Development of congestion Pricing for Selected Arterial Road in Ahmedabad City

Mr. Milan A. Patel
M.E. Student
Department of Civil Engineering
Government Engineering College, Modasa, Gujarat, India

Mr. H. K. Dave
Associate professor
Department of Civil Engineering
Government Engineering College, Modasa, Gujarat, India

Abstract

The number of trips on the urban road networks has been increased in cities of India. Extra widening of roads and provision of new roads became the pattern to provide additional capacity to deal with increment of traffic particularly in developing cities like India. Today, even with the addition of new roads / flyovers or widening of roads has an addition of more traffic congestion within a short interval of time, observed in recent times in the road network in Ahmedabad urban area due to high growth of vehicle ownership. Traffic congestion is a road condition given by volume beyond the capacity, low operating speeds, higher travel times and environment degradation due to pollutants of exhaust gases coupled with increased queuing of vehicles. Mostly the working hour times, the traffic volume remains very higher above its capacity, mostly at morning peak between 10:00 to 11:30 as well as in evening peak between 5:30 to 7:00. In this paper, to determine the congestion pricing for a particular selected road in walled city of Ahmedabad, the method adopted for the determination of optimum pricing is related to the Point of pricing where the external costs are met by the revenue generated by the pricing level pricing for two-wheeler, three wheeler and four wheeler motorized vehicles has been considered.

Keywords: volume, capacity, travel time, pollutant emission, congestion pricing, vehicle operating cost

I. INTRODUCTION

"Congestion pricing" is also known as "value pricing," "peak-period pricing," time-of-day pricing," and "variable pricing." To avoid the word "toll," transportation experts and politicians have coined various terms for the same concept. Congestion pricing charges motorists a toll for using a particular stretch of highway or bridge or for entering a particular area. It is a market or demand-based strategy designed to encourage a shift of peak period trips to: a. off-peak periods; b. to routes away from congested facilities or c. to alternative modes – high occupancy vehicles or public transit – during the peak demand periods. Congestion pricing proposes to guide and internalize the transportation and environmental costs – delay, pollution, accidents – associated with congestion, costs that are largely unaccounted for in the current transportation system. Variable pricing, lane charging – including HOT or FAIR lanes – and cordon tolls are three main forms of congestion pricing. A distinction should be drawn between tolls to fund roadways and tolls to reduce congestion as these have different objectives and impacts. Charging for the use of urban roads facilities through the collection of tolls has long been a means to generate the funds needed to develop and operate urban roads facilities. In recent years, the concept of directly charging users of urban roads has expanded to include various pricing schemes aimed at managing travel demand in and around densely populated urban areas. Many of the leading examples of road pricing to manage urban area congestion can be found outside in major metropolitan areas characterized by high density urban cores, highly constrained roadway networks, significant transit capabilities and utilization, and limited public funding to pay for expanding transportation infrastructure. Traffic pattern on Indian road is highly heterogeneous n nature. There are around 58.8 million vehicles in India, which are growing at the rate of 10% annually. It is found that two wheelers make a major contribution(70%) to the total newly registered vehicles in India, followed by cars(13%), goods vehicles(6%), and one percent of buses. In India work trips are the most important component of the traffic demand during peak hours of the day. Transport demand is likely to increase by about 2.5 times from 1991 to 2010 in large metros and other medium sized cities by about 3-3.5 times. India's transportation system has a number of drawbacks, which causes problems of delays, safety, air pollution and inadequate parking. And also, the situations are like that cannot any possibility to provide any of the traffic facilities like specialized exclusive tracks, tunnels, under bridges or over bridges. So that after all the only the last option remained is to provide such policies that reduce the travel trip or to make people to use an alternative road facilities like bypasses and ring roads. For that kind of the situations the uses of the congestion pricing policies become helpful to reduce traffic problems and easement to users and being of an eco-friendly environment.

II. MEASUREMENT OF CONGESTION

Congestion is usually measured by analyzing the cost of time lost. There are two basic approaches which are traditionally used to measure congestion4. These are as under:
a) Engineering approaches b) Economic approaches

1) Engineering Approaches: Time loss is measured by calculating the difference between the time spent by travelers in the actual congested network and the time spent when roads are empty. The cost of time lost is priced at average hourly income levels generally with some adaptation. The basic advantage of the approach is that it is simple, but it has a flaw as it misses the link for the desired speed on a road.
2) Economic Approaches: Economic approaches consider an optimum traffic level, which is a function of the demand for road use. The desirable situation would be the optimum speed that is linked to willingness to pay. But apart from these two approaches, following elements can be considered to measure congestion.

