



Addis Ababa University
Addis Ababa Institute of Technology
School of Civil and Environmental Engineering
Graduate studies

Parking Demand and Supply Analysis
A case study of Arat Kilo to Piazza road

By
Biruk Mulu

Thesis submitted to school of civil and environmental engineering of Addis Ababa
institute of Technology in partial fulfilment of the requirements for the degree of
Master of Science in
Civil Engineering
(Road and Transport Engineering)

Advisor
Dr. Bikila Teklu

April 2017

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Declaration

I, the undersigned, declare that this thesis is my original work performed under the supervision of my research advisor Dr. Bikila Teklu and has not been presented as a thesis for a degree in any other university. All sources of materials used for this thesis have been duly acknowledged.

Name: Biruk Mulu

Signature _____

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Addis Ababa

Date: April, 2017

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Abstract

This study was intended to analyze the parking demand and supply of Arat kilo to Piazza road. The study establishes the peak parking demand rates by land use analysis for each land uses and compared with the ITE peak parking demand rate standards. The data were collected by on-site survey including counting of the parking volume in each time interval of the day and calculating of some parking statistical terms by using license plate survey. In addition to this some questionnaires were distributed to the drivers to strength the parking demand of the area.

The results suggest that the street needs many more additional parking spaces in the case of both for the actual and ITE parking demand rates. Beside this the derived actual peak demand rates shows that there is a gap between the two standards and as a result, directly applying the ITE standards to the study area may not be appropriate as it may not be economical to the current growth of country.

The research conclude that the main problem of parking in the area is lack of enough on-street, off-street and building parking space supplies, lack of parking policy and management system, absence of parking signs and marks results which results confusion for finding available parking spaces and lack of knowledge of users for parking usage and shared parking strategies.

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Acronyms

ITE: Institute of Transport Engineers.

IRC: Indian Roads Congress.

ULI: Urban Land institute.

CBD: Central Business District.

GSF: Gross Square Footage.

SUV: Sub-urban Utility Vehicle

TDM: Transportation Demand Management

VTPI: Victorian Transport Provision Institution

TRAM: Traffic Restraint Analysis Model

EFM: External Forecasting Model

Chapter 1 Introduction

1.1 Background of the study

Parking is an essential component of the transportation system. Parking in Addis Ababa is very critical, most parking is done on the street and it clogs major transportation arteries. Parking demands exceed available supply. There has not been sufficient off-street parking available or developed over the last ten years of the master plan's implementation period. Off-street parking is usually found in private and government premises, or fuel stations. In few areas small underground parking is available under high rise buildings.

Addis Ababa has a large concentration of motorized vehicles. About 80 percent of the total vehicles in the country operate in the city. According to (Ministry of transport, 2011), in 2011, registered vehicles in the capital city have reached 202,123. It has 27.27 percent growth when compared with 2006 data that was 158,252. The number of paid parking places on street increased from 19 in 2003 to 72 in 2008. Management of parking spaces is left to registered parking operators' associations. Parking related jobs increased from 207 in 2003 to 1,244 in 2008. This number is expected to be growing at a rapid pace with the development of the socio-economic activity of the city and growing purchasing power of its people. This challenge demands proactive planning to accommodate the growth. According to studies there seems to exist no comparative parking strategy. "Neither the city's transport authority, nor Addis Ababa city roads authority nor urban land administration of Addis Ababa claim responsibility to the development of off-street parking." In addition, there is no responsible agency to claim for the development of parking of different forms-off-street parking, parking lot, underground garage, multi-story parking. Although now days one of the proposals of the revised master plan of the city is the provision of adequate parking spaces by developing proper off-street parking facilities to reduce bottlenecks and congestion at critical road intersections and locations.

Arada sub-city which is one of the 10 sub-cities in Addis Ababa, with an area of 9.5km², a population size of 212009 and a population density of 22316.7peoples/sq.km is getting many parking related problems. This is due to as the sub-city is center of old and the buildings are not properly maintained, the existing parking facilities are unable to serve their purposes properly. The road segment from Arat-kilo to piazza has been chosen for this study as the street is the most business and center of movement area.

1.2 Statement of the problem

Various social and economic problems are being faced by Addis Ababa. Still lack of sufficient transportation is a major difficulty although the city administration is said to be working on it with huge budget allocation to construct new roads.

The transportation fluidity problem is not expected to be solved with just the construction of new roads; the city administration needs to see related aspects to develop the sector. The existing parking service is inadequate and suffers from structural problems, mainly street parking. Consequently it has contributed to inefficient utilization of the road network, safety and congestion problems. Especially Arada sub-city is priority areas that need immediate parking lots as it is the center of old and there is a large concentration of vehicles in these areas that lack sufficient parking facilities compared with the traffic flow, to study these critical road section which is a road from Arat kilo to piazza has been selected for this thesis as it is center of varies business activities and contain varies land uses and buildings that are running out of services.

With this limited parking spaces in the sub- city, the drivers cannot drop their customers at the specific location that customers want them to, the drivers are forced to drop passengers in the middle of the road, which is illegal, due to lack of on-street parking (terminal) spaces, this kind of problem has created disagreement between drivers and customers. And vehicles parks at business centers are boring of searching free parking spaces and as a result performing day today business activities become very difficult. Thus parking remains one of the critical issues that need to be addressed through the transport planning of the city. Comparative parking policy including parking norms and space standards and development of off street and on street parking facilities are commendable, a similar study recommended. Generally the following list identifies the kinds of problems that typically occur in the sub- city.

1. **Inefficient use of existing parking capacity:** due to lack of parking policy and strategy of the City the existing parking facilities are not serving for their intended purposes. i.e. most of the building parking spaces are used as shops and stores. Due to lack of shared parking strategy the nearby spaces are not utilized whenever ones parking space become full.
2. **Excessive automobile use:** The selected street has excessive automobile use compared with the other streets which finally results the unbalanced parking facility usages.
3. **Economic environmental and aesthetic impacts of parking facilities:** ones a vehicle park in a certain place it will generate some incomes whether by parking fees or the service it will use. Finally it will affect the economic aspects of the country as a whole. A vehicle tries to park or un-park to a certain parking place will release smokes and emissions to the surround and unsuitable parking will more. Vehicles parks here and there illegally will affect the aesthetic view of the area.
4. **Parking spaces that are an inconvenience:** most of the parking lots in the area are unsuitable in the case of safety and doesn't give comfort to the users.
5. **Loading and unloading zones**

Due to lack of sufficient parking facilities in the area the Taxi drivers as well as short term delivery trucks can't drop their customers to the available nearest services.

6. **Inadequate pricing methods:** parking pricing not to be fixed throughout the day and area.it should be adjusted according to the peak and non-peak hour of the day and the purpose of the services.
7. **Confusing or no parking policies:** The major problem occurs in the area is due to lack of parking policy and strategy developed in national level which finally results inefficient utilization of existing parking facilities.
8. **Lack of sufficient parking at event site:** at event site there should be enough parking spaces that will afford the additional parking generations.

1.3. Objectives of the study

1.3.1 General objectives

Generally this thesis has a general objective of assessing and analyzing the parking demand and supply of the Arada sub-city (a case study of Arat kilo to piazza road) with their recommended solutions.

1.3.2 The specific objectives

- To assess the adequacy of the existing parking supply.
- To make recommendations for additional parking or parking improvements.
- To study the efficiency of the existing parking capacity.
- To compare the actual demand rates of the study area with the ITE demand rates.

1.4 Significance of the study

Generally the research has the following advantages:

- ✓ It will give best solution to the current most problematic parking lots of the selected streets.
- ✓ It recommends the best parking management.
- ✓ Improves the Inefficient use of existing parking capacity.
- ✓ Improves the Economic, environmental and aesthetic impacts of parking facilities.
- ✓ To reduce traffic congestion through improved parking enforcement.

- ✓ The study area will get its own parking demand rates that are used for further parking lot design and used as an indication of the future as the country gets its own standard parking demand rate manual.

1.5 Scope and limitation of the study

It is not possible to cover the whole area of the sub cities. Therefore, after having a number of deliberations with research supervisor and keeping the nature of research problem in view, case study approach has been adopted. Accordingly the Arada sub city has been selected as study area for the present research as it attracts the highest number of trips from all sub-cities, and parking generation activity is exclusively high in the zone in comparison with the other nine sub cities of Addis within this sub-city Arat kilo to piazza road has been selected as a case study as the street is center of movement and contains various services.

This study offers an overview of Arat kilo to piazza road current parking requirements and compares them with the actual (observed) parking demand rates. Parking requirements that do not reflect the contextual variability of parking demand incur unnecessary costs on both developers and cities, and create excesses of parking supply that may reduce an area's walkability and attractiveness so the study derives its own parking demand rates in addition to the ITE standards. The aim of the research is to show the way to further studies in parking related problems. Although the study is comprised of some objectives that are effective for the further development of parking of the study area, it has few limitations.

- There is no available data of the parked cars in the concern authority;
- Lack of man power to survey the study area, and the driver does not maintain the traffic rules. They parked their cars here and there. There are no proper rules for parking.
- Lack of willingness of some drivers to response for questionnaires was also other limitation of the study.

Chapter 2 Literature Review

2.1 Conceptual Background

2.1.1 Parking

Parking is the act of stopping a vehicle and leaving it unoccupied for more than a brief time. Parking on one or both sides of a road is commonly permitted, though often with restrictions. Parking facilities are constructed in combination with most buildings, to facilitate the coming and going of the buildings' users. (L. R Kadiyali, 1987)

2.1.2 Parking type

1. *On Street Parking*

As the name itself suggests, “On-street Parking” means the area allotted for parking purpose at the sides of the roads. For efficiency in Parking system; the on street Parking is divided into three types. This classification is based on the angle in which the vehicles are parked with respect to the road alignment. As per IRC the standard dimensions of a car is taken as 5×2.5 meters and that for a truck is 3.75×7.5 meters. (L. R Kadiyali, 1987)

- a. Parallel Parking
- b. Perpendicular Parking (efficient Parking Method)
- c. Angular Parking

a. Parallel parking

With parallel parking of cars, these are arranged in a line, with the front bumper of one car facing the back bumper of an adjacent one. This is done parallel to a curb, when one is provided. Parallel parking is the most common mode of street side parking for cars. It may also be used in parking lots and parking structures, but usually only to supplement parking spaces that use the other modes. Here there is no backward movement involved while parking or un-parking 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 curb length. This method of parking produces least obstruction to the on-going traffic on the road since least road width is used.

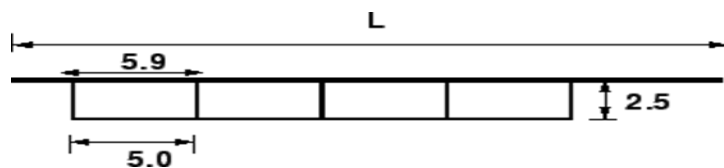


Figure 2.1: Illustration of parallel parking

The length available to park N number of vehicles, $L = \frac{N}{5.9}$

b. Perpendicular parking

With perpendicular parking of cars, these are parked side to side, perpendicular to an aisle, curb, or wall. This type of car parking is more scalable than parallel parking and is therefore commonly used in car parking lots and car parking structures. In right angle parking or 90 parking, the vehicles are parked perpendicular to the direction of the road. Although it consumes maximum width curb length required is very little. In this type of parking, the vehicles need complex maneuvering and this may cause severe accidents. This arrangement causes obstruction to the road traffic particularly if the road width is less. However, it can accommodate maximum number of vehicles for a given curb length. Length available for parking N number of vehicles is $L = 2.5N$.

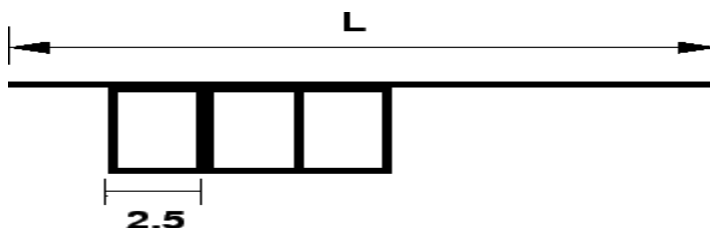


Figure 2.2: Illustration of 90° parking

c. Angular parking

Angle parking, known as echelon parking in Britain, of cars is similar to perpendicular parking for these vehicles, except that cars are arranged at an angle to the aisle (an acute angle with the direction of approach). The gentler turn allows easier and quicker parking, narrower aisles, and thus higher density than perpendicular parking. While in theory the aisles are one way, in practice they are typically wide enough to allow two cars to pass slowly when drivers go down the aisles the wrong way. The angular parking can be 30° parking, 45° parking or 60° parking.

30° parking: In thirty degree parking, the vehicles are parked at 30° with respect to the road alignment. In this case, more vehicles can be parked compared to parallel parking. Also there is better maneuverability. Delay caused to the traffic is also minimum in this type of parking.

From the figure below, For N vehicles = $AC + (N-1) CE = 5.58 + (N-1)5 = 0.58 + 5N$

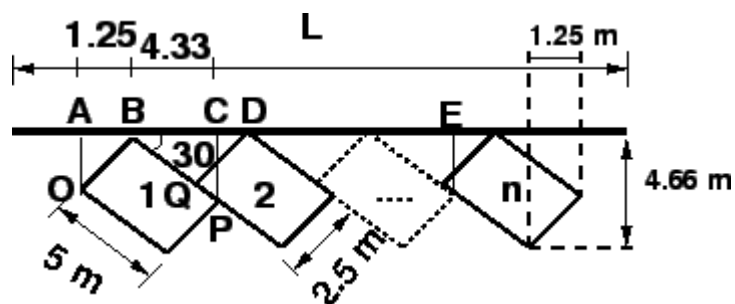


Figure 2.3: Illustration of 30°parking

45° parking: As the angle of parking increases, more number of vehicles can be parked. Hence compared to parallel parking and thirty degree parking, more number of vehicles can be accommodated in this type of parking. From figure 3, length of parking space available for parking N number of vehicles in a given curb is $L = 3.54 N + 1.77$.

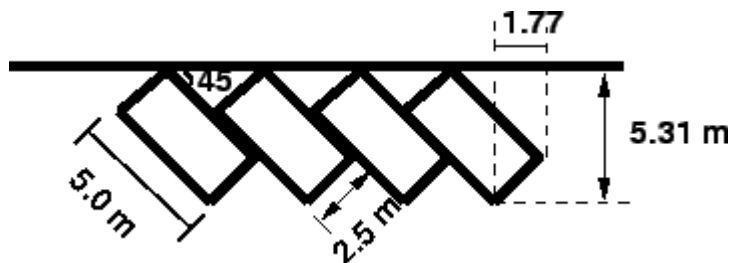


Figure 2.4: Illustration of 45°parking

60° parking: The vehicles are parked at 60° to the direction of road. More number of vehicles can be accommodated in this parking type. From the figure 4, length available for parking N vehicles $= 2.89N + 2.16$.

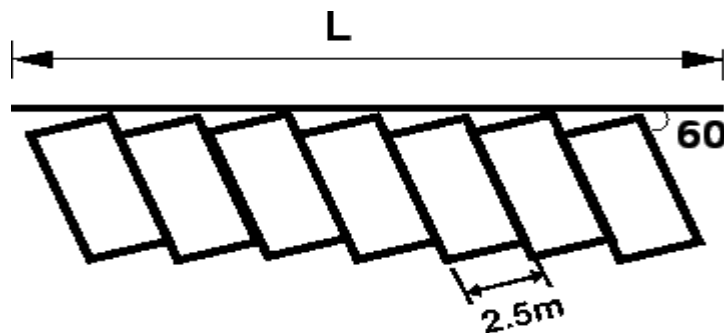


Figure 2.5: Illustration of 60°parking

2. *Off street parking*

As the name suggests, off street Parking means a Parking Area is designed adjacent to the Road or in a place or building which is not the part of the road.

In many urban centers, some areas are exclusively allotted for parking which will be at some distance away from the main stream of traffic. Such a parking is referred to as off-street parking. They may be operated by either public agencies or private firms. A typical layout of an off-street parking is shown in figure 2.6

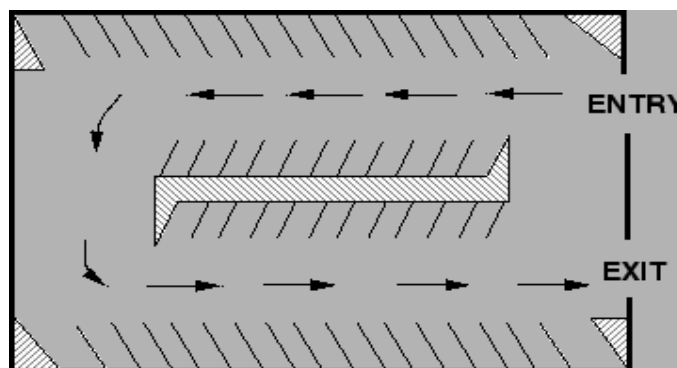


Figure 2.6: Illustration of off-street parking

2.1.3 Parking space

The width of angled and perpendicular parking spaces usually ranges from 2.3 to 2.75 meters (7.5–9.0 ft.). For example, normal parking spaces in a city are 8.5 feet wide, while compact spaces are 7.5 feet wide. Because the boundary between parking space and driving area is not always well-defined, the length of a parking space is more difficult to establish. However, most angled and perpendicular spaces are considered to be between 3.2 and 5.5 meters (10 and 18 ft.) in length. Parallel parking spaces are typically cited as being approximately 2.76 meters (9.1 ft.) wide by 6.1 meters (20 ft.) long.

2.1.4 Parking demand

Parking Demand refers to the amount of parking that would be used at a particular time, place and price. It is a critical factor in evaluating parking problems and solutions. Parking demand is affected by vehicle ownership, trip rates, mode split, duration (how long motorists park), geographic location (i.e., downtown, regional town Centre or suburban), the quality of travel alternatives, type of trip (work, shopping, recreational), and factors such as fuel and road pricing.

2.1.5 Parking supply

(Kadlyali, 2010) Define parking supply as the amount of legal space provide for parking. It may be off street parking space or on street parking space and gives the following defined terms.

Parking volume: The number of vehicles parking in a particular area over a given period of time is called parking volume. It is usually measured in vehicles per day.

Parking load: The area under the parking accumulation curve during a specific period is called parking load.

Parking duration: The length of time spent in a parking space is called the parking duration.

Parking accumulation: is the number of parked vehicles in a study area at any specified time. These data can be plotted as a curve of parking accumulation against time, which shows the variation of the parking accumulation during the day. Many parking studies seek to establish the distribution of parking accumulation over time to determine the peak accumulation and time of occurrence.

Parking Index: Parking Index is the percentage of parking bays actually occupied by the parked vehicles as compared to the theoretical number available.

$$\text{Parking Index} = \frac{\text{number of bays occupied}}{\text{theoretical number of bays available}} * 100$$

Parking turn-over: The rate of the usage of the available parking space is called parking turnover. Thus if there were 10 parking spaces used by 100 vehicles in a period of, say time 12 hours, then the parking turn over would be = $\frac{100}{10}$ vehicles perspace in a period of 12 hours.

2.2 Effects of parking on urban traffic

Various authors investigated impact outcome relationships between parking and urban traffic.

(Bentsen, 1967), investigated the relation between the number of parking spaces available and the number of trips to and from the town Centre. He found a close correlation between availability of parking spaces and the number of trips in Danish and American towns.

Further, (Shoup, 2006) analyzed the problem of traffic generation through cruising for parking in downtown areas and summarized different studies. On average 30% of urban traffic was cruising for parking and the average search time for a parking space is 8.1 minutes.

(Hoglund, 2004) Investigated the impact of parking on the environment and found that especially due to cruising for parking off-street parking creates about 40% less emissions than kerb-side

parking. This means that 100 parking vehicles off-street give about the same emissions as 50-70 vehicles parking at the curb-side.

2.3 Parking demand and supply analysis

The industry standard, best practice, and most accurate method for determining current parking conditions in a street is to conduct turnover and occupancy license plate field surveys because they provide factual evidence of parking supply and demand,(Institute of Transportation Engineers (ITE),1987).

If license plate field surveys had been too cost-prohibitive, then an alternative approach would have been to inventory the street land uses and generate a parking demand estimate using ITE's industry publication "Parking Generation". This approach would have yielded an estimate of parking demand, but would not have provided the level of quantitative data that can be obtained from performing field studies. The Urban Land Institute publishes a standard industry book called "The Dimensions of Parking(4th ed.), 2000,"states that "Trip Generation, published by ITE, is the most commonly recognized resource document used by traffic engineers to determine the volume and characteristics of traffic generated by a land use service by a parking facility. In most cases, ITE's Trip generation can be used to estimate the traffic to be generated by a development. Occasionally, local governments apply their own trip generation rates and peak-hour traffic volumes associated with various land uses. In cases of specialized land uses [such as mixed-use downtowns], more thorough field studies may be required."

2.3.1 Parking demand

The necessity for a car to be parked is called parking demand. If the number of cars in a locality, neighborhood or a city increases, so does the demand for parking spaces. The demand further grows when a majority of the cars in the locality are in transit, as they need more than one parking place. In many developing countries, the proportion of the population that has access to a car is small; for example, in Istanbul, the number of cars per 1,000 population is 134 (Gercek, 2005), and in south Asia, 10 (world Bank, 2006). Nonetheless, the density of the population of many lower and middle income cities, often combined with little off-street parking, means that the impacts of parked cars on the streets in the more affluent parts of such cities is enormous. In addition, the growth rates in car ownership in the developing world are much higher than in wealthy countries: according to the World Bank, the number of motor vehicles per thousand people in low and middle income countries combined rose from 25 in 1990 to 47 in 2003. This constitutes an 88% increase, compared to —just 25% in high income countries.

In 2000, there were more than 750million cars and light duty vans in the world, a number growing at about 2% per year. There are only two places where these vehicles can be found: they are either on-street or off-street. If they are on-street, they can be considered to be parked,

searching for parking or in transit. Almost all cars that are off-street will be parked. Estimates show that cars spend more than 95% of their lives parked (Collins, 1991).

Parking problems begin to arise when demand for parking space exceeds supply. Typically, town and city centers are where these problems occur first, and then they spread outwards from there.

Analysis

This portion of the parking demand analysis uses ITE’s Parking Generation to derive parking demand rates. The ITE parking analysis was conducted using two methods with the project’s proposed land use program as it fits within ITE designations:

1. A standard analysis of ITE parking demand based on the peak parking demand for each land use as defined by a peak demand rate (e.g. 1.2 cars per residential unit) without regard to the site’s location or transportation characteristics.

The rates used and the corresponding source for rate is provided in table 1.

Table 2.1 : parking demand rate and their corresponding sources

Land use	Peak rates		Source
	Week day	Weekend	
Gov’t office	3.65/1,000gsf	.05	Weekday: ITE base w/5%transitredution Weekend, ULI shared parking
Legislative office	3.65/1,000gsf	.05	Same as above
General office	2.65/1,000gsf	.05	ITE
Bank	.63/1,000gsf	.09	ITE
Residential(per unit)	1 per unit	1	ULI
Church/fraternal org	.64/1,000gsf	4.3	ITE, modified for seating capacity
Restaurant/club	9.08/1,000gsf	6.96	ITE
Hotel(per unit)	0.25 per unit	0.25	Hotel operators
Tourist retail	2.86/1,000gsf	2.86	Shop operators

Other retail	3.8/1,000gsf	4.0	ULI
Misc. Land use area	Varies	Varies	Various operators of facilities
<ol style="list-style-type: none"> 1. ITE: from institute of transportation engineers parking generation 2nd edition, ULI: from urban land institute, shared parking, 1983 2. Capital office building and government offices in O sub-area use 2.65/1,000gsf based on type of visitation 3. ULI: urban land institute, shared parking, 1983. Rates for CBD and developments of mixed use. gsf=gross square feet 			

Parking demand calculation based on the day of week shared parking methodology is as follows:

$\text{Parking demands of each land use} = \text{peak rates} * \text{land use}$

2. An enhanced analysis utilizing the URBEMIS software model to quantify the effects of features such as nearby transit service and the built environment on parking demand

2.3.2 Parking supply

Minimum parking requirements guarantee a large supply of off-street parking, especially in the U.S. This leads many drivers to expect that parking will be available, and usually free. On the other hand, cities in Europe have adopted an opposite approach. For example Copenhagen, Denmark, is reducing its supply of parking by 2-3% per year. In Munich, Germany, parking supply reduction is used as the chief device to decrease car travel, especially to the inner city (Cervero, 1998).

A large off-street parking supply leaves on-street spaces unused or underused. This eliminates any of the benefits of parking discussed above, especially to the pedestrian. But despite eliminating the need for on-street spaces, many road design specifications insist on roads wide enough for parked cars on each side. Therefore, the public, on-street supply is abundant but unnecessary. This poses the question: why design for them in the first place?

Internationally, it is instructive to look at how other cities are handling on-street parking. In Europe, planners recognize that automobile use and public transportation are competing modes, and restricting parking supply is used to tip the scales towards transit. Street parking is scarce, and in Munich, on-street parking is actually being eliminated in the CBD and near train stations to promote transit, bicycling and walking (Cervero, 1998).

As stated above, minimum parking requirements ensure a large supply of off-street parking. According to Childs, —there are approximately seven parking stalls for every car in an

American city (Childs, 1999). In a study by Richard Wilson, peak parking filled only about half of the suburban parking supplies (Wilson, 1995). Theoretically, then, the seven parking stalls for every car can be reduced to three or four and parking would still be free. The ULI states that the ideal parking requirements are those that fit local needs (ULI, 2000). However, this is rarely done, partly because many local governments lack the resources to conduct studies on their own parking needs (Wilson, 1995).

Despite all the problems and costs associated with providing parking, communities have various reasons for requiring it. Many communities see adequate parking as a key to the success of a development project, and thus take a stake in requiring it. This comes from the conception that automobile accessibility is the only type of accessibility, and in many communities it is. Moreover, some tenants have a high parking demand, and local governments feel that the development should accommodate them and their occasional peaks. Finally, future uses of the development may require more parking than current tenants need, and towns and cities usually have no future recourse to demand it. Therefore, they require it in advance to prevent potential shortages (Wilson, 1995).

The ULI states that zoning should not require excessive parking (ULI, 2000). It claims that excessive parking, in addition to being a cost burden on the developer and tenant, accounts for unused and inefficiently used land. The developer, in providing an attractive space to locate, can better spend the same amount of money on building facilities (ULI, 2000). This comes in light of the fact that the supply of parking is much higher than demand throughout suburban developments (Wilson, 1995). The vicious cycle begins as an over-supply of parking creates an over-demand (because of the low price relative to the cost), which is then observed and used to set future parking requirements of over-supply. The fact that most offices never fill their parking capacity is rarely observed (Shoup, 1995), and this idea can be extended to shopping centers and other developments as previously shown by Wilson.

All of the above literatures show that minimum parking requirements of developed countries are excessive, wasteful, and expensive and lead to oversupplies that cause more driving. The oversupply of off-street parking renders on-street parking more or less useless, eliminating benefits to pedestrians and bikers. However alternatives exist and are currently implemented, such as maximum parking allowances.

2.2 Benefits of Parking

Despite the aforementioned problems with parking, there are certain recognized benefits. 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 (Hass-Klau, 1992). It can be an effective buffer between vehicle traffic in the street and the pedestrian environment on the sidewalk, making

walking more pleasant. Many communities use off-street parking as a technique to prevent or reduce spillover traffic from nearby business activities or higher density residential developments (Wilson, 1995). Indeed, the rationale for requiring off-street parking in the first place was to reduce demand for on-street parking. This benefit, however, ignores other effective strategies to prevent spillover parking such as residential parking permits, time limits on parking, and parking meters (Dueker, 1998).

2.3 Parking pricing

The literature focusing on parking pricing investigates on various aspects. The most important are the general economic evaluation of parking pricing, the elasticity of parking demand, the efficient pricing of curb-side parking and off-street parking and the possibilities to use parking pricing as a second best for road pricing.

The costs of parking have received little attention until the past decade. The trend in the United States (except in large cities) is that minimum parking requirements ensure an oversupply of parking, so that parking is free for 99% of automobile trips (Shoup, 1995). This oversupply, as stated above, increases driving and single occupancy vehicle rates because the variable costs per trip are much less than they should be. Parking is expected to be free, while future models of parking demand are based on the artificial over-supply of free parking. This has been documented in the U.S. but is true in any part of the world.

As proof of the effects of free parking, results of pricing parking are telling. Shoup shows that when drivers pay, they drive less (Shoup, 1995). This seems intuitive considering that, when priced, parking would follow other economic rules. With regards to transit, studies show that raising the price of parking has a higher impact on increasing transit ridership than improving service does (Dueker, 1998). Many cities in other countries have already adopted measures to reduce parking supply. Copenhagen has raised parking prices in areas well served by transit, and Ottawa is eliminating free parking for federal employees (Cervero, 1998).

(Anderson S.P and de Palma A., 2004) investigated the economies of pricing parking. Starting point of their analysis is that parking is a common property resource. The analysis is directed towards finding out the benefits of pricing parking. In the case parking is unpriced the market equilibrium won't be optimal. The resource will be overused which causes cruising for parking and congestion. They argue that the social optimum can be achieved under private ownership of the parking lots. Therefore, Anderson and de Palma suggest that the parking operator has to act in a monopolistic manner.

These articles showed that free parking is resulting in an inefficient market equilibrium which does not create a welfare maximum. However, the above reviewed articles show that parking

pricing or the reduction of the maximum parking time does not affect all user groups (residents, visitors and commuters) the same way because of different parking demand elasticity.

2.4 Parking management

Parking management is activity of supply, price and regulation of parking facilities (Victoria Transport Policy Institute, 2015). If parking becomes more abundant and cheaper, will lead to increase automobile demand that result in large volume of vehicles. On other side, it can play a great role in solving congestion problem if it managed well. The provision of parking should not be too much as well as insufficient. Thus, parking policy and provision requirements are essential in reducing traffic congestion. Moreover, (Hitge and Roodt, 2006) state clearly as: the duration of car parking has a direct relation with the size of shopping center, economic activity of the center district, and policy, like parking cost. So that, from different alternative, factors like availability of suitable public transport, proximity of parking, and paid parking would lead to a reduction in parking demand.

(Litman, 2008) argued that the total impacts of parking management strategies are multiplicative not additive i.e. as the strategy to include more mutually supportive elements so the benefits increase more rapidly. Most parking management strategies have modest individual impacts, typically reducing parking requirements by 5-15%, but their impacts are cumulative and synergistic. A comprehensive parking management program that includes an appropriate combination of cost-effective strategies can usually reduce the amount of parking required at a destination by 20-40%, while providing additional social and economic benefits. Shared parking reduces the parking requirements by 10%, to 90% of the original level.

2.5.1 Parking Management Strategies

This section describes a variety of specific parking management strategies. See (Litman, 2006) and related chapters in (VTPI, 2005).

i. Shared Parking

Shared Parking means that a parking facility serves multiple users or destinations (VTPI, 2005). This is most successful if destinations have different peak periods, or if they share patrons so motorists park at one facility and walk to multiple destinations. Parking facilities can be shared in several ways.

- **Shared rather than reserved spaces.** Motorists share parking spaces, rather than being assigned a reserved space. For example, 100 employees can usually share 60-80 parking spaces, since at any particular time some are on leave, commuting by an alternative mode, in the field, or working another shift. Hotels, apartments, condominiums and dormitories can share parking spaces among several units, since the number of vehicles

per unit varies over time. Sharing can be optional, so for example, motorists could choose between \$60 per month for a shared space or \$100 for a reserved space.

- **Share parking among destinations.** Parking can be shared among multiple destinations. For example, an office building can share parking with a restaurant or theater, since peak demand for offices occurs during weekdays, and on weekend evenings for restaurants and theaters, as indicated in Table 2.2 Sharing can involve mixing land uses on single site, such as a mall or campus, or by creating a sharing arrangement between sites located suitably close together.

Table 2.2: Typical peak parking periods for various land uses

Weekday	Evening	Weekend
Banks and public services	Auditoriums	Religious institutions
Offices and other employment centers	Bars and dance halls	Parks
Park & Ride facilities	Meeting halls	Shops and malls
Schools, daycare centers and colleges	Restaurants	
Factories and distribution centers	Theaters	
Medical clinics	Hotels	
Professional services		

This table indicates peak parking demand for different land use types. Parking can be shared efficiently by land uses with different peaks.

- **Public Parking Facilities.** Public parking, including on-street, municipal off-street, and commercial (for profit) facilities generally serve multiple destinations. Converting from free, single-use to paid, public parking allows more efficient, shared use.
- **In Lieu Fees.** “In lieu fees” mean that developers help fund public parking facilities instead of providing private facilities serving a single destination. This tends to be more cost effective and efficient. It can be mandated or optional.

- **Special Parking Assessment.** Businesses in an area can be assessed a special assessment or tax to fund parking facilities in their area, as an alternative to each business supplying its own facilities. This is often implemented through a downtown business improvement district.

ii. Parking Regulation

Parking regulations control who, when and how long vehicles may park at a particular location, in order to prioritize parking facility use. The table below describes common regulations and the type of parking activity they favor.

Table 2.3 parking regulations for varies activities

Name	Description	Favored Activity
User or vehicle type	Spaces dedicated to loading, service, taxis, customers, rideshare vehicles, disabled users, buses and trucks.	As specified.
Duration.	Limit parking duration (5-minute loading zones, 30-minutes adjacent to shop entrances, 1- or 2-hour limits).	Short-term users, such as deliveries, customers and errands.
Time period restrictions	Prohibit occupancy at certain times, such as before 10 am, to discourage employee use, or between 10 pm and 5 am to discourage resident use.	Depends on restrictions.
Employee restrictions.	Require or encourage employees to use less convenient parking spaces.	Customers, deliveries and errands.
Special events	Have special parking regulations during special events.	Depends on restrictions.
Accommodate short-term users.	Provide options for vehicles that make numerous short stops, such as special parking	Delivery and service vehicles.

	passes.	
Residential parking permits	Use Residential Parking Permits (RPPs) to give area residents priority use of parking near their homes.	Residents.
Options for special users.	Establish a system that allows specific parking spaces to be reserved for service and construction vehicles.	Vehicles used for special activities.
Restrict overnight parking	Prohibit overnight parking to discourage use by residents and campers.	Shorter-term parkers
Street cleaning restrictions	Regulations that prohibit parking on a particular street one day of the week to allow street sweeping.	Street cleaning. Insures motorists move their vehicles occasionally.
Large vehicle restrictions	Limit on-street parking of large vehicles, such as freