GIS BASED TRAFFIC FLOW ANALYSIS IN THE ROAD NETWORK USING REAL TIME OPEN SOURCE DATA

Nidhi Singh[1], Dr. S. K. Katiyar[2*]

[1]*M. Tech, Geoinformatics & its application, MANIT, Bhopal, M.P, India*
[2]*Professor, Civil Engineering Department, MANIT, Bhopal, M.P, India*

---***---

Abstract - *Transportation system acts as a backbone in any urban area and traffic management is a complicated task due to complexity of relationship between the involved parameters. Thus, it is much of concern to have a well-developed transportation system to increase accessibility and mobility with reduced travel cost and time. Traffic congestion is one of the serious concerns in any metropolitan city and it requires immediate attention of transportation planners, engineers, and researchers for giving appropriate solution for this problem. Nowadays, for the city road network traffic flow analysis, GIS based techniques are preferred due to availability of various analysis tools using geospatial data in combination with the attribute information. For performing network analysis, one requires correct information about the traffic situation of the road network. Collection of reliable and up-to-date traffic volume data is not an easy task due to various issues and limitations. Under these circumstances, theroad network traffic analysis results may not be very effective and reliable for suggesting the appropriate remedial measures for various issues and problems in the urban transportation system. In this research work analysis has been carried out for the Bhopal city road network traffic congestion locations by taking input from the real time information of congestion using open source Google Maps.*

Keywords-Network analysis, GIS, Remote sensing, traffic density, congestion.

1. INTRODUCTION

Roads play an important and crucial role in the economic development and growth as well as in the implementation of various projects for the social benefits. When there is discussion of a road, the term 'traffic' generally comes along with it. Traffic refers to the number of vehicles running on a particular road. Traffic flow is an important parameter in the urban transportation planning and excessive flow would led to occurrence of congestion in urban road networks. Conventionally, the information related to traffic congestion can be collected by carrying out traffic volume survey and it is time consuming and having some limitations. Also, it is extremely difficult get real time information on the traffic congestion of a specific section of the road network.

Nowadays, the high resolution Remote sensing satellite images and GPS based data can provide important data to perform versatile traffic flow analysis using Geographic Information System (GIS) techniques. GIS can have a significant role in the transportation planning due to fact that GIS is an efficient tool for the data capture, store, analysis and display, in view of its location, character and linkages with transportation planning variables. Earlier many researchers developed their own models to study traffic flow and evaluate congestions so that traffic congestion control measures could be taken [5]. [6] based on the field study identified three locations in the traffic volume survey. The collected data were incorporated in GIS platform. GIS analysis was carried out to identify the alternate routes in the study area for effective traffic management.

[2] presented dynamic method based on the theory of non-linear dynamic used in mathematical physics and engineering laws. Three main policies were proposed by them i.e., governmental policy to control increment of number of cars; stimulated public travel demand management to cover the potential increased number of cars; and supply management by good transportation planning. A mathematical model was developed to study waiting time and number of vehicles at route intersection [3]. In this study, it was suggested that the best action to manage traffic congestion at route intersection is replacement of un-signalized intersection to signalised intersection. Earlier researchers have emphasized that for the effective route planning, inclusion of traffic data is very important.[1] aimed to evaluate traffic congestion spots during working hours in a day using many GIS functions such as network analyst, overlay analysis and Kernel density. The traffic volume data available with various traffic departments may be very old and it may not be available for all the roads and intersections. Also, collection of reliable and up-to-date traffic volume data is not an easy task due to various issues and limitations [7].

This research work is focussed on evolving an alternative methodology by using open source real time data for the determination of traffic congestion zones in any city. This derived traffic flow data can be further analysed in the GIS environment for an effective traffic management on the day to day basis.

2. STUDY AREA AND DATA RESOURCES

In this research work investigations were carried out for the study area in the Bhopal city in Madhya Pradesh, India, which is covered in the latitude and longitude extents of 23°21'45.15"N to 23° 6'16.67"N and 77°13'39.87"E to 77°31'49.59"E respectively. The digitized road network superimposed on the satellite image is shown in the Fig.1. The traffic congestion zones on various roads of the city were identified at different dates, days and times by using open source data available on Google Maps. Various type GIS based analysis were carried in the ESRI ArcGIS software.

