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Chapter 1.0 Introduction

1.1 Project Background

Pune city is the cultural capital of Maharashtra having a population of 25.40 lakhs (2001 Census) and stands second in Maharashtra. Pune is a Metropolitan city and one of the important industrial and commercial centers in Maharashtra. It is also known as Educational Center since long. Government of Maharashtra has declared Pune city as Information and Technology center. The population of Pune city is growing exponentially resulting in increase in vehicle population. The decadal population growth of Pune Municipal Corporation (PMC) during 1971-2001 varies from 30.26% (1981-1991) to 49.33% (1991-2001).

Due to rapid development in economic, industrial and commercial activities, there is an enormous increase in traffic, causing traffic congestion, pollution and other related problems. There are many arterial roads passing through Pune city. National Highway No. 4, 9 and 50 and some other important State Highways cross Pune city. The present road network in the study area, especially in PMC area is inadequate to carry high volume of traffic with comfortable Level-of-Service (LOS), which causes traffic congestion during peak hours and thereby increases travel time. Limited scope is available for widening of some of the major roads, construction of new roads etc. to meet the future traffic demand.

Traffic management measures like installation of traffic signals, one-way streets, enforcement of parking control regulations, installation of traffic actuated traffic signal system etc. are some of the cost effective solutions for increasing the capacity of the roads. PMC authorities are effectively implementing some of these traffic management measures to improve the traffic operating conditions on major corridors in PMC area.

CDAC, Thiruvananthapuram in association with Pune Municipal Corporation and with financial assistance from Department of Information Technology (DIT), Ministry of Communication and Information Technology, Government of India, has developed an Area Traffic Control System (ATCS) for Indian conditions and has implemented the same in Pune City. Thirty-eight intersections on six corridors have been identified in Pune for implementation of ATCS. CDAC has appointed M/s Consulting Engineering Services (India) Private Limited, Mumbai for carrying out Evaluation and Impact Analysis of Area Traffic Control System (ATCS) being implemented in Pune City.



Consultants have submitted the Task I Report, covering details of parking inventory survey, topographic survey conducted at 38 intersections on the selected 6 major corridors in Pune city and the suggested Junction Improvement Plans. Various traffic surveys including Turning Movement Count Surveys, Delay and Accumulation Survey at 38 intersections and Speed and Delay Survey on the six corridors, had been carried out as part of pre-implementation stage of ATCS. The analysis of various surveys conducted was presented in Task II Report submitted in September 2004. The present report is the Task III Report and mainly covers Impact Analysis of ATCS.

1.2 Need for the Study

Implementation of any traffic management measures needs generally pre and post Implementation analysis to study the effectiveness of the proposed traffic management measures. Identification and quantification of Measure of Effectives (MoEs) to describe the traffic characteristics along the corridor and at the intersections for the scenario of pre and post implementation of advanced traffic control systems like ATCS involve specialized traffic surveys and studies.

Moreover, installation of traffic actuated signals is relatively capital intensive compared to other low cost traffic management measures like introduction of one-way schemes, installation of normal traffic signals etc.

1.3 Study Corridors

CDAC in association with PMC authorities have identified the following 6 major corridors in PMC area for implementation of ATCS.

1. Karve Road
2. Jangli Maharaj Road
3. Tilak Road
4. Laxmi Road
5. Shivaji Road
6. Bajirao Road

The above project corridors are shown in **Figure 1.1** and brief characteristics of these corridors are presented in **Table 1.1**. For implementation of ATCS, CDAC has identified 38 intersections (30 signalised intersections and 8 unsignalised intersections) on the 6 study corridors and the list of junctions are presented in **Table 1.2**. The project corridors and junctions are presented in **Figure 1.2A** to **Figure 1.2E**. Karve Road, Jangli Maharaj Road and Tilak Road are Two-Way corridors and Laxmi Road, Shivaji Road and Bajirao



Roa Road are one-way corridors. Landuse along these corridors is mainly commercial. As Laxmi Road, Shivaji Road and Bajirao Roa Road are located in central area of Pune city; these roads are highly congested inspite of one-way system, mainly due to high pedestrian activity along and across the roads, encroachment of footpaths and carriageways by hawkers, loading/unloading activities, numerous minor uncontrolled intersections, high parking demand, etc.

Table 1.1 Characteristics of Study Corridors

Sl. No	Corridor Name	Longitudinal Features			Cross Sectional Features			Traffic Features	
		Start Point	End Point	Road Len. (Km)	Road width (m)	No. of Lanes	Divided/ Undivided	Traffic Pattern	No. of Siganlised Junctions
1.	Karve Road	Nal Stop Chowk	Kandojibaba Chowk	1.9	16 to 20.8	4	Divided	Two-Way	6
2.	J.M. Road	Kandojibaba Chowk	SG Barve Chowk	1.9	15 to 20	4	Divided	Two-Way	5
3.	Tilak Road	Alka Chowk	Jedhe Chk	2.2	17.5 to 19.5	4	Undivided	Two-Way	7
4.	Laxmi Road	Alka Chowk	Hamjekhan Chowk	2.0	12 to 15	4	Undivided	One-Way	7
5.	Shivaji Road	SG Barve Chowk	Jedhe Chowk	3.3	12.5	3	Undivided	One-Way	7
6.	Bajirao Road	Hegdewar Chowk	Puram Chowk	3.1	9 to 14	4	Undivided	One-Way	3

Table 1.2 List of Intersections and Brief Details

Jun. No.	Junction Name	Corridor	No. of Approaches	Pre-* Implementation Signalised /Unsignalised	No. of Movements
1	Nal Stop Junction	Karve Road	4	S	12
2	Swatantra Chowk	Karve Road	4	S	8
3	Rasashala Chowk	Karve Road	4	S	8
4	Yaswantrao Chowk	Karve Road	3	S	6
5	Shelarmama Chowk	Karve Road	4	Blink	6
6	Kkandoji Baba Junction	Karve Road	3	S	6



Jun. No.	Junction Name	Corridor	No. of Approaches	Pre-* Implementation Signalised /Unsignalised	No. of Movements
7	Good Luck Chowk	J.M. Road	4	S	7
8	Natraj Chowk	J.M. Road	3	S	6
9	Jhansi Rani Chowk	J.M. Road	4	S	10
10	S.G. Barve Chowk	J.M. Road	4	S	12
11	Shivaji Chowk	Shivaji Road	5	S	8
12	Premeir Chowk	Shivaji Road	4	S	9
13	Hedgewar Chowk	Shivaji Road	4	US	7
14	Jijamatha Chowk	Shivaji Road	4	S	6
15	Budhwar Chowk	Shivaji Road	4	S	5
16	Belbaug Chowk	Shivaji Road	4	S	4
17	Rameswar Chowk	Shivaji Road	3	US	3
18	Gotiram Chowk	Shivaji Road	4	US	5
19	Phatgate Chowk	Shivaji Road	4	S	5
20	Rashtrabhushan Chowk	Shivaji Road	4	US	7
21	Jedhe Chowk	Tilak Road	4	S	12
22	Herabaug Chowk	Tilak Road	4	US	12
23	Puram Chowk	Tilak Road	5	S	12
24	Acharya Vinoba Bhave Chowk	Tilak Road	4	US	9
25	S P College Chowk	Tilak Road	5	S	10
26	Tilak Smarak Chowk	Tilak Road	4	S	8
27	Sahitya Parishat Chowk	Tilak Road	4	S	11
28	New English School Chowk	Tilak Road	5	S	9
29	Alka Talkies Chowk	Tilak Road	5	S	19
30	Holkar Chowk	Laxmi Road	4	US	10
31	Umbriya Ganapathi Chowk	Laxmi Road	4	S	5
32	Kunte Chowk	Laxmi Road	4	S	4
33	Sevasadan	Laxmi Road	4	S	4
34	Sonya Muruti Chowk	Laxmi Road	4	S	4
35	Hamjekhan Chowk	Laxmi Road	4	S	5
36	Appa Balwant Chowk	Bajirao Road	4	S	7



Jun. No.	Junction Name	Corridor	No. of Approaches	Pre-* Implementation Signalised /Unsignalised	No. of Movements
37	Sahnipark Chowk	Bajirao Road	4	S	7
38	Sanasputta Chowk	Bajirao Road	4	S	12

* All are signalized as part of ATCS

1.4 Study Objectives

The primary objective of the study is to evaluate the impact due to implementation of traffic actuated signal system and Area Traffic Control System (ATCS). The specific objectives are as follows:

1. Preparation of junction improvement plans
2. Preparation of traffic database: Traffic characteristics, signal timing plans, parking inventory etc. before implementation of ATCS.
3. Traffic Analysis: Evaluation of corridor wise average journey speed and average delay at intersections, average fuel consumption for the scenarios *pre* and *post* implementation of ATCS.
4. Carrying out the impact analysis of ATCS

1.5 Scope of Services

The major components of the study include:

Task I:

1. Preparation of junction improvement plans
2. Topographic survey of 38 intersections
3. Parking inventory survey on six corridors
4. Collection of existing signal phasing

Task II: (Pre implementation of ATCS)

1. Turning movement survey during peak hours (for 16 hours at 10 intersections and for 8 hours at 28 intersections)
 - a. Speed and Delay Survey on Six Corridors
 - b. Traffic Delay and Accumulation survey at 38 intersections



Task III: (Post implementation of ATCS)

1. Turning Movement Survey during peak hours (for 8 hours at 38 intersections)
2. Speed and Delay survey on six corridors
3. Traffic Delay and Accumulation survey at 38 intersections

1.6 Report Structure

This report is organized in 4 chapters. Chapter 1 gives the project background, need for study, study corridors and objectives and scope of services. Chapter 2 deals with Work Approach and Methodology adopted for the study. Chapter 3 presents the details about various traffic surveys carried out as part of post implementation stage and their analysis. Chapter 4 deals with Evaluation and Impact analysis in terms of average speeds, average delays, fuel consumption and average time saving for pre and post implementation scenario.



Chapter 2.0

Work Approach and Methodology

2.1 Introduction

Earlier chapter focused on description of project corridors and intersections, objectives and scope of the present study. The adopted work approach and methodology to meet the study requirements is presented in this chapter.

2.2 Work Approach and Study Methodology

The overall study has been divided into three major tasks, Task I and Task II for the evaluation of pre-implementation of ATCS Scenario and Task III for evaluation of post implementation of ATCS scenario. Task I activities mainly include topographic surveys, collection of existing traffic signal timings, parking inventory surveys & analysis and preparation of junction improvement plans. Task II activities mainly include traffic surveys and analysis to evaluate the existing traffic operating conditions on the project corridors for pre implementation of ATCS. Task III activities mainly include traffic surveys and analysis to evaluate the traffic operating conditions on the project corridors for post implementation of ATCS. The methodology adopted in the present study is outlined in **Figure 2.1**. The sub tasks in each major task are discussed in the following sections.

2.3 Task I & Task II

Before implementation of ATCS, Consultants had conducted detailed topographic survey, Classified Turning Movement Count Survey, Parking Survey, Speed & Delay Survey and Delay & Accumulation Survey. Details of topographic surveys and junction improvement plans are presented in Task I Report. The details of various surveys carried out as part of pre-implementation stage are provided in Task II Report submitted in September 2004.

