Analysis of a BRT System for a Feasible Solution to Design New Public Transportation of a Smart City

Rohit R. Galande
M. Tech Student
Department of Civil Engineering
G. H. Raisoni College of Engg, Nagpur

Dr. P.Y. Pawade
Project Associate & Head of Dept.
Department of Civil Engineering
G. H. Raisoni College of Engg, Nagpur

Dr. B. V. Khode
Professor
Department of Civil Engineering
G. H. Raisoni College of Engg, Nagpur

Abstract

Nowadays traffic is increasing at higher rate because of high population growth rate. It is reason we need more numbers of road and bridges while considering Traffic management issues. In such situations we engineers have to be more accurate at our own work. Though we take care of smooth functioning of traffic operation in smart cities, there is need of smart mode of public transportation like Bus Rapid Transit System which is proved as very beneficial in developed countries. In this research authors consider prior and feasibility study BRTs of cities where BRTs is already implemented or proposed to work. Traffic measurement and improvement parameters, such as flow of traffic, time and speed of travel, stop time, delay time, consumption of fuel, were modeled to investigate the impact of BRT. Before actual implementation of any new public transport mode one must have to study user's behavior, impact on current urban traffic system, demand performance. Some operations like modeling, simulation, and demand supply analysis, availability of land or land acquisition need, government byelaws related to project should be analyzed. For all the above study wise capital of Maharashtra Nagpur city taken as case study and Pune BRT is taken as model system. Aundh to Ravet BRT track of Pune BRT is the study corridor for existing system study. BRT standards design by Institute for Transportation Development Planning are principles on which we had design an ideal BRT system for Amravati road to chhatrapati square stretch of Nagpur city ring road. As a conclusion BRT is found to be a very impressive and easy mode of transport for Nagpur city because of its benefits such as low construction cost, less time for implementation, easy to grasp system for new users. BRTs is provided with smart facilities equivalent to metros like collection of fare off board, advanced buses with dedicated right of way, separate alignment for buses throughout its road stretch, platform level boarding, special designed bus preferred intersection treatment.

Keywords: Bus Rapid Transit (BRT), Public Transportation, Traffic speed, Traffic management, Urban traffic, Modelling, Simulation

I. INTRODUCTION

Recently some cities in Maharashtra state of India were announced to develop as smart city but only two cities out of that were approved for it. For making them smart enough public transportation system of a city need to be smart. On the other side capital city of India is facing serious traffic congestion issue. They were planned to direct traffic in even odd patterns. I.T hub of Maharashtra- Pune is also facing problem of traffic management and air pollution control level. It is ranked as second most number of vehicle carrying cities in Asia after Delhi. Orange city, wise capital of Maharashtra Nagpur is growing toward the largest industrially developed city in India. If infrastructure is developed with such tremendous way then obviously their transportation network should have in such a manner that not only present scenario of traffic but also next few decades road traffic is works smoothly.

If we consider the growth of population we are able to understand the need of increased need of trips and trip generation. As number of trip generated increases, naturally they will split indifferent modes of transportation. When a transportation engineer makes trip assignment for future development of traffic he needs to think first about Public transportation of city. Nonproductive public transportation of city indirectly results into surplus of vehicles to road network. Under Indian economic scenario people are unable to buy individual vehicle for their daily need of trip generation, still they are willing to buy same so as a consequence of poor public transportation facilities. Effect this shows excess of vehicle, and it is the exact reason for increase in traffic congestion. On the other side government is also trying to give valuable and impressive transportation, but as a developing country funds available for improvement of infrastructural development are limited. To resolve the problem of both user and service provider

authority Bus rapid transit is the best solution for fast and worth development. It is the most economical as well as relatively cheap modern mode of transportation.

Speed, traffic flow, travel time, delay time, stop time, and fuel consumption of both current and proposed Bus system(that is BRTS) by V. M. Patankar et. al,(2012) to study traffic quality parameters such as for betterment of public transportation of Delhi corridor. Impact of dedicated lanes have to investigate, it is done by selecting a 6.4 km long heterogeneous traffic corridor beginning from Ambedkar Nagar upto Moolchand in Delhi. This section is part of a 24 km long road patch, where BRTS is projected by authority as well as operation of it will start very shortly. TRANSYT-12, aaSIDRA2.1, AIMSUNv4.2 are the computer based softwares had been used to compare two public transportation system on road section.

Pune a city of two wheeler is analyzed by A. Rangarajan (2010).Swarget to Karaj route of public buses was selected for study which is 13 km in length. A model of microsimulation traffic was established for both systems and also the validation is done with the help of measured data using methods of statistics. Layoff time for both systems was determined for both the systems and compared to get advantageous solution.

S. A. Wankhade et. al,(2014) study current public transport system to get accident data analysis of same and also they considered public opinion towards current public transport by man to man survey. Capacity of road and level of service of roads are calculated to get superior option to Nagpur city traffic flow. AVL technology is used for proposed BRT system

Darshit M. Shah et. al,(2014) studies journey speed, queue lengths and average running speed at intersection and discover relevance of BRT system for Ahmadabad city.

