Jimma University

School of Graduate Studies

Jimma Institute of Technology

Faculty of Civil & Environmental Engineering

Highway Engineering Stream

Evaluation on the Effect of Parking Problems on Transportation System in Addis Ababa: Case Study in Addis Ketema Sub- City

A Thesis Submitted to Jimma University Post Graduate Studies, Faculty of Civil and Environmental Engineering in Partial Fulfillment of the Requirement for the Degree of Master of Science in Civil Engineering Highway Engineering Stream

By

Taye Abu

December 2017

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Taye Abu

Main Advisor: **Prof. Emer T. Quezon (Professor-Full)**

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December 2017

Jimma, Ethiopia

Declaration

I, the undersigned, declare that this thesis entitled "**Evaluation on the Effect of Parking Problems on Transportation System in Addis Ababa: Case Study in Addis Ketema Sub- City.**" is my original work, and has not been presented by any other person for an award of a degree in this or any other University, and all sources of material used for this thesis have been duly acknowledged.

Candidate:

Taye Abu

Signature_____

As Master's Thesis Advisors, we hereby certify that we have read and evaluated this MSc Thesis prepared under our guidance, by TAYE ABU entitled: **Evaluation on the Effect of Parking Problems on Transportation System in Addis Ababa: Case Study in Addis Ketema Sub- City.**."

We recommend that it can be submitted as fulfilling the MSc Thesis requirements.

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Co- Advisor	Signature	Date

ABSTRACT

Parking is the act of stopping and disengaging a vehicle and leaving it unoccupied. These days, parking is a major challenge in different sub cities of Addis Ababa. Among Addis Ababa sub-cities, Addis ketema sub-city where, public circulation is one of the most obvious problems, and parking seems to be an overlooked element of transportation development. Sites of activities such as market centers, shops, churches, mosques, offices, schools, and similar places often generate huge parking demands, and increase the parking problems in the sub-city.

Thus, the main objective of this study is to evaluate the effect of parking problems in Addis Ababa, Addis ketema sub-city. The study also seek to identify the effectiveness of parking utilization to enable the parking spaces to accommodate a large number of vehicles and the effect of on-street parking on travel time.

The study used the License plate method of parking survey for both on street and off-street parking surveys. These have been done for two days, one from the weekday Friday and one from the weekend Saturday from 9:00AM-5:00PM. The existing parking conditions were analyzed using Ms-excel. The relationships of utilized parking spaces to the available parking capacity were developed by SPSS software. The effects of on-street parking on travel time have been also analyzed using vissim simulation modeling software in two different situations one by considering roadside parking and the other by removing roadside parking.

Based on the findings the average parking occupancy of off-street and on-street parking was 90% and 80% respectively. However, off-street parking turnover is lower than on-street parking. This means the average parking duration of off-street parking were about 4hr per vehicle while the average parking duration of on-street parking were 2hr per vehicle. Using linear regression analysis, the relationship developed between utilized parking spaces and the available parking capacity of off-street and on-street parking show that parking spaces have been nearly full utilization of available capacity. The total average segment delay of total duration along the road segment due to roadside parking P4, P5 and P6 were 7.29, 12.01 and 25.95 seconds per vehicle respectively.

Lastly, the intervention through fare rate and time-restriction parking will improve the parking turnover and roadside parking would be shifted to off-street parking to improve the transportation system of the sub-city. Formulating parking control enforcement also to access the space, provide a clearway allowing the parking lane to be used as a through lane where peak hour traffic volumes exceed the available lane capacity.

Keywords: off-street parking, on-street parking, parking efficiency, parking utilization, travel time

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EQUATIONS

ACRONYMS

AACG: Addis Ababa City Government

AACRA: Addis Ababa City Road Authority

AACTPMO: Addis Ababa City Transport Program Management Office

AU: Africa Union

ITS: Intelligent Transport System

JiT: Jimma Institute of Technology

RHR: Relative Hazard Ratio

TDM: Transportation Demand Management

TPMO: Transport Program Management Office

SPSS: Statistical Package for the Social Sciences

UN: United Nation

VISSIM: **V**erkehr **I**n **S**tadten **SIM**ulation "in Dutch"

CHAPTER ONE

INTRODUCTION

1.1 Background

Globally, the rate of urbanization is increasing at an alarming rate with 50% of the world population expected to live in urban areas by 2025 and more transformation are expected in developing countries (World Bank, 2003). Despite some economic benefits, the rapid urban growth in these developing countries is outstripping the capacity of most cities to provide adequate services for their citizens (Cohen, B 2004). A high urbanization rate in combination with the intensity of desire for car ownership in developing countries causes a rapid growth of motorization (Gakenheimer, R 199).

The urban transport problems today manifest in the form of poorly maintained urban road network and road complementary facilities; inefficient public transport system and poor land-use-transport planning (Aderamo et al., 2013). But, cities and their transport systems are fully complementary. Cities are locations with a high level of accumulation and concentration of economic activities, which form complex spatial structures that are supported by transport systems (Rodrigue et al., 2006). The transportation systems according to Berry and Horton (1970) are the veins and arteries of urban areas linking together social and functional zones. Urban productivity is highly dependent on the efficiency of its transport systems to move people and goods between multiple origins and destinations. Thus, the most important transport problems are often related to urban areas when transport systems, for a variety of reasons cannot satisfy the requirements of urban mobility (Rodrigue et al., 2006).

Addis Ababa, capital of Ethiopia, is commercial and political center and exemplary of the rapid urban growth of Ethiopia. According to Central Statistical Agency, Ethiopia (2007) the population of Addis Ababa has nearly doubled every decade since the 1980s. The 2013 population size of the city is estimated at 3.1 million and is estimated to reach 12 million in 2024. It is also home to two continentally important institutions: the AU Commission and UN Economic Commission for Africa. It also accommodates many international Aid and Development organization and more than 100 embassies. Addis Ababa plays a critical role in sustaining the country's double-digit economic growth and delivering the potential benefits of urbanization.

According to Federal Road Transport Authority report,2011 in Addis Ababa, as elsewhere, where cars are one of the dominant modes of transportation, public circulation is one of the most obvious problems, and parking seems to be an overlooked element of transportation development.

Parking is defined as Wikipedia definition; it is the act of stopping and disengaging a vehicle and leaving it unoccupied. Parking on one or both sides of a road is often permitted, though sometimes with restrictions. Some buildings have parking facilities for the use of the buildings' users. Countries and local governments have rules for design and use of parking spaces.

Now, this research paper specifically evaluates the effect of parking efficiency and parking problems on transportation system in Addis Ababa, specifically in Addis ketema sub-city. The existing parking service is inadequate and suffers from operational problems, mainly street parking. Consequently, it has contributed to inefficient utilization of the road network, safety and congestion problems. Thus, parking remains one of the critical issues that need to be addressed through the transport planning of the city.

1.2 Statement of the Problem

People in business and customers regard on-street parking as an essential service because on-street parking occupies less land per space than off-street parking and provides convenient access to destinations. But, according to (Hongwei Guo et.al. 2012), on-street parking should be prohibited. Their reasons are that on-street parking occupies the resources of roadways; including car lanes, bike lanes, and sidewalks and that the parking maneuver (entering parking stalls) and un parking maneuver (departing from parking stalls) increase the delay of through traffic and reduce the capacity of the adjacent travel lane. Also, on-street parking has been found to increase traffic accidents.

Transport Policy of Addis Ababa; August, 2011, report identified parking as one of the key "infrastructural" challenges in Addis Ababa sub- city. Illegal parking is a major problem in different location of the city. Roadside parking is a common phenomenon, which reduces the traffic corridors meant for the efficient movement of automobiles and taxies. The resultant effect of such illegal parking is traffic congestion which also leads to delay in travel time and increases the cost of travel time. Unfortunately, off – street parking facilities are absent in most parts of the city. Especially, in Addis Ketema sub-

city around Merkato, which is the largest center of market place in Africa, on-street parking has been dominating and off street parking under story building has been converted to other purposes such as shops and stores. Places of activities such as market centers, shops, churches, mosques, offices and similar places often generate enormous parking demands, and create parking problems in the sub-city. Thus, parking today has become a major obstruction to smooth flow of traffic in the entire sub-cities of the capital.

This study, therefore, intends to fill the identified gap, by reviewing the practices of parking in the sub-city so as to find out the challenges and prospects faced by the concerned bureau in its efforts to reduce road traffic congestion, to increase parking efficiency and to evaluate the constraints encountered in implementing and execution of the parking management practice.

1.3 Research Questions

1. What are the characteristics and nature of existing parking condition of Addis Ketema sub-city?
2. How the relationship of utilized parking spaces and available parking capacity of on-street and off-street parking are developed at a given selected locations?
3. What are the factors influencing of on-street parking on travel time (moving traffic) at selected road sections?
4. What are the possible countermeasures of parking problems on transportation system of the city?

1.4 Research Objectives

1.4.1 General Objective

The general objective of the study was to evaluate the effect of parking and problems on transportation system in Addis Ketema sub-city.

1.4.2 Specific Objectives

- To study the characteristics and nature of the existing parking condition of Addis Ketema sub-city.
- To develop the relationship of utilized parking spaces and available parking capacity of on-street and off-street parking of selected locations.
- To evaluate the influence of on-street parking on travel time (moving traffic) at selected road sections.

- To develop an implementation plan or scheme that overcomes the problems associated with parking.

1.5 Significance of the Study

Success in parking management policy directly influences the efficiency of the transportation system, the economic competitiveness of a city, and the quality of life for the communities**.** Hence, the goal of this research would be provided an updated and comprehensive scan of current practices in on-street parking operations for congestion and concerned with off-street parking management and municipal authorities. Furthermore, the findings obtained from the study is helpful to gain information and knowledge about the parking and the corresponding impact in the city, which in turn, could help to develop countermeasures that could reduce the related transportation problem in the city. Also, this information initiates the investors to invest towards the parking generating.

In addition, the result of the study is expected to generate important findings that can help as useful input for further research to refine the conceptual and methodology of the present study.

1.6 Limitation of the Research

Due to time constrict and difficulty to collect parking data for all seven days to get the existing parking condition of each day because of the method of parking survey which is labor intensive, but the researcher take only two days parking survey. The availability of licensed version of Vissim software which is not found privately for the analysis purposes also, a challenge for the researcher.

1.7 The Scope of the Study

The study conducted in particular context of the Addis Ketema sub-city and focused only on the sub-city's utilized parking spaces and problems on transportation system. Further the study conducted on traffic delay and parking problems by giving special emphasis on on-street parking and off street parking existing parking condition of the study area.

CHAPTER TWO

REVIEW OF RELATED LITERATURES

2.1 Parking Types and Its Characteristics

Any vehicle traveling on a highway will at one time or another be parked for either relatively short time or a much longer time, depending on the reason for parking. The provision of parking is therefore an essential element of the highway mode of transportation.

Generally, according to Madhuri et al. (2012) parking is classified broadly in to on-street parking and off-street parking.

2.1.1 On-Street Parking

On-street parking means, the vehicles are parked on the sides of the street itself. This will be usually controlled by government agencies itself. Common types of on-street parking are as listed below (Madhuri et al. 2012).

It includes:

1. Parallel Parking

The vehicles are parked along the length of the road. Here there is no backward movement involved while parking or unparking the vehicle. Hence, it is the safest parking from the accident perspective. However, it consumes the maximum curb length and therefore only a minimum number of vehicles can be parked for a given curbed length. This method of parking produces least obstruction to the on-going track on the road since least road width is used (Madhuri et al. 2012).

2. Angle Parking

30^0 parking: - 30^0 parking in thirty-degree parking, the vehicles are parked at 30 concerning the road alignment. In this case, more vehicles can be parked compared to parallel parking. Delay caused to the road is also minimum in this type of parking (Madhuri et al. 2012).

3. 45^0 parking: - As the angle of parking increases, number of vehicles can be parked. Hence compared to parallel parking and thirty-degree parking, number of vehicles can be accommodated in this type of parking (Madhuri et al. 2012).
4. 60^0 parking:-The cars are parked at 60^0 to the direction of road. A number of vehicles can be accommodated in this parking type (Madhuri et al. 2012).
5. 90^0 parking: - In right angle parking or 90^0 parking, the vehicles are parked perpendicular to the direction of the road. Although it consumes maximum width curbed length required is very little. In this type of parking, the vehicles need complex maneuvering, and this may cause severe accidents. This arrangement obstructs to the road track particularly if the road width is less. However, it can accommodate maximum number of vehicles for a given curbed length (Madhuri et al. 2012).

Figure 2.1: Parallel On-street parking

Source: (www.engineeringcivil.com/parking) available [on line]

2.1.2 Off-Street Parking

Off-street parking means vehicles are parked off the street. This is usually controlled by commercial agencies (Madhuri et al. 2012).

It includes

- Surface car parking

- Multistory car parking
- Roof parking
- Mechanical car parking
- Underground car parking.

Figure 2.2: off-street parking

Source: www.engineeringcivil.com/parking [available on line]

2.2 Definitions of Parking Terms

J. Garber and A. Hoel (2009) define some terms commonly used in parking studies including parking volume, parking accumulation, parking load, parking duration, parking turnover and parking efficiency/occupancy J. Garber & A. Hoel (2009).

1. **Parking Volume**: Total number of the vehicles used the parking space is called parking volume.
2. **Parking accumulation**: It is defined as the number of vehicles parked at a given instant of time. Normally this is expressed by accumulation curve. Accumulation curve is the graph obtained by plotting the number of bays occupied with respect to time.
3. **Parking turnover**: It is the ratio of number of vehicles parked in duration to the number of parking bays available. This can be expressed as number of vehicles per bay per time duration.

Parking turnover = parking volume/no. of bays available…… Equation (2. 1)

4. **Parking load**: Parking load gives the area under the accumulation curve. It can also be obtained by simply multiplying the number of vehicles occupying the parking area at each time interval with the time interval. It is expressed as vehicle hours.
5. **Average parking duration**: It is the ratio of total vehicle hours to the number of vehicles parked.

   Parking duration =parking load/parking volume…….Equation (2.2)
6. **Parking efficiency**: Parking efficiency is also called occupancy or index. It is defined as the ratio of number of bays occupied in time duration to the total space available. It gives an aggregate measure of how effectively the parking space is utilized. Parking efficiency can be found out as follows.

   Parking efficiency = parking load/parking capacity× 100 …… Equation (2.3)
7. **Parking capacity** : the total number of parking space available

2.3 Types of Parking Survey Data

Parking surveys are conducted to collect the above said parking statistics. The most common parking surveys conducted is in-out survey, fixed period sampling and license plate method of survey (Tom.V, 2014).

2.3.1 License Plate Method of Survey

This type of parking survey is the most accurate and realistic data. In this case of survey, every parking stall is monitored at a continuous interval of 15 minutes or so and the license plate number is noted down. This will give the data regarding the duration for which a particular vehicle was using the parking bay. This will help in calculating the fare because fare is estimated based on the duration for which the vehicle was parked. If the time interval is shorter, then there are less chances of missing short-term parkers. But this method is very labor intensive (Tom.V, 2014).

2.4 Collection of Parking Data

Accumulation: Accumulation data are obtained by checking the amount of parking during regular intervals on different days of the week. The checks are usually carried out on an hourly or 2-hour basis between 6:00 AM and 12 midnights. The selection of the times

depends on the operation times of land-use activities that act as parking generators. For example, if a commercial zone is included, checks should be made during the times when retail shops are open, which may include periods up to 9:30 PM on some days. On the other hand, at truck stops, the highest accumulation may occur around midnight which requires information to be collected at that time. The information obtained is used to determine hourly variations of parking and peak periods of parking demand J. Garber & A. Hoel (2009).

Turnover and Duration: Information on turnover and duration is usually obtained by collecting data on a sample of parking spaces in a given block. This is done by recording the license plate of the vehicle parked on each parking space in the sample at the ends of fixed intervals during the study period. The length of the fixed intervals depends on the maximum permissible duration. For example, if the maximum permissible duration of parking at a curb face is 1 hour, a suitable interval is every 15 minutes. If the permissible duration is 2 hours, checking every 30 minutes would be appropriate. The manual collection of parking data is still commonly used J. Garber & A. Hoel (2009).

2.5 Parking Facility

Yulong et al., 2012 stated a few factors affecting parking service, such as type of parking facility, parking time, ratio of parking space utilization, turnover rate, and etc. Ratio of space utilization includes both peak-hour and average parking space occupying.

The quality of parking service, to a large degree, depends on vehicle parking characteristics that varies in time and space. It is necessary to select a single parking evaluation index that reflects dynamic parking service. Since the type of a parking facility and its capacity are fixed, they should not be considered in the service assessment. From supply-demand point of view, capacity (the maximum number of parking vehicles can be accommodated at one time) and demand (number of parking vehicles at one time) are key factors of service performance. The utilization rate of a single parking space reflects parking time and turnover rate. Two variables are selected for parking performance evaluation, which are defined in the following (Yulong et al., 2012).

1. Ratio of space utilized to capacity during peak-hour

$$\Lambda = \frac{S}{C} \qquad \text{……Equation (2.4)}$$

Where, λ: Parking occupancy

S: number of parking vehicles during peak-hour

C: parking facility's capacity

2. Average parking space utilization rate

$$\mu = \frac{\sum(t*P)}{T*C} * 100\% \quad \text{……Equation (2.5)}$$

Where, μ: Average parking space utilization rate

C: parking facility's capacity

t: vehicle parking time in minute

P: number of vehicles with parking time t

T: duration of survey time

The understanding of parking demand is critical to the findings associated with parking studies. Most literatures refer to parking demand as the observable parking occupancy of a defined parking facility. (Rye. T, 2010) describes it as the extent to which drivers use the existing supplies of these transport infrastructures; on-street parking spaces and off-street parking lots. Simply put parking demand as the necessity for a car to be parked.

In order to provide optimal parking supply, it is the practice in conventional planning to determine how much parking to be provided at a particular site by planners based on recommended minimum parking standards published by various professional organizations. This provides an index or parking ratio used to calculate the number of spaces to supply at a particular location. These are unconstrained and unadjusted values, which generally reflect the maximum supply that could be needed. These standards are often excessive and can usually be adjusted significantly downward (Litman, 2009).

The management of parking is considered to be borne out of the need to control the generation and the demand for parking verses the existing parking supply with the aim of achieving efficiency of the roadway system. Thus, the management of parking is considered to be transportation demand management (TDM) oriented. According to (Litman, 2012) parking management refers to various policies and programs that result in more efficient use of parking resources.

According to Spack, M., et al., (2010) describes TDM as a binding agreement outlining the efforts the owner/renters towards reducing their traffic impact and to reduce parking

demand and traffic generation by 10 to 20 percent compared to typical demand standards of the Institute of Transportation Engineers (ITE) Spack, M., et al.,(2010).

Conventional parking standards are based on parking demand surveys but the analysis does not usually take into account geographic, demographic and economic factors that can affect parking demand such as whether a site is urban or suburban, and whether parking is free or priced. These standards blunder toward over supply in many ways. They are derived from parking demand studies that were mostly performed in car-dependent locations. Applying these standards results in far more parking supply than is usually needed at most destinations, particularly where land use is mixed, there are good travel options, parking is managed for efficiency or priced (Bradley,1997).

2.6 The Effects of On-Street Parking on Travel Time

According to Hongwei.G, et al., 2012 the occupancy of the parking area shows a negative effect on travel time. The low occupancy (40%) is 4.39 times more likely than the high occupancy (100%) to make the vehicles have shorter travel times [see Fig. 2.3]. The effect of occupancy can be explained in two ways. First, the high occupancy means the time spent on cruising for a parking stall becomes longer. Therefore, the through vehicles have to follow the slow vehicles, and the travel-time increases simultaneously. On the other hand, the higher occupancy means more un parking vehicles than for the low occupancy at the same departure rate. The relative hazard ratio (RHR; it is also called the relative hazard index). It represents the ratio of the hazard for a vehicle with a given set of variables to the hazard for an average vehicle that has an average value for every variable. If the RHR is greater than 1 the effects of the variables can increase the hazard, and therefore, the variables are favorable. That is to say, the travel time in such favorable conditions is less than the average level of the survey sample.

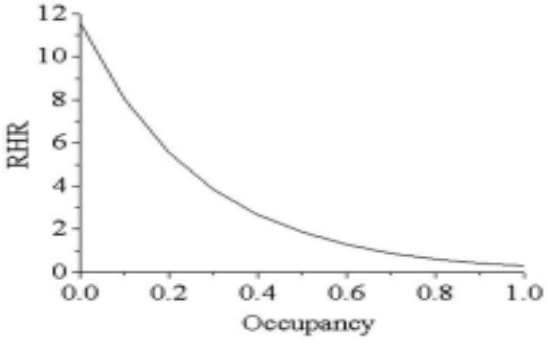

Figure 2.3: Relative Hazard Ratios (RHR) with parking occupancy

The paper provides several important insights into the determinants of the distribution of travel time under the influence of on-street parking. First, the results indicate that the influence of on-street parking results from various related factors. Such influence can be reflected by the distribution of travel time. The effective lane width and traveling conflict (related to the turnover) can be considered as the most significant influencing factors. The distribution of travel time estimated by the model would give a quantitative analysis of the influence of on-street parking. Additionally, the influential factors related to the characteristics of on-street parking should be given full consideration in the planning and designing of on-street parking (Hongwei.G, et al., 2012).

Another researcher Litman, 2009 states the effects of on-street parking on congestion, accidents, pollution, obstruction to fire-fighting operations etc.

Congestion: Parking takes considerable street space leading to the lowering of the road capacity. Hence, speed will be reduced; journey time and delay will also subsequently increase. The operational cost of the vehicle increases leading to great economical loss to the community (Litman, 2009).

Accidents: Careless maneuvering of parking and un parking leads to accidents which are referred to as parking accidents. Common type of parking accidents occur while driving out a car from the parking area, careless opening of the doors of parked cars, and while bringing in the vehicle to the parking lot for parking (Litman, 2009).

Environmental pollution: They also cause pollution to the environment because stopping and starting of vehicles while parking and un parking results in noise and fumes. They also aced the aesthetic beauty of the buildings because a car parked at every available space creates a feeling that building rises from a plinth of cars (Litman, 2009).

Obstruction to firefighting operations: Parked vehicles may obstruct the movement of firefighting vehicles. Sometimes they block access to hydrants and access to buildings.

Literature provides valuable information about the influence of on-street parking. In general, an important aspect of the influence is that on-street parking could reduce capacity and cause congestion. Chick, 1996 used the number of lanes and the number of parking maneuvers per hour as the variables to represent the capacity reduction caused by

on-street parking, and the results were adopted in the Highway Capacity Manual(Transportation Research Board 2000).

2.7 On-street Parking and Traffic Congestion

Olorunfemi S, et al. examines that parking and traffic congestion is synonymous to each other because failure to meet parking demand of people in a city lead to on street parking that results to traffic congestion. To reduce the menace, policy measures are recommended among which are; institution of enforcement of traffic rules and regulations by disciplined law enforcement agents, relocation of certain activities that caused on-street parking and introduction of intelligent transport system (ITS) which make use of sustainable devices, traffic management improvement and provision of off-street parking services in the city plan (Olorunfemi S, et al, 2014).

