Synchronization of Traffic Signals
"A Case Study – Eastern Ring Road, Indore"

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Abstract **-** During the past decade major cities have under gone haphazard growth of Industrialization, urbanization of country. Consequently the urban population has to travel greater distances within minimum possible time. To manage travel demand the intersection should be give least resistance to traffic flow so that the travel time can be minimized. The present requirement of metropolitan cities is to absorb the growing traffic demand but within the same physical dimension at the intersection. These days all around the globe efforts are being put forward to protect the environment to save earth. In this paper an attempt has been made to study the various intersections, so as to minimize the delays at these intersections and consequently improve the level service. Traffic signal can be synchronized so that a vehicle starting at one end of the Street and traveling at Preassigned speed can go to other end without stopping for red light. At each intersection the existing traffic has been estimated and then signal designed. Improve the level of service at intersections and to minimize delay, optimized signal has been synchronize and estimated the benefits.

I. INTRODUCTION

Transportation is involved with the movement of people and material from one place to other i.e. from origin to designation. Transportation creates place and time utility for goods for both finished and raw, but also ensuring that the right kinds of goods are available at the right time. Doing this efficiently, in other words at the least cost in the least time, also satisfies in the essence of transportation, the relative facilities. The increasing vehicular traffic on urban road in network demands effective measure of traffic control on road –network, especially at the intersection, where turning movement of vehicle and mixed traffic creates congestion, traffic jam. All the Metropolitan cities in India face this problem in acute form. The provision of signal at the intersection is one of the methods to control the traffic, signal permits the leg wise movement of the traffic and synchronization is the coordination between relative signals.

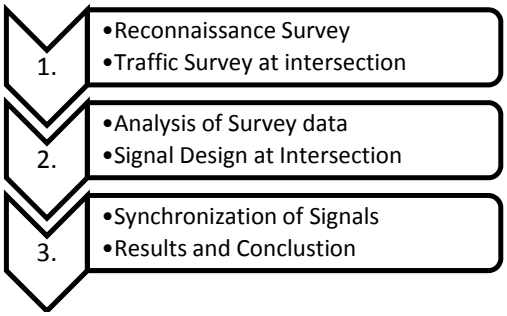
In congested parts of the cities, traffic control at road intersection in practical and economical only with the help of traffic signals under the prevailing conditions. A major objective of Traffic Signal Synchronization at intersection is to clear maximum number of vehicles through the intersection in a given length and time with least number of accidents, at maximum safe speed and with minimum delay. Indore city having many heavy traffic corridors like Agra bombay road, Mahatma gandhi road, Eastern ring road, MR-10, Western ring road. In which Eastern ring road is one of the most important roads having traffic 22716 PCU per day.

A. Need of Study

Due to mixed nature of traffic it becomes very difficult to accommodate the traffic on road particularly at intersection. The loss of time and fuel due to delay and traffic congestion on urban road is phenomenon. Traffic congestion is a severe problem at an intersection in urban, having create many critical problems like traffic jam, delay, pollution, accidents etc. It challenges in major and most populated cities around the world. Which can be solved by applying traffic signal management and engineering measures?

At the time of heavy traffic condition, traffic jam condition is developed on ring road. Due to more traffic jam the delay of vehicles is more. Excessive fuel is loss due to low running speed and delays. Excessive burned fuel creates excessive smoke in nature which creates air pollution. More traffic jam and delay is also reason of the noise pollution which is the reason of many health problems. Due to these traffic jams intersection traffic handling capacity and road capacity will reduce. The objectives of present study are to reduce the delay and time saving due to synchronization of signal in series, to reduce pollution produced by traffic and fuel loss due to low running speed.

II. MATHADOLOGY



III. TRAFFIC SURVEY AND DATA COLLECTION

Eastern ring road corridor having eleven intersections between Devash naka to Rajeev gandhi intersection. The traffic growth on this road is day by day increase rapidly because new colony and town ship developing along corridor. Now day's problem facing at various intersections due to rapid growth in this section.

