International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 11 | Nov 2022 www.irjet.net p-ISSN: 2395-0072

PERFORMANCE ANALYSIS OF BRTS OF INDORE CITY FOR SUSTAINABLE TRANSPORT SYSTEM

Suchi Singhai[1], Mr. Vivek Thakre[2], Dr. (Mrs.) Vandana Tare[3]

[1] M.E. Student, Transportation Engineering, Shri G.S. Institute of Technology and Science, Indore, India
[2] Junior Research Fellow, CE&AMD, Shri G.S. Institute of Technology and Science, Indore, India
[3] Professor, CE&AMD, Shri G.S. Institute of Technology and Science, Indore, India

---

Abstract - *India has developed phenomenally at a very fast pace during recent years and the Urban transport system is a key issue nowadays due to the incredible growth rate of population in urban areas and improper planning to accommodate the incoming population. To curb the problem of mass mobilization, the "Bus Rapid Transit System" has been opted countrywide under the JNNURM scheme with the main aim of providing a safe and quality transport system. Indore Bus Rapid Transit System has been working since May 2013 and has been successfully operating to serve as a dedicated corridor for rapid transit of bus passengers since then. The system in Indore has a 12.046km straight corridor along an old highway transecting the city and dealing with transiting heavy populations from one station to another. This study deals with the usefulness of the BRT system on the traffic of Indore city and its contribution towards the development of traffic and fulfilling the needs of citizens.*

Key Words: BRTS, PCU, User Satisfaction, Mass Mobilization, Congestion.

1. INTRODUCTION

In the present scenario, the mixed traffic lane along the BRTS corridor faces problems due to huge traffic flow, including heavy congestion during the evening hours. Such problems cause a lower level of service and also affect the growth opportunities of the city negatively. With the increase in urban population and the living standards of people, traffic is also increasing rapidly on the roads of the city, which in turn results in mobility problems and congestion on the roads due to less amount of available land for widening of the road. This traffic problem needs to be solved to reduce the traffic congestion on the roads. Due to the lack of good public transportation facilities in various areas, there is an increase in private vehicles on the road or user-based vehicular growth. Due to this increase in vehicles, the city infrastructure needs to keep pace with the growth of traffic volume by giving them access to restricted lanes (BRT lanes) and provisions. One of the key solutions to this is mass rapid transit.

1.1 BRTS

Bus Rapid Transit (BRT) is a high-quality bus-based transit system that delivers fast, comfortable, and cost-effective services at metro-level traffic capacities. It does this through the provision of dedicated lanes, with busways and iconic stations typically aligned to the center of the road, off-board fare collection, also fast and frequent operations.

The Indian government urged the city to create a bus rapid transit system through the JNNURM (Jawaharlal Nehru National Urban Renewal Mission) initiative, and a detailed BRT master plan was developed in 2007 with a proposal for a 120-kilometer road network to be completed in three phases. An 11.45-kilometer corridor along the Agra Bombay Road (AB road), one of the busiest arterials of the city, was chosen for execution as a pilot project for the BRT master plan. The chosen corridor starts from Rajeev Gandhi Intersection to Niranjanpur Square. The project was started in 2007 and finished in March 2013 after overcoming various hurdles, and full passenger service began in June 2013.

1.2 Objectives of Study

The purpose of this study is to compare the utility of BRTS, its contribution, and its impact on the city's traffic system. The main objectives of this study will be:

- To ascertain the percentage of mode shift of passengers to other modes of transportation.
- To determine the present condition of traffic and comparing it with the design capacity of roads.
- To study overall user satisfaction based on various parameters of bus services.
- Forecasting the future passenger growth rate in BRTS and finding its feasibility in future.

2. LITERATURE REVIEW

[1]Muhammad Nadeem, Muhammad Azam et.al. (2021)

This paper evaluates the performance of the BRT system in Multan, based on the passengers' perceptions and the BRT standard scorecard. The data were collected at 21 BRT stations, and a face-to-face questionnaire survey was carried out with 420 users and it was found that around 54% of passengers are highly satisfied and opted for BRT due to comfort. Reliability analysis concluded that most of the BRT stations possess the acceptable value ($0.8 > \alpha \geq 0.7$), with

only six out of 21 stations categorized as unacceptable (α < 0.5). BRTS achieved an overall 79 score and was classified as Silver-Standard BRT. The study suggests critical insights to improve the citizens' mobility with the existing BRT system, serving as a benchmark for policymakers and transport planners [1].