After thorough study and analysis of all traffic conditions for different cities in India all the above researchers meet to a same solution that is BRT is most suitable public transportation system for Indian traffic scenario.

II. METHODOLOGY ADOPTED FOR RESEARCH

1) Before beginning of any work previous researches were studied. Herein also we have reviewed earlier studies of BRT prior to implementation of same Indian cities as that of we need in our work in last title.
2) Standards defined by Institute for transportation and development policy (ITDP) are used as a standard tool for designing new BRT system as well as evaluation of existing BRT system.
3) BRT section from Aundh to Ravet of Pune BRT (branded as Indradhanu) is taken as case study for evaluation; this section is marked according to valuation scheme defined by ITDP.
4) Drawbacks founded in above analysis are tried to solve using BRT standards for selected road section.
5) Amravati road to Chhatrapati Square of Nagpur city ring road is investigated for suitability of BRT system.
6) While designing the above some physical as well as traffic parameters are considered to get a perfect public transportation system.
7) A Static three dimensional model with proposed BRT system is made to get exact idea above new concept of public transportation.
8) By using traffic data collected peak hour scheduling for new bus system considering all public transport users is done.

III. BRT STANDARDS AND MARKING FOR PUNE BRT (INDRADHANU)

ITDP gives evaluation scheme for BRT system; very few such marking schemes are available at present. BRT Standards is one of them. In this particular system various parameters of BRT systems are given different situations possible in different cases and accordingly marks were allotted to it. There are six main headings and under these heading some sub points containing marks for it. A separate provision of deduction of marks is also in marking scheme. Following are the points the points to be considered

A. Basics Points of BRT:

These are the most important parameters and much necessary points for BRT system; It include separate access fare collection, Junction signal management, flat boarding at stations.to Buses, Position of Busway, Advanced

Fig. 1: Separate access to Buses, Position of Busway

Fig. 2: Advanced Fare collection facilities

Fig. 3: Junction signal management

Fig. 4: flat boarding at stations

B. Planning of BRT:

This point includes planning parameter of BRT. It comprises of availability multiple directions, Various Public services, center of control, global position of BRT, corridor type, operation timings, and maximum Corridor network. Pune BRT is having Multiple lanes of operation, various local services are also provided in Indradhanu,

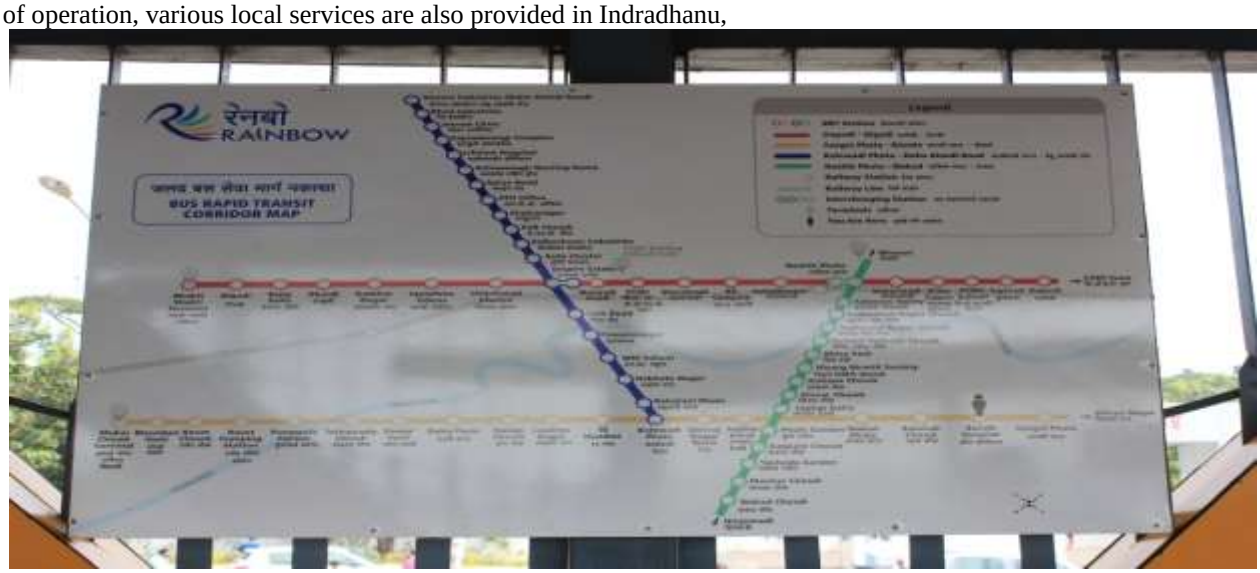

Fig. 5: Multiple directions of Pune BRT

C. Infrastructure of System:

This parameter is useful to keep system good enough while comparing it with other systems. It includes points as another lane for overtaking at station, bus emission should be low, distance available from intersection, center main stations, quality of pavement made. Pune BRT is having another lane for overtaking at station, Buses used are Euro IV, all bus stops are 100 meters away from intersection.