III. NEED OF STUDY

The industrial revolution and the scope of the businesses, arising of the vehicle population, and growth of the people, migration towards urban area, their income increment, capability to make travel that causes the numbers of the vehicle increment. As the time passes, these cities were expanded their boundaries, and getting larger, so that people has to travel towards the older city area for businesses and jobs. That's why the roads of the older cities becomes congested that causes the harmful effects on the environment, travel time delays, affecting on heritage buildings of old city areas, accidents etc problems becomes sever now a days, that's why road width were become insufficient to carry out the traffic effectively and efficiently. To find out the problem regarding to congestions at the urban city area.

IV. OBJECTIVES

The main objective is to develop an optimum pricing for each two wheeler, three wheeler and four wheelers categories. Also to carry out the external cost of each type of vehicle separately for selected road.

V. SELECTED STUDY AREA

Ahmedabad is having population of about 54.53 lakhs Traffic pattern on Indian road is highly heterogeneous n nature. There are around 58.8 million vehicles in India, which are growing at the rate of 10% annually. Total numbers of the vehicles registered in 2006-07 were nearly about 15.18 lakh, particularly in Ahmedabad. The composition of the vehicle are around 70% two wheelers, 15% of cars, 8% of three wheelers1% of bus and remained are other type of vehicles including non-motorized for Ahmedabad city. The road stretch selected for study is shown in the figure which is heavyly congested. The road stretch is having width averagely 25 meters, and length is 2.011 km from electricity house to kalupur railway station.

Fig. 1: Actual Stretch of "Relief Road"

VI. SURVEYS CONDUCTED

1) Traffic Volume Count: Manually at each intersections and both the ends of the road with 15 minutes of interval, for 8.5 hours including morning and evening peak.
2) Travel Time: The average travel time of each type of the vehicle by following of the vehicle method.

3) Opinion Survey : willingness to pay for each type of vehicle person , for maximum how much he / she can pay for desired travelling condition at desired level of service.

VII. ANALYSIS

The road is having undivided section with four lane, have maximum capacity of road is 4300 PCU per hour as per IRC: SP30 (2009). For the 15 minute interval of the time maximum capacity is shown in the figure is 1075 PCU per 15 minute. And calculated total traffic is shown by total calculated PCU for a whole day. The calculated PCU is higher for all the day than the maximum capacity of the road. So that jamming conditions may also be developed. The speed of the vehicles generally falls between 10 to 20 kmph. The maximum volume reaches at morning 10:15 to 10:30 and at evening 5:00 to 5:30.at off peak hours also volume is higher or equal to the maximum capacity, so that the v/c ratio remains more than 1 throughout the working hours.

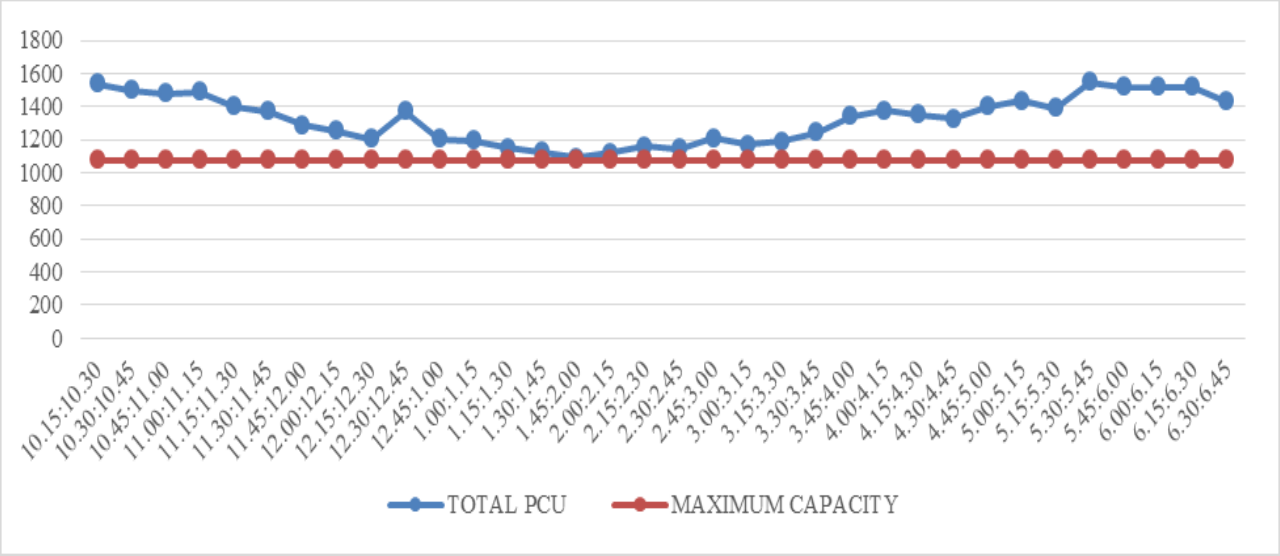

Fig. 2: Total Volume Distribution and Maximum Capacity of Road

The demand curve are to be plotted as per willingness to pay for the persons, the demand curve from the opinion survey data are established for two wheelers, three wheelers and four wheelers. The total external cost of each type of the vehicle is given by calculating the vehicle operating cost, travel time cost and pollution cost. Then the marginal cost for a single vehicle is carried out.

Table – l

external Cost of Two Wheelers at Peak Time Interval

external cost of two wheelers (peak 15 minutes)											
					travel time cost			*pollutant cost*			
name of stretch	*pcu / 15 minutes*	*2w*	*distance*	*total vehicle operating cost (Rs)*	*travel time for single 2w (sec.)*	*travel time for all 2w (hours)*	*travel cost of two wheelers(Rs)*	*total pollutant (kg/km)*	*total cost of pollutant(Rs)*	*total external cost(Rs)*	*marginal cost(Rs)*
relief cinema	*1590*	*848*	*0.215*	*288*	*60*	*14*	*572*	*22*	*118*	*979*	*1.15*
ghee kanta	*1645*	*890*	*0.450*	*638*	*110*	*27*	*1101*	*23*	*260*	*2000*	*2.25*
ratan pol	*1561*	*814*	*0.261*	*335*	*80*	*18*	*733*	*21*	*138*	*1205*	*1.48*
kalupur police station	*1576*	*753*	*0.465*	*552*	*150*	*31*	*1271*	*20*	*227*	*2050*	*2.72*
railway station cross	*1651*	*961*	*0.620*	*950*	*165*	*44*	*1784*	*25*	*387*	*3121*	*3.25*

Table – 2

External cost of two wheelers for working hours

external cost of two wheelers (8.5 hours working day)											
					travel time cost			*pollutant cost*			
name of stretch	*whole day pcu*	*2w*	*distance*	*total vehicle operating cost(Rs)*	*travel time for single 2w (sec)*	*travel time for all 2w (hours)*	*travel cost of 2w (Rs)*	*total pollutant (kg/km)*	*total cost of pollutant(Rs)*	*total external cost(Rs)*	*marginal cost(Rs)*
relief cinema	*44217*	*25433*	*0.215*	*8645*	*61*	*430*	*17420*	*664*	*3550*	*29615*	*1.16*
ghee kanta	*44921*	*25279*	*0.450*	*18127*	*108*	*759*	*30739*	*660*	*7386*	*56252*	*2.23*
ratan pol	*38300*	*21457*	*0.261*	*8818*	*76*	*453*	*18353*	*560*	*3636*	*30807*	*1.44*
kalupur police station	*36629*	*20303*	*0.465*	*14884*	*141*	*795*	*32212*	*530*	*6130*	*53226*	*2.62*
railway station cross	*46906*	*28092*	*0.620*	*27776*	*154*	*1199*	*48567*	*734*	*11309*	*87651*	*3.12*

External cost are to be calculated for peak 15 minute, whole day and 15 minute interval of whole day. Two wheeler external cost sheet is showing here above in table 1 and table 2. The method where the revenue generated will offset the external costs involves estimation of the variation of external costs with traffic. This relationship when seen along with the demand elasticity of the traffic with respect to pricing gives a level of traffic where the external costs generated by the traffic would be equal to the acceptable charge enforced.