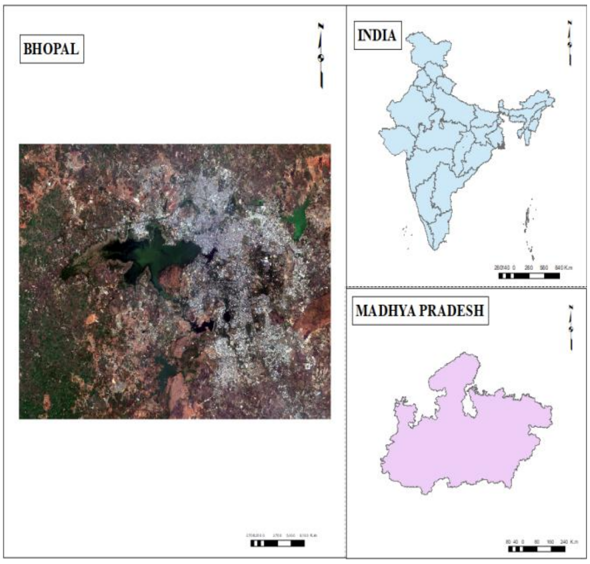

Fig-1: Imagery of Bhopal city, Madhya Pradesh, India

3. METHODOLOGY

Methodology for the present research work investigations is summarised below:

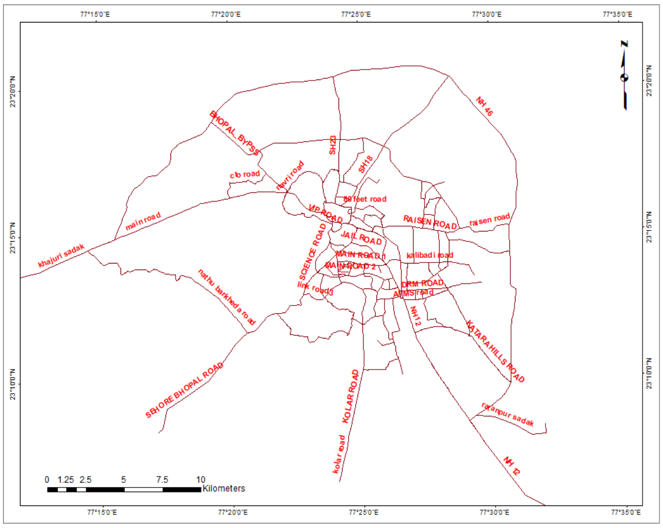

Fig-2: Digitized road network of Bhopal

Digitization of study area road network in the ArcGIS software by using open source high resolution remote sensing satellite imagery from Google Earth as shown in Fig.2.

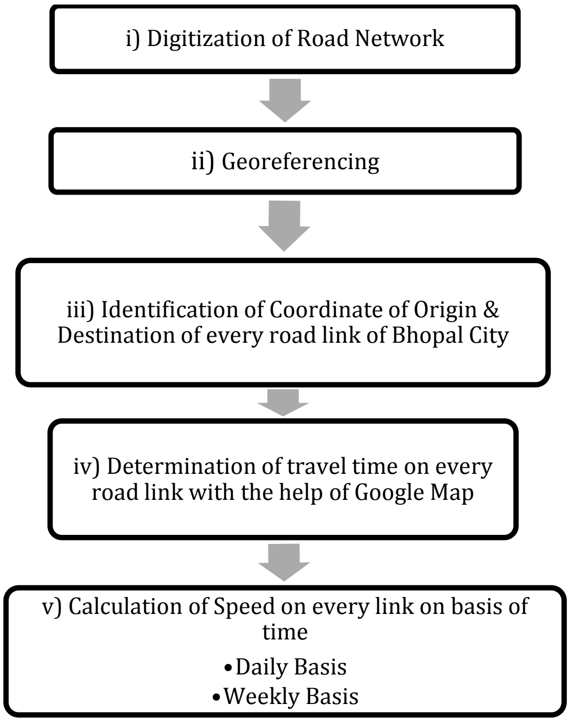

Fig-3: Methodology for Traffic Data Acquisition

Incorporation of road traffic data on the assumption that road facing problems of traffic congestion would have less average traffic speed i.e., vehicles passing through that road would take longer time as compared to roads having less congestion, refer to Table 1.