D. Station Characteristics:

Stations are the most important fact in BRT systems. Markings are depend on distances between two adjacent stations, safety and comfortless of stations, doors available on door, bays for docking and sub stations, existence of bus with sliding door. In Pune BRT stations are 0.6 km away from adjacent station and having sliding doors.

E. Communication:

Is consists of only two point branding of system and availability of current situation to passengers. Pune BRT is having brand name Indradhanu and exact true location information is available on each station on display board.

F. Access to passenger and Integration:

This point includes access to each and every passenger, other public transportation mode availability, safe entry for pedestrians, sharing facility of bicycle parking and separate lane for it.

Following table clears idea about marking scheme given by ITDP very clearly. It shows maximum marks can be given to any system in last column. The marks obtained by Pune BRT are on the basis of BRT standards. The photographs shown above are proof of the got by Pune BRTS. According to the following table total maximum marks are 100. Medal distribution System is as if Marks are between 85to100 then system got Gold medal, If it is between 70to 84 then system got silver medal, If it is between 55 to 69 then bronze medal. Here Pune BRT got 79 marks hence got Silver Medal.

Table – 1
Marking Scheme BRT according to ITDP

Sr. No.	*Parameter Of BRT*	*Marks obtained By Pune BRT*	*Max Marks By ITDP*
1	*Separate access to Buses,*	*7*	*8*
2	*Position of Busway,*	*8*	*8*
3	*Advanced fare collection facility*	*7*	*8*
4	*Junction signal management*	*5*	*7*
5	*Flat boarding at stations*	*7*	*7*
6	*Availability multiple directions,*	*4*	*4*
7	*Various Public services,*	*2*	*3*
8	*Center of control*	*1*	*3*
9	*Global position of BRT*	*0*	*2*

10	*Corridor type*	*2*	*3*
11	*Operation timings*	*1*	*2*
12	*Maximum Corridor network*	*1*	*2*
13	*Another lane for overtaking at station*	*2*	*4*
14	*Bus emission should be low*	*2*	*3*
15	*Distance available from intersection*	*3*	*3*
16	*Center main stations*	*2*	*2*
17	*Quality and surface of pavement made*	*2*	*2*
18	*Distances between two adjacent stations*	*2*	*2*
19	*Doors available on transit unit*	*3*	*3*
20	*Bays for docking and sub stations*	*2*	*3*
21	*Presence of sliding door in bus.*	*3*	*3*
22	*Branding of system*	*2*	*3*
23	*Availability of current situation to passengers*	*2*	*2*
24	*Access to each and every passenger*	*2*	*3*
25	*Other public transportation mode availability*	*3*	*3*
26	*Safe entry for pedestrians, parking and separate lane for it.*	*2*	*3*
27	*parking and separate lane for bicycles*	*0*	*2*
28	*Sharing facility of bicycle*	*2*	*2*

G. *Drawbacks of Pune BRT:*

Treatment for buses at junction may be increase so that the entire junction is get bus priority signals.
There is only one control center in a very long route if number of center increases then functioning of system will be smooth
To reduce bus emission, extra lane for overtaking at station, operation of buses at midnight some financial issues is faced by government authority.

Bus stations are at center of road section, access to all passengers are provided with senior citizen crossing and with separate traffic signal for them, if it is provided grade passing for pedestrians then marks of system may increase.
In this system a separate for bicycle is provided but there is no provision for parking of same and there is no bicycle providing authority on station. If this provision for bicycle is made then Pune BRT will become the most successful BRT in the World.

IV. STUDY AREA AND PARAMETERS

A. *Study Location:*

Nagpur city is wise capital of Maharashtra state. Though it is well planned city in India, it faces some traffic jam problem in some areas where growth of population is more. Nagpur is having two ring roads so that traffic load transfers automatically via these ring roads. Hingana area in the Nagpur city is the most industrialized area in the city as well as many top educational institutes are situated in this area. As a result numbers of vehicles run on nearby areas are more. Therefore problem of traffic congestion is more this area. We cannot reduce numbers of trip generated due large industrialization. The only way to reduce traffic congestion is motivate people to use public transportation. For the same purpose we have improve public transportation system of city. Recently the work of Nagpur Metro had begun and goes on with relevant speed. Nagpur Municipal Corporation had suggested some routes for BRT and LRT in the city. Out of which the area selected for BRT implementation is Amravti road to Chhatrapati square part of ring road of Nagpur city. The reason behind selecting the same is it most congested area in peak hour and the same road is connected to two proposed metro tracks. There is no standard mode of transportation connecting metro to other public locality. Following figure will clear the study area selected for study.

