simulation model developed in VISSIM v. 5.4 software. A Bus stop was selected with its 500ft upstream and downstream segment for field survey as a study area.

Study Area

Nowadays congestion in Dhaka city become intolerable, Azimpur Road (Shown in Fig. 1) is not different from that. This study covers insight into traffic impact caused by the curbside bus stop and bus bay. We chose a curbside bus stop at the midblock road segment of Azimpur road. There was no turning vehicle, only through traffic present, since no side roads or intersections near the road segment. Numbers of educational institutes, such as Azimpur Girls' High School, Eden College and Home Economics College are located around Azimpur. Such development surrounding along with proximity with the New market and Mirpur road, Azimpur road attracts a considerable amount of trips and causes an increase in traffic flow in this area. The undisrupted mobility provokes more road users to use the road segment as a diversion from a congested one. Although people are perusing for full utilization of this road for mobility, this road is unable to accommodate this increased demand.

Field survey

A field survey was conducted to count classified vehicles within the survey time. The survey date was December 2, 2019, and the day was Monday. The survey time was 9:00-10:00 AM. The survey team has consisted of 4 members. The traffic data sheet was prepared and collected data through video recording. A datasheet was used to enumerate the vehicle counting. The data sheet consisted of classified vehicle counts for 1-hour at peak time, measured lane width and count numbers of the lane in the road segment.

Vehicle composition

Total counted vehicles were 395 within 1579 seconds, (approximately 27 minutes). Among them, Microbus, car, the bus was 73, 93 and 229 respectively. There was no non-motorized vehicle (NMV). Calculating composition, Microbus, car and bus were 18.48%, 23.54% and 57.97% respectively. The traffic flow rate was 901 vehicle/hr.

VISSIM models

VISSIM is a powerful microscopic traffic simulation software. VISSIM v. 5.4 has been used for modelling in our study. Model 1 was the curbside bus stop and input traffic composition, geometric property in VISSIM. Model 2 was including a bus bay instead of a curbside bus stop in the VISSIM model and input existing traffic composition and same geometry. 275.0m length of road segment was considered for each model. A Snapshot of VISSIM models are presented in Figure 2.

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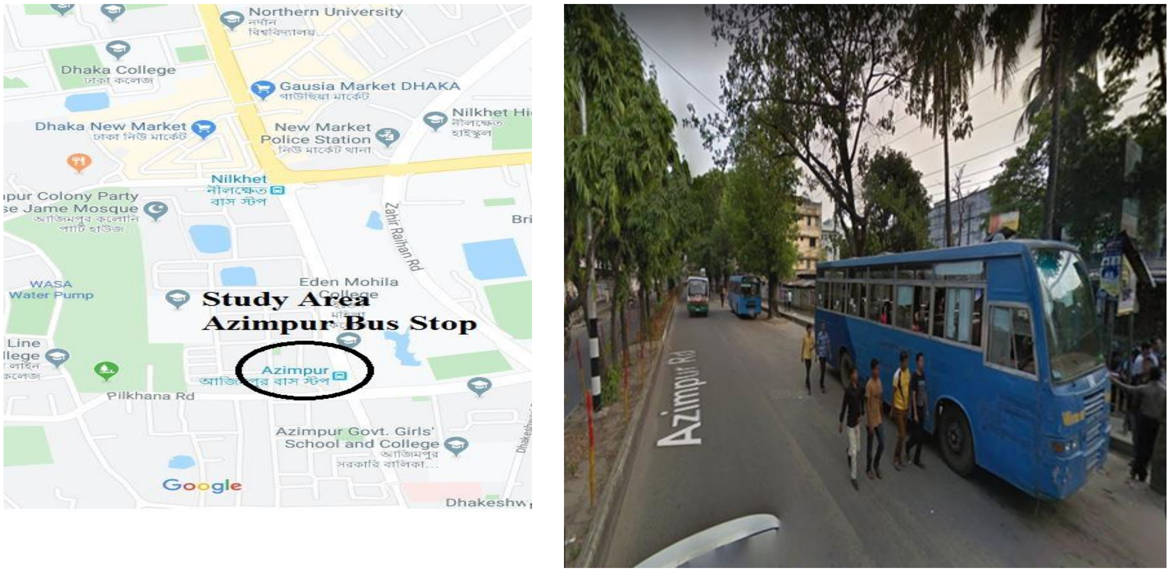


