

Study of Optimization of Traffic Congestion at Intersection using BRT Lane

(Case Study of Katraj-Swargate BRT Corridor, Pune)

Prof. Abhishek K. Taware ^{*1}, Arvind Nadar ²

^{*1}Assistant Professor, Department of Civil Engineering, K J College of Engineering and Management Research, Pune, Maharashtra, India

²Student, Department of Civil Engineering, K J College of Engineering and Management Research, Pune, Maharashtra, India

ABSTRACT

Bus Rapid Transit was introduced as a flexible, low-cost alternative to Metro and Light-Rail systems which also aimed at encouraging people to opt for public transport instead of private vehicles. But due to the restriction of right-of-way in the existing road, implementation of BRT system has affected the other lanes. The Motorized vehicle lanes get congested and the total throughput in every direction is affected. Thus, the BRT system needs to be integrated with other modes of transport for optimization of the traffic situation as a whole. This paper presents a study in which the motorized vehicles are given passage into the BRT Lane at a 'appropriate distance' before the intersection taking into account the traffic signal cycle and also the traffic signal used at 'entry spot' of the BRT Lane. VISSIM, a microscopic simulation model is used to investigate the results of the above model and its effects on the traffic situation. It has been observed that if motorized vehicles are allowed on Bus lane at a distance from the intersection, there is an increase in number of vehicle-throughput, average speed, and reduction in average delay time and with minimal impact on the BRT system.

Keywords : Bus Rapid Transit(BRT), Appropriate Distance, Motorized Vehicle, Traffic Congestion, Intersection, Heterogeneous Traffic.

I. INTRODUCTION

In current day to day life man has become more officious due to Technology and Research. Road Transport has become a basic factor for man to travel from one place to other. On the other hand, road transport has also become a huge problem due to increase in use of private vehicles. Bus Rapid Transit was implemented for a faster, cost-effective mode of transport which also aimed at encouraging people to opt for public transport instead of private vehicles.

Bus Rapid Transit (BRT) is a high-quality bus transit system that offers fast, comfortable, and economical services at metro-level capacities. It does this through the provision of dedicated lanes, with busways and terminals typically aligned to the centre of the road, off-board fare collection, and fast and frequent operations.

Bus Rapid Transit (BRT) has become a solution to the transport problem, especially in developing countries such as India, where cost is the main criterion for choosing a bus system. It costs significantly less than a metro system and a light rail transit (LRT) system. A

BRT project can be planned within a period of 1 year to 1.5 year. However, urban roads in developing countries restrict the right of access to roads, and the introduction of BRT in the scope of such road access affects the flexibility of motor vehicles (other than buses), the congestion of motor vehicle (MV) lanes, and the flexibility of the motor vehicle (MV) lanes [5][6].

As the transport goes at a specific rate of administration, the committed lane stays unused for more often, while the mechanized heterogeneous traffic on the MV path experiences blockage. In any case, if the transport keeps running in blended rush hour gridlock, there is not any more fast travel. Consequently, an answer is expected to take care of this issue and improve the execution of the whole stream. The impact of the devoted BRT framework on the MV Path turns out to be progressively evident at the convergence. Crossing points are normally the bottleneck of the system and are the biggest and most direct wellspring of traffic accidents.

The basic perspective for viability any street framework lies in expanding the throughput of the crossing point. In this way, enhancement of traffic execution as a whole, at crossing point is required so that BRT may not significantly diminish by and large potential limit of framework at convergence; in the meantime, benefits of BRT as fast travel might be kept up.

Nevertheless, the states or countries which are opting for BRT realized that BRT is a resolution at the monetary value of congestion of other motorized traffic. Therefore, it is only a change in congestion from one style to another. Hence, there is a necessity of optimization of traffic as a whole so that all the modes may get advantage from the solution and there may be maximum relieving of congestion.

Pune was the first city in India to begin operations of a BRT corridor in December 2006. The total planned

length of the BRT system is 117 km of which the pilot corridor is 17 km from Katraj to Hadapsar along the Satara and Solapur road. At main intersections, commuters have to wait for transit of traffic on the other three arms of the intersection before getting a green sign. On BRT corridors, the signal cycle is far more convoluted and, as a consequence, a lot longer. Also due to the restriction in the road width for the motorized vehicles there is perceivable problem of traffic congestion while the BRT lanes are empty many at times. Many literatures show that BRT is a better solution for traffic congestion, but BRT has not shown marginal effect in improvement of traffic congestion in Pune.

The organization of this document is as follows. In Section 2, Objectives are mentioned, In Section 3 describes Scope and Limitations of the framework. In section 4, Literature Survey is done. In section 5, Methodology covers the data collection and analysis and in section 6, analysis results are mentioned. In section 7, concludes the work.

II. OBJECTIVES

- Effective utilization of BRT lane without significantly affecting the BRT system.
- To reduce queue length of the motorized vehicles before intersection.
- To increase vehicle throughput.
- To reduce signal time at main intersections.

III.SCOPE AND LIMITATIONS

- This study is only applicable to the Katraj-Swargate BRT route.
- The right-turning vehicles only should be allowed in BRT lane.
- The local buses should move on the motorized vehicle lane instead of BRT lane to be able to take a right-turn using the diversion.

- This method is not applicable at intersections which have signal prioritization to BRT bus.

IV. LITERATURE SURVEY

Chetan Kumavat, et. al. [1], studied the overall outlook of Delhi and Pune BRT systems and emphasized on some common problems in operating both the systems. Some recommendations were that the bus stops should be at a convenient distance for ease of access for the passengers and skywalks and subways should be provided at possible locations.

Sumeet Kaur, Ketankumar Varmora [2] deals with the study of mix vehicular traffic and traffic analysis done by using simulation model in VISSIM software and it is used in transit signal priority for existing BRTS in Ahmedabad. They represented that VISSIM is able to simulate various parameters and analyze for improvement in the system, study of signalized and non-signalized intersections, signal priority and vehicle detection characteristics can be modelled in VISSIM.

Burak Cesme, Selman Z. Altun and Barrett Lane [3], determined the benefits proposed by various preferential treatments: Queue Jump Lanes, Transit Signal Priority and stop position by executing an extensive simulation runs under several scenarios at an isolated intersection using VISSIM. The study concluded that queue jump lanes save approximately 9 seconds per bus per intersection for ideal conditions.

Chaudhari Dron, Prof..N. D Hajiani [4], determined the problems created by BRTS corridor on parallel lane traffic and also expressed the public opinion survey done on the problematic stretch to find out the problems faced by the people. The study area was Ahmedabad city, from AEC Bridge to Sola Bridge. They concluded that there is a reduction in speed by 58% in other transit modes which are running parallel to the BRTS and the AMTS (Ahmedabad Municipal Transport Services) buses and cars should

be allowed in the dedicated BRTS corridor due to low BRT bus frequency.

Hemant Kumar Sharma and B.L. Swami [5], presented the effect If the bus route ends "at an appropriate distance" before the Stop Line, at a heavy traffic signalling intersection, the bus lane of this space can be used for all traffic at the intersection (heterogeneous traffic). The case study of Rambagh intersection of Jaipur city was studied for the analysis of the method adopted. They noticed that the queue length was trimmed down, average delay time per vehicle gets reduced by 34%, vehicle throughput was increased, the emission of Carbon Mono-oxide (CO) and VOC (Volatile Organic Compounds) were subdued, and the average velocity of vehicle in the network gets increased by roughly 34%.

Hemant Kumar Sharma, Mansha Swami and B.L. Swami [6], also dealt with the problem of dedicated BRT lane on Motorized vehicle (MV) lanes due to reduction in right-of-way in the Chirag Delhi intersection which is fourth junction on the BRT corridor at CH 2980. The report concluded that there is a significant reduction in average queue, maximum queue length and average delay time per vehicle. The throughput gets increased and there is a significant decrease in emissions and fuel consumption. The mean velocity of vehicles in the network gets increased by roughly 23%.

V. METHODOLOGY

A. Implementation

- Collection of Traffic Volume data at intersection on BRT corridor.
- Selection of Software for Simulation of model.

The method of diversion is shown in the figure 1.

- Simulation of current Traffic situation / Calibration of the software.

- Simulation of model when motorized traffic is allowed in BRT lane.
- Comparison and analysis of both traffic scenarios.

1) Collection of Data

According to Regional Transport Office of Pune data, there has been an average increase in vehicle population by 9.7% per year during the period of 10 years. As of September 2016, the vehicle composition in Pune based on ownership is approximately 17.67% cars/jeeps, 1.53% Auto-Rickshaws, 2.19% Tractors/Tankers/Trucks, 0.36% Buses, 75.05% Two-Wheelers, 2.25% Delivery Vans and 0.95% other vehicles. The modal share of transport in Pune is shown in the figure below.

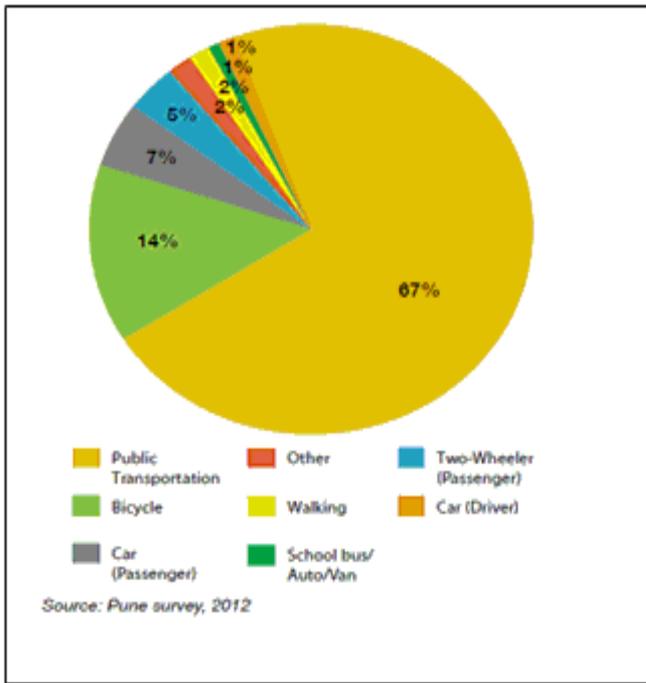


Figure 1 : Modal Share of Pune city (2012)[7]

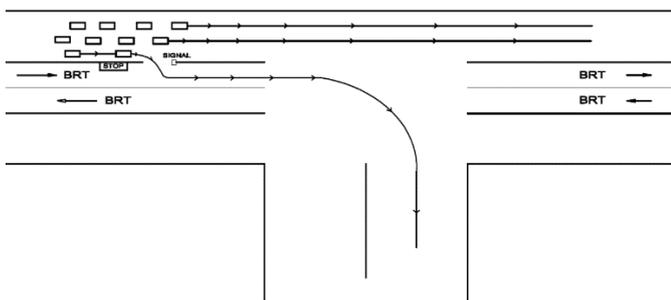


Figure 2. Representation of the diversion model along the BRT lane

Pune is the first city to introduce BRTS in India, a Pilot Project along the route Swargate-Katraj-Hadpsar in 2006. The BRTS route is comprised of 27 bus stops, 29 Junctions and 6 terminals. The pilot BRTS associates 6 terminals and significant movement zones like Hadpsar, Magarpatta, Swargate, Cantonment area, Bibvewadi, Balajinagar and Katraj with one another. The BRTS framework for Pune is a framework with a blend of devoted and non-committed BRT paths relying on the accessibility of option to proceed. The Pilot BRT route of Pune city are shown in Fig. 3 below.

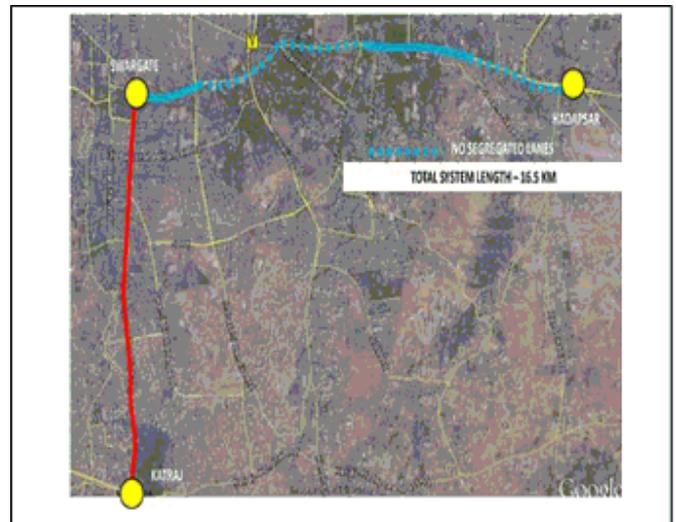


Figure 3 : Image representing the Pilot BRT route of Pune city.[8]

Katraj- Swargate Route is selected as the study area for the implementation of the method as it consists BRT lane and the congestion in motorized lane is prevalent. This corridor is also one of the busiest in Pune. The congestion is severe near intersections due to bottlenecks. Flyovers have been constructed along the majority of the route. Thus, intersections where flyovers are not feasible are selected along the route for studying the effect of the method.

Traffic volume data of Utsav Chowk/ Intersection during morning peak hour (9a.m. to 10 a.m.) is collected using Manual collection.

2) Simulation software

The various traffic simulation software are:

- a) Quadstone paramics
- b) VISSUM
- c) VISSIM
- d) AIMSUN
- e) Matism
- f) SUMO
- g) Repast
- h) MAINSIM

The intersection diagram showing the traffic volume at the intersection is shown in Fig.4. The following table shows the traffic composition at the intersection:

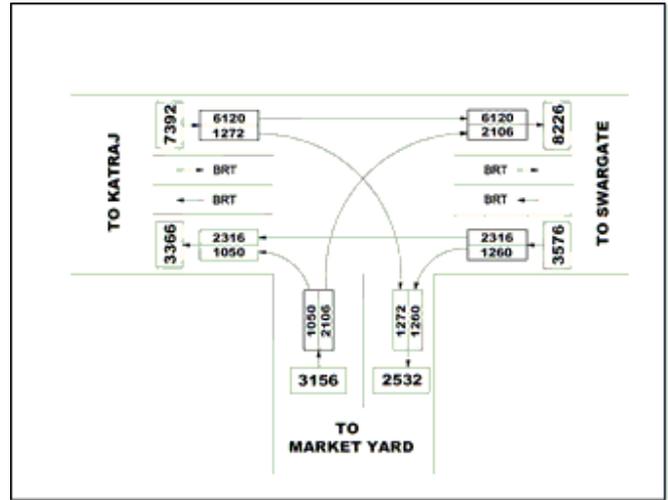


Figure 4 : Traffic flow diagram of Utsav Intersection during morning peak

VISSIM was selected due to availability of literature and its ease of use. VISSIM is a microscopic traffic simulation software which is able to simulate heterogeneous traffic.

Table 1 : Traffic Composition at Utsav Intersection during morning peak hour (9 am to 10 am)

S.N	Approach Route	Traffic Composition in %					Right Turning	Left Turning	Through	No. of Vehicles
		Cars/Jeeps	Auto-Rickshaws	Two-Wheelers	Buses	Others				
1	From Katraj	25%	14%	56%	8/min	5%	1272 (17.2%)	-	6120 (82.8%)	7392
2	From Swargate	25%	14%	56%	8/min	5%	-	1260 (35.2%)	2316 (64.8%)	3576
3	From Marketyard	26%	5%	60%	-	9%	2106 (66.7%)	1050 (33.3%)	-	3156

In VISSIM the following types of traffic can be simulated:

- Vehicles (cars and trucks)
- Public transport (trams, buses)
- Cycles (bicycles, motorcycles)
- Pedestrians
- Rickshaws

VISSIM can model the movements of individual vehicles under various constraints like: traffic signal, road geometry, speed limit, type of vehicle, etc.

The road intersection at Utsav building near city pride multiplex is generated using links and connectors, which are the building blocks of VISSIM network. The existing number of lanes on road with total width of road and other transport helping structures like traffic islands, dividers generated according to actual situation. After generating this model, traffic volume is linked by giving input to VISSIM software. This was followed by specifying the various routes in which vehicles travelled. The other features viz. priority at conflict zones, stop signs, signal heads was inputted. After the data was inputted, the current traffic scenario and

proposed scenario was analysed using VISSIM based on parameters like: vehicle throughput, vehicle delay, emissions (VOC, CO, NOx), fuel consumption, queue length.

VI. RESULTS AND DISCUSSION

The effectiveness of the proposed model is found out after comparison of result of the proposed model with the result of current traffic model. The vehicles were diverted into the BRT lane at a distance of 50m before the intersection. The following results are found.

- **Time Interval:** At every 360 seconds, the results are computed.
- **Movement:** The movement of traffic from one link to another link
- **QLEN:** The queue length behind stop line (i.e. no movement of vehicles) is calculated per second for 360 seconds and then mean of these values gives the QLEN. Measured in meter.
- **QLEN MAX:** The queue length behind stop line is calculated per second for 360 seconds and the

maximum of these values gives the QLEN MAX. Measured in meter.

- **VEHS (ALL):** The number of vehicles, which pass 'Point A' (Stop Line) node of intersection and reach 'Point B' (Destination) node along the route for the respective time interval.
- **VEHDELAY (ALL):** Vehicle Delay = (Actual Travel Time- Ideal Travel Time)where,

Ideal Travel Time = Time taken by vehicle to cover distance from 'Point A' to 'Point B' without stopping at signal and in queue.

- **STOPDELAY (ALL):** Stop delay is the delay caused due to signals and bus stops only.
- **Emission CO:** Emission of Carbon Monoxide in gram.
- **Emission NOx:** Emission of various forms of Nitrogen Oxides in grams.
- **Emission of VOC:** Emission of Volatile Organic Compounds in grams
- **Fuel Consumption:** Fuel Consumption in US liquid gallons.
(1 US Liquid Gallon = 3.785 litres)

Table 2 : Comparison of results of Proposed and Current traffic model at Utsav Intersection

INTERSECTION	MODEL	QLEN (m)	QLENMAX (m)	VEHS(ALL)	VEHDELAY(ALL) in s	STOPDELAY(ALL) in s	EMISSIONS CO	EMISSIONS NOX	EMISSIONS VOC	FUEL CONSUMPTION
Utsav										
1	Proposed	187.318	295.368	592	67.04	47.317	1114.3858	216.8192	258.2697	15.9425
2	Current	184.764	295.372	568	74.539	55.382	1113.1333	216.5754	257.9794	15.9247

The Emissions are calculated based on the speed, acceleration and vehicle types of individual vehicles. The emissions for when vehicles are moving and while at rest are added together. The formula from TRANSYT 7-F program are used to calculate these values [12] [11].

VII. CONCLUSION

BRT is an innovative, high capacity, lower cost public transit solution that aims to improve urban mobility. However, introduction of BRT in existing restricted right-of-way creates conflict of interest with other modes and it seriously hampers the mobility of other vehicles. Thus in order to derive the benefits of BRT without adversely affecting other motorized vehicular traffic, optimization of road system at intersection is required.

In case of at-grade intersections with BRTS corridor, if motorized vehicles are allowed to enter the bus way at

50 meter distance before the stop line of the intersection the following results were observed:

- There is significant reduction in average delay time per vehicle at both the intersections.
- The number of vehicles passing the intersection in an hour has increased.

In spite of above positive effects of the model, it has following limitations:

- The diversion model can only be implemented at some intersections which fulfil the criteria for diversion.
- The proposed diversion model increases the emission of VOC, NOx, CO slightly.
- The bus stop has to be shifted further away from the intersection before the diversion. So, it may incur extra cost for movement.
- Initially, the buses along the BRT lane may get affected due to the diverting vehicles.
- The model may lead to accidents until better understanding of the working of the diversion model develops in the commuters.

- The diversion signals have to be installed thus incurring extra cost for implementation of the model.
- The bus drivers may need some training program to adopt to the diversion model, thus increasing the cost.

The model has minimal effect on the BRT system thus; it can retain its capacity of rapid transit.

This solution does not improve the performance significantly of intersection and network as a whole.

However, this model can be implemented considering it has benefits like increased vehicle throughput and reduced vehicle delay at the intersection.

Further study is required for significant result and improvement of the diversion model.

VIII. REFERENCES

- [1]. Chetan Kumavat, Harshal Sonawane, Trushik Patel, Xitij Sakhalkar, Anuradha Pansare, "Effective Learning From Delhi Brts –A Case Study Of Pune Brts," Volume No. 05, April 2016, pp.149-154.
- [2]. Sumeet Kaur, Ketankumar Varmora, "Use of Vissim in Heterogeneous Traffic Modelling-A Review," Volume No.:- 4, Issue: 5, May 2015, pp.453-454.
- [3]. Burak Cesme, Selman Z. Altun, Barrett Lane, "Queue Jump Lane, Transit Signal Priority and Stop Location: Evolution of Transit Preferential Treatment Using Microsimulation," 14 July 2014.
- [4]. Chaudhari Dron, Prof. N.D Hajiani, "Traffic Impact Analysis of BRTS - A Case Study of Ahmedabad BRTS," Volume No.:- 2, Issue 2, 2014, pp.1956-1959.
- [5]. Hemant Kumar Sharma, B.L. Swami, "Performance Enhancement and Congestion Reduction at Busy Signalized At-Grade Intersection with Bus Rapid Transit Corridor and Mixed Traffic in India," Urban Public Transportation Systems, 2013, pp.136-147.
- [6]. Hemant Kumar Sharma, Mansha Swami and B.L.Swami, "Optimizing Performance of atgrade Intersection with Bus Rapid Transit Corridor and Heterogeneous Traffic", International Journal of Transportation Science and Technology · vol. 1 · no. 2 · 2012 – pages 131 – 146.
- [7]. Madhav Pai, Ranjit Gadgil, Anjali Mahendra, Shweta Vernekar, Rebecca Heywood, Radha Chanchani, "Motorized Two-Wheelers in Indian Cities- A Case Study of the City of Pune, EMBARQ India, March 2014, pp.20.
- [8]. IBI Group, CEE Urban Programmes Group, "Learnings from Pune's Pilot BRTS Project," Pune BRTS Promotions and Outreach Programme, May 2015, pp.11.
- [9]. Thaned Satiennam, Atsushi Fukuda, Ryosuke Oshima, "Case Study on Bangkok Metropolitan Administration Project," A Study on the Introduction of Bus Rapid Transit System in Asian Developing Cities, Volume No.:- 30, July 2006.
- [10]. Geetam Tiwari, Deepty Jain, "BRTS Projects in Indian Cities Status Report," Volume No:- TRIPP-RP10-02, June 2010, pp.1-29.
- [11]. Dhurra Lahon, P.E. Ptoe, "Modelling Transit Signal Priorities and Queue Jumpers of Bus Rapid Transit," December 2011.
- [12]. Aleksandar Stevanovic, Jelka Stevanovic, Kai Zhang, and Stuart Batterman, "Optimizing Traffic Control to Reduce Fuel Consumption and Vehicular Emissions," Transportation Research Record 2128, 2009.
- [13]. Karen R. Den Braven, Ahmed Abdel-Rahim, Kristian Henrickson, and Amanda Battles, "Modeling Vehicle Fuel consumption and Emissions at Signalized Intersection Approaches: Integrating Field-collected data into Microscopic Simulation," July 2012.

Cite this article as : Prof. Abhishek K. Taware, Arvind Nadar, "Study of Optimization of Traffic Congestion at Intersection using BRT Lane (Case Study of Katraj-Swargate BRT Corridor,Pune)", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 6 Issue 2, pp. 406-412, March-April 2019. Available at doi : <https://doi.org/10.32628/IJSRSET196215>
Journal URL : <http://ijsrset.com/IJSRSET196215>