Fig. 6: Study area of Nagpur BRT

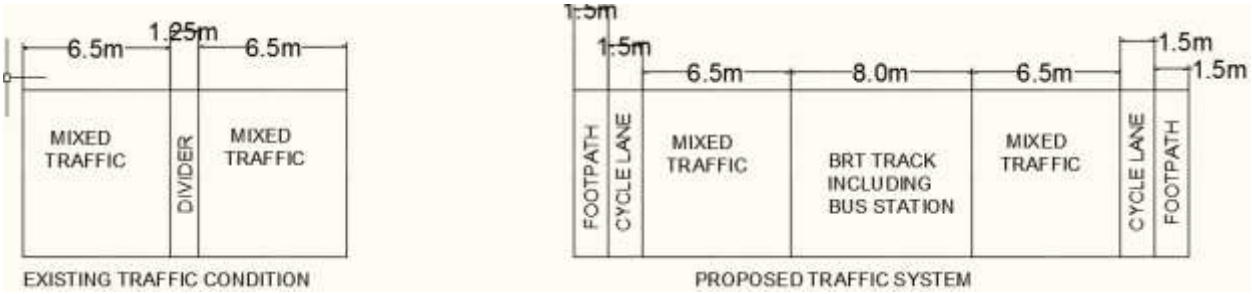

Fig. 7: Traffic system existing and proposed

B. Width calculation

The essential requirement of BRT is only width of road where system is to be applied. Width of selected road is vary from 14 meters to 28 meters different at different locations. At present situation worst width of road is as shown in figure7 that is 6.5 meters on each side for miscellaneous traffic. In proposed system road width required is 27 meters it includes 6.5 meters miscellaneous traffic on opposite sides, BRT track is at center of road having width 8 meters, footpath and cycle track takes 1.5 meters each. For better traffic flow we can increase widths of some lane shown in section wherever possible or width is available with no complications. If we sum up all numbers, total width of road required is 27 meters. The road width can be extended up to 28 meters and in some cases it is 30 meters. The following table shows measured width of roads at different locations.

Table – 2
Widths of selected road stretch at different locations

Sr. No.	*Location (Nagpur City Ring Road)*	*Available Width*	*Width Extended Up to*
1	*RMC company MIDC*	*16m*	*30m*
2	*BOM MIDC*	*16m*	*30m*
3	*Near Ocrti Post*	*14m*	*28m*
4	*At Priyadarshani Hostel Gate*	*30m*	*30m*
5	*NIT Garden*	*30m*	*30m*
6	*Haldiram*	*30m*	*30m*
7	*HDFC & Dhanlakshmi bank*	*30m*	*30m*
8	*Bajaj Showroom*	*30m*	*30m*

C. Existing Public Transportation

Nagpur Municipal Transport gave contract of public buses to Vansh Vinay Infrastructures Limited Company for limited period. This company provides local bus service in Nagpur city. It is normally known as Starbus . There are total 58 routes on which these buses run. Out of which three Bus routes passes though selected road stretches for study. At present there are 240 buses in current operation with distance between two adjacent bus stops equal to 0.5 to 0.8 Kms. Accident data of public buses is as shown in figure.

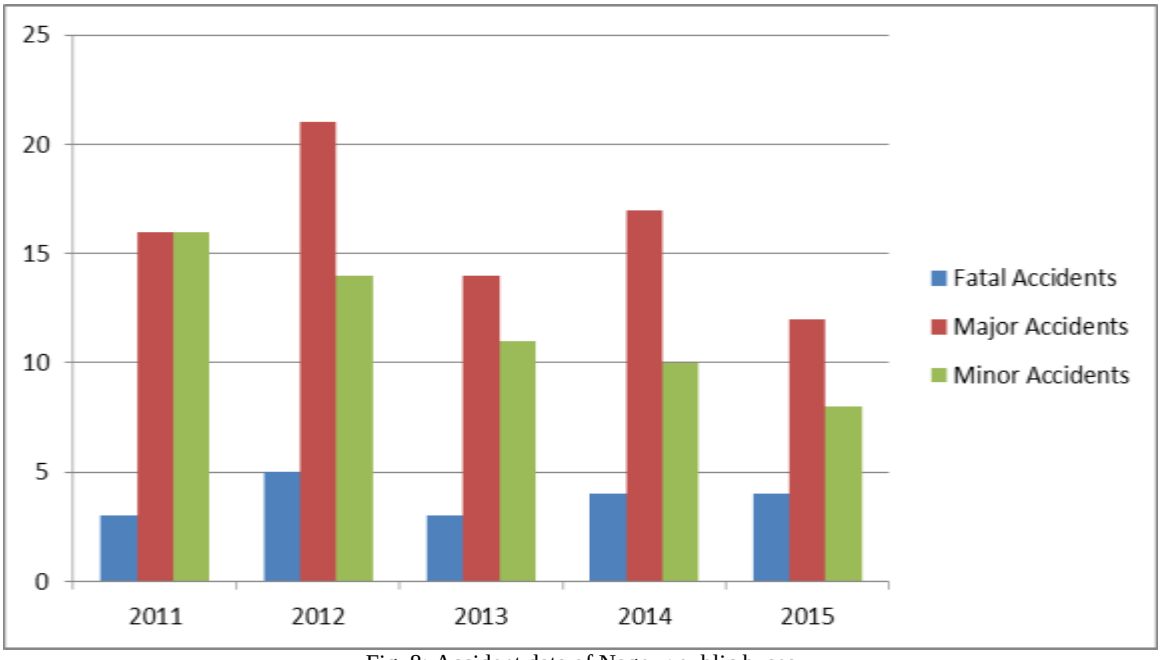

Fig. 8: Accident data of Nagpur public buses

V. COLLECTION OF DATA, MODELLING, SCHEDULING

A. Data Collection:

While collecting traffic data the whole road stretch is divided into three parts for convenience viz. Amravati road to Wadi naka, Wadinaka to Priyadarshani T point, Priyadarshani T point to Chhatrapati square. On each part of road we have collected traffic data by videography for three week days for morning and evening peak hours.