According to Litman (2007), recommendation an integrated parking plan which should be adjusted to reflect the needs of a particular situation. The steps include defining the geographic scope of analysis such as the site, street, district/neighborhood and regional scale; carefully defining the parking problems; parking planning should be coordinated with a community's overall strategic vision and development of a comprehensive evaluation framework. A survey of parking supply and demand in the study area is then conducted after which a list of potential solutions using ideas from both the survey and stakeholders' ideas, each option is then evaluated with respect to evaluation criteria (Litman, 2007).

The findings by other researchers were to overcome parking congestion it is essential to accurately determine parking space requirements and to understand the origins of demand. It has been established that economic activities generate trips which further generate parking requirements; however, there is a great variety in the parking demand depending on the nature of each activity. What is more, induced demand is often noted when parking is offered free of charge, and hence, determining the minimum parking requirements for different economic activities and attempting to meet them has been found to be an in adequate method to address the problem and to relieve parking congestion. This is because the minimum parking requirements are based on the assumption that the demand for parking does not depend on its price and that the supply should not depend on its cost. Neglecting the pricing and cost elements is unreasonable, as the land market cannot be regulated to meet these assumptions. Charging policies, on

the other hand, allow for the counterbalance of demand by pricing, enabling transport and urban planners to overcome parking congestion and utilize land in better ways (Shoup, DC, 1999).

In most of the cities in developing countries the planning of road networks lacks the provision of the entire basic infrastructure to be provided for the safe and orderly movement of the vehicles (Akhuewu, 2010); Olorunfemi, 2013). An ideal road network should have exclusive lanes to segregate fast moving and slow moving vehicles, cycle lanes, exclusive bus bay and service lanes (Sivabramanian and Malarvizhi, 2007). However, increase in numbers of vehicles without adequate infrastructure, has accentuated the problems of traffic congestion, traffic delay, parking problems, accident, and urban land use severance (Raji and Wasiri, 2008). This has led to the encroaching of commercial activities on the footpath and ultimately on the carriageway. However, the carriage way is most often encroached with hawking activities and parking of vehicle (Sivabramanian and Malarvizhi, 2007). Asiyanbola and Akinpelu, (2012), show that one of the major goals of transportation planning is to ease the movement of passengers and goods on urban roads. In many towns and cities all over the world, there is undesirable degree of traffic congestion on urban roads. The provision of new roads is often expensive and most municipal governments usually consider the choice of widening existing roads which involves the demolition of houses and properties. The literature reveals that widening of roads and concomitant destruction of buildings are not necessarily the panacea needed in controlling traffic congestion on our roads. According to Obot and Umoh,(2007), in Nigeria, like elsewhere, where cars are one of the dominant modes of transportation, urban circulation is one of the most obvious problems and parking seems to be an overlooked element in transportation development. Several studies have shown that improvement in the living standards of people as a result of wage increase contributes almost as much as the growth of cities to contemporary urban traffic condition in Nigeria (Tanimowo and Atolagba, 2006). However, for a city to function as a system, transportation must be efficient and reliable to facilitate, not only intercity movement of people and their activities, but encourage intra-city movements within the city. These movements are from point of origin to the point of destination (Akhuewu, 2010). Asiyanbola and Akinpelu, (2012), observes categories of space in urban center include exchange space and movement space which related to motor park, interchange point etc. As city transportation system expands, it takes up more spaces.

The construction of new roads, the expansion of the existing roads, the building of parking lot requires the acquisition of part of the exchange space, the more space allocated to transport, the greater the requirement for more traffic space. Automobile therefore has an insatiable appetite for space, it uses space at home, at work, shopping and even when some spaces are empty, and it is tied up or reserved for the automobile. Automobile do not only have exclusive space for moving, they also have a" zone of influence" which expands as the speed and quantity of traffic increases, thus reducing the effectiveness of exchanges space and the level of interaction. Meanwhile, on-street parking in most cases results into chaotic traffic due to parked cars along the road and this has led to large amount of traffic circulating looking for a parking space, thus contributing to congestion and pollution (Rye, 2010). Akhuewu (2010) identifies the characteristic of on-street parking which are noted to be the nature of parking which affects the street based on the nature of the environment. He observes that in developed countries like Europe and America, majority of the vehicle owners in a commercial area parked their cars in accordance to the parking principles and guideline. This is because there are provisions of parking space that are enough for both the users of the spaces and those residing within the area. This was as a result of planning with the inclusion of parking facilities to discourage any obstruction on the streets. The various characteristics that are linked with street parking are advantageous due to monitoring and control of street parking in the developed nations of the world. In African context, the nature of street parking is different from the way it is in developed nations. Norman and Wesley (2008) identified a number of ways by which on-street parking could be of importance. These are:

•Higher efficiency: Users of the downtowns consistently select on-street parking spaces over off-street surface lots and garage parking. The on-street spaces experience the most use and the highest turnover.

Better land use: Using the curbside for parking saves considerable amounts of land from life as an off-street surface parking lot. Medium-sized town centers can save an average of more than two acres of land by providing street parking. This efficiency can allow for much higher-density commercial development than the center to rely solely on off-street surface lots.

• Increased safety: Drivers tend to travel at significantly slower speeds in the presence of features such as on street parking and small building setbacks. Slower vehicle speeds provide pedestrians, cyclists and drivers more time to react, and when a crash occurs, the chance of it being life-threatening is greatly reduced. In short, on street parking can help to create a safer environment. On-street parking can slow automobile traffic, making streets safer for bicyclists and pedestrians. In many communities in Europe, on-street parking is used as chicanes to make the road appear narrower and slow traffic in residential areas (Christopher, 2006). It can be an effective buffer between vehicle traffic in the street and the pedestrian environment on the sidewalk, making walking more pleasant.

On-street parking also creates potential hazards for bicycles or motorcycles, which are often struck by car doors opening. Children who are too short to be seen through car windows can also dart out into traffic from between parked cars (Christopher, 2006) and (Olorunfemi, 2013). In order to allow easy movement in the city, there is need for proper monitoring and transportation system must include adequate parking facilities in all places that attract vehicle traffic (Asiyanbola and Akinpelu, (2012)) and (Olorunfemi 2013). Asiyanbola and Akinpelu, (2012) opined that the argument in the literature is that the provision of parking for all automobile must be widely recognized as a responsibility where adequate facilities are not otherwise provided. He stressed that major attention should be on on-street parking for passengers cars as parking needs to reduce traffic congestion in a city.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Study Area

According to Addis Ababa City Government, 2010 report the current administration of Addis Ababa constitutes ten sub-cities, 'Kefle Ketemas'and 116 Woredas. Among these sub-cities the researcher intended to study the parking condition of Addis ketema sub-city due to the high volume of vehicles. This is because Addis Ketema sub-city possesses different public centers; the largest market center "Merkato," the city bus station, main cross country bus station of the city and, the Grand Anwar Mosque and the St. Raquel Orthodox church also found in this sub-cities. Also, Addis ketema sub-city is the smallest sub-city in Addis Ababa. It covers only an area of 7.41 square kilometers. Moreover, the rise in automobile ownership together with the condition of the roads has resulted in the high level of traffic risk and parking problems that forces the vehicle drivers to park on street roads and results traffic congestion. This calls for the development of effective parking management policy within the sub-city. Therefore, this study primarily focused on the Addis ketema sub-city as it believed that it is where the predicament of parking problems and management challenges are extreme (AACG, 2010).

Figure 3. 1: Map of Addis Ababa City showing the sub-cities

The location that studied by the researcher were shown in the figure 3.2 which was selected due to the location is found around one of the largest commercial center Merkato and the road segment is the road feeder to this commercial center.

Figure 3. 2: Off-street and On-street parking location of the study area

Source: Satellite image of study area taken from Google Earth on August 5, 2017

3.2 Study Design

Both quantitative and qualitative types of data were used during the study period. Quantitative data was used to explore numerical information on the existing parking condition whereas qualitative type of data was used to describe the effect of on-street parking on travel time.

Parking data were surveyed using license plate method of survey and volume traffic flows were counted using video camera. Characteristics of road geometry like gradient, lane width and segment length were also measured directly from the study area. These were the methods of parking data collections. The methodologies of analyses used in this research paper were Microsoft-Excel, linear regression analysis and Vissim simulation model software analysis, which were collected from the study area. To achieve the objectives of the research, the researcher performed the following activities. After thoroughly, organizing literature review of different previous published researches, indicate the gap and develop parking occupancy and parking space utilization by analyses of on street and off street parking occupancy.

- After the problem is identified:-
  - ✓ Organizing literature review of different previous published researches,
  - ✓ Develop research questions and objectives
  - ✓ Primary and secondary data were collected
  - ✓ Analyze the data collected. Finally, after analyzing those data appropriate recommendation and conclusion based on results were given.

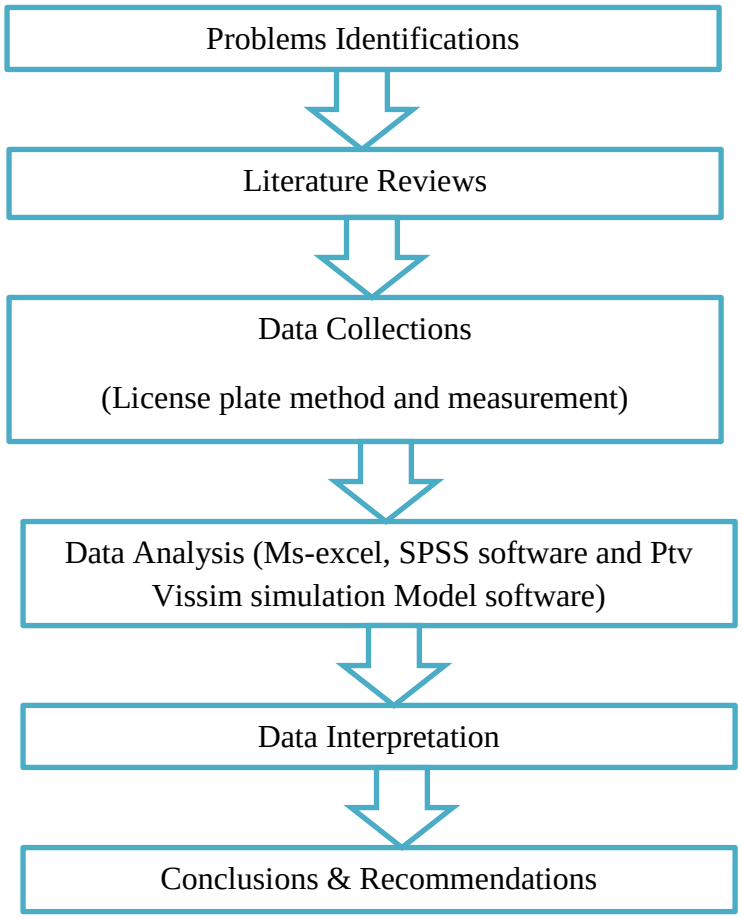

Figure 3. 3: Flow chart showing general outline of the study

3.3 Population of the Study

All vehicles that parked at study area of off-street and on-street parking spaces were the population of the study.

3.4 Sample Size and Procedures

Three major off-street parking labeled from P1-P3 and three major on-street parking labeled from P4-P6 along road segments were chosen in the sub-city, through purposive sampling, to collect data from both off-street and on-street parking. The designated public

centers selected for off-street parking are Yirga Haile building underground parking, Tana surface parking and Urago market center surface parking. Yirga Haile building was one of the major market centers in the sub-city which has underground off-street parking (P1) with story building from G-2 to G-0 and it can hold about 60 vehicles once at a time. Tana parking (P2) was found at the center of Merkato which was surface off-street parking with 185 parking bays. The other was found near Urago market center (P3) which was surface off -street parking. It can hold about 50 vehicles. The location of on-street parking were front of Grand Anwar Mosque (P6), Tesema Aba Kemaw Street both sides (P4-P5). To illustrate on-street parking, Tesema Aba Kemaw St. starts from Teklehaymanot square to Urago market center to the right side (P4) and to the left side (P5). The street was two-way traffic with six lanes highway, and it is the major road feeder to the Merkato market center of the sub -city. Figure 3.4 shows the sampled road P6 used for the study.

Figure 3. 4: Sample of roadside parking

Source: Satellite image of study area taken from Google Earth on August 5, 2017

3.5 Study Variables

3.5.1 Dependent Variables

The dependent variables of the study are effects of parking efficiency problems on transportation system.

3.5.2 Independent Variables

The independent variables of this study are;

- Parking volume

- Parking accumulation
- Parking load
- Parking turnover
- Parking duration
- Parking efficiency
- Traffic volume
- Parking capacity
- Road width and
- Road segment length

3.6 Data Collection Process

A simple method was adopted to study the condition of both off-street and on-street parking. This simple method includes three important parts like preparation, survey and output. In the preparation part, papers related to the parking were collected and examined the general character of the area. In survey part some of the primary surveys were conducted, primary surveys like; parking volume count, parking capacity, accumulation and parking duration. In the third part, the outcome of the survey was analyzed to see the requirement to implement the new parking policy.

Direct observations were used for the collection of data using the license plate method of surveying, for both off-street parking and on-street parking. Information on a number of vehicles parked in chosen parking bays at a particular period was collected. The survey was conducted between 9:00 AM – 5:00 PM on Friday from weekday and Saturday from the weekend. To get accurate result it is important to survey at least for 7 days but due to economic and time constraint the survey was only for two days. These days selected based on the researcher observation and information collected from the traffic police. In addition, some local parking services syndicates were also gave the information about the study area of parking condition and the parking statistics from Monday to Saturday were checked for all study locations by checking the fare tickets from parking owners and parking syndicates from studied area. These show that parking on Friday and Saturday is significant that an activity take over at the location was during the daytime due to it was the commercial area. The method of parking survey needs skilled man-power and is very labor intensive. However, this surveying techniques is the most accurate and realistic data.

Figure 3. 5: On-street parking sample during parking survey

Source: Photo captured during parking survey by the researcher on August 5, 2017.

Therefore, the primary data were collected through direct surveying of the raw data from the study area of the sub-city for these two days. The data collected were number of vehicles parked on both sides of the road, number of vehicles parked per 15 minutes interval, number of vehicle moving through the road segment to determine the effect of on-street parking along the road segment on travel time. The traffic volume was counted for two peak hours using video camera.

Secondary data, geometric data and traffic volume obtained from the two local government areas, the Addis Ababa City Road Authority (AACRA) and the Addis Ababa City Transport Program Management Office (AACTPMO). Finally, after collecting and

analyzing those data appropriate recommendation and conclusion based on results were given on parking occupancy and parking space utilizations of the sub city.

Figure 3. 6: Off-street parking sample during parking survey

3.7 Data Analysis

Generally, in this research paper two basic analyses were carried out. These are parking space utilization of both on street and off street parking using linear regression analysis and influence of on street parking on travel time (moving traffic) using Vissim simulation model software. Microsoft excel also used to analyze parking parameters.

3.7.1 Characteristics and Nature of the Existing Parking Condition

To know the characteristics and nature of the existing parking condition, analysis of parking parameters should be carried out. These were as follows;

3.7.1.1 Parking Studies

Before taking any measures for the betterment of parking conditions, data regarding availability of parking space, extent of its usage and parking demand is essential. Parking surveys intended to provide all these information. Since the duration of parking varies with different vehicles, several statistics are used to assess the parking need.

3.7.1.2 Parking Statistics

All information regarding to parking are parking statistics. The license plate method of survey was used for parking study. In the license plate method of survey, every parking bays monitored at a continuous interval of 15 minutes or so and the license plate number noted down. This gave the data regarding the duration for which a particular vehicle is using the parking bays. This method also help in calculating the fare because fare estimated based on the duration for which the vehicle parked. If the time interval is shorter, then there are less chances of missing short-term parkers. A parking study using a license plate method conducted in weekday (Friday) and weekend (Saturday). The parking survey was from 9:00 AM-5:00 PM for eight hours for both days. According to the syndicates Friday and Saturday have the highest parking volume due to the study area is found around Grand Anwar mosque so that parking is high on Friday. Saturday is an off day for most public officers so that they come for marketing purpose at the area.

All the necessary data for the six locations were collected using 19 data collectors. A maximum of 37 parking bays were given for an individual. Data collectors had collected license plate of 3305 different vehicles in these two days. Besides, video camera recorded and the data was counted by video playback. The video data was required for determining traffic flow characteristics along the road segment.

Before taking any measures for develop an implementation plan, data regarding availability of parking space, nature of the existing parking condition, extent of its usage and parking space utilization is essential. Parking surveys are intended to provide all this information. Since the duration of parking varies with different vehicles, several statistics are used to access the parking need.

3.7.2 The Relationship of the Utilized Parking Spaces and Parking Capacity of On-Street and off- street parking

In a regression analysis the researcher studied the relationship, called the regression function, between one variable **y**, called the dependent variable, and several others xi, called the independent variables. Regression function also involves a set of unknown parameters Bi. If a regression function is linear in the parameters, it termed as a linear regression model. In this case, there were one dependent variable (utilized parking spaces) and one independent variable (parking capacity). The data collected were analyzed using linear regression statistics. The results were shown using tables and equations. The linear regression method used to develop the relationship between utilized parking spaces and capacity of parking. The Statistical Package for the Social Sciences (SPSS 20.0) was employed in the regression analysis to develop parking utilized spaces of both on-street and off-street parking. The maximum utilized parking spaces are determined from parking accumulation curve during the study period. Parking accumulation is number of vehicle parked in an area at each hour interval of time. The data collected were useful in quantifying variation in utilized parking spaces over the course of the day. It also helped in identifying the peak period of parking occupancy. The parking occupancy was used to understand the utilization of parking space on the street and off- the street. Parking peak occupancy is one of the peak parking space utilized determinations. Therefore, the maximum utilized parking spaces are the percentages of the peak occupancy of the total available parking capacity. Thus, the relationships are developed from the peak parking occupancy rates.

3.7.3 Travel-Time Study Considering On-Street Parking

Travel time is the observed time for a vehicle to traverse the test section over a specified route under existing traffic conditions. To determine the effect of on-street parking on travel time; the characteristics, nature of the existing parking condition and its associated challenges should be known. To know these factors parking volume, parking rate and

parking duration should be determined first. These were done using the License plate method of survey under parking statistics above. Vissim simulation model were used to analyze the effect of on-street parking on travel-time. Vissim is the leading microscopic simulation program for modeling multimodal transport operations and belongs to the vision traffic suite software. Realistic and accurate in every detail, Vissim creates the best conditions for researchers to test different traffic scenarios before realization. Vissim is now have been used worldwide by the public sector, consulting firms and universities. To analyze the effect of on-street parking on travel time the necessary parking data first analyzed. Those data were number of parking bays, parking volume, parking duration, parking occupancy and traffic flow volume along the road segment.

The travel time is observed in two scenarios: the first scenario is the travel time by considering roadside parking along the road segment and the second scenario is travel time by removing roadside parking along the road segment. The differences of these two scenarios were considered as additional delay. Finally, the total segment delay of a vehicle was obtained from stopped delay in seconds per vehicles without at public transport stops and in parking bays, and additional delay in seconds per vehicle.

Steps to be followed to analyze input data using vissim software

Step1. Drawing the geometric features of the road segments on the Network object

Step2. Defining parking routes

A vehicle to use a parking lot, define a vehicle route of the type Parking lot that leads to the desired parking lot. To define a parking route, insert a routing decision on a link and on a destination section located on the parking lot of choice. For a routing decision, also define multiple destination sections located on different parking lots. Routing decision may lie on a connector. The destination section may also lie on a connector, if the parking lot is located on a connector.

Step3. Then select Parking lot and insert the size of parking lot. The initial parking occupancy also inserted.

Step4. Select the travel time measurement and specify the test section along the road segment.

3.7.4 Field Measurements

The field measurements have been conducted on the geometric feature of the road segment selected. During field measurement, alignment of the road segment, length of road segment, widths of traffic lanes and number of lanes have been measured for the selected road segment along P4, P5 and P6.

The width of traffic lane and segment length measurement is done manually using tape meter. The rest of the data were collected by visual observation. The collected data are summarized in the following table for the three selected road segment.

Table 3.1: Geometric Data for road segments

Road Segment Along	Number of lanes	Lane width	Segment length	Gradient (%)	Median
P4	3	3m	230m	3.5	yes
P5	3	3m	215m	-3.5	yes
P6	2	3.5m	245m	0.9	yes

CHAPTER FOUR

RESULTS AND DISCUSSION

Different types of data were collected which is relevant in assessing the current parking condition of the study area, and the results are presented in the following sections with the brief explanation.

4.1 The Characteristics and Nature of the Existing Parking Condition

The characteristics and nature of the existing parking condition were shown with parking accumulation curve of a total number of vehicles with time interval in which the vehicles parked for some period.

In the following part, the parking locations (P1-P6) were analyzed individually. The parking locations were shown in diagram with respective locations. All parking parameters (parking statistics) results were presented in tabular form. Accumulation curve also provided for the two days. A total number of vehicles parked in an area at each fifteen minutes interval. It expressed in a number of vehicle parked. The data collected were useful in quantifying variation in demand over the course of the day. It also helped in identifying the peak period. Graph was plotted time vs number of vehicles. The variation was because of the land use, purpose, etc.

4.1.1. Parking Location P1

Figure 4.1: Off-street parking location P1

Source: Satellite image of study area taken from Google Earth on August 5, 2017

Table 4.1: Evaluation result for parking location P1- Yirga Haile underground parking

Analysis	Unit	Date	
		Friday	Saturday
Study Period	hour	8	8
Total number of bays	Bays	60	60
Parking volume	vehicles	89	84
	vehicle/hour	11.1	10.5
Parking load	vehicle-hour	435.5	457.5
Ave. Parking duration	minutes	298.99	334.64
Ave. Parking turnover	veh/bay/hour	0.19	0.18
Ave. Parking occupancy/ efficiency	percent	91%	95%
Parking capacity	vehicle-hour	480	480

Results from table 4.1 shows about 11veh/hr were parked in both days. Long term parking vehicles were predominant at P1. Vehicles were parked for an average of five hours in both days. The efficiency of parking P1 was 91% on Friday and 95% on Saturday. That is parking spaces were utilized more on Saturday.

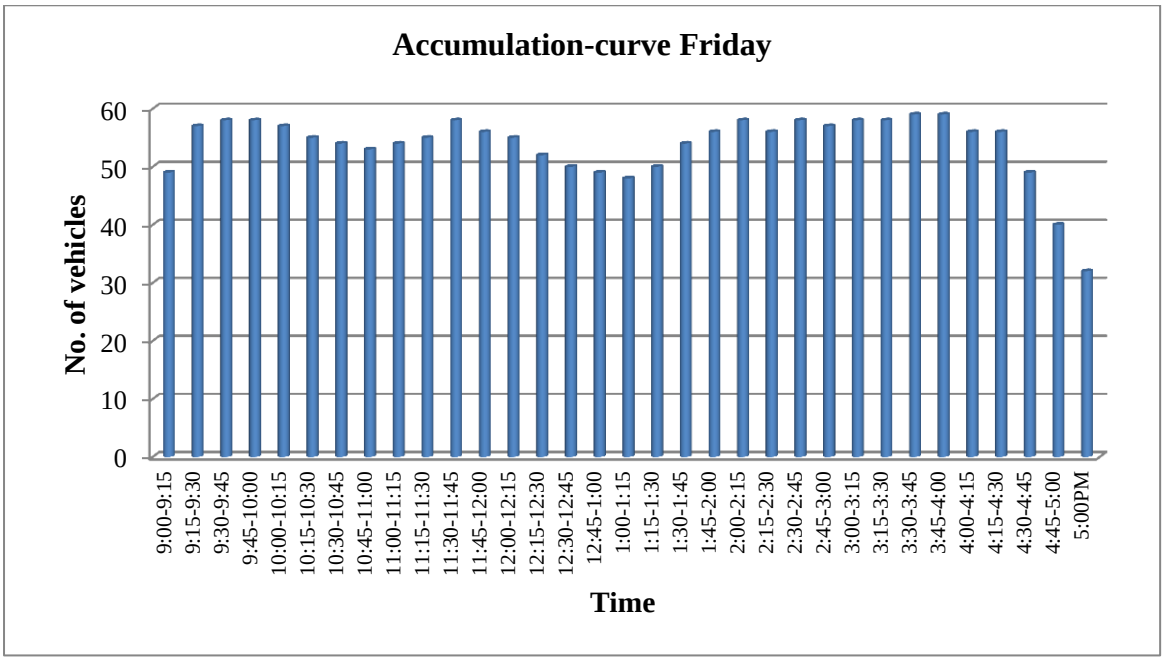

Figure 4.2: Vehicle accumulation graph of P1 on Friday

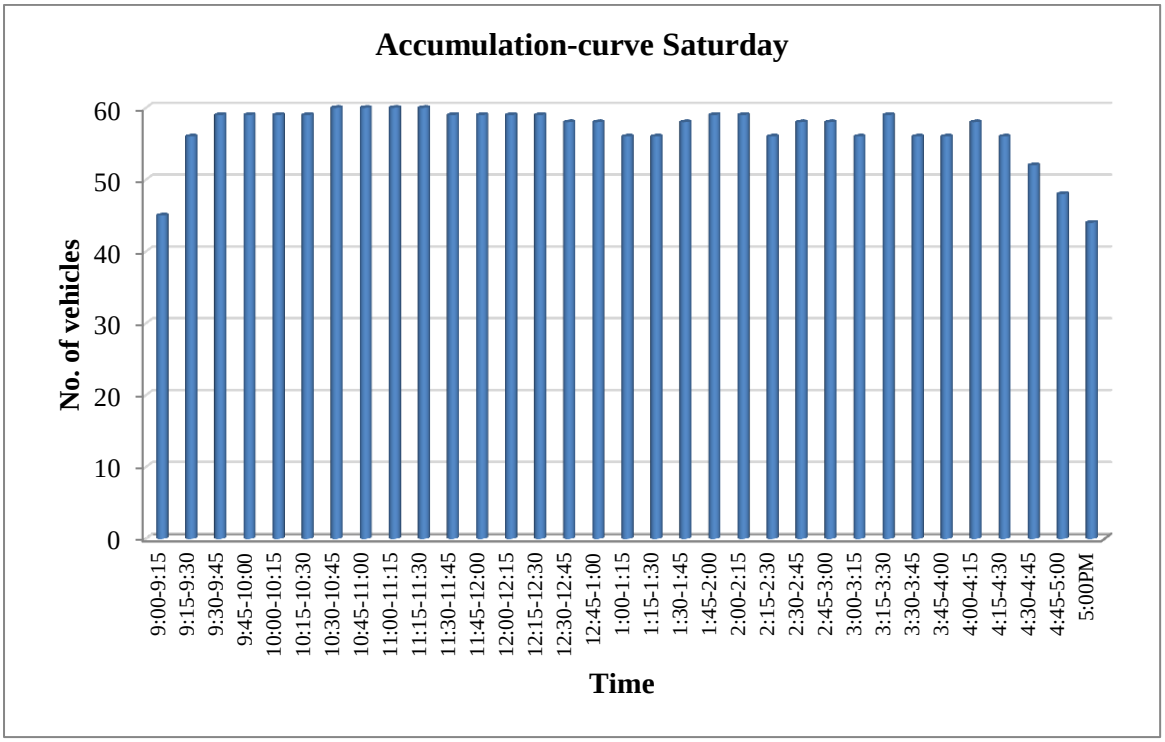

Figure 4.3: Vehicle accumulation graph of P1 on Saturday

4.1.2. Parking Location P2

Figure 4.4: Off-street parking location P2

Source: Satellite image of study area taken from Google Earth on August 5, 2017

Table 4.2: Evaluation result for parking location of P2-Tana parking

Analysis	Unit	Date	
		Friday	Saturday
Study Period	hour	8	8
Total number of bays	Bays	185	185
Parking volume	vehicles	728	826
	vehicle/hour	91.0	103
Parking load	vehicle-hour	1269.5	1307.75
Ave.Parking duration	minutes	104.11	97.2276
Ave.Parking turnover	veh/bay/hour	0.49	0.56
Ave.Parking occupancy/ efficiency	percent	86%	88%
Parking capacity	vehicle-hour	1480	1480

Results from table 4.2 shows about 91veh/hr were parked on Friday and 103veh/hr on Saturday. Long term parking vehicles were not predominant at P2. Vehicles were parked for an average of 100 minutes in both days. The efficiency of parking P2 was 86% on Friday and 88% on Saturday. That is parking spaces were utilized more on Saturday.

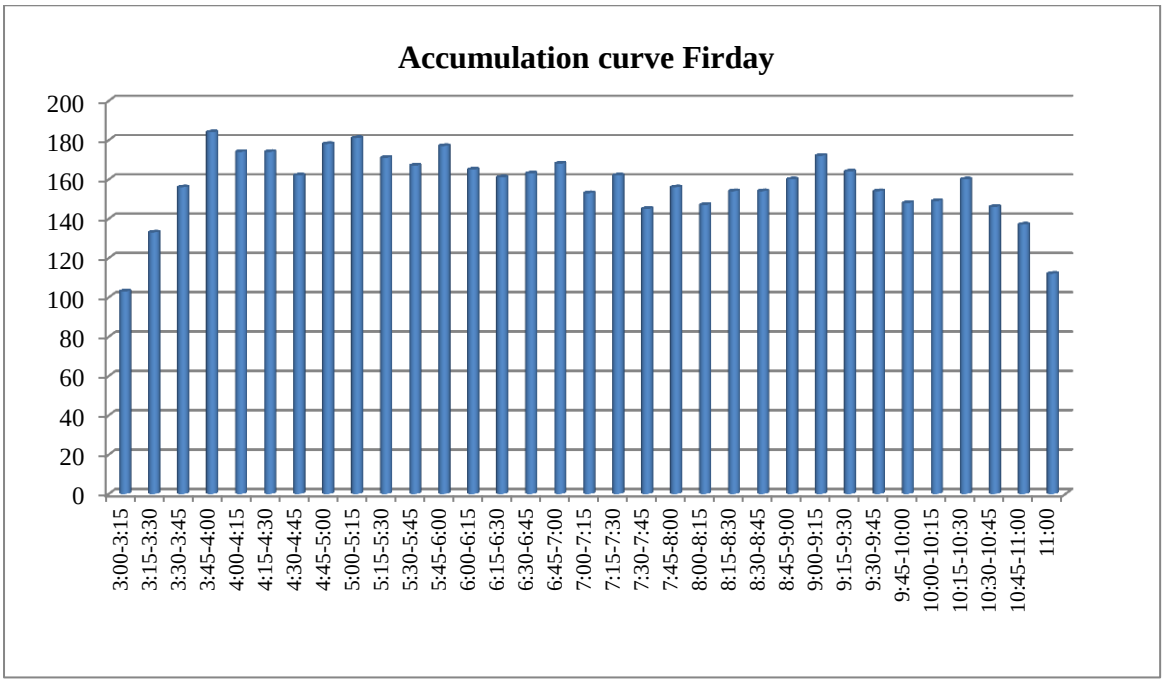

Figure 4.5: Vehicle accumulation graph of P2 on Friday

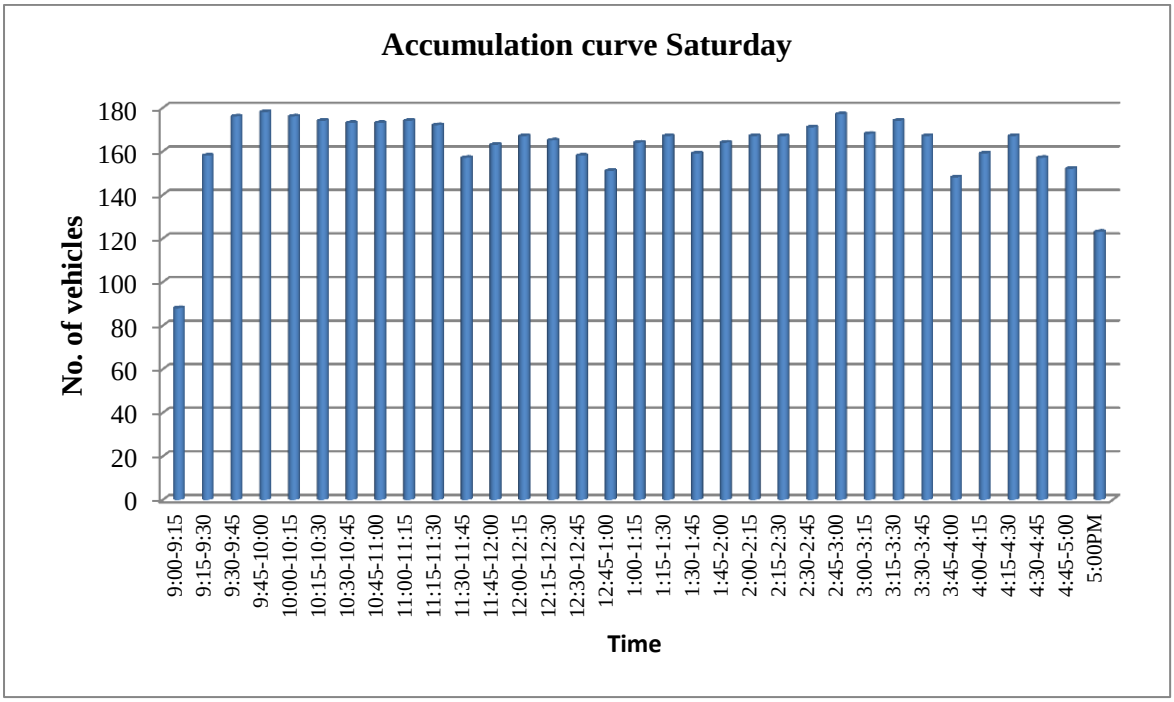

Figure 4.6: Vehicle accumulation graph of P2 on Saturday

4.1.3. Parking Location P3

Figure 4.7: Off-street parking location P3

Source: Satellite image of study area taken from Google Earth on August 5, 2017

Table 4.3: Evaluation result for parking location of P3- surface parking

Analysis	Unit	Date	
		Friday	Saturday
Study Period	hour	8	8
Total number of bays	Bays	50	50
Parking volume	vehicles	68	78
	vehicle/hour	9	10
Parking load	vehicle-hour	363.0	368.3
Ave. Parking duration	minutes	325.1	288.85
Ave. Parking turnover	veh/bay/hour	0.17	0.20
Ave. Parking occupancy/ efficiency	percent	91%	92%
Parking capacity	vehicle-hour	400	400

Results from table 4.3 shows about 9veh/hr were parked on Friday and 10veh/hr on Saturday. Long term parking vehicles were predominant at P3. Vehicles were parked for an average of six hours in both days. The efficiency of parking P3 was 91% on Friday and 92% on Saturday. That is parking spaces were utilized more on Saturday.

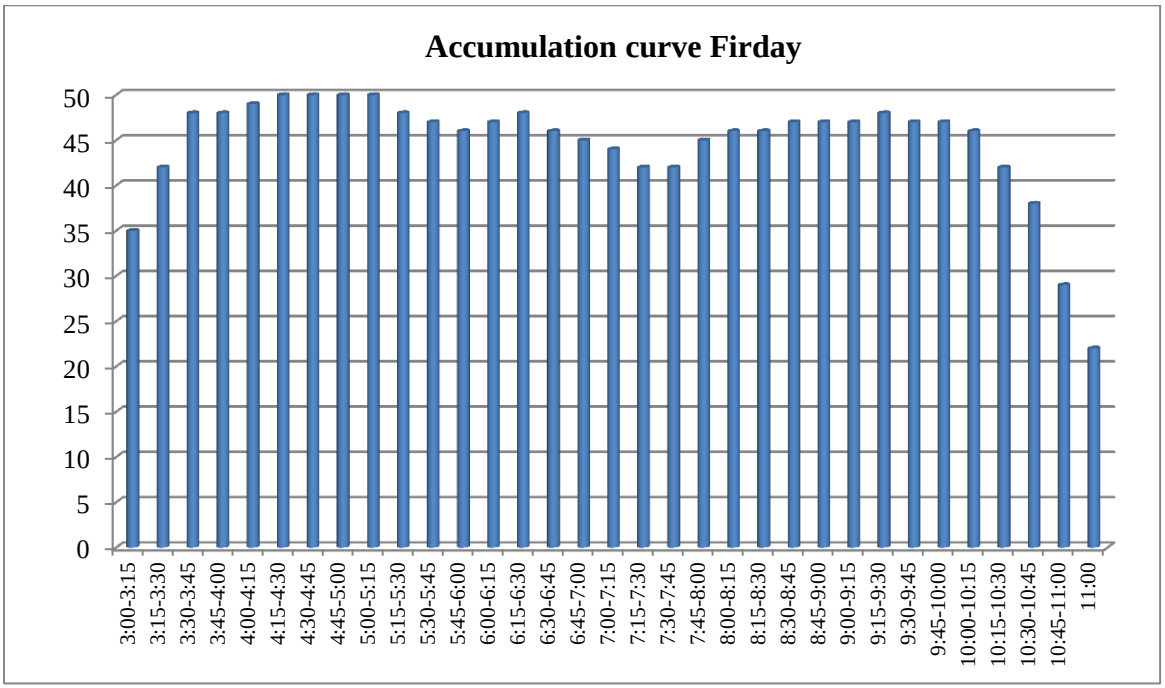

Figure 4.8: Vehicle accumulation graph of P3 on Friday

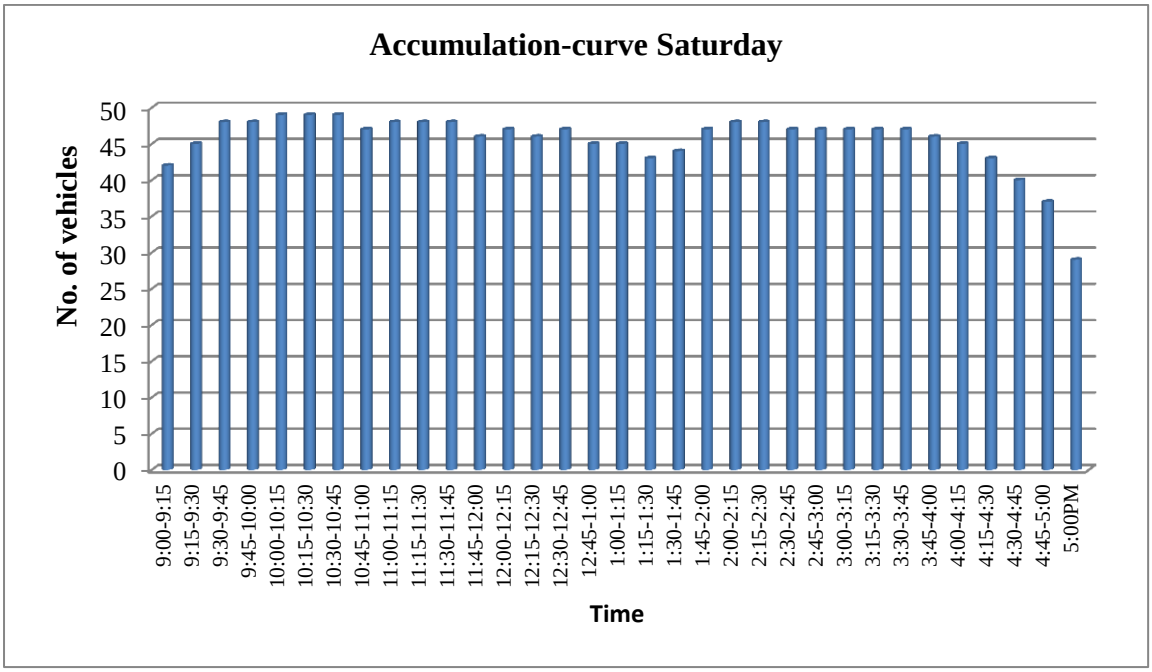

Figure 4.9: Vehicle accumulation graph of P3 on Saturday

4.1.4. Parking Location P4

Figure 4.10: On-street parking location P4

Source: Satellite image of study area taken from Google Earth on August 5, 2017

Table 4.4: Evaluation result for parking location of P4 on street parking

Analysis	Unit	Date	
		Friday	Saturday
Study Period	hour	8	8
Total number of bays	Bays	61	61
Parking volume	vehicles	299	309
	vehicle/hour	37	39
Parking load	vehicle-hour	406.0	413.25
Ave. Parking duration	minutes	83.13	81.84
Ave. Parking turnover	veh/hour/bays	0.61	0.63
Ave. Parking occupancy/ efficiency	percent	81%	82%
Parking capacity	vehicle-hour	504	504

Results from table 4.4 shows about 37veh/hr were parked on Friday and 39veh/hr on Saturday. Long term parking vehicles were not predominant at P4. Vehicles were parked for an average of 80 minutes in both days. The efficiency of parking P4 was 81% on Friday and 82% on Saturday. That is parking spaces were utilized more on Saturday.

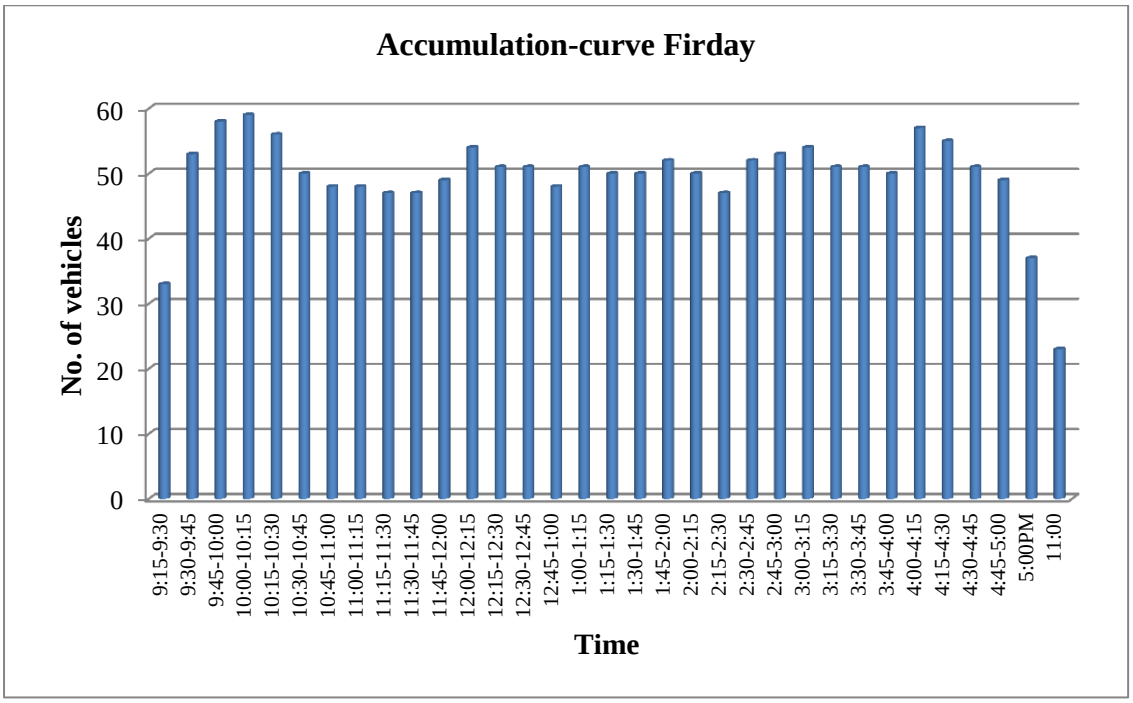

Figure 4.11: Vehicle accumulation graph of P4 on Friday

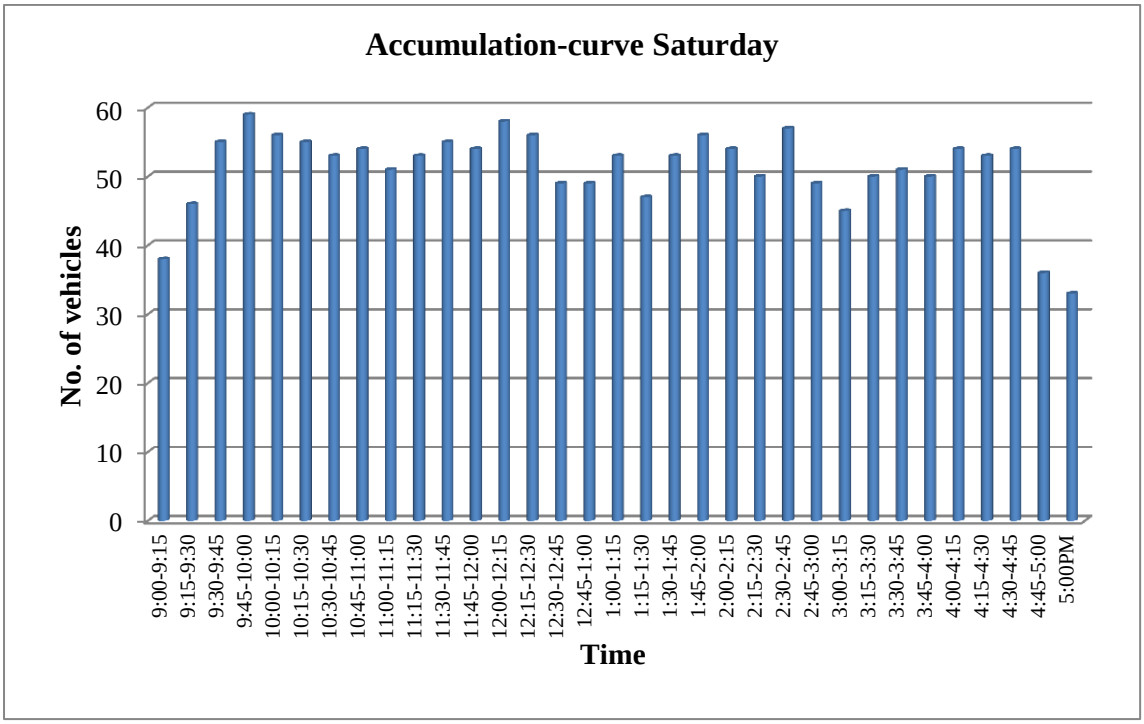

Figure 4.12: Vehicle accumulation graph of P4 on Saturday

4.1.5. Parking Location P5

Figure 4.13: On-street parking location P5

Source: Satellite image of study area taken from Google Earth on August 5, 2017

Table 4.5: Evaluation result for parking location of P5 on street parking

Analysis	Unit	Date	
		Friday	Saturday
Study Period	hour	8	8
Total number of bays	Bays	56	56
Parking volume	vehicles	120	143
	vehicle/hour	15.0	18
Parking load	vehicle-hour	355.0	365.3
Ave. Parking duration	minutes	180	155
Ave. Parking turnover	veh/bay/hour	0.27	0.32
Ave. Parking occupancy/ efficiency	percent	79%	82%
Parking capacity	vehicle-hour	448	448

Results from table 4.5 shows about 15veh/hr were parked on Friday and 18veh/hr on Saturday. Long term parking vehicles were not predominant at P5. Vehicles were parked for an average of 170 minutes in both days. The efficiency of parking P5 was 79% on Friday and 82% on Saturday. That is parking spaces were utilized more on Saturday.