2.4 Post Implementation (Task III) Traffic Surveys

After proper implementation of ATCS on the six corridors of Pune City, Consultants have conducted the Classified Turning Movement Count Survey, Speed & Delay Survey and Delay & Accumulation Survey similar to Task II surveys. The details of the surveys are presented in the following sections.

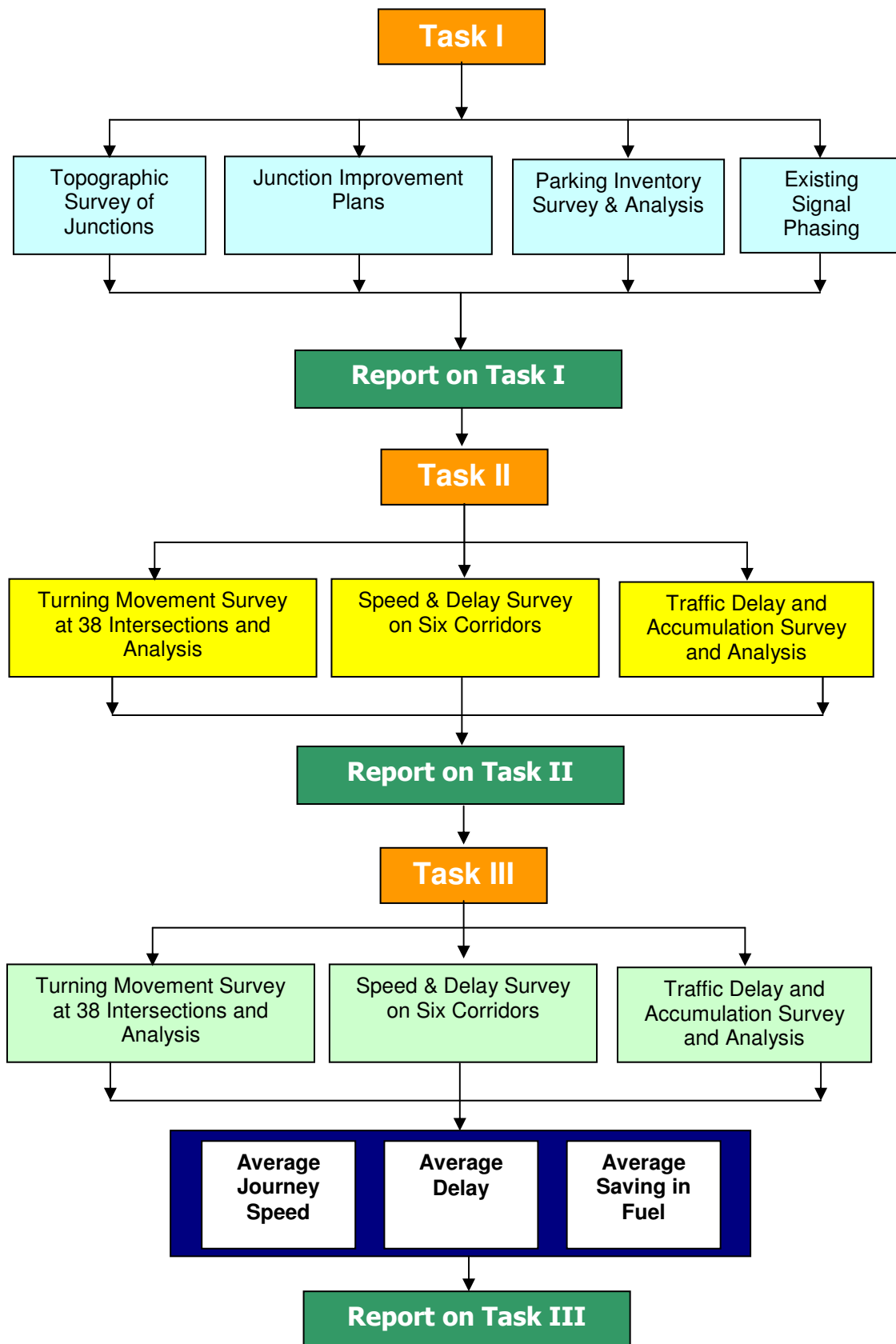


Figure 2.1 Methodology for the Study



2.4.1 Collection of Signal Timing Details

Consultants collected the traffic signal timing details for all the signalised intersections from CDAC. During reconnaissance survey of the junctions, Consultants observed that the traffic signal timings under operation were same whereas the phase pattern was different for different cycle timings. Consultants have noted down the traffic signal timing plans during the time of Delay and Accumulation surveys, as delay and queue lengths are highly dependent on traffic signal timings. The operating traffic signal timings are presented in **Chapter 3**.

2.4.2 Turning Movement Count Survey

Classified Turning Movement count data is the basic data for any intersection analysis with respect to junction improvement, evaluation of operating conditions, estimation of benefits, etc. Classified Turning Movement Count surveys were carried out at all 38 intersections to appreciate traffic characteristics in terms of volume, composition, peak hour traffic, directional split etc.

Turning Movement Count surveys were conducted for 8 hours during peak periods i.e. from 8:00 hrs. to 12:00 hrs. and 16:00 hrs. to 20:00 hrs. at all the 38 intersections on a typical working day.

Passenger Car Units

The traffic in the study area is heterogeneous i.e. mixed type. As different vehicles will have different dimensions and characteristics, the same will cause effect on traffic. For the ease of analysis and design, passenger car units have to be considered to convert it into standard dimension. Equivalent Passenger Car Unit (PCU) values as per IRC SP: 41-1994 (Guidelines on Design of At-Grade Intersections in Rural and Urban Areas) are presented in **Table 2.1** and the same have been adopted for converting various categories of vehicles.

The data generated from the surveys is useful in assessing the junction volume, traffic signal design, estimation of benefits etc. The details of traffic survey analysis are presented in **Chapter 3**.



Table 2.1 PCU Factors

Vehicle Type	Equivalent PCU Factor
Passenger Car, Jeep	1.0
Taxi	1.0
Auto-Rickshaw	0.75
Two Wheelers/Motor Cycle	0.5
Truck or Bus	3.0
Mini Bus	2.0
Light Commercial Vehicle (LCV)	1.5
Multi Axle Vehicle	4.5
Bicycle	0.5

2.4.3 Speed and Delay Survey

The objective of this survey was to assess the speed and delay characteristics on the project corridors for evaluating the pre and post implementation of ATCS.

Speed and delay survey, along the project corridors, was carried out by Moving Car Method. 8 to 12 runs were made during peak period of 4 hours. In addition, speed & delay survey was carried out during very low traffic flow conditions i.e. during early morning hours to know the free flow speeds. For each corridor, reference points have been established like starting point, stop lines at project intersections etc. Initially, pilot runs were made during the peak period to familiarize survey staff with the method and route. The driver has been trained and instructed to drive the test vehicle in such a way that, the number of overtaking vehicles and the number of overtaken vehicles are approximately equal. The driver has also been instructed not to change his driving style. Moreover, the same driver has been used in speed & delay studies on all the project corridors. Information regarding time when the test vehicle cross the reference points, cause and quantum of delay etc. were noted.

The following outputs have been analysed from the Speed and Delay survey.

- Average Travel Speed along the corridors
- Average Running Speed of the links between the junctions
- Delays at intersections and other locations and cause of delays



Data is presented by link wise (from the stop line of up stream junction to stop line of down stream junction) and corridor wise. The details of speed & delay survey analysis carried out as part of post implementation of ATCS are presented in Chapter 3.

2.4.4 Delay and Accumulation Survey

Delay is extra travel time incurred when a vehicle is impeded, in excess of the journey time if not impeded. Most delays in urban areas arise at intersections. Intersection delay is a measure of intersection performance, usually presented in the form of average delay in sec./vehicle.

During the reconnaissance survey of the junctions, Consultants have found that, some of the signalised intersections on the project corridors are operating at very high degree of saturation levels. Moreover at un-signalised intersections, the vehicle users from the minor roads generally do not follow the traffic regulations and they simply enter into the intersection forcing the traffic on major streets to stop till they cross the intersection. Consultants have reviewed alternative field procedures for finding the average delay. The effective field measurement of average delay for this type of traffic operating conditions is Inflow-Outflow Method and the same has been adopted in the present study for estimating the average delay at the intersections.

Inflow-Outflow Method:

Inflow-Outflow method of measurement of delay is most suitable when the arrival flows are higher than the capacity of lane group under consideration i.e. over saturation scenarios at signalised intersections. Moreover this is the general method for finding average delay at unsignalised intersections as well. The adopted method and field survey procedure are as follows:

- For the subject lane group, the arrival pattern of the vehicles has been observed dynamically at the time of joining the queue at an interval of 5 seconds for the period of 8 to 12 cycles period in case of signalised intersections and 8 to 10 minutes in case of un-signalised intersection by a group of 3 trained traffic engineers (One for informing the vehicle arrivals like C, M, MB, SB, T etc., one for informing the timing intervals, say 5, 10, 15 like that and the last one for noting the vehicle arrivals). The starting point for these observations is starting of red. Residual queue if any, cycle time, green and red time, lane group width etc. have been noted down before start of survey.
- For the subject lane group, the discharge pattern of the vehicles has been observed at an interval of 5 seconds during the survey period at the Stop Line by a group of 3



trained traffic engineers (One for informing the vehicle arrivals like C, M, MB, SB, T etc., one for informing the timing intervals, say 5, 10, 15 like that and the last one for noting the vehicle arrivals).

- Different vehicles have been converted into PCUs using appropriate PCU factors
- Cumulative arrival and discharge graphs have been prepared for the entire survey period.
- The total delay is the area between the cumulative arrivals and cumulative discharge graphs (PCU-Sec) and the average delay/PCU is obtained by dividing the total delay by total number of vehicles arrived during the analysis period.
- Level of Service (LOS) has been calculated as per HCM 2000 Guidelines, **Table 2.2**.

Table 2.2 Average Delay and level of Service: HCM 2000

Average Delay (Sec/PCU)	LOS
≤10	A
>10-20	B
>20-35	C
>35-55	D
>55-80	E
>80	F

2.5 Evaluation of Impact of ATCS

The following Measure of Effectives (MOEs) are considered for evaluation of impact of ATCS.

- Average Travel Speed
- Average Delay
- Average Saving in Fuel
- Average Time Saving

Average travel speed is obtained from the analysis of speed & delay survey. Average delay is obtained from speed and delay survey and delay and accumulation surveys.

Average Saving in Fuel

Fuel consumption of vehicles for pre and post implementation of ATCS scenarios is estimated based on the VOC equations developed as part of the Traffic and Transportation Study for Bandra-Worli Sea Link project carried out by IIT Bombay in 2000.



The delay estimated from Speed & Delay survey data is used for assessing the fuel consumption of vehicles along the corridor while for the fuel consumption across the corridor, delay & accumulation survey data is used.

Fuel consumption estimation along the corridor includes consumption during journey, stop & start operation consumption (can be called as deceleration & acceleration consumption). Fuel consumption estimation across the corridor includes stop & start operation consumption and idling consumption only.

Average Time Saving

Implementation of ATCS reduces waiting time delay at each junction, because of signal coordination and optimization of cycle length at each junction. Reduction in idling time also results in saving in overall travel time for vehicle users.

Benefits due to time savings are assessed based on estimated time savings multiplied by no. of vehicles (mode-wise) and unit VOT/vehicle values. The adopted unit VOT/vehicle values for different modes for estimating time saving benefits are presented in **Chapter 4**.



Chapter 3.0

Post Implementation Traffic Studies and Analysis

3.1 Introduction

Consultants have carried out post implementation traffic studies in addition to pre-implementation surveys and the results of the post implementation surveys analysis are presented in this Chapter.

3.2 Traffic Surveys and Schedule

To estimate the impact of ATCS on various corridors, it is required to compare the traffic studies of pre & post implementation of ATCS. Post implementation surveys have been carried out in similar lines of pre-implementation surveys and the survey schedule is presented in **Table 3.1**.

Table 3.1 Primary Traffic Surveys

Sl. No.	Type of Survey	Karve Road (6 Junc.)	J. M. Road (4 Junc.)	Laxmi Road (6 Junc.)	Shivaji Road (10 Junc.)	Bajirao Road (3 Junc.)	Tilak Road (9 Junc.)
1	Classified Turning Movement Count Survey	17/03/2006 and 21/03/2006	20/03/2006 and 21/03/2006	22/03/2006 to 24/03/2006	27/03/2006 to 29/03/2006	31/03/2006	03/04/2006 and 04/04/2006
2	Speed & Delay Survey	16/03/2006 to 04/04/2006					
3	Delay and Accumulation survey	05/04/2006 and 06/04/2006	07/04/2006 to 10/04/2006	12/04/2006 and 13/04/2006	17/04/2006 and 18/04/2006	19/04/2006	20/04/2006 and 21/04/2004

3.3 Traffic Signal Timing Data

Consultants have collected the traffic signal timing details for all the signalized intersections from CDAC and the same are presented in **Table 3.2**.



Table 3.2 Cycle Lengths in Operation at Various Junctions

Junction No.	Junction Name	Corridor Name	Post Implementation Cycle Length
1	Nal Stop Junction	Karve Road	120
2	Swatantra Chowk	Karve Road	60
3	Rasashala Chowk	Karve Road	60
4	Yaswantrao Chowk	Karve Road	60
5	Shelarmama Chowk	Karve Road	60
6	Kkandoji Baba Junction	Karve Road	120
7	Good Luck Chowk	Jangli Maharaj Road	130
8	Natraj Chowk	Jangli Maharaj Road	65
9	Jhansi Rani Chowk	Jangli Maharaj Road	130
10	S.G. Barve Chowk	Jangli Maharaj Road	130
11	Shivaji Chowk	Shivaji Road	70
12	Premeir Chowk	Shivaji Road	70
13	Hedgewar Chowk	Shivaji Road	70
14	Jijamatha Chowk	Shivaji Road	70
15	Budhwar Chowk	Shivaji Road	70
16	Belbaug Chowk	Shivaji Road	70
17	Rameswar Chowk	Shivaji Road	70
18	Gotiram Chowk	Shivaji Road	70
19	Phatgate Chowk	Shivaji Road	70
20	Rashtrabhushan Chowk	Shivaji Road	70
21	Jedhe Chowk	Thilak Road	170
22	Herabaug Chowk	Thilak Road	110
23	Puram Chowk	Thilak Road	110
24	Acharya Vinoba Marg	Thilak Road	110
25	S P College Chowk	Thilak Road	110
26	Tilak Smarak Chowk	Thilak Road	110
27	Sahitya Parishat Chowk	Thilak Road	110
28	New English School Chowk	Thilak Road	110
29	Alka Talkies Chowk	Thilak Road	110
30	Holkar Chowk	Laxmi Road	80
31	Umbriya Ganapathi Chowk	Laxmi Road	80
32	Kunte Chowk	Laxmi Road	40
33	Sevasadan	Laxmi Road	40
34	Sonya Muruti Chowk	Laxmi Road	40



Junction No.	Junction Name	Corridor Name	Post Implementation Cycle Length
35	Hamjekhan Chowk	Laxmi Road	40
36	Appa Balwant Chowk	Bajirao Road	110
37	Shanipark Chowk	Bajirao Road	110
38	Sanasputta Chowk	Bajirao Road	110

3.4 Classified Turning Movement Count Survey

This survey has been carried out at all 38 intersections and the peak hour intersection traffic volume in terms of vehicles and PCUs for morning and evening peak hours are presented in **Table 3.3**. Average traffic composition at various study intersections is presented in **Table 3.4**. The following inferences and observations are made based on the analysis of intersection traffic data.

- ❖ The highest peak hour intersection volume was 17337 PCUs/hr. observed at Nal Stop in the evening peak hour 19.00 hours to 20.00 hours followed by Jedhe Chowk (16976 PCUs/Hr) in the evening peak hour 20.00 hours to 21.00 hours.
- ❖ The lowest peak hour intersection volume was 2138 PCUs/hr observed at Phadgate Chowk in evening peak hour 18.00 hours to 19.00 hours.
- ❖ Maximum proportion of Two-Wheelers was observed at Hedgewar Chowk (60.97%)
- ❖ Maximum proportion of Cycles was observed at Hamje Khan Chowk. (18.88%)
- ❖ Maximum proportion of Buses was observed at Kandojibaba Chowk (7.46%)

The results of traffic analysis in the form of peak hour traffic flow diagrams, hourly variation of intersection volume, traffic composition, etc. at various intersections are presented in **Annexure 3.1**.

Table 3.3 Peak Hour Intersection Traffic

S. No	Junction Name	Morning Peak Hour	Peak Hour Traffic		Evening Peak Hour	Peak Hour Traffic	
			Vehicles	PCUs		Vehicles	PCUs
1	Nal Stop	10:00-11:00	20691	14453	19:00-20:00	25120	17331
2	Swatantra Chowk	10:00-11:00	7983	5729	18:00-19:00	9577	6529
3	Rasashala Chowk	11:00-12:00	12110	8466	19:00-20:00	13582	8711
4	Yashvant Rao Chowk	10:00-11:00	9444	6123	18:00-19:00	8603	5587
5	Shelar mama	09:00-10:00	8082	5710	19:00-20:00	9520	6452
6	Kandojibaba	11:00-12:00	8559	7511	19:00-20:00	10930	9983



S. No	Junction Name	Morning Peak Hour	Peak Hour Traffic		Evening Peak Hour	Peak Hour Traffic	
			Vehicles	PCUs		Vehicles	PCUs
7	Good Luck Chowk	10:00-11:00	9562	6657	18:00-19:00	9433	6441
8	Natraj Chowk	12:00-01:00	5813	4387	19:00-20:00	6522	5271
9	Jhansi Rani Chowk	12:00-13:00	11164	8007	19:00-20:00	13078	9156
10	S.G Barve Chowk	11:00-12:00	8562	7434	19:00-20:00	9138	7309
11	Shivaji Chowk	11:00-12:00	8791	7176	19:00-20:00	8175	6627
12	Premier Chowk	11:00-12:00	5817	4241	18:00-19:00	7323	4970
13	Hedgewar Chowk	11:00-12:00	12327	7993	19:00-20:00	11950	7891
14	Jijamata Chowk	11:00-12:00	5097	3875	19:00-20:00	5685	4191
15	Budhwar Chowk	11:00-12:00	7368	4996	18:00-19:00	8484	5796
16	Belbaug Chowk	11:00-12:00	2982	2330	19:00-20:00	4548	3196
17	Rameshwar Chowk	12:00-13:00	4727	3580	16:00-17:00	4441	3315
18	Gotiram	12:00-01:00	3165	2476	19:00-20:00	3541	2591
19	Phadgate Chowk	11:00-12:00	4166	2910	18:00-19:00	3089	2138
20	Rastrabhushan Chowk	10:00-11:00	5601	3590	18:00-19:00	5776	3749
21	Jedhe Chowk	10:00-11:00	14232	11915	20:00-21:00	15489	12276
22	Hirabaug Chowk	10:00-11:00	7322	5857	18:00-19:00	8963	6163
23	Puram Chowk	11:00-12:00	12517	9144	16:00-17:00	11316	8002
24	Vinoba Bhava Chowk	9:00-10:00	3758	2751	19:00-20:00	4078	2908
25	SP College Chowk	10:00-11:00	8280	5460	19:00-20:00	10622	7067
26	Tilak Smarak Chowk	11:00-12:00	6456	4382	17:00-18:00	5793	4093
27	Sahitya Parishat Chowk	10:00-11:00	5361	3527	19:00-20:00	6324	4259
28	New English School	10:00-11:00	3056	2146	19:00-20:00	3386	2377
29	Alka Chowk	11:00-12:00	9696	7922	18:00-19:00	10740	9051
30	Holker Chowk	11:00-12:00	4835	3290	19:00-20:00	4402	2810
31	Umbriya Ganapati Chowk	11:00-12:00	6299	4025	18:00-19:00	6255	4016
32	Kunte Chowk	11:00-12:00	5424	3595	17:00-18:00	6621	4453
33	Sevasadan Chowk	11:00-12:00	8247	5712	18:00-19:00	9337	6282
34	Sonya Maruthi Chowk	10:00-11:00	5323	3317	18:00-19:00	5302	3278
35	Hamjekhan Chowk	10:00-11:00	3824	2354	18:00-19:00	4059	2446
36	Appa Balwan Chowk	11:00-12:00	12258	8052	17:00-18:00	9904	6612
37	Shanipar Chowk	11:00-12:00	12140	8298	17:00-18:00	11581	8578
38	Sanas Putta Chowk	11:00-12:00	14864	10492	18:00-19:00	17356	12188



Table 3.4 Average Traffic Composition at Project Intersections (%)

S. No	Junction Name	Motorised Vehicles										NM Veh	
		TW	Auto	C/J/T	Bus			Truck			Agri. Tractor	Cycl e	Oth ers
					MB	PB	ST	LC V	2/3-Axle	MAV			
1	Nal Stop	54.49	18.30	17.92	0.36	0.40	1.66	0.67	0.27	0.01	0.01	5.91	0.01
2	Swatantra Chowk	50.79	21.64	16.96	0.28	0.22	1.78	1.02	0.14	0.00	0.00	7.13	0.04
3	Rasashala Chowk	52.84	21.28	13.68	0.09	0.09	1.26	1.32	0.14	0.01	0.00	9.25	0.04
4	Yashvant Rao Chowk	66.64	12.35	10.94	0.20	0.39	1.88	0.14	0.34	0.00	0.02	7.07	0.02
5	Shelar mama	57.37	17.62	12.71	0.44	0.47	2.17	1.22	0.11	0.01	0.02	7.82	0.05
6	Kandoji Baba	31.40	28.02	21.34	0.91	0.97	5.58	1.39	0.19	0.00	0.00	10.11	0.10
7	Good Luck Chowk	51.02	22.12	17.23	0.28	0.22	0.97	1.29	0.12	0.01	0.00	6.62	0.11
8	Natraj Chowk	46.05	21.89	17.44	0.47	0.52	3.50	2.29	0.08	0.00	0.00	7.70	0.05
9	Jhansi Rani Chowk	53.30	19.66	15.17	0.37	0.34	1.91	1.67	0.04	0.00	0.00	7.47	0.06
10	S.G Barwe Chowk	43.28	23.55	17.63	0.52	0.47	5.41	1.86	0.21	0.01	0.02	6.89	0.15
11	Shivaji Chowk	37.06	28.78	13.71	0.11	0.16	3.59	2.90	0.27	0.00	0.01	13.16	0.24
12	Premier Chowk	46.67	25.12	12.72	0.10	0.18	2.42	1.52	0.24	0.00	0.00	11.01	0.02
13	Hedgewar Chowk	60.97	17.40	10.85	0.08	0.17	1.34	1.68	0.49	0.01	0.00	6.89	0.10
14	Jijamata Chowk	38.80	24.06	14.37	0.17	0.18	3.21	3.40	0.01	0.00	0.00	15.79	0.00
15	Budhwar Chowk	50.11	27.19	10.21	0.15	0.04	1.21	2.96	0.16	0.01	0.00	7.87	0.11
16	Belbaug Chowk	38.14	29.75	13.87	0.14	0.08	2.75	2.20	0.31	0.04	0.02	12.49	0.21
17	Rameshwar Chowk	31.82	29.85	14.96	0.09	0.04	2.11	2.45	0.05	0.00	0.00	18.17	0.46
18	Gotiram	48.03	22.58	6.07	0.94	1.13	2.29	3.60	0.12	0.00	0.00	14.58	0.67
19	Phadgate Chowk	52.98	22.70	8.18	0.09	0.03	1.67	3.84	0.12	0.00	0.00	10.31	0.08
20	Rastrabhushan Chowk	47.92	22.89	9.77	0.21	0.11	0.92	1.04	0.09	0.02	0.00	16.93	0.11
21	Jedhe Chowk	39.39	29.66	17.11	0.39	0.36	4.77	0.95	0.26	0.06	0.07	6.90	0.09
22	Hirabaug Chowk	48.28	25.01	13.48	0.37	0.27	3.09	1.11	0.09	0.05	0.05	7.94	0.28
23	Puram Chowk	52.50	22.01	16.83	0.21	0.26	1.73	1.29	0.27	0.01	0.00	4.81	0.08
24	Vinoba Bhava Chowk	41.12	25.23	16.92	0.25	0.19	1.32	2.47	0.36	0.00	0.01	11.82	0.31
25	SP College Chowk	51.02	24.05	13.47	0.17	0.12	0.57	1.70	0.10	0.02	0.00	8.64	0.13
26	Tilak Smarak Chowk	45.84	25.15	11.70	0.05	0.03	1.07	1.43	0.15	0.01	0.00	14.25	0.31
27	Sahitya Parishat Chowk	53.03	21.41	12.36	0.12	0.06	0.87	2.00	0.02	0.01	0.06	9.90	0.15
28	New English School	45.66	18.71	17.33	0.44	0.11	1.43	1.35	0.26	0.02	0.03	14.52	0.15
29	Alka Chowk	28.91	32.09	24.48	0.33	0.30	2.68	2.09	0.45	0.07	0.03	8.42	0.14



S. No	Junction Name	Motorised Vehicles										NM Veh	
		TW	Auto	C/J/T	Bus			Truck			Agri. Tractor	Cycl e	Oth ers
					MB	PB	ST	LC V	2/3-Axle	MAV			
30	Holker Chowk	53.56	21.66	10.81	0.07	0.02	1.16	0.89	0.02	0.00	0.00	11.74	0.07
31	Umbriya Ganapati Chowk	52.59	25.47	9.06	0.13	0.03	1.02	1.48	0.18	0.00	0.00	9.99	0.05
32	Kunte Chowk	46.38	26.01	10.19	0.08	0.09	0.78	2.35	0.17	0.01	0.00	13.83	0.12
33	Sevasadan Chowk	55.80	20.92	10.27	0.07	0.04	2.39	1.22	0.08	0.00	0.00	9.14	0.08
34	Sonya Maruthi Chowk	57.42	25.87	2.97	0.04	0.00	0.52	1.98	0.08	0.03	0.00	10.80	0.28
35	Hamjekhan Chowk	57.10	16.00	3.28	0.36	0.02	0.70	3.30	0.20	0.02	0.01	18.88	0.12
36	Appa Balwan Chowk	48.56	27.48	11.63	0.07	0.05	1.16	1.05	0.04	0.01	0.00	9.95	0.01
37	Shanipar Chowk	45.10	24.99	15.21	0.06	0.16	1.71	1.21	0.22	0.01	0.01	11.19	0.14
38	Sanas Putta Chowk	42.80	25.79	19.51	0.14	0.07	0.42	1.66	0.17	0.01	0.04	9.35	0.04

Note: TW = Two Wheeler, Auto = Auto Rickshaw, C/J/T = Car/Jeep/Taxi, MB = Mini Bus, PB = Private Bus, ST = State Transport Bus, LCV = Light Commercial Vehicle, 2/3 Axle = 2/3 Axle Truck, MAV = Multi Axle Vehicle

3.5 Speed & Delay Survey

The Speed & Delay survey procedure followed during pre-implementation study is adopted for post implementation studies. Speed & Delay survey has been carried out separately for Karve Road, Jangli Maharaj Road, Tilak Road and Laxmi Road and together for Shivaji Road and Bajirao Road. The routes have been fixed in such a way that, the average time to complete the run is below 20 to 30 minutes so that 6 to 8 runs can be made during the peak period of 4 hours. In addition to speed and delay survey during peak periods, survey was carried out during early morning hours to capture the speed and delay characteristics on the corridors during free flow conditions.

3.5.1 Karve Road

Corridor Description: This road starts from Karve Putla and ends at Khandojibaba Chowk (i.e. Deccan) and in the present study, Karve road from Paud Flyover to Khandojibaba Chowk has been considered which is about 1.9 kms. The ROW of the road is about 32 m, the carriageway on either side is about 10 to 12 m. The width of the median is about 0.9 to 1.0 m and the paved shoulder is present on both the sides of the road. The width of the footpath on either side is about 2 to 2.5 m. However, most of the footpath is encroached by the shopkeepers. Predominant landuse on both the sides of the road is commercial. Presently concretization of the drainage lines is in progress and



the shoulder is fully digged on both the sides of the road. Because of this activity there is high traffic congestion on the corridor during peak periods.

Speed & Delay Study Analysis: The survey is carried out both during morning and evening peak periods. The total number of runs made was 8. Route characteristics are presented in **Table 3.5** and shown in **Figure 3.1**. The link wise analysis results are presented in **Table 3.6** and corridor level analysis results are presented in **Table 3.7**. Average Free flow speed, Running speed, Travel speed and Intersection delay are pictorially presented in **Figure 3.2**.

Table 3.5 Route Characteristics: Karve Road

Sl. No.	Ref. Point	Intersection/ Location Name	Link No.	Dist. (m)
1	1	Below Paud Flyover		
2	2	Nal Stop Junction, North	1	507
3	2A	Nal Stop Junction, South	2	29
4	3	Swatantra Chowk	3	364
5	4	Rasashala Chowk	4	389
6	5	Yeshwant Rao Chawan Chowk	5	383
7	6	Shelarmama Junction	6	120
8	7	Khandojibaba Chowk	7	117
9	10	Shelarmama Junction	8	91
10	11	Yeshwant Rao Chawan Chowk	9	121
11	12	Rasashala Chowk	10	382
12	13	Swatantra Chowk	11	388
13	14	Nal Stop Junction, South	12	327
14	15	Nal Stop Junction, North	13	60
15	1	Below Paud Flyover	14	536

Table 3.6 Link Wise Speed and Delay Survey Analysis: Karve Road

Link No.	Travel Speed (Kmph)	Running Speed (Kmph)	Free Flow Travel Speed (Kmph)	Average Delay (Sec.)
1	20.06	26.33	32.91	34
2	7.08	9.53	17.90	6
3	22.29	28.54	44.43	13
4	21.94	26.32	43.44	12



Link No.	Travel Speed (Kmph)	Running Speed (Kmph)	Free Flow Travel Speed (Kmph)	Average Delay (Sec.)
5	24.18	28.57	33.51	9
6	24.80	29.67	33.43	4
7	17.18	22.95	27.20	14
8	14.94	14.94	20.32	0
9	25.94	30.18	39.60	5
10	31.51	41.27	40.11	15
11	23.26	49.73	42.85	27
12	12.85	18.09	43.84	88
13	20.94	20.94	33.43	0
14	21.64	24.99	27.01	6

Table 3.7 Corridor Level Speed and Delay Survey Analysis: Karve Road

Run No.	Travel Time (sec)	Running Time (sec)	Travel Speed (kmph)	Running Speed (kmph)
1	757	537	18.13	25.56
2	687	536	20.00	25.61
3	700	573	19.61	23.95
4	605	452	22.70	30.35
5	735	560	18.67	24.52
6	1352	1124	10.15	12.22
7	1197	677	11.47	20.28
8	818	625	16.78	21.98
Average Speed (kmph)			17.19	23.06

The following inferences and observations are made based on the analysis of Speed & Delay survey on Karve Road:

- ❖ The maximum travel speed is 31.51 kmph observed between Yashwant Rao Chawan Chowk and Rasashala Chowk and maximum running speed is 49.73 Kmph observed between Rasashala Chowk and Swatantra Chowk.
- ❖ The minimum travel and running speeds are 7.08 Kmph and 9.53 Kmph observed between Nal Stop, North and Nal Stop, South respectively.
- ❖ The maximum free flow speed is 44.43 Kmph, observed between Nal Stop Junction, South and Swatantrata Chowk.
- ❖ The maximum intersection delay of 88 seconds is observed at Nal Stop, South.



- ❖ At corridor level, the average travel speed and running speeds are 17.19 kmph and 23.06 kmph respectively.

3.5.2 J M Road

Corridor Description: This road starts from Khandojibaba Chowk and ends at Subhash Chandra Bose Chowk and the traffic movement is two-way. The corridor is about 2.0 km in length and is one of the congested roads of the city. The carriageway width is in the range of 16-20 m. Between Jhansi Laxmi Chowk and Sanas Bridge there are number of minor lanes which bring turning traffic from Apte Road to Jangli Maharaj Road. This turning traffic reduces vehicles speed and causes unsafe conditions on the road. Due to presence of highly commercial activities on both sides of the road, heavy pedestrian movement both along and across the road is observed. On-street parking facility is provided on both sides of the road and parking maneuvering especially during the peak hours hinders the movement of traffic.

Free right turning movement is allowed at the Good Luck Cafe without sufficient space for the turning maneuverability. Immediate bus stop at Natraj Chowk obstructs the through movement of traffic. There is no proper co-ordination between the corridor cycle times and the cycle times at Kudale Chowk and Bhosale Chowk. This causes heavy irregular flows on to Jhansi Chowk.

Speed & Delay Study Analysis: Speed & Delay survey was carried out on J.M Road during the morning and evening peak periods. The total number of runs made was 9. Route characteristics are presented in **Table 3.8** and shown in **Figure 3.3**. The link wise analysis results are presented in **Table 3.9** and corridor level analysis results are presented in **Table 3.10**. Average Free flow speed, Running speed, Travel speed and Intersection delay are pictorially presented in **Figure 3.4**.

Table 3.8 Route Characteristics: J. M. Road

Sl. No.	Ref. Point	Intersection/ Location Name	Link No.	Dist. (m)
1	1	Near Bhosale Arcade		
2	2	Good Luck Junction	1	427
3	CSR	Case Sunrise	2	167
4	3	Natraj Junction	3	74
5	4	Kudale Chowk	4	277
6	5	Jhansi Rani Chowk	5	434
7	6	Bhosale Chowk	6	282



Sl. No.	Ref. Point	Intersection/ Location Name	Link No.	Dist. (m)
8	7	S. G. Barve Chowk	7	315
9	8	S. G. Barve Chowk	8	552
10	9	Bhosale Chowk	9	323
11	10	Jhansi Laxmi Chowk	10	276
12	11	Kudale Chowk	11	440
13	12	Natraj Junction	12	267
14	1	Near Bhosale Arcade	13	77

Table 3.9 Link Wise Speed and Delay Survey Analysis: J. M. Road

Link No.	Travel Speed (kmph)	Running Speed (kmph)	Free Flow Travel Speed (kmph)	Average Delay (sec.)
1	23.07	23.07	32.09	0
2	23.07	23.07	32.00	0
3	19.76	20.94	29.60	3
4	28.73	35.83	47.87	6
5	21.02	22.62	56.40	5
6	17.98	26.11	55.41	24
7	14.80	25.69	43.57	39
8	11.68	21.34	33.39	73
9	17.31	22.42	40.28	16
10	13.48	24.46	46.13	47
11	35.72	36.91	46.39	8
12	18.48	29.08	49.46	26
13	14.51	16.39	64.68	1



Table 3.10 Corridor Level Speed and Delay Survey Analysis: J.M Road

Run No.	Travel Time (sec)	Running Time (sec)	Travel Speed (kmph)	Running Speed (kmph)
1	789	544	17.84	25.88
2	841	587	16.74	23.99
3	928	641	15.17	21.97
4	837	674	16.82	20.89
5	836	711	16.84	19.80
6	755	514	18.65	27.39
7	962	727	14.64	19.37
8	1094	750	12.87	18.77
9	944	605	14.91	23.27
Average Speed (kmph)			16.05	22.37

The following inferences and observations are made based on the analysis of Speed & Delay survey on JM Road

- ❖ The maximum travel speed and running speed are 35.72 kmph and 36.91 kmph respectively observed between Jhansi Laxmi Chowk and Kudale Chowk.
- ❖ The minimum travel speed and running speed are 13.48 kmph and 24.46 kmph respectively observed between Bhosale Chowk and Jhansi Chowk.
- ❖ The maximum free flow speed of 64.68 Kmph was observed between Natraj Chowk and Bhosale Arcade.
- ❖ The maximum intersection delay was 73 seconds observed near S G Bharve Chowk.
- ❖ At corridor level, the average travel speed and running speeds are 16.05 kmph and 22.37 kmph respectively.

3.5.3 Tilak Road

Corridor Description: This road starts from Jedhe Chowk and ends at Alka Chowk and the traffic movement is two-way. This corridor is about 2.3 km in length and has 6-10 m of carriageway width and 8-12 m of right of way. Along this road, due to presence of some major educational institutions like SP College, Maratha Mandal, Abhinav College etc., large number of educational trips is observed. There is a lot of pedestrian movement, both along and across the road particularly during the morning peak hours. There are number of uncontrolled intersections where vehicles and pedestrians obstruct



free flow of through traffic on Tilak Road. On-street parking is provided on one of the sides of the road on alternative day basis.

Speed & Delay Study Analysis: Speed & Delay Survey was carried out on Tiak Road during the morning and evening peak periods. The total number of runs made was 6. Route characteristics are presented in **Table 3.11** and shown in **Figure 3.5**. Speed & Delay survey analysis results are presented in **Table 3.12**. At corridor level, average travel speed and running speeds are estimated and the details are presented in **Table 3.13**. Average Free Flow Speed, Running Speed, Travel Speed and Intersection Delay are pictorially presented in **Figure 3.6**.

Table 3.11 Route Characteristics: Tilak Road

Sl. No.	Ref. Point	Intersection/ Location Name	Link No.	Dist. (m)
1	1	Near Laxmi Narayan Chowk		
2	1A	Near Jedhe Chowk	1	213
3	2	Jedhe Chowk	1A	90
4	3	Jn. of Tilak Rd. x Shivaji Rd.	2	52
5	4	Herabagh Chowk	3	441
6	5	Puram Chowk	4	203
7	6	Vinobha Bhav Chowk	5	105
8	7	S. P. College Chowk	6	241
9	8	Tilak Smarak Chowk	7	185
10	9	Sahitya Parishat Chowk	8	354
11	10	New English School Chowk	9	91
12	11	Shahir Annabhav Sate Chowk	10	157
13	12	Lokamanya Tilak Chowk	11	40
14	13	Shahir Annabhav Sate Chowk	12	40
15	14	New English School Chowk	13	107
16	15	Sahitya Parishat Chowk	14	141
17	16	Tilak Smarak Chowk	15	397
18	16A	S. P. College Chowk, North	16	136
19	17	S. P. College Chowk, South	17	31
20	18	Vinobha Bhav Chowk	18	241
21	19	Puram Chowk	19	137
22	20	Herabagh Chowk	20	253
23	21	Jn. of Tilak Rd. x Shivaji Rd.	21	486
24	22	Jedhe Chowk	22	45
25	1	Near Laxmi Narayan Chowk	23	353



Table 3.12 Link Wise Speed and Delay Survey Analysis: Tilak Road

Link No.	Travel Speed (kmph)	Running Speed (kmph)	Free Flow Travel Speed (kmph)	Average Delay (sec.)
1	12.02	20.58	41.95	51
2	12.82	12.82	20.80	0
3	20.68	20.68	39.69	0
4	15.11	17.92	28.45	10
5	10.51	10.85	17.28	2
6	12.25	16.35	36.24	24
7	13.88	16.95	38.77	12
8	14.70	17.00	35.15	10
9	15.41	15.41	23.05	0
10	10.92	21.32	34.05	26
11	4.37	8.09	14.40	27
12	11.92	11.95	18.00	0
13	20.57	20.57	18.32	0
14	18.05	23.20	47.75	8
15	18.05	23.20	47.75	8
16	15.61	15.61	41.10	0
17	13.32	15.48	41.58	19
18	18.76	19.08	34.54	3
19	13.11	17.21	29.89	17
20	20.52	21.14	32.65	2
21	21.91	21.91	38.83	0
22	4.98	13.29	17.07	68
23	32.73	32.73	48.88	0



Table 3.13 Corridor Level Speed and Delay Survey Analysis: Tilak Road

Run No.	Travel Time (sec)	Running Time (sec)	Travel Speed (kmph)	Running Speed (kmph)
1	1369	1000	11.93	16.33
2	1222	989	13.37	16.52
3	1402	1048	11.65	15.60
4	1136	885	14.39	18.47
5	980	798	16.67	20.48
Average Speed (kmph)			13.60	17.48

The following inferences and observations are made based on the analysis of Speed & Delay survey on Tilak Road

- ❖ The maximum travel speed and running speed are 32.73 kmph and 32.73 kmph respectively observed between Jedhe Chowk and Near Laxmi Narayan Chowk
- ❖ The minimum travel and running speeds are 4.37 kmph and 8.09 kmph respectively observed between Shahir Annabhav Sate Chowk and Lokamanya Tilak Chowk.
- ❖ The maximum free flow speed is 48.88 kmph, observed between Jedhe Chowk and Near Laxmi Narayan Chowk.
- ❖ The maximum intersection delay of 68 seconds is observed near Jedhe chowk.
- ❖ At corridor level, the average travel speed and running speeds are 13.60 kmph and 17.48 kmph respectively.

3.5.4 Laxmi Road

Corridor Description: Laxmi Road starts from Hamjekhan Chowk and ends at Alka Chowk and the traffic movement is one-way from Hamjekhan Chowk to Alka Chowk. In the present study entire length of corridor has been considered for Speed & Delay study which is about 2.0 kms. Laxmi Road has about 6 to 8 meter of carriageway width. It is a major road of the city with mix type of markets on both the sides of the road such as cloth market, jeweler shops, general shops etc. Footpaths are highly encroached by shop keepers and also by petty shops resulting into significant pedestrian movement on the carriageway exposing them to accidents. There is a provision for parking on either side of the road on alternative day basis. Moreover, unauthorized parking is observed on many sections of this road. Among all vehicles parked on the road, major share is of two wheelers with very less proportion of four wheelers and other modes.



Speed & Delay Study Analysis: Speed & Delay survey was carried out on Laxmi Road during the morning and evening peak periods. The total number of runs made was 12. Route characteristics of Laxmi Road are presented in **Table 3.14** and shown in **Figure 3.7**. Speed & Delay survey results are presented in **Table 3.15**. At corridor level, average travel speed and running speeds have been estimated and the details are presented in **Table 3.16**. Average Free Flow Speed, Running Speed, Travel Speed and Intersection Delay are pictorially presented in **Figure 3.8**.

Table 3.14 Route Characteristics: Laxmi Road

Sl. No.	Ref. Point	Intersection/ Location Name	Link No.	Dist. (m)
1	1	Duliya Maruti Mandir		
2	2	Hamjekhan Chowk	1	87
3	2A	Azad Chowk	2	208
4	3	Sonya Maruti Chowk	3	38
5	3A	Kedari Chowk	4	148
6	3B	Kegale Chowk	5	122
7	4	Bebaug Chowk	6	57
8	4A	Ganapati Chowk	7	158
9	5	Sevasadan Chowk	8	137
10	6	Kunte Chowk	9	157
11	7	Umbriya Ganapati Chowk	10	227
12	7A	Gokhale Chowk	11	224
13	7B		12	125
14	8	Holker Chowk	13	199
15	9	Alka Chowk	14	137



Table 3.15 Link Wise Speed and Delay Survey Analysis: Laxmi Road

Link No.	Travel Speed (kmph)	Running Speed (kmph)	Free Flow Travel Speed (kmph)	Average Delay (sec.)
1	18.29	19.07	22.06	1
2	19.34	20.33	30.29	4
3	10.64	12.77	10.72	3
4	20.01	20.38	40.02	1
5	23.62	24.31	30.62	4
6	17.83	19.57	31.63	3
7	19.10	19.63	32.15	1
8	13.15	16.61	24.66	3
9	15.56	17.47	24.73	5
10	13.02	15.17	34.30	1
11	23.02	24.36	37.73	10
12	23.71	23.71	35.44	5
13	27.29	27.76	41.16	11
14	14.80	18.89	30.00	3

Table 3.16 Corridor Level Speed and Delay Analysis: Laxmi Road

Run No.	Travel Time (sec)	Running Time (sec)	Travel Speed (kmph)	Running Speed (kmph)
1	429	394	16.97	18.48
2	411	371	17.74	19.66
3	466	396	15.63	18.42
4	603	478	12.09	15.23
5	591	465	12.34	15.67
6	487	396	14.97	18.42
7	390	316	18.69	23.06
8	326	314	22.34	23.20
9	343	324	21.24	22.48
Average Speed (kmph)			16.89	19.40



The following inferences and observations are made based on the analysis of Speed & Delay survey on Laxmi Road

- ❖ The maximum travel speed and running speed are 27.29 kmph and 27.76 kmph respectively observed between Ghokhale Chowk and Holker Chowk.
- ❖ The minimum travel speed and running speed are 10.64 kmph and 12.77 kmph respectively observed between Azad Chowk and Sonya Maruthi Chowk.
- ❖ The maximum free flow speed of 41.16 kmph is observed between Gokhale Chowk and Holker Chowk.
- ❖ The maximum intersection delay is 11 seconds, observed at Holker Chowk.
- ❖ At corridor level, the average travel speed and running speeds are 16.89 kmph and 19.40 kmph respectively.

3.5.5 Shivaji Road & Bajirao Road

Corridor Description: Shivaji Road and Bajirao Road are major one-way roads in old Pune city. Shivaji Road starts from Simla Office Junction on University Road and ends at Jedhe Chowk; Bajirao Road starts from Puram Chowk on Tilak Road and ends at Hedgewar Chowk. In the present study, Shivaji Road from S. G. Barve Chowk to Jedhe Chowk and Bajirao Road from Puram Chowk to Hedgewar Chowk have been considered. The route length covered in Speed & Delay study is about 6.9 kms, which includes both Shivaji Road and Bajirao Road. Shivaji Road is one of the congested and saturated roads with mix type of market on both the sides of the road. In spite of one way movement, the traffic intensity on these roads is very high with a major share of two wheelers and three wheelers. Due to the on-street parking on both the roads, large number of vehicles are parked making the road congested. High pedestrian flows are observed both along and across the roads.

Carriageway width of Shivaji Road and Bajirao Road varies from 6 m to 8 m and 8 m to 10 m respectively. Encroachment on the footpaths by shopkeepers and also by petty shops is observed which reduces the capacity of the road leading to congestion.

Speed & Delay Study Analysis: Speed & Delay survey was carried out on Tiak Road during the morning and evening peak periods. The total number of runs made was 10. Route characteristics are presented in **Table 3.17** and shown in **Figure 3.9**. Speed & Delay results are presented in **Table 3.18**. At corridor level, average travel speed and running speeds have been calculated and the details are presented in **Table 3.19**. Average Free Flow Speed, Running Speed, Travel Speed and Intersection Delay are pictorially presented in **Figure 3.10**.



Table 3.17 Route Characteristics: Shivaji Road & Bajirao Road

Sl. No.	Ref. Point	Intersection/ Location Name	Link No.	Dist. (m)
1	1A	S. G. Barve Chowk		
2	3	Shivaji Chowk	1	250
3	4	Premier Chowk	2	240
4	5	Hedgewar Chowk	3	400
5	6	Jijamata Chowk	4	214
6	7	Budhwar Chowk	5	260
7	8	Belbaug Chowk	6	100
8	9	Rameshwar Chowk	7	300
9	9A	Gotiram Chowk	8	130
10	10	Phadgate Chowk	9	400
11	11	Rashtra Bushan Chowk	10	600
12	12	Jedhe Chowk	11	400
13	12A	Sant Tukadoji Maharaj Chowk	12	520
14	13	Sanas Putta Chowk	13	320
15	14	Puram Chowk	14	148
16	15	Shani Park Chowk, Near Mandir	15	900
17	16	Shani Park Chowk, Near Chitale Sweets	16	66
18	17	Sevasadan Chowk	17	92
19	18	Appa Balawant Chowk	18	215
20	18A	Near Shaniwar Wada	19	400
21	19	Hedgewar Chowk	20	169
22	19A	Starting of Shivaji Bridge	21	50
23	20	Premier Chowk	22	300
24	21	Shivaji Chowk	23	129
25	1A	S. G. Barve Chowk	24	298



Table 3.18 Link Wise Speed and Delay Survey Analysis: Shivaji Road & Bajirao Road

Link No.	Travel Speed (kmph)	Running Speed (kmph)	Free Flow Travel Speed (kmph)	Average Delay (sec.)
1	26.04	29.35	45.30	10
2	38.73	40.33	54.39	2
3	25.48	25.48	37.14	0
4	10.90	13.93	19.08	17
5	21.61	25.23	47.78	9
6	5.48	7.72	15.81	20
7	15.87	15.87	31.25	0
8	13.04	14.06	31.97	15
9	14.39	14.75	23.28	3
10	23.26	24.40	31.59	5
11	14.12	19.43	23.80	36
12	23.90	23.90	33.38	0
13	22.83	34.14	39.96	21
14	10.77	24.00	40.45	29
15	25.58	27.03	34.97	10
16	25.68	25.68	26.97	0
17	20.12	20.68	20.43	3
18	13.10	23.50	41.60	32
19	27.15	27.15	54.04	0
20	23.45	23.45	30.51	0
21	10.63	10.63	10.18	0
22	17.27	18.56	28.16	7
23	30.56	30.56	43.92	0
24	21.33	22.53	36.22	3



Table 3.19 Corridor Level Speed & Delay Survey Analysis: Shivaji Road & Bajirao Road

Run No.	Travel Time (sec)	Running Time (sec)	Travel Speed (kmph)	Running Speed (kmph)
1	1338	1091	18.57	22.78
2	1629	1369	15.25	18.14
3	1635	1281	15.19	19.39
4	1697	1391	14.64	17.86
5	1439	1251	17.26	19.86
6	1228	1101	20.23	22.57
7	1243	1159	19.99	21.44
Average Speeds (kmph)			17.31	20.29

The following inferences and observations are made based on the analysis of Speed & Delay survey on Shivaji Road & Bajirao Road

- ❖ The maximum travel speed and running speed are 38.73 kmph and 40.33 kmph respectively observed between Shivaji Chowk and Premier Chowk.
- ❖ The minimum travel speed and running speed are 5.48 kmph and 7.72 kmph respectively observed between Budhwar Chowk and Belbaug Chowk.
- ❖ The maximum free flow speed of 54.39 kmph was observed between Shivaji Chowk and Premier Chowk.
- ❖ The maximum intersection delay is 36 seconds, observed at Jedhe Chowk.
- ❖ At corridor level, the average travel speed and running speeds are 17.31 kmph and 20.29 kmph respectively.

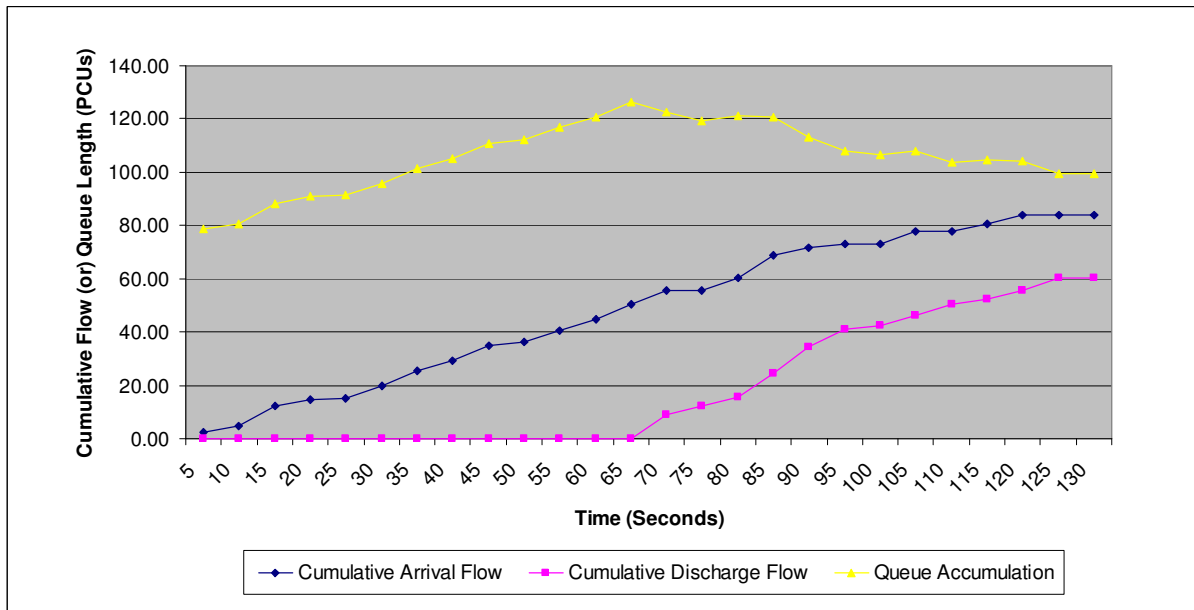
3.6 Delay & Accumulation Survey

Delay & Accumulation survey was carried out on the same approaches/lane groups which were selected for pre-implementation survey. Since, most of the through approaches/ lane groups have been covered as part of Speed & Delay survey as explained in earlier sections, more number of minor road approaches have been selected on sample basis for Delay & Accumulation survey. Delay & Accumulation survey has been carried out at 38 junctions over 70 approaches. The details of delay in Seconds/PCU, maximum queue length in PCUs, Level of Service as per HCM 2000 are presented in **Table 3.20** and **Table 3.21**. The following inferences have been made based on the delay and accumulation survey data analysis.



- Out of the 70 approaches 59 approaches are surveyed, 9 approaches are operating at LoS F, 13 approaches are operating at LoS E, 20 approaches are operating at LoS D, 14 approaches are operating at LoS C, 3 approaches are operating at LoS B, no approaches are operating at LoS A.
- Maximum delay of 213 sec./PCU has been observed at Jedhe Chowk for Shankar Sheth approach. The average maximum queue length is 45 PCUs.
- At Jhansi Laxmi Chowk on Congress House Road side approach-Right and Through movements, the maximum observed delay is 54 sec./PCU and average maximum queue length is 20 PCUs.
- At Alka Talkies Chowk on Sambhaji Bridge side approach-Right, Through and Left movements, the maximum observed delay is 74 sec./PCU and average maximum queue length is 15 PCUs.
- At Khandojibaba Chowk on Shelarmama Junction side approach-Left turning movement, the maximum observed delay is 54 sec./PCU and average maximum queue length is 21 PCUs.
- At Swantanrya Chowk on Rasashala Chowk side approach, the maximum observed delay is 56 sec./PCU and average maximum queue length is 11 PCUs.
- At Goodluck Junction on Khandoji Baba side approach, the maximum observed delay is 23 sec./PCU and average maximum queue length is 10 PCUs.
- At Belbagh Chowk on Budhwar Chowk side approach, the maximum observed delay is 24 sec./PCU and average maximum queue length is 21 PCUs.
- At Sevasadan Chowk on Bajirao Road side approach, the maximum observed delay is 13 sec./PCU and average maximum queue length is 10 PCUs.