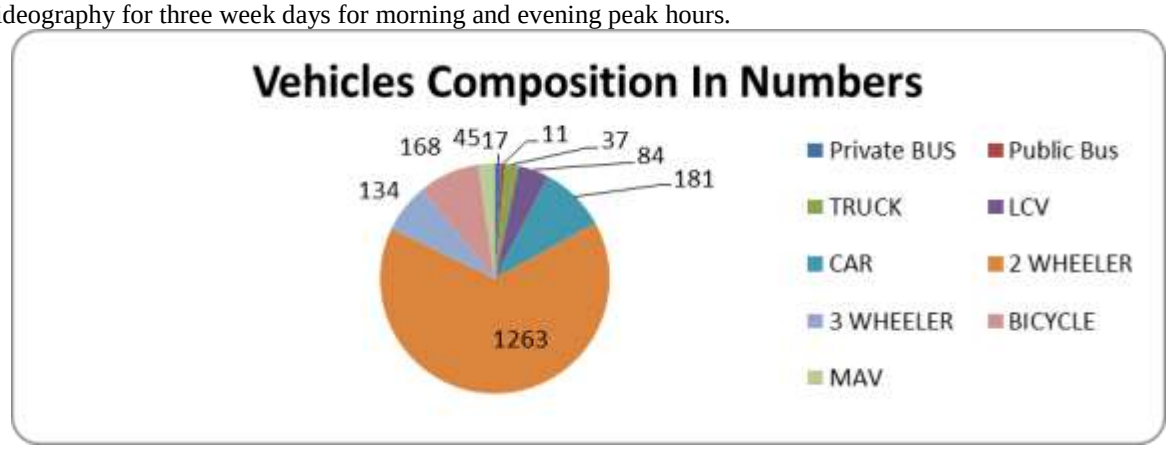

Fig. 9: Vehicle composition on selected road stretch

B. Static 3D model

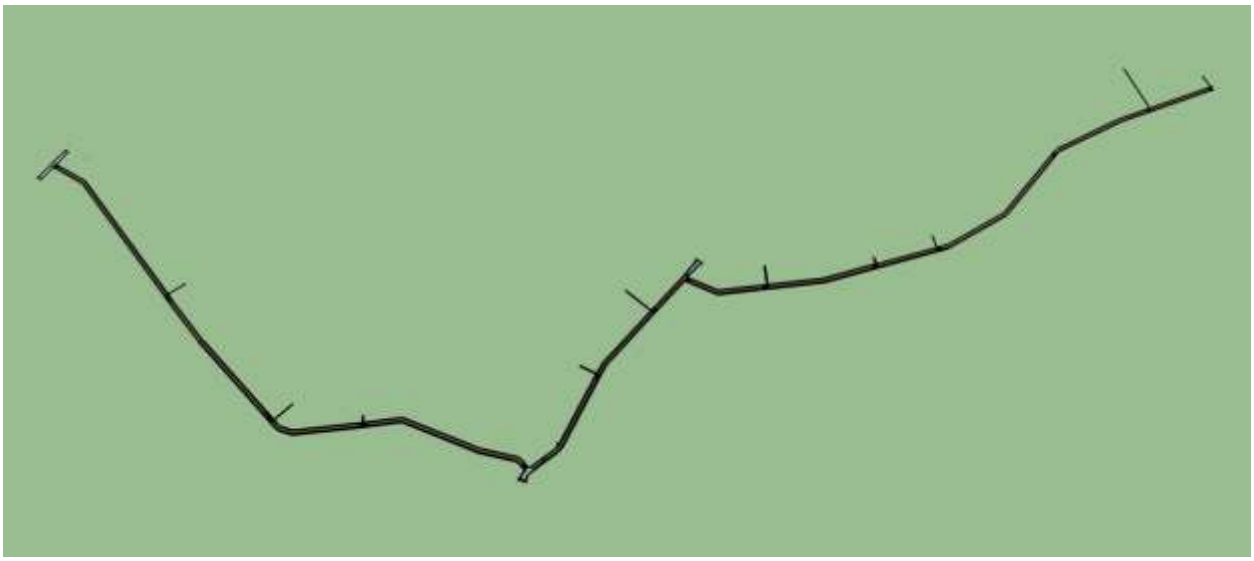

Fig. 10: Model showing locations of bus stops

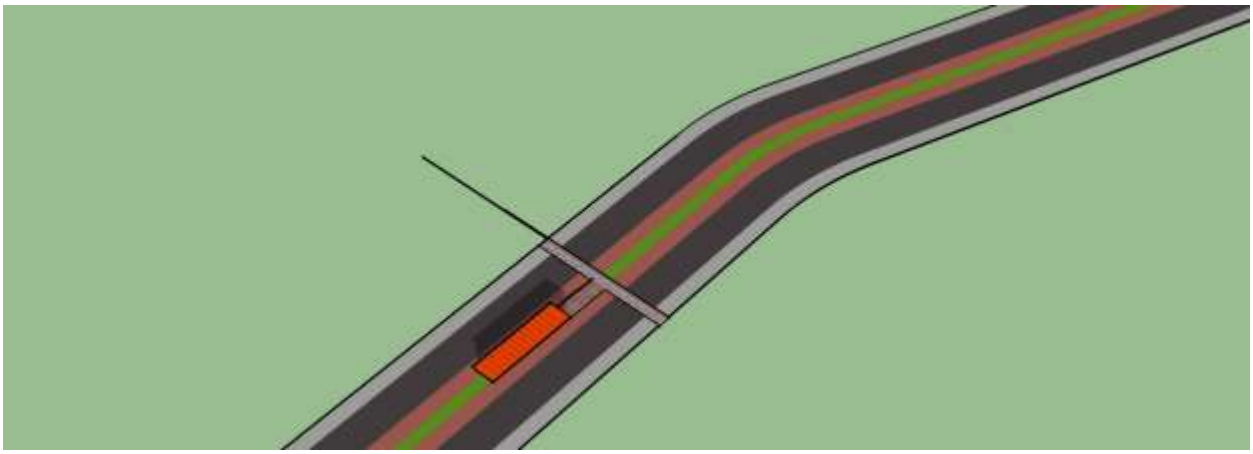

Fig. 11: Model showing exact road stretch of BRT system

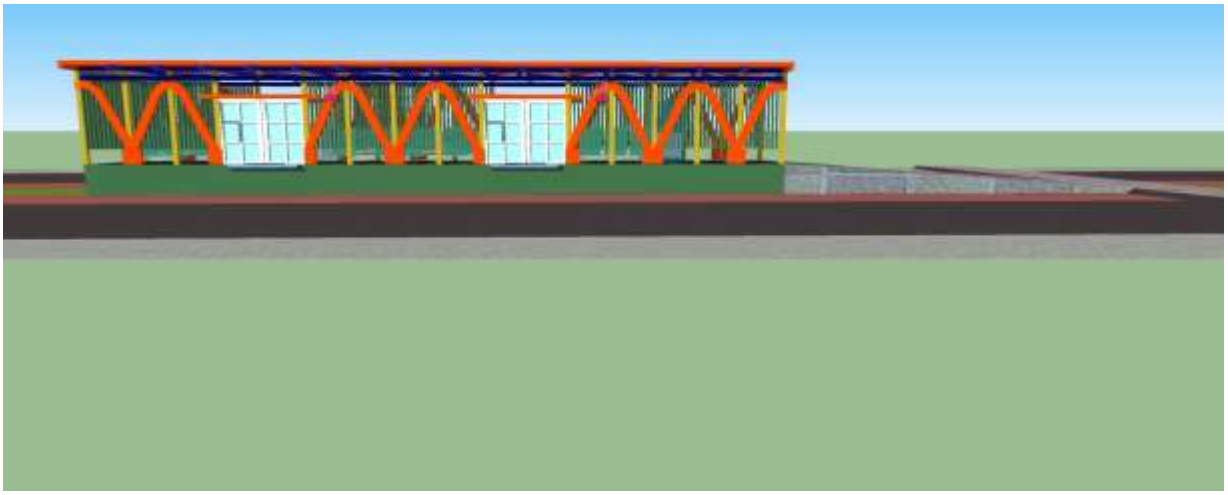

Fig. 12: Model showing structure bus stop

C. *Fleet Size Calculation*

Vehicle composition data of selected road stretch for three week day is collected. Vehicles are classified according vehicle classes. Out of this data maximum volume of one hour for morning and evening is selected. From these vehicles public transport vehicles are separated and number of passenger travelling in that peak hour by public transport vehicles is measured. By this way we got exact numbers of people using public transport. If we divide this number of people by maximum carrying capacity of standard bus we can get number of buses required per hour. To get fleet size these six minutes is divided into number of required. Another important parameter required for scheduling is location of bus stop. It can be found by personal interview method. For this purpose we had made roadside interview of people travelling daily in that peak hour. Data collected and scheduling done is shown in following figures.

