Research Article

Travel Time & Congestion Analysis under Heterogeneous Traffic Condition of C.B.D. Area Case Study of Surat-Rajmarg (Chowk Bazar to Delhi Gate)

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Abstract

The vehicular population in Surat is around 24,21,043 (2015) so it is very essential to manage its movements and ill effects like as air and noise pollution, traffic congestion, time loss, and so on. Rajmarg (Road connecting Chowk Bazar to Delhi Gate) has 2.4 km long stretch of Surat, an oldest and most important link, is passes through the C.B.D. area. For addressing the traffic congestion, classified volume count survey of 3 days i.e. Saturday, Sunday and Monday (by Video Graphic method), travel time and delay survey (by Moving Observer Method), Origin – Destination Survey (by License plate matching method) for 3 days i.e. Saturday, Sunday, Monday from (Date 27/02/2016 to 29/02/2016), and for speed-flow-density relationship Spot speed study at Chowk Bazar, Bhagal and Delhi Gate has been performed and analyzed. From the calculated data, graph of flow v.s. density, speed v.s. density and speed v.s. flow relationship has been developed with the R^2 value of each relationship. Analysis proved that the travel time taken by vehicle to reach the destination is usually higher than the travel time in free flow condition. From all analyzed data, alternate remedial measures are explored. Based on those alternative remedial measures best alternative is chosen and validated in the VISSIM simulation Model and design in AutoCAD for better clarification of issue.

Keywords: Travel Time, Congestion, Heterogeneous, Traffic, VISSIM, Simulation Model, Surat, Rajmarg.

1. Introduction

Over the last two decades the rapid growth in the urbanization has increased in India. Due to the urbanization the demand in transportation facilities which are the basic need of the country's population increases tremendously. The growth of the urban population is increased because of the more people are heading towards the employment to earn the wages that is also boosting the urbanization.

In race of the rapid growth, it increased the industrialization of some region, to full fill the requirement of demand, it requires the rapid transportation. As the urbanization increases the per capita income is also increased that leads them to use their own vehicle for easy movement of origin to destination. In fact, the growth rate of the country's economic development raise too fast and perhaps much faster than infrastructure development causing limited road space to deal with the ever increasing demands in automobile travel.

Motorized transport availability due to increase in the household income and increase in commercial and industrial activities that would have further added to transport demand. There are many cases where demand has overcome the road capacity. Increased congestion and delays in the many cities of India indicate the ill-effects of traffic related issues. It has been concluded that traffic accidents are among the primary cause of accidental deaths in Indian cities. The main reason of these problems is the case of imbalance in modal split and insufficient transportation infrastructure. Public transportation fails to keep the same level with rapid and significant increases in demand over the past few decades.

To convince people with reasoning to shift from personal vehicles to public transport is among the most important elements of any strategy to meet the growing urban travel demand in a sustainable manner. This is because public transport occupies less road space, consumes less fuel and emits fewer pollutants on a per passenger basis for every unit of travel demand that it satisfies, compared to other motorized modes of travel.(Agarwal, 2006, p. 110)

The Central Business District (C.B.D.) is the center of all major activities mirroring the culture of a metropolitan city in the most convenient manner with several key significances. In old cities the space which were provided before is still the same or little bit of variation in it while the demand of such type of space

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has increased tremendously higher than it was which restricting the new implementation of function to overcome the existing situation. So it is prime objective of transportation fraternity to provide new and impactful solution of the existing situation for better management especially for the C.B.D.

2. Aim of Study

The aim of study is to analyze travel time and congestion under heterogeneous traffic condition in C.B.D. area Surat- Rajmarg (Chowk Bazar to Delhi gate) and propose remedial measure in existing traffic condition.

3. Objectives

1. To find Travel Time and Delay.
2. To develop Speed-Flow-Density relationship.
3. Proposal and evaluation of traffic problems simulate in VISSIM software and provide feasibility checks for other alternatives.

4. Scope of Work

To achieve the above objectives scope of work limited to:
1. To do road inventory survey on selected stretch from Chowk Bazar to Delhi gate.
2. To perform classified volume count (CVC) at strategic locations.
3. To perform Origin – Destination survey.
4. To perform Moving Car Observer Survey.

5. Literature Review

There is not an exact or broadly accepted definition of traffic congestion. One of the main reasons for this lack of clearance is that congestion is both:-
−   A physical phenomenon relates with manner in which vehicle impede each other's progression as demand for limited road space consuming full capacity.
−   A relative phenomenon relates with the user expectations as well as road system performance.

Both operational and user perspectives are important in understanding congestion and its impact, congestion is a situation in which demand for road space exceeds supply. It is the reaction of vehicles occurring on each other, due to the speed flow relationship, in conditions where the use of a transport system approaches capacity. Congestion is a relative phenomenon that is connected to the difference between the roadway system performance that users expect and in which way the system actually performing.

Travel Time Study: Travel time is an important study in traffic control and highway improvements. It has observed that the importance of travel time and delay and since travel time studies is widely used to

document congestion and to quantify the actual impact of highway improvements. Determining the amount of time required to travel from one point to another on a given route requires a travel time study. Different information may also be collected on the locations, duration and causes of delays in conducting study. This study is known as a travel time and delay study. Data obtained from travel time and delay studies give a good indication of the level of service on the study section. These data also gives brief information for identifying problem locations, which may require special attention in order to improve the overall flow of traffic in the route. (Iaem C. Mauricio, OCTOBER, 2003).

