COORDINATED SIGNAL SYSTEM PROPOSAL FOR URBAN ROAD, SURAT

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ABSTRACT

Nowadays because of mixed flow of traffic, congestion has become a major problem at intersections because of conflicting streams in big cities. For traffic congestion at intersection, somewhere one reason is because of improper traffic signal design at different intersections. So for smooth operation or friction-less movement of vehicles at an intersection it is necessary to resolve this traffic congestion by providing proper coordinated traffic signal systems. Traffic congestion at intersections results in delay and causes halt of vehicles at different junctions, which increase frustration & stress on driver. Because of delay in traffic clearance at intersection leads to more fuel consumption & also create unhealthy environment. Proper coordination between traffic signal at intersection helps in reducing the travelling time i.e. delay time is reduced, reduces fuel consumption and pollution& which can helps to improve mental health of communities. For the study of traffic congestion the area selected is Majura-gate to Parle Point road. Selected intersection is busiest junction especially in peak hours. After the study of this area, proposal for coordinated signal systems throughout the route will be provided. This will minimize the delay time & will provide flawless & friction-less traffic signal at intersection for easy & smooth functioning.

Key Words : Intersection Improvement, Rotary, Capacity of Rotary, Traffic Congestion Lane capacity

1. INTRODUCTION

The Increase in the vehicular traffic is becoming sever problem. And this problem is arriving due to owning of personal motor vehicles. To effectively controlling of this increasing traffic on road some traffic control measures are used on road i.e. traffic rotary, traffic signal, channelization of road etc. but there are some limit of traffic which can be handled by this measures. India is developing country with population of about 125 crores and with that ranking 2nd in world. As traffic flow in India is heterogeneous, so to carry out analysis of traffic is difficult. Surat has been selected as the study area located on the bank of Tapi River. For study the route selected is from Majura-gate to Parle Point through Ghod-dod road. reason For selecting this route because ghod-dod road is such a link which connects Parle point and turning point and also has high standard of living. Reasons of using this road link is because many commercial building are situated on the road such as a school named Saint Xavier's, Abhinandan market, Agrawal samaj bhavan, Ram chawk Temple, many jewelry showrooms, many banks, Malls and Residencies and in nearby areas there is Indoor stadium, Convent school, Narmad Library, jogger's park, etc. Because of this it is a busiest route especially during peak hours. Mainly

three junctions are selected for which coordinated signal system is required they are:

1. Majura Fire-Station
2. Ram Chawk
3. Narmad Library or Union Park

Figure:- 1 Route of study area from Majura-gate to Parle point

2. OBJECTIVES OF STUDY

- To study current scenario of traffic volume from Majura-gate to parlepoint.
- To study the parameters causing traffic congestion.
- To study traffic volume, traffic composition and turning movements of vehicles at the junctions
- To study the existing traffic signal system and its significance.
- To design coordinated traffic signal system for the study area.

3. Traffic Volume Survey (PUC Count)

3.1 Weakly traffic Volume Survey

	Intersection	From	Towards/ Turn	Vehicles					Total	PCU Count
				2 Wheeler	4 Wheeler	Rickshaw	Bicycle	Bus		
1	NARMAD LIBRARY	Narmad Library	Left	95	85	15	3	0	199	152
			Straight	230	159	62	0	0	451	336
			Right	127	53	19	1	0	200	136