The vehicle operating cost is calculated for per km length. Vehicle operating cost contains two costs they are time related congestion cost and distance related congestion cost. Both the cost are multiplied with the time related and distance related congestion factors, because the v/c ratio is higher than the value 1. Then the total vehicle operating cost is obtained. The detailed table of vehicle operating cost for different type of vehicles given on IRC: SP 30 (2009). The travel time cost is calculated with multiplying the total travel time with the vehicle occupancy and the cost of time. That gives the travel time cost. Vehicle occupancy is obtained by manually survey. Then pollution cost is estimated for the pollutants in gram per km. and total pollutant obtained in kg per km. cost of the 1kg pollutant is given 50 Rs. And travel time cost for an hour is obtained is 27 Rs. This are the common values for all type of vehicles.

For calculating the pollution cost for the car, it is assumed that 75% of the cars are petrol users and 25% are diesel users.so that emissions are different for both the cars. The emission norms are taken as per bharat stage 4 (BSIV).

Table 3 gives the maximum volume to decreasing by 2500 PCU and change in the marginal cost is showing. The curve is plotted between this external cost and opinion pricing is to be carried out. 46905 PCUs are daily working hours PCUs. The table 3 gives the values for the two wheelers, same as gradual marginal cost is carried out for the three wheelers and four wheelers also.

The optimum pricing for the two wheelers plotted two graphs opinion pricing and external cost on the same scale and intersecting point gives the optimum value for the congestion pricing at Figure 3. Optimum pricing for the two wheelers is around 11Rs for 2 km of the stretch. For three wheelers the optimum pricing value is 22 Rs at Figure 4. And four wheelers optimum pricing is 28 Rs. At figure 5.

As from the table 3 v/c ratio is 1, when the volume PCU is nearly 37500. Means the capacity of road for work in 8.5 hour is 37500 PCU at that time 33000 two wheelers,9375 three wheelers and 750 four wheelers are to be maintained for predefined vehicle composition.

Table – 3
two wheelers gradual marginal cost.

			total vehicle operating cost (Rs)	*travel time cost*		*pollutant cost*		*total external cost (Rs)*	
pcu	*2w*	*v/c*		*total 2w time (hour)*	*total travel time cost in (Rs)*	*total pollutant (kg)*	*total pollution cost (Rs)*		*total mrginal cost (Rs)*
46905	*41276*	*1.28*	*124213*	*10783*	*291137*	*1077*	*108299*	*523648*	*12.69*
45000	*39600*	*1.23*	*118283*	*10200*	*275403*	*1033*	*103900*	*497585*	*12.57*
42500	*37400*	*1.16*	*110614*	*9454*	*255256*	*976*	*98128*	*463999*	*12.41*
40000	*35200*	*1.09*	*103075*	*8729*	*235680*	*919*	*92356*	*431111*	*12.25*
37500	*33000*	*1.03*	*95664*	*8025*	*216674*	*861*	*86584*	*398922*	*12.09*
35000	*30800*	*0.96*	*88383*	*7342*	*198239*	*804*	*80811*	*367433*	*11.93*
32500	*28600*	*0.89*	*81231*	*6680*	*180373*	*746*	*75039*	*336643*	*11.77*
30000	*26400*	*0.82*	*74208*	*6040*	*163077*	*689*	*69267*	*306552*	*11.61*
27500	*24200*	*0.75*	*67314*	*5420*	*146352*	*631*	*63495*	*277161*	*11.45*
25000	*22000*	*0.68*	*60549*	*4822*	*130197*	*574*	*57722*	*248468*	*11.29*
22500	*19800*	*0.62*	*53913*	*4245*	*114611*	*517*	*51950*	*220475*	*11.14*
20000	*17600*	*0.55*	*47407*	*3689*	*99596*	*459*	*46178*	*193181*	*10.98*
17500	*15400*	*0.48*	*41029*	*3154*	*85151*	*402*	*40406*	*166586*	*10.82*
15000	*13200*	*0.41*	*34780*	*2640*	*71276*	*344*	*34633*	*140690*	*10.66*
12500	*11000*	*0.34*	*28661*	*2147*	*57972*	*287*	*28861*	*115494*	*10.50*
10000	*8800*	*0.27*	*22671*	*1675*	*45237*	*230*	*23089*	*90997*	*10.34*
7500	*6600*	*0.21*	*16809*	*1225*	*33073*	*172*	*17317*	*67199*	*10.18*
5000	*4400*	*0.14*	*11077*	*795*	*21478*	*115*	*11544*	*44100*	*10.02*

