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DESIGN OF TRAFFIC RESPONSIVE PLAN SIGNALS AT SIGNALIZED INTERSECTION

Mohammed Bin Saleh Mehdi[1], Dr. Mir Iqbal Faheem[2], Mohd. Minhajuddin Aquil[3]

[1,2,3] Department of Civil Engineering, Deccan College of Engineering & Technology,
Affiliated to Osmania University, Hyderabad

Abstract— The goal of this study is to improve efficiency of traffic control at the intersection by the provision of Traffic Responsive Plan Selection mode (TRPS) system which works on real-time detections and eliminates the wastage of green time allotted to a phase. The first step this research is to collect the data from the field, Generation of traffic states, Development of signal timing plans, Simulation and evaluation. Smart Eye video-detection system was used to monitor and record the volume data. This system is able to perform the analysis of the distribution of the traffic flows along the whole road intersections in real time and through implemented algorithms manage TRPS mode in the most suitable way. The sensor detects the traffic volume at all approaches on the junction and automatically discard the unusual spikes or dips in traffic flow from further consideration. The second problem is generation of different traffic scenarios, which can encounter in the future, and definition of threshold for each of this state. Detailed plot of the 15-minutes volume data by time of day over specific weekday was prepared and subjected to the next examinations. TRPS mechanism selects and associates timing plans to traffic state, then activate a specific timing plan after recognition of this adjacent traffic state. . The activation mode is applied through a pattern matching mechanism, where new timing plan is implemented, when the traffic volume is associated to its similar to state. Nearest Neighbourhood classification method was used as pattern matching mechanism. It is a basic calculation that stores every single accessible case and group's new cases in light of closeness measure such as remove capacities. Therefore, it is very important to cluster the traffic states into groups with similar characteristics and after associate suitable traffic plan, lest fail through activation of inadequate timing plan. Subsequently, optimal timing plans for all traffic states are designed. The purpose of this step was to select the best timing plans, which ensure good progression in both directions along the artery. Existing phase sequence at the intersections is kept the same as the sequence in the current time of day mode, because this sequence is governed by the geometry at each intersection. Synchro was selected and used in order to develop the optimal solutions. The last step was the simulation and evaluation of time of day mode and traffic responsive control. Evaluation of created timing plans with traffic scenarios was performed using SimTraffic simulation implemented in Synchro. This evaluation is very important since it provides estimated values for numbers of stops and total delay for both modes, TOD and TRPS. Afterwards, was carried out the comparison of two discussed modes. In comparison with TOD mode, TRPS bring up the most suitable timing plans for the existing traffic condition. Instead, TOD is limited to bringing up timing plans according to a fixed time schedule regardless of the existing traffic condition. To conduct a fair comparison between the TRPS and TOD mode, the six hours simulations with actual and designed timing plans was executed. It was necessary to predict the total delay expected from implementing a TRPS mode and actual delay connected with TOD mode. Simulations show 19% reduction of average travel time per vehicle with TRPS mode in comparison to TOD mode. Moreover, total delay, numbers of total stops and fuel consumption also decrease. This study shows how to implement the traffic responsive control mode in the traffic network improvement in the overall system performance.

Keywords: TRPS, Clustering, Synchro Studio, Sim-traffic

I. INTRODUCTION

The purpose of traffic signals is to separate conflicting movements in time for a given space. A signal timing plan is developed for safe and efficient operation of the signal control for a given traffic demand. In other words, it is necessary to reduce the total delay by optimizing significant traffic parameters according to changes in traffic flow, such as: cycle length, green splits, phase sequences and offset. Implementation of an optimal signal-timing plan in response to traffic demand has always been challenging. This becomes a major concern when traffic demand varies widely and is highly unpredictable.

In closed-loop traffic control systems, there are two control modes for the selection of particular timing plan at a given instant: Time of Day mode (TOD) and Traffic Responsive Plan Selection mode (TRPS). The difference between TOD and TRPS mode is that in TOD mode the timing plans are based on the historical traffic conditions, while in TRPS mode the plans change according to actual traffic demand. TOD mode assumes that traffic patterns are interactive; hence plans are implemented and actuated at the same time every day, regardless of the existing traffic condition. It works very well on networks with predictable traffic conditions. However, with unexpected traffic flows signal timing plan working in TOD mode can be inappropriate. Moreover, timing plans have to be continuously updated to match temporal traffic trends. In order to implement the most suitable signal-timing plan for a current demand and overcome the aforementioned limits of TOD implementation, this dissertation introduces and presents a novel traffic responsive plan selection mode, which is mostly based on TRPS mode. TRPS mode depends on framework identifiers to appraise request on the system and pick the ideal movement design in light of real conditions. The efficiency of traffic control at the intersection can now only be improved by the provision of Traffic Responsive Plan Selection mode (TRPS) system which works on real-time detections and eliminates the wastage of green time allotted to a phase. The Traffic Responsive Plan Selection mode, if effectively arranged, gives a proficient task because of its ability to adjust irregular movement conditions, for example, unique occasions, episodes, and occasion activity. The TRPS mode is able to reduce the need for frequent updates or redesign the signal timing plans. It can operate more optimally and efficiently than TOD mode, but its parameters have to be set up correctly for proper operation of the system. Otherwise, inappropriate timing plans will be selected or system will run in a continuous transitioning state. Due to the cumbersome configuration procedure of optimal TRPS system parameters and thresholds, traffic engineers usually choose the time of day mode of operation for its easiness of setup. However, this approach significantly limits the potential benefits that traffic monitoring could gather by combining system detectors with TRPS mode.

II. LITERATURE REVIEW

This section discusses the previous work done on intelligent traffic signal design with their application on regional roads with author's name using different methods and models with the overview of the relevant research works. This gives the reader a background into smart signal designing work the literature review focuses mainly on the smart signal design. Ishant Sharma and Pardeep Kumar Gupta (2017) proposed the achievability of supplementing existing movement signals with a framework to screen the activity stream consequently in rush hour gridlock signals where sensors are settled in which the time feed is made dynamic and programmed by handling the live identifications. The paper manages the practicality of arrangement of inductive circle identification based activity motions instead of existing pretimed movement motions by contrasting their execution, reasonableness and financial matters. Er. Faruk Bin Poyen, Amit Kumar Bhakta, B.Durga Manohar, Imran Ali (2016). They proposed an instrument in which the day and age of green light and red light is alloted based on the thickness of the activity exhibit around then. This is accomplished by utilizing PIR (proximity Infrared sensors). Once the thickness is computed, the gleaming time of green light is allocated by the assistance of the microcontroller (Arduino). The sensors which are available on sides of the street will recognize the nearness of the vehicles and sends the data to the microcontroller where it will choose to what extent a flank will be open or when to change over the flag lights. J R Latha and U Sunman (2015) completed an examination on smart movement light controller. The primary point of their exploration is to outline a canny activity light controller utilizing implanted framework. This exploration likewise expects to outline a sheltered and productive activity stream, to relegate the correct way and limits the deferral or holding up time at street. Faizan Mansuri and Viraj(2014) Panchal proposed the basic activity light controller configuration venture was acquainted with ease this weakness and pick up involvement in taking care of usage and interfacing issues of a cutting edge computerized framework. They execute a completely practical activity flag controller for a four-way crossing point. Crossing point is finished with sensors to recognize the nearness of vehicles holding up at or moving toward the intersection. These incorporate VHDL for demonstrating and limited state machines, serial correspondence, and transferring the VHDL configuration code on ALTERA pack for check of plan. Rashid Hussain (2013) proposed the idea of Wireless sensor organize innovation have the real-time movement information at a crossing point and after that to apportion the timings to the activity to tidy up the convergence. This method was proceeded to be efficient as it didn't required any built in system in vehicles for its working. Dinesh Rotake (2012) develop a intelligent traffic signal control (ITSC) system in his research paper the estimation the traffic volumes of road networks has been proposed, in which real time traffic information is not provided. Genetic algorithm was used to estimate the unknown traffic volumes for such road section whose traffic information not available. Present work considered a simple road sections under static environments. Dave McKenney (2011) proposed a distributed/adaptive algorithm which can operate within a realistic environment. A realistic model of a section of downtown Ottawa is also developed and used to test the performance of the algorithm. Through simulation, acceptable algorithm parameters are identified and the algorithm's performance is compared to that of a fixed controller.

Shilpa (2009) worked on a new technique "Intelligent traffic light controller" which was made by making use of GSM services as it included providing the information regarding traffic flow to users by sending SMSs in addition to the sensors provided on the intersection to allocate the timings to clear off the intersection. This system was compared with fixed traffic signals and found to be more efficient. W. Wen and C. L. Yang (2006) have designed a framework for a dynamic and automatic traffic light control system and developed a simulation model coded in Arena to help design the system. The model adopts average arrival time and departure times, which are physically observed at each intersection of Chung San North road, Taipei, Taiwan, to simulate the arrival and leaving number of cars during the run time period. Past research regarding TRPS mode only considers only the trivial threshold mechanisms to implement traffic responsive in traffic networks, because this approach is widely adopted and supported by many controller manufacturers. Nonetheless, the machine learning community has developed many smarter decision support systems approaches, which are mostly based on pattern recognition. There is still a very limited research in applying such methodologies to the signal control problem, and this is one of the major contributions of this dissertation. This study provide guidelines regarding the design of a new TRPS mode for urban artery, where a pattern recognition approach has been adopted to identify a much more meaningful and descriptive set of traffic features, rather than mere threshold. Moreover, a second contribution of this dissertation has been the evaluation of traffic responsive control on Abids and Koti arterial network in Hyderabad, analysed through the video camera Smart Eye detector, by mesoscopic simulation using SIMTRAFFIC.

III. RESEARCH METHODOLOGY

Study Area: Abids and Koti Street network, because of its extended size, is divided into two functional synchronized parts. First part that is discussed in this dissertation consists of six intersections and it is 914 m. in length. Speed limit for the main arterial and side streets is 20-25 km/h. Abids Street is one of the most congested artery in Hyderabad. The Figure 1 presents the street under study.

Figure 1 Study area

SynchroModel: Traffic ware Inc. develops Synchro and it has the best user interface of signal-timing software currently available. Synchro is complete software for design and optimization of traffic signal timing plans. SYNCHRO bases on Highway Capacity Manual to analyse the intersection capacity and improve signal timing through optimization of cycle lengths, offsets and splits. This eliminates the need to search the best signal timing plans by trying multiple plans. The software reduces delays in the network and is able to model actuated signals. Synchro provides optimization of cycle length by analysing all cycles in the user defined range and increment. In order to determine network cycle length, Synchro minimizes the performance index (PI). Optimization of offset has multiple stages, which depend on the optimization level selected by user (number of stages and search step size). Synchro tests all possible offsets. The optimal signal timing plans minimize the delays between the intersection and its immediate neighbouring intersections. Synchro recalculates the delay based on the departure patterns for a junction and its adjacent node. Split optimization is accomplished by first attempting to service critical lane's 90^{th} percentile traffic flow. Synchro attempts to serve 70^{th} or 50^{th} percentile traffic flow, if the cycle time is too short to achieve this. Main phases get any extra green time.

Synchro assumes random arrivals that follow a Poisson distribution and uses 10th, 30th, 50th 70th and 90th scenarios for the delay calculations, in order to calculate the variability of traffic flow. The delay output by the model is the average of these five scenarios weighted by the percentile flow rates, which gave similar results to Webster's formula. However, the method is more indicated to actuate signals in the presence of skipped or pedestrian phases. Timing plans are developed in Synchro based on detected volumes from Smart Eye sensors. These timing plans were subsequently adjusted manually after observation of the real traffic conditions in the field. Timing plans were then simulated in two software Sim Traffic in order to test their level of performance.

***Development of Traffic Signal Plan through Synchro software*:** The traffic signal plan needs optimally serve a demand state. Calculation of best-suited signal timing plan for given demand on the network can be performed with many software programs, such us PASSER II, SYNCHRO or TRANSYT-7F. Due to scope of this study, signal-timing plans were generated using SYNCHRO. The model built in SYNCHRO must be as accurately as possible with respect to signal timing parameters, roadway geometry and volume

Step 1: This is the page we get when we open the synchro studio software, in this first we have to create our file in order save our project for that we have to go to the tool bar from we have to select the file option the then select new after selecting that give name to your file. After making the file then we can proceed for making our project, to draw the link we have to select the add link option from the tool bar, we can draw link easily by selecting the add link option. Screen shot of the page in shown in Figure 2.

Step 2: In this it shows the link which is drawn by using add-link tool from the tool bar. This link is drawn to for design as of the route of our intersection, the link which is to be examined can easily draw by taking the add link option from the tool bar. The above link represent the route our case study in the above link we have to add nodes as of our study area. In the next step adding of nodes to the links is presented in Figure 3.

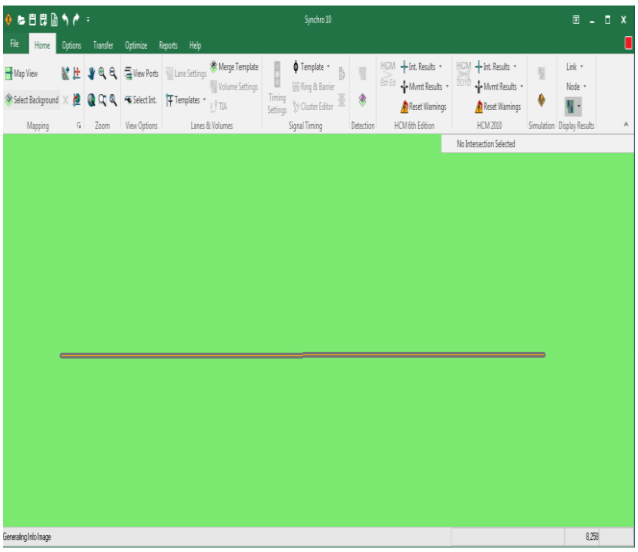

Figure 2 Preparing links

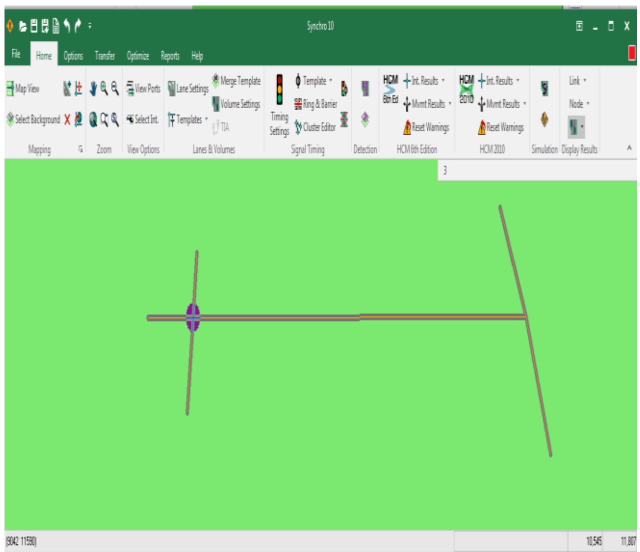

Figure 3 Preparing nodes

Step 3: After drawing the links the nodes will be added, the making of is similar to the to making of the links but in order nodes first we have to draw the links then we can draw a nodes at our desire point of the link by just drawing a perpendicular line to the link. After making nodes we have to give the details of the road which is shown in the Figure 4.

Step 4: In this step it shows how the link nodes are provided lanes. In order to provide the number of lanes to the link we have to go to the lane settings from the tool bar when we click on the on the lane settings it opens a lane setting menu in that first option is for providing the number of lanes we can provide lanes as the per our requirements. As presented in Figure 5.

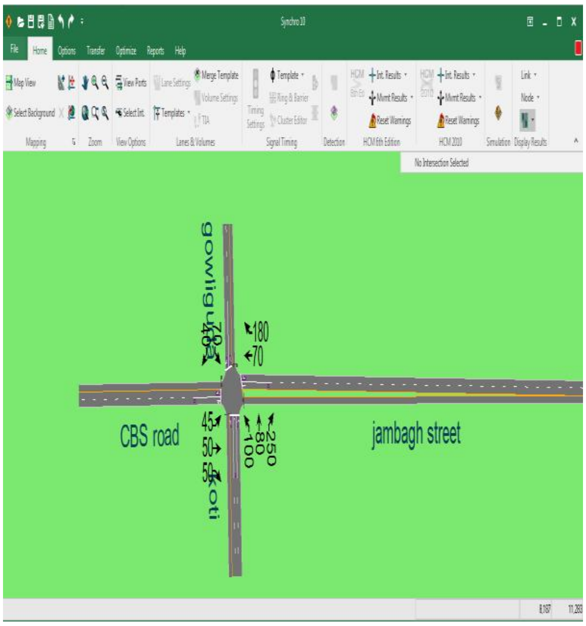

Figure 4 Preparing nodes

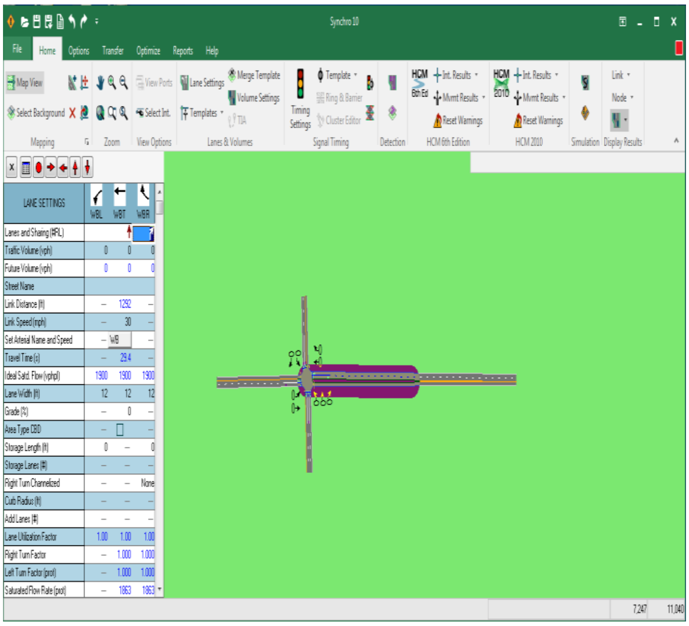

Figure 5 Providing details at nodes

Step 5:

After providing the number of lanes the second option is for providing the traffic volume we can easily put our data according each lane, the next option is for providing the future volume of traffic. After that a street name option is present below the future traffic which provide as ease for giving name to the links .as shown in above figure the three options have been used in the first part of the model. As presented in Figure 6.

Step 6: As in the fifth step we provide the data of the lanes, in this step also we are providing data at the other node, to provide the data at the other points same steps should be follow as in the fifth step. You can see in the figure that the nodes are provided with data and the labelling of links has been done ,after providing the this data we can create the signal timing plans to obtain the signal plans we have to follow the following steps as shown in next step. As presented in Figure 7.

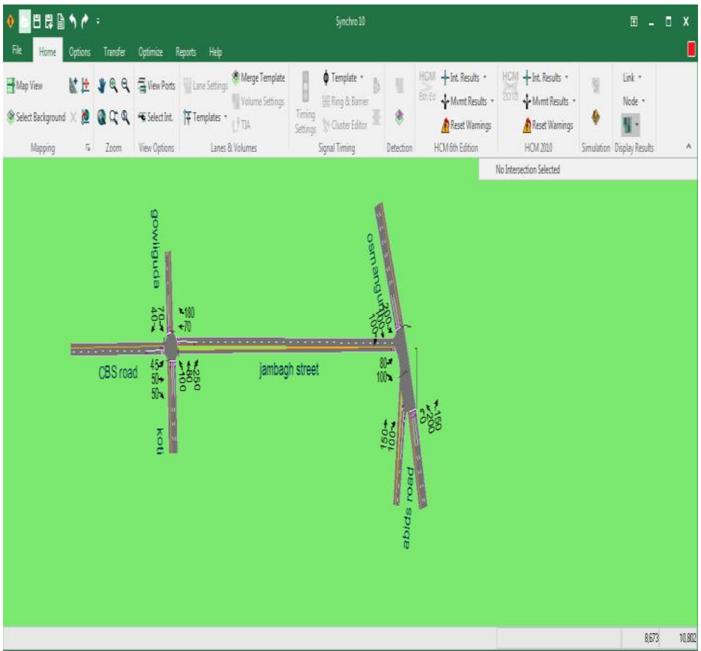

Figure 6 Providing details at nodes

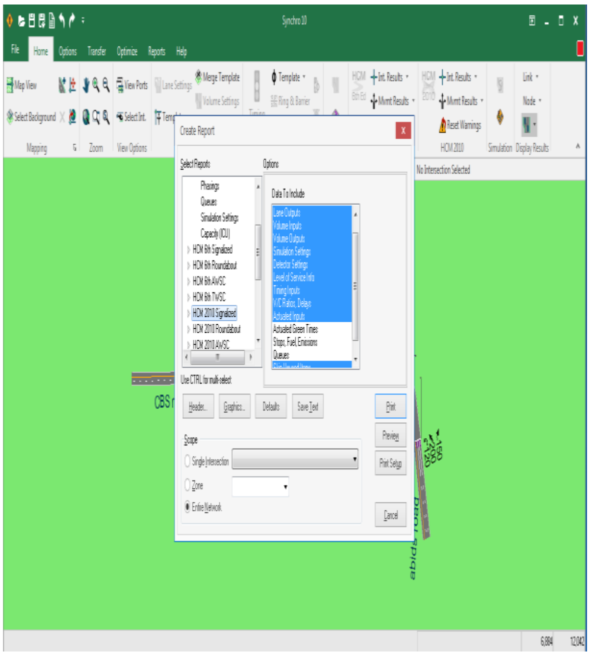

Figure 7 Creating report

Step 7:

In this report the model which is developed is used to create the signal timing plans to create report we have to select the file option from tool bar in that we at last third we will been seen a option of the “Create Report” when clicking that option we will get the menu of create report option on the screen, in that at the left side it shows select report menu and at the right data to be include in the results is selected. After selecting the options from above to menu we preview check the data in the preview option, and we also have an option of selecting the entire network or a desire network as shown in the figure below in the scope part. In preview we see the cycle length and the other data which is selected. As presented in Figure 8. **Step 8:** This step shows the preview of the created report in which it gives the details of the cycle length, approach delay, control type of signal, it gives the result and names of the intersection of the road .further the data obtain is evaluated using the Sim-Traffic software. As presented in Figure 9.

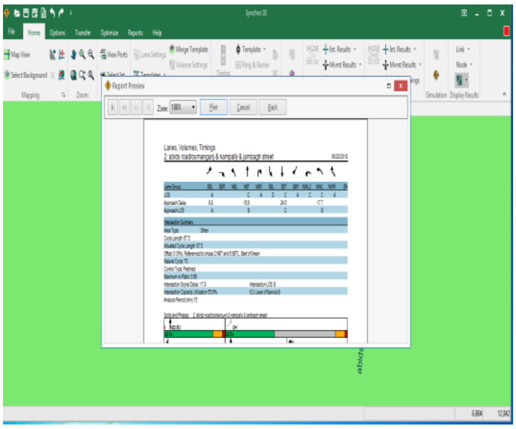

Figure 8 Preview report

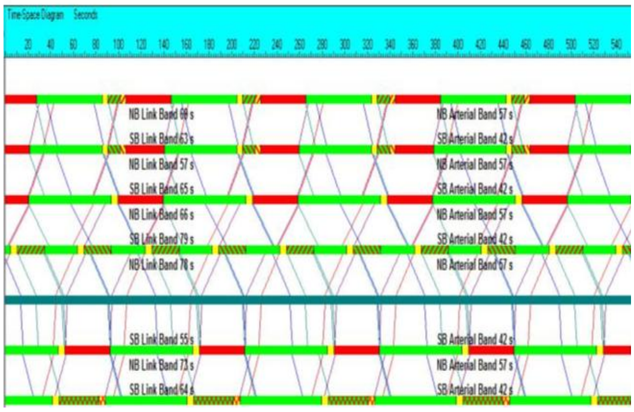

Figure 9 Time-space Diagram

IV. RESULTS

The results obtained from the simulation using synchro software are used to plan the signals timing at the intersection the different cycle length were created for each intersection for different timing state the Table 1 gives the detail of the time of day mode which is fixed at particular time of the day and Table 2 gives the timing plan for different type of traffic.

In Figures 10 and 11 the comparison between the traffic scenarios has been shown by using the Traffic Responsive Plan System and Time of Day mode system. It clearly shows the effectiveness of the usage of the traffic responsive System over the Time of Day Mode system. The synchro studio adds an offset for each timing plan in order to maintain the flow very feasible. For each of traffic plan, an adequate offset was developed by SYNCHRO and subsequently adjusted manually. The offset needs to minimize delays of the corridor and possess a green band as constant as possible along the itinerary

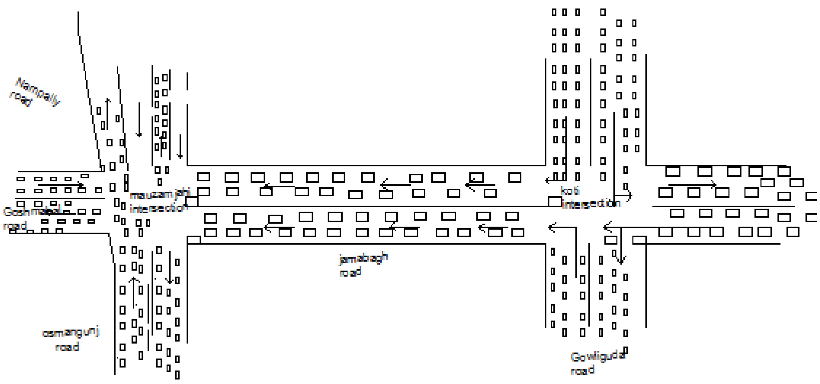

Figure 10 Intersection with Signal Timing of TOD

In Figure 10 it shows the traffic handling with the time of day signal system. It clearly shows the traffic congestion if the at the intersections , In order to reduce the congestion and to make the flow feasible the Traffic Responsive Plan Signals are introduced at the intersections. After introducing the Traffic Responsive Plan Signals (TRPS) the congestion at the intersection are reduce due to eliminating of wastage of green time at the other road which doesn't have traffic. Table 1 shows the signal timing plans for Time of Day Mode

Table 1 Signal Timing Plans for TOD

State	intersection	Cycle length	NBL	NBT+R	SBL+U	SBT+R	EB	WB	OFFSET (sec.)
1	Mauzamjahi	132	16	79	-	63	-	40	-
	Koti		-	69	-	85	34	-	65
2	Mauzamjahi	102	15	67	-	82	-	49	-
	Koti		-	73	-	88	43	-	60
3	Mauzamjahi	120	13	98	-	85	-	42	-
	Koti		-	91	-	104	37	-	144
4	Mauzamjahi	93	7	72	-	65	-	42	-
	Koti		-	71	-	78	37	-	160
5	Mauzamjahi	81	13	72	-	59	-	42	-
	Koti		-	65	-	78	37	-	190
6	Mauzamjahi	95	12	68	-	56	-	42	
	Koti		-	62	-	74	36	-	92

In Table 1 and 2 the comparison of the signal timing plans for Time of Day Mode (TOD) and Traffic Responsive Plan Selection (TRPS) are shown for the same amount of traffic. In TRPS the offset for every signal timing is the minimum percent of the cycle length between coordinated phases from koti to intersection to Mauzamjahi intersection traffic signal.

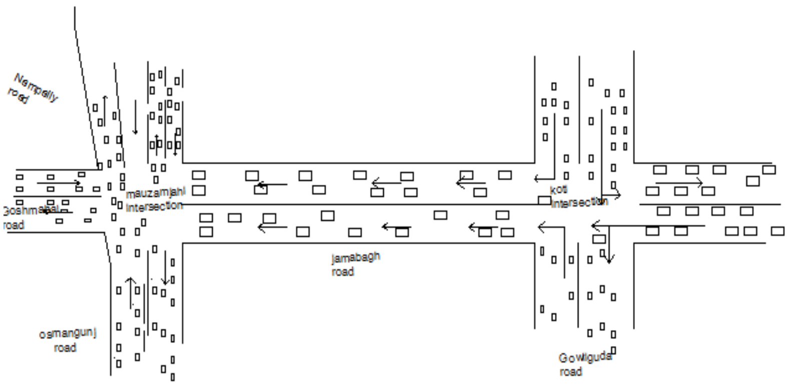

Figure 11 Intersections with Signal Timing of TRPS

Figure 11 to shows the traffic levels at the intersection after applying the Traffic Responsive Plan Selection (TRPS). After applying the traffic responsive traffic signals the wastage of green time is eliminated, the traffic signals are design according to the demand of the traffic. Table 2 shows the signal timing plans for TRPS.

Table 2 Signal Timing Plans for TRPS

State	intersection	Cycle length	NBL	NBT+R	SBL+U	SBT+R	EB	WB	OFFSET (sec.)
1	Mauzamjahi	119	16	79	-	63	-	40	-
	Koti		-	69	-	85	34	-	65
2	Mauzamjahi	102	15	67	-	82	-	49	-
	Koti		-	73	-	88	43	-	60
3	Mauzamjahi	110	13	98	-	85	-	42	-
	Koti		-	91	-	104	37	-	134
4	Mauzamjahi	90	7	72	-	65	-	42	-
	Koti		-	71	-	78	37	-	150
5	Mauzamjahi	80	13	72	-	59	-	42	-
	Koti		-	65	-	78	37	-	180
6	Mauzamjahi	110	12	68	-	56	-	42	
	Koti		-	62	-	74	36	-	92

In Table 1 and 2 the comparison of the signal timing plans for Time of Day Mode TOD and Traffic Responsive Plan Selection TRPS are shown for the same amount of traffic. In TRPS the offset of each signal timing is shown as the minimum percent of the cycle length between coordinated phases from koti to intersection to Mauzamjahi intersection traffic signal.

V. CONCLUSION

The study attempted to create a traffic responsive plan in order to reduce the travel time and delays. A methodology for design and evaluate TRPS mode has been conducted in this study, by introducing a strategy to cluster and detect traffic conditions through pattern recognition techniques. The study concludes: (1) Systematic description on how to set up TRPS mode after detecting and collecting 15-minutes traffic volume data. Measurements of traffic flow at the intersection with Smart Eye video detection system. Video detector data to utilize to simplify the process of timing plan development, as well as to allow a means for constant feedback on performance of signal timing plans. (2) Investigated different types of input data for cluster analysis in order to get the maximum efficiency and the best separation of groups. (3) In comparison with TOD mode, TRPS bring up the most suitable timing plans for the existing traffic condition. Instead, TOD is limited to bringing up timing plans according to a fixed time schedule regardless of the existing traffic condition. To conduct a fair comparison between the TRPS and TOD mode, the six hours simulations with actual and designed timing plans was executed. It was necessary to predict the total delay expected from implementing a TRPS mode and actual delay connected with TOD mode. (4) Simulations showed that 19% reduction of average travel time per vehicle with TRPS mode in comparison to TOD mode. Moreover, total delay, numbers of total stops and fuel consumption also decrease. (5) The implementation of traffic responsive control mode in the traffic network improves the overall system performance.

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