		Majura	**Left**	144	101	58	11	0	315	240
			Straight	680	288	290	0	10	1268	948
			Right	110	56	40	2	0	213	167
		Jogars Park	**Left**	55	20	19	4	0	98	69
			Straight	318	134	42	0	1	495	338
			Right	422	306	42	3	0	773	561
		Parle Point	**Left**	37	19	19	0	0	76	60
			Straight	793	297	278	0	0	1368	972
			Right	88	87	54	8	4	241	201
2	**Ram Chawk**	**Bhatar**	**Left**	235	132	74	17	0	460	338
			Right	544	302	154	29	0	1033	755
		Parle Point	**Straight**	938	496	389	27	2	1852	1374
			Right	39	32	26	8	0	106	85
		Majura	**Left**	295	249	97	4	0	645	496
			Straight	488	403	159	14	1	1065	816
3	**Parle Point**	**Ghod-Dod**	**Parle Point**	665	298	289	29	0	1286	949
		Parle Point	**Ghod-Dod**	1120	632	367	49	2	2170	1590
4	**Turning Point Circle**	**Majura**	**Ghod-Dod**	2256	1123	598	134	0	4111	2916
		Majura	**Bhattar**	834	289	320	67	0	1510	1060
		Bhattar	**Majura**	698	156	256	24	1	1139	788
		Bhattar	**Ghod-Dod**	267	74	78	4	0	423	288
		Ghod-Dod	**Majura**	1820	435	507	65	0	2827	1885
		RamChawk	**Turning All**	1568	1206	355	57	0	3186	2374

Table :- 1 Traffic Volume Survey Conducted During Average Daily Morning Peak Hours

	Intersection	**From**	**Towards/Turn**	**Vehicles**					**Total**	**PCU Count**
				2 Wheeler	**4 Wheeler**	**Rickshaw**	**Bicycle**	**Bus**		
1	**NARMAD LIBRARY**	**Narmad Library**	**Left**	86	74	12	2	0	174	130
			Straight	236	150	52	0	0	438	320
			Right	112	46	16	0	0	174	118
		Majura	**Left**	150	90	44	8	0	292	213
			Straight	668	262	250	0	8	1188	870
			Right	116	42	30	0	0	192	142

		Jogars Park	**Left**	50	18	14	4	0	86	59
			Straight	306	122	40	0	0	468	315
			Right	430	288	42	2	0	762	546
		Parle Point	**Left**	32	18	14	0	0	64	48
			Straight	818	258	242	0	0	1318	909
			Right	74	66	34	6	2	182	146
2	**Ram Chawk**	**Bhatar**	**Left**	238	102	68	14	0	424	302
			Right	534	270	108	24	0	940	669
		Parle Point	**Straight**	934	444	352	22	2	1754	1280
			Right	32	22	12	6	0	72	53
		Majura	**Left**	282	222	80	4	0	588	445
			Straight	470	378	148	12	0	1008	767
3	**Parle Point**	**Ghod-Dod**	**Parle Point**	700	262	246	26	0	1238	883
		Parle Point	**Ghod-Dod**	1126	590	328	46	2	2092	1510
4	**Turning Point Circle**	**Majura**	**Ghod-Dod**	2184	1034	514	98	0	3830	2689
		Majura	**Bhattar**	808	248	284	52	0	1392	962
		Bhattar	**Majura**	674	130	204	20	0	1032	693
		Bhattar	**Ghod-Dod**	222	68	64	2	0	356	244
		Ghod-Dod	**Majura**	1760	388	468	48	0	2664	1760
		RamChawk	**Turning All**	1508	1132	306	44	0	2990	2214

Table :- 2 Traffic Volume Survey Conducted During Average Daily Morning Peak Hours

4. Vehicle Composition

Narmad Library Circle or Union Park Circle

Here are vehicles PCU counts as per the hourly volume analyzed from the data collected by traffic volume survey at the individual intersection for the selected study area. The table and graph below describes the PCU counts and percentage of the vehicle composition at Narmad Library Circle or Union Park Circle during morning peak hour,

NARMAD LIBRARY	**Two Wheelers**	**Four Wheelers**	**Rickshaw**	**Bicycle**	**Bus**	**Other**	**Total**
Total	3099	1605	938	32	15	8	5697
Percentage	54.39	28.17	16.46	0.56	0.26	0.14	