Moving Observer method: In this method, the observer moves in the traffic stream and makes a round trip on a test section. The enumerator starts at section, drives the car in a particular direction say eastward to another section, turns the vehicle around drives in the opposite direction say westward toward the previous section again. Let, the time in minutes it takes to travel east (from X-X to Y-Y) is t_a, the time in minutes it takes to travel west (from Y-Y to X-X) is t_w, the number of vehicles traveling east in the opposite lane while the test car is traveling west be m_a, the number of vehicles that overtake the test car while it is traveling west be m_o, and the number of vehicles that the test car passes while it is traveling west from be m_p.
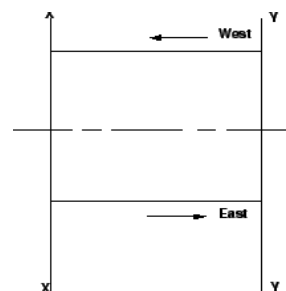

Fig. 1 Moving Observer Method

The volume (q_w) in the westbound direction can then be obtained from the equation (1) and the average travel time in the westbound direction is obtained from equation (2) below.

$$q_w = \frac{m_a + m_o - m_p}{t_a + t_w} \qquad (1)$$

$$t_{w\ (Avg)} = t_w - \frac{m_o - m_p}{q_w} \qquad (2)$$

Classified Volume Count: The most common method of collecting traffic flow data is a manual method, which consists of assigning enumerator to record traffic as it passes. This method of data collection can be expensive in terms of manpower, but it is nonetheless necessary in most cases where vehicles are to be classified with a number of movements recorded separately, such as at intersections.

At intersection sites, the vehicles on each arm should be counted and recorded separately for each movement. It is of paramount importance that the

traffic on roads with more than one lane is counted and classified by direction of traffic flow.

Permanent traffic-counting teams are normally set up to carry out the counting at the various locations throughout the road network at set interval. The duration of the count is determined prior to commencement of traffic counting, and it is dictated by the end use of data. The teams are managed and supervised by the technical staff to ensure efficient and proper collection of data.

Tentative Capacities of Urban Roads: Tentative Capacities of Urban Roads between intersections are presented in Table 1 for different road environment, traffic directions (one way, two ways) and carriageway width.

Table 1 Tentative Capacity of Urban Roads

No. of traffic lanes and widths	Traffic flow	Capacity in PCUs per hour for various traffic conditions		
		Roads with no Frontage access, no standing vehicles, very little cross traffic	Road with frontage access but no standing vehicle and high capacity intersections	Roads with free frontage access, parked vehicles and heavy cross traffic
2 –lane	One way	2400	1500	1200
(7-7.5 m)	Two-way	1500	1200	750
3-lanes (10.5-11m)	One way	3600	2500	2000
4-lane	One way	4500	3000	2400
(14 m)	Two-way	4000	2500	2000
6-Lane	One way	3600	2500	2200
(21 m)	Two-way	6000	4200	3000

Source: Geometric Design Standards of Urban Roads in Plains, IRC 86-1983

6. Study Area Profile

Surat is a city located on the western part of India in the state of Gujarat. Surat is one of the most dynamic cities of India with the impression of one of the fastest growth rate due to immigration from various parts of Gujarat and other states of India.

Surat is one of the cleanest cities of India and it is also known by several other names like THE SILK CITY, THE DIAMOND CITY, THE GREEN CITY, etc. It has some of the most vibrant present and the excellent equally varied heritage of the past. It is the city where the British first land in India. In the other hand the Dutch and the Portuguese also established there business centers in Surat, the monuments of which are still preserved in the modern day Surat.

In past this was a glorious port with ships of more than 84 countries anchored in its harbor at any time. Still at present, Surat continues the same tradition as people from all around the country flocks in for business and jobs, Surat has practically zero percent unemployment rate and jobs are easier to get here due to very fast development of various industries in and around Surat city.

Study Area Description: Study area location is the oldest location of Surat. The walled city of Surat is having a geographical spread over 8.18 km² i.e. about 7.28% of present city area under Surat Municipal Corporation administration. Study area location has mixture of residential, commercial and industrial uses. The study area has length of about 2.4 km from start to end. It has much indirect accessible road connectivity that making the traffic flow slow.

Study area is the shortest route to reach Railway station among all corridors. Also study area is concentration of activities for shopping, business. Study area has mixture of government; residential, commercial building that is generating tremendous amount of traffic, and also the width of the study area road is comparatively small. The area around study area has high land value.

Thus it is the oldest and shortest path to reach Railway station and for business activity. The amount of vehicular traffic is more. Study area has many inner roads which connect to the main road, due to its traffic congestion and delay in travel occurs. Having less width of road the study area also has the parking issues. Due to less curb width and pedestrian path, parking of vehicle is not sufficient enough so that due to illegal parking of vehicle reducing the travel width path and making congestion.

Road Inventory: Road from Chowk Bazar to Delhi Gate is known as Rajmarg constructed in 1865. This road is also one of the oldest and popular roads of the old city area. This road connects Chowk Bazar area to the Surat railway station. This road has shortest connectivity of railway station from Rander. Due to its mix activities traffic congestion occurs regularly. This road always found congested due to heavy traffic of shoppers and railway station trips.

Roadway inventory is given in Table 2 and road section is shown in Figure 2 & 3.