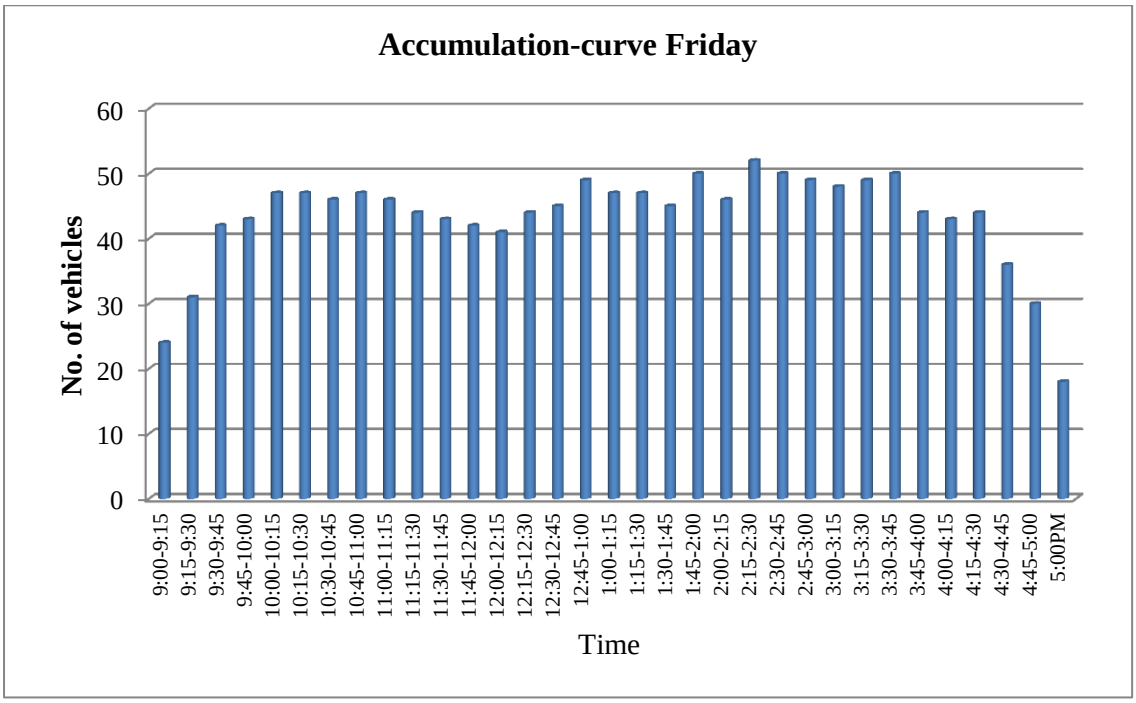

Figure 4.14: Vehicle accumulation graph of P5 on Friday

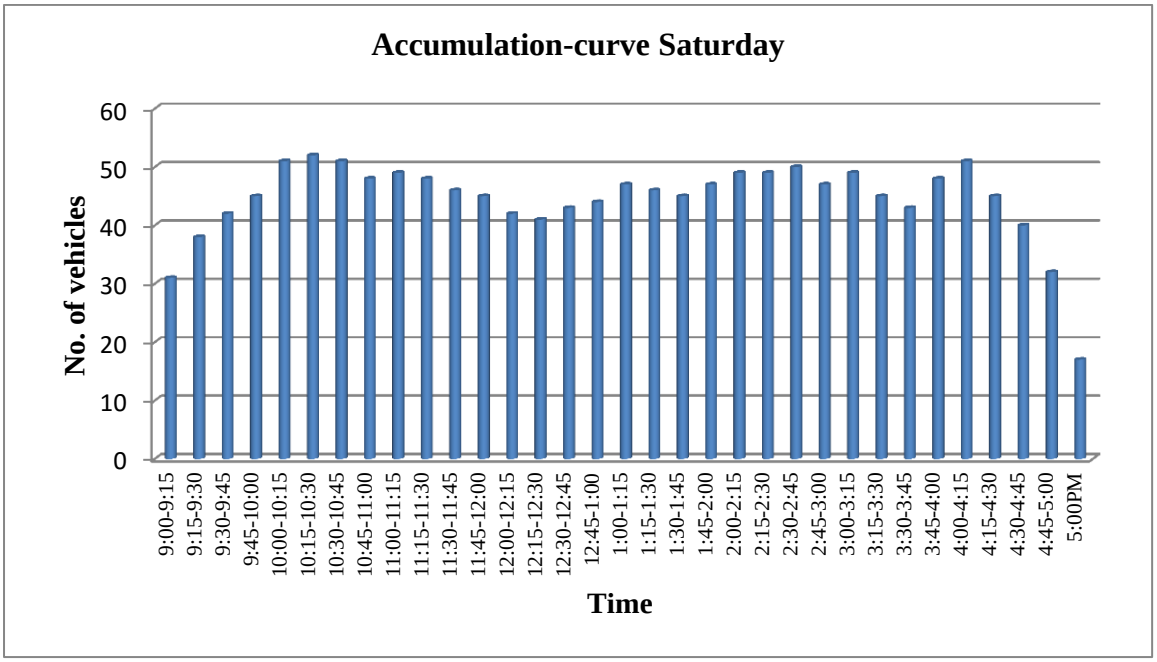

Figure 4.15: Vehicle accumulation graph of P5 on Saturday

4.1.6. Parking Location P6

Figure 4.16: On- street parking location P6

Source: Satellite image of study area taken from Google Earth on August5, 2017

Table 4.6: Evaluation result for parking location P6 on street parking

Analysis	Unit	Date	
		Friday	Saturday
Study Period	hour	8	8
Total number of bays	Bays	64	64
Parking volume	vehicles	267	294
	vehicle/hour	33	37
Parking load	vehicle-hour	424.8	424.75
Ave. Parking duration	minutes	97.13	83.01
Ave. Parking turnover	veh/bay/hour	0.52	0.57
Ave. Parking occupancy/ efficiency	percent	83%	83%
Parking capacity	vehicle-hour	512	512

Results from table 4.6 shows about 33veh/hr were parked on Friday and 37veh/hr on Saturday. Long term parking vehicles were not predominant at P6. Vehicles were parked for an average of 90 minutes in both days. The efficiency of parking P6 was 83% on Friday and 83% on Saturday. That is parking spaces were utilized equally in both days.

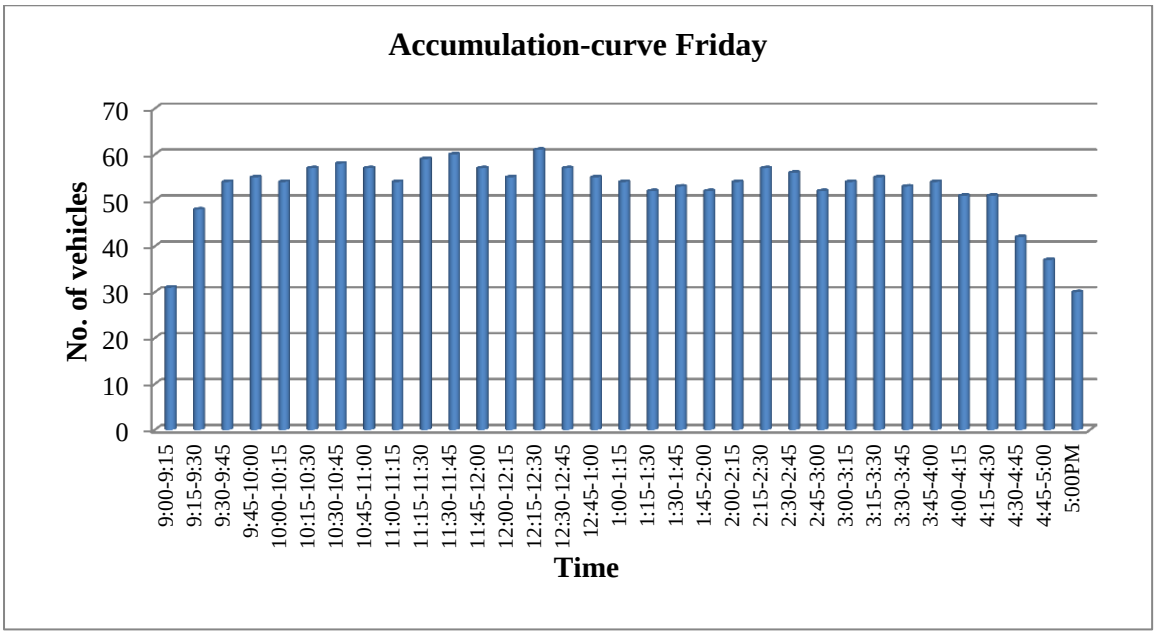

Figure 4.17: Vehicle accumulation graph of P6 on Friday

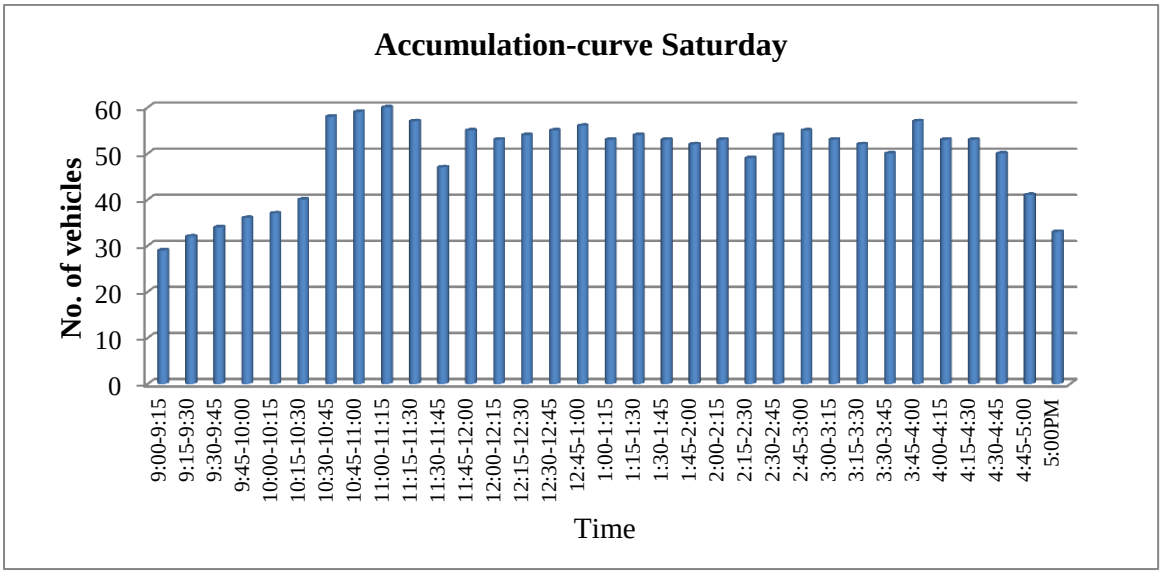

Figure 4.18: Vehicle accumulation graph of P6 on Saturday

4.1.7 Aggregated Summary

4.1.7.1 Aggregated summary of Off-street Parking

Table 4.7: Aggregated data analysis for Off-street parking

Analysis	Unit	Date	
		Friday 4/08/2017	Saturday 5/08/2017
Study Period	hour	8	8
Total number of bays	Bays	295	295
Parking volume	vehicles	885	988
	vehicle/hour	112	125
Parking load	vehicle-hour	2068	2133.55
Ave. Parking duration	minutes	243	240
Ave. Parking turnover	veh/bay/hour	0.29	0.31
Ave. Parking occupancy/ efficiency	percent	88%	90.4%
Parking capacity	vehicle-hour	2360	2360

The following graphs show the result of aggregated accumulation curve for off-street.

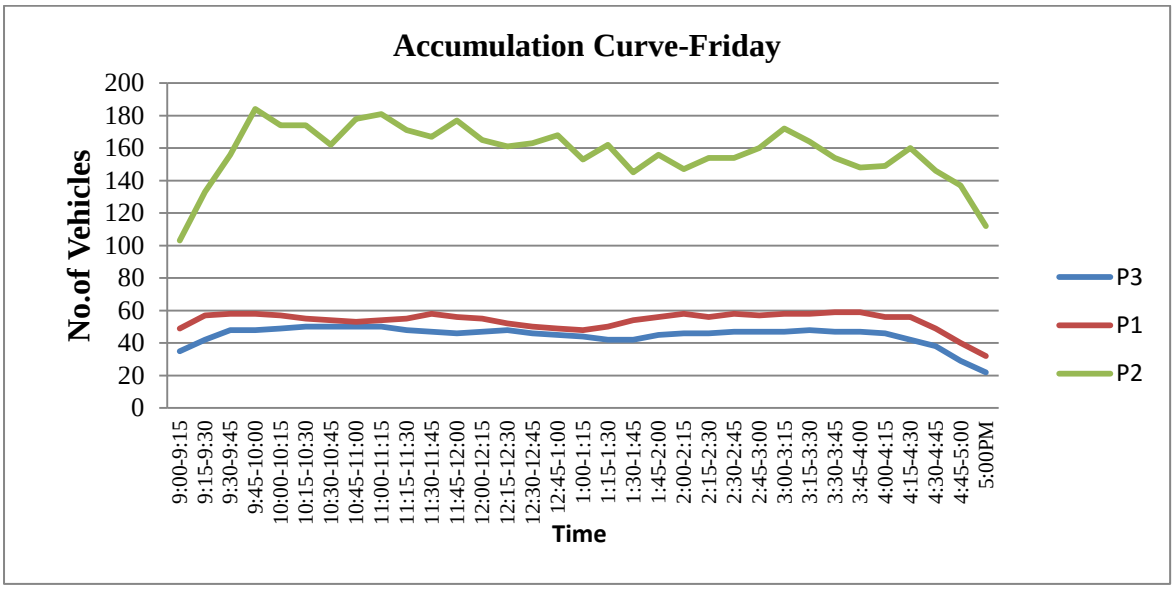

Figure 4.19: Vehicle accumulation graph of Off-street parking on Friday

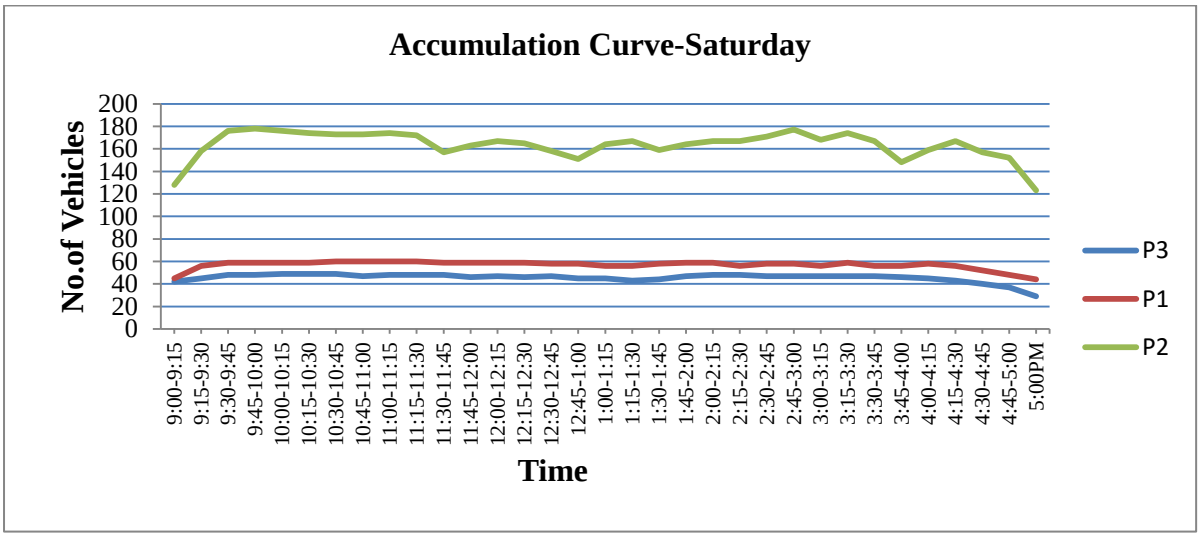

Figure 4. 20: Vehicle accumulation graph of Off-street parking on Saturday

The study conducted parking survey at off-street parking, which consists of 295 parking bays. The parking facility created exclusively for the cars and mini-buses. Tana surface parking (P2) has evolved as a predominantly shopping center and it attracts customers from all over the city. It is one of the largest surfaces parking among others in the study area. It consists of 185 parking bays. Urago market center surface parking (P3) and Yirga Haile underground parking (P1) consist of 50 and 60 parking bays respectively. Between 10:00AM and 12:00AM and between 3:00PM and 4:00PM the parking bays utilized at a maximum level of available parking space. The graphical representation of parking

accumulation reveals that the trend accumulation almost constant from 9:00AM up to 5:00 PM specially, at P1 and P3 which indicates long-term parking duration of vehicles.

Generally, the study found that the average occupancy/ efficiency of off-street parking are about 89.2 percent. However, the average parking turnover was very poor. Long-term duration of vehicle parking is predominant in the parking area. The average parking duration of a vehicle of P1, P2 and P3 were 330, 100 and 300 minutes respectively. This is because of the parking fare rate of P2 is 6Birr per vehicle per first hour and increasing 1 Birr per consecutive hours, and for less than an hour the minimum fare rate is 3Birr. For the case of P1 the parking fare rate is 10Birr per vehicle per full day that is around 0.83Birr per hour and at P3 fare rate is 3Birr per vehicle per hour. That is the higher the duration of parking vehicles the lower number of vehicles per bay per time durations.

Therefore, the fare rate influence the rate of parking turnover which indicates P2 has better rate of turnover compared to P1and P3 parking.

4.1.7.2 Aggregated summary of On-street Parking

Table 4.8: Aggregated data analysis for On-street parking

		Date	
Analysis	Unit	Friday 4/08/2017	Saturday 5/08/2017
Study Period	hour	8	8
Total number of bays	Bays	181	181
Parking volume	vehicles	686	746
	vehicle/hour	87	94
Parking Load	vehicle-hour	1185.8	1203.3
Ave. Parking duration	minutes	120	107
Ave. Parking turnover	veh/bay/hour	0.47	0.51
Ave. Parking occupancy/ efficiency	percent	82%	83%
Parking capacity	vehicle-hour	1448	1448

The following graphs show the result of aggregated accumulation for on-street parking.

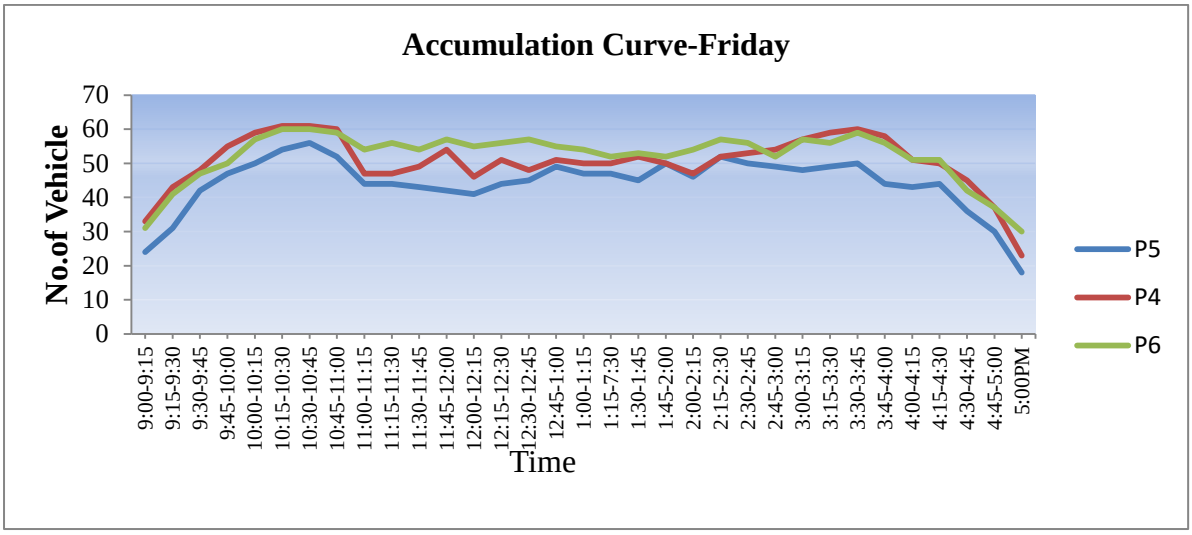

Figure 4.21: Vehicle accumulation graph of On-street parking on Friday

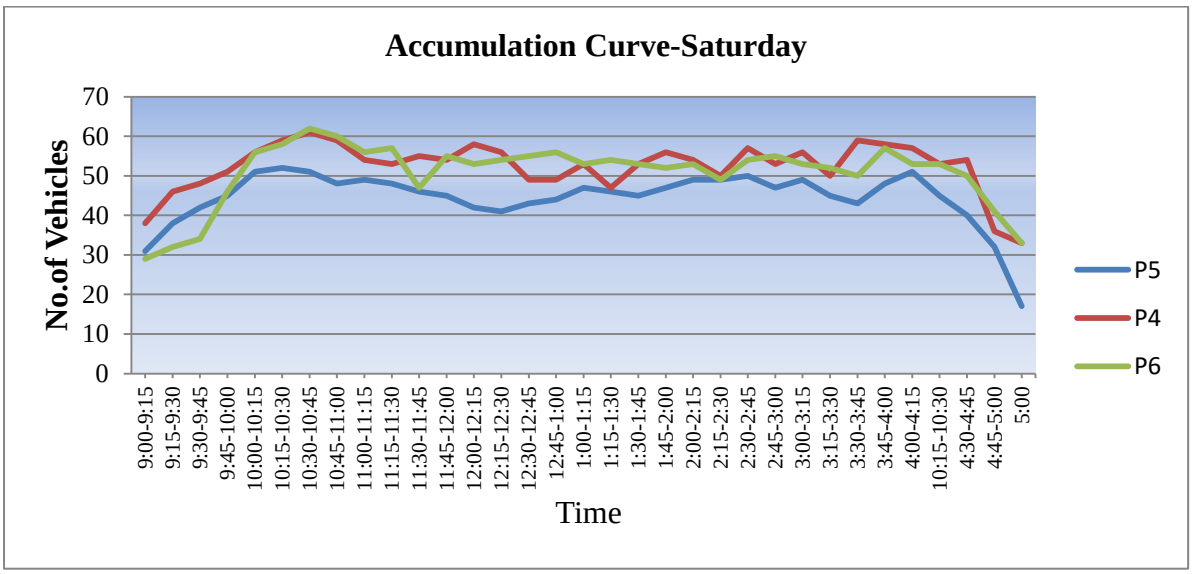

Figure 4.22: Vehicle accumulation graph of On-street parking on Saturday

As shown from the figure 4.21 and figure 4.22 the parking accumulations were the highest between 10:00AM-11:00AM in the morning and 3:00PM-4:00PM in the afternoon. P4, P5 and P6 are roadside parking along the street as the designation by the researcher. The parking accumulation of P4 was slightly higher than that of P5 and P6 throughout the study period. The average occupancy/efficiency of P4, P5 and P6 are about 81.5, 81.5 and 83 percent respectively. This shows that the average occupancy/efficiency of P4 is higher than that of P5 and P6. The average parking durations of P4, P5 and P6 are 83, 90 and 168 minutes respectively. This shows that the average parking turnover of P4 is higher than that of P5 and P6. Thus, vehicles at P4 parked for short time that increases the number of vehicles per bay per time durations.

Generally, the study found that the average occupancy/ efficiency of on-street parking are about 82 percent. However, the average parking turnover was better than off-street parking. Short-term duration of a vehicle in the study area was predominant.

Also, the table shows that the parking accumulation on Saturday was relatively uniform and higher than Friday. Therefore, the researcher select Saturday for travel time analysis.

4.1.8 Aggregated Data Analysis

The following table shows the result of aggregated data analysis of all parking locations.

Table 4.9: Aggregated data analysis

Analysis	Unit	Date	
		Friday 4/08/2017	Saturday 5/08/2017
Study Period	hour	8	8
Total number of bays	Bays	476	476
Parking volume	vehicles	1571	1734
	vehicle/hour	199	219
Parking load	vehicle-hour	3253.8	3336.85
Ave. parking duration	minutes	182	174
Ave. parking turnover	veh/bay/hour	0.38	0.41
Ave. parking occupancy/ efficiency	percent	85%	87.6%
Parking capacity	vehicle-hour	3808	3808

The road segment along P4, P5 and P6 were the major road feeder for the largest market center of Merkato and it evolved as a predominantly commercial and religious center. The roadside parking start from Teklehaymanot square to Grand Anwar mosque and covers about 690m road segment length (P4, P5 and P6 as the researcher designation). It is one of the largest roadside parking among others in the study area. Parking provided both sides of the road except in front of Grand Anwar mosque. There are about 181 illegal parking bays along the street. Parking accumulation level of the vehicle is linearly increasing from 9:00AM to 11:00AM; it means the demand for parking space was almost

increasing. The maximum demand was found is 97 percent i.e. around 10:00AM-11:00AM and 3:00PM-4:00PM, and the minimum demand was 18 percent around 8:00AM-9:00AM and 5:00PM. Turnover rate of vehicle parking per space were 4veh/bay, which is more compare to the off-street parking. It observed that 51 percent of vehicles parked for the duration of 113minutes. This means the average parking duration of a vehicle was about 2 hours. The study found that on-street parking was short term parking duration than that of off-street parking. But, it was roadside parking; it hinders the traffic flow of the area. The study found that the demand for vehicle parking was significantly high during afternoon and some of the car owners/ drivers failed to find parking bays to park their vehicles. On the other hand, the street road segments along P4, P5 and P6 were one of the busy commercial centers areas.

Generally, based on the aggregated data analysis, the following conclusions and recommendations are forwarded.

There are about 300 legal off-street parking and about 180 on-street parking spaces in study area. The parking spaces are serving the demand with on street and off-street facility.

From 10:00AM -4:00PM, the utilized spaces for off-street parking of P1 and P2 were almost constant. The parking accumulation was almost uniform between 9:00AM – 5:00PM. Here, parking space utilization of off-street parking less when compared to on - street parking as had shown from figure 4.20 and 4.22. These show that, on-street parking was preferred to park by vehicle owners. Because, the park/un park time is short. The parking capacity is good. It can serve additional 14% of the vehicle-hour in weekday and up to 571 vehicle-hours on Saturday.

The parking spaces utilized on Saturday is higher than that of the weekdays. Based on this, the parking users expected to be significantly associated with commercial trips than work trips.

The hourly parking volume for study area is about 219 veh/hr on Saturday and 199veh/h for weekdays. In other words, in every one-hour a minimum of 199 different vehicles have parked.

Average parking duration is 182 minutes for weekday and 174 minutes for weekend. The average parking turnover is 0.38veh/bay/hour for weekday and 0.41veh/bay/hour on Saturday. This result shows a poor value of parking turnover because vehicles have parked for a long time about 3 hours.

The average weighted efficiency is from 85% to 87%. More than 14% of the parking capacity have not utilized for different reasons. For example, the easiness to find a vacant parking space

4.2 The Relationship of Utilized Parking Spaces and Parking Capacity of On-Street and off- street parking

The relationship of parking utilized spaces and the available parking capacity of off-street and on-street parking were analyzed using linear regression model of analysis. Regression function involves a set of unknown parameters Bi and constant value B. If a regression function is linear in the parameters, it termed as a linear regression model. In this case, there were one dependent variable (utilized parking space) and one independent variable (parking capacity).

Parking occupancy is one of the utilized parking space determinations. Therefore, the utilized parking space is the percentage of parking occupancy of the actual number of available parking capacity. The on-street and off-street utilization of parking was recorded in six study areas within the sub-city. The graphs below (Figure 4.23 and 4.24) summarize the occupancy results of the combined study areas of off-street and on-street parking.

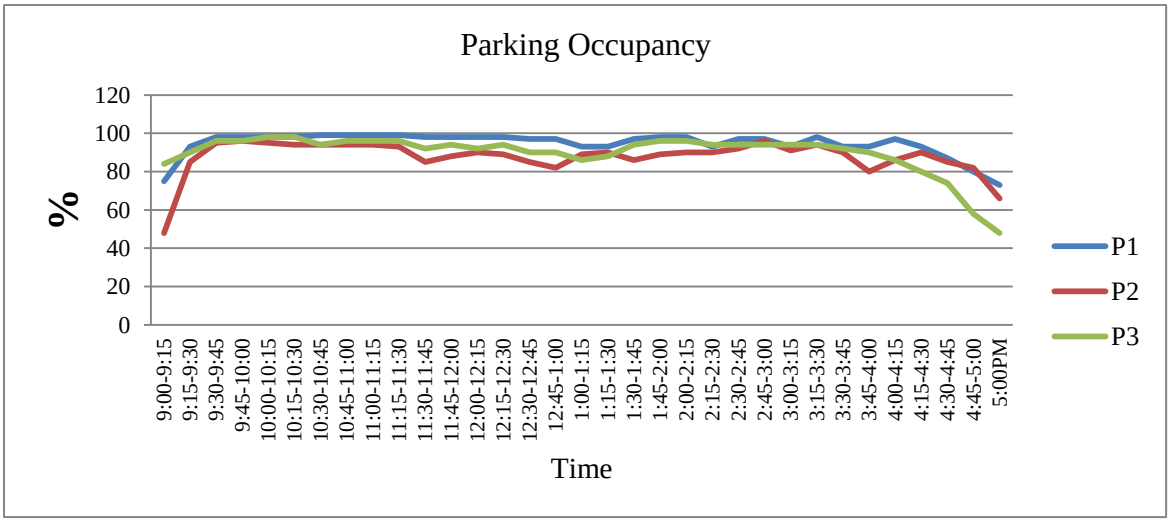

Figure 4.23: Parking occupancy of off-street parking

The results show that between the times 10:00AM-11:00AM the maximum occupancy (about 99%) was observed on Saturday at P1. For location P2 the peak occupancy was about 96% during 9:00AM to 10:30AM and for location P6 it was about 98% occurred during 10:15AM to 11:15AM. This is, on Saturday because many professional public centers and government entities located in Addis Ababa are not open on so that movement towards Merkato increases during morning period.

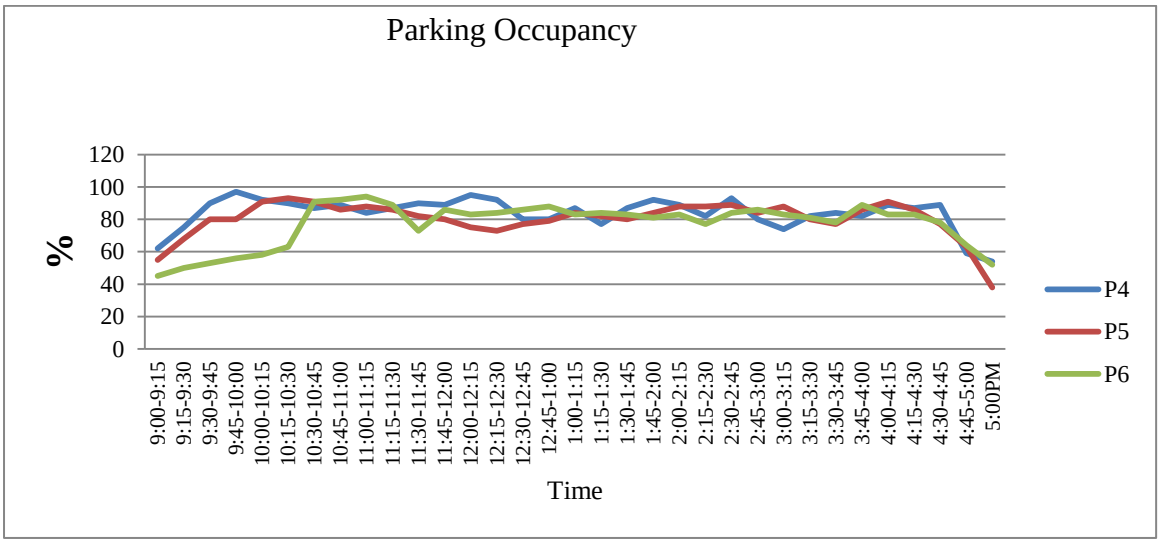

Figure 4.24: Parking occupancy of on-street parking

The above graph results shows based on the 61 on-street spaces evaluated, the peak occupancy occurred during 9:30AM-10:30AM (about 97%) was observed on Saturday at P4. For location P5 the peak occupancy occurred during 10:15AM-11:15AM about 93% while location P6 the peak occupancy occurred during 10:30AM-11:30AM about 94% Since, the study area was found within business areas the parking occupancy is higher in the morning and higher than others day. Overall, the occupancy rates for the on-street parking spaces were relatively low compared with off-street parking. In general, the maximum utilized parking spaces are the maximum parking occupancy of the actual parking capacity. Parking occupancy is the ratio of space utilized to capacity during peak-hour.

Table 4.10: Regression input table of Off-street parking

Location	No. of bays (C)	Peak-occupancy (%) $(\lambda = \frac{S}{C})$	Max. Utilized parking space (S)
P1	60	99	59
P2	185	96	178
P3	50	98	49

Table 4.11: Regression input table of On-street parking

Location	No. of bays (C)	Peak-occupancy (%) $(\lambda = \frac{S}{C})$	Max. Utilized parking space (S)
P4	61	97	59
P5	56	93	52
P6	64	94	60

Table 4.12: Regression Output table of Off-street parking

Regression statistics	
R	1
R Square	1
Adjusted R square	0.999
Standard Error	0.024
F	1636.81
Significance F	0.016
Constant (B)	-0.993
Co efficient of X (Beta)	0.966

Where, R Square is called the coefficient of determination and R is the correlation coefficient. The magnitude and direction of influence is indicated by the B and Beta values. The Beta-value (0.966) implies with an increase by a unit change in parking space is expected to yield a change in increase utilized parking spaces by 0.966 units. The sign of the linear regression coefficient (Beta) is positive, implying that an increase in parking space will bring about a corresponding increase in utilization of parking spaces by 0.966 units for every unit change in parking capacity.

The relationship developed was Ps = 0.966 C – 0.993

Where, Ps = No. of utilized parking space and C= No. of parking Capacity

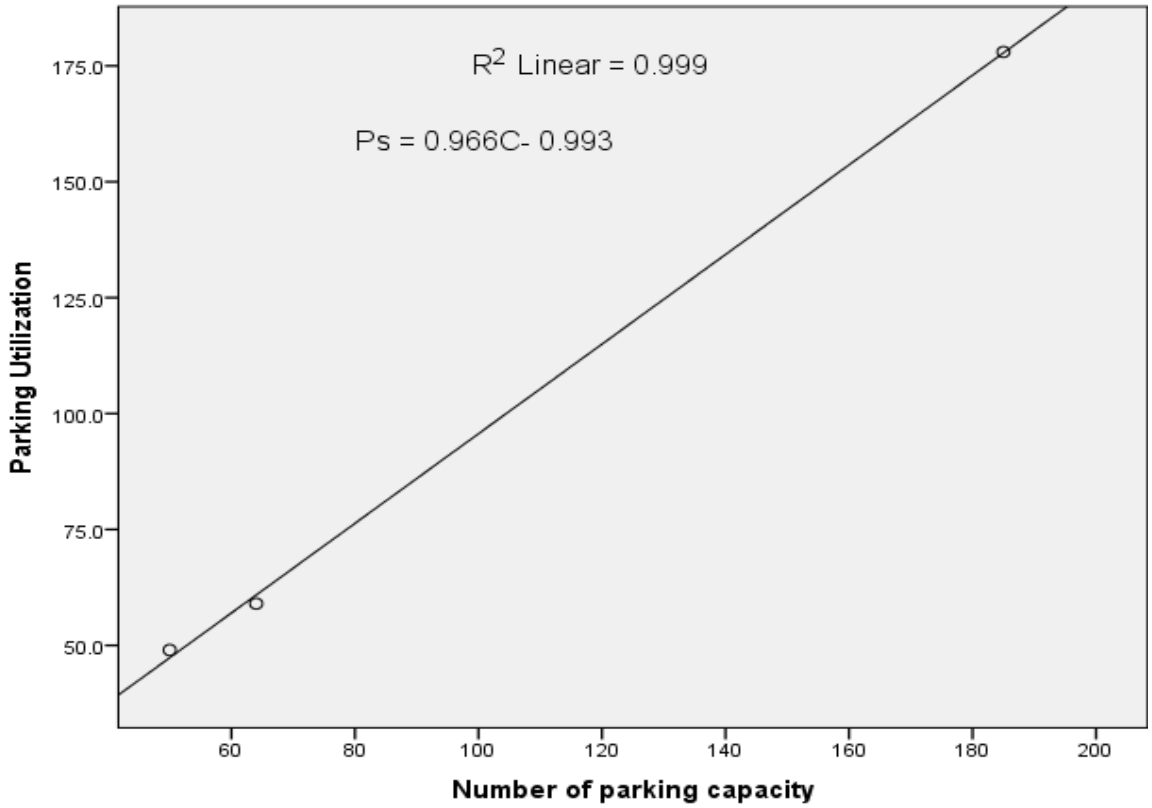

Figure 4.25: Parking bay utilized vs. total parking capacity graph of off-street parking

Table 4.13: Regression Output table of On-street parking

Regression statistics	
R	0.965
R Square	0.931
Adjusted R square	0.863
Standard Error	0.283
F	13.547
Significance F	0.169
Constant (B)	-5.796
Co efficient of X (Beta)	1.041

The linear regression analysis results in the regression summary between utilized parking spaces and the parking capacity of on-street parking shown from table 4.13. The value of R square is 0.931. The regression summary shows that the independent variable explains

93.1% of the variation in utilized parking spaces. This means that the remaining 6.9% are due to variables, which are not included in the model.

The magnitude and direction of influence indicated by the B and Beta values. The coefficient (Beta) 1.041 implies with an increase by a unit change in parking space expected to yield a change in utilized parking spaces by 1.041 units. The sign of the regression coefficient (Beta) is positive, implying that an increase in parking space will bring about a corresponding increase in utilized parking spaces by 1.041 units for every unit change in parking capacity.

The relationship developed was, Ps = 1.041C– 5.796

Where, Ps = No. of utilized parking space and C = No. of parking capacity

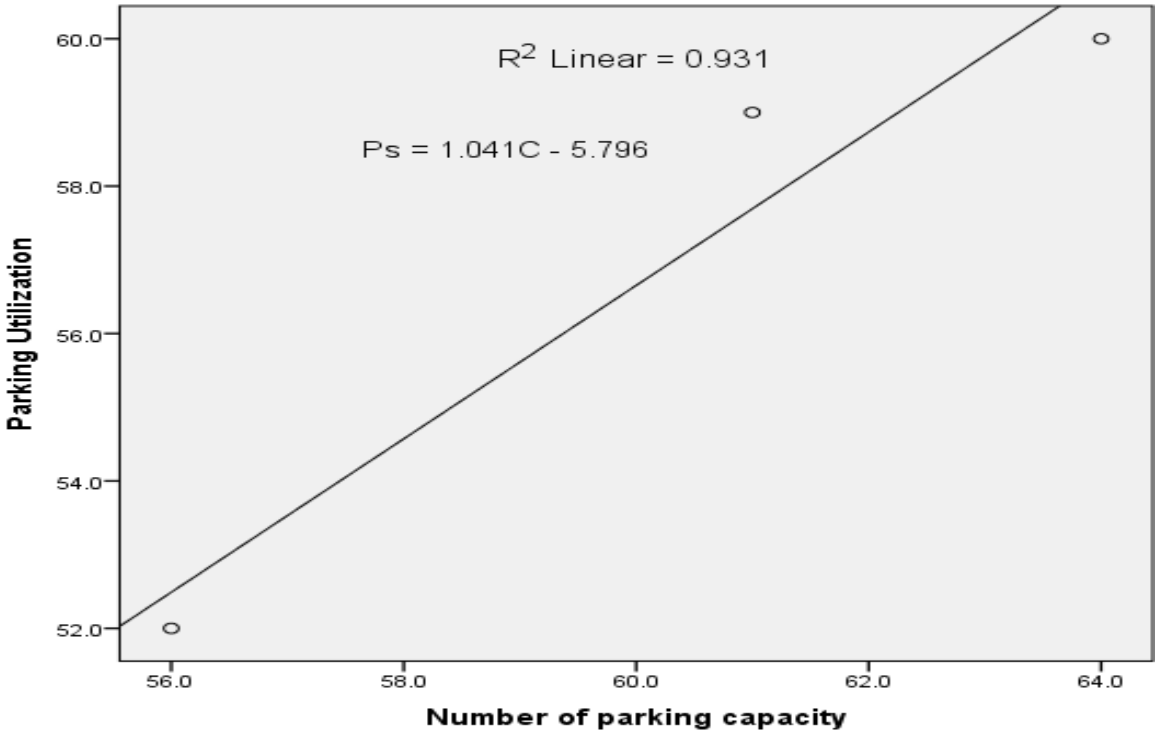

Figure 4.26: Parking utilized vs. parking capacity graph of on-street parking

Generally, from the above figures the utilized parking spaces is linearly correlated with available parking capacity. As the number of available parking capacity increases the utilized parking spaces by a vehicles also increases. That is the larger parking capacity available there are more vehicles utilized it. The relationship is shown by developed equations.

4.3 The Influence of On Street-Parking on Travel Time (Moving Traffic)

4.3.1. Travel-Time Study Considering On-Street Parking

Travel time is the actually observed time for a vehicle to traverse the test section over a specified route under existing traffic conditions. The travel-time study measures the total elapsed time of travel, including stops and delay due to on-street parking.

The travel time analysis has done only on the selected roadside parking location along road segment. These were

- P4 roadside parking along Tesema Aba Kemaw St. from right side (Teklehymanot square to Urago market center)
- P5 roadside parking along Tesema Aba Kemaw St. from left side (Teklehymanot square to Urago market center)
- P6 roadside parking in front of Grand Anwar mosque (Urago market center to Fitawurari Gebeyehu St.)

From the parking survey data, the observed peak parking counts at each parking area through the period of survey have been taken as the peak parking accumulation for the respective parking areas. The researcher took peak hour reading for the purpose of travel time analysis to indicate the influence of on street parking on travel time throughout the day reading. From the figure 4.21 and 4.22 and table 4.8 show that, the parking accumulation on Saturday was relatively uniform and higher than Friday. Therefore, the researcher select Saturday for travel time analysis to indicate the effect of roadside parking on travel time.

The test sections selected are three-lane, two-way streets with illegal on-street parking. The lengths of the test sections were 230m, 215m and 245m of P4, P5 and P6 respectively. The widths of the sections were about 9m for each P4 and P5 but not P6 it is about 7m.

According AACRA, Geometric Design Parking Manual, the width of the parallel parking space will vary depending on the space usage:

- ✓ 2.3m wide for cars and light commercial vehicles.
- ✓ 2.1m wide for cars and light commercial vehicles where there is a restricted roadway width and the parking of wide vehicles is unlikely. Where a continuously line marked narrow parking lane will aid traffic flow.

- ✓ 2.6m wide for trucks and large buses.

Under low speed urban conditions, where traffic speed past the site do not exceed 60km/hr, to establish the width from the kerb to the right hand edge of the nearest moving traffic lane, add 0.5m clearance to the widths. This clearance should be increased by 1.0m for each 10km/hr by which the traffic speeds exceed 60km/hr to a maximum clearance of 3.0m. Where parking turnover is high and vehicles backing into parking spaces cannot be readily tolerated increased space lengths up to 8.0m should be considered (AACRA, 2004).

The type of parking practiced at the study area was parallel parking, which is along the traffic flow direction. Finally, three segments from one street selected in the study area; these test sections were located in business (commercial) areas. The study conducted for the period of 8 hours (9:00 AM–5:00PM).

Table 4.14: Characteristics of Test Sections

Test section	Section1, P4	Section2, P5	Section3, P6
No. of Parking bays	61	56	64
Ave. Parking load(veh-hour)	53	46	51
Ave. Number of parking vol.(veh/h)	39	18	37
Occupancy (%)	87	80	77
Section length(m)	230	215	245
No. of lane	3	3	2
Lane width	3m	3m	3.5m
Gradient (%)	3.5	-3.5	0.9

Therefore, the influences of on-street parking on travel time measured by average travel time. The average travel time determined first, by considering on-street parking along the road segment, and then, by removing on-street parking. The difference of these values can determined the effect of on-street parking on travel time.