A. Detail Information of Road

[Devesh naka Intersection (N) to Rajeev Gandhi Intersection(S)]

Name of road : Eastern Ring Road Corridor.

Total Length of road: 14.6 km.

No of Intersection: 11No.

Rotary at Intersections: 08 No.

B. Geometry and Traffic at intersection survey

The detail measurements have taken for analysis of road. Line diagram of ring road at fig.1, Video survey have accuracy higher than the accuracy of manual data collectors methods, this method has been used to determine traffic survey at each intersection of road.

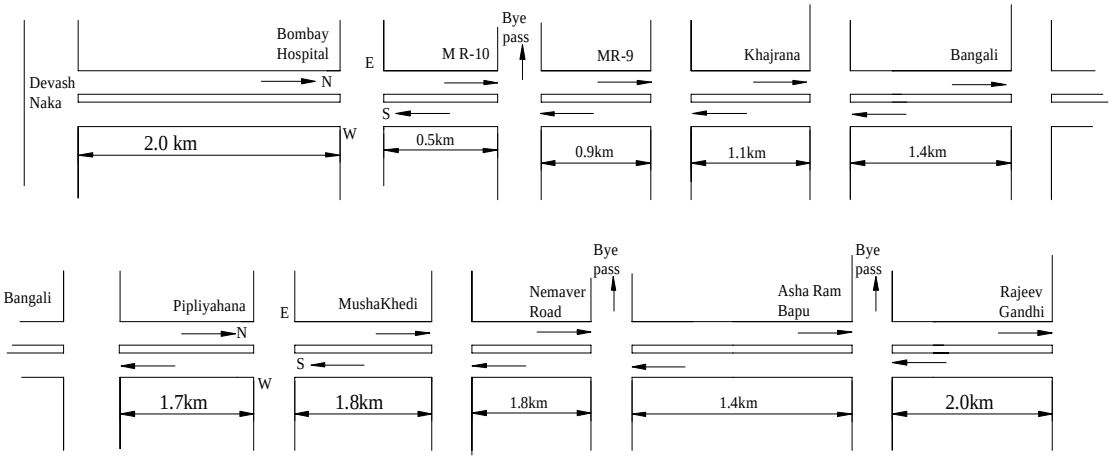


Fig. 1 : Line Diagram of Eastern Ring Road Devesh Naka to Rajeev Gandi intersection

Table 1 : Traffic Survey Data at Intersections of Eastern Ring Road (PCU)

Sr. No.	Name of Intersection	Distance (m.)	From		N			E			S			W	
			To	E	S	W	S	W	N	W	N	E	N	E	S
1	**Devash naka Junction**	800		-	-	-	225	146	-	621	-	195	-	89	612
2	**Bombay Hospital Junction**	2000		111	1135	191	192	229	70	409	757	296	228	370	378
3	**M R -10 Junction**	500		378	728	236	162	628	468	648	760	300	165	412	456
4	**M R - 9 Junction**	900		165	1462	232	114	107	63	357	1285	197	102	138	196

5	**Khajrana Junction**	1100		311	1231	327	113	474	136	123	663	46	401	608	169
6	**Bangali Junction**	1400		247	938	227	133	681	103	224	1086	195	193	717	221
7	**Pipliya Junction**	1700		152	927	549	52	103	49	299	867	68	582	112	161
8	**Musha khedi Junction**	1800		100	828	388	49	126	75	119	864	174	204	285	53
9	**Nemaver road Junction**	1800		267	1027	172	181	846	183	607	747	625	337	871	177
10	**Asharam Bapu Junction**	1400		382	845	242	208	651	265	92	901	143	346	466	57
11	**Rajeev Gandhi Junction**	2000		-	1109	-	-	-	-	-	1046	-	-	-	-

Chart-1 Avg. Vehicle Flow N to S (Veh/hr)

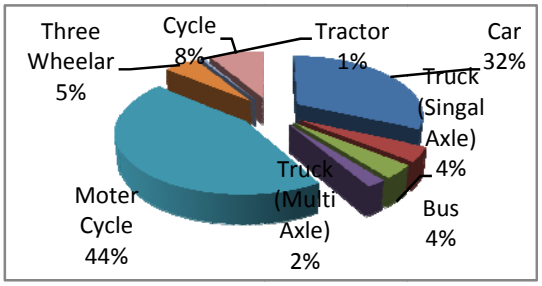
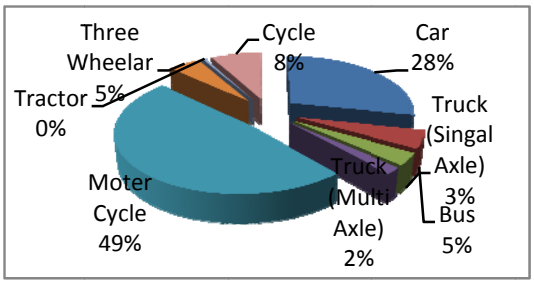


Chart-2 Avg. Vehicle Flow S to N (Veh/hr)



IV. RESULTS

All intersection Signal Design based on webster's signal design method. Detail design One of them is given below in table 2.

Table.2. Traffic Signal Design at Intersection of Eastern Ring Road

Approach	**N**	**E**	**S**	**W**		
Approach Width W	10.5	10.5	10.5	10.5	Optimum Cycle Time Co (sec.)	103
Flow V (PCU/hr.)	963	1096	1041	864	Effective Green Time G_E (sec.)	87
Green Phase (sec.)	25	28	27	23	Inter Section Capacity	4656
Green Time G (sec)	20	23	22	18	Determination of Critical lane group	0.72
Amber Time (sec.)	5	5	5	5	Critical V/C Ratio for Intersection Xc	0.85
Red Time (sec.)	78	75	76	80	Total Intersection Delay D_I (sec.)	34.37
Delay di (sec./veh.)	34.8	32.9	33.7	36.3	Intersection Level of Service	D
V/C Ratio (X)	0.89	0.89	0.89	0.90		

Fig. 2 : Timing Diagram of MR-10 Intersection

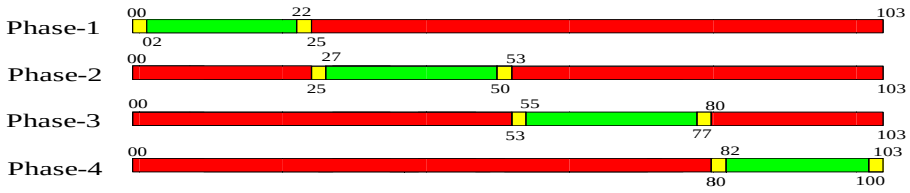


Table3. Signal Design Detail Intersections

Sr. No	Name of Intersection	Distance (m.)	Cycle Time Co	Green Phase (sec.)				Red Phase (sec.)			
				1	2	3	4	1	2	3	4
1	Bombay Hospital Intersection	-	102	33	14	27	28	69	88	75	74
2	M R -10 Intersection	500	103	25	28	27	23	79	76	77	81
3	M R - 9 Intersection	900	101	41	10	36	15	61	92	65	86
4	Khajrana Intersection	1100	136	47	29	24	36	89	107	112	100
5	Bangali Intersection	1400	182	46	43	50	43	137	139	132	139
6	Pipliyahana Intersection	1700	65	28	8	19	11	37	57	46	54
7	Musha khedi Intersection	1800	65	24	9	21	12	42	56	44	53
8	Nemaver road Intersection	1800	185	48	41	54	42	137	144	131	143
9	Asharam Bapu Intersection	1400	82	24	21	23	14	58	61	59	69

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Table. 4 : Different parameters of Signal Design

Sr. No	Name of Intersection	Distance (m.)	Cycle Time	V/C Ratio	Delay Sec/Veh	LOS
1	Bombay Hospital	-	102	0.85	31.89	D
2	M R -10	500	103	0.85	34.37	D
3	M R - 9	900	101	0.85	27.59	D
4	Khajrana	1100	136	0.89	42.13	E
5	Bangali	1400	182	0.92	57.52	E
6	Pipliyahana	1700	65	0.73	19	C
7	Musha khedi	1800	65	0.74	20.26	C
8	Nemaver Road	1800	185	0.92	58.4	E
9	Asharam Bapu	1400	82	0.80	27.38	D