Table 2 Road Inventory of Stretch

Name of Area	Chowk Bazar, Bhagal Road	Station Road
Type of road	Undivided	Undivided
Right of way	16.5 m to 18.5 m	17.8 m to 24.5 m
Width of the carriageway	9.5 m to 11.5 m	14.8 m to 20.5 m
Width of the parking space	2.0 m	2.0 m
Width of the footpath	1.5 m	1.5 m

Table 3 Moving Observer data collection sample

E-W from Chowk Bazar to Delhi Gate						
Location	Direction	Journey Time (Min.)	Stopped Time (Min.)	Number Of Vehicles		
				Over Taking	Over Taken	In Opposite Direction
Chowk Bazar To Delhi Gate	E-W	8.01	0.51	22	31	651
		9.70	0.53	55	29	713
		9.02	1.08	51	40	852
		11.18	1.30	77	26	1092
		10.24	1.01	31	25	1007
		14.03	4.38	73	31	1019
Total		62.18	8.81	309.00	182.00	5334.00
Mean of 6 Runs		10.36	1.47	51.50	30.33	889.00

Table 4 Analysis of Moving observer data

m_w = Overtaking vehicle minus overtaken vehicle (PCUs)	21.17
m_a = Average number of vehicle in opposite direction. (PCUs)	988.83
t_w = Avg. journey time when vehicle is travelling in the stream	10.36 min.
t_a = Avg. journey time when vehicle is travelling in opposite stream	11.58 min.
(Flow) q veh./hr=	2762.08 veh./hr
Avg. Journey time	10.36 min.
Avg. journey speed = (2.4*60) / 10.36	13.91 Kmph
Avg. Running time = Avg. journey time – Avg. Stopped Delay	8.89 min.
Avg. Running Speed = (2.4 * 60)/8.89	16.20 Kmph
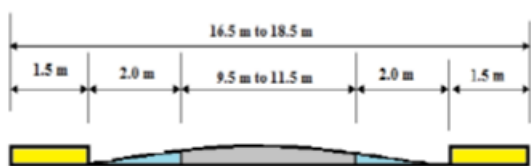
Fig. 2 Section View of Chowk Bazar - Bhagal Road
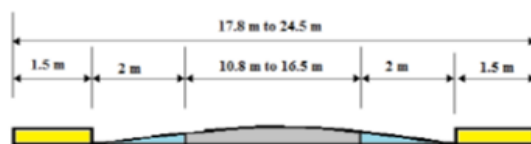
Fig. 3 Section View of Station Road

7. Data Collection & Analysis

Moving Observer Method: Moving Observer survey was carried out on selected stretch of Surat City (From Chowk Bazar to Delhi Gate) by observer moving in the traffic stream and make round trip on a test section.

The 6 number of enumerator performing the survey, starts at section, drives the car in a particular direction by counting number of vehicle traveling opposite lane, the number of vehicle that overtakes the test car, and the number of vehicles that the test car passes while it is traveling to the stream. Enumerator acts as observer while records duration of delay and travel time too.

Table 3 shows the data observed and its analysis shown in Table 4.

From the Moving Observer Method vehicle flow on selected stretch for 3 days was calculated using equation (1) & (2) and sample data shown in Table 4.

The calculation gives the value of Average journey time when vehicle is travelling in the opposite stream (t_a), Average journey time when vehicle is travelling in the stream (t_w), Average number of vehicle in opposite direction (m_a), Difference between Overtaking vehicle and Overtaken vehicle, Flow (q), Average journey time and Average Running time, Average stopped delay.

Travel Time & Delay Analysis: From the data analysis it is revealed that on Sunday the Average journey time, average running time and delay is lowest compared to working day. The results are represented in Table 5 and hourly flow in PCU/hr in Table 6.

Table 5 Travel Time and Delay

Days	Time (In Minutes)	Morning		Afternoon		Evening	
		E-W	W-E	E-W	W-E	E-W	W-E
Saturday	Average Journey Time	10.36	11.5	11.0	14.2	14.1	18.0
	Average Running Time	9.29	9.00	8.32	10.2	10.1	10.3
	Delay	1.07	2.57	2.37	3.51	3.56	7.25
Sunday	Average Journey Time	7.32	8.14	8.07	8.31	9.20	9.03
	Average Running Time	7.14	7.33	7.41	7.28	8.11	8.31
	Delay	0.18	0.41	0.26	1.03	1.09	0.32
Monday	Average Journey Time	10.21	10.3	14.0	13.3	15.4	16.5
	Average Running Time	10.11	8.30	11.2	11.5	11.2	10.5
	Delay	0.10	2.00	2.32	1.45	4.20	6.07

Table 6 Vehicle Flow (PCU/hr)

------	Days	Morning		Afternoon		Evening	
		E-W	W-E	E-W	W-E	E-W	W-E
Vehicle Flow (PCU/hr)	Saturday	2762	2506	2440	2354	2273	2409
	Sunday	2835	2801	2347	2349	2324	2611
	Monday	3893	2790	1358	2250	2048	2965

Classified Volume Count: Manual Classified volume count survey is carried out from Video recording, carried out on dated 27/02/2016 (Saturday), 28/02/2016 (Sunday), 29/02/2016 (Monday). Here survey days is chosen as one full working day (i.e. Monday), one half working days (i.e. Saturday) and one is holiday (i.e. Sunday) to track the variation in vehicle flow. On each of day Survey is done for 6 hour at three different locations (3 hour of morning peak & 3 hour of Evening peak).

Vehicle counts are done at three locations in both directions namely Chowk Bazar, Bhagal & Delhi Gate of study area. In Figure 5 the survey locations are shown.
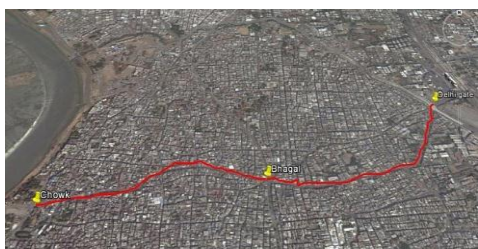

Fig. 4 Survey Locations

All Survey locations are marked with identity number shown in Figure 5.