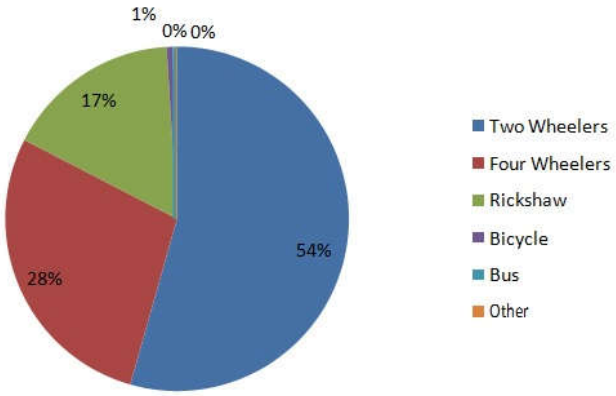


Figure :-2 Vehicle Composition At Narmad Library Circle or Union Park Circle

Ram Chawk

Here are vehicles PCU counts as per the hourly volume analyzed from the data collected by traffic volume survey at the individual intersection for the selected study area. The table and graph below describes the PCU counts and percentage of the vehicle composition at Ram Chawk during morning peak hour,

Ram Chawk	Two Wheelers	Four Wheelers	Rickshaw	Bicycle	Bus	Other	Total
Total	2539	1614	899	99	3	7	5161
Percentage	49.19	31.27	17.41	1.91	0.0	0.13	

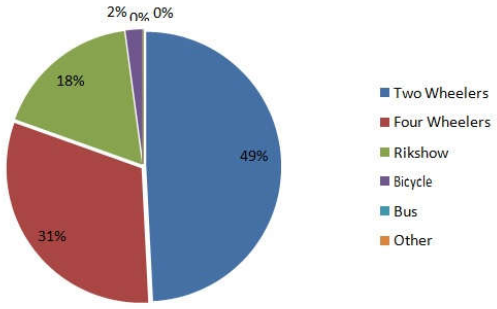


Figure:-3 Vehicle Composition At Ram Chawk

Turning Point Circle

Here are vehicles PCU counts as per the hourly volume analyzed from the data collected by traffic volume survey at the individual intersection for the selected study area. The table and graph below describes the PCU counts and percentage of the vehicle composition at Turning Point during morning peak hour,

Turning Point Circle	Two Wheelers	Four Wheelers	Rickshaw	Bicycle	Bus	Other	Total
Total	12779	5018	4198	660	13	5	22673
Percentage	56.36	22.13	18.51	2.91	0.05	0.02	

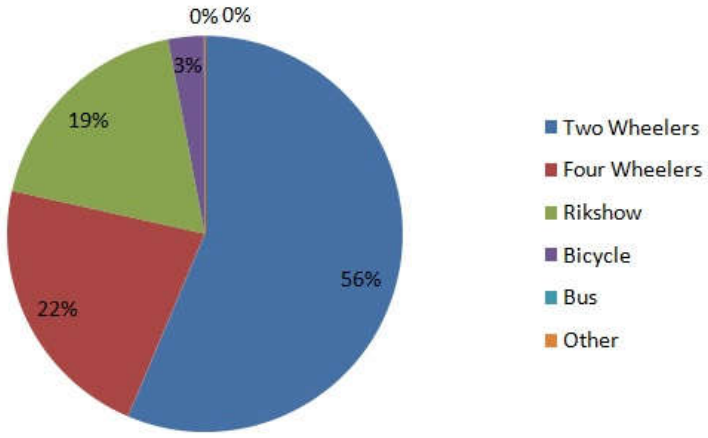


Figure:-4 Vehicle Composition At Turning Point Circle

5. Webster's Approach/Model

To design a signal system firstly we have to calculate its cycle length on basis of its demand (as per the vehicular/PCU counts). For higher number of counts cycle length is different than the lesser number of counts at each intersection. Thus intersection having higher demand can be said as critical intersection. For these critical intersections optimum cycle length is calculated. This optimum cycle length helps in designing the signal system at particular intersection. This higher demand may also be at other intersection which is nearer to the intersection which may also have higher demand. Therefore there may be more number of critical intersections in a single route, which may have lesser distances between them. So it may not be possible to get the optimum cycle length which is best suited for the intersections. As described earlier, to design a signal system optimum cycle length has to be calculated, for this Webster's approach is used. Webster had given a formula to obtain a optimum cycle length to minimize the delay period. The formula to calculate optimum cycle length is as,

$C= (1.5L + 5) / (1.0 - Y)$

Where,

C = Optimum cycle Length

Y = Critical Lane Volume divided by the saturation flow, summed over the phases L = Lost time per cycle

