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Improvisation of Signal Coordination at Ghod Dod Road

[1]Shivam Singh, [2]Sanket Davara
[1]Student, [2]Assistant Professor
[1]Department of Civil Engineering,
[1]Pacific School of Engineering, Surat, Gujarat, India

Abstract: Traffic on the intersection is the major reason which affects the performance of the urban road network. Signal Coordination improves the quality of life and mobility through any area. For signals that are closely spaced, it is necessary to coordinate the green time so that the vehicles may move effectively through the set of signals. This study is for two consecutive signalized intersections at Ghod Dod Road (Ram Chowk Junction and Jolly Arcade Junction). Data collection is done by Videography method. Various traffic surveys are conducted such as, Inventory Survey, Delay and Travel Time Survey, Spot Speed Survey and Traffic Volume Survey. Data Analysis is done using MS Excel and by Webster's Method the optimum cycle time is determined. Also, Green – Amber – Red time is calculated. Signal Coordination is done using Simple Progressive System to achieve effective traffic flow with zero delay between these intersections. Also, the optimum signal is compared with existing signal and effectiveness of optimum signal is achieved.

Keywords – Coordination system, Traffic Congestion, Signalized Intersection, Webster Method

I. INTRODUCTION

Traffic congestion occurs on road networks due to day by day increase in vehicles. This increase in the number of vehicles demands for effective signal system on all roadway, which doesn't get fulfilled and it result in traffic congestion. And this traffic congestion results in long queues at intersection, unnecessary delay, slower speed of vehicle and longer trip time. Also, there's increase in the fuel consumptions and greenhouse gas emissions. And these problems cannot be solved simply by providing more and more roadway infrastructure. The proper balance has to be developed between the demand and supply in the traffic movement.

(Gitakrishnan, R., 2015) presented three novel strategies that address congested heterogenous traffic flow. The first two strategies – keeping intersection signal cycle times shorter and bottleneck metering while the third – exclusive lanes and storage area near intersections for two wheelers. (D. Pengdi, 2012) used Synchro 6.0 as a platform to minimize the intersection delay, optimize single signal cycle and split for Zhonghua Street in Handan City. Also, linear control system is used to optimize the phase for the arterial road in their system which results in improvement of both the capacities and service levels. (Zhou, 2011) reduces the number of vehicle parking stops and traffic delays and improve operating speed and travel safety by coordinating traffic signal control of the Huai'An south road using Webster Method. (Dilshad, A. M., & Aso Faiz, S.T., 2021) selected four successive signalized intersections on Barzani Street and Zakho Street and the traffic signal coordination on these selected intersections led to high reduction in intersection control delays. (Yin, 2019)improved the signal timing by Webster timing method for Xi'an North Street intersection. The results before and after the improvement are simulated by VISSIM Simulation software. As a result, Vehicle delay, parking time and vehicle queue length are reduced. (Li et al., 2021) used Webster signal timing method to optimize the signal timing scheme of intersection, and then VISSIM software is used to simulate the two schemes and the queue length, parking times, travel time, delay time and pollution emission are improved.

Objective of the Study

- To find the overall delay to traffic streams.
- To find queue length of vehicles at both intersections.
- To find overall travel time & spot speed of vehicle.
- To find the amount of traffic on that stream during peak hours.
- To coordinate the existing signalized intersection using above data collection and analysis.

1.1 Concept of Signal Coordination

When a signal indicates a stop aspect at a junction a queue of vehicles is formed behind the stop line. When the signal changes to green, the vehicles start moving in a platoon. If this platoon is made to meet a green aspect at the next junction, no delay is caused to the vehicles. This linking of adjacent signals to secure maximum benefits to the flow of traffic is called Signal Coordination. Proper Signal Coordination will result in reduce in overall delay, it prevents long queue formation at intersection and allows the maximum traffic flow without any enforced halts.

Various systems for Signal Coordination are: (R. P. Rethaliya, 2017)

1. Simultaneous System
2. Alternative System
3. Simple Progressive System
4. Flexible Progressive System

1. Simultaneous System: - With this system, all the signals at adjacent intersection on a given street always display the same indication to the same traffic stream at the same time. E.g., At all intersection, it will be red or green at the same time.

2. Alternate System: - For this system, all the signals at adjacent intersection on a given street always display the alternate indication to the same traffic stream at the same time. E.g., At first intersection if it is red, then at other adjacent intersection it will be green.

3. Simple Progressive System: - For this system, the various signals along a given street will display green or red according to the pre-determined schedule to get maximum traffic flow will less halts.

4. Flexible Progressive System: - This system is an improvement over the simple progressive system, as the various signals along a given street display green or red according to the traffic at that particular time.

II. STUDY AREA

The study area of our project is Ghod Dod Road, Surat, Gujarat to fulfil the study objectives. We have selected Two Signalized Intersections adjacent to each other on a straight path. Two Signalized Intersections are *Jolly Arcade Signal Junction* and *Ram Chowk Signal Junction*, which are 600 m apart from each other.