At Chowk Bazar survey is done in both direction at location AA'; (1) From Chowk Bazar towards Bhagal (2) From Bhagal towards Chowk Bazar, At Bhagal survey is done in both direction at location BB'; (1) From Bhagal toward Delhi Gate (2) From Delhi Gate towards Bhagal, and At Delhi Gate survey is done in both direction at location CC'; (1) At Delhi Gate (2) From Delhi Gate toward Bhagal.
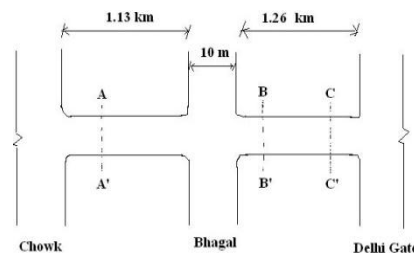

Fig. 5 Survey Location Identification

The street view at Chowk Bazar area is given in Figure 6. It shows the intensive land use in both sides of road.

Fig. 6 Chowk Bazar Area

The directional distribution obtained with directional split is given in Table 7 to 9.

Table 7 Classified Volume Counts on Saturday (PCUs)

Locations	Morning			Evening		
	10:00 to 11:00	11:00 to 12:00	12:00 to 01:00	04:00 to 05:00	05:00 to 06:00	06:00 to 07:00
At Chowk Bazar	2527	2378	2504	1935	1790	1463
From Chowk Bazar towards Bhagal	2919	2538	2257	1512	1863	1846
From Bhagal Towards Delhi Gate	1315	1562	1631	1209	1323	1528
At Delhi Gate Entry	1619	1911	1729	1543	1572	1664
From Delhi Gate Towards Bhagal	2240	2834	2785	1907	1920	1838
From Bhagal Towards Chowk Bazar	1964	2082	1760	2238	2267	2221

Table 8 Classified Volume Count on Sunday (PCUs)

Locations	Morning			Evening		
	10:00 to 11:00	11:00 to 12:00	12:00 to 01:00	04:00 to 05:00	05:00 to 06:00	06:00 to 07:00
At Chowk Bazar	2580	2734	2640	2652	2987	3250
From Chowk Bazar towards Bhagal	3147	3472	4046	2704	2795	2937
From Bhagal Towards Delhi Gate	2123	2337	2058	1864	1953	1900
At Delhi Gate Entry	1575	1806	1504	1407	1271	1532
From Delhi Gate Towards Bhagal	2846	3026	2907	3061	3251	3328
From Bhagal Towards Chowk Bazar	1731	1858	1634	2849	2849	2844

Table 9 Classified Volume count on Monday

| Locations	Morning			Evening		
	10:00 to 11:00	11:00 to 12:00	12:00 to 01:00	04:00 to 05:00	05:00 to 06:00	06:00 to 07:00
At Chowk Bazar	3828	3192	3549	2915	2460	2160
From Chowk Bazar towards Bhagal	3180	3505	3292	3245	3338	3600
From Bhagal Towards Delhi Gate	1938	2052	2249	1615	1768	1967
At Delhi Gate Entry	1919	1796	1509	1493	1612	1734
From Delhi Gate Towards Bhagal	2908	3088	3538	3453	3571	3632
From Bhagal Towards Chowk Bazar	1649	1948	2126	2390	2041	1857
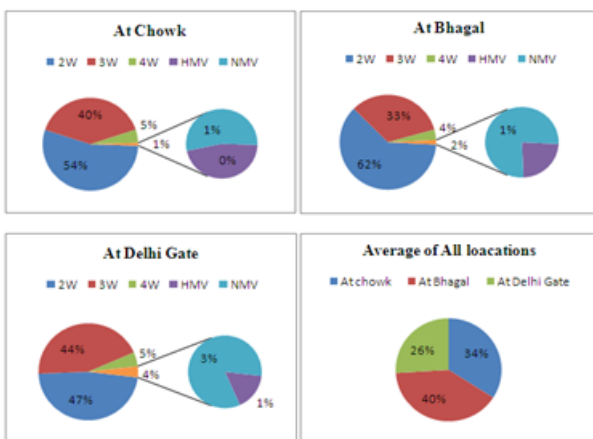
Fig. 7 Vehicular Composition on Saturday
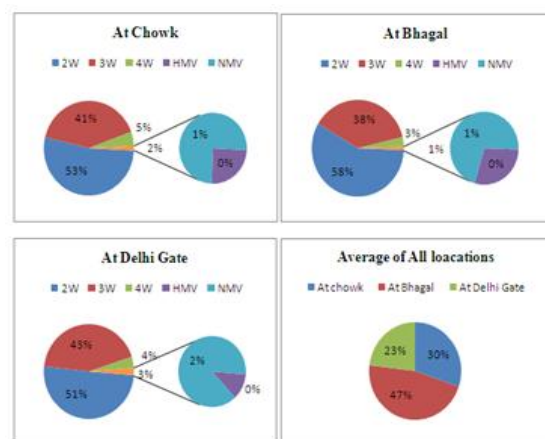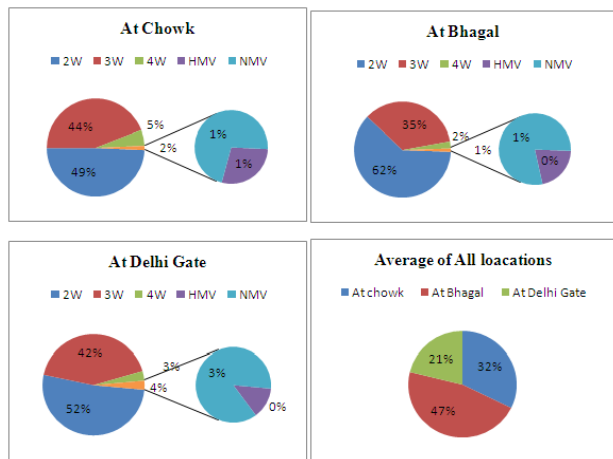

Fig. 8 Vehicular Composition on Sunday

Fig. 9 Vehicular Composition on Monday

Origin – Destination Survey: Origin – Destination Survey is carried out to find different output like Vehicle flows on links, Junction movements, Passenger flows, Traffic variability, Peak-hour factors, Average Annual Daily Traffic etc. It has mainly two method (1) Manual Counts (2) Automatic Counts.

Here, Survey is carried out by using Registered license plate method from video graphic data which were recorded for classified volume count survey for 3 days (Monday, Saturday and Sunday) of Morning and Evening Peak hour both. Three survey points are taken for origin destination Survey (1) From Chowk Bazar to Bhagal to Delhi Gate (2) From Delhi Gate to Bhagal to Chowk Bazar as shown in Figure 5.

Registered license plate method consist of registration number of vehicles entering or leaving an area at survey points located on the cordon line, by matching the license plate number of vehicles at the points of Entry and Exit from the area.

Fundamental Relationships: Here, Fundamental parameters are Speed, Flow, Density and relationship as equation (3) and the diagram generated are shown from Figure 10 to 18 the relationship between Speed-Flow, Speed-Density and Flow-Density are the fundamental diagram of traffic flow.

To find the Speed, Flow and Density Spot Speed Method were adopted. From video graphic data analysis carried out by using AVIDMUX software to draw the trap and measure the vehicle entry time and exit time. Length of trap is been measured physically on survey spot. The data are shown in Table 10 to 12.

Calculation

q = kv   (3)

Where, q = flow, k = Density, v = Average Speed

Table 10 Calculation of fundamental parameters at Chowk Bazar

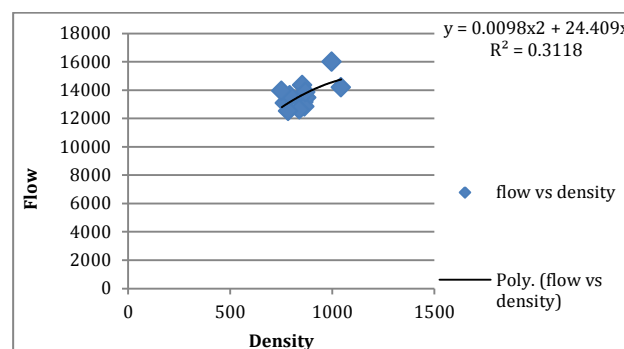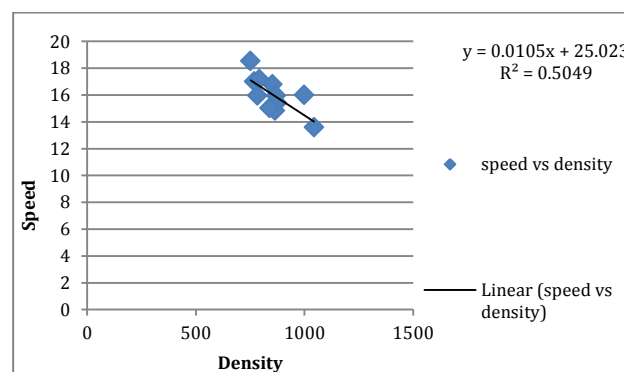| Time	Avg. speed(km/)	Flow(pcu/h)	Density(pcu/km)
10:00-10:05	15.27	13140	860.46
10:05-10:10	15.42	13470	873.31
10:10-10:15	16.02	15990	998.41
10:15-10:20	17.02	13080	768.56
10:20-10:25	17.18	13620	792.96
10:25-10:30	14.84	12840	865.03
10:30-10:35	13.59	14190	1043.87
10:35-10:40	16.80	14340	853.71
10:40-10:45	15.03	12630	840.13
10:45-10:50	15.96	13860	868.65
10:50-10:55	15.95	12510	784.16
10:55-11:00	18.55	13950	751.93

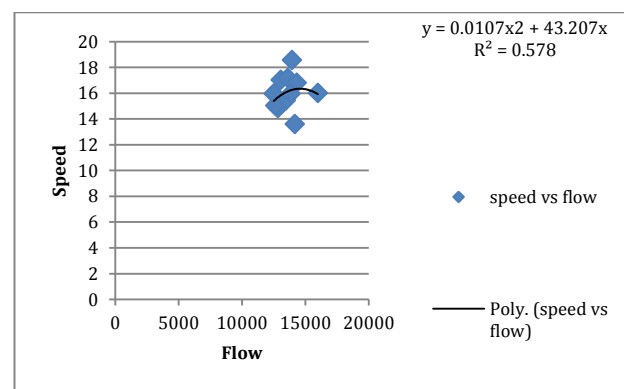**Fig. 10** Flow Vs Density

Fig. 11 Speed Vs Density

Fig. 12 Speed Vs Flow

Table 11 Calculation of fundamental parameters at Bhagal

Time	Avg. speed(km/h)	Flow(pcu/h)	Density(pcu/km)
10:15-10:20	20.70	1824	88.12
10:20-10:25	19.90	1794	90.14
10:25-10:30	17.45	1764	101.09
10:30-10:35	15.61	1578	101.06
10:35-10:40	17.86	1578	88.36
10:40-10:45	20.35	1572	77.25
10:45-10:50	19.11	1488	77.87
10:50-10:55	16.94	1788	105.55
10:55-11:00	18.46	1704	92.31
11:05-11:10	18.38	1584	86.19
11:10-11:15	17.59	1506	85.63
11:15-11:20	19.67	1476	75.02

Table 12 Calculation of Fundamental Parameters at Delhi Gate Road

Time	Avg. speed(km/h)	Flow(pcu/h)	Density(pcu/km)
10:20-10:25	46.87	3870	82.56
10:25-10:30	45.66	3480	76.21
10:30-10:35	41.02	3840	93.61
10:35-10:40	43.08	3570	82.87
10:40-10:45	42.68	3720	87.16
10:45-10:50	41.93	4020	95.88
10:50-10:55	39.90	3690	92.49
10:55-11:00	38.77	4200	108.32
11:00-11:05	43.05	3660	85.02
11:05-11:10	43.05	4020	93.39
11:10-11:15	42.82	3660	85.48
11:15-11:20	43.47	3510	80.75

$y = 0.0325x^2 + 28.742x + 1480.2$
$R^2 = 0.7669$

Fig. 13 Flow Vs Density

$y = 10.109x^2 - 362.89x + 4870.4$
$R^2 = 0.436$

Fig. 15 Speed Vs Flow

$y = 0.2117x + 61.459$
$R^2 = 0.6775$

Fig. 14 Speed Vs Density

$y = 0.0325x^2 + 28.742x + 1480.2$
$R^2 = 0.7669$
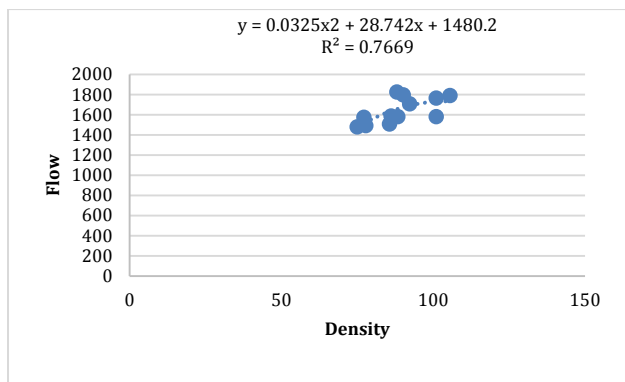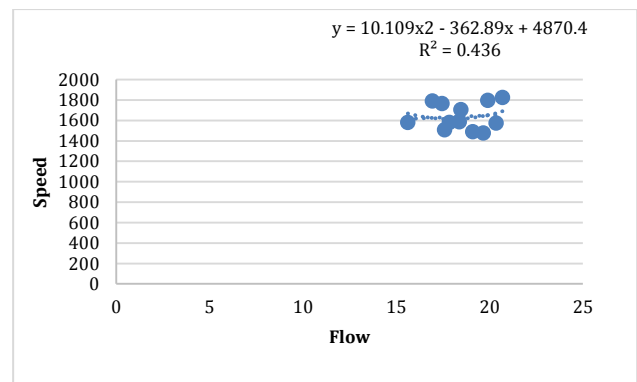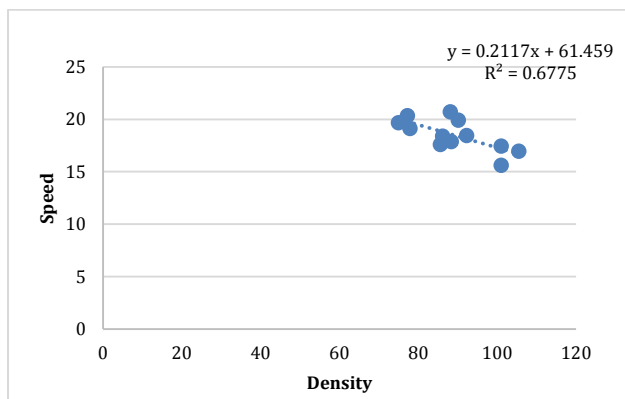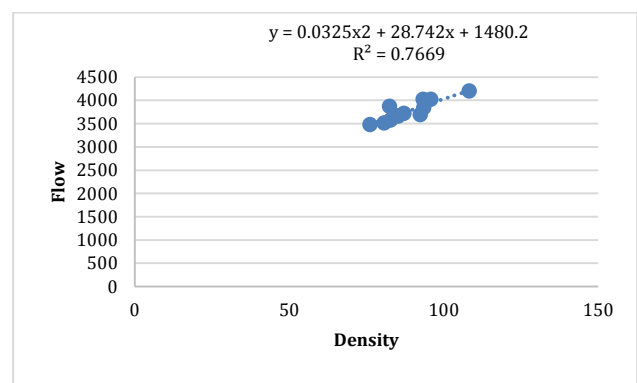
Fig. 16 Flow Vs Density