- **Signal Designing by Webster's Approach**

The data obtained from the survey that is traffic volume survey is analyzed and the vehicular counts are converted to the PCU counts using standard format of IRC SP 41. From these counts at different intersections traffic signal design can be done. Here with the help of the analyzed data using Webster's approach to design an

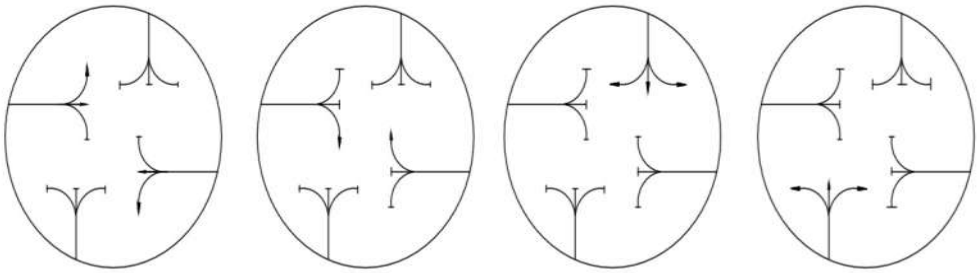
isolated signal system at the intersections.

Narmad Library Circle

Using Webster's approach of designing a signal, an isolated signal system is designed at the Narmad Library Circle. As tabulated below have number of vehicles per hour and also their PCU counts per hour and also their saturation flow as per the number of vehicles in the lane which is as follows:

Narmad Library Circle/Union Park Circle/Rangeela Circle												
Approach	**Narmad Library**			**Jogger's Park**			**Ram Chawk**			**Parle Point**		
	L	**S**	**R**	**L**	**S**	**R**	**L**	**S**	**R**	**L**	**S**	**R**
Veh./Hr.	199	451	200	98	495	773	315	1268	213	76	1368	241
PCU/Hr.	152	336	136	69	338	561	240	948	167	60	972	201
Saturation	2216			2216			5697			5697		

A four phase signal system is designed at Narmad Library Circle, a four legged intersection using Webster's Approach. The phase diagram is as shown below:



Phase Diagram - I Phase Diagram - II Phase Diagram - III Phase Diagram - IV

For designing firstly critical values i.e. y for each phase is calculated, which is shown in tabulated form as below:

Phase Wise	**Phase-I**	**Phase-II**	**Phase-III**	**Phase-IV**
Main Road vph	972			
Right Turn vph		240		
Side Road 1			336	
Side Road 2				338
Saturation	3027	1796	2216	2216
Critical y-	0.32	0.1336	0.1516	0.1518

For $Y = y_1 + y_2 + y_3 + y_4$ Where, $y_1 = 0.32$,

$y_2 = 0.1336$,

$y_3 = 0.1516$,

$y_4 = 0.1518$

Therefore, Y = 0.32 + 0.1336 + 0.1516 + 0.1518

Y = 0.75

Lost Time L = nl + a

= (4 x 2) + (3 x 4)

= 20 sec

Optimum Cycle Time, C =C= (1.5L + 5) / (1.0 - Y) C= {(1.5 x 20)+5} / (1-0.75)

Therefore, C = 140 sec

Now, Effective Green E_g = C – L

= 140 – 20

= 120 sec

Therefore, for Main road E_{gm} = (0.32/0.75) x 120 = 52 sec For right turn E_{gr} = (0.1336/0.75) x 120 = 22 sec