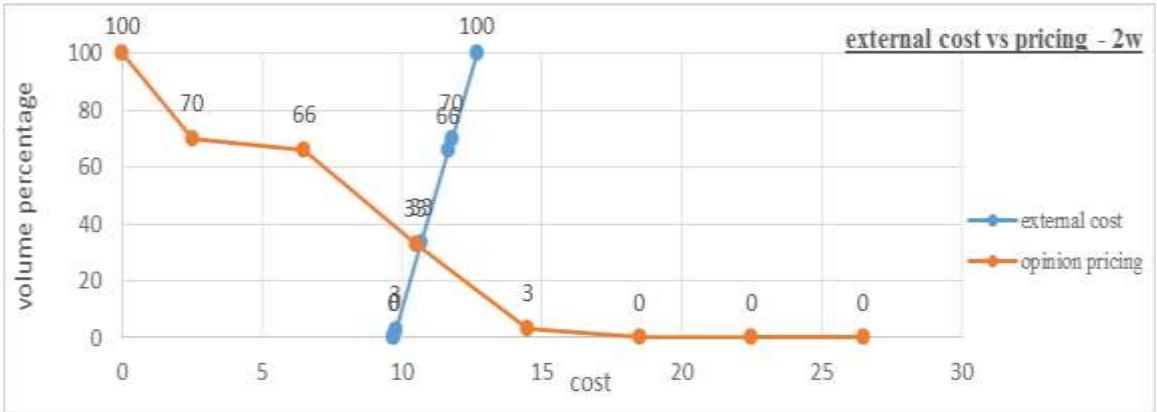

Fig. 3: Optimum Pricing For Two Wheelers

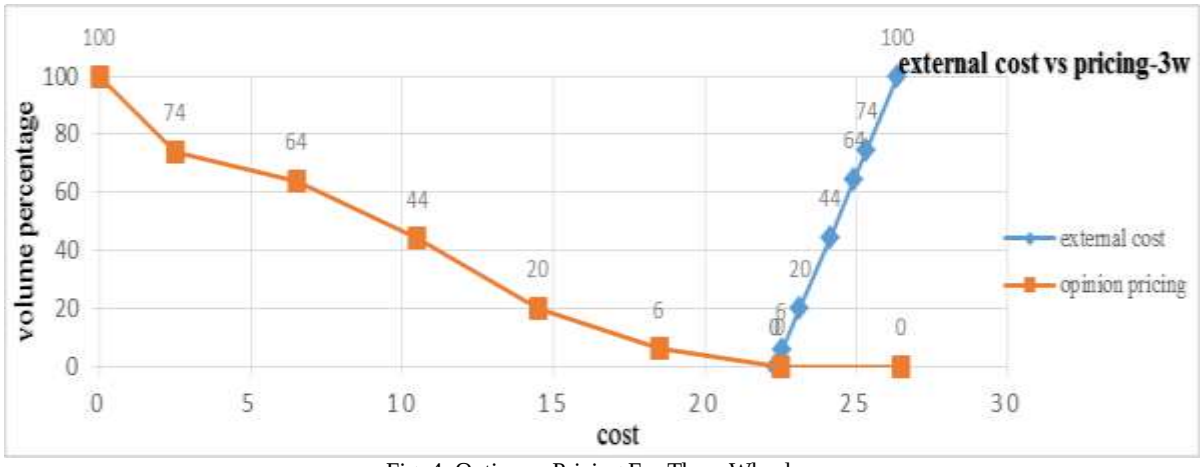

Fig. 4: Optimum Pricing For Three Wheelers

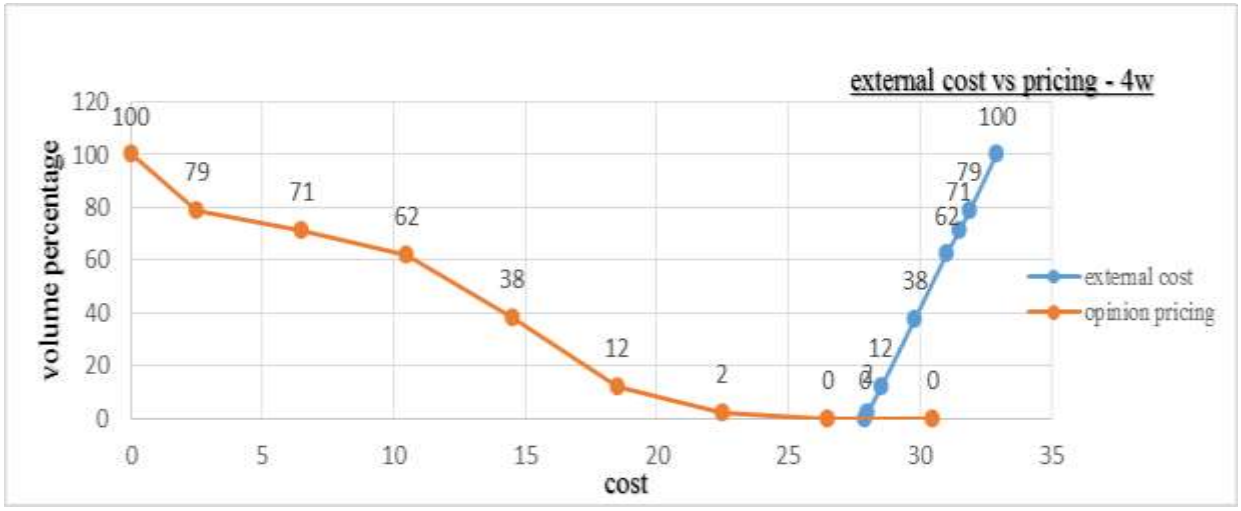

Fig. 5: Optimum Pricing For Three Wheelers

VIII. CONCLUSION

The level of service given by v/c ratio, and it can be easy to estimate the total pcu to maintain that predefined composition. Design capacity can be also estimated from v/c ratio, and different composition of vehicle can be maintained. This congestion can be considered as an impediment to mobility to more services are demanded than can be supplied at a given time and place. A range of approaches and tools must be applied to solve the pervasive transportation congestion problems that the city faces in the next decade and beyond. The desire level of services can be maintained by adjusting the pricing at certain content. This the tool for the Congestion management when there is no any space available to improvement. This congestion pricing also helps to increase he ride sharing and public transport system. only one of several approaches that can be used to reduce congestion on city's roads, shows in reducing congestion and ensures the existing transportation systems are used efficiently. Congestion pricing can potentially reduce congestion by providing incentives for drivers to shift trips to off-peak periods, use less congested routes, or use alternative modes, thereby spreading out demand for available transportation infrastructure. Congestion pricing also has the potential to create other benefits, such as generating revenue to help fund transportation investment.

REFERENCES