Table 1 Speed Observation Table derived by Google Maps

Link FID	Origin	Destination	Length(m)	Time1(TF,min)	Speed 1(Tue)	Speed2(wed)	Speed3(thu)
0	77°25'50.782"E 23°15'7.337"N	77°26'30.126"E 23°14'0.172"N	2508.40	5	30.10	29.98	27.36
1	77°26'31.304"E 23°13'39.84"N	77°26'31.184"E 23°12'58.44"N	1280.16	2	38.40	38.12	38.40
2	77°23'43.141"E 23°15'33.688"N	77°23'49.118"E 23°14'39.663"N	2129.60	6	21.29	18.25	19.66
3	77°14'35.075"E 23°14'30.786"N	77°23'42.486"E 23°15'34.005"N	16750.54	25	40.20	40.30	38.66
4	77°24'5.531"E 23°13'59.385"N	77°24'12.757"E 23°13'18.138"N	1294.86	3	25.90	25.76	25.90
5	77°24'13.749"E 23°13'15.691"N	77°25'5.351"E 23°13'2.956"N	1584.16	3	31.68	31.68	32.68
6	77°25'36.532"E 23°12'56.615"N	77°26'13.741"E 23°13'24.413"N	1496.43	3	29.93	29.93	25.65
7	77°24'4.112"E 23°14'15.115"N	77°24'5.618"E 23°13'59.331"N	489.43	1	29.37	29.21	30.10
8	77°23'53.675"E 23°14'27.7"N	77°24'4.138"E 23°14'15.13"N	492.61	2	14.78	14.50	19.70
9	77°23'49.101"E 23°14'39.648"N	77°23'49.18"E 23°14'39.076"N	17.86	0.05	21.43	21.43	21.43
10	77°24'50.842"E 23°15'8.409"N	77°24'38.352"E 23°14'38.94"N	1003.32	3	20.07	19.59	24.08
11	77°23'55.55"E 23°15'21.375"N	77°24'50.827"E 23°15'8.448"N	1677.89	7	14.38	12.58	15.49
12	77°23'43.219"E 23°15'33.732"N	77°23'55.443"E 23°15'21.35"N	596.07	2.5	14.31	17.88	14.31
13	77°24'2.323"E 23°15'58.918"N	77°24'40.105"E 23°15'51.299"N	1119.18	6	11.19	13.43	16.79
14	77°24'2.144"E 23°15'58.888"N	77°23'36.013"E 23°16'1.063"N	766.37	2	22.99	30.65	25.43
15	77°26'10.411"E 23°17'44.152"N	77°28'42.474"E 23°15'17.938"N	6719.77	11	36.65	36.65	35.47
16	77°28'47.128"E 23°15'3.311"N	77°30'39.86"E 23°15'9.71"N	3536.47	9	23.58	21.22	23.58
17	77°22'43.783"E 23°15'38.323"N	77°22'11.965"E 23°16'23.548"N	2389.66	6	23.90	35.84	31.86
18	77°14'35.015"E 23°14'29.807"N	77°20'35.598"E 23°11'37.747"N	13602.60	20	40.81	40.81	41.10
19	77°22'46.488"E 23°12'52.972"N	77°23'35.278"E 23°12'47.069"N	1599.74	3	31.99	24.00	21.99
20	77°22'46.62"E 23°12'54.057"N	77°23'19.755"E 23°13'39.352"N	1755.26	3	35.11	35.11	34.62
21	77°21'12.053"E 23°17'49.878"N	77°22'11.535"E 23°16'23.223"N	3678.23	8	27.59	24.52	25.96
22	77°21'25.941"E 23°17'3.091"N	77°20'0.478"E 23°16'13.705"N	3950.40	11	21.55	21.55	20.61
23	77°22'11.76"E 23°16'22.677"N	77°23'35.578"E 23°16'43.349"N	3324.75	8	24.94	22.16	24.94
24	77°24'11.691"E 23°17'4.4"N	77°23'42.329"E 23°16'0.736"N	2929.76	11	15.98	14.65	17.58
25	77°25'2.68"E 23°13'1.666"N	77°24'29.581"E 23°8'16.14"N	9013.53	18	30.05	25.75	29.23
26	77°17'9.624"E 23°8'14.031"N	77°22'39.117"E 23°12'44.559"N	13486.98	24	33.72	33.72	35.18
27	77°25'49.325"E 23°15'8.216"N	77°28'46.972"E 23°15'3.445"N	5173.29	11	28.22	28.31	29.56