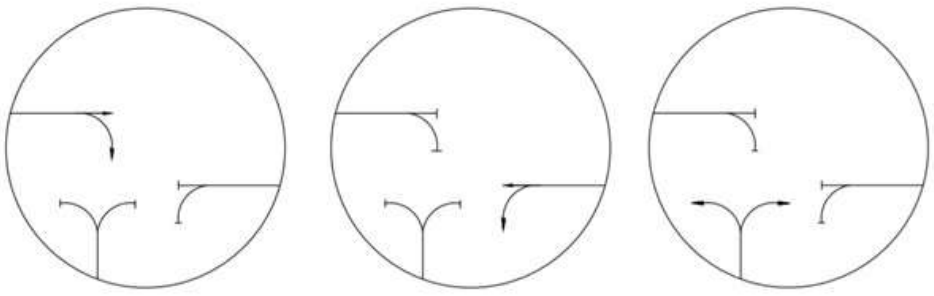
For side road 1 E_{gs1} = (0.1516/0.75) x 120 = 18 sec For side road 2 E_{gs2} = (0.1525/0.75) x 120 = 18 sec

Therefore, the obtained optimum cycle length for Narmad library Circle is 170 sec. Similarly for other two intersections optimum cycle length is calculated from which, one is as follows

Ram Chawk

Ram Chawk has three legged intersection so for this using the analyzed data an isolated signal system is to be designed by Webster's approach. As done for Narmad Library a tabular form is as below:

Ram Chawk						
Approach	**Narmad Library**		**Majura fire station**		**Bhatar**	
	S	**R**	**S**	**L**	**L**	**R**
Veh./Hr.	1852	106	1065	645	460	1033
PCU/Hr.	1374	85	816	496	338	755
Saturation	5161		5161		5161	



Phase Diagram - I Phase Diagram - II Phase Diagram - III

As per Webster's Approach, first values of y are calculated; the table below shows the values of y:

Phase Wise Flow	**Phase – I**	**Phase – II**	**Phase – III**
Main Road 1 vph	1852		
Main Road 2 vph		1065	
Side Road vph			756
Saturation Flow	5161	5161	5161
Critical y – values	0.358	0.206	0.146

Therefore, Y = 0.358 + 0.206 + 0.146 = 0.71

Lost Time L = nl + a

= (3 x 2) + (3 x 4) = 18 sec

Optimum Cycle Length time, C=C= (1.5L + 5) / (1.0 - Y) C = {(1.5 x 18) + 5} / (1 – 0.71)

Therefore, C = 111sec Effective green E_g = C – L

= 93 sec

For main road 1 E_{gm1} = (0.358/0.71) x 93 = 47 sec For main road 2

E_{gm2} = (0.206/0.71) x 93 = 27 sec For side road E_{gs} = (0.15/0.71) x 93 = 20 sec

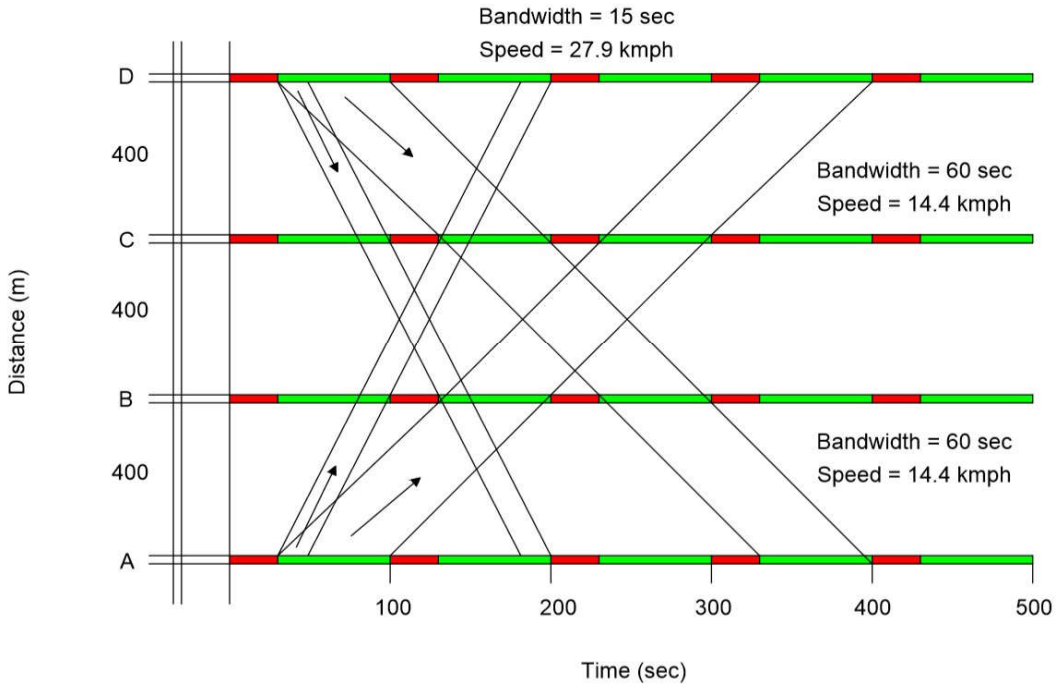
Therefore the optimum cycle length at Ram Chawk intersection is 111 sec.