Evening Public transport Volume Per hour

	Wadi naka To Priyadarshani T point	Wadi naka To Priyadarshani T point
Public Transport Buses	13	13
Other Modes Of Public Transport	108	119
Total Passenger CarringCapacity	1368	1412
No. Of Buses Required	19	19.61
Rounded Up Buses	19	20
Fleet Size	3 Min	3 Min

Fig. 13: Fleet Size calculation for evening Peak hour

Morning Public transport Volume Per hour

	Wadi naka To Priyadarshani T point	Priyadarshani T point to Wadi naka
Public Transport Buses	11	11
Other Modes Of Public Transport	67	54
Total Passenger Carring Capacity	1060	1008
No. Of Buses Required	14.72	14
Rounded Up Buses	15	14
Fleet Size	4 Min	4 Min

Fig. 14: Fleet size calculation morning peak hour

D. Scheduling

Morning Peak Hour Scheduling for One Hour Chhatrapati to Priyadarshani to Wadi naka to Amravati Road

Chhatrapati	Khamla	Pratap Nagar	Nagoba Mandir	Trimurti	Mangalmurti	Priyadashani	Takliseem	Yashoda Nagar	Wadi Naka	BOM/ MIDC Police Station	Raisoni Polytechnic	Paradsinga	Amaravati Road
8.41	8.43	8.45	8.48	8.50	8.52	8.54	8.56	8.58	9.00	9.03	9.04	9.07	9.11
8.45	8.47	8.49	8.52	8.54	8.56	8.58	9.00	9.02	9.04	9.07	9.08	9.11	9.15
8.49	8.51	8.53	8.56	8.58	9.00	9.02	9.04	9.06	9.08	9.11	9.12	9.15	9.19
8.53	8.55	8.57	9.00	9.02	9.04	9.06	9.08	9.10	9.12	9.15	9.16	9.19	9.23
8.57	8.59	9.01	9.04	9.06	9.08	9.10	9.12	9.14	9.16	9.19	9.20	9.23	9.27
9.01	9.03	9.05	9.08	9.10	9.12	9.14	9.16	9.18	9.20	9.23	9.24	9.27	9.31
9.05	9.07	9.09	9.12	9.14	9.16	9.18	9.20	9.22	9.24	9.27	9.28	9.31	9.35
9.09	9.11	9.13	9.16	9.18	9.20	9.22	9.24	9.26	9.28	9.31	9.32	9.35	9.39
9.13	9.15	9.17	9.20	9.22	9.24	9.26	9.28	9.30	9.32	9.35	9.36	9.39	9.43
9.17	9.19	9.21	9.24	9.26	9.28	9.30	9.32	9.34	9.36	9.39	9.40	9.43	9.47
9.21	9.23	9.25	9.28	9.30	9.32	9.34	9.36	9.38	9.40	9.43	9.44	9.47	9.51
9.25	9.27	9.29	9.32	9.34	9.36	9.38	9.40	9.42	9.44	9.47	9.48	9.51	9.55
9.29	9.31	9.33	9.36	9.38	9.40	9.42	9.44	9.46	9.48	9.51	9.52	9.55	9.59
9.33	9.35	9.37	9.40	9.42	9.44	9.46	9.48	9.50	9.52	9.55	9.56	9.59	10.03
9.37	9.39	9.41	9.44	9.46	9.48	9.50	9.52	9.54	9.56	9.59	10.00	10.03	10.07
9.41	9.43	9.45	9.48	9.50	9.52	9.54	9.56	9.58	10.00	10.03	10.04	10.07	10.11

Fig. 15: Scheduling work for morning peak hour

Evening Peak Hour Scheduling for One Hour Amravati road to Wadi Naka to Priyadarshani To Chhatrapati