Typical cumulative arrival, discharge pattern and queue length graphs are presented in **Figure 3.11** to **Figure 3.12**.



Note: Graph shows the details of cycle no. 6 and the residual queue at the end of cycle no. 5 is 78.50 PCUs, which is the ordinate of Queue accumulation curve at the starting of cycle No. 6. The discharge during green time is shown at saturation flow rate.

Figure 3.11 Cumulative Arrival, Discharge Patten and Queue Length for D.T. Colony Side Approach, Nal Stop Junction

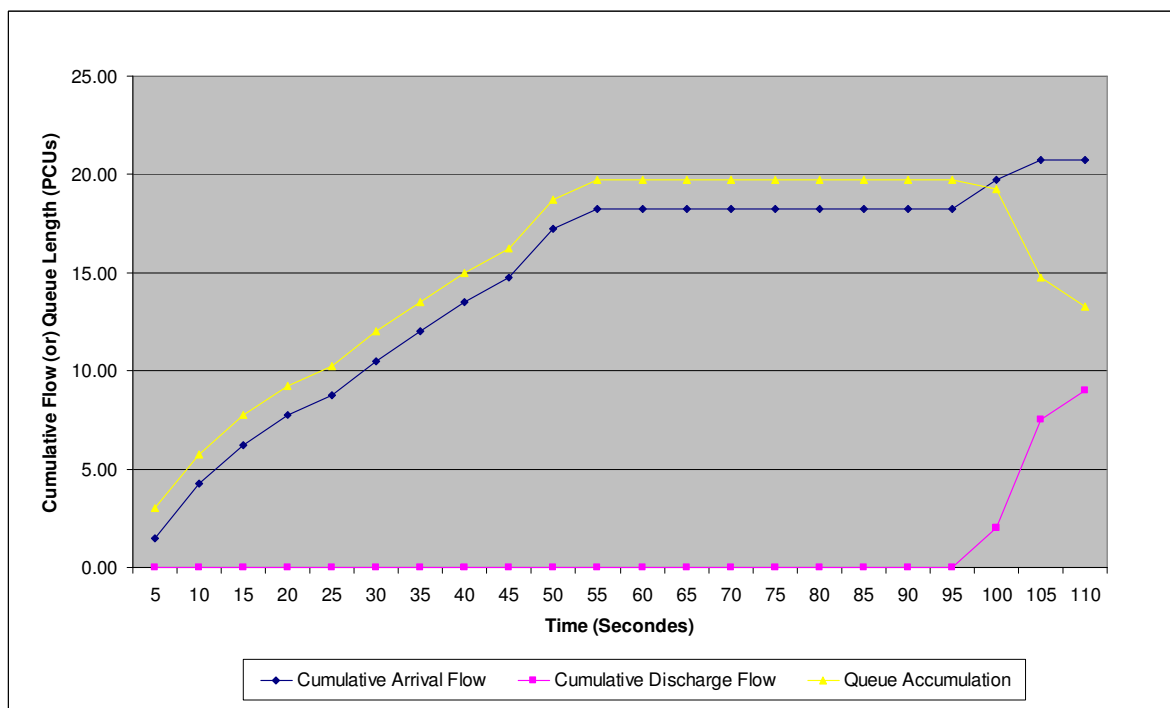


Figure 3.12 Cumulative Arrival, Discharge Patten and Queue Length for Siddhivinayak Chowk side Approach, Herabaug Chowk



Chapter 4.0

Evaluation & Impact Analysis

4.1 Introduction

With the rapid growth in vehicle population, traffic congestion has become a major concern on most of our city roads. Increasing the capacity by increasing the road width is a highly expensive proposition, and in many cases not possible. Better management of city traffic with the state-of-the-art technology, like ATCS, is the way out to a large extent. The Area Traffic Control System (ATCS) is an intelligent, fully adaptive traffic control system that use data from vehicle detectors and optimize traffic signal settings to reduce vehicle delays and stops.

The Level of Service (LOS) of any urban street mainly depends on the available carriageway, road geometry, traffic intensity, intersections and their geometry, type & efficiency of signal operation, etc. Area Traffic Control System plays a major role for smooth flow of traffic on urban streets. To evaluate impact of such system a comparative traffic study of Pre Implementation and Post Implementation is required. As part of present study Consultants have carried out required traffic studies during pre and post implementation stage of ATCS. This chapter presents Measure of Effectives (MoEs) during the pre and post implementation stage and the impact of ATCS.

4.2 Methodology for Impact Analysis

Following Measure of Effectives (MoEs) have been considered for evaluation of impact of ATCS:

- Average Travel Speed
- Average Delay
- Average Saving in Fuel
- Average Saving in Time

In the present analysis it has been assumed that the Geometric Improvements are minimal and their impact on the Measure of Effectives is not considered. However, the change in traffic volume from pre-implementation (2004) to post implementation (2006) has been considered while assessing the MoEs.



4.3 Intersection Traffic Volume Changes

Turning movement count surveys have been carried out at all 38 junctions after full implementation of ATCS. Ideally the total 24 hour daily traffic volume is to be compared for assessing the change in the traffic volume during pre and post implementation of ATCS. However, with the available data, only 8 hours traffic data (morning and evening peak hours) has been compared between pre and post implementation. It has been observed that there is considerable change in the peak period traffic at some of the intersections. These variations are mainly because of changes in traffic movement, new developments and other construction activities.

Corridor-wise traffic volume change (8 hours) on the six project corridors from the pre implementation (2004) to post implementation (2006) stage is presented in **Table 4.1**.

Table 4.1 Corridor wise Traffic Volume Change (PCUs)

Corridor Name	Pre Implementation Stage Traffic (2004)	Post Implementation Stage Traffic (2006)	Percentage Change
Karve Road	331425	351310	6.0%
J.M Road	248984	197655	-20.6%
Shivaji Road	253798	300976	18.6%
Tilak Road	329993	393168	19.1%
Laxmi Road	147834	152041	2.8%
Bajirao Road	131447	182696	39.0%

Traffic has increased on all the corridors except on JM Road. The maximum traffic increase is on Bajirao Road (39.0%) followed by Tilak Road (19.1%) and Shivaji Road (18.6%). Decrease in the traffic has been observed on JM Road. This is mainly because of traffic diversion at some of the junctions on this corridor and the construction activities in the surrounding areas.

The increase in the traffic volume during 2004-2006 has considerable impact on the average speeds and delays along the corridor. A factor has been applied on average speed and delay observed during post implementation stage to consider the increase in traffic. The average traffic growth during 2004-2006 is about 4.5% per annum.



4.4 Signal Cycle Time Optimization

During pre implementation stage of ATCS there were 30 fixed signalized intersections and 8 un-signalized intersections and under ATCS all these intersections were signalized and coordinated. Pre and Post implementation Cycle length at various junctions is presented in **Table 4.2**.

Table 4.2 Pre & Post Implementation Cycle Length (Seconds)

Junction No.	Junction Name	Corridor	Pre Implementation Cycle Length	Post Implementation Cycle Length
1	Nal Stop Junction	Karve Road	145	120
2	Swatantra Chowk	Karve Road	75	60
3	Rasashala Chowk	Karve Road	65	60
4	Yaswantrao Chowk	Karve Road	98	60
5	Shelarmama Chowk	Karve Road	Blinking	60
6	Kkandoji Baba Junction	Karve Road	120	120
7	Good Luck Chowk	Jangli Maharaj Road	130	130
8	Natraj Chowk	Jangli Maharaj Road	92	65
9	Jhansi Rani Chowk	Jangli Maharaj Road	145	130
10	S.G. Barve Chowk	Jangli Maharaj Road	105	130
11	Shivaji Chowk	Shivaji Road	105	70
12	Premeir Chowk	Shivaji Road	100	70
13	Hedgewar Chowk	Shivaji Road	US	70
14	Jijamatha Chowk	Shivaji Road	55	70
15	Budhwar Chowk	Shivaji Road	75	70
16	Belbaug Chowk	Shivaji Road	65	70
17	Rameswar Chowk	Shivaji Road	US	70
18	Gotiram Chowk	Shivaji Road	US	70
19	Phatgate Chowk	Shivaji Road	US	70
20	Rashtrabhushan Chowk	Shivaji Road	85	70
21	Jedhe Chowk	Tilak Road	135	170
			120	170
			140	170
22	Herabaug Chowk	Tilak Road	US	110
23	Puram Chowk	Tilak Road	120	110



Junction No.	Junction Name	Corridor	Pre Implementation Cycle Length	Post Implementation Cycle Length
24	Acharya Vinoba Marg	Tilak Road	US	110
25	S P College Chowk	Tilak Road	135	110
26	Tilak Smarak Chowk	Tilak Road	115	110
27	Sahitya Parishat Chowk	Tilak Road	100	110
28	New English School Chowk	Tilak Road	100	110
29	Alka Talkies Chowk	Tilak Road	145	110
30	Holkar Chowk	Laxmi Road	US	80
31	Umbriya Ganapathi Chowk	Laxmi Road	85	80
32	Kunte Chowk	Laxmi Road	57	40
33	Sevasadan	Laxmi Road	97	40
34	Sonya Muruti Chowk	Laxmi Road	65	40
35	Hamjekhan Chowk	Laxmi Road	50	40
36	Appa Balwant Chowk	Bajirao Road	105	110
37	Sahnipark Chowk	Bajirao Road	100	110
38	Sanasputta Chowk	Bajirao Road	125	110

By implementing ATCS, cycle lengths of various intersections are optimized. The maximum cycle length of 170 seconds was at Jedhe Chowk. Corridor wise cycle length optimization is presented in **Table 4.3**.

Table 4.3 Pre & Post Implementation Cycle Length

Corridor	Pre Implementation Cycle Length (Sec)	Post Implementation Cycle Length (Sec)	% Optimization
Karve Road	503	420	17%
JM Road	472	455	4%
Shivaji Road	485	420	13%
Tilak Road	847	830	2%
Laxmi Road	354	240	32%
Bajirao Road	330	330	0%

4.5 Average Travel Speed

Speed and Delay Survey analysis of pre and post implementation stages of ATCS is used for evaluating the ATCS impact on the travel speed on the project corridors. The



effect of increase in the traffic has been considered while comparing the speeds of pre and post implementation stage. Average travel speed and percentage change in speed during pre and post implementation stages of ATCS on all 5 corridors (6 Roads) are presented in **Table 4.4** and shown in **Figure 4.1**.

