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Traffic Simulation for Improved Travel Corridor Performance – A Case Study in Bengaluru City

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Abstract

Congestion has become a main concern in cities like Mumbai, Bengaluru, Kolkata, and Delhi. Bengaluru City has witnessed a phenomenal growth in vehicle population from 48.69 lakh to 70.28 lakh in last 10 years. In this project an attempt is made to reduce the volume on the road by identifying and assigning traffic volume to underutilized road to decease the delay. The study area is selected from Outer ring road via Hoskeralli junction till Katriguppe circle as main road and 2nd main road via water tank road to Katriguppe circle. The road inventory survey, Traffic volume, delay study was done and to understand driver perception of choosing a particular road, Road side interview was conducted. The driver responses were analyzed and traffic was assigned to second main road by Wardrop's user equilibrium function. The field data was simulated and calibrated by using VISSIM software. Traffic volume of the Outer Ring Road from Karnataka Power Transmission to Katriguppe via Hoskerehalli junction was observed to be 4324 vehicles / hour. On the 2nd main via water tank road to Katriguppe was observed to be 2609 vehicle/hour. The capacity of both roads was found to be 3284 vehicles/ hour. V/C ratio is 1.32 on outer ring road and 0.79 on 2nd main road. On Outer ring road traffic volume of 3035 vehicles/hour shall be diverted to second main road to reduce travel time by 3 minutes per vehicle. In order to reduce congestion and maintain V/C ratio less than 1, traffic volume of 3808 vehicles/hour and 3035 vehicles/hour shall be assigned on Outer ring road and 2nd main road

respectively with travel time of 2 minutes 49 seconds on both the roads by reducing the delay at intersection.

***Keywords**: Traffic Simulation, Congestion, Improved Travel Corridor*

INTRODUCTION

Congestion is caused due to the imbalance in Volume by capacity ratio. This ratio needs to be maintained less than or equal to one for having better speed and lesser travel time. As the volume increases the ratio becomes greater than one thus indicating congestion. In earlier days the capacity of roads were increased to reduce the V/C ratio which lead to acquisition of land. In this project an attempt is made to reduce the volume on the road by identifying the underutilized roads as an alternative to congestion road and by assigning certain volume of travelers to those roads so that the delay is reduced.

A study was done to understand and locate various high traffic density corridors in the city of Bengaluru and the Outer Ring Road from Karnataka power transmission to Katriguppe circle via Hoskerehalli as main road here in depicted as Outer Ring Road and 2nd main via Water tank road to Katriguppe circle as parallel road, here in depicted as 2nd Main road was selected as the study area. The data collection was done at the study area to understand exiting features which included traffic volume studies, delay studies, travel time, road geometrics and intersection details.

To understand the travelers perception about choosing a particular route, road side interview was done, forming a set off questionnaires. The responses were analyzed and Wardrop's User equilibrium Function[5]was selected to find the traffic volume that need to be diverted to the 2nd main to reduce delay due to congestion.

OBJECTIVES OF PROJECT

The objective of the project is to reduce the delay due to congestion on road stretch from the Outer Ring Road from Karnataka Power Transmission to Katriguppe via Hoskerehalli junction by

1. Understanding the route choice behaviour of the riders and assign traffic to underutilized stretch.
2. Incorporating the existing network in VISSIM software and build the simulation model[1].
3. Comparing the field data simulation with user equilibrium data simulation [6].

STUDY AREA CHARACTERISTICS

The study area considered is near Hoskerahalli junction is shown in Fig 1.1 .

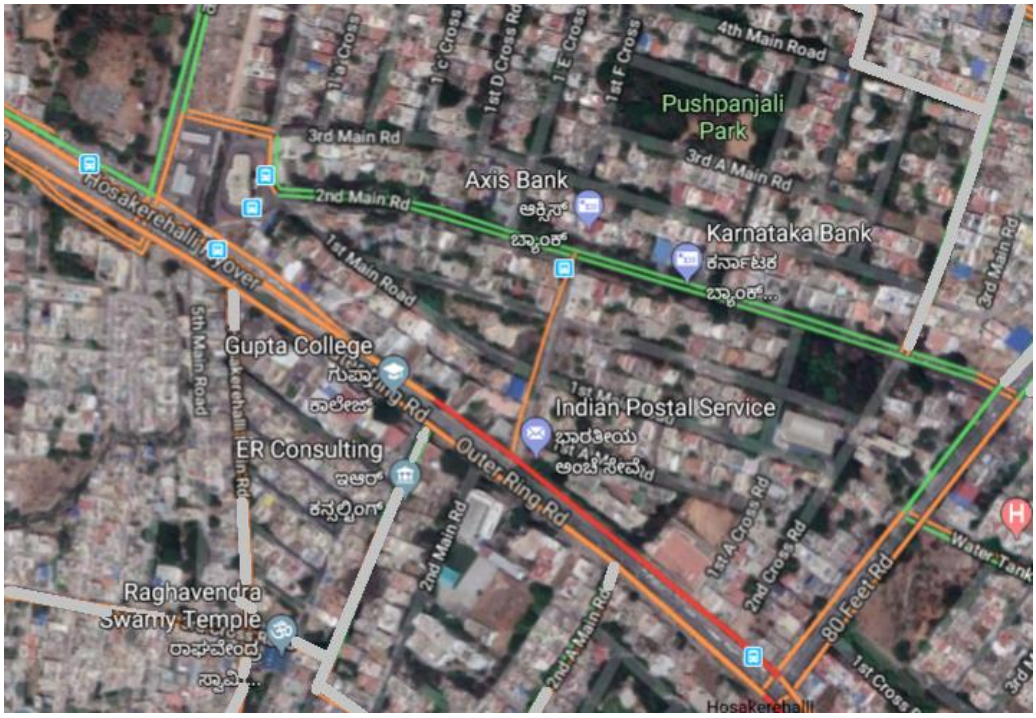

Fig 1.1 Indian petrol bunk to Katriguppe circle (study area near Hoskerehalli junction)

The road stretch from Banashankari 3rd stage post office to till Katriguppe junction the traffic congestion is too high. The underutilized and existing road network was identified and conducted the survey to solve the problem of traffic congestion by assigning the traffic to those routes and optimizing the travel corridor performance.

METHODOLOGY ADOPTED

The methodology adopted to reduce the delay due to congestion on the road stretch from Outer ring road Karnataka power transmission to Katriguppe via Hoskeralli junction. The detailed approach adopted in order to obtain the required results and to achieve the objectives of the project.

Selection of study area:

Among the above listed areas the Outer Ring Road(Hoskerehalli Junction to Devegowda petrol bunk) was selected and it observed high congestion at junction, and this Outer Ring Road here onwards depicted as Outer Ring Road which had an underutilized 2nd main here onwards depicted as 2nd main as required under the study. The Outer Ring Road from the Karnataka Power Transmission to the

Katriguppe junction is the main stretch, andthe intersection selected is Hoskerehalli junction which is identically high congestion junction. The parallel alternative selected was the second main, via water tank road to the Katriguppe circle is shown in Fig 1.1

Road inventories & estimation traffic volume:

The existing road geometrics like the road width, no of lanes, median width, etc. and the exiting signal phases at the intersection were obtained. The traffic volume was also determined using the videography method. The video cameras were set up at the data collection points (main turns, near the approach) for a period four hours (two hours in the morning and two hours in the evening) for two days (week day and weekend day). Then the recorded video was brought to the office and replayed to count the different vehicles. Traffic volume of the Outer Ring Road from Karnataka Power Transmission to Katriguppe via Hoskerehalli junction was observed to be 4324 vehicles / hour.Traffic volume on the 2nd main via water tank road to Katriguppe was observed to be 2609 vehicle/hour. The existing signal timing and phasing at intersection is shown in table number1.0

Table 1.0 Existing Signal Timings

Phases	**Existing phase timings**		
	Red	Amber	Green
Phase-1	90	3	47
Phase-2	90	3	54
Phase-3	120	3	22
Phase-4	120	3	36
Phase-5	12 (Pedestrian signal)		

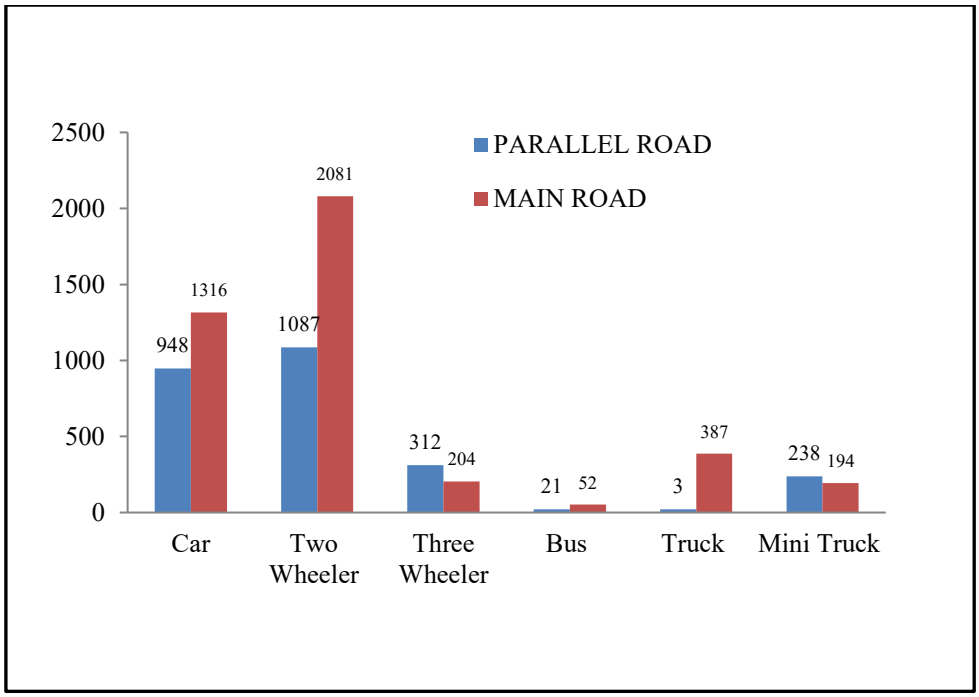

Fig 1.2 Comparison between Outer Ring Road& 2nd main road traffic volume counts

Road side interview survey

The road side interview survey was conducted to understand the road user's perception about their selection routes to build the route choice model. The questionnaire was formed and the responses for 810 travelers were recorded on the basis of following.

Purpose of travelling

1. Age group of travellers
2. Gender of travelers
3. Preferences while travelling
4. Reason for choosing the particular route
5. Reason for not choosing the other alternative route.

The preference of the travelers was determined using four parameters as listed below:

1. Minimum travel distance
2. minimum travel time
3. Avoid turns
4. Avoid signals.

Among the major four preferences of the travelers the highest preferred route was the one which had minimum travel time. About 47% of the travelers prefer the route with minimum travel time.

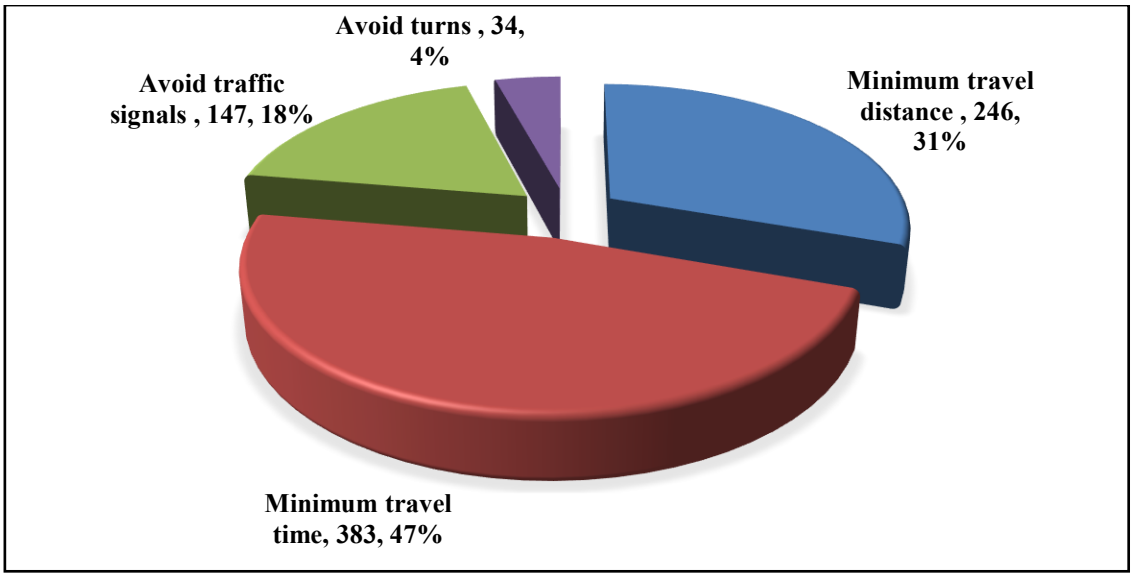

Fig 1.3 Pie Chart representing Preferences while travelling

About 510 travelers were aware about the 2nd main road in the network. Therefore to understand the route choice behavior, the responses by these travelers were considered. The major reason for not choosing Outer Ring Road was due to congestion. About 50% of the traveller's response said they did opt for Outer Ring Road due to congestion. The major reason for choosing the 2nd main Road was decreased in travel time due to less congestion. About 62% of the traveler's response was observed to be this.

User equilibrium model

The iterations carried out to find out the traffic volume when the equilibrium condition occurs (both routes have same travel time) is given in Table1.1 [6]

Link Performance Function given by Bureau of Public Roads (BPR) as given in equation 2.

Tf =total travel time in minutes = 1:56 min

To= free flow travel time in minutes = 2:25 min

V main =4234 vehicles / hour

V parallel = 2609 vehicles / hour

V= Volume in veh/hour = 6843 vehicles / hour

C= Capacity in veh/ hour

C= (1000 v)/S = 3284 vehicle/ hour

S=0.278 v*t+L = 0.278*40*0.70 + 4.4 =12.18 m

Table 1.1 user equilibrium iterations

User equilibrium function			
Iterations	**Time and volume**	**Main road**	**Parallel road**
	T(0)	1.56	2.25
1	Sn(1)	6843	0
	T(1)	5.97	2.25
2	Sn(2)	0	6843
	T(2)	1.96	8.62
3	Sn(3)	2500	4343
	T(3)	2.06	3.28
4	Sn(4)	3000	3843
	T(4)	2.16	2.88
5	Sn(5)	3500	3343
	T(5)	2.34	2.61
6	Sn(6)	3000	3843
	T(6)	2.16	2.88
7	Sn(7)	3250	3593
	T(7)	2.24	2.73
8	Sn(8)	3500	3343
	T(8)	2.34	2.61
9	Sn(9)	3808	3035
	T(9)	2.49	2.49

At the end of 9th iteration it is observe that the travel time on both the roads have same travel time of 2:49 minutes, the obtained traffic volume of the Outer Ring Roads 3808 vehicles per hour, whereas on the 2nd main is 3035 vehicles per hour.

Simulation and Modeling:

TheVISSIM software is developed for homogenous traffic it needs to be calibrated for the Indian type of traffic i.e. mixed heterogeneous traffic and no lane discipline. The entire study area network is (geometrics and the signal control system) represented in the VISSIM software[2][3], using the network object tools like links, connector, signal programme, signal heads. Then the vehicle class, type and their composition are defined. Once the vehicles are defined the routes need to be defined and vehicle input need to be done on the routes. Once everything is represented in VISSIM the simulation run is done to evaluate the delay caused, the field delay and the simulation delay should be equal, if not then the model needs to be calibrated and validated for the another set of reading. Therefore major processes involved can be summed as geometric representation, vehicle representation, traffic representation, calibration and validation. [3]

Once all these parameters are defined in the software the simulation is run with interval of 183 seconds (Cycle length) and with the default Wiedemann Parameters (2, 2, and 3). The first simulation run result is given in Table 1.2.

The field delay observed was 83.29 sec but the simulation delay 84.33 sec with the absolute error 1.04 sec. Therefore the software needs to be calibrated.

Table 1.2 Simulation Result

SIMULATION RUN	TIMEIN	QLEN	QLEN MAX	VEHS (ALL)	PERS (ALL)	STOP DELAY(ALL)
1	183	54.6	200.03	140	140	82.29
1	183	51.89	160.59	134	134	85.16
1	183	52.09	157.34	149	149	85.54
Average delay						84.33

CALIBRATION

Table 1.3 Driving Behavior Parameters for Calibration

Sl.No.	Wiedemann 74 parameter			Interval	Field delay (s)	Simulated delay (s)	Absolute error
	Average standstill distance	Additive part of safe distance	Multiplicative part of safe distance				
1	2	2	3	183s	83.29	84.33	1.04
2	2	1.5	3	183s	83.29	85.69	2.40
3	2	2	3.5	183s	83.29	75.58	7.71
4	2	1.5	3.95	183s	83.29	82.71	0.58

The calibration is done using Wiedemann 74 parameters which includes

1. average standstill distance
2. additive part of safe distance
3. multiplicative part of safe distance

By changing the value of this parameter, the simulated delay was calculated and compared to field delay. The calibration results are tabulated from Table 1.4 to Table 1.5. the calibrated driving behavior Wiedemann 74 parameters is shown in Fig 1.4.

Validation

To validate the VISSIM simulation another set of data was entered and the results were checked. The traffic volume entered was 7125 vehicles per hour and the simulated delay was observed. The field delay was observed to be 93.62sec. The absolute error was 0.61 seconds.

Hence the model is validated. Now entering the traffic volume at the conditions of user equilibrium, the simulation is obtained and delays are compared. The user equilibrium delay is given in Table 1.4.

The traffic volume on Outer Ring Road is 3808 vehicles/ hour

The traffic volume on the 2nd main is 3035 vehicles/ hour

It was observed that the delay was reduced when the equilibrium condition occurred.

Table 1.4 User Equilibrium Delay.

SIMULATION RUN	TIMEINT	QLEN	QLEN MAX	VEHS (ALL)	PERS (ALL)	STOP DELAY(ALL)
1	183	457.74	512.32	769	769	62.71
1	183	458.27	512.32	61	61	64.95
1	183	29.47	102.4	385	385	58.89
Average delay						62.18

CONCLUSIONS

In this study an attempt is made to reduce the congestion on the road by the non-traditional method. The volume by capacity ratio plays a major role in planning and designing of network. An effort is made to decrease the volume on the Outer Ring Road so that delay is reduced. The following conclusions are drawn.

1) Traffic volume of the Outer Ring Road from Karnataka Power Transmission to Katriguppe via Hoskerehalli junction was observed to be 4324 vehicles / hour. The travel time was 5:48 minutes with a delay of 1:23 minutes.

2) Traffic volume on the 2nd main via water tank road to Katriguppe was observed to be 2609 vehicle/hour. The travel time was 3:36 minutes with a delay of 48 seconds.

3) The capacity of both roads were determined using theoretical maximum capacity formula and was obtained as 3284 vehicles/ second.

4) To understand the traveller's perception about their routes selection, the road side interview for around 810 travellers was conducted and their responses were recorded in which 47% of the people preferred to choose a route which had minimised their travel time.

5) About 510 travellers were aware about the 2nd main road in the network. Therefore to understand the route choice behaviour, the responses by these travellers were considered. 50% of the travellers said that they did not choose the Outer Ring Road due to high congestion.About 62% of the

travellers choose the 2nd main road as it decreases their travel timing.

6) The free flow travel time was 1:56 seconds and 2:25 seconds on Outer RingRoad and 2nd main road respectively. The User equilibrium volume was obtained to be 3808 vehicles/ hour and 3035 vehicle/ hour on Outer Ring Road and 2nd Main road respectively.

7) The existing network was represented in VISSIM, and simulated with default Wiedemann's parameter values. The simulated delay obtained was 84.33 seconds and field delay observed was 83.29 seconds with an absolute error of 1.04 second.

8) The VISSIM software was then calibrated by sensitivity analysis of Wiedemann's parameters and it was estimated that when the parameters are set as 2,1.5 and 3.95 the absolute error between the simulated delay and field delay was 0.58 seconds.

9) VISSIM was then validated for another set of data with the traffic volume to be 7125 vehicles/ hour and field delay to be 93.23 seconds. The absolute error was 0.61 seconds.

10) The User Equilibrium volume was represented in VISSIM to obtain the delay. The simulated delay was observed to be 62.18 seconds which was less than the existing delay.

11) If the traffic flow gets assigned according to User equilibrium the Travel time can be reduced to 2:49 minutes on both the roads.

Future scope of the project

1) Traffic gets assigned on alternative routes as per the user equilibrium conditions the delay can be reduced at the intersection. And it is observed that the total travel performance of the road is improved.

2) This project is done for a small stretch of road it can be implemented in long routes which reduces the congestion and increases the level of service of existing road networks.

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