- **Signal Coordinated signal system having equal block length**

Here as discussed earlier three different coordinated systems namely, simultaneous system, alternate system and flexible system are taken up for the same block lengths, cycle times and g/C ratios at the four intersections A, B, C and D, and inter-block lengths of 400 m each to understand the flow bands in both directions.

5.1 Simultaneous System of Coordination

To develop this type of system the offset between the adjacent signals is kept zero seconds. So if there is green at one upstream intersection then there will also be green at downstream intersection. A simultaneous system developed for three intersections at equal distances is shown in figure below. Assume cycle length of 100 sec at each intersection and green time „g" as 70 sec including amber „a" of 3 sec before red.



Graph :- 1 Simultaneous System of Coordination

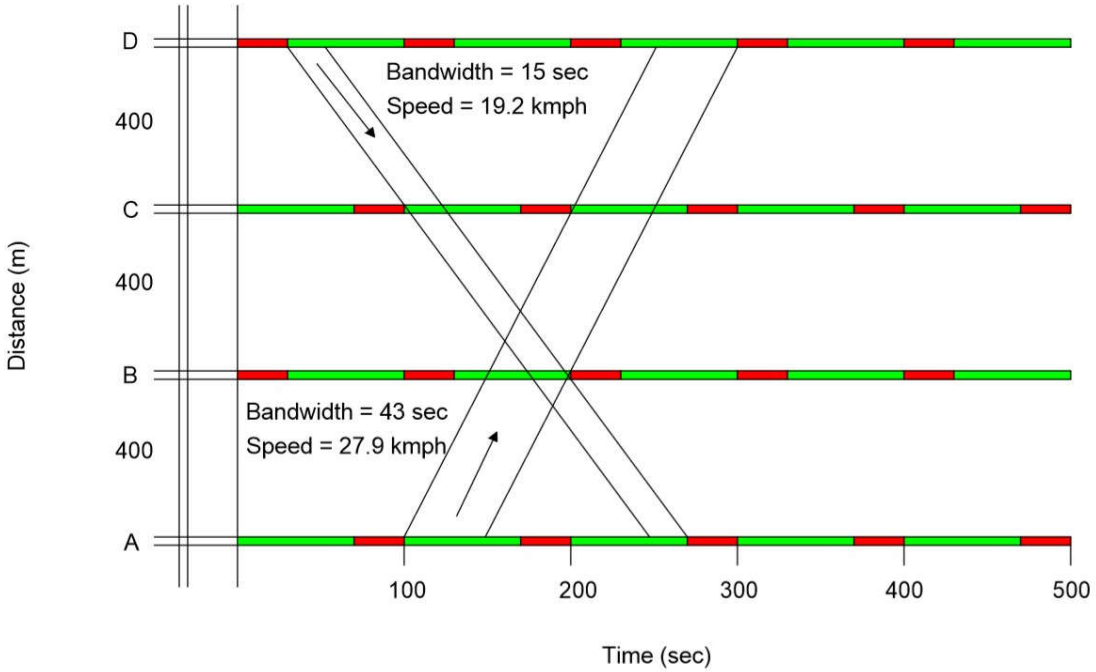
A Time Space diagram for this system is shown in figure. The slope of the line represents the speed of the vehicle on the stretch.

The maximum bandwidth (BW) or through band obtained while moving from intersection A to D is 60 sec with a speed (S) of 14.4 kmph.