Table 4.4 Average Travel Speed on Various Corridors

Corridor	Stage	Travel Speed (kmph)
Karve Road	Pre Implementation	16.77
	Post Implementation	17.19
	% Change	2.49%
JM Road	Pre Implementation	15.71
	Post Implementation	16.05
	% Change	2.19%
Tilak Road	Pre Implementation	12.18
	Post Implementation	13.60
	% Change	11.70%
Laxmi Road	Pre Implementation	15.72
	Post Implementation	16.89
	% Change	7.41%
Shivaji Road & Bajirao Road	Pre Implementation	15.96
	Post Implementation	17.31
	% Change	8.41%

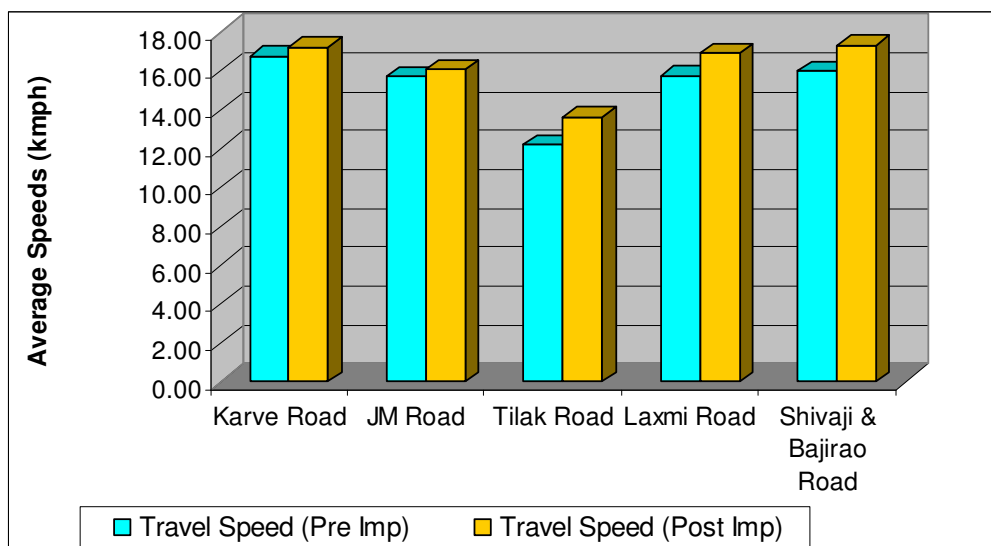


Figure 4.1 Comparison of Average Travel Speed



On all the corridors the average travel speeds have increased after implementing ATCS. The maximum increase was observed on Tilak Road (11.70%) followed by Shivaji Road & Bajirao Road (8.41%).

4.6 Average Delay

ATCS is fully adaptive traffic control system and coordinates all the junction traffic signals along the corridor. Signal coordination will lead to reduction in idling delays at each junction. Speed and Delay analysis of pre and post implementation stages of ATCS is used for evaluating the impact of ATCS on delay characteristics i.e., Average Delay at each junction along the project corridors. Average delay for pre and post implementation stages of ATCS and percentage change in delay on all 5 corridors (6 Roads) are presented in **Table 4.5** and shown in **Figure 4.2**.

Table 4.5 Average Delay on Various Corridors

Road	Stage	Delay (Sec)
Karve Road	Pre Implementation	260.67
	Post Implementation	231.88
	% Change	11.05%
JM Road	Pre Implementation	282.50
	Post Implementation	248.11
	% Change	12.17%
Tilak Road	Pre Implementation	397.11
	Post Implementation	277.41
	% Change	30.14%
Laxmi Road	Pre Implementation	78.83
	Post Implementation	65.74
	% Change	16.61%
Shivaji Road & Bajirao Road	Pre Implementation	293.56
	Post Implementation	223.08
	% Change	24.01%

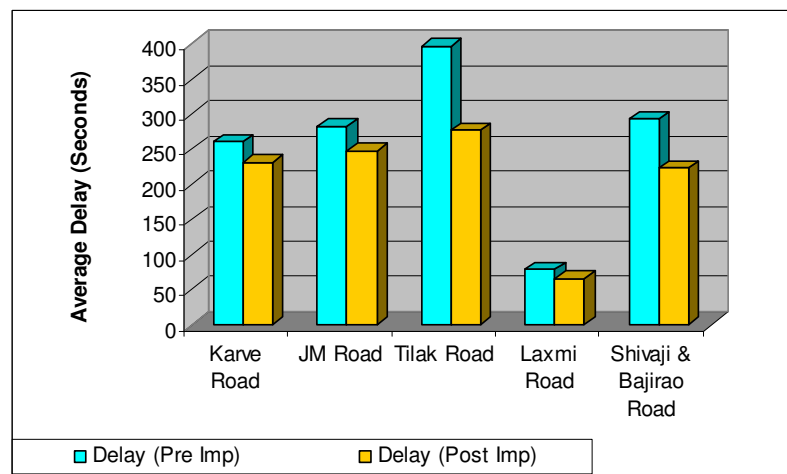


Figure 4.2 Comparison of Average Delay

The following observations are made based on the comparison of delays of pre and post implementation stages of ATCS:

- Maximum percentage of reduction in average corridor delay was observed on Tilak Road (30.14%) followed by Shivaji Road & Bajirao Road (24.01%)
- Percentage reduction in average corridor delay on Laxmi Road, JM Road and Karve Road are 16.61%, 12.17% and 11.05% respectively.
- ❖ On Laxmi Road mix type of commercial activities are located on both sides of the road such as cloth market, jeweler shops, general shops etc. Footpaths are highly encroached by shopkeepers and also by petty shops resulting into significant pedestrian movement on the main carriageway.
- ❖ On JM Road it was observed that there is improper co-ordination between Natraj Chowk and Kudale Chowk and Jhansi Laxmi Chowk and Bhosale Chowk
- ❖ Concretization of the drainage lines was in progress during the survey period on Karve Road and shoulders were fully dug on both sides of the road. Because of this activity there is high traffic congestion on the corridor during the peak periods.



4.7 Saving in Fuel Consumption of Vehicles

Fuel consumption for pre and post implementation stages of ATCS is estimated based on the equations developed as part of *Traffic and Transportation Study for Bandra Worli Sea Link Project* by IIT Bombay in the year 2000. For determining Fuel consumption of vehicles along the corridor, speed & delay survey data is used. This includes consumption during travel and stop & start operation (can be called as deceleration & acceleration consumption).

Fuel Consumption during Travel:

$$FC = A + B/V + C * V * V$$

FC (CAR) Rs.	=	(10.69+1737.72/V +0.0138 * V*V)*petrol*adist/1000
FC (AUTO) Rs.	=	(3.38+549.57/V +0.00436 * V*V)*petrol*adist/1000
FC (TW) Rs.	=	(3.38+549.57/V +0.00436 * V*V)*petrol*adist/1000
FC (BUS) Rs.	=	(42.2+4997.94/V +0.0265 * V*V)*diesel*adist/1000
FC (TRUCKS) Rs.	=	(57.54+5115.08/V +0.0271 * V*V)*diesel*adist/1000
FC (LCV) Rs.	=	(35.96+3185.44/V +0.0169 * V*V)*diesel*adist/1000

FC (Rs.) = Fuel Consumption during Travel

V (kmph) = Travel Speed

petrol (Rs.) = Petrol Price

diesel(Rs.) = Diesel Price

adist (Km) = Link Distance

Fuel Consumption during start/ stop from/to Cruise Speed:

For typical TRRL car (from Robertson et al., *Coordinating Traffic Signals to Reduce Fuel Consumption*, TRRL Report LR 934, Crowthorne, 1980), Fuel Consumption due to 1 PCU-stop/start from/to cruise speed is 9.4cc

Assumptions for Estimating the Fuel Savings:

- Only the traffic during peak period (8 hours of morning and evening peak periods) of pre implementation stage was considered for estimating the fuel savings.
- Fuel savings due to the reduction in delay for the cross traffic is not considered
- It is assumed that only 75% of vehicles on each corridor would be subjected to stop/start operation at the intersections.



- 360 days are considered in a year for estimation of annual savings
- Petrol and Diesel prices are taken as Rs. 53.89 and Rs. 40.78 respectively

Corridor wise annual fuel consumption of vehicles in the base year for pre & post implementation stages and estimated fuel savings are presented in **Table 4.6**. The estimated annual fuel savings in the year 2006 due to implementation of ATCS is about Rs. 4.77 crores.

Table 4.6 Estimated Annual Fuel Savings

(Rs. Crores)

S. No	Corridor Name	Fuel Consumption (Pre-Implementation)	Fuel Consumption (Post-Implementation)	Fuel Savings
1	Karve Road	18.13	17.05	1.07
2	J. M. Road	18.94	18.51	0.43
3	Tilak Road	16.55	15.63	0.91
4	Laxmi Road	7.60	7.38	0.23
5	Shivaji Road & Bajirao Road	24.14	22.01	2.13
Total		85.36	80.58	4.77

4.8 Travel Time Savings

Implementation of ATCS would reduce idling delay at each junction, mainly because of signal coordination and optimization of cycle length. Reduction in idling time will result into saving in overall travel time of vehicle users.

Time savings due to reduction in idling time at each intersection are estimated based on speed and delay survey data collected during pre and post implementation stages of ATCS. Benefits due to time saving are assessed based on the estimated time savings multiplied by number of vehicles and unit VOT/vehicle values. It is assumed that only 75% of vehicles on each corridor would be subjected to delay at the intersections. The adopted unit VOT/vehicle values for different modes for estimating time saving benefits are presented in **Table 4.7**. Corridor wise annual time saving benefits (in terms of rupees) due to implementation of ATCS is presented in **Table 4.8**. The estimated annual time saving benefits in the year 2006 due to implementation of ATCS is about Rs. 0.83 crores.



Table 4.7 Unit VOT Values

Type of Vehicles	Car	Auto	TW	Bus	Trucks	LCV
Unit VOT (Rs./Hr.)	102.77	53.35	38.03	805.97	159.68	106.45

Source: Detailed Engineering & Final Design for SATIS – Chembur Station Area (2001)
(World Bank Project - Updated to year 2006 prices).

Table 4.8 Annual Travel Time Saving Benefit

S.No	Corridor Name	VOT Savings (Rs. Crores)
1	Karve Road	0.16
2	J. M. Road	0.18
3	Tilak Road	0.20
4	Laxmi Road	0.08
5	Shivaji Road & Bajirao Road	0.22
Total		0.83

4.9 Summary

Implementation of any capital intensive traffic management measures needs pre and post Implementation analysis to study the effectiveness of the proposed measures. Based on the detailed pre and post implementation traffic studies, it is found that there is a substantial impact of ATCS on each of the project corridors in terms of increase in speeds and decrease in delays. The measure of effectiveness (MoEs) are estimated both for pre and post implementation stages of ATCS. Summary of these MoEs are as follows:

- ❖ The average travel speed increase is in the range of 2% to 12%.
- ❖ The reduction in average delay is in the range of 11% to 30%.
- ❖ The estimated annual fuel savings in the year 2006 due to implementation of ATCS is about Rs. 4.77 crores.
- ❖ The estimated annual time saving benefits in the year 2006 due to implementation of ATCS is about Rs. 0.83 crores.
- ❖ Total annual saving in the year 2006 due to implementation of ATCS on the 6 project corridors is about Rs. 5.60 crores.