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# Analysis of Delay and Travel Time for Pre-timed Traffic Signal Coordination on Close Continuous Intersections

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## Abstract

Signal Coordination of consecutive intersections were carried out by thumb rule by coupling the indices depend on ratio of traffic volume to distance as well as modelled flow. As eminent resolution data is easily available from intersections, it becomes desire to analyses the actual stream of vehicle flow better to characterize is signal coordination desirable? As increase in vehicular population causes not only congestion, delay in travel time but also pollution at road. To handle the influence of these travel demand at urban area, signalized intersection present on arterial roads have minimum resistance to flow of traffic for minimizing the travel time. If signalized intersections are coordinated then the time pollution will be optimum, air and noise pollution as well. This paper composed of analysis of the previously developed methodology and results of delay caused due to pre-timed two way signal coordination with least time pollution and environmental pollutions. Traffic efficiency is affected by placing the signalized intersections at close continuous manner. This paper concluded with most suitable methodology and simulation techniques for coordination to reduce the time pollution as well as improve the traffic efficiency.
**Keywords- Signal Co-ordination, Close continuous intersection, Simulation, Delay**

## I. INTRODUCTION

The interference of traffic flow leaven by the shortest length of closely placed intersections, intently have effect on the road way capacity and congestion as result in time pollution. Close continuous intersections will account many savior issues such as time loss of green phase, increasing pollution, may cause accidents, and congestion. From perspective of accumulation of surplus traffic and inadequacy of possibility for expansion of infrastructure in urbanized road networks. The bottom line of all these problem will be solved by studying the close continuous intersections. The dilemma like congestion, time pollution, fuel energy consumption and environmental pollutions after a while induces incorporation of vehicle operation and maintenance cost. Pre-timed traffic signal co-ordination is consummated while traffic flow on the incurred phase of maneuver at one intersection will inherit green phase on its accession at consequent intersection.[1] It aggrandizes lenient maneuvering of traffic stream at some definitive speed on the outside of advocated halts and abate overall delay. The foremost objective of signal coordination is to clear paramount traffic flow through the intersections in an injured length and specified time with minimal number of accidents, with minimal numbers of stops, at paramount safe speed and minimal delay. It abates the speed alteration with furnishing a smooth traffic maneuvering results in enhance in capacity, subsidence in energy consumption and environmental pollution, this bring out curtail overall operation cost of maneuvering.

In urban areas, approaches of all signalized intersections are so dense during peak hours of the day that it is difficult to maneuver with ease. Decisive measure to coordinate the network in all directions in place of single corridor. Heterogeneity of traffic have adverse effect on accommodation of traffic at intersection. Using traditional approach of modelling of network it is absolutely labored to enhance the performance of traffic signal control strategy as smooth, not only due to variability in time, non-determinacy, non-linearity, but also fuzziness in the system. It becomes bottom line of research hotspot to exploit artificial intelligence techniques in urban traffic signal control system. Too many theories had put for the traffic signal coordination as well as software based control system were advanced. Various optimization and simulation techniques had emerged for aiding in the optimization process. The most simulation based software are availed by delay and its inheritance as desire objective. TRANSYT-7F brings off optimization concerning on disutility index. SYNCHRO synchronizes signal timing in reference to the percentile delay. As delay is a equivocal variable and for acute condition an average values while optimizing the signalized intersection abort the system performance. VISSIM is time step, concerning the behavior of driver and microscopic simulation model advanced to illustrative urban traffic condition as well as operation of public transportation.[2] For transportation researchers, it is admired that to change the signal timing plan as well as lane allocation at signalized intersections for controlling the operation. The traffic signals which operates efficiently and design of lane markings can abate the congestion with result in significant payoff in time pollution and energy consumption. [3]

### *A. Traffic Characteristics of Close Continuous Intersections*

The road stretch between upstream and downstream intersection, if divided into three consecutive sections such as dispatching or accelerating section, interwoven or weaving section and deferral or decelerating sections.[4] While maneuvering between intersections, if dispatching section dissatisfy vehicles smoothly from initial acceleration i.e zero to the desired design speed, the weaving section also dissatisfy the vehicles lane changing behavior and deferral sections dissatisfy vehicles tends to stop at downstream intersection safely, such a intersections are referred as close continuous intersections.[5]

The spacing between intersections is as less as 200m, due to minimal spacing the road parking between the intersections also restricted. As the traffic flow at upstream intersection is heavy, signal timing is not reasonable as well, then it stimulate the traffic congestion on downstream intersection with abating the traffic competence. This affect the vehicle maneuvering from one lane to another.

## II. LITERATURE SURVEY

Taxonomy of approach adapted to the signal control, had been noticed in agreement to the real time traffic network i.e. adaptive and non-adaptive traffic signal control strategies. Transportation system dealing with microscopic models and macroscopic models for traffic simulation were illustrated considering the non-adaptive strategies of signal control. The methods confess various traffic maneuvering actions within the traffic management system, although existing traffic posture were not taken into account, while traffic signal system were triggered. Two physical planning contexts such as static methods and dynamic methods. Static methods set objective for obtaining regulation of different sets of signalized intersections within the developed network. The Mathematical Programmed with equilibrium constraints formulates the problem of signal regulation. Optimization takes place in accordance with fixed cycle length and paramount traffic volume flowing through network. Static methods such as genetic algorithms, dynamic programming, queuing theory, neural networks are adopted for signal retiming. [6] Dynamic method assets to the mobile demand arrangement. Whole day was divided into several intervals i.e. Time of Day. In each interval volume of traffic flowing was immobile. The closely spaced intersections in the urban road network seriously have effect on the efficiency of traffic flowing on road. The special state of close and continuous intersections in the urban road network had studied the various methods of traffic signal control with the objective of the design of phase and setting of timing for coordination. By taking case study simulation was done using VISSIM. For timing setting various parameters such as cycle duration, green signal ratio, time distance between phases were considered. Further selected study corridor, for three consecutive intersections, the phase design and timing of coordinated signal was set. After design and timing setting, simulation model were developed in VISSIM for present control condition and coordinated control condition and the result were shown that not only the coordinated control method could satisfactorily reduce the delay time, but also improved the speed of vehicle, and hence the efficiency of the close continuous intersection was improved. Optimal timing of signal was uttermost adequate and viable approach abate delay in city areas. Unstipulated approach was contemplated for optimization suitable in Indian heterogeneous traffic conditions. Road network were coded in VISSIM with extant timing of signal, field delay was correlated to simulated delay as validation. Cycle times were conformed to various parameters bestow minimal delay. Sensitivity analysis were carried out with different parameter such as delay queue length for different deviating green time. [7] Synchronization relationship was introduced to set out signal at optimum cycle length. One methodology developed for coordination of two way oriented traffic signals on busiest corridor. Two phase pattern was conjectured with suitability in coordination of signal in odd-even pattern phase alterations betwixt two signals. Approach was commodious for fixed time signal with abating 30 % travel time barring cost for any sensors as well as software. A heuristic techniques was applied in bandwidth type signal timing depend on partition method. A signalized intersections in large arterials are divided into subsystems with three to five intersections in each subsystem. Maximum efficiency of bandwidth was achieved by optimizing each subsystem 1D systems progression bandwidth was introduced in peck flow approach. Signal timing was set to accord maximal progression in peak direction with keeping partial approach of progression in off peak direction also. From the proposed case study signal timing solutions were compared with traditional software. CORSIM evaluated the signal timing solutions which showed efficiencies of bandwidth for both the directions were improved with travel speed.[8]Influence of travel time and delay on coordination of close continuous intersections was carried out by acknowledging time space diagram of distinct cycle lengths. Coordination was done with considering optimum cycle length as maximal cycle time access the delay, at the same time for minimal cycle time abate delay, access the capacity, reduces queue formation. [9]

## III. METHODOLOGY ADOPTED

### *A. Phase Difference Plan Method*

If traffic flows in two way direction is heavier for desiring minimal delay, both directions should be coordinated. As intersections are closely spaced about 1000 m, it is sensible to seize uniform signal cycle length and equal phase at every intersection to lay low dispensable delay to vehicle with uninterrupted maneuvering in both directions. Sequence and phase plan are imperative to abstain delay. In Indian scenario, intersections with four arms including four phases are designed with free maneuvering for left turners. Travel time of maneuvering from upstream as well as from downstream s intersections are advised to be same. Sequence of phases are acclimatize in order that right turners accessing to capital corridor on similar direction, it is necessary to have minimal time gap to enter the abutting intersection. If through traffic is paramount than right turners, to reduce minimal delay on consequent intersections through traffic should be given right of way to clear the maneuvering. From this it is cleared that through and right turning traffic is getting prompt clearance on dominant corridor in the couple of directions.

Distant phase timing as well as discordant phase consecution on two chronological four arm intersections, accord comprehensive delay to the traffic. For illustration, figure 1 shows distant phase timing and discordant phase sequence. It was ascertained that vehicle from maneuvering upstream intersection –I was waiting in queue for extensive for time interval towards downstream intersection –II, correspondingly vehicles maneuvering from downstream intersection- II is waiting for extensive queue towards intersection –I. A scenario at which downstream traffic annoyance causes increased delay at upstream intersections. If equal phase timing, appropriate phase sequence were arranged then vehicles will have to interim lesser time in a queue. For this illustration, figure 2 shows equal phase timing and concordant phase sequence.

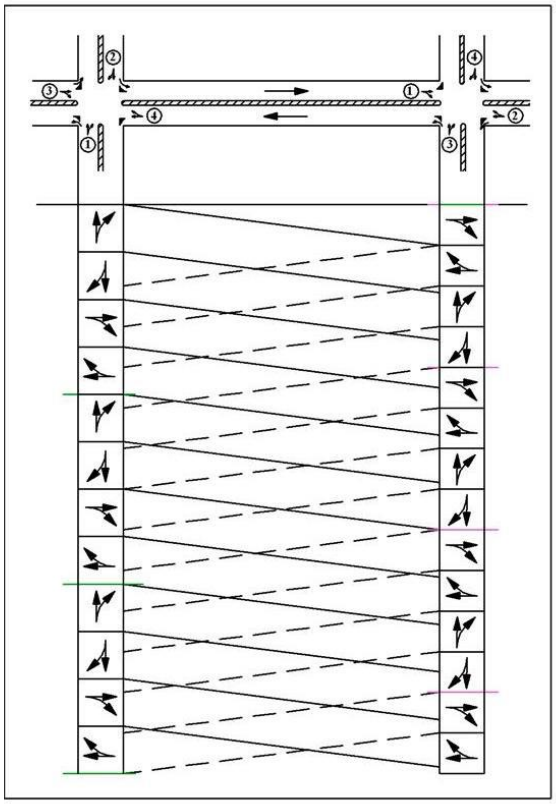

Fig. 1: Distant phase timing, discordant Phase sequence.

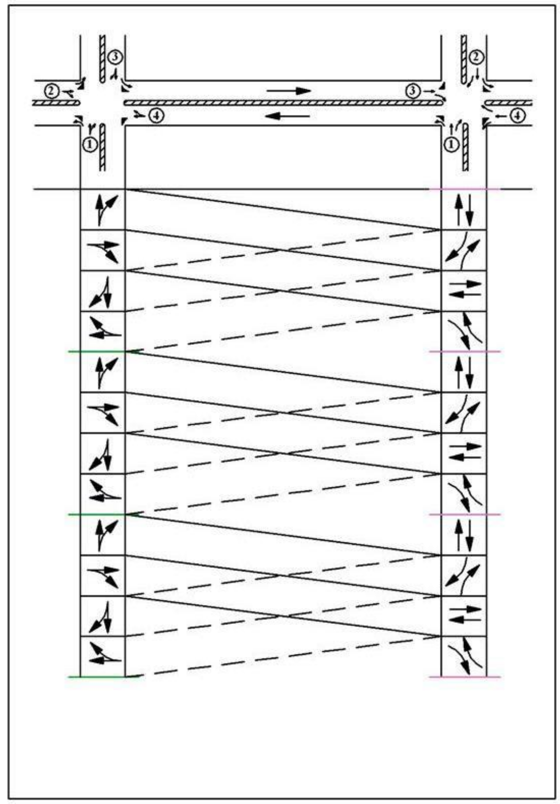

Fig. 2: Equal phase timing, appropriate Phase sequence.

From illustration -1, it was cleared that delay for right turning movement traffic in forward direction was three phases and for through traffic delay was for one phase. Delay in backward direction for through and right turners was one phase.

From illustration -2, it was cleared that delay for right turners in forward direction was single phase and for through traffic there was no such delay. Consequently delay for right turners in backward direction is single phase and for through traffic there is no such delay.

Coordination of signal in two way direction, it is desirable to maintain an equal signal optimum cycle length of the intersections of selected corridor. If cycle length on each intersections is in between 100sec to 140 sec, then average 120 sec cycle length is adopted and vehicles flowing on each approach is same during peak hours a day then identical phase timing as 30 sec (green + amber) maintained for every phase with cycle length as 120 sec of four phases. The difference of phases between two consecutive intersections (i.e. average travel time of maneuvering between consecutive intersections) depends on average speed of vehicle, distance, geometric properties of link, type of vehicle, etc. Strategy for signal coordination is planned according to difference of phases and adopted for all consecutive intersections present on selected route of study area. A strategy for signal coordination simple phase plan is considered as Phase plan –A, Phase plan –B shown in figure.

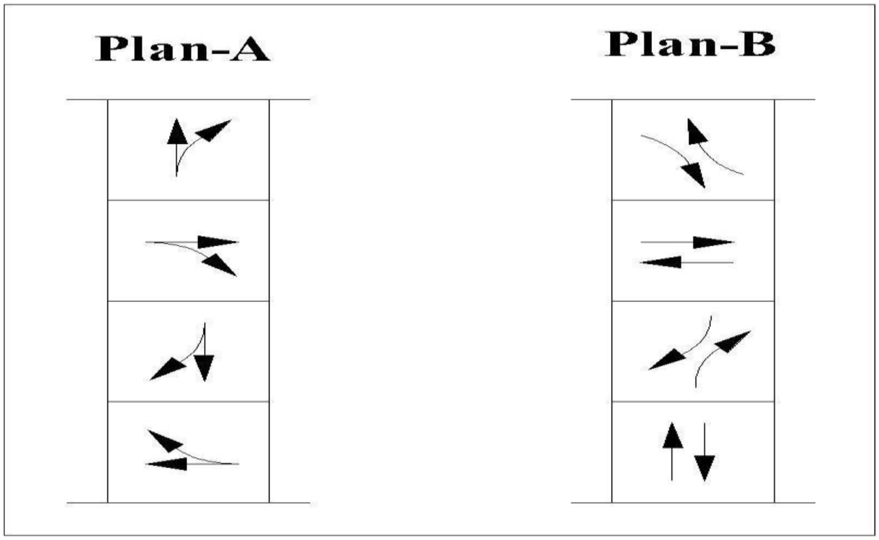


Fig. 3: Phase signal plan Phase Plan –A and Phase plan –B

The above plans were analyzed for intersections with four arms for altered phase time like phase 1. Phase 2, phase 3 and so on. For various odd and even phase alteration on average travel time.

*Table 1: Delay for odd phase alteration*

| | | *Plan A to A* | | *Plan B to B* | | *Plan A to B* | |
|---|---|---|---|---|---|---|---|
| *Sr. No.* | *Direction* | *Forward Direction (sec)* | *Backward Direction (sec)* | *Forward direction (sec)* | *Backward Direction (sec)* | *Forward direction (sec)* | *Backward Direction (sec)* |
| *1* | *R to R* | *15* | *75* | *45* | *0* | *45* | *15* |
| *2* | *R to S* | *15* | *75* | *15* | *75* | *15* | *15* |
| *3* | *S to R* | *0* | *45* | *15* | *75* | *15* | *0* |
| *4* | *S to S* | *0* | *45* | *0* | *45* | *0* | *0* |
| | *Total* | *30* | *240* | *75* | *195* | *75* | *30* |
| | *Combined* | *270 sec* | | *270 sec* | | *105 sec* | |

(R –Right Turners, S- Straight movers)

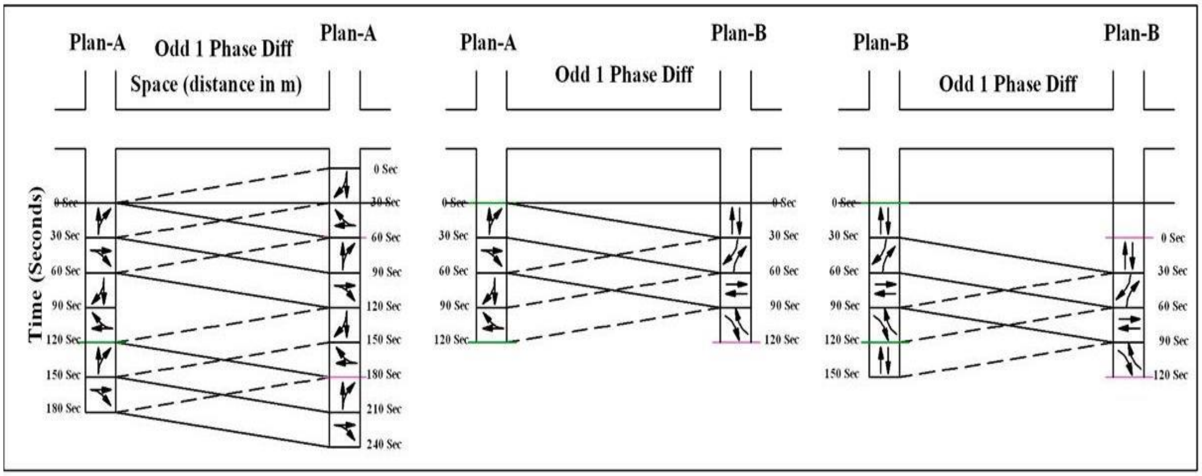


Fig. 4: Strategies for Odd phase alterations

Strategies for odd phase alteration is shown is figure 4 which shows action capability of two phase plan for odd phase alteration. For phase of 30 sec, a) 1 phase difference might be taken as 0 to 40 sec on average travel time. b) 2 phase difference might be taken as 41 to 70 sec on average travel time. c) 3 phase difference might be taken as 101 to 130 sec, and so on. The obtained result for this strategies are illustrated in following table which shows delay calculation from obtained results.
Strategies showing action capability of two phase plan for even phase alteration is represented in figure 5

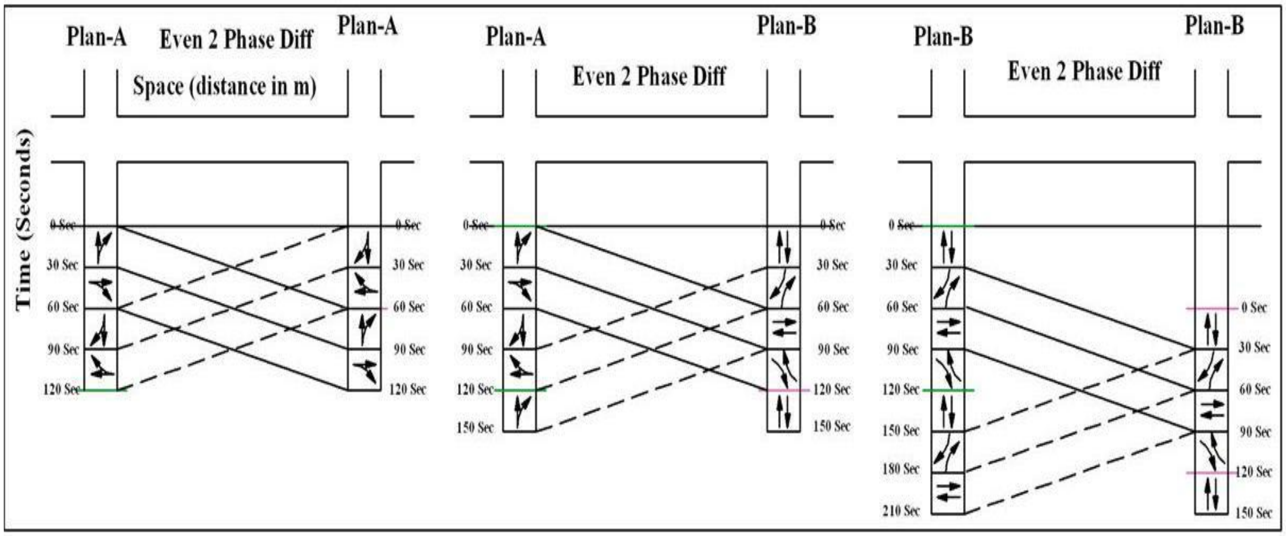


Fig. 5: Strategies for Even phase alterations

The phase timing and phase difference is kept same as in odd phase alteration and obtained result for delay on average travel time between two consecutive intersections is represented in following table. [1]

*Table 2: Delay for even phase alteration*

| | | *Plan A to A* | | *Plan B to B* | | *Plan A to B* | |
|---|---|---|---|---|---|---|---|
| *Sr. No.* | *Direction* | *Forward Direction (sec)* | *Backward Direction (sec)* | *Forward direction (sec)* | *Backward Direction (sec)* | *Forward direction (sec)* | *Backward Direction (sec)* |
| *1* | *R to R* | *15* | *15* | *45* | *45* | *15* | *0* |
| *2* | *R to S* | *15* | *15* | *15* | *15* | *0* | *0* |
| *3* | *S to R* | *0* | *0* | *15* | *15* | *0* | *75* |
| *4* | *S to S* | *0* | *0* | *0* | *0* | *75* | *75* |
| | *Total* | *30* | *30* | *75* | *75* | *90* | *150* |
| | *Combined* | *60 sec* | | *150 sec* | | *240 sec* | |

(R –Right Turners, S- Straight movers)

From above methodology adopted for odd, even alteration, we concluded that

- In odd phase alteration, phase plan A to plan B present minimal overall delay in forward as well as backward direction in comparison to phase plan A to plan A and B to B. Hence, plane A to B is desirable for odd phase alteration.
- In even phase alteration, phase plan A to A accord minimal overall delay for both the directions of maneuvering in comparison to Phase plan B to B and A to B, Hence, phase plan A to A is desirable for even phase alteration.
- In even phase alteration, if upstream intersection has plan B then Plan B to B is desirable.
- Phase plan A accomplish priority for straight as well as right turners in single phase in comparison to phase plan B.

### *B. Time Space Diagram Method*

Three consecutive signalized intersections were selected spaced 900 m. The turning movement at each intersection was extracted from video filming techniques, and saturation flow were determined. Signal cycle length was designed based on Webster's method and optimal cycle length of 120 sec was desired for study. According to time of phasing and spacing between intersection time space diagrams was prepared. Signals were coordinated manually with variation of time with respect to space. The obtained result before and after coordination was shown in following table. [9]

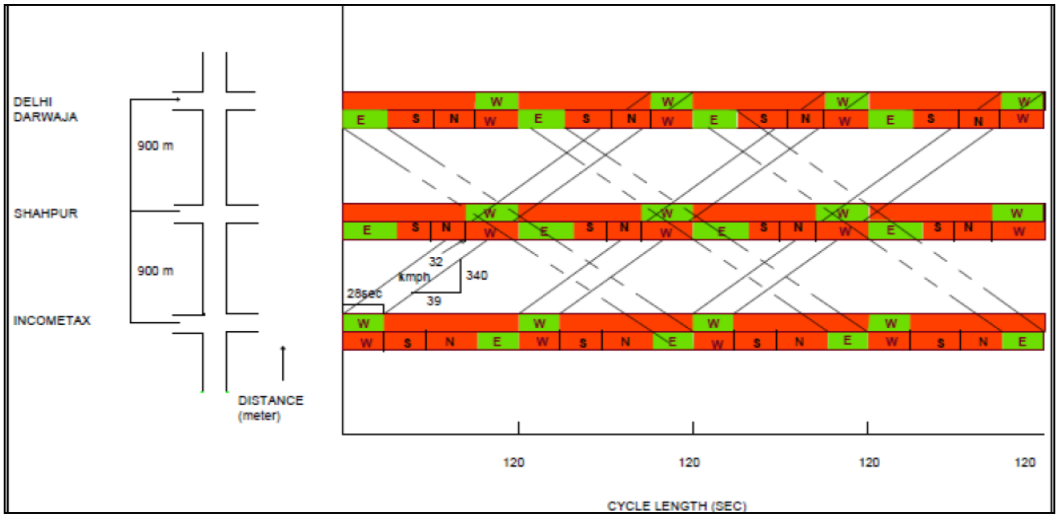


*Table 3: Comparison of stopped Delay before and after coordination.*

| *Intersection* | *Before Coordination* | *After coordination* |
|---|---|---|
| *Incometax* | *99* | *35* |
| *Shahpur* | *72* | *31* |
| *Delhi Darwaja* | *81* | *30* |

## IV. CONCLUSION

From selected methods, coordination of signals had been appraised for close continuous intersections and it is concluded that coordination of signal plays a vital role to abate congestion, reduces travel time as well as waiting time at signalized intersection. Coordinated signals improves the speed for maneuvering of vehicles. The phase difference plan method is best suited for signal coordination as this results in minimal delay in overall average travel time.

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