$y = 0.2117x + 61.459$
$R^2 = 0.6775$

Fig. 17 Speed Vs Density

$y = 13.349x^2 - 1188.6x + 30122$
$R^2 = 0.3473$

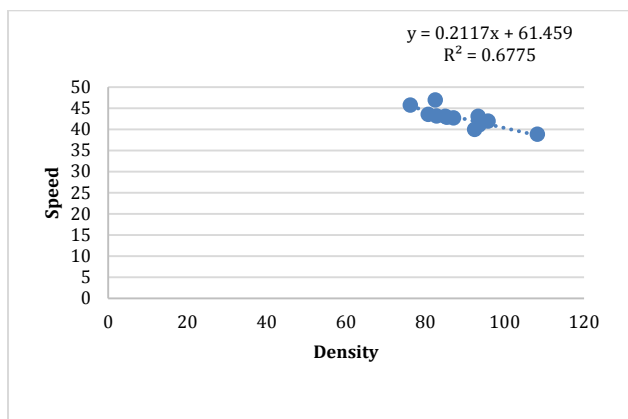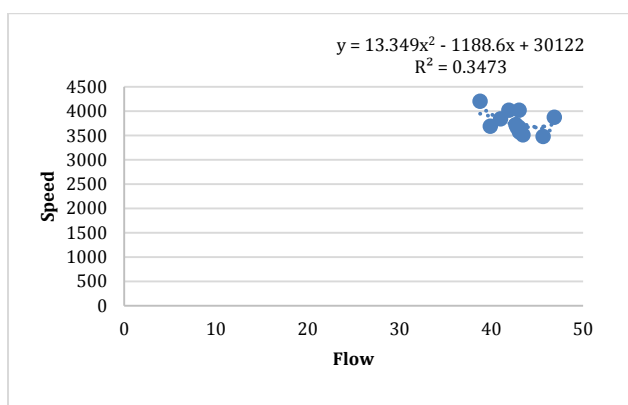**Fig. 18** Speed Vs Flow

Level of Service: From Spot speed data given in Table 10 to 12, Average Travel Speed has been obtained for given stretch and current required Level of Service are obtained. Comparing data with Highway Capacity Manual, 2000 requirements.

Table 13 Level of Service

Urban Street	Chowk Bazar	Bhagal	Delhi Gate
Range of Free Flow Speed(FFS)	55 to 50 km/hr	55 to 50 km/hr	90 to 70 km/hr
Typical FFS	55 km/hr	55 km/hr	80 km/hr
Level of Service			
Average Travel Speed (Km/hr)	15.97 km/hr	18.50 km/hr	42.69 km/hr
Design Level of Service	C	C	C
Existing Level of Service	F	E	C

The level of service F and E shows the congestion conditions.

8. Remedial Measures

As per data collected and analyzed, short term and long term measures are proposed to reduce traffic congestion on Rajmarg. By using VISSIM (Visual Simulation) Software proposal of constructing elevated over bridge from Chowk Bazar to Delhi Gate can be possible to overcome the congestion problem and providing user to direct access from Chowk Bazar to Delhi gate in the means of elevated over bridge**.**
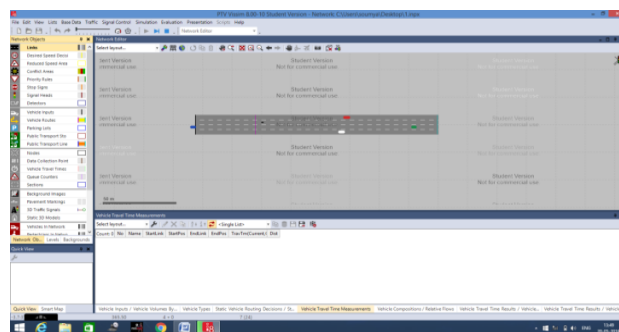

Fig. 19 Running Interface of VISSIM Software

Simulation Data: By preparing the simulation model in VISSIM Software, Vehicle Category and Volume feed as an input data. After completion of simulation model, model is run and data is obtain in form of excel sheet and graph were prepared in VISSIM Software from obtained data.

Due to Limitation of Student Version of VISSIM software length of stretch kept up to 1 km and time of simulation period is restricted to 600 second, according to that data is obtained in following conditions.

Here, Vehicle Travel Time Measurement Graphs from data for current condition of traffic and for modified route condition of traffic alternatives are shown below.
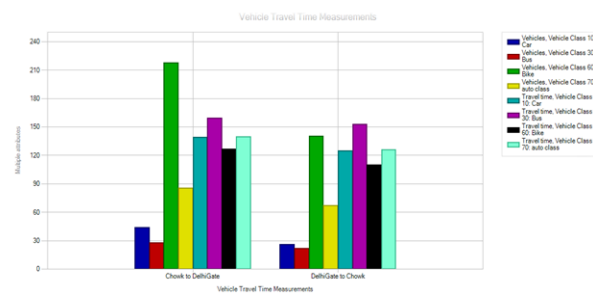

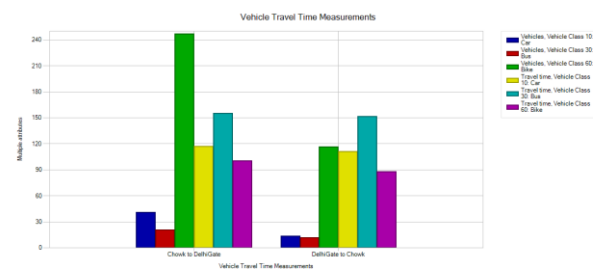**Fig. 20** Vehicle Travel Time Measurement for Current Traffic Condition

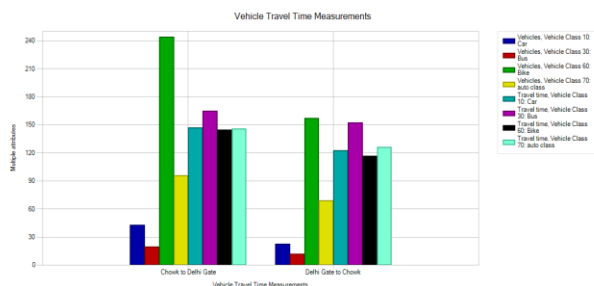**Fig. 21** Vehicle Travel Time Measurement for Modified Route (Non-Elevated Section)

Fig. 22 Vehicle Travel Time Measurement for Modified Route (Elevated section)

Future Traffic Forecasting: For any road project proposal, traffic forecasting is very important consideration to know its feasibility. For establishment of future traffic growth rates, past trends in traffic growth on the survey area is observed and growth rate is found out. In below Table 14, future traffic forecasting is done for next 10 year i.e. 2026 from the past data of 2005 (CRRI, 2005) and from the current survey data of 2016 for the identified location of traffic congestion on Rajmarg.

- Decadal Growth rate

$$= \frac{(\text{Average PCU on Rajmarg in 2016} - \text{Average PCU on Rajmarg in 2005}) \times 100}{\text{Average PCU on Rajmarg in 2005}}$$

$$= \frac{(4602 - 2751)}{2751} \times 100 = 67.28$$

- Yearly Growth rate = 67.28/11 **= 6.12 %**

The scenario after 10 years is shown in below Table 15, if no treatment is provided to the identified congestion location.

Table 14 Future Traffic Forecasting (On Existing Situation)

Year	Average PCU/hour on Rajmarg
2005	2751
2016	**4602**
2017	4884
2018	5183
2019	5500
2020	5837
2021	6194
2022	6573
2023	6975
2024	7402
2025	7855
2026	8336

Table 15 Existing situation Vs Future scenario

	Existing situation (Year 2016)	Future scenario (Year 2026)
Average PCU/hr	4602	8336
Road width(m)	16-25	More than 34m (Required)
After Providing Elevated Over-bridge		
Total Number of Lanes	4 to 6	6 to 8
Capacity of Rajmarg (PCU/hr)	5000	9000

Design Section View of Proposed Elevated Over-Bridge
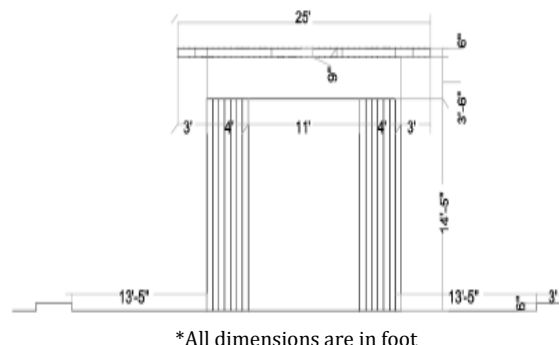

*All dimensions are in foot

Fig.23 Section View of Proposed Elevated Over-Bridge

9. Results, Conclusions and Recommendations

The proposed remedial measures are based on the solution of basic problem of traffic management. To reduce the traffic congestion either on urban road or in urban area, most important thing to manage the traffic flow. As the study area having very old CBD characteristics, the width of road is very narrow and uneven where widening of road by demolition is not possible due to court decision.

- From Moving Observer Method survey it is concluded that on Saturday, Evening (W-E) trip has highest Average Journey Time (18.00 min.), highest Average Running Time (10.35 min.) and highest delay (7.25 min.) in a day. On Sunday, Evening (E-W) trip has highest Average Journey Time (9.20 min.), Evening (W-E) trip has highest Average Running Time (8.31 min.) and Evening (E-W) trip has highest delay (1.09 min.). On Monday, Evening (W-E) trip has highest Average Journey Time (16.58 min.), Afternoon (W-E) trip has highest Average Running Time (11.52 min.) and Evening (W-E) trip has highest delay (6.07 min.). Same as for Vehicle Flow Comparison on Saturday, Morning (E-W) trip has highest vehicle flow (2762.08 veh./hr). On Sunday Morning (E-W) trip has highest vehicle flow (2834.96 veh./hr) and on Monday Morning (E-W) trip has highest vehicle flow (3892.59 veh./hr).

- From Classified Volume Count Survey it is concluded that on Saturday, morning peak hour 10:00 to 11:00 am from Chowk Bazar towards Bhagal has highest PCU value i.e. 2919 compare to other directions. On Sunday, Morning peak hour 12:00 to 01:00 pm from Chowk Bazar towards Bhagal has highest PCU value i.e. 4046 compare to other directions. On Monday, morning peak hour 10:00 to 11:00 am at Chowk Bazar has highest PCU value i.e. 3828 compare to other directions.

- From Spot Speed Study it has been concluded that at Chowk Bazar road value of R^2 for flow Vs density relationship is 0.311, for speed Vs density is 0.504 and for speed Vs flow is 0.578. At Bhagal Road

value of R^2 for flow Vs density relationship is 0.767, for speed Vs density is 0.678 and for speed Vs flow is 0.436. At Delhi Gate road value of R^2 for flow Vs density relationship is 0.766, for speed Vs density is 0.676 and for speed Vs flow is 0.347.

- From VISSIM Simulation model it has been concluded that on construction of elevated over bridge along the length of the stretch to provide direct access for user and use of Auto Rikshaw and 2 wheeler only on the elevated bridge section gives a huge travel time difference between existing traffic condition and traffic condition after providing elevated bridge, it also shows less volume and density at the non- elevated section due to the segregation of traffic on and above the elevated bridge section.

- Need of bus facility as major transport mode with the frequency of 1 bus/minute in both the direction of Rajmarg.

- Rajmarg contains minor road intersection that is making congestion on arterial road that minor street roads should be prohibited as one way or No entry.

- Stretch should be divided with the permanent or temporary Road Dividers, with minimum width.

- Parking facilities like Multilevel parking should be provided at Chowk Bazar, Bhagal and Railways Station with user charges.

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