[2]Aditya kushwah, Akshat Man Gupta, Yogesh Rajput (2018)

This paper analyses the traffic impact of Indore BRTS on mixed vehicle lanes of some intersections which suffered from heavy traffic congestion before the implementation of the BRTS. For the evaluation of the BRTS various traffic surveys were carried out at selected intersections along the BRTS corridor which includes traffic volume study, volume capacity analysis, etc. and concluded that the traffic flow between the bottleneck section is high and exceeds the capacity of the section, The industry house intersection seems to be heavily congested and saturated which calls for the redesigning of this intersection. The queue length observed at 31.5m section i.e. the bottleneck section of the BRTS corridor is high as compared with the other similar roads and intersections around the city [2].

[3]Sudhanshu Dube et al. (2017)

The paper aimed at evaluating the performance of the system based on the perception of services and improvement opportunities. A questionnaire was prepared and the opinion of 368 passengers was collected and analyzed. It was found that on the majority of the questions, the passengers have shown satisfaction and overwhelmingly appreciated the system. However, certain points require proper attention such as proper parking facilities in the surroundings and proper feeder facilities that will improve the performance of the system [3].

[4]Chetan Kumavat, Harshal Sonawane. et al. (2016):

This paper emphasizes the common problems endured by Delhi and Pune BRTS corridor. This paper gives an overall outlook of Delhi and Pune BRT systems and observed some common problems in operating both systems some recommendations are mentioned that could help improve Pune BRTS immensely and influentially and have a better result avoiding bottlenecks faced by Delhi BRTS. The present study intended to highlight the problems such as the Long Traffic signal cycle (4 minutes in the peak hour), Long queues, and Pedestrian carelessness (i.e. walking, etc.), and to overcome those problems some good solutions have been provided [4].

[5]Tisa V. Agarbattiwala, Bhasker Vijaykumar Bhatt (2016)

The objective of this study is to analyze the existing performance of the Surat BRT system and to recommend measures to improve and make the BRT system sustainable. Surat BRT system is in its initial stage at present, hence improving its performance will encourage people to use the BRT system efficiently. The performance of the BRT system is analyzed by service quality and user satisfaction surveys. The present study is carried out with the objectives to explore the performance of the existing BRT system within the study area and analyze user satisfaction based on a survey for services rendered in future BRT systems [5].

[6]Dr. Md. Mazharul Hoque, Dhrubo Alam et.al (2013)

In this paper, an attempt has been made to discuss the concepts, needs, and opportunities of the BRT system. The paper in particular highlights Dhaka's transport problem characteristics and the potential of the implementation of the BRT system for enhanced and improved public transport services in Dhaka [6].

[7]Anuj Jaiswal, K. K. Dhote (2012)

One of the most important technical innovations in the transportation field involves the way bus services are operated and infrastructure is used to optimize their speed, comfort, and capacity. Ahmadabad has become the first city in South Asia to receive an award for a sustainable transport system. It has bagged for successful implementation of the BRTS. This paper examines the impact of the BRT System on Ahmadabad's transport sector and the changes that can be brought about by the introduction of the BRT System in other cities. BRTS Ahmadabad has improved access for local riders and advanced public transportation systems while reducing the environmental impacts of transportation. Moving people quickly, at a low cost, with reduced greenhouse gases and air pollutants helps cities grapple with rapid growth, congestion, and environmental concerns [7].

3. METHODOLOGY

3.1 Study Area

To study in detail bus rapid transit system of Indore, the stretch of road i.e. from Niranjanpur bus station to Rajiv Gandhi station which are possessing different volumes of passengers, bicyclists, motorists, pedestrians, and other heavy vehicles are taken into account. User's response played an important role irrespective of age and gender and has been collected from a sample population of Indore city for the work. There are 21 stops on the BRTS route in which there are more than 10 signalized intersections, one signalized rotary, one non-signalized rotary, and a small portion of about 200m mixed lane traffic which has only a kerb side bus stop impending buses to change lanes twice. These factors increase the travel time of the I-buses.

3.2 Data Collection

A self-administered questionnaire of 21 questions was used for data collection. The study was based on method of

collecting information during the research work.We have conducted the survey to collect the data and it was a reliable way because it was known where it came from and how it was collected and analyzed. The rating of user satisfaction consists of responses on scale of 1- Very poor to 5-Excellent.

Table 1: Station Name and Length

S.No.	Name of Stations	Length in km.
1	Rajiv Gandhi to Bhawarkuan	1.49
2	Bhanwarkua To Navlakha	1.26
3	Navlakha To Indra Pratima	0.66
4	Indra Pratima To Gpo	0.49
5	Gpo To Shivaji Vatika	0.68
6	Shivaji Vatika To Geetabhavan	0.78
7	Geetabhavan To Palasia	0.66
8	Palasia to Guitar Square	0.18
9	Guitar Square To Industry House	0.24
10	Industry House To Lig	0.73
11	Lig To Mr9	1.02
12	Mr9 To Rasoma	0.73
13	Rasoma To Vijay Nagar	0.28
14	Vijay Nagar To Satya Sai	0.45
15	Satya Sai To Scheme 78	0.35
16	Scheme 78 To Niranjanpur Circle	0.5