4.3.2 Input Data for Travel Time Analysis Using Vissim Software

Table 4.15: Peak hour input data for travel time analysis along (P4)

Vehicle type	Total No. of Vehicles	Relative flow	Ave. parking rate (%)	Ave. Speed (km/hr)	Time Distribution(sec)	
					Mean	St dev.
Cars	621	0.553	87	40	4931	19
Mini-buses	349	0.331				
Buses	7	0.006				
Trucks	93	0.083				
Motor cycles	52	0.046				
Total	1122	1.000				

Table 4.16: Peak hour input data for travel time analysis along (P5)

Vehicle type	Total No. of vehicles	Relative flow	Ave. parking rate (%)	Ave. Speed (km/hr)	Time Distribution	
					Mean	St dev.
Cars	670	0.594	80	40	9360	40
Mini-buses	317	0.281				
Buses	12	0.011				
Trucks	98	0.087				
Motor cycles	31	0.027				
Total	1128	1.000				

Table 4.17: Peak hour input data for travel time analysis along (P6)

Vehicle type	Total No. of Vehicles	Relative flow	Ave. parking rate (%)	Ave. Speed (km/hr)	Time Distribution(sec)	
					Mean	St dev.
Cars	491	0.505				
Mini-buses	359	0.369				
Buses	7	0.007				
Trucks	78	0.080	77		4980	27
Motor cycles	38	0.039		40		
Total	973	1.000				

The speed of traffic flow at a scenario of roadside parking is determined from the actual travel time that recorded the traffic flow of each vehicle between the test sections.

So, speed = distance between test section/ actual travel time

Distance between the test section= 230m

Actual travel time= 21seconds

Speed= 230/21= 10.95m/sec which is equal to 40Km/hr.

According to Vissim 9.0 Manual, the time distribution is allocated in the parking routing decisions. A vehicle, which assigned a parking space via a parking routing decision, carries out on an automatically generated route and parks for as long as the time distribution specifies. After the time expires, the vehicle leaves the parking bays and begins on an automatically generated route.

4.3.3. Travel Time

Average travel time at15min interval was determined for the selected road segments. These were done by considering two scenarios: by considering roadside parking and by removing roadside parking along the road segment. The results were shown from the table below.

Table 4.18: Travel time output by considering the two scenarios

Time int.	Travel time with roadside parking (sec)			Travel time without roadside parking (sec)		
	P4=230 m	P5=215 m	P6=245 m	P4=230 m	P5=215 m	P6=245 m
9:00-9:15AM	29.53	28.01	88.31	19.55	18.73	28.04
9:15-9:30AM	26.25	28.01	107.04	19.53	18.76	28.03
9:30-9:45AM	56.66	87.7	139.52	19.55	18.77	28.09
9:45-10:00AM	81.61	76.53	126.61	19.61	18.7	28.1
10:00-10:15AM	105.48	126.98	148.77	19.62	18.74	28.08
10:15-10:30AM	96.19	108.71	131.85	19.59	18.74	28.18
10:30-10:45AM	91.88	107.11	141.24	19.54	18.78	27.98
10:45-11:00AM	91	103.27	127.54	19.52	18.74	27.97
11:00-11:15AM	39.1	56.04	157.88	19.55	18.77	28.03
11:15-11:30AM	39.08	56.05	143.45	19.51	18.84	27.99
11:30-11:45AM	39.1	56.11	94.95	19.56	18.78	28.01
11:45-12:00AM	39.16	56.08	37.46	19.55	18.78	28.01
12:00-12:15AM	39.16	56.11	37.47	19.54	18.77	27.94
12:15-12:30AM	39.23	56.31	37.48	19.55	18.77	28.1
12:30-12:45AM	39.07	56.06	37.53	19.51	18.7	27.97
12:45-1:00AM	39.03	55.97	37.55	19.62	18.84	28.18
1:00-1:15PM	39.09	56.02	37.56	19.6	18.7	28.08
1:15-1:30PM	39.03	56.03	37.63	19.61	18.73	28.11
1:30-1:45PM	39.06	56.02	37.56	19.63	18.72	28.18
1:45-2:00PM	19.58	28.05	27.96	19.53	18.8	18.7
2:00-2:15PM	19.56	27.98	27.97	19.51	18.74	18.8
2:15-2:30PM	19.55	28.06	28.09	19.49	18.78	18.78
2:30-2:45PM	19.56	27.99	28.01	19.5	18.73	18.76
2:45-3:00PM	19.59	27.96	27.96	19.53	18.76	18.74
3:00-3:15PM	89.63	114.82	101.05	19.55	18.73	28.05
3:15-3:30PM	97.16	117.51	133.14	19.52	18.76	27.98
3:30-3:45PM	89.85	142.82	111.96	19.55	18.78	27.98

3:45-4:00PM	92.2	139.98	112.04	19.6	18.7	28.08
4:00-4:15PM	19.57	28.03	28.11	19.53	18.7	18.79
4:15-4:30PM	19.55	27.98	27.95	19.5	18.82	18.8
4:30-4:45PM	19.55	27.99	28.01	19.51	18.78	18.76
4:45-5:00PM	19.74	28.05	27.94	19.57	18.77	18.82

The table above shows the travel time by considering on-street parking was greater than the travel time without considering on-street parking. The average travel time along roadside parking of P4, P5 and P6 were 48, 64.1 and 75.55 seconds respectively. Also, the results were shown using graphs to interpret each roadside parking along the road segment. According to the result shown in the figure 4.27 below, it shows the morning and afternoon peak periods recorded the highest travel time and the lowest travel time recorded during mid-day for all road segments along P4, P5 and P6 roadside parking. This is because the road connects the residential area of the city to the largest market center, Merkato, and the area is surrounded with commercial shops, in which the parking demand is high between peak hour 10:00 AM and 11:00 AM as shown from parking statistics. Road segment along P5 has a higher travel time during afternoon peak period. This is because of the workday ending around 4:00 PM, before this time the employee go to commercial areas before they are leaving to their homes so that parking is high.

Similarly, these segments have the highest travel time during the morning period than afternoon time. However, for the road segment along P4, it has relatively less travel time even though it has slightly higher in the morning and afternoon peak. When they compared to each other, the three-road segment on the different segment length, the road segment along P6 has the highest travel time from the other. On the other hand, road segment along P6 has low travel time during mid-day.

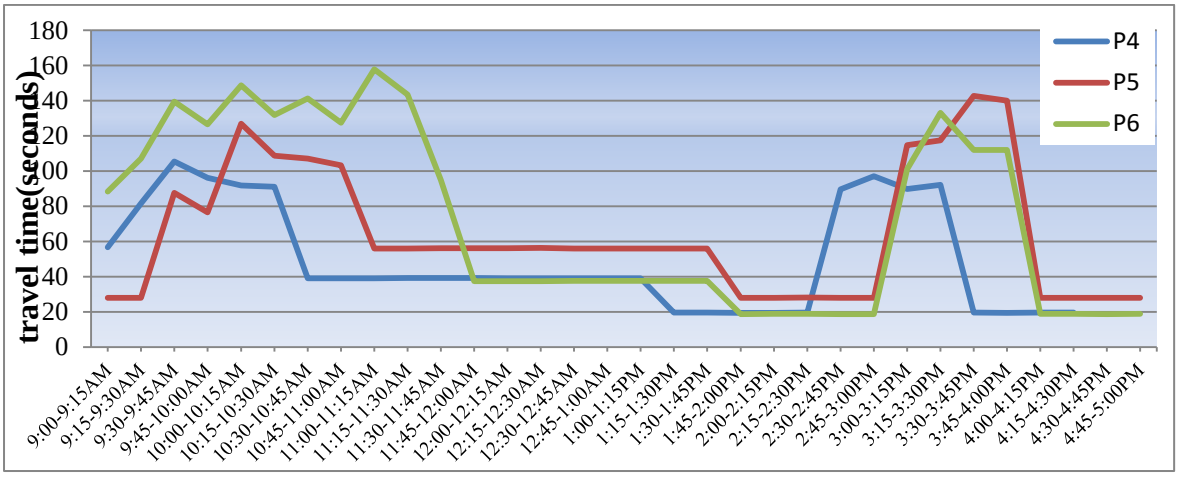

Figure 4.27: Travel time for roadside parking along the road segment

4.3.4 Total Segment Delay

Delay is the additional time experienced by a road user in association to the theoretical (ideal) travel or the actual travel time. The delay of vehicles in leaving travel time measurement is obtained by subtracting the theoretical (ideal) travel time from the actual travel time. The theoretical (ideal) travel time is the travel time that achieved if there were no other vehicles and/or no signal control or other reason for stops by removing on-street parking. The actual travel time is the travel time that achieved by considering on-street parking.

Total segment delay was the summation of average stopped delay in seconds per vehicle without at public transport stops and in parking bays and the average vehicle delay (additional delay) in seconds per vehicle determined above. The average delay of each 15 minutes interval was considered to determine the total segment delay as shown from table 4.19.

Additional delay= Actual travel time – theoretical (ideal) travel time

Total segment delay= ∑(Ave. sopped delay + Additional delay) sec/veh

Table 4.19: Total segment delay of on-street parking along the road segment

Time int.	Average stopped delay (sec/veh)			Average additional delay (sec/veh)		
	P4	P5	P6	P4	P5	P6
9:00-9:15AM	5	10.35	15.41	9.98	9.28	60.27
9:15-9:30AM	5.55	20.32	30.92	6.72	9.25	79.01
9:30-9:45AM	7.12	14.3	21.33	37.11	68.93	111.43
9:45-10:00AM	7.6	4.02	14.82	62	57.83	98.51
10:00-10:15AM	8.02	6.96	8.95	85.86	108.24	120.69
10:15-10:30AM	5.86	5.68	35.57	76.6	89.97	103.67
10:30-10:45AM	6.91	14.12	26.77	72.34	88.33	113.26
10:45-11:00AM	13.24	25.29	23.82	71.48	84.53	99.57
11:00-11:15AM	10.69	2.43	10.69	19.55	37.27	129.85
11:15-11:30AM	10.87	11.01	24.91	19.57	37.21	115.46
11:30-11:45AM	7.98	12.51	31.07	19.54	37.33	66.94
11:45-12:00AM	8.21	24.32	21.67	19.61	37.3	9.45
12:00-12:15AM	6.19	24.59	29.72	19.62	37.34	9.53
12:15-12:30AM	7.68	32.27	25.19	19.68	37.54	9.38
12:30-12:45AM	3.21	23.45	34.66	19.56	37.36	9.56
12:45-1:00AM	5.5	6	38.96	19.41	37.13	9.37
1:00-1:15PM	8	5.68	33.95	19.49	37.32	9.48
1:15-1:30PM	3.33	13.9	43.61	19.42	37.3	9.52
1:30-1:45PM	12.1	8.2	37.47	19.43	37.3	9.38
1:45-2:00PM	10.64	11.2	38.03	0.05	9.25	9.26
2:00-2:15PM	11.9	9	7.9	0.05	9.24	9.17
2:15-2:30PM	5.3	9.3	7.88	0.06	9.28	9.31
2:30-2:45PM	1.18	4.9	4.43	0.06	9.26	9.25
2:45-3:00PM	2.59	9.54	10.13	0.06	9.2	9.22
3:00-3:15PM	6.54	5.39	15.43	70.08	96.09	73
3:15-3:30PM	6.56	11.44	22.78	77.64	98.75	105.16
3:30-3:45PM	8.95	9.97	33.84	70.3	124.04	83.98
3:45-4:00PM	12.59	8.32	42.61	72.6	121.28	83.96
4:00-4:15PM	5	18	37.59	0.04	9.33	9.32
4:15-4:30PM	8	10	37.47	0.05	9.16	9.15
4:30-4:45PM	6	4.4	38.03	0.04	9.21	9.25
4:45-5:00PM	5.3	8.1	7.7	0.17	9.28	9.12

The table 4.19 shows the total segment delay which is the summation of average stopped delay per vehicles in seconds and the average vehicle delay (additional delay) per

vehicles in seconds. The total average segment delay along P4, P5 and P6 were 7.29, 12.01 and 25.95 seconds per vehicle respectively.

Figure 4.28 shows the total segment delay in seconds per vehicles for the selected road segment length by considering the length of the given segment. The result in the figure should not be compared each other because these segments are not equal in length, therefore, it should be read for a single road segment only at once.

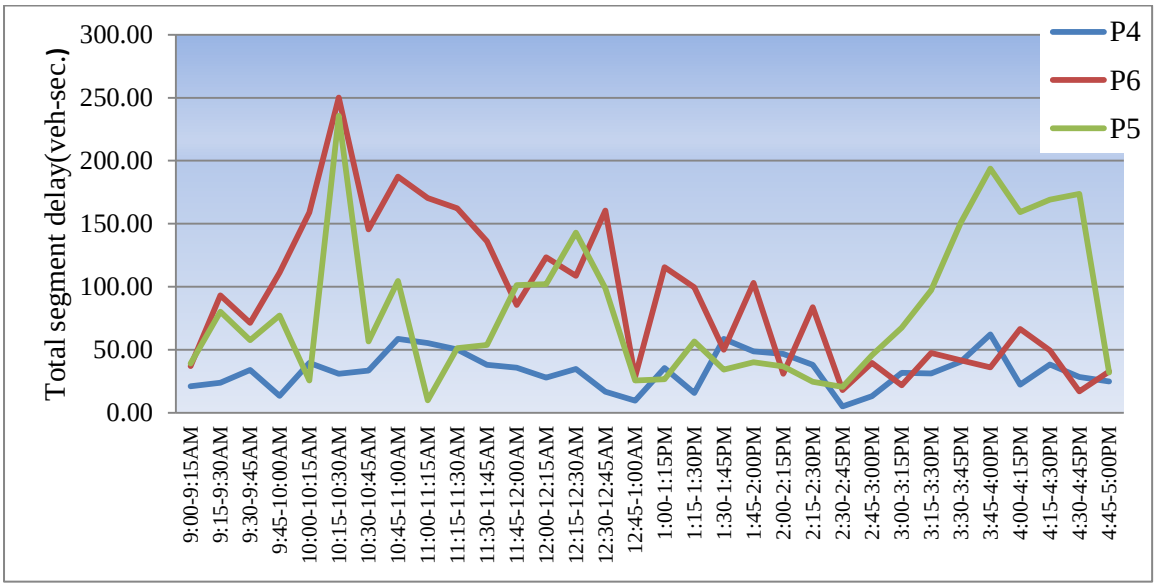

Figure 4.28: Total segment delay of the road segment of roadside parking

The total segment delay of road segment along P6 has maximum during morning peak hour because the parking volume has increase during this hour and the travel time of vehicle in a given segment also increase as a result the total segment delay of road segment along P6 is maximum. In the same case, total segment delay of road segment along P5 during afternoon peak-hour time became the highest because of parking volume and travel time increase simultaneously. For the case of road segment along P4 has similar appearances with a little variation throughout the day.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

- There are about 300 legal off-street parking and about 180 on-street parking spaces were evaluated in the study area. The hourly parking volume for study areas were about 219veh/h on Saturday and 199veh/h for weekdays. In other words, in every one hour a minimum of 199 different vehicles park.
- The average parking occupancy/efficiency of off-street parking and on-street parking were around 90% and 82% respectively. But, the average parking duration of off-street parking were about 4 hours and 2 hours at on-street parking.
- The average parking turnovers of off-street and on-street parking were 0.30veh/h/bay and 0.50veh/hour/ bay respectively. This result shows vehicles are parked at off-street parking for a long time than on-street parking.
- The aggregate weighted efficiency is from 85% to 86%. More than 14% of the parking capacity is not utilized for different reasons. For example, the easiness to find a vacant parking space.
- The relationships have been developed for estimating on-street and off-street utilized parking spaces of selected streets and off-street parking facilities in the study area. Therefore, the utilized parking spaces show nearly full utilization of the available parking capacity; in turn this create further parking investment in the study area.
- The average travel time along roadside parking of P4, P5 and P6 were 48, 64.1 and 75.55 seconds respectively.
- According to the segment delay analysis results the total average segment delays of parking P4, P5 and P6 along road segments were 7.29, 12.01 and 25.95 seconds per vehicle respectively.

5.2 Recommendation

- According to the findings of the study the vehicles parked for the average parking duration of 180 minutes. In location P1 and P3; one car was observed parked for at least six hours and five hours respectively. Additionally, based on the turnover rate 0.19; these parking are very un-utilized. Therefore, there should be parking time-restriction and intervention through parking fare rate at these parking locations. These interventions will improve the parking turnover. This also shift on-street parking to off-street parking since improving parking turnover will increase parking capacity.
- The weighted parking efficiency is 85% to 86%. For example, the easiness to find a vacant parking space can be increased by implementing ITS tools. In return, this will increase the efficiency of utilizing available parking space. The average occupancy rate were above 80 percent in all parking types, the reason for high parking demand were not only related to short of parking supply, but also related to high parking duration and poor parking managements. So, there should give attention to parking policies and management.
- The analysis result shows that the road segments are serving more for roadside parking than moving traffic. Therefore, the city administration should consider this issue and formulate parking control enforcement. Parking control can be used to limit parking duration, control types of vehicles or users allowed to access the space, provide a clearway allowing the parking lane to be used as a through lane where peak hour traffic volumes exceed the available lane capacity.
- Transport related office especially Addis Ababa City Transport Program Management Office (TPMO) should work further on parking problems.

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Appendix-A

Parking Survey

Table 1: Sample of parking volume count of off-street parking (P3) on August5, 2017 using License Plate Method

# of bay	9:00-10:00AM				10:00-11:00AM				11:00-12:00AM			
	9:00-9:15	9:15-9:30	9:30-9:45	9:45-10:00	10:00-10:15	10:15-10:30	10:30-10:45	10:45-11:00	1100-11:15	11:15-11:30	11:30-11:45	11:45-12:00
1	28770	28770	28770	28770	28770	28770	28770	28770	28770	28770	28770	28770
2	99578	99578	99578	99578	99578	99578	99578	99578	99578	99578	99578	99578
3	51335	51335	51335	51335	51335	51335	51335	51335	51335	51335	51335	51335
4	60861	60861	60861	60861	60861	60861	60861	60861	60861	60861	60861	60861
5	71572	71572	71572	71572	71572	71572	71572	71572	71572	71572	71572	71572
6	03799	03799	03799	03799	03799	03799	03799	03799	03799	03799	03799	03799
7	31420	31420	31420	31420	31420	31420	31420	31420	31420	31420	31420	31420
8	40963	40963	40963	40963	40963	40963	40963	40963	40963	40963	40963	40963
9	82691	82691	82691	82691	82691	82691	82691	82691	82691	82691	82691	82691
10	76762	76762	76762	76762	76762	76762	76762	76762	76762	76762	76762	76762
11	99578	99578	99578	99578	99578	99578	99578	99578	99578	99578	99578	99578
12	47707	47707	47707	47707	47707	47707	47707	47707	47707			
13	76087	76087	76087	76087	76087	76087	76087	76087	76087	76087	76087	76087
14	17061	17061	17061	17061	17061	17061	17061	17061	17061	17061	17061	17061
15	16879	16879	16879	16879	16879	16879	16879	16879	16879	16879	16879	16879
16	15940	15940	15940	15940	15940	15940	15940	15940	15940	15940	15940	15940
17	53871	53871	53871	53871	53871	53871	53871	53871	53871	53871	53871	53871
18	31102	31102	31102	31102	31102	31102	31102	31102	31102	31102	31102	31102
19	39026	39026	39026	39026	39026	39026	39026	39026	39026	39026		
20	42052	42052	42052	42052	42052	42052	42052	42052	42052	42052	42052	42052
21	78433	78433	78433	78433	78433	78433	78433	78433	78433	78433	78433	78433
22	35885	35885	35885	35885	35885	35885	35885	35885	35885	35885	35885	35885
23	70052	70052	70052	70052	70052	70052	70052	70052	70052	70052	70052	70052
24	61731	61731	61731	61731	61731	61731	61731	61731	61731			
25	97747	97747	97747	97747	97747	97747	97747	97747	97747	97747	97747	97747
26	45399	45399	45399	45399	45399	45399	45399	45399	45399	45399	45399	45399
27	78143	78143	78143	78143	78143	78143	78143	78143	78143	78143	78143	78143
28	51093	51093	51093	51093	51093	51093	51093	51093	51093	51093	51093	51093
29	25243	25243	25243	25243	25243	25243	25243	25243	25243	25243	25243	25243
30	03136	03136	03136	03136	03136	03136	03136	03136	03136	03136	03136	03136
31	20891	20891	20891	20891	20891	20891	20891	20891	20891	20891	20891	20891
32	23062	23062	23062	23062	23062	23062	23062	23062	23062	23062	23062	23062
33	93468	93468	93468	93468	93468	93468	93468	93468	93468	93468	93468	93468
34	81810	81810	81810	81810	81810	81810	81810	12183	12183	12183	12183	12183
35	95143	95143	95143	95143	95143	95143	95143	95143	95143	95143	95143	95143
36		54241	54241	54241	54241	54241	54241	54241	54241	54241	54241	54241
37		93597	93597	93597	93597	93597	93597	93597	93597	93597	93597	93597

38		62677	62677	62677	62677	62677	62677	62677	62677	62677	62677	62677
39		00887	00887	00887	00887	00887	00887	00887	00887	00887	00887	00887
40		43662	43662	43662	43662	43662	43662	43662	43662	43662	43662	43662
41		82777	82777	82777	82777	82777	58286	58286	58286	58286	58286	58286
42		29568	29568	29568	29568	29568	29568	29568	29568	29568	29568	29568
43			93468	93468	93468	93468	93468	93468	93468	93468	93468	
44			76364	76364	76364	76364	76364	76364	76364	76364	76364	76364
45			58685	58685	58685	58685	58685	58685	58685	58685	58685	58685
46			28713	28713	28713	28713	28713	28713	28713	28713	28713	28713
47			56906	56906	56906	56906	56906	28713	56906	56906	56906	56906
48			26587	26587	26587	26587	26587	28713	26587	26587	26587	26587
49					12543	12543	12543	28713	12543	12543	12543	12543
50						18465	18465	28713	18465	18465	18465	18465

