PERFORMANCE EVALUATION OF AT GRADE INTERSECTIONS AND IMPROVEMENT USING SIGNAL COORDINATION

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Abstract

As the traffic in the existing road system in cities grows, congestion, delay, environmental pollution and high energy consumption become a serious problem. Medium and long term solutions like construction of new roadways, widening of existing roadways, providing elevated fly over's, etc are restricted by shortages of funds and right of way availability. The ability to accurately quantify vehicle delays at signalized intersections is a critical component for the planning, design and analysis of signal controls.

The study area selected for the analysis Koramangala in Bangalore because of wide spread commercial, industrial, government, private and other activities. Seven intersections are selected for the study and traffic surveys conducted such as turning volume count, intersection inventory study, signal cycle length study etc., The Study is performed to analyze the existing condition of Traffic, Hourly variations, Capacity and Level of Service (LOS). Highway capacity manual defines six level of service based on control delay, so delay at intersections is recorded by using moving observer method.

The traffic data is analyzed results show that traffic flow from all the approach roads is over loaded and this is due to inefficient green times. It was seen that Capacity of all the study intersections is reduced below the design capacity. It is observed that V/C ratio of all the intersections is more than one and Level of Service is reduced to F, which shows all the study intersections performance is least. The signal timings are optimized using PTV Vistro software and it is found that performance is increased considerably.

Keywords- *Capacity, Level of Service, Signal timing, Saturation Flow, Control delay, Signal optimization, Signal coordination*

1. Introduction:

The growth in urban traffic has been recognized as serious problem in metropolitan areas in the country, with significant effect on economy, travel behavior, land use and cause of discomfort for millions of motorists. Bangalore today is obviously one of the most sought after cities in the country what with the rapid growth in the IT industry and the rise in the number of job opportunities in the city. According to BTRAC-2010 website rapid population growth because of IT and other associated industries in Bangalore has led to an increase in the vehicular population to about 1.5 million, with an annual growth rate of 7-10%.With the increase in population and the expansion of the city, the problem of connectivity of the populace has arisen. Quite obviously personalized modes of transport have grown at a tremendous rate and two wheelers along with the cars almost comprise 90% of the total registered vehicular population in the city. Two wheelers constitute more than 70% of the total volume, while cars comprise 15%, autos 4% and the remaining 8% includes other vehicles such as buses, vans and tempos.

As the traffic in the existing road system in cities grows, congestion, delay, environmental pollution and high energy consumption become a serious problem. Medium and long term solutions like construction of new roadways, widening of existing roadways, providing elevated fly over's , etc The traffic streams moving in various directions are separated with respect to time as the right of way is allocated to the traffic streams one by one. The vehicles released from signals often maintain their grouping for certain distances. Hence the pattern of arrival flow at signalized intersections generally changes from "random" to "platoon" in the signal network.

2. Literature Review:

Arash Moradhkhani Roshandeh 2008, suggested a methodology to study and evaluate the performance and efficiency of traffic signal setting at signalized intersection. This study only involves traffic count, actual green and saturation flow rate measurement data during the survey. The data from the site has then been analyzed, using manual calculation and computer programs TRANSYT 13. As a result the test signalized intersection has acceptable headway, saturation and lost

time. The major arm of the intersection has level of service C while minor arm has level of service D, which was still acceptable. The existing traffic demand is still less than the intersection capacity, which means that the flow in this intersection is not oversaturated yet. Therefore, no upgrading is needed for this intersection.

Common measures by which the performance of an intersection may be evaluated include (1) delay, (2) stops, and (3) queue length. Each of these may be expressed as values, which represent totals or averages for the entire intersection or for particular approaches or movements within the intersection. Averages are often expressed on a per vehicle basis. Other measures, which have been used to characterize the performance, are throughput and total travel time, Amudapura Mohan et al, 2012. Ali Payıdar and A. Graham R. Bullen 2006, conveys that the estimation of delay at signalized intersections is a complex process and depends on a number of parameters among which the degree of saturation (x = v/c) is the most important. This paper presents a new methodology for estimating delay parameter *k*, and proposes an analytical delay model for signalized intersections that considers the variation in traffic flow. Unlike the existing delay models in the literature, the delay parameter *k* is not a fixed value and is expressed as a function of the degree of saturation. Delay, specifically the control delay is the measure used in the signalized intersection methodology of the HCM 2000 and the primary measure used in the number of signalization optimization procedure. Performance measures are critical part of all Intersection design methodologies.