Amaravati road	Paradsinga	Raisoni polytechnic	BOM/MIDC Police station	wadi naka	Yashoda nagar	Takliseem	Priya darshani T point	Mangal murti	Trimurti	Nagoba mandir	Pratap nagar	khamla	Chatrapati
3.49	3.53	3.56	3.57	4.00	4.02	4.04	4.06	4.08	4.10	4.12	4.15	4.17	4.19
3.52	3.56	3.59	4.00	4.30	4.05	4.07	4.09	4.11	4.13	4.15	4.18	4.20	4.22
3.55	3.59	4.02	4.03	4.60	4.08	4.10	4.12	4.14	4.16	4.18	4.21	4.23	4.25
3.58	4.00	4.05	4.06	4.90	4.11	4.13	4.15	4.17	4.19	4.21	4.24	4.26	4.28
4.01	4.03	4.08	4.09	4.12	4.14	4.16	4.18	4.20	4.22	4.24	4.27	4.29	4.31
4.04	4.06	4.11	4.12	4.15	4.17	4.19	4.21	4.23	4.25	4.27	4.30	4.32	4.34
4.07	4.09	4.14	4.15	4.18	4.20	4.22	4.24	4.26	4.28	4.30	4.33	4.35	4.37
4.10	4.12	4.17	4.18	4.21	4.23	4.25	4.27	4.29	4.31	4.33	4.36	4.38	4.40
4.13	4.15	4.20	4.21	4.24	4.26	4.28	4.30	4.32	4.34	4.36	4.39	4.41	4.43
4.16	4.18	4.23	4.24	4.27	4.29	4.31	4.33	4.35	4.37	4.39	4.42	4.44	4.46
4.19	4.21	4.26	4.27	4.30	4.32	4.34	4.36	4.38	4.40	4.42	4.45	4.47	4.49
4.22	4.24	4.29	4.30	4.33	4.35	4.37	4.39	4.41	4.43	4.45	4.48	4.50	4.52
4.25	4.27	4.32	4.33	4.36	4.38	4.40	4.42	4.44	4.46	4.48	4.51	4.53	4.55
4.28	4.30	4.35	4.36	4.39	4.41	4.43	4.45	4.47	4.49	4.51	4.54	5.00	5.01
4.31	4.33	4.38	4.39	4.42	4.44	4.46	4.48	4.50	4.52	4.54	5.00	5.03	5.04
4.34	4.36	4.41	4.42	4.45	4.47	4.49	4.51	4.53	4.55	5.00	5.03	5.06	5.07
4.37	4.39	4.44	4.45	4.48	4.50	4.52	4.54	4.56	5.00	5.03	5.06	5.09	5.10
4.40	4.42	4.47	4.48	4.51	4.53	4.55	4.57	5.00	5.03	5.06	5.09	5.12	5.13
4.43	4.45	4.50	4.51	4.54	4.56	4.58	5.01	5.03	5.06	5.09	5.12	5.15	5.16
4.46	4.48	4.53	4.54	4.57	4.59	5.02	5.04	5.06	5.09	5.12	5.15	5.18	5.19
4.49	4.51	4.56	4.57	5.00	5.01	5.05	5.07	5.09	5.12	5.15	5.18	5.21	5.22

Fig. 16: Scheduling for evening peak hour

VI. CONCLUSION

- The real time BRT system in Pune facing some problems regarding to the delay and congestion due to unavailability of bus transit priority rules as well as the BRT Network in Pune is spread very long way in spite of that it has only one operational center to manage the system. The result of that, many times the system lags the schedule and users have to face inconvenience. But the fluency of the system can be achieved by increasing the numbers of operational centers and there proper management.
- Around the study done before a statement can be done that Nagpur city fulfils the required parameters to establish a BRT system. The parameters such as population, physical parameters of road network and the frequency of public transport users observed in origin destination survey provides the strong weightage of need of BRT system in Nagpur.
- It is clearly seen from above study that if width of road increase with proper priority of lane for different traffic category then load of traffic on urban routes automatically decreases with remarkable benefits and useful results can be found.
- Strategies used for new public transportation system cutback the travel time and delay of both public transport users and personal vehicle users.
- Cost required for application of system is very less as compared to other options available which can be balances in future when many people use public transport.

- Due to decrease in volume and use of evolutionary buses, bad air fumes produced by city have to reduce up to some extent; this is good for healthy environment of city in next few years.

REFERENCES

[1] Vaishali M. Patankar et. al, " Impacts of Bus Rapid Transit Lanes on Traffic and Commuter Mobility" ASCE(American Society of Civil Engineers)Journal of Urban Planning and Development, Vol.133, No. 2, June 1, 2007.
[2] Ananth Rangarajan "BRTS- Bus Rapid Transit System in Pune Modeling, Simulation and Feasibility Analysis" 2010 International Conference on Industrial Engineering and Operations Management Dhaka, Bangladesh, January 9 – 10, 2010
[3] Safal A. Wankhade et. al, "Implementation of Bus Rapid Transit System in Nagpur City" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 11, Issue 3 Ver. II (May- Jun. 2014)
[4] Darshit M. Shah et. al, "Impact of Brts on Urban Traffic a Case Study of Ahmedabad" Volume : 2 | Issue : 4 | April 2013 • ISSN No 2277 – 8160 Global Research Analysis
[5] Agarwal P K et. Al, "AN OVERVIEW ON BUS RAPID TRANSIT SYSTEM" Journal of Engineering Research and Studies JERS/Vol.I/ Issue II/Oct.-Dec.,2010
[6] Tiwari, G. 2003. "Transport and land-use policies in Delhi." Bull. World Health Organ, 816, 444–450.
[7] WikiPedia online Encyclopedia; www.wikipedia.com.
[8] Jawaharlal Nehru National Urban Renewal Mission (JNNURM); Sub Mission-1; www.jnnurm.nic.in
[9] Institute for Transportation and Development Policy (ITDP)