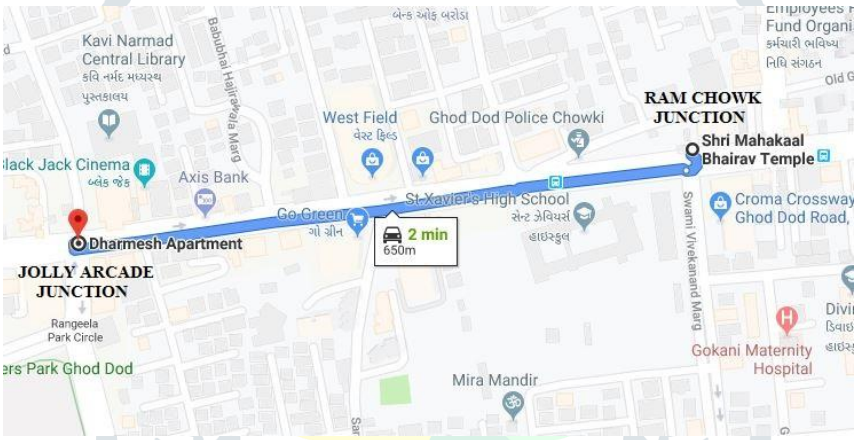

Figure 1 Location Map of Ghod Dod Road (Study Area)

III. METHODOLOGY

In this study, the data collection is carried out using Videography method and Floating Car Method for various surveys like,

- Road Inventory Survey
- Traffic Volume Survey
- Delay and Travel Time Survey
- Spot Speed Survey

Analysis of all this collected data for various survey is carried out for signal design. Also, signal coordination using Simple Progressive System is done.

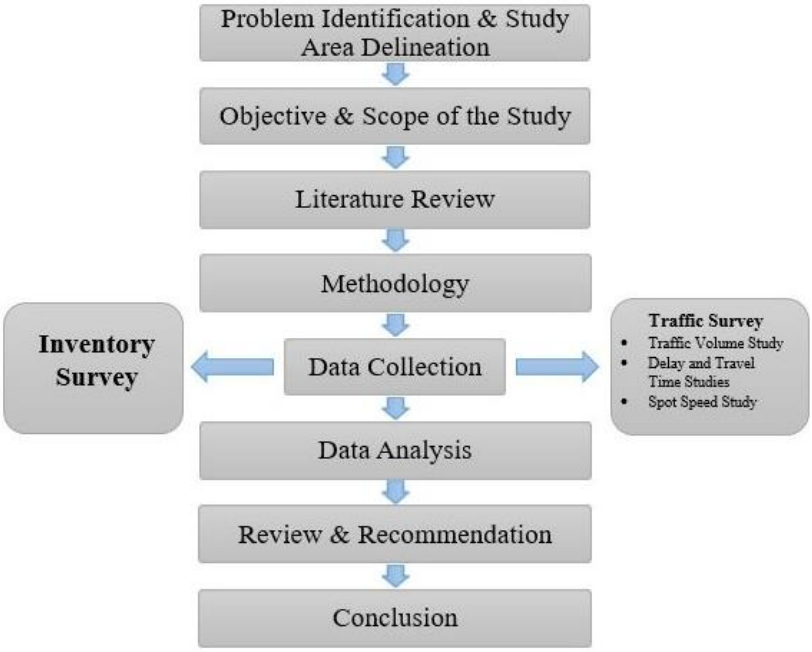

Chart 1 Methodology Flow Chart

IV. DATA COLLECTION

For this study, various surveys were carried out like traffic volume study, spot speed study, travel time & delay study, road inventory survey, queue length, etc. by manual method as well as videography method for data collection. Survey was conducted for three days – two weekdays (08 January, 2020 and 09 January, 2020) and one weekend (12 January, 2020) from 10:00 A.M. to 1:00 P.M. and 5:00 P.M. to 7:00 P.M.

4.1 Road Inventory Survey

Road Inventory Survey is done manually using Measure Tape. Both the selected intersection (Jolly Arcade Intersection and Ram Chowk Intersection) including the roadways connecting them is considered in this survey. This survey was carried on 12th January at 11 PM to 2 AM. Length of this Route is 600 meters.

Table 1 Inventory at Jolly Arcade Intersection

Inventory at Jolly Arcade Intersection								
Parameters	North		South		East		West	
	L	R	L	R	L	R	L	R
No. of lanes	2	2	3	2	2	2	2	2
Width (m)	6.40	5.40	12.75	7.39	9.62	8.85	9.51	9.64
Median (m)	0.30		0.90		0.90		0.90	
Green Time (s)	37		53		42		42	
Red Time (s)	155		139		150		150	
Amber Time (s)	4		4		5		5	
Cycle Time (s)	197						5	

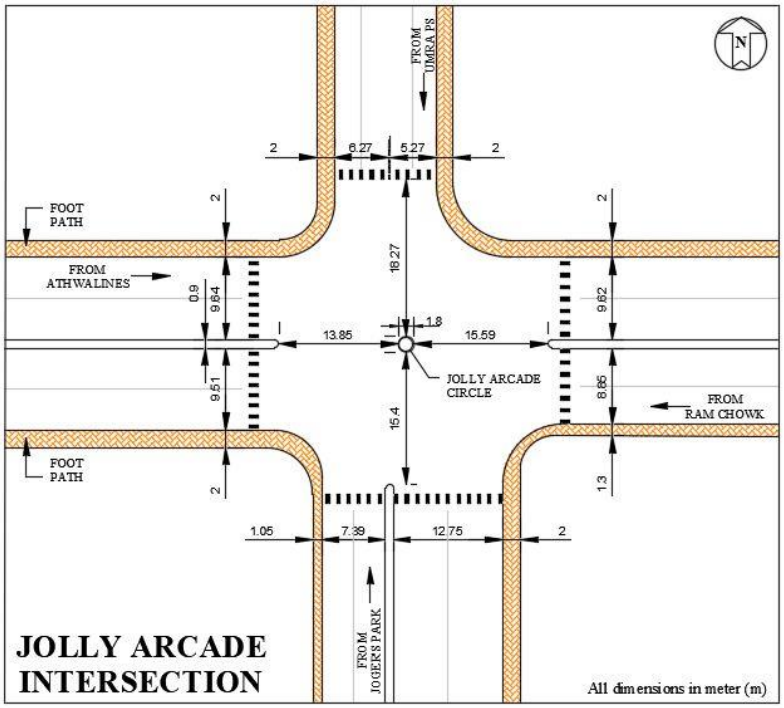

Figure 2 Inventory at Jolly Arcade Intersection

Table 2 Inventory at Ram Chowk Intersection

Inventory at Ram Chowk Intersection						
Parameters	South		East		West	
	L	R	L	R	L	R
No. of lanes	2	2	2	2	2	2
Width (m)	9.00	7.20	9.29	8.45	9.15	9.43
Median (m)	0.90		0.90		0.90	
Green Time (s)	30		40		75	
Red Time (s)	4		4		4	
Amber Time (s)	92		81		46	
Cycle Time (s)	125					

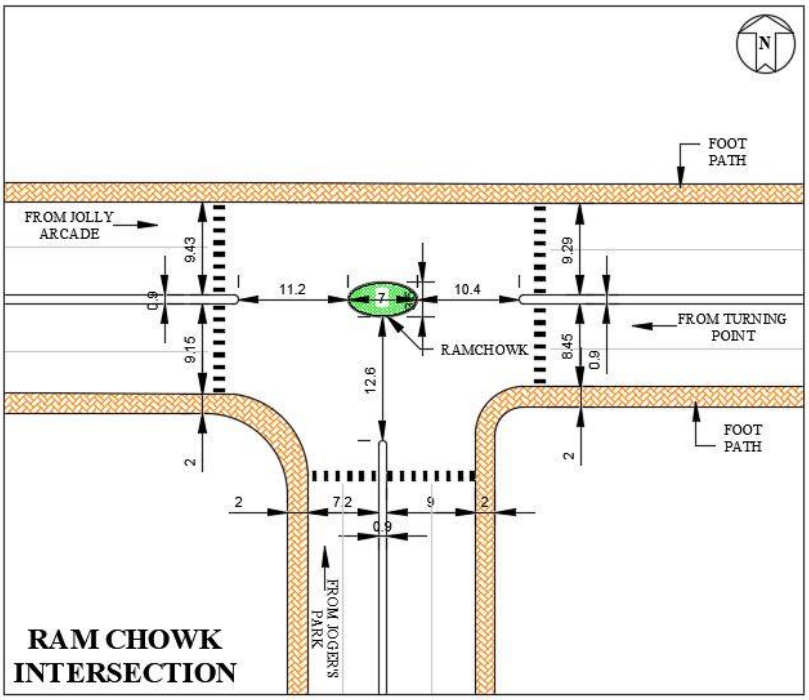

Figure 3 Inventory at Ram Chowk Intersection

The Inventory data collected for Jolly Arcade – Ram Chowk Route includes the geometric features such as width of footpath, width of carriageway, width of median and right of way as mentioned in the table below.

Table 3 Inventory of Jolly Arcade - Ram Chowk Route

Distance (m)	Road from Ram Chowk		Width of Median (m)	Road towards Ram Chowk		Right of Way (m)
	Width of Footpath (m)	Width of Carriageway (m)		Width of Carriageway (m)	Width of Footpath (m)	
0 to 200	2.00	9.62	0.90	8.85	1.30	22.67
200 to 400	2.20	9.13	0.90	9.13	2.07	23.43
400 to 600	2.00	9.43	0.90	9.15	1.80	23.28

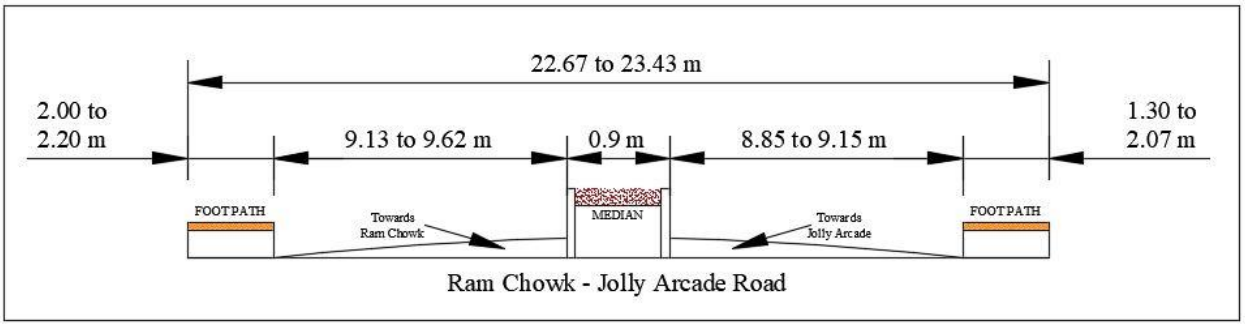

Figure 4 Inventory of Jolly Arcade - Ram Chowk Route

4.2 Traffic Volume Study

For Traffic Volume Study, the videos were recorded on both intersections and from this record videos the vehicle count for all the approaches of both intersections are done. Vehicle composition observed at both this intersection is given below:

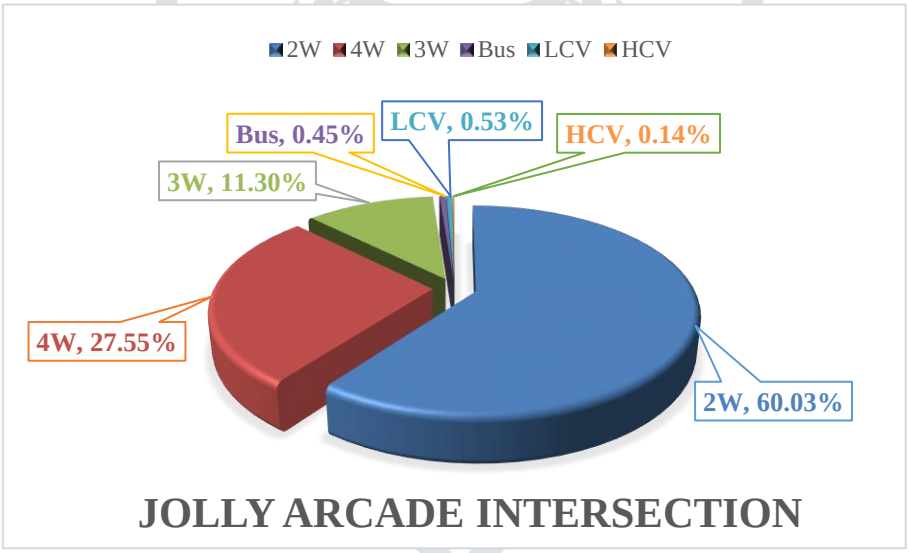

Figure 5 Vehicle Composition at Jolly Arcade Intersection

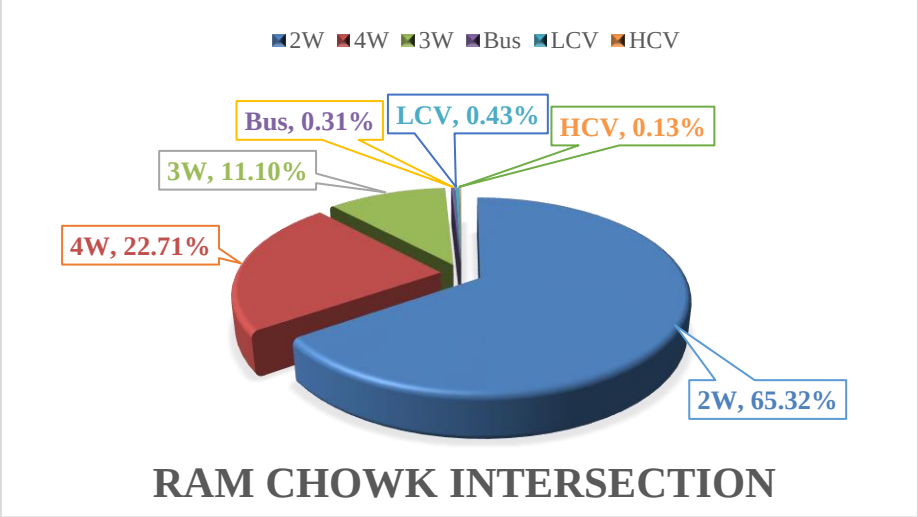

Figure 6 Vehicle Composition at Ram Chowk Intersection

From the above charts of Vehicular Composition at both this intersection, it is clear that the vehicle counts for Two – Wheelers (2W), Four – Wheelers (4W) and Three - Wheelers (3W) is maximum. While the vehicle counts for Bus, LCV and HCV is negligible.