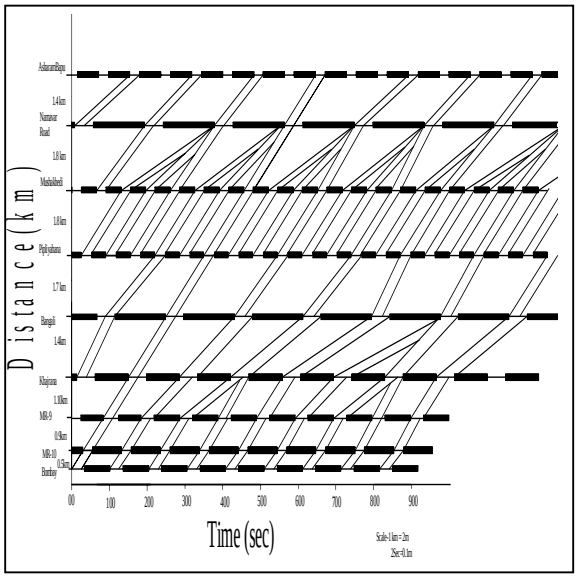

Fig. 4 : Time and Distance Diagram Bombay Hospital to Asharam Bapu Intersection (N to S)

A. Synchronization of Signals

Traffic signal synchronization allows a series of lights along a street to turn green based on synchronized timers set and preassigned speed to current traffic patterns and congestion levels. It is a cost effective way to reduce overall stops and travel delays. Synchronization of traffic Signals has been done and it's detail is given in Figure 4 and Figure 5.

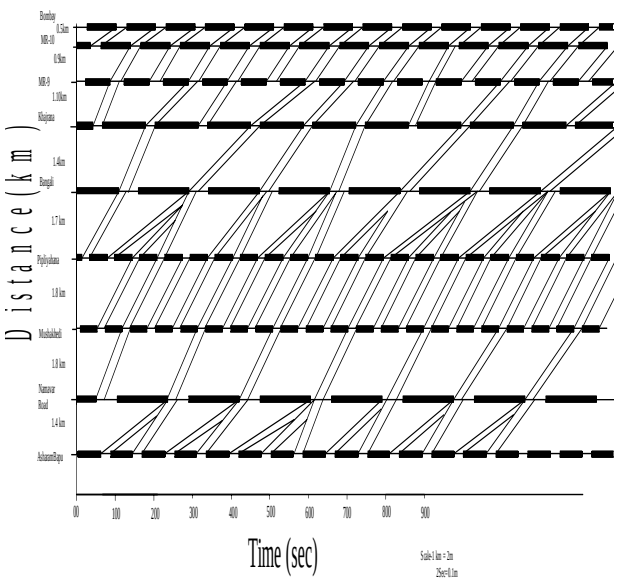

Fig. 5 : Time and Distance Diagram Asharam Bapu to Bombay Hospital Intersection (S to N)

B. Economic Analysis Details

After Applying Synchronization saving time per hour per passenger is 210 sec. and 151 sec. As per Avg. Traffic survey detail Converted into passenger per hour 3332 and 3211. By the report of Advance Estimation of National income 2010-11 estimates at current prices Per Capita income is Rs. 54,527, so per capita per sec. income is Rs 0.00519. Peak traffic hours of the day is 6 hour, then benefits in terms of money is Rs 21,725 per Day and Rs 15,052 per Day. Due to low running Speed of vehicle the extra fuel has been burn, synchronization of signal can save this loss from N-S & S-N, Petrol 627.02 Lit/Day and Diesel 911.44 Lit/Day. Cost of this fuel is Petrol Rs.42,870 and Diesel Rs.41,115. Due to Delay the vehicle burn extra fuel , this fuel loss is ideal fuel consumption of vehicles, it can save loss of fuel Petrol 34.32 Lit/Day and Diesel 20.90 Lit/Day, Cost of fuel Rs.2347 and Rs.949. Detail of this data given below in table 6 & table 7.

Table 6 : Results of Synchronization

	N to S Time Saving-		S to N Time Saving-	
	Before	**After**	**Before**	**After**
Journey time (sec)	986	776	995	844
Journey Speed (kmph)	38.70	49.14	38.352	45.19
Delay time (sec)	31	0	45	0
No of Passengers per hr	3332		3211	
Time Saving Sec/hr/pass.	210		151	

Table 7:Benefits of peak hours traffic in terms of Money

Direction	**Bombay Hospital To Asharam Bapu (N-S)**		**Asharam Bapu To Bombay Hospital (S-N)**		**Total**
Save Time (Sec./Day)	4188382		2901843		
Time Saving in Rs. (Per Day)	21725		15052		36777
Low Running Fuel Loss(Lit/Day)	343.73 P	491.53 D	283.29 P	419.91D	
Loss of fuel in Rs. (Per Day)	45821		38436		84257
Delay Fuel Loss (Lit./ Day)	15.01 P	9.37 D	19.31 P	11.53 D	
Loss of Fuel in RS. (Per Day)	1452	1844	3296		
Total Rs. (Per Day)	68997	55332	124392		
Total Rs. (Per Annum)	25184070	20196251	45380320		

C. Carbon Dioxide (CO_2) Emission

Now days Global Warming is very big problem in front of us. One of the important cause of the global warming is Emission of CO_2. After applying Synchronization fuel save up to 241 kl petrol and 340 kl diesel per annum, so emission of CO_2 may be reduce 1.50 Million kg per Annum.

Fuel (Per Liter)	**CO_2 Emission (kg.)**
Petrol	2.3
Diesel	2.7

V. CONCLUSIONS

Based on analysis of data collated from Eastern ring road, conclusions are signal design and synchronization has been done for nine intersections of eastern ring road to minimize delay. Journey time 241Sec. N to S and 151sec. S to N are reduced by synchronization. 241 kl petrol and 340 kl diesel per annum have been saved. The loss occurred of Rs.1.20 million/annum, 30.15 million/annum and 13.42 million/annum due to vehicle delay, low running speed of vehicle and loss of people's time of respectively. CO_2 emission is estimated to reduce by 1.50 million Kg. per annum through

REFRENCES

[1] Hu Qionghong and Zhou Zhiyun, "Study on the urban road traffic safety management" Eastern Asia Socitey for Transportation Studies-05, 2005, pp 2062-2074,.

[2] Dr. Parida, Dr. Gangopadhay and Goel, "Transport measure to reduce fuel loss on chelmsforad road, New Delhi" Institute of Urban Transportation, 07 (01), 2006, pp 42-51.

[3] Kiran Sandhu and Gurodh Dhillon, "Roads or death traps? impacts and quality of life outcome of road traffic accidents" Highway Research journal, special issue-2008, pp.65-72.

[4] C.T. Wannige and D.U.J. Sonnadara, "Adaptive neuro-fuzzy traffic signal control for multiple junctions", International Conference on Industrial and Information Systems, 2009, 28-31.

[5] Stefan Lammer and Dirk Helbing "Self-stabilizing decentralized signal control of realistic, saturated network traffic" Journal of Transportation Engineering (ASCE), 2009, pp.01-17.

[6] Lin Dong and Wushan Chen, "Real-time traffic signal timing for urban road multi-intersection" Intelligent Information Management, 02, 2010, pp.483-486.

[7] HaiBo Mu, JianNing Yu and LinZhong Liu (). "Traffic Signals Ccontrol of Urban Traffic Intersections Group Based on Fuzzy Control" Seventh international Conference on fuzzy Syatems and knowledge discovery, 2010, pp. 763-767.

[8] Liang-Tay Lin, Li-Wei Chris Tung and Hsin-Chuan Ku. "Synchronized signal control model for maximizing progression along an arterial" Journal of Transportation Engineering (ASCE), 136 (08), 2010, pp.727-735.

[9] Government of India Central Statistics office report on "Advance Estimation of National Income 2010-11".

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