The questionnaire survey consist of details of the following questions:

Table 2: Questionnaire Survey Form

S.No.	Questions	Answers and Ratings
1.	Name	
2.	Origin Station	
3.	Destination Station	
4.	Age	
5.	Gender	
6.	Means of Transport from origin to I-bus station	
7.	Means of Transport from I-bus station to destination	
8.	Travel time from origin to I-bus station(Min)	
9.	Travel time from I-bus station to destination (Min)	
10.	Average number of days of using I-bus in a week	
11.	Bus punctuality	
12.	Comfort at station	
13.	Comfort in I-Bus	
14.	Safety and security at Station	
15.	Safety and security at bus	
16.	Speed of I-Bus	
17.	Reliability of I-Bus	
18.	Convenience of using the bus service	
19.	Frequency of Buses at the station	
20.	Cleanliness of buses and station	
21.	Pedestrian Crossing at Stations	
22.	Width of Footpath	
23.	Overloading Problem in I-bus	
24.	I-bus is having reasonable fare	
25.	Overall Satisfaction	
26.	What mode of transport would you use if not using I-bus	

Traffic Volume Count is the counting of number of vehicles passing through the road over the period of time. It is usually expressed in terms of Passenger Car Unit (PCU) and measured to calculate the Level of Service of the road and related attributes like congestion, carrying capacity, V/C Ratio, identification of peak hour, etc. Traffic volume count or TVC is usually done as a part of transportation surveys, TVC can be classified or unclassified. This study includes four stations where traffic volume count was conducted i.e. Bhawarkuan, Shivaji Vatika, Geeta Bhawan, and Palasiya. For the traffic volume count survey, we used CCTV footage from ITMS and decided the peak hour by studying the footage only.

For calculating passengers' growth rate in I-bus in upcoming years we used a secondary data collection technique by taking a trend chart of population growth in the last years from AICTSL and forecasting it for future.

3.2 Data Analysis

The responses of Google forms and offline forms about journey details and user satisfaction were collected individually from a sample of 1000 passengers traveling in I-Bus during the survey period. These responses were analyzed thoroughly and frequency charts or histograms were developed for the percentage of satisfaction the user is getting based on the answers of passengers. The response to one particular question i.e. "What mode of transport would you use if not using I-bus" was analyzed and the percentage of mode shift of passengers to other modes of transportation was derived which in continuation helped in getting the increase in PCU on the mixed vehicle lanes alongside the BRTS lane if the sample of passengers shifted from mass transport system to other modes of transportation. To calculate the total PCU increment by two-wheelers and four-wheelers, Table 1 of "Recommended PCU Factors for Various Types of Vehicles on Urban Roads was used" from IRC: 106-1990 is used.

The vehicle count of different categories under the traffic volume count survey was also converted into standard PCU by using the PCU table mentioned above and then the final PCU at peak hour on the given road is considered as the volume of traffic which is compared with the capacity of the road taken from IRC: 106-1990 "Recommended Design Service Volumes (PCU's per hour)" table.

The trend chart collected from AICTSL was analyzed and it was seen that the passenger growth was in geometric progression so by calculating the "r" value of geometric progression and averaging every last three-year data passenger growth forecast has been done. The ridership data collected for forecasting is from 2013 to 2022 as follows:

Table 3: I-BUS Average Ridership 2013 to 2022

Year	Avg. Ridership in Passengers Per Day
2013	20986
2014	31370
2015	40426
2016	43543
2017	48217
2018	49363
2019	53108
2020	25594
2021	24804
2022	44428

4. RESULTS

The user satisfaction graphs of responses from approximately 1000 for various parameters related to features of I-BUS and BRTS have been drawn as follows:

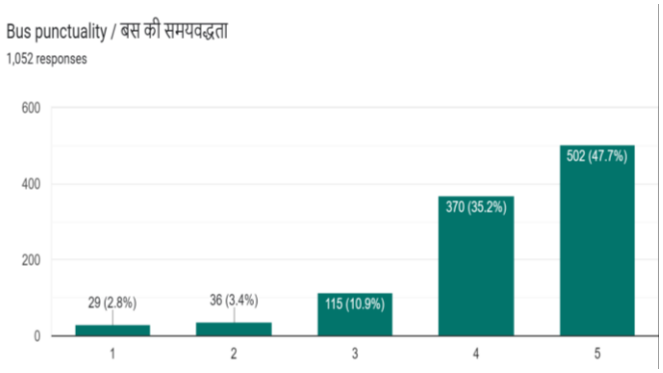

Fig.1 Percentage of response on bus punctuality

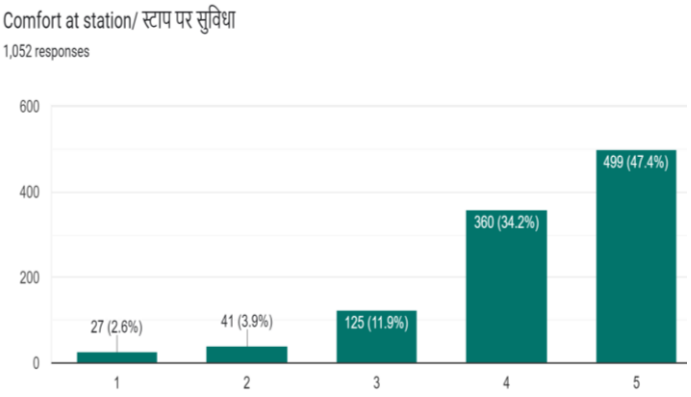

Fig.2 Percentage of response on comfort at station

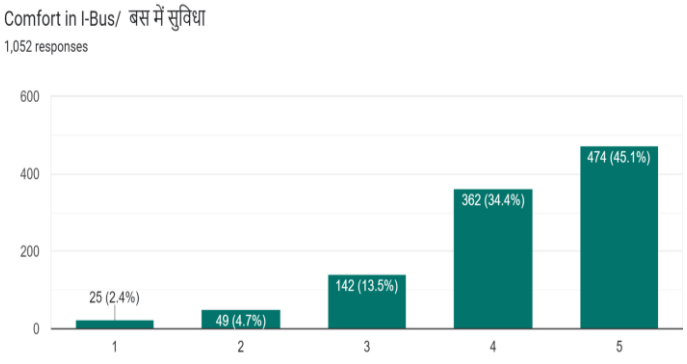

Fig.3 Percentage of response on comfort in I-Bus

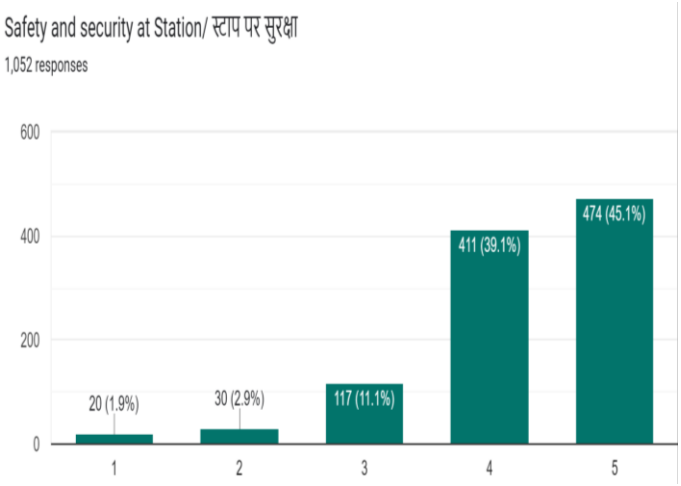

Fig.4 Percentage of response on safety and security at station

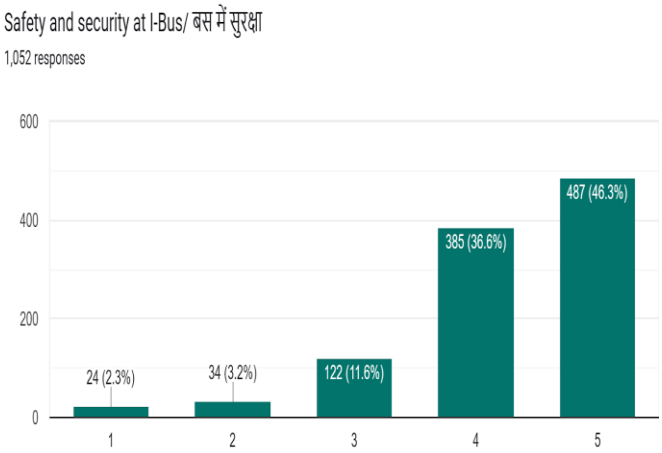

Fig.5 Percentage of response on safety and security at I-Bus

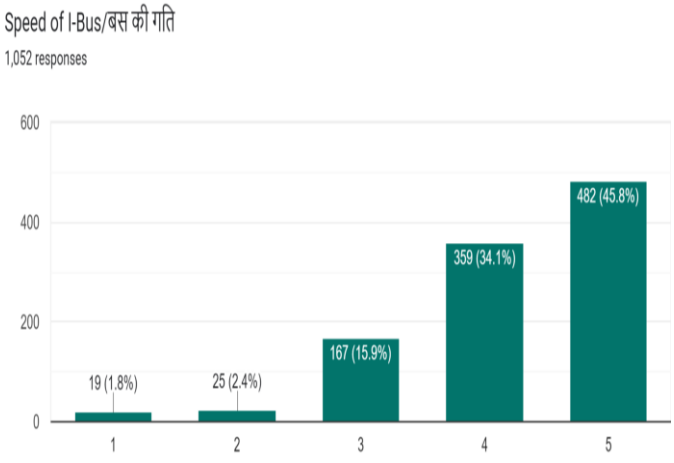

Fig.6 Percentage of response on speed of I-bus

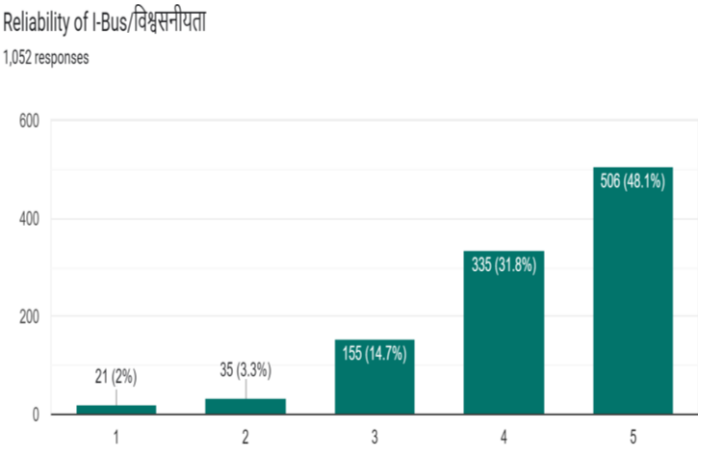

Fig.7 Percentage of response on reliability of I-Bus

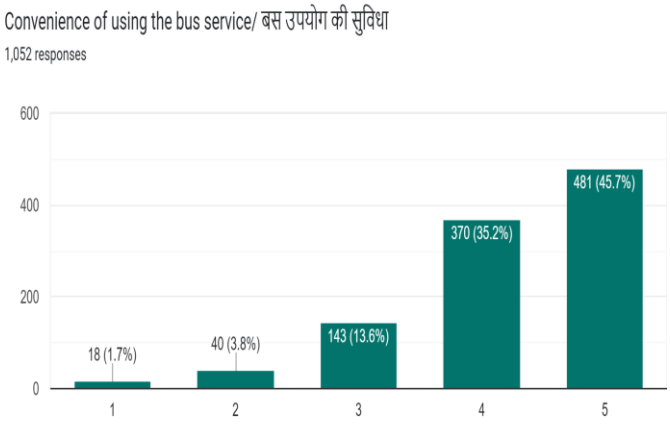

Fig.8 Percentage of response on convenience of bus service

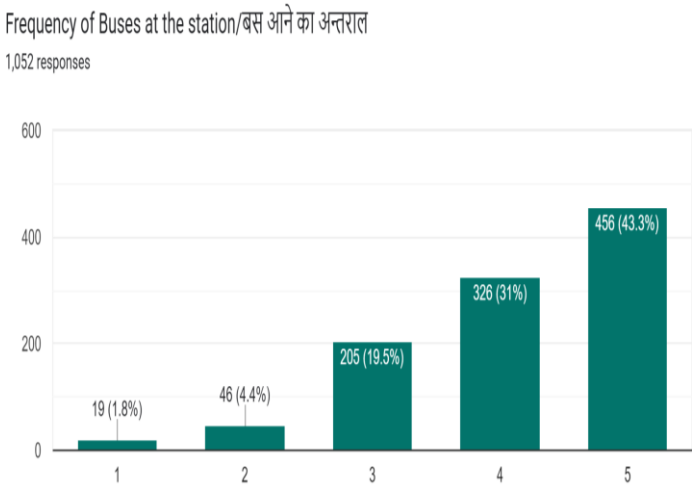

Fig.9 Percentage of response on frequency of buses

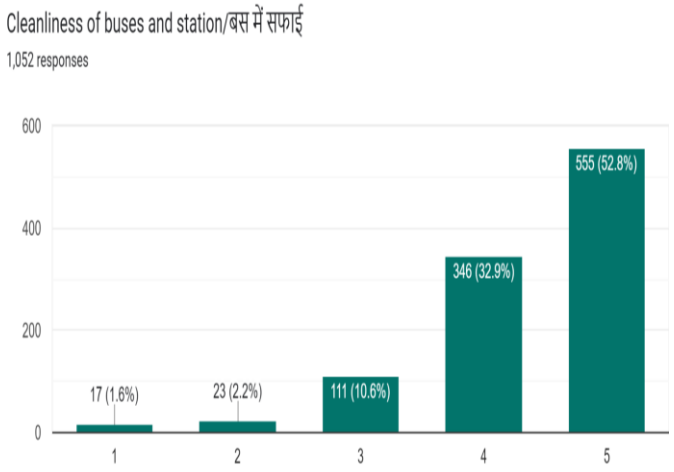

Fig.10 Percentage of response on cleanliness of bus and stations

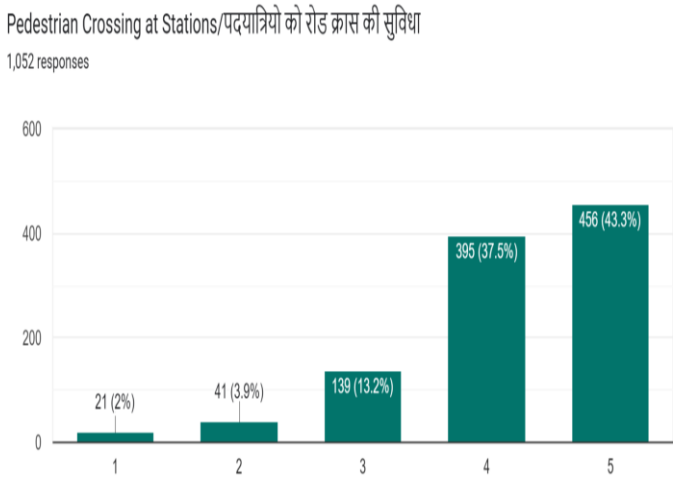

Fig.11 Percentage of response on pedestrian crossing at station

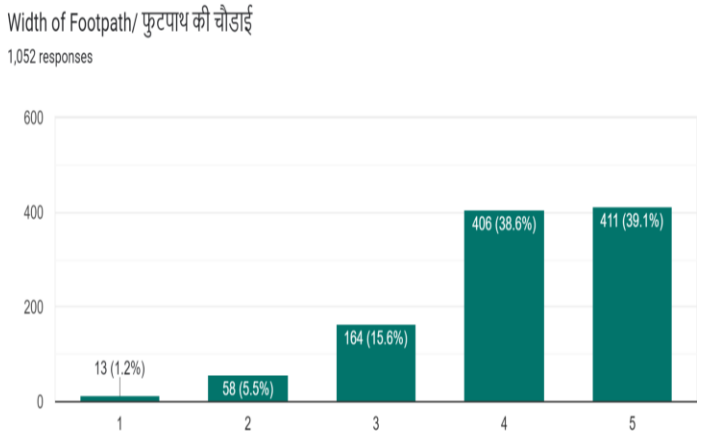

Fig.12 Percentage of response on width of Footpath

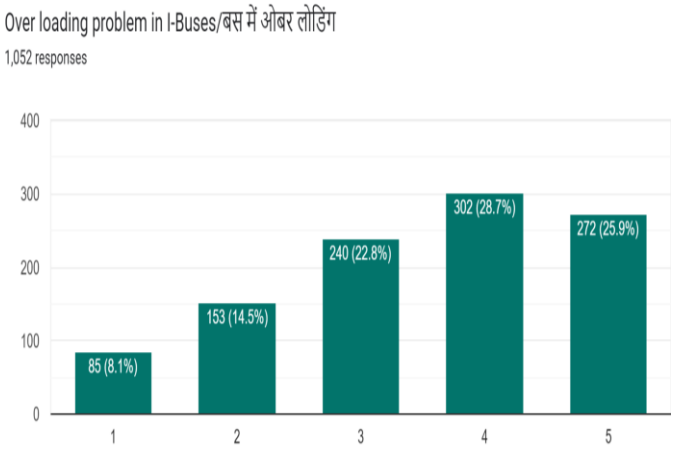

Fig.13 Percentage of response on overloading problem in I-Bus

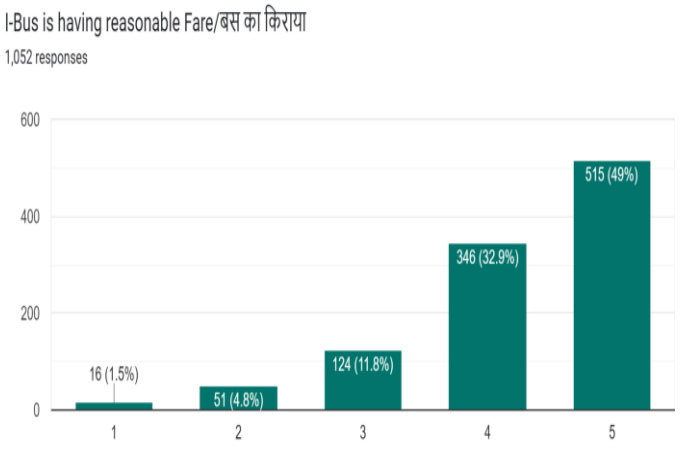

Fig.14 Percentage of response on reasonable fare

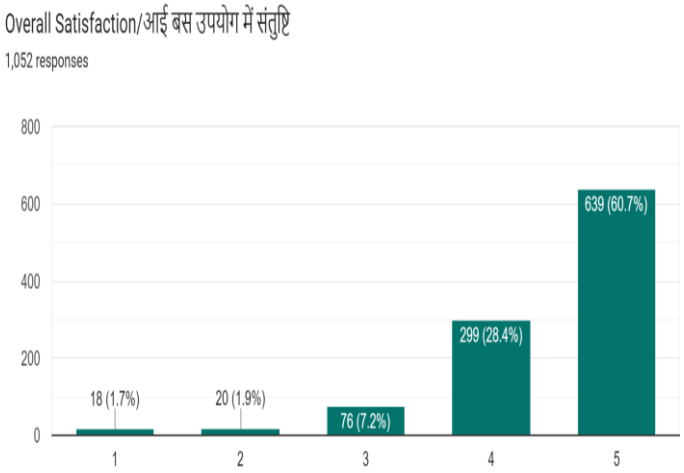

Fig.15 Percentage of response on Overall satisfaction

The responses from the user satisfaction google forms (Fig.16) also showed that approximately 25.6% of passengers from the sample will prefer to travel by two-wheeler and 15.4% will use cars or four-wheelers if not using I-bus. According to this data out of 1052 passengers, approximately 270 people may take two-wheelers and 162 people may prefer four wheelers which on interpolating for daily ridership of 44428 gives 11403 people (2-wheeler) and 6842(4-wheeler) for a full day i.e. 760 two-wheelers per hour and 456 four wheelers per hour. The PCU conversion of these two shows that there will be an increment of 570 (PCU by 2-wheeler per hour) and of 456 (PCU by 4-wheeler per hour) if people will not prefer to travel by mass transit system.

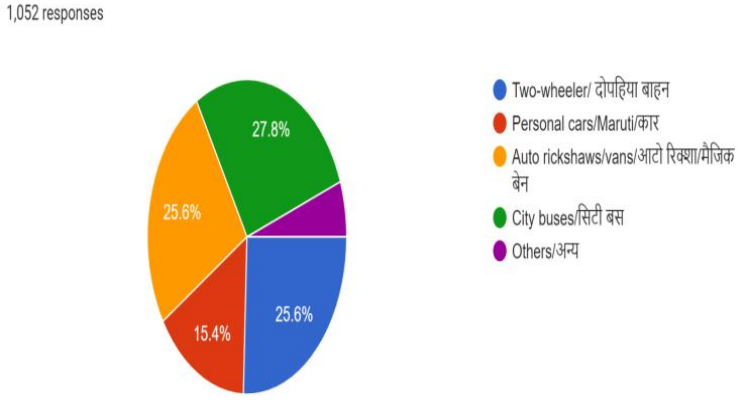

Fig.16 Percentage of people preferring different types of vehicles

The Traffic Volume Count survey conducted in peak hour at eight different stretches of road resulted in following data. Firstly from Bhawarkuan to Vishnupuri peak hour traffic was 4810 PCU and from Bhawarkuan to Navlakha Square it was 3048 PCU. Secondly from Shivaji Vatika to GPO it was 2310 PCU and from Shivaji Vatika to Geeta Bhawan it was 3552 PCU. Thirdly from LIG to Industry House it was 4433 PCU and from LIG to MR9 it was 4942 PCU and lastly, from Scheme 78 to Niranjanpur it was 2750 PCU and from Niranjanpur to Scheme 78 it was 4135 PCU. This data was compared with the design traffic capacity of these one-way-two-lane or one-way-three-lane arterial roads in the table given below:

Table 4: Comparison of volume of different stretches with design capacity of those types of arterial roads

S.No.	Name of Stretch	Peak Traffic Volume of Stretch	Design Capacity of Stretch
1.	Bhawarkuan to Vishnupuri	4810	3600
2.	Bhawarkuan to Navlakha Square	3048	3600
3.	Shivaji Vatika to G.P.O	2310	2400
4.	Shivaji Vatika to Geeta Bhawan	3552	2400
5.	LIG to Industry House	4433	3600
6.	LIG to MR9	4942	2400
7.	Scheme 78 to Niranjanpur	2750	3600
8.	Niranjanpur to Scheme 78	4135	3600

After comparison, it was found that 5 stretches i.e. Bhawarkuan to Vishnupuri, Shivaji Vatika to Geeta Bhawan, LIG to Industry House, LIG to MR9 and Niranjanpur to Scheme No. 78 were found to be heavily congested during a specified time of a day and two stretches i.e. Bhawarkuan to Navlakha Square and Shivaji Vatika to Geeta Bhawan is near to over congestion in future.

The passenger growth rate forecast data shows that there can be 7-8% growth in the upcoming years and hence resulting in 62313 passengers in the upcoming 5 years and 85764 passengers after 10 years.

5. CONCLUSION

A comprehensive study of different works of literature and working on this research for a significant time derived many conclusions which are as follows:

1. BRTS of Indore is a highly efficient system of mass transportation because it has a large accommodation space for passengers. Currently, it is transiting approximately 45000 passengers per day.

2. According to passenger details from the sample, it can be concluded that 56.9% of males and 43% of females uses the bus service safely and comfortably.

3. From the data, it can also be seen that the system is youth-centric as 47.4% of passengers are from 16 to 25 age group, 24.3% of passengers are from 26-40 age group, 19% of passengers are from 41-55 age group and 7.3% of passengers are from 56-65 age group.

4. I-Bus is used for educational purposes as 38.7% of users are related to the education sector, then it is used for work purposes with 31% users in this sector, 13.3% users in recreational/social sector, 9.3% users in shopping purposes and 7.7% for other purposes.

5. It is widely used by passengers as maximum users are using it for 5 and above days in a week i.e. 42.1% are using it for daily purposes, 18.3% are using it for 4 days, 16.9% are using it for 3 days, 12.5% are using it for 2 days and 10.1% are using it for 1 day in a week.

6. Users are highly satisfied with bus service as well as by facilities which are being given by AICTSL regarding comfort, safety, etc. It was seen that 52.8% of users gave an excellent rating on cleanliness then 45-50% of users gave an excellent rating on bus punctuality, comfort at the station, comfort in I-bus, safety and security at the station and in I-bus, speed of I-bus, reliability of bus service, convenience in I-bus and at the station and also for the reasonable fare of I-bus and 40-45% of users gave an excellent rating for frequency of bus service, and pedestrian crossing. On the other hand, only 39.1% of people were satisfied with the width of the footpath provided, and only 25.9%are satisfied with the overloading problem in I-bus.

7. As per overall satisfaction with bus service, it was seen that 60.7% of people are extremely satisfied, 28.4% people are satisfied and 7.2% people are fairly satisfied with the service.

8. After a comparison of PCU of existing traffic, it was found that out of 4 stations 2 i.e. Bhawarkuan and LIG are overly congested, and shifting from personal vehicles to a mass transportation system will help significantly in curbing the congestion issue.

9. It was also concluded that if people will shift from I-Bus to personal vehicles then there will be a huge PCU increment on roads i.e. 570 PCU per hour by 2 wheeler and 456 PCU per hour by 4 wheeler which will deteriorate traffic conditions as well as road surfaces badly so BRTS will be the appropriate solution for the sustainable transport system.

10. In comparison to BRTS of other cities, Indore's system has some better features such as less waiting time, high bus frequency, good connectivity of road network, etc.

11. The information technology system of bus service is efficient enough for gaining real-time information on buses, accidents, or any other incidents at the control center of BRTS.

6. REFERENCES

[1] M. Nadeem, M. Azam, M. Asim, M. A. Al-Rashid, O. C. Puan, and T. Campisi, "Does bus rapid transit system (Brts) meet the citizens' mobility needs? Evaluating performance for the case of multan, pakistan," *Sustainability (Switzerland)*, vol. 13, no. 13, Jul. 2021, doi: 10.3390/su13137314.

[2]A. Kushwah, A. M. Gupta, Y. Rajput, B. Tech Student, and B. Tech, "Traffic Impact of BRTS-A case study of Indore BRTS," © *2018 IJEDR* |, vol. 6, no. 1, 2018, [Online]. Available: www.ijedr.org

[3]S. Dube, "Evaluation of Indore BRT: Passengers' Perception of Services and Improvement Opportunities," *International Journal of IT, Engineering and Applied Sciences Research*, [Online]. Available: www.irjcjournals.org

[4]C. Kumavat, H. Sonawane, T. Patel, X. Sakhalkar, and A. Pansare, "EFFECTIVE LEARNING FROM DELHI BRTS-A CASE STUDY OF PUNE BRTS eSAT Journals EFFECTIVE LEARNING FROM DELHI BRTS-A CASE STUDY OF PUNE BRTS", [Online]. Available: http://ijret.esatjournals.org

[5]T. v Agarbattiwala and B. Vijaykumar Bhatt, "Performance Analysis of BRT System Surat," no. 5, p. 2016, 2016, doi: 10.17950/ijer/v5s6/621.

[6]M. Mazharul Hoque, D. Alam, S. Abdullah Al Mamun, and H. Mohammed Ahsan, "Bus Rapid Transit (BRT): What is it and why Do We Need it for Dhaka."

[7]A. Jaiswal, K. K. Dhote, R. Y. Krishnan, and D. Jain, "BUS RAPID TRANSIT SYSTEM: A MILESTONE FOR SUSTAINABLE TRANSPORT: A CASE STUDY OF JANMARG BRTS, AHMEDABAD, INDIA".

[8]IRC: 106-1990, "Guidelines for Capacity of Urban Roads in Plain Areas"