V. DATA ANALYSIS

From the collected data, the analysis for Traffic Volume Study, Spot Speed Study, Travel Time & Delay Study and Queue Length Study is done.

5.1 Traffic Volume Study

For the traffic volume data, the PCU calculation is carried out for different vehicles using the PCU values as per IRC: 64 – 1990. The total PCU/hr at Jolly Arcade Intersection and Ram Chowk Intersection on 9th January, 2020 for Evening Session (17:00 to 19:00) are 4132 PCU/hr and 4926 PCU/hr respectively.

Table 4 Vehicle Flow (PCU/hr) at both intersection

Jolly Arcade Intersection		**Ram Chowk Intersection**	
Approach	Traffic in PCU/hr	Approach	Traffic in PCU/hr
Umra PS (N)	664	Turning Point (E)	2144
Ram Chowk (E)	1346	Shivaji Park (S)	1157
Joger's Park (S)	973	Jolly Arcade (W)	1625
Atwalines (W)	1149		
Total	**4132**	**Total**	**4926**

5.2 Spot Speed Study

Spot Speed Study was conducted on the midblock of both these intersections using Videography Method. The length of selected section of the roadway for this study is 10.25 m. Spot Speed Study were carried out simultaneously with traffic volume study for each class of vehicles.

Table 5 Spot Speed Study Results

Approach	**Category**	**No. of Samples**	**Spot Speed (kmph)**
Ram Chowk Cross Road to Jolly Arcade Cross Road	2W	510	40.90
	3W	510	35.85
	4W	510	37.45
	Bus	106	32.04
	LCV	124	30.68
	HCV	16	30.50
	Average (2W, 3W & 4W)		**38.07**
Jolly Arcade Cross Road to Ram Chowk Cross Road	2W	300	40.25
	3W	300	34.75
	4W	300	35.74
	Bus	51	22.07
	LCV	31	30.94
	HCV	13	24.15
	Average (2W, 3W & 4W)		**36.91**

5.3 Queue Length Study

Queue Length is found out for each intersection on considered approach viz. East and West during the Traffic Volume Study. Overall Average Queue Length from above data analysis is mentioned below for all approaches:

Table 6 Queue Length Result

Intersection	**Approach**	**Average Queue Length**
Jolly Arcade Intersection	Atwalines	119 m
	Ram Chowk	153 m
Ram Chowk Intersection	Turning Point	34 m
	Jolly Arcade	32 m

5.4 Travel Time Study

Travel Time is defined as the time taken by a vehicle to cover selected section of road. Data collection of Travel Time Study is carried out using Floating Car Method. This study is carried for two-wheelers, four-wheelers, three-wheelers and buses. The Average Travel Time in seconds for each vehicle type is given below:

Table 7 Travel Time Study Results

Direction	Category	Average Travel Time (sec)
Jolly Arcade Intersection to Ram Chowk Intersection	2W	96
	4W	107
	3W	90
	Bus	135
	Overall Avg. Travel Time	**107**
Ram Chowk Intersection to Jolly Arcade Intersection	2W	153
	4W	199
	3W	226
	Bus	165
	Overall Avg. Travel Time	**186**

5.5 Delay Study

In Delay Study, information regarding duration of delay and its causes such as traffic signal delay, loading & unloading of passenger's delay and delay due to slow moving vehicle are considered. Data collection of Delay Study is carried out using Floating Car Method. This study is carried for two-wheelers, four-wheelers, three-wheelers and buses. The Average Delay in seconds for each vehicle type is given below:

Table 8 Delay Study Results

Direction	Category	Avg. Signal Delay (sec)	Avg. Delay Due to Loading & Unloading (sec)	Avg. Slow Moving Vehicle (sec)	Avg. Delay (sec)
Jolly Arcade Intersection to Ram Chow Intersection	2W	18	0	12	30
	4W	19	0	16	35
	3W	19	5	10	34
	Bus	35	13	17	65
	Average	**23**	**5**	**14**	**42**
	Delay (%)	**54.76**	**11.90**	**33.33**	
Ram Chowk Intersection to Jolly Arcade Intersection	2W	69	0	18	87
	4W	128	0	39	167
	3W	102	6	23	131
	Bus	47	12	50	109
	Average	**87**	**5**	**33**	**125**
	Delay (%)	**69.60**	**4.00**	**26.40**	

From the above analysis, all the factors contributing to delays are determined in percentage (%). For direction from Jolly Arcade Intersection to Ram Chowk Intersection, Avg. Signal Delay is 54.76%, Avg. Delay due to Loading & Unloading is 11.90% and Avg. Slow Moving Vehicle Delay is 33.33%. For direction from Ram Chowk Intersection to Jolly Arcade Intersection, Avg. Signal Delay is 69.60%, Avg. Delay due to Loading & Unloading is 4.00% and Avg. Slow Moving Vehicle Delay is 26.40%.