- Same speed and bandwidth is obtained while moving in other direction i.e. from D to A.
- The bandwidth is high, but the travel speed is very low in both the directions. Another through band is obtained for vehicles moving with the average speed of 28 kmph but bandwidth is of 15 sec indicating uninterrupted flow is reduced to 25 %.
- Option is between speeds and % direct flow.

5.2 Alternate System of Co-ordination:

In this system the alternate intersections show green indication at the same time. Considering the same scenario as before, C = 100 sec, g = 70 sec an alternate and block length L = 400 m an alternate system can be developed as shown in figure below.



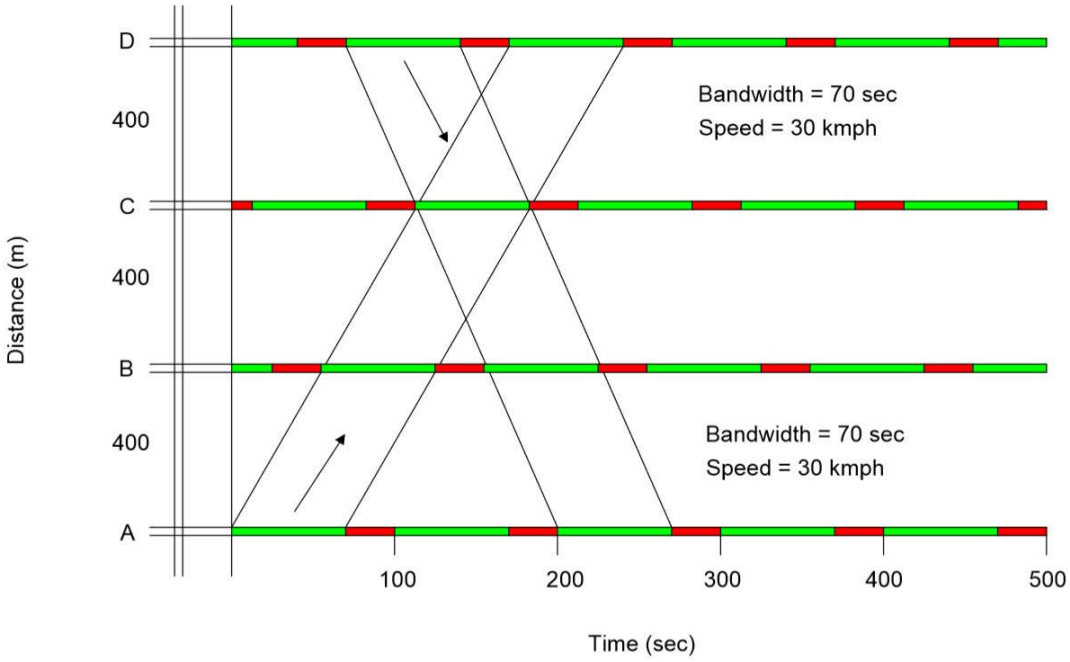
Graph :- 2 Alternate System of Co-ordination

As vehicles move from A to D the BW of 15 sec is obtained with the speed (S) of 19.2 kmph.

- In other direction, as the vehicles move from D to A the BW of 43 sec is obtained with a speed of 27.9 kmph.
- Differential speeds and BW are observed direction wise.
- Preferable for the situation where traffic volume is rather high in one direction.

5.3 Flexible System of Co-ordination

- It is clear from the graph shown in Figure that here the through band obtained is maximum than other two system.
- Equal through band of 70 sec and speed of 30 kmph are possible in both the directions.
- The system is better to earlier two for assumed traffic situation.



Graph :- 3 Flexible System of Co-ordination

6. CONCLUSION AND RESULT

The study has been carried out for the selected route which is Ghod-dod road connecting Majura gate and Parle Point. This road is majorly used especially during peak hours as on this road two types of activities are there that is commercial and residential activities. Traffic volume survey has been conducted on this road to get the total PCU counts. The selected route or stretch requires a coordinated signal system at the intersection to have a smooth flow of traffic throughout the route. Because of this coordination there will be reduction in delay time which makes less travel time and improves the traffic flow performance.

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