(a) (b)

Figure 1: Study area (a) google map showing Azimpur Bus Stop (b) Photograph of the existing Bus stop

Source: Google Map

Model Calibration and Validations

After the creation of the road segment, the vehicle volume and composition were input for the road links according to the survey. The geometry of the existing road segment was created using links and link connectors. The number of lanes per road and width of each lane, central median, traffic islands and other road features was specified as a pre-existing condition. The calibrated models were validated against field dataset considering travel time parameter. % variations in Model 1 and Model 2 with field data were found 3.6% and 4.3% respectively. The obtained variations in field datasets with simulated datasets are quite considerable and thus validated the simulated models.

(a) (b)

Figure 2: Snapshot of VISSIM V. 5.4 models (a) Model 1: Curbside existing bus stop at Azimpur (b) Model 2: Proposed bus bay at Azimpur

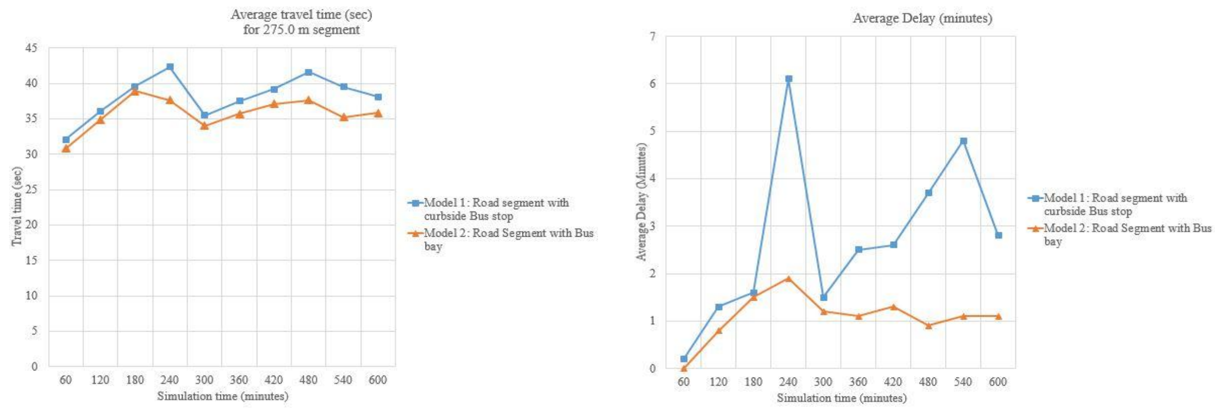
RESULTS AND DISCUSSION

The average travel time of Model 1 varies from 30.2 seconds to 38.9 seconds as shown in Figure 3(a). Because, on-street blockage of the bus, the road segment becomes congested in Model 1. Hence, travel time is more in Model 1 compare to Model 2.

Travel delay is the difference between actual travel time and free-flow travel time in a road segment. Model 1 has a higher delay compare to Model 2 as shown in Figure 3(b). The average delay is very high at 240 seconds of a simulation run in Model 1. The reason is, due to the bus waiting and dwell at the curbside lane, the road becomes congested.

The average speed at 50m upstream and 50m downstream are 1.37% and 1.39% higher in Model 2 compare to Model 1. The average speed downstream is lower than the average speed upstream due to the presence of the bus stoppage in all cases. However, this effect is more severe in Model 1, where the bus stopped at the curbside lane in the road.

Traffic density in Model 1 is much higher compared to Model 2. The downstream road segment becomes congested due to the curbside bus stop. Density in Model 2 reduced by 61.29% compared to Model 1.