VI. SIGNAL DESIGN

Webster's Method is considered for Signal Design by determining optimum cycle length. While selecting the cycle length, it should be considered that the delay should be minimum for the traffic passing through the intersection. (R. P. Rethaliya, 2017)

Optimum Cycle Time is calculated using below equation,

$$\mathbf{C_0 = \frac{1.5L + 5}{1 - Y}\ (seconds)}$$

Effective green time per cycle,

$$\mathbf{G = C_0 - L}$$

Effective green time per phase can be calculated as follows:

$$\mathbf{g_{NS} = \frac{y_{NS}}{Y}(C_0 - L)}$$

$$\mathbf{g_{EW} = \frac{y_{EW}}{Y}(C_0 - L)}$$

For Saturation Flow, a simple formula derived by the Road Research Laboratory, U.K. used for designing new signal installations is,

$\mathbf{S = 525 \cdot w}$ (PCU/hr) … for road width greater than 5.5 m

where,

S = Saturation flow

w = width of approach road in meters

For the study, four phase system is adopted at Jolly Arcade Intersection and three phase system is adopted at Ram Chowk Intersection. The final optimum cycle length for both the intersections determined using Webster's Method, are mentioned below:

Table 9 Optimum Cycle Length

Intersection	Approach	Green Time (sec)	Amber Time (sec)	Red Time (sec)	Total Cycle Time (sec)
Jolly Arcade Intersection	From Atwalines (Phase 1)	17	5	67	89
	From Umra PS (Phase 2)	14	5	70	
	From Joger's Park (Phase 3)	21	5	63	
	From Ram Chowk (Phase 4)	17	5	67	
Ram Chowk Intersection	From Jolly Arcade (Phase 1)	35	5	49	89
	From Turning Point (Phase 2)	23	5	61	
	From Shivaji Park (Phase 3)	16	5	68	

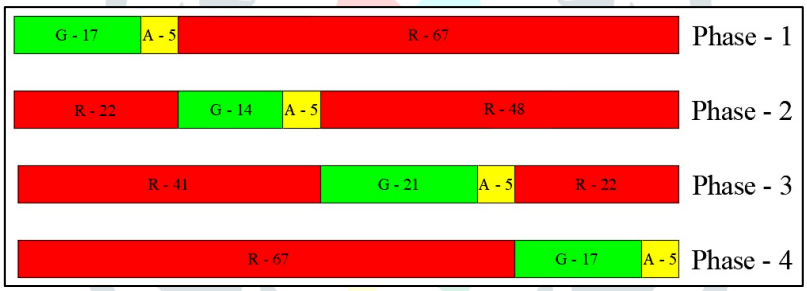

Figure 7 Time Diagram - Jolly Arcade Intersection

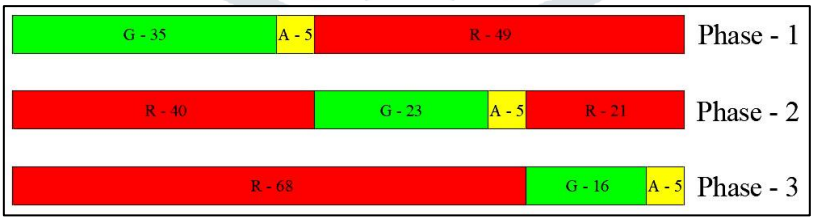

Figure 8 Time Diagram - Ram Chowk Intersection

VII. SIGNAL COORDINATION

7.1 Offset

The offset is defined as the difference between the start of green period at the successive upstream and downstream signal. The offset to be provided at upstream should be equal to travel time from downstream to upstream signal and vice versa.

The equation used for offset calculation is,

$$\mathbf{Offset} = \frac{\mathbf{D}}{\mathbf{V}} \times \mathbf{3.60}$$

where,

D = distance between upstream and downstream signal in meters

V = speed of the vehicle in kmph

Table 10 Offset between Consecutive Intersections

Approach	Average Spot Speed (kmph)	Distance (meters)	Offset Calculated (seconds)	Offset Provided (seconds)
From Jolly Arcade Intersection to Ram Chowk Intersection	36.91	600	58.52	59
From Ram Chowk Intersection to Jolly Arcade Intersection	38.07	600	56.74	57

7.2 Two – way Coordination by Simple Progressive System

- **Existing Cycle Time:**

It is very simple to present one-way coordination than two-way coordination. As shown in figure 9, it is considered existing cycle length for both directions. Traffic flows in both the direction between Jolly Arcade Intersection and Ram Chowk Intersection. The offset time of route from Jolly Arcade intersection to Ram Chowk intersection is 59 seconds and from Ram Chowk intersection to Jolly Arcade intersection is 57 seconds. Traffic volume at one intersection starts moving, when the green indicator starts as soon as it reaches at other intersection it doesn't gets green indicator for all signal cycle in both the direction which result in delay for traffic volume.