[1] Madhu Errampalli, Velmurugan Senathipathi, Deepa Thamban, "Effect Of Congestion On Fuel Cost And Travel Time And cost On Multi-Lane Highways In India", International Journal For Traffic And Transport Engineering, 2015, 5(4): 458 – 472
[2] Tanzila Khan, Md. Rashedul Islam Mcips. "Estimating Costs Of Traffic Congestion In Dhaka City", International Journal Of Engineering Science And Innovative Technology (Ijesit) Volume 2, Issue 3, May 2013
[3] Amudapuram Mohan Rao, Kalaga Ramachandra Rao, "Measuring Urban Traffic Congestion – A Review", International Journal for Traffic and Transport Engineering, 2012, 2(4): 286 – 305
[4] Aditi Singh, P. K. Sarkar, "Determination Of Congestion Cost In Central Business District Of New Delhi - A Case Study", Journal of the Indian Roads Congress, July-September 2009, Paper No. 552
[5] Small, Kenneth A., "Using the Revenues from Congestion Pricing", University of California Transportation Center, 12-01-2001
[6] Levinson, David, "An Economic Analysis of Network Deployment And Application To Road Pricing", California Path Program Institute Of Transportation Studies University Of California, Berkeley, 01-01-1998.

[7] IRC-106 (1990), "Guidelines For Capacity Of Urban Road in Plain Area", The Indian Road Congress.
[8] IRC:SP30 (2009), "Manual On Economics Evaluation Of Highway Projects In India",
[9] IRC:SP28 (1996)," ROAD TRANSPORT AND ENERGY"
[10] Report on " Status Of Pollution Generated From Road Transport In Six Cities" by CENTRAL POLLUTION CONTROL BOARD, MARCH 2015
[11] Dr. L. R. Kadiyali, "Traffic engineering and transport planning".
[12] S. K. Khanna and C. E. G. Justto, "Highway Engineering".
[13] C. Jotin Khisty and B. Kent Lall, "Transportation engineering An introduction"
[14] Tom V. Mathew and K. V. Krishna Rao, "Fundamental Parameters Of Traffic Flow" NPTEL (may 2006);