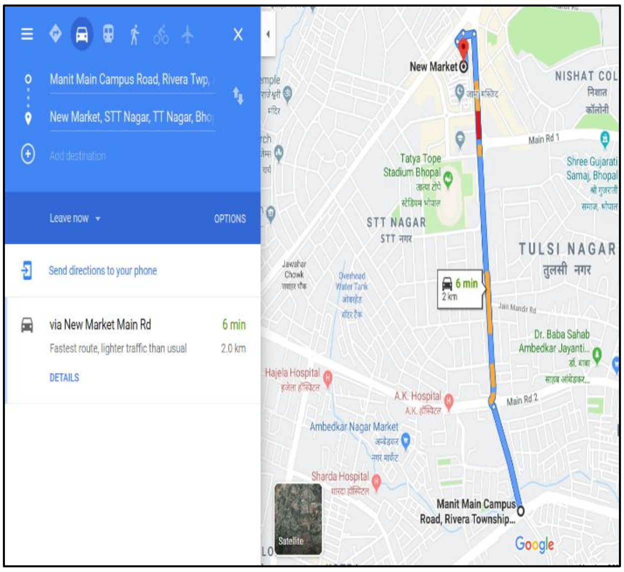

Fig-4: Google Maps observation

Extraction of traffic data Traffic data is not easy to derive and also not possible to collect for every point, therefore here Google Maps will play an important role in giving idea of road traffic. The methodology outline is shown below in Fig.3. The Google Maps is used in mobile with GPS enabled on mobile, before starting to drive, search for desirable destination as in Fig.4. Google Maps tracks the android phone with the help of data sent back by the android phones to them and measures the time taken by the android phone to cover certain length of road. When speed of one phone is combined with the speed of other phones on the road, across thousands of phones moving around a city at any given time, we can get a pretty good picture of live traffic conditions. With the help of this, average speed is calculated and hence traffic information is fed into Google Maps. [5] The more people that participate, the better the resulting traffic information. After incorporating road traffic data i.e., average traffic speed in the road network dataset, network analysis was performed to generate efficient routes avoiding congestions and finding shortest path.

4. RESULTS AND INFERENCES

4.1 IDENTIFICATION OF TRAFFIC CONGESTION ZONE

For the identification of traffic congestion zone, average traffic speed has been adopted as a parameter as adopted by some of the researchers. The cut-off speed for marking as 'highly congested road' was taken as 15 km/hr which means that those roads having average traffic speed less than 15 km/ hr will be considered as 'highly congested roads', whereas roads having average traffic speed greater than 40 km/ hr will be considered as 'minimum congestion zones'. Even roads with average traffic speed in the range of 15 – 20 km/ hr are also considered in 'congested roads' (Anitha *et al.,* 2017). Fig 6. 1 shows the map of Major road network of Bhopal, colour coded as per the average traffic speed. Average traffic speed can be considered as an indication of Traffic congestion on roads as roads with high traffic density will slower the average speed of vehicles, hence time taken by vehicles to cross particular stretch of road increases thereby it can be derived that for particular road average traffic speed is less. Considering this idea as the basis, secondary data for traffic congestion was derived.

Idea of road traffic. The methodology outline is shown below in Fig.3. The Google Maps is used in mobile with GPS enabled on mobile, before starting to drive, search for desirable destination as in Fig.4. Google Maps tracks the android phone with the help of data sent back by the android phones to them and measures the time taken by the android phone to cover certain length of road. When speed of one phone is combined with the speed of other phones on the road, across thousands of phones moving around a city at any given time, we can get a pretty good picture of live traffic conditions. With the help of this, average speed is calculated and hence traffic information is fed into Google Maps. [5] The more people that participate, the better the resulting traffic information. After incorporating road traffic data i.e., average traffic speed in the road network dataset, network analysis was performed to generate efficient routes avoiding congestions and finding shortest path.

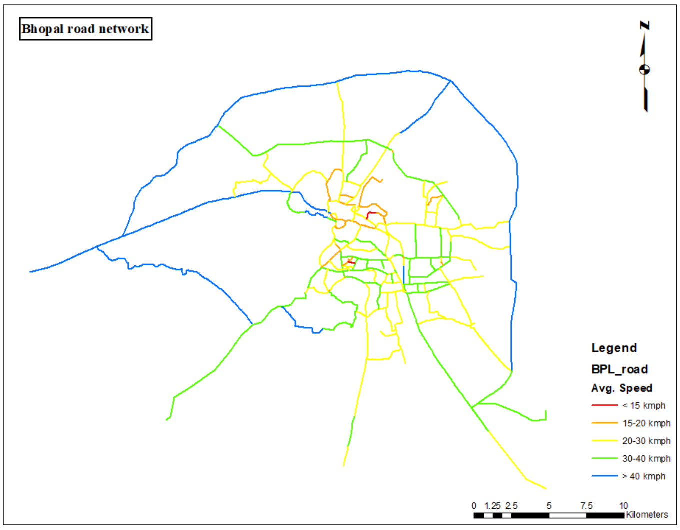

Fig-5: Traffic zones on major road links of Bhopal city

4.2 STUDY OF VARIATION OF TRAFFIC SPEED

As per the study done some roads like Chetak bridge square were identified as the road with most variation in traffic speed in a day. The peaks in graph Fig.6.(a) shows the maximum traffic speed which is generally observed in morning and late night hours which shows that traffic density is less at those hours. Whereas at peak hours like 9 am to 12 noon and 6 pm-8 pm, graph shows lowest traffic speed showing maximum traffic density. On Chetak Bridge road, maximum variance was observed up to 10.06 during weekdays and minimum variance as 0.07. The maximum variance on Chetak Bridge was found during the evening time i.e., between 6 p.m. to 8 p.m. Hence it can be said that as Chetak Bridge road is a commercial road and many working class travel along that road hence it shows wide variation at peak hours.

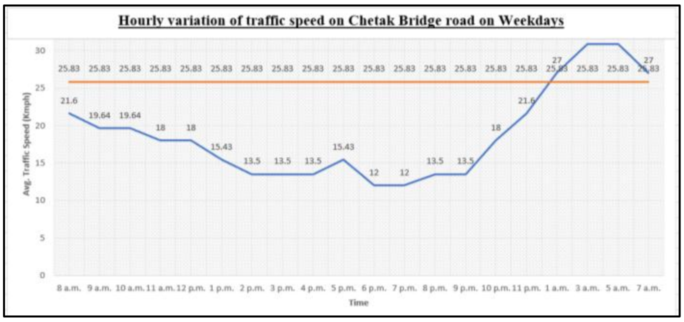

Fig-6.(a)

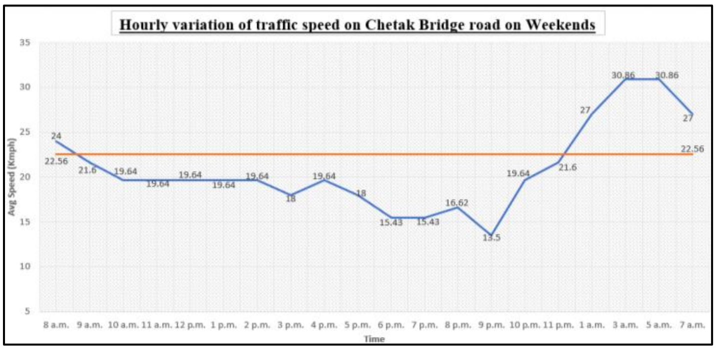

Fig-6.(b)

Fig-6: Observation of variation of traffic speed on hourly basis on Chetak Bridge

Also variation in average traffic speed can be observed on weekly basis. It was observed that mostly in weekdays average traffic speed were at lowest point on main commercial roads such as Chetak Bridge road, Lalghati road, Roshanpura road, Hamidia road, etc. The reason for low traffic speed during weekdays can be that most of the offices, commercial buildings as well as institutions lies along these roads making these roads as busiest during weekdays.

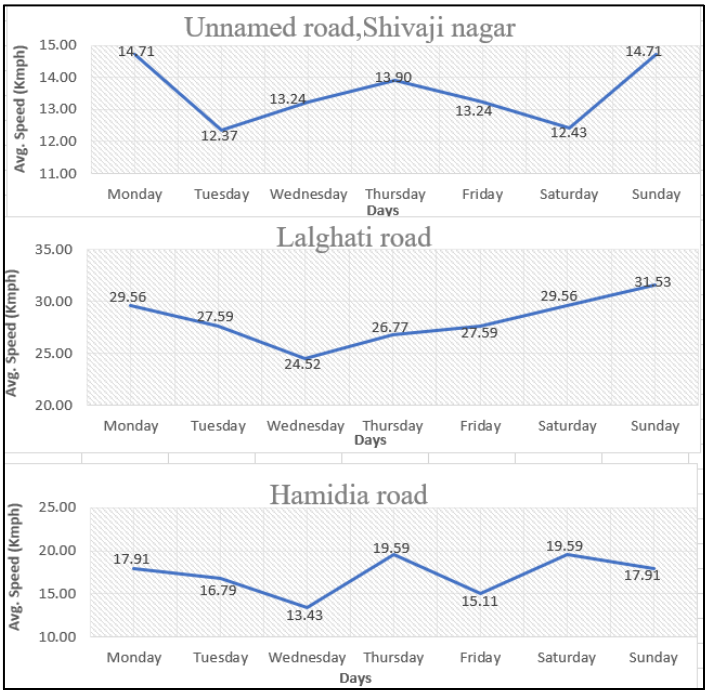

Fig-7: Weekly variation of traffic speed as per observation

4.3 SHORTEST ROUTE BETWEEN ORIGIN AND DESTINATION

In this shortest route is computed between origin and destination as per "Average Traffic Speed" instead of Design Speed. This route derived takes into

consideration the traffic congestion factor also and hence gives route with minimum traffic and travel time.
While computing shortest route two cases were considered:

- Restrictions considered (High congestion roads).
- Restrictions avoided.

It can be observed in Fig.8 shortest route between origin and destination when restrictions were considered i.e. High congestion roads (average traffic speed < 15kmph). Time taken by this route is 18.43 minutes. Whereas when restrictions were not considered the shortest route between same origin and destination was observed to be different as shown in Fig.9 than the earlier route. Time taken by this route is 13.347 minutes.

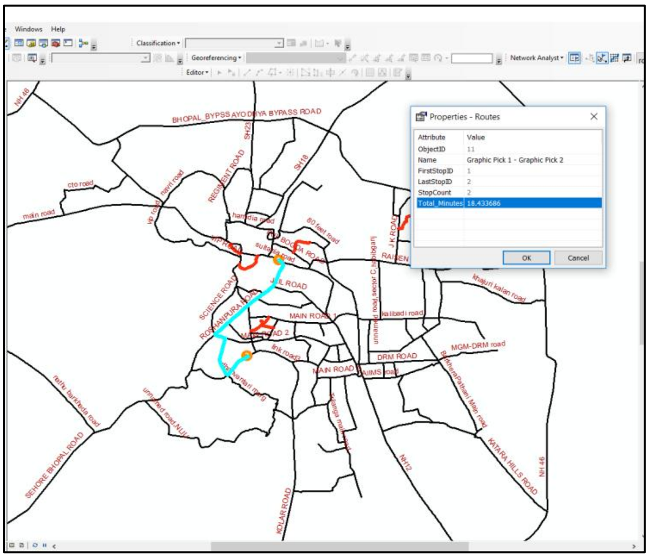

Fig-8: Shortest route between origin and destination as per restrictions (considering high traffic congestion roads)

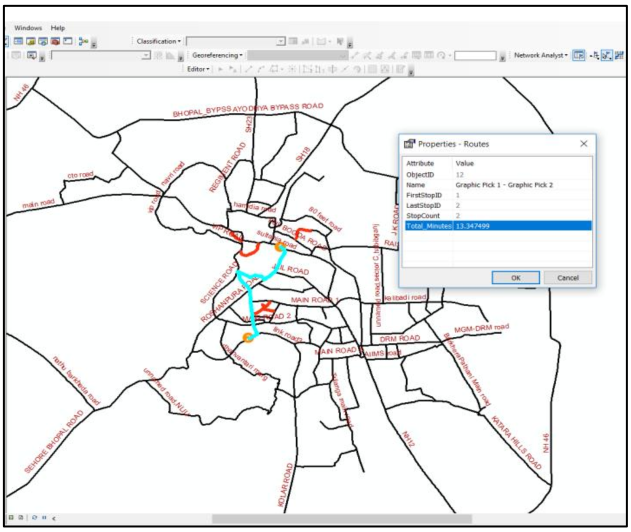

Fig-9: Shortest route between origin and destination without restrictions

5. CONCLUSION

The study therefore concludes that GIS based analysis can be used as an effective tool for the Road Transportation and Management system for the vehicle routing and traffic congestion related studies. It was observed in our investigations that using open source platform Google Maps, the real time identification of traffic congestion zones can be done and vehicles can be diverted through the alternate routes if needed. The road traffic conditions/volume in real time can be indirectly interpreted to some extent using the open source Google Map data. This is based on the assumption that if the traffic is more on a particular road then average time taken to travel that particular road will be more and hence average speed will be less. Also it was found that GIS based network analysis can help in the identification of shortest route between two places, which are helpful in the route analysis and alternative route generation in minimum time after considering the road traffic conditions also.

REFERENCES

[1] Anitha, S. S. D., Prince, A. G., Srisanthi, V.G., 2017, A GIS Based Traffic Congestion Evaluation for Coimbatore City. International Journal of ChemTech Research CODEN (USA):IJCRGG, ISSN:0974-4290, ISSN(Online):2455-9555, Vol.10 No.8, pp 382-387.

[2] Frederick, A., David, O., & Alex, A., 2010, A system dynamics approach to explore traffic congestion and air pollution link in the city of Accra, Chana. Journal of Sustainability, 2, 252-265.

[3] Kakcoza, R., Lubobi, L., & Mugisha, J., 2005, Modeling traffic flow and management at signalized and roundabout road intersection. Journal of Mathematics and Statistic,1(3), 194-202.

[4] Omer, W. M. and Al-Taei, A. K. A., 2011, Traffic Congestion in Urban Roads Network Using GIS Technology, Academia-Edu, at https://s3.amazonaws.com/academia.edu.documents/31517641/paper-1.pdf.

[5] Sinha, A. K., 2012, https://nextbigwhat.com/google-live-traffic-in-india-data-source/

[6] Sureshkumar, M., Supraja, S., Sowmya, R. B., 2017, GIS Based Route Optimization for Effective Traffic Management. International Journal of Engineering Research and Management (IJERM) ISSN: 2349- 2058, Volume-04, Issue-03, March 2017

[7] Turner, S., 2004, Defining and measuring traffic data quality: White paper on recommended approaches. Transportation research.