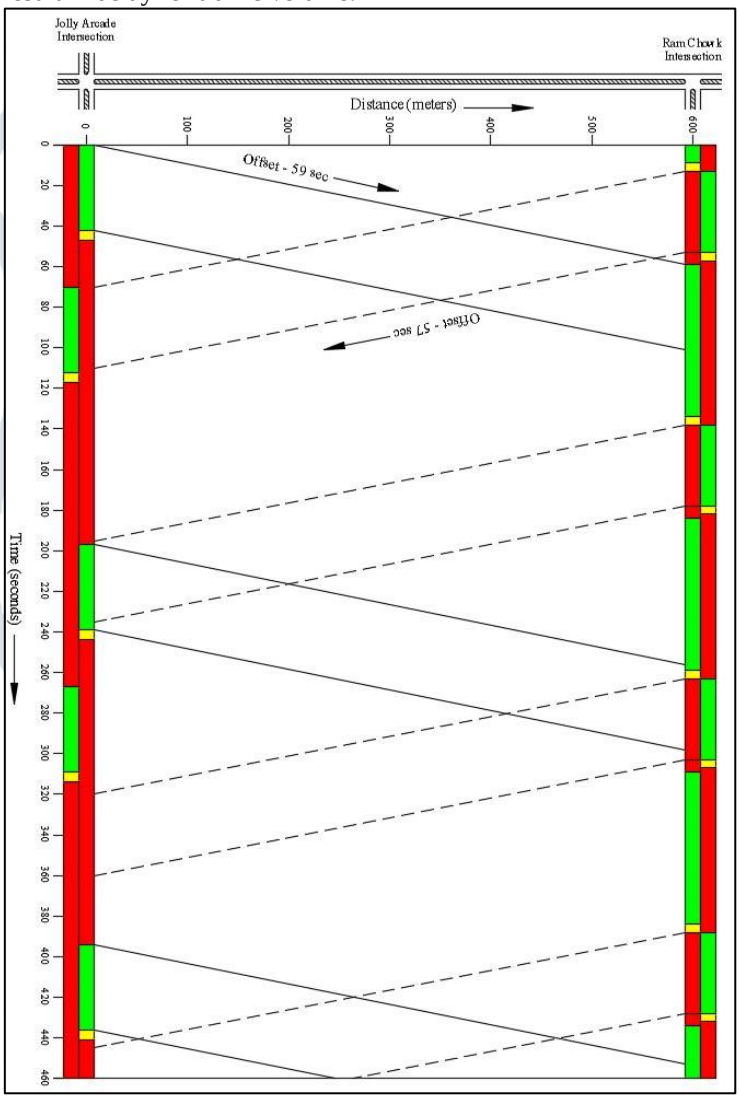

Figure 9 Time Space Diagram for Two - Way Coordination using existing cycle length by Simple Progressive System

Here, the continuous line indicates movement from Jolly Arcade to ram Chowk and dotted line indicates movement from Ram Chowk to Jolly Arcade.

- **Optimum Cycle Time:**

It is very simple to present one-way coordination than two-way coordination. As shown in figure 10, it is considered optimum cycle length for both directions. Traffic flows in both the direction between Jolly Arcade Intersection and Ram Chowk Intersection. The offset time of route from Jolly Arcade intersection to Ram Chowk intersection is 59 seconds and from Ram Chowk intersection to Jolly Arcade intersection is 57 seconds. Traffic volume at one intersection starts moving, when the green indicator starts as soon as it reaches at other intersection it gets green indicator for all signal cycle in both the direction which result in no delay for traffic volume.