12:00-1:00AM				1:00-2:00PM				2:00-3:00PM			
12:00-12:15	12:15-12:30	12:30-12:45	12:45-1:00	1:00-1:15	1:15-1:30	1:30-1:45	1:45-2:00	2:00-2:15	2:15-2:30	2:30-2:45	2:45-2:00
28770	28770	28770					14578	14578	14578	14578	14578
99578	99578	99578	99578	99578	99578	99578	99578	99578	99578	99578	99578
51335	51335	51335	51335	51335	51335	51335	51335	51335	12254	12254	12254
60861	60861	60861	60861	60861	60861	60861	60861	60861	60861	60861	60861
71572	71572	71572	71572	71572	71572	71572	71572	71572	71572	71572	71572
03799	03799	03799	03799	03799	03799	03799	03799	03799	03799	03799	03799
31420	31420	31420	31420	31420	31420	31420					
40963	40963						12547	12547	12547	12547	12547
82691	82691	82691	82691	82691	82691	82691	82691	82691	82691	82691	82691
76762	76762	76762	76762	76762	76762					76762	76762
99578	99578	99578	99578	99578	99578	99578	99578	99578	99578	99578	99578
95699	95699	95699	95699	95699	95699	95699	95699	95699	95699	95699	95699
76524	76524	76524	76524	76524	76524	76524	76524	76524	76524	76524	76524
17061	17061	17061	17061	17061	17061	17061	17061	17061	17061	17061	17061
70039	70039	70039	70039	70039	70039	70039	70039	70039	70039	70039	70039
15940	15940	15940	15940	15940	15940	15940	15940	15940	15940	15940	15940
53871	53871	53871					01565	01565	01565	01565	01565
31102	31102	31102	31102	31102	31102	31102	31102	31102	31102	31102	31102
	41827	41827	41827	41827	41827	41827	41827	41827	41827	41827	41827
42052	42052	42052	42052	42052	42052	42052	42052	42052	42052	42052	42052
78433	78433	78433	78433	78433	78433	78433	78433	78433	78433	78433	78433
35885	35885	35885	35885	35885	35885	35885	35885	35885	35885	35885	35885
70052	70052	70052	70052	70052	70052	70052	70052	70052	70052	70052	70052
	19854	19854	19854	19854	19854	19854	19854	19854	19854	19854	19854
97747	97747	97747	97747	97747	97747	97747	97747	97747	97747	97747	97747
45399	45399						17895	17895	17895	17895	17895
78143	78143	78143	78143	78143	78143	78143	78143	78143	78143	78143	78143
51093	51093	51093	51093	51093	51093	51093	51093	51093	51093	51093	51093
25243	25243	25243	25243	25243	25243	25243	25243	25243	25243	25243	25243
03136	03136	03136	03136	03136	03136	03136	03136				03136
20891	20891	20891	20891	20891	20891	20891	20891	20891	20891	20891	20891
23062	23062	23062	23062	23062	23062	23062	23062	23062	23062	23062	23062
93468	93468	93468	93468	93468	93468	93468	93468	93468	93468	93468	93468
12183	12183	12183	12183	12183	12183	12183	12183	12183	12183	12183	12183
95143	95143	95143	95143	95143	95143	95143	95143	95143	95143	95143	95143
54241	54241	54241	54241	54241	54241	54241					

93597	93597	93597	93597	93597	93597	93597	93597	93597	93597	93597	93597
62677	62677	62677	62677	62677	62677	62677	62677	62677	62677	62677	62677
00887	00887	00887	00887	00887	00887	00887	00887	00887	00887	00887	00887
43662	43662	43662	43662	43662	43662	43662	43662	43662	43662	43662	43662
58286	58286	58286	58286	58286	58286	58286	58286	58286	58286	58286	58286
29568	29568	29568	29568	29568	29568	29568	29568	29568	29568	29568	29568
			25747	25747	25747	25747	25747	25747	25747	25747	
76364	76364	76364	76364	76364	76364	76364	76364	76364	76364	76364	76364
58685	58685	58685	58685					58685	58685	58685	58685
28713	28713	28713	28713	28713	28713	28713	28713	28713	28713	28713	28713
56906	56906	56906	56906	56906	56906	56906	56906	56906	56906	56906	56906
26587							11254	11254	11254	11254	11254
12543	12543	12543	12543	12543				32567	32567	32567	32567
18465	18465	18465	18465	18465	18465	18465	18465	18465	18465	16523	16523

3:00PM-4:00PM				4:00PM-5:00PM					Turn over
3:00-3:15	3:15-3:30	3:30-3:45	3:45-4:00	4:00-4:15	4:15-4:30	4:30-4:45	4:45-5:00	5:00	
14578	15874	15874	15874	15874	15874	15874			3
99578	99578	99578	99578	99578	99578	99578	99578		1
12254	12254	12254	12254	12254					2
60861	60861	60861	60861	60861	60861	60861	60861		1
71572	71572	71572	71572	71572	71572	71572	71572	71572	1
03799	03799	03799	03799	A03799	A03799	A03799	A03799	03799	1
11658	11658	11658	11658	11658	11658				2
12547	12547	12547	12547	12547					2
82691	82691	82691	82691						1
76762	76762	76762	76762	76762	76762	76762	76762		1
99578	99578	99578	99578	99578	99578				1
95699	95699	95699	95699	95699	95699	95699			2
76524	76524	76524	76524	76524	76524	76524			2
17061	17061	17061	17061	17061	17061	17061	17061		1
70039	70039	70039	70039	70039	70039	70039	70039	70039	2
15940	15940	15940	15940	15940	15940	15940	15940	15940	1
01565	01565	01565	B01565	B01565	B1565	B01565	B01565	01565	2
31102	31102	31102	31102	31102	31102	31102	31102	31102	1
41827	41827	41827	41827	41827	41827	41827	41827	41827	2
42052	42052	42052	42052	42052	42052	42052	42052	42052	1
78433	78433	78433	78433	78433	78433	78433	78433	78433	1
35885	35885								1
70052	70052	70052	70052	70052	70052	70052	70052	70052	1
									2
97747	97747	97747	97747	97747					1
17895	17895	17895	17895	17895	17895	17895			2
78143	78143	78143	78143	78143	78143	78143	78143		1
51093	51093	51093	51093	51093	51093				1
25243	25243	25243	25243	25243	25243	25243	25243	25243	1
03136	03136	03136	B03136	B03136					1
20891	20891	20891	20891	20891	20891	20891	20891	20891	1
23062	23062	23062	23062	23062	23062	23062	23062	23062	1
93468	93468	93468	93468	93468	93468	93468	93468	93468	1
12183	12183	12183	12183	12183	12183	12183	12183	12183	2
95143	95143	95143	95143	95143	95143	95143	95143		1

	44147	44147	44147	44147	44147	44147			2
93597	93597	93597	93597	93597	93597	93597	93597	93597	1
62677	62677	62677	62677	62677	62677	62677			1
00887	00887	00887	A00887	A00887	A00887				1
43662	43662	43662	43662	43662	43662	43662			1
58286	58286	58286	58286	58286	58286	58286	58286	58286	2
29568	29568	29568	29568	29568	29568	29568	29568	29568	1
									2
76364	76364	76364	76364	76364	76364	76364	76364	76364	1
58685	58685	58685	58685	58685	58685	58685	58685	58685	1
28713	28713	28713	28713	28713	28713	28713	28713	28713	1
56906	56906	56906	56906	56906	56906	56906	56906	56906	1
11254	11254	11254	11254	11254	11254	11254			2
32567	32567	32567	32567	32567					2
16523	16523	16523	16523	16523	16523	16523			2

Table 2: Sample of parking volume count of on-street parking (P5) on August5, 2017 using License Plate Method

# of bays	9:00-10:00AM				10:00-11:00AM				11:00-12:00AM			
	9:00-9:15	9:15-9:30	9:30-9:45	9:45-10:00	10:00-10:15	10:15-10:30	10:30-10:45	10:45-11:00	11:00-11:15	11:15-11:30	11:30-11:45	11:45-12:00
1	96372	96372	96372	96372	96372	96372	96372	96372	96372	96372	96372	96372
2	46166	46166	46166	46166	46166	46166	46166	46166	46166	46166	46166	46166
3	6756	6756	6756	6756	6756	6756	6756	6756	6756	6756	6756	6756
4	86591	86591	86591	86591	86591	86591	86591	86591	86591	86591	86591	86591
5	39534	39534	39534	39534	39534	39534	39534	39534	39534	39534	39534	39534
6	12383	12383	12383	12383	12383	12383	12383	12383	12383	12383	12383	12383
7	39539	39539	39539	39539	39539				40273	40273	40273	40273
8	13266	13266	13266	13266	13266	13266	13266					34049
9	83714	83714	83714	83714	83714	83714	83714	83714	83714	83714	83714	83714
10	96142	96142	96142			8171	8171	8171	8171	8171	8171	8171
11	84453	84453	84453	84453	84453	84453	84453	84453	84453	84453	84453	84453
12	14248	14248	14248	14248	14248	14248	14248	14248	14248	14248	14248	
13	65998	65998	65998	65998	65998	65998	65998					21981
14	1404	1404	1404	1404	1404	1404	1404	1404	1404	1404	1404	
15	76412	76412	76412	76412	76412	76412	76412	76412	76412	76412	76412	76412
16	99593	99593	99593	99593	99593	99593	99593	99593	99593	99593	99593	99593
17	32339	32339	32339	32339	32339	32339			21367	21367	21367	21367
18	45284	45284	45284	45284	45284	45284	45284	45284	45284	45284	45284	45284
19	23629	23629	23629	23629	23629	23629	23629	23629	23629	23629	23629	23629
20	43049	43049	43049	43049	43049	43049	43049	43049	43049	43049	43049	43049
21	81082	81082	81082	81082	81082	81082	81082				34571	34571
22	77546	77546	77546	77546	77546	77546	77546	77546	77546	77546	77546	77546
23	88644	88644	88644	88644	88644	88644	88644				37188	37188
24	20538	20538	20538						92252	92252	92252	92252
25	34763	34763	34763	34763	34763	34763	34763	34763	34763	34763	34763	34763
26	9481	9481	9481	9481	9481	9481	9481	9481	9481	9481	9481	9481
27	97758	97758	97758	97758	97758	97758	97758	97758	97758	97758	97758	97758
28	18926	18926	18926	18926	18926	18926	18926	18926				
29	79569	79569	79569	79569	79569	79569	79569	79569	79569	79569	79569	79569
30	93571	93571	93571	93571	93571	93571	93571	93571	93571	93571	93571	93571
31	5131	5131	5131	5131	5131	5131	5131	5131	5131	5131		
32		92314	92314	92314	92314	92314	92314				15125	15125
33		3266	3266	3266	3266					24900	24900	24900
34		13363	13363						29846	29846	29846	29846
35		29600	29600	29600	29600	29600	29600	29600				
36		18772	18772	18772	18772	18772	18772	18772	18772			
37		87981	87981	87981	87981	87981	87981	87981	87981	87981	87981	87981
38		66649	66649	66649	66649	66649	66649	66649	66649			
39			10093	10093	10093	10093	10093	10093	10093	10093	10093	10093

40			27614	27614	27614	27614	65557	65557	65557	65557	65557	65557
41			92275	92275	92275	92275	92275	92275	92275	92275		
42			93290	93290	93290	93290	93290	93290	93290	93290	93290	93290
43			80752	80752	80752	80752	80752	80752	80752	80752		
44			79497	79497	79497	79497	79497	79497	79497			
45			67123	67123	67123	67123	67123	67123	67123	67123		
46				37188	37188	37188	37188	37188	37188	37188	37188	37188
47				40102	40102	40102	40102	40102	40102	40102	40102	40102
48				41207	41207	41207	41207	41207	41207	41207	41207	41207
49					85119	85119	85119	85119	85119	85119	85119	85119
50					19862	19862	19862	19862	19862	19862	19862	19862
51					1167	1167	1167	1167	1167	1167	1167	1167
52					7263	7263	7263	7263	7263	7263	7263	7263
53					29438	29438	29438	29438	29438	29438	29438	97298
54					67234	67234	67234	67234	67234	67234	67234	67234
55						942	942	942	942	942	942	942
56						7748	7748	7748	7748	7748	7748	7748

12:00-1:00AM				1:00-2:00PM				2:00-3:00PM			
12:00-12:15	12:15-12:30	12:30-12:45	12:45-1:00	1:00-1:15	1:15-1:30	1:30-1:45	1:45-2:00	2:00-2:15	2:15-2:30	2:30-2:45	2:45-3:00
				00673	00673	00673	00673	00673	00673	00673	
46166	46166	46166	46166	46166	46166	46166	46166	46166	46166	46166	73557
6756	6756			69670	69670	69670	69670	69670	69670	69670	69670
86591	86591	86591	86591	86591	86591	86591	86591	86591	86591	86591	86591
		83539	83539	83539	83539	83539	83539	83539	83539	83539	83539
12383	12383	12383	12383	12383							74652
40273	40273	40273	40273	40273	40273	40273	40273	40273	40273	40273	
34049	34049	34049	34049	34049	34049	34049	34049	34049	34049		
83714	83714	83714	83714	83714	83714	83714	83714	83714	83714	83714	83714
8171	8171	88524	88524	88524	88524	88524	88524	88524	88524	88524	88524
				28401	28401	28401	28401	28401	28401	28401	28401
	95924	95924	95924	95924	95924	95924	95924	95924	95924	29709	29709
21981	21981	65998	65998	65998	65998	65998	65998	65998	65998	65998	65998
										98000	98000
76412	76412	76412	76412	76412	76412	76412	76412	76412	76412	76412	76412
99593	99593	99593	99593	99593	99593	99593	91119	91119	91119	91119	91119
21367	21367	21367	21367	21367	21367	21367	21367	21367	21367	21367	21367
45284	45284	45284	45284	45284	45284	45284	45284	45284	45284	45284	45284
23629	23629	23629	23629				63469	63469	63469	63469	63469
43049	43049	43049	43049	43049	43049			64215	64215	64215	64215
34571	34571	34571	34571	34571	34571	34571	34571	34571	34571	34571	34571
77546	77546	77546	77546	77546	77546	77546	77546	77546	77546	77546	77546
37188	37188	37188	37188	37188	37188	37188	37188	37188	37188	37188	37188
92252	92252	92252	92252	92252	92252	92252	92252	92252	92252	92252	92252
34763	34763	34763						74052	74052		
9481	9481	9481	9481	9481	9481					73891	73891
97758	97758	97758	97758	97758	28401	28401	28401	28401	28401	28401	28401
				73138	73138	73138	73138	73138	7430	7430	7430
79569	79569	79569	79569	79569	79569	79569	79569	23985	23985	23985	23985
93571	93571	93571	93571	93571	93571	93571				00673	00673
				86286	86286	86286	86286	86286	86286	86286	86286
15125	15125	15125	15125						73557	73557	73557
24900	24900	24900	24900	24900	24900	24900	24900	24900	24900		
29846	29846	29846	29846	29846	29846	29846	29846	29846			
				7142	7142	7142	7142	7142	7142	7142	7142
83927	83927	83927	83927	83927	83927	83927	83927	83927	83927	83927	83927
87981	87981	87981	27090	27090	27090	27090	27090	27090	27090	27090	27090
29026	29026	29026	29026	29026	29026	29026	29026	29026	29026	29026	29026
10093	10093	10093	10093	10093	10093	10093	10093	10093	10093	10093	10093
65557					65890	65890	65890	65890	49709	49709	49709
							27170	27170	27170	27170	27170
93290	16464	16464	16464	16464	16464	16464	16464	16464	16464	16464	16464

58885	58885	58885	58885	58885				00874	00874	00874	00874
		11258	11258	11258	11258	11258	11258	11258	11258	11258	11258
			5632	5632	5632	5632	5632	5632	5632	5632	26203
		44413	44413	44413	44413	44413	44413	44413	44413	42156	42156
40102					5415	5415	5415	5415	5415	5415	
	41941	41941	41941	41941	41941	41941	41941	41941	41941	29047	29047
			97712	97712	97712	97712	97712	97712	97712	97712	
19862	19862	19862	19862	19862	19862	19862	39597	39597	39597	39597	39597
				82933	82933	82933	82933	82933	82933	82933	82933
7263	7263	7263	7263	7263	7263	7263				81223	81223
97298	97298	97298	97298				7973	7973	7973	7973	7973
67234	67234	67234	67234			A00856	A00856	A00856	A00856	A00856	
94200	94200	94200					73136	73136	73136	73136	73136
07748	07748	07748	07748	07748	07748	07748	07748				70852

3:00-4:00PM				4:00-5:00PM					Turnover
3:00-3:15	3:15-3:30	3:30-3:45	3:45-4:00	4:00-4:15	4:15-4:30	4:30-4:45	4:45-5:00	5:00	
			46707	46707	46707	46707	46707	46707	3
73557	73557	73557	73557	73557	73557	73557	73557		2
69670	69670	69670	69670	69670	69670	69670	69670		2
86591	86591	86591	86591						1
83539				A00534	A00534	A00534	A00534	A00534	3
74652	74652	74652	74652	74652	74652	74652			2
			65980	65980	65980	65980	65980	65980	3
	73891	73891	73891	73891					3
83714			35644	35644	35644	35644	35644	35644	2
									3
28401	28401	28401	28401	28401	28401	28401	28401	28401	2
29709	29709	29709	10844	10844	10844	10844	10844	10844	4
65998	65998	65998	65998	65998	65998				1
98000	98000	98000	98000	98000	98000	70113	70113	70113	4
76412	76412	97365	97365	97365	97365	97365	97365	97365	2
91119	91119	91119							2
21367	21367	29065	29065	29065	29065	29065	29065	29065	3
45284	45284	6586	6586	6586	6586	6586	6586	6586	2
63469	63469	29316	29316	29316	29316	29316	29316	29316	3
64215	64215	64215	64215	64215	64215	64215			2
34571	34571	34571	34571	34571	34571				2
77546						14342	14342		2
37188	37188	37188	37188	37188	37188				2
92252	92252	92252	92252	92252	92252				2
			22820	22820	22820	22820	22820		3
73891	73891	73891	73891	73891	73891				2
28401	28401	28401	28401	28401	28401	28401	28401		2
7430	41753	41753	41753	41753	41753	41753	41753	41753	4
23985	23985	23985	23985	23985	23985	23985	23985	23985	2
B00673	B00673	B00673	B00673	B00673	B00673	B00673	B00673	B00673	2
86286	86286	86286	86286	86286	86286	86286			2
73557	73557	73557	73557	73557	73557	73557			3
8137	8137	8137	8137	8137	8137	8137			3
12311	12311	12311	12311	12311	12311	12311	12311		3
7142	7142	7142	7142	7142					2
43334	43334	43334	43334	43334	43334	43334	43334		3
80239	80239	80239	80239	80239	80239	80239	80239		3
17349	17349	17349	17349	17349	17349	17349	17349	17349	3
11047	11047	11047	11047	11047	11047	11047	11047	11047	2
49709				16640	16640	16640			5
27170				82595	82595	82595	82595		3
16464	16464	16464	16464	16464	16464	16464	16464		2

B00874	B00874	B00874	B00874	B00874	B00874	B00874	B00874	B00874	3
11258	11258	11258	11258	11258	11258	11258	11258		2
26203	26203	26203	26203	26203	26203	26203			3
42156	42156	42156	42156	42156	42156	42156			3
			73317	73317	73317	73317	73317	73317	3
29047	29047	29047	29047	29047	29047	29047	29047	29047	3
	8300	8300	8300	8300	8300	8300	8300	8300	3
39597	39597	39597	39597	39597	39597	39597	39597	39597	2
82933	82933								2
81223	81223	81223	81223	81223	81223				2
7973	7973	7973	7973	7973	7973	7973			3
			63907	63907	63907	63907	63907		3
73136	73136			34454	34454	34454	34454		3
70852	70852	70852	70852	70852					2

Table 3: Parking Statistics of both Off-street and On-street parking on Friday

Time Int.	Accumulation (No. of Vehicles)						Parking Occupancy (%)						Parking duration (Minutes)					
	P1	P2	P3	P4	P5	P6	P1	P2	P3	P4	P5	P6	P1	P2	P3	P4	P5	P6
9:00-9:15	49	103	35	33	24	31	82	56	70	61	50	48	8.26	2.12	7.72	1.86	3.5	1.74
9:15-9:30	57	133	42	53	31	48	95	72	84	87	64	75	9.61	2.74	9.26	2.66	4.5	2.7
9:30-9:45	58	156	48	58	42	54	97	84	96	95	75	84	9.78	3.21	10.6	2.91	5.25	3.3
9:45-10:0	58	184	48	59	43	55	97	99	96	97	77	86	9.61	3.79	10.6	2.96	5.38	3.09
10:-10:15	57	174	49	56	47	54	95	94	98	92	84	84	9.27	3.59	10.8	2.81	5.88	3.03
10:15-10:30	55	174	50	50	47	57	92	94	100	82	84	89	9.1	3.59	11	2.51	5.88	3.2
10:30-10:45	54	162	50	48	46	58	90	88	100	79	82	91	8.93	3.34	11	2.41	5.75	3.26
10:45-11:00	53	178	50	48	47	57	88	96	100	79	84	89	9.1	3.67	11	2.41	5.88	3.03
11:00-11:15	54	181	50	47	46	54	90	98	100	77	82	84	9.27	3.73	11	2.36	5.75	3.31
11:15-11:30	55	171	48	47	44	59	92	92	96	77	79	97	9.78	3.52	10.6	2.36	5.5	3.37
11:30-11:45	58	167	47	49	43	60	97	90	94	80	77	94	9.44	3.44	10.4	2.46	5.38	3.2
11:45-12:00	56	177	46	54	45	57	93	96	92	89	75	89	9.27	3.65	10.2	2.71	5.25	3.09
12:00-12:15	55	165	47	51	42	55	92	89	94	84	73	86	8.76	3.4	10.4	2.56	5.13	3.43
12:15-12:30	52	161	48	51	41	61	87	87	96	84	79	95	8.43	3.32	10.6	2.56	5.5	3.2
12:30-12:45	50	163	46	48	43	57	83	88	92	79	80	84	8.26	3.36	10.2	2.41	5.63	3.09
12:45-1:0	49	168	45	51	44	55	82	91	90	84	88	86	8.09	3.46	9.93	2.56	6.13	3.03
1:00-1:15	48	153	44	50	47	54	80	83	88	82	84	84	8.43	3.15	9.71	2.51	5.88	2.92
1:15-1:30	50	162	42	50	46	52	83	88	84	82	84	81	9.1	3.34	9.26	2.51	5.88	2.98
1:30-1:45	54	145	42	52	45	53	90	78	84	85	80	83	9.44	2.99	9.26	2.61	5.63	2.92
1:45-2:00	56	156	45	50	50	52	93	84	90	82	89	81	9.78	3.21	9.93	2.51	6.25	3.03
2:00-2:15	58	147	46	47	46	54	97	79	92	77	82	84	9.61	3.03	10.2	2.36	5.75	3.2
2:15-2:30	56	154	46	52	52	57	93	83	92	85	93	89	9.78	3.17	10.2	2.61	6.5	3.15

2:30-2:45	58	154	47	53	50	56	97	83	94	87	89	88	9.78	3.17	10.4	2.66	6.25	2.92
2:45-3:00	57	160	47	54	49	52	95	86	94	89	88	81	9.94	3.3	10.4	2.71	6.13	3.03
3:00-3:15	58	172	47	51	48	54	97	93	94	84	86	84	9.94	3.54	10.4	2.56	6	3.09
3:15-3:30	58	164	48	51	49	55	97	89	96	92	88	86	9.44	3.38	10.6	2.81	6.13	2.98
3:30-3:45	59	154	47	50	50	53	98	83	94	82	89	83	9.44	3.17	10.4	2.51	6.25	3.03
3:45-4:00	59	148	47	57	44	54	98	80	94	93	79	84	8.26	3.05	10.4	2.86	5.5	2.87
4:00-4:15	56	149	46	55	43	51	93	81	92	90	77	80	6.74	3.07	10.2	2.76	5.38	2.87
4:15-4:30	56	160	42	51	44	51	93	86	84	84	79	80	9.78	3.3	9.26	2.56	5.5	2.36
4:30-4:45	49	146	38	49	36	42	82	79	76	80	64	66	6.25	3.01	8.38	2.46	4.5	2.29
4:45-5:00	40	137	29	37	30	37	67	74	58	66	54	58	6.12	2.82	6.4	2.01	3.75	2.31
5:00	32	112	22	23	18	30	53	61	44	54	32	47	5.39	2.31	4.85	1.66	2.25	2.25