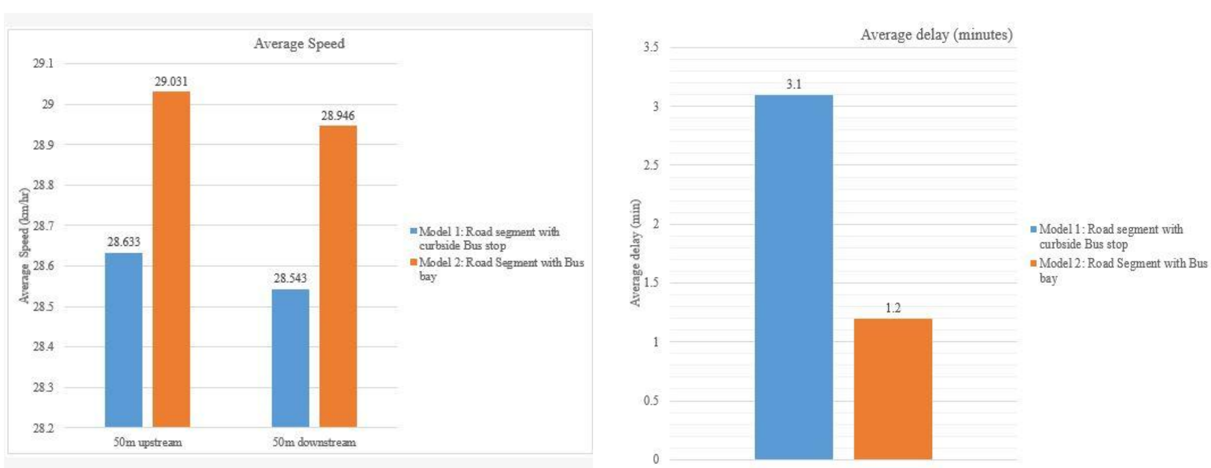


(a) (b)

Figure 3: Graphical comparison of Model 1 and Model 2 in terms of (a) Average travel time and (b) Average delay

Table 1: Comparison between Model 1 and Model 2

Criteria/models	Model 1	Model 2
Average speed at 50m upstream segment (km/hr)	28.633	29.031
Average speed at 50m downstream segment (km/hr)	28.543	28.946
Average delay (minutes)	3.1	1.2



(a) (b)

Figure 4: Graphical comparison of Model 1 and Model 2 in terms of (a) Average speed (upstream and downstream) and (b) average density

CONCLUSIONS

This study assessed the impact of bus bay for exiting traffic of the Azimpur mid-block road segment. Detail roadway, traffic and control data were collected to assess the current traffic operating conditions in the study area. Weekday traffic flows were surveyed for a 1-hour to determine the hourly traffic flow at the study mid-block road segment. Thorough microscopic modeling, traffic-operating conditions were investigated and analyzed at the network level.

The study found that travel time, density, and delay decrease insignificantly in Model 2, i.e. road segment with bus bay compare to Model 1, i.e. road segment with the curbside bus stop. In some cases of upstream Model 1 showed a higher average speed than Model 2. However, in most of the simulation time, traffic in Model 2 showed higher average speed compare to Model 1. Because of boarding and alighting passengers at the curbside lane in Model 1, the road became congested. Presences of long wait time of the bus at the curbside lane, Model 1 produced many more delays. On the contrary, traffic flow was not interrupted in Model 2 due the presence of bus bay, which was located outside of the traffic lanes.

LIMITATIONS AND FUTURE SCOPE

The study can be extended by performing a sensitivity study on vehicle composition. Our study conducted for the midblock road segment. Hence, future studies can be done for intersections and highways. The effects of non-motorized vehicles and lane changing the behavior of traffic can be studied. The proposed study can be used as a reference for the further feasibility study of bus bay in various locations of Dhaka city.

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CONFLICT OF INTEREST

There is no conflict of interest in this study.

ETHICAL STANDARDS

The submitted manuscript is original and novel. The manuscript neither published elsewhere before not under review in any other publication.

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