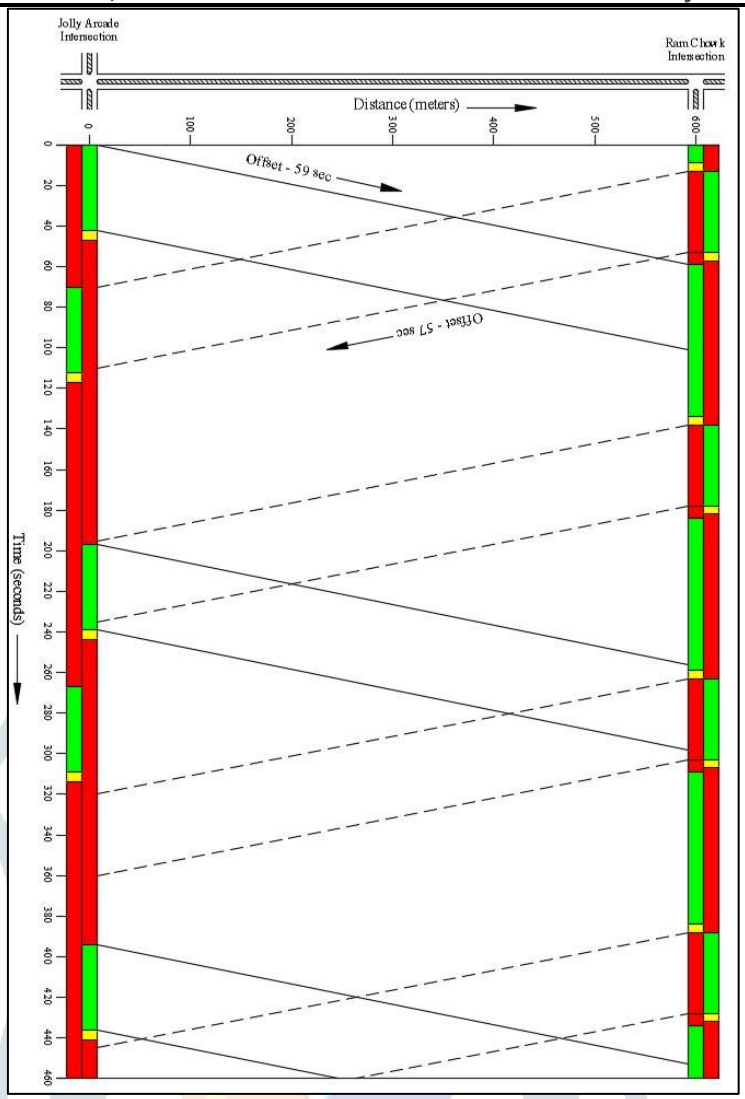

Figure 10 Time Space Diagram for Two - Way Coordination using existing cycle length by Simple Progressive System

Here, the continuous line indicates movement from Jolly Arcade to ram Chowk and dotted line indicates movement from Ram Chowk to Jolly Arcade.

VIII. CONCLUSION

- It has been found that average queue length of vehicle at Jolly Arcade Intersection for Atwalines approach is 119 m and for Ram Chowk approach is 153 m. And the average queue length at Ram Chowk Intersection for Turning Point approach is 34 m and for Jolly Arcade approach is 32 m. It is usually long as compared to proper coordinate intersections.
- From Delay Survey, it has been determined that the overall average delay in the direction from Jolly Arcade Intersection to Ram Chowk Intersection is 42 seconds and in the direction from Ram Chowk Intersection to Jolly Arcade Intersection is 125 seconds. This delay results in more journey time.
- Overall average travel time from Jolly Arcade Intersection to Ram Chowk Intersection is 107 seconds and from Ram Chowk Intersection to Jolly Arcade Intersection is 186 seconds. For a corridor of 600 m, the travel time is normally high.
- Average Spot Speed determined for vehicle category with maximum vehicle composition (2W, 3W & 4W) in direction from Ram Chowk Intersection to Jolly Arcade Intersection is 38.07 km/hr and in direction from Jolly Arcade Intersection to Ram Chowk Intersection is 36.91 km/hr. This speed is considered to determine offset and coordinate both the intersections.
- The amount of traffic observed on Jolly Arcade Intersection during peak hours (17:00 to 19:00) is 6314 Veh/hr. And the amount of traffic observed on Ram Chowk Intersection during peak hours (17:00 to 19:00) is 7485 Veh/hr.
- It has been found that the present cycle time of Jolly Arcade Intersection and Ram Chowk Intersection is 197 seconds and 125 seconds respectively. And delay at all approaches of both these intersections can be optimized with cycle time as 89 seconds with effective green time is 69 seconds for Jolly Arcade Intersection and 74 seconds for Ram Chowk Intersection. Also, the amber time is 3 seconds and starting lost time is 2 seconds for both intersections.
- From coordination of both these intersections, using Simple Progressive System for Optimize Cycle Length in both the direction. It has been observed that, the green indicators are obtained for all signal cycle in both the direction of traffic flow which results in no delay for traffic volume.
- Also, adapting the new cycle time results in reduction in queue length and increase in travel time.

REFERENCES

[1] Dilshad A.M., & Aso, Faiz, S.T. (2021). Coordination of Traffic Signals on Arterial Streets in Duhok City. *ZANCO JOURNAL OF PURE AND APPLIED SCIENCES*, *33*(5). https://doi.org/10.21271/zjpas.33.5.2

[2] Gitakrishnan, R,. (2015). Strategies for Traffic Signal Control in Indian Cities *COMSNETS 2015 : 2015 7th International Conference on Communication Systems and Networks : proceedings : 6-10 January 2015, Bangalore, India.*

[3] Diao, P., Nurelan, M., Wang, Z., Zhang, Z., & Dong, H. (2012). *2012 24th Chinese Control and Decision Conference.*

[4] Li, Y., Qin, Z., & Zhu, C. M. (2021). Optimal design of transportation signal control at the intersection based on Webster signal timing method. *Journal of Physics: Conference Series*, *1972*(1). https://doi.org/10.1088/1742-6596/1972/1/012130

[5] Yin, M. (2019). Intersection Signal Timing Optimization based on Webster Timing Method. *IOP Conference Series: Earth and Environmental Science*, *371*(5). https://doi.org/10.1088/1755-1315/371/5/052034

[6] Zhou, J. (2011). Traffic Signal Coordination Control of City Arterial Road that Based on Graphic Method. In *International Conference on Electronic & Mechanical Engineering and Information Technology*.

[7] R. P. Rethaliya. (2017). *Traffic Engineering*.