Table 4: Parking Statistics of both Off-street and On-street parking on Saturday

	Accumulation (No. of Vehicles)						Parking Occupancy (%)						Parking duration (Minutes)					
Time Int.	P1	P2	P3	P4	P5	P6	P1	P2	P3	P4	P5	P6	P1	P2	P3	P4	P5	P6
9:00-9:15	45	88	42	38	31	29	75	48	84	62	55	45	8.04	1.6	8.08	1.84	3.25	1.48
9:15-9:30	56	158	45	46	38	32	93	85	90	75	68	50	10	2.9	8.65	2.23	3.99	1.63
9:30-9:45	59	176	48	55	42	34	98	95	96	90	80	53	10.5	3.2	9.23	2.67	4.72	1.73
9:45-10:0	59	178	48	59	45	36	98	96	96	97	80	56	10.5	3.2	9.23	2.86	4.72	1.84
10:-10:15	59	176	49	56	51	37	98	95	98	92	91	58	10.5	3.2	9.42	2.72	5.35	1.89
10:15-10:30	59	174	49	55	52	40	98	94	98	90	93	63	10.5	3.2	9.42	2.67	5.45	2.04
10:30-10:45	60	173	49	53	51	58	100	94	94	87	91	91	10.7	3.1	9.42	2.86	5.35	2.96
10:45-11:00	60	173	47	54	48	59	100	94	96	89	86	92	10.7	3.1	9.04	2.72	5.03	3.01
11:00-11:15	60	174	48	51	49	60	100	94	96	84	88	94	10.7	3.2	9.23	2.67	5.14	3.06
11:15-11:30	60	172	48	53	48	57	100	93	96	87	86	89	10.7	3.1	9.23	2.57	5.03	2.91
11:30-11:45	59	157	48	55	46	47	98	85	92	90	82	73	10.5	2.9	8.85	2.62	4.83	2.46
11:45-12:00	59	163	46	54	45	55	98	88	94	89	80	86	10.5	3	9.04	2.48	4.72	2.81
12:00-12:15	59	167	47	58	42	53	98	90	92	95	75	83	10.5	3	8.85	2.57	4.41	2.7
12:15-12:30	59	165	46	56	41	54	98	89	94	92	73	84	10.5	3	9.04	2.67	4.3	2.76
12:30-12:45	58	158	47	49	43	55	97	85	90	80	77	86	10.4	2.9	8.65	2.62	4.51	2.81
12:45-1:0	58	151	45	49	44	56	97	82	90	80	79	88	10.4	2.7	8.65	2.82	4.62	2.86
1:00-1:15	56	164	45	53	47	53	93	89	86	87	84	83	10	3	8.27	2.38	4.93	2.7
1:15-1:30	56	167	43	47	46	54	93	90	88	77	82	84	10	3	8.46	2.38	4.83	2.76
1:30-1:45	58	159	44	53	45	53	97	86	94	87	80	83	10.4	2.9	9.04	2.57	4.72	2.7
1:45-2:00	59	164	47	56	47	52	98	89	96	92	84	81	10.5	3	9.23	2.28	4.93	2.65
2:00-2:15	59	167	48	54	49	53	98	90	96	89	88	83	10.5	3	9.23	2.57	5.14	2.7

2:15-2:30	56	167	48	50	49	49	93	90	94	82	88	77	10	3	9.04	2.72	5.14	2.5
2:15-2:30	58	171	47	57	50	54	97	92	94	93	89	84	10.4	3.1	9.04	2.62	5.24	2.76
2:30-2:45	58	177	47	49	47	55	97	96	94	80	84	86	10.4	3.2	9.04	2.43	4.93	2.81
2:45-3:00	56	168	47	45	49	53	93	91	94	74	88	83	10	3.1	9.04	2.77	5.14	2.7
3:00-3:15	59	174	47	50	45	52	98	94	94	82	80	81	10.5	3.2	9.04	2.38	4.72	2.65
3:15-3:30	56	167	47	51	43	50	93	90	92	84	77	78	10	3	8.85	2.18	4.51	2.55
3:30-3:45	56	148	46	50	48	57	93	80	90	82	86	89	10	2.7	8.65	2.43	5.03	2.91
3:45-4:00	58	159	45	54	51	53	97	86	86	89	91	83	10.4	2.9	8.27	2.48	5.35	2.7
4:00-4:15	56	167	43	53	45	53	93	90	80	87	86	83	10	3	7.69	2.43	5.03	2.7
4:15-4:30	52	157	40	54	40	50	87	85	74	89	77	78	9.29	3	7.12	2.62	4.51	2.55
4:30-4:45	48	152	37	36	32	41	80	82	58	59	63	64	8.57	2.9	5.58	1.75	3.67	2.09
4:45-5:00	44	123	29	33	17	33	73	66	48	54	38	52	7.86	2.8	4.85	1.6	2.2	1.68
5:00	32	112	22	23	18	30	53	61	44	54	32	47	5.39	2.31	4.85	1.66	2.25	2.25

Table 5: Parking duration of On-street parking of Friday

S/NO.	P4(min)	P5(min)	P6(min)	(P4i-P4mean)	(P5i-P5mean)	(P6i-P6mean)^.5
1	1.86	3.5	1.74	0.437	4.490	1.690
2	2.66	4.5	2.7	0.019	1.252	0.116
3	2.91	5.25	3.3	0.151	0.136	0.068
4	2.96	5.38	3.09	0.193	0.057	0.002
5	2.81	5.88	3.03	0.084	0.068	0.000
6	2.51	5.88	3.2	0.000	0.068	0.026
7	2.41	5.75	3.26	0.012	0.017	0.048
8	2.41	5.88	3.03	0.012	0.068	0.000
9	2.36	5.75	3.31	0.026	0.017	0.073
10	2.36	5.5	3.37	0.026	0.014	0.109
11	2.46	5.38	3.2	0.004	0.057	0.026
12	2.71	5.25	3.09	0.036	0.136	0.002
13	2.56	5.13	3.43	0.002	0.239	0.152
14	2.56	5.5	3.2	0.002	0.014	0.026
15	2.41	5.63	3.09	0.012	0.000	0.002
16	2.56	6.13	3.03	0.002	0.261	0.000
17	2.51	5.88	2.92	0.000	0.068	0.014
18	2.51	5.88	2.98	0.000	0.068	0.004
19	2.61	5.63	2.92	0.008	0.000	0.014
20	2.51	6.25	3.03	0.000	0.398	0.000
21	2.36	5.75	3.2	0.026	0.017	0.026
22	2.61	6.5	3.15	0.008	0.776	0.012
23	2.66	6.25	2.92	0.019	0.398	0.014
24	2.71	6.13	3.03	0.036	0.261	0.000
25	2.56	6	3.09	0.002	0.145	0.002
26	2.81	6.13	2.98	0.084	0.261	0.004
27	2.51	6.25	3.03	0.000	0.398	0.000
28	2.86	5.5	2.87	0.115	0.014	0.029
29	2.76	5.38	2.87	0.057	0.057	0.029
30	2.56	5.5	2.36	0.002	0.014	0.462
31	2.46	4.5	2.29	0.004	1.252	0.563
32	2.01	3.75	2.31	0.261	3.493	0.533
33	1.66	2.25	2.25	0.741	11.350	0.624
Sum	83.18	179.82	97.27	2.379	25.869	4.671
	2.599	5.619	3.040			
Mean(sec.)	4990.8	10789.2	5836.2			
	0.273	0.419	0.308			
St.Dev(sec)	16.359	25.143	18.492			

Appendix-B

Travel Time Analysis Output of PTV VISSIM

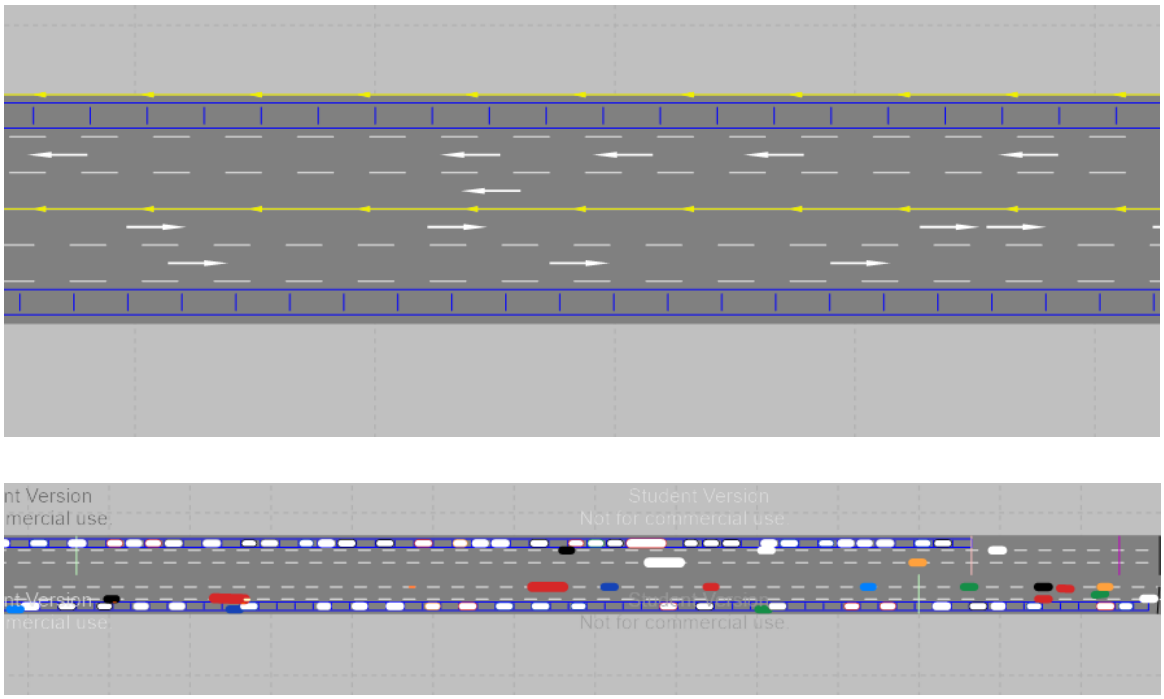

Figure 7: P4 and P5 along road segment on VISSIM soft ware

Table 8: Travel time output of road segment along roadside parking using Vissim software considering on-street Parking.

Time int.	Travel time (seconds)			No. of vehicles		
	P4=230m	P5=215m	P6=245m	P4	P5	P6
9:00-9:15AM	29.53	28.01	88.31	254	227	144
9:15-9:30AM	26.25	28.01	107.04	257	237	181
9:30-9:45AM	56.66	87.7	139.52	287	242	201
9:45-10:00AM	81.61	76.53	126.61	298	257	178
10:00-10:15AM	105.48	126.98	148.77	296	220	191
10:15-10:30AM	96.19	108.71	131.85	316	272	268
10:30-10:45AM	91.88	107.11	141.24	291	241	259
10:45-11:00AM	91	103.27	127.54	266	248	251
11:00-11:15AM	39.1	56.04	157.88	310	246	280
11:15-11:30AM	39.08	56.05	143.45	278	280	248
11:30-11:45AM	39.1	56.11	94.95	287	258	263
11:45-12:00AM	39.16	56.08	37.46	261	250	237
12:00-12:15AM	39.16	56.11	37.47	271	249	249
12:15-12:30AM	39.23	56.31	37.48	271	266	259
12:30-12:45AM	39.07	56.06	37.53	311	253	278
12:45-1:00AM	39.03	55.97	37.55	270	270	252
1:00-1:15PM	39.09	56.02	37.56	267	281	257
1:15-1:30PM	39.03	56.03	37.63	281	244	258
1:30-1:45PM	39.06	56.02	37.56	291	251	273
1:45-2:00PM	19.58	28.05	18.7	275	215	256
2:00-2:15PM	19.56	27.98	18.8	236	245	235
2:15-2:30PM	19.49	28.06	18.78	286	238	263
2:30-2:45PM	19.5	27.99	18.76	258	252	242
2:45-3:00PM	19.53	27.96	18.74	304	249	270
3:00-3:15PM	89.63	114.82	101.05	292	244	263
3:15-3:30PM	97.16	117.51	133.14	285	249	256
3:30-3:45PM	89.85	142.82	111.96	273	250	268
3:45-4:00PM	92.2	139.98	112.04	296	259	273
4:00-4:15PM	19.53	28.03	18.79	253	222	254
4:15-4:30PM	19.5	27.98	18.8	287	297	271
4:30-4:45PM	19.51	27.99	18.76	283	231	274
4:45-5:00PM	19.57	28.05	18.82	281	242	250

Table9: Travel time out put without considering on-street Parking

Time int.	Travel time (seconds)			No. of vehicles		
	P4=230m	P5=215m	P6=245m	P4	P5	P6
9:00-9:15AM	19.55	18.73	28.04	254	227	144
9:15-9:30AM	19.53	18.76	28.03	257	237	181
9:30-9:45AM	19.55	18.77	28.09	287	242	201
9:45-10:00AM	19.61	18.7	28.1	298	257	178
10:00-10:15AM	19.62	18.74	28.08	296	220	191
10:15-10:30AM	19.59	18.74	28.18	316	272	268
10:30-10:45AM	19.54	18.78	27.98	291	241	259
10:45-11:00AM	19.52	18.74	27.97	266	248	251
11:00-11:15AM	19.55	18.77	28.03	310	246	280
11:15-11:30AM	19.51	18.84	27.99	278	280	248
11:30-11:45AM	19.56	18.78	28.01	287	258	263
11:45-12:00AM	19.55	18.78	28.01	261	250	237
12:00-12:15AM	19.54	18.77	27.94	271	249	249
12:15-12:30AM	19.55	18.77	28.1	271	266	259
12:30-12:45AM	19.51	18.7	27.97	311	253	278
12:45-1:00AM	19.62	18.84	28.18	270	270	252
1:00-1:15PM	19.6	18.7	28.08	267	281	257
1:15-1:30PM	19.61	18.73	28.11	281	244	258
1:30-1:45PM	19.63	18.72	28.18	291	251	273
1:45-2:00PM	19.53	18.8	27.96	275	215	256
2:00-2:15PM	19.51	18.74	27.97	236	245	235
2:15-2:30PM	19.55	18.78	28.09	286	238	263
2:30-2:45PM	19.56	18.73	28.01	258	252	242
2:45-3:00PM	19.52	18.76	27.96	304	249	270
3:00-3:15PM	19.55	18.73	28.05	292	244	263
3:15-3:30PM	19.52	18.76	27.98	285	249	256
3:30-3:45PM	19.55	18.78	27.98	273	250	268
3:45-4:00PM	19.6	18.7	28.08	296	259	273
4:00-4:15PM	19.57	18.7	28.11	253	222	254
4:15-4:30PM	19.55	18.82	27.95	287	297	271
4:30-4:45PM	19.55	18.78	28.01	283	231	274
4:45-5:00PM	19.54	18.77	27.94	281	242	250

Table 10: Total segment delay output of road segment along roadside parking using VISSIM software.

Time int.	Travel time with roadside parking (sec)			Travel time without roadside parking (sec)			Additional delay(seconds/veh)		
	P4=230m	P5=215m	P6=245m	P4=230m	P5=215m	P6=245m	P4	P5	P6
9:00-9:15AM	29.53	28.01	88.31	19.55	18.73	28.04	9.98	9.28	60.27
9:15-9:30AM	26.25	28.01	107.04	19.53	18.76	28.03	6.72	9.25	79.01
9:30-9:45AM	56.66	87.7	139.52	19.55	18.77	28.09	37.11	68.93	111.43
9:45-10:00AM	81.61	76.53	126.61	19.61	18.7	28.1	62	57.83	98.51
10:00-10:15AM	105.48	126.98	148.77	19.62	18.74	28.08	85.86	108.24	120.69
10:15-10:30AM	96.19	108.71	131.85	19.59	18.74	28.18	76.6	89.97	103.67
10:30-10:45AM	91.88	107.11	141.24	19.54	18.78	27.98	72.34	88.33	113.26
10:45-11:00AM	91	103.27	127.54	19.52	18.74	27.97	71.48	84.53	99.57
11:00-11:15AM	39.1	56.04	157.88	19.55	18.77	28.03	19.55	37.27	129.85
11:15-11:30AM	39.08	56.05	143.45	19.51	18.84	27.99	19.57	37.21	115.46
11:30-11:45AM	39.1	56.11	94.95	19.56	18.78	28.01	19.54	37.33	66.94
11:45-12:00AM	39.16	56.08	37.46	19.55	18.78	28.01	19.61	37.3	9.45
12:00-12:15AM	39.16	56.11	37.47	19.54	18.77	27.94	19.62	37.34	9.53
12:15-12:30AM	39.23	56.31	37.48	19.55	18.77	28.1	19.68	37.54	9.38
12:30-12:45AM	39.07	56.06	37.53	19.51	18.7	27.97	19.56	37.36	9.56
12:45-1:00AM	39.03	55.97	37.55	19.62	18.84	28.18	19.41	37.13	9.37
1:00-1:15PM	39.09	56.02	37.56	19.6	18.7	28.08	19.49	37.32	9.48
1:15-1:30PM	39.03	56.03	37.63	19.61	18.73	28.11	19.42	37.3	9.52
1:30-1:45PM	39.06	56.02	37.56	19.63	18.72	28.18	19.43	37.3	9.38
1:45-2:00PM	19.58	28.05	27.96	19.53	18.8	18.7	0.05	9.25	9.26
2:00-2:15PM	19.56	27.98	27.97	19.51	18.74	18.8	0.05	9.24	9.17
2:15-2:30PM	19.55	28.06	28.09	19.49	18.78	18.78	0.06	9.28	9.31
2:30-2:45PM	19.56	27.99	28.01	19.5	18.73	18.76	0.06	9.26	9.25

2:45-3:00PM	19.59	27.96	27.96	19.53	18.76	18.74	0.06	9.2	9.22
3:00-3:15PM	89.63	114.82	101.05	19.55	18.73	28.05	70.08	96.09	73
3:15-3:30PM	97.16	117.51	133.14	19.52	18.76	27.98	77.64	98.75	105.16
3:30-3:45PM	89.85	142.82	111.96	19.55	18.78	27.98	70.3	124.04	83.98
3:45-4:00PM	92.2	139.98	112.04	19.6	18.7	28.08	72.6	121.28	83.96
4:00-4:15PM	19.57	28.03	28.11	19.53	18.7	18.79	0.04	9.33	9.32
4:15-4:30PM	19.55	27.98	27.95	19.5	18.82	18.8	0.05	9.16	9.15
4:30-4:45PM	19.55	27.99	28.01	19.51	18.78	18.76	0.04	9.21	9.25
4:45-5:00PM	19.74	28.05	27.94	19.57	18.77	18.82	0.17	9.28	9.12

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Table11: Total segment delay output of road segment along roadside parking using Vissim software.

Time int.	Stop vehicles(sec/veh)			Vehicle delay(sec/veh)			Total delay(sec/veh)			Veh-sec		
	P4	P5	P6	P4	P5	P6	P4	P5	P6	P4	P5	P6
9:00-9:15AM	1.23	3.67	6.01	3.77	6.68	9.4	5	10.35	15.41	1270	2349	2219
9:15-9:30AM	1.19	8.76	13.1	4.36	11.56	17.82	5.55	20.32	30.92	1426	4816	5597
9:30-9:45AM	2.03	5.46	8.53	5.09	8.84	12.8	7.12	14.3	21.33	2043	3461	4287
9:45-10:00AM	2.23	0.68	5.55	5.37	3.34	9.27	7.6	4.02	14.82	2265	1033	2638
10:00-10:15AM	2.49	2.36	2.94	5.53	4.6	6.01	8.02	6.96	8.95	2374	1531	1709
10:15-10:30AM	1.22	1.7	15.2	4.64	3.98	20.37	5.86	5.68	35.57	1852	1545	9533
10:30-10:45AM	1.87	5.63	11.26	5.04	8.49	15.51	6.91	14.12	26.77	2011	3403	6933
10:45-11:00AM	4.98	11.16	10.02	8.26	14.13	13.8	13.24	25.29	23.82	3522	6272	5979
11:00-11:15AM	3.9	0.17	3.69	6.79	2.26	7	10.69	2.43	10.69	3314	598	2993
11:15-11:30AM	3.81	4.18	10.21	7.06	6.83	14.7	10.87	11.01	24.91	3022	3083	6178
11:30-11:45AM	2.42	4.73	13.15	5.56	7.78	17.92	7.98	12.51	31.07	2290	3228	8171
11:45-12:00AM	2.57	10.74	9.01	5.64	13.58	12.66	8.21	24.32	21.67	2143	6080	5136
12:00-12:15AM	1.47	10.75	12.4	4.72	13.84	17.32	6.19	24.59	29.72	1677	6123	7400
12:15-12:30AM	2.85	14.57	10.09	4.83	17.7	15.1	7.68	32.27	25.19	2081	8584	6524
12:30-12:45AM	3.2	10.87	13.85	0.01	12.58	20.81	3.21	23.45	34.66	998.3	5933	9635
12:45-1:00AM	3.5	2.4	16.28	2	3.6	22.68	5.5	6	38.96	1485	1620	9818
1:00-1:15PM	2	5.3	14	6	0.38	19.95	8	5.68	33.95	2136	1596	8725
1:15-1:30PM	3.3	5.3	18.48	0.03	8.6	25.13	3.33	13.9	43.61	935.7	3392	11251
1:30-1:45PM	4.5	1.3	14.9	7.6	6.9	22.5	12.1	8.2	37.47	3521	205	1022

			7								8	9
1:45-2:00PM	4.3	2.3	16.12	6.34	8.9	21.91	10.64	11.2	38.03	2926	2408	9736
2:00-2:15PM	5.6	1.1	2.1	6.3	7.9	5.8	11.9	9	7.9	2808	2205	1857
2:15-2:30PM	0.8	1.5	0.98	4.5	7.8	6.9	5.3	9.3	7.88	1516	2213	2072
2:30-2:45PM	0.33	1.93	1.81	0.85	2.97	2.62	1.18	4.9	4.43	304.4	1235	1072
2:45-3:00PM	0.79	4.32	4.23	1.8	5.22	5.9	2.59	9.54	10.13	787.4	2375	2735
3:00-3:15PM	1.84	1.5	5.17	4.7	3.89	10.26	6.54	5.39	15.43	1910	1315	4058
3:15-3:30PM	1.72	4.09	8.64	4.84	7.35	14.14	6.56	11.44	22.78	1870	2849	5832
3:30-3:45PM	2.87	3.43	14.54	6.08	6.54	19.3	8.95	9.97	33.84	2443	2493	9069
3:45-4:00PM	4.64	2.75	18.62	7.95	5.57	23.99	12.59	8.32	42.61	3727	2155	11633
4:00-4:15PM	2	9	12.46	3	9	25.13	5	18	37.59	1335	3996	9548
4:15-4:30PM	3	6	14.97	5	4	22.5	8	10	37.47	2296	2970	10154
4:30-4:45PM	2	2.1	16.12	4	2.3	21.91	6	4.4	38.03	1698	1016	10420
4:45-5:00PM	1.8	3.6	1.2	3.5	4.5	6.5	5.3	8.1	7.7	1489	1960	1925