3. Objectives:

The following are the objectives of the Study:

- To determine the Capacity of approach roads of intersections
- To determine the Saturation flows of approach roads of the intersections.
- To determine the V/C ratio for the intersections.
- To determine the Present Level of Service provided by the intersections.
- To coordinate traffic Signals using PTV Vistro.

4. Methodology:

1. Reconnaissance Survey.
2. Road inventory Survey.: The inventory data includes the following details about the selected pavement sections: name of road, category of road, carriageway and shoulder width, drainage conditions, surface type and Median, Shoulder type etc. for all the approach roads of study intersections is performed. The data collected is required to evaluate capacity and Level of Service of intersections.
3. Turning movement survey of Vehicles at junctions.:Objective of intersection Turing movement survey is to assess the traffic flow and delay characteristics on individual arms at the intersection. Classified volume with turning movements are collected for the selected intersections from 6am to 10pm.. Traffic volume is used as a quantity measure of flow; the commonly used units are vehicles per day and vehicles per hour. For calculation purposes, all vehicles are converted into passenger car units
4. Signal Cycle Study: The signal timing and phasing is measured manually using stop watch or by collecting Information from the B-TRAC website. Complete information regarding signalization is needed to perform an analysis. This information includes a phase diagram illustrating the phase plan, cycle length, green times, and change-and-clearance intervals.

5. Capacity, Delay and Level of Service

Capacity and Level of service calculation for Sony world junction is calculated as per HCM 2000 manual as shown in Table 1, similarly it is calculated for all intersections and given in Table 2.

Table 1: Capacity, Delay and Level of Service values of Krupanidhi college junction

Adjusted flow rate, v (veh/h)	2539	1194	1123
Lane group	1694	596	775
capacity, c (veh/h)			
v/c ratio,2 X = v/c	1.49	2.00	1.44
Total green ratio, g/C	0.369	0.130	0.25
Uniform delay, d1(s/veh)	47	65	56
Incremental delay calibration, k	0.5	0.5	0.5
Incremental delay,d2(s/veh)	33	46	39

Progression adjustment factor, PF	1	1	1
Delay, d = d1(PF) +d2 (s/veh)	80	111	95
LOS by lane group	F	F	F
Approach flow rate, vA (veh/h)	2539	1194	1123
Intersection delay, dA (s/veh)	91.		
Intersection LOS	F		

Table 2: Capacity, Delay and Level of Service values of Wipro park junction

Adjusted flow rate, v (veh/h)	968.04	1430.93	1259.79	1558.02
Lane group capacity, c (veh/h)	426.18	422.70	1413.11	824.31
v/c ratio,2 X = v/c	2.27	3.39	0.89	1.89
Total green ratio, g/C	0.14	0.14	0.46	0.27
Uniform delay, d1(s/veh)	86.08	86.08	49.90	73.42
Incremental delay calibration, k	0.50	0.50	0.50	
Incremental delay,d2(s/veh)	60.25	60.25	34.93	51.39
Progression adjustment factor, PF	1.00	1.00	1.00	1.00
Delay, d = d1(PF) +d2 (s/veh)	146.33	146.33	84.83	124.81
LOS by lane group	F	F	F	F
Approach flow rate, vA (veh/h)	968.04	1430.93	1259.79	1558.02
Intersection delay, dA (s/veh)	125.05			
Intersection LOS	F			

Table 3: Capacity, Delay and Level of Service values of koramangala80ft road 4th block junction

Adjusted flow rate, v (veh/h)	1048	500	2036	1396
Lane group capacity, c (veh/h)	426	423	1413	824
v/c ratio,2 X = v/c	2.46	1.18	1.44	1.69
Total green ratio, g/C	0.14	0.14	0.46	0.27
Uniform delay, d1(s/veh)	86.08	86.08	54.43	73.42
Incremental delay calibration, k	0.50	0.50	0.50	
Incremental delay,d2(s/veh)	60	60	38	51
Progression adjustment factor, PF	1.00	1.00	1.00	
Delay, d = d1(PF) +d2 (s/veh)	146	146	92	124
LOS by lane group	F	F	F	F
Approach flow rate, vA (veh/h)	1048	500	2036	1396
Intersection delay, dA (s/veh)	118.30			
Intersection LOS	F			

Table 4: Capacity, Delay and Level of Service values of Sony world junction

Adjusted flow rate, v (veh/h)	3416	3200	2177	2870
Lane group capacity, c (veh/h)	1216	1129	689	821
v/c ratio,2 X = v/c	2.80	2.83	3.15	3.49
Total green ratio, g/C	0.26	0.25	0.22	0.26
Uniform delay, d1(s/veh)	97	99	103	97
Incremental delay calibration, k	0.5	0.5	0.5	
Incremental delay,d2(s/veh)	68.	70	72	68
PF	1	1	1	1
Delay, d = d1(PF) +d2 (s/veh)	165	169	175	165
LOS by lane group	F	F	F	F
Approach flow rate, vA (veh/h)	3416	3200	2176	2870
Intersection delay, dA (s/veh)	168			

Intersection LOS	F

Table 5: Capacity, Delay and Level of Service values of Indoor stadium junction

Adjusted flow rate, v (veh/h)	1696	213	3282	1865
Lane group capacity, c (veh/h)	696	434	1248	705
v/c ratio,2 X = v/c	2.44	0.49	2.63	2.65
Total green ratio, g/C	0.23	0.14	0.40	0.23
Uniform delay, d1(s/veh)	57	59	45	58
Incremental delay calibration, k	0.50	0.50	0.50	0.5
Incremental delay,d2(s/veh)	40	41	31	40
Progression adjustment factor, PF	1.00	1.00	1.00	1.00
Delay, d = d1(PF) +d2 (s/veh)	99	101	76	98
LOS by lane group	F	F	E	F
Approach flow rate, vA (veh/h)	1696	213	3282	1865
Intersection delay, dA (s/veh)	88.19			
Intersection LOS	F			

6. Signal coordination using PTV Vistro:

PTV Vistro is a intersection analysis Software which optimizes signal timing based on Traffic distribution and coordinates successive signal timings to reduce Delays. It gives us all the tools necessary to complete traffic engineering studies and evaluations. With PTV Vistro, we can evaluate development impacts, optimize and re-time traffic signals, evaluate intersection levels of service, and generate report-ready tables and figures.

Traffic Signals are optimized using PTV Vistro software, optimum cycle length of 120 seconds is obtained for the coordinating intersections and Time Space Diagram is obtained to coordinate successive Traffic Signals by respective offsets obtained.

6.1 Time-Space Diagram

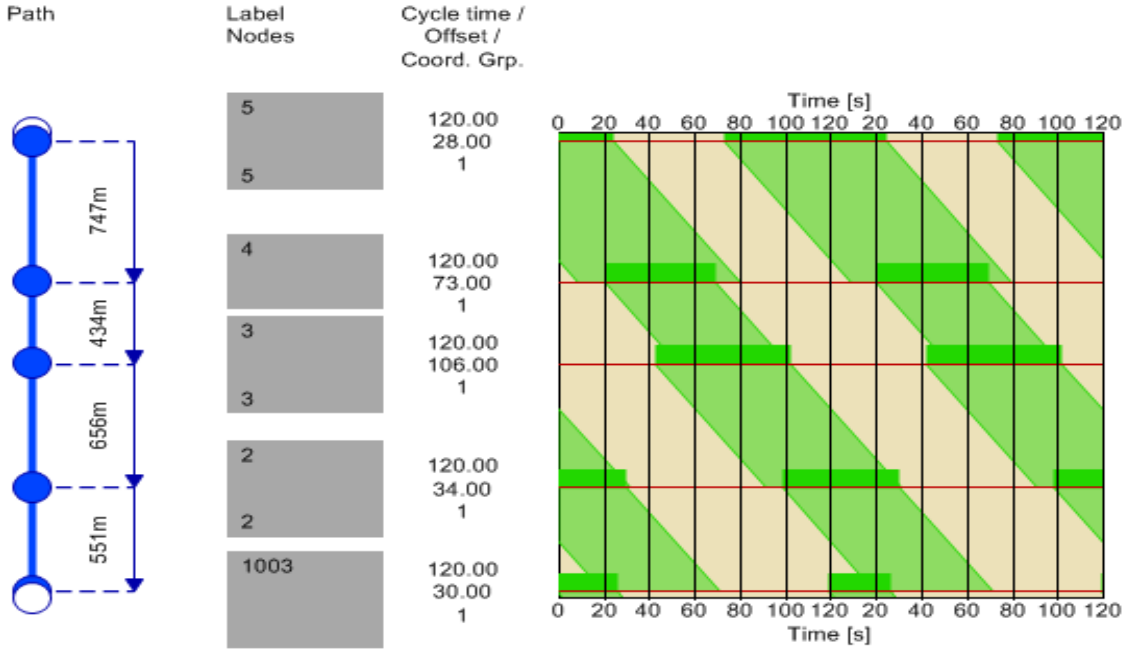

Figure 1: Time-Space Diagram

Time-Space diagram is plotted to show the progression in southbound direction. The yellow period is included in the green period. There are fractures in the band of progression due to irregular block lengths unequal speeds. Generally, the vehicles will increase their speed after seeing green signal indication from some distance ahead of intersection (distance

from which the signal indication may see clearly or distance from which the drivers are able to perceive the movement of queue). The end edge of bandwidth is shown with some increased speed in the diagram. It indicates that if the last vehicle enters into the upstream intersection increase the speed after seeing green signal indication at the downstream intersection in such a way that the average journey speed of the vehicle approaches to the required increased speed to pass the next intersection, then the vehicle will pass the next downstream intersection without stoppage.

9. V/C ratio of intersections before and after Optimization

The V/C ratios obtained after optimization is considerably reduced for all the signalized intersections and it is presented in the table below. The V/C ratios of krupanidhi college junction, Wipro park junction, tarnish junction, Sony world junction and NGV junction are 3.12, 1.92, 1.65, 3.12 and 2.42 respectively before optimization and after optimization it reduced to 1.41, 1.23, 155, 2.40 and 2.18 respectively, which shows Capacity is considerably increased after optimization.

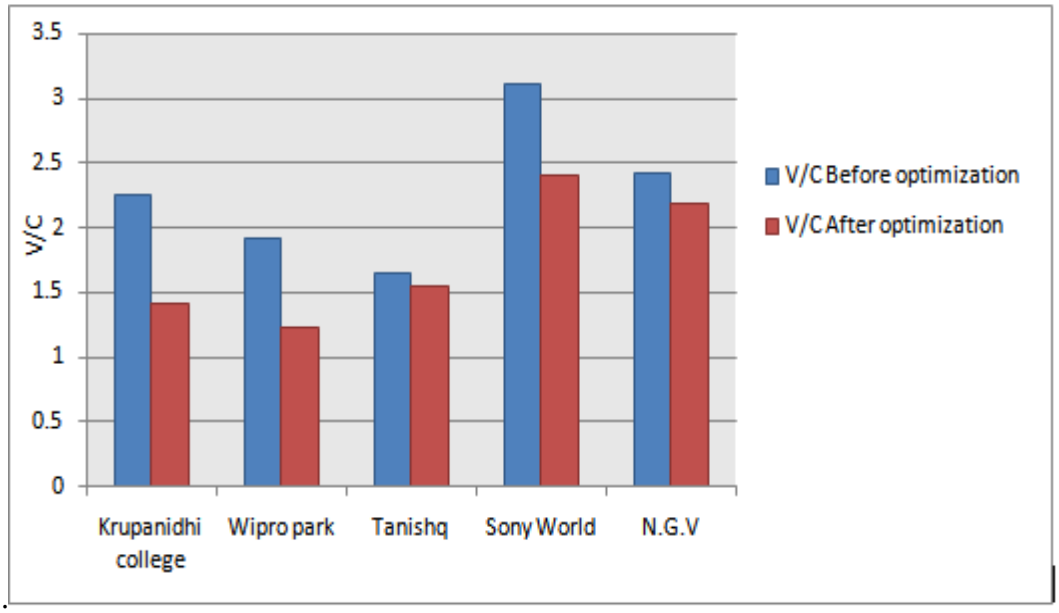

Figure 2: Comparison of V/C before and after optimization

10. Conclusions:

The main findings of this study are:

- V/C ratio for Sony world junction , Krupanidhi college junction and Indoor stadium junction 3.12,2.25 and 2.41 which shows maximum delay occurring at these intersections.
- V/C ratio of all the intersections is exceeded one and Level of Service is reduced to F, Which shows all the study intersections performance is least.
- Maximum Delay of 165 seconds is occurring at Sony world junction and 135 seconds at Wipro park junction.
- Traffic Signals are optimized using PTV Vistro software, optimum cycle length of 120 seconds is obtained for the coordinating intersections and Time Space Diagram is obtained to coordinate successive Traffic Signals by respective offsets obtained.
- The V/C ratios of Krupanidhi college junction, Wipro park junction, tanishq junction, Sony world junction and NGV junction are 3.12, 1.92, 1.65, 3.12 and 2.42 respectively before optimization and after optimization it reduced to 1.41, 1.23, 155, 2.40 and 2.18 respectively, which shows Capacity is considerably increased after optimization.

References:

1. ArashMoradkhaniRoshandeh, “Saturation flow at traffic signal using transyt. Sensors, signals, visualization, imaging, simulation and materials”. Vol 9 (16) Journal for Traffic and Transportation engineering,2009.
2. Amudapuram Mohan Rao,KalagaRamachandraRao,”Measuring Urban Traffic Congestion – A Review”,International Journal for Traffic and Transport Engineering, 2(4): 286 – 305,2012.

3. Ali PayıdarAkgungor, A. Graham R. Bullen. "A New Delay Parameter For Variable Traffic Flows At Signalized Intersections", Journal Of Advanced Transportation. 22 (2), 2006.
4. Xin Alyx Yu and Panos D. Prevedouros,"Left-Turn Prohibition and Partial Grade Separation forSignalized Intersections: Planning-Level Assessment",Journal Of Transportation Engineering,ASCE,139,pp399-406,2013.
5. Andrew M. Churchill YorghosTripodis and David J. Lovell,"Sun Glare Impacts on Freeway Congestion: Geometric Model and Empirical Analysis",JournalOf Transportation Engineering, ASCE,138,pp1196-1204,OCTOBER 2012.
6. Xiaoguang Yang, Xiugang Li, and Kun Xue," A New Traffic-Signal Control for Modern Roundabouts: Method and Application" IEEE Transactions On Intelligent Transportation Systems, Vol. 5, No. 4, December 2004.
7. Andre de Palma, Robin Lindsey," Traffic congestion pricing methodologies and technologies", Transportation Research Part C 19 ,2011.
8. Theodore Tsekeris, Nikolas Geroliminis," City size, network structure and traffic congestion"Journal of Urban Economics 76,2013.
9. LUO Qingyu, JUAN Zhicai, SUN Baofeng, JIA Hongfei," Method Research on Measuring the External Costs of Urban Traffic Congestion" Journal Of Transportation Systems Engineering And Information Technology Volume 7, Issue 5, October 2007.
10. Kiyoshi Kobayashi, Myungsik Do," The informational impacts of congestion tolls upon route traffic demands" Transportation Research Part A 39,2005.
11. R. Bauza,J.Gozalvez" Traffic congestion detection in large-scale scenarios using vehicle-to-vehicle communications" Journal of Network and Computer Applications, 36,2013,
12. Bor-SenChen,"Fuzzy Adaptive Predictive Flow Control of ATM Network Traffic",IEEE Transactions On Fuzzy Systems, Vol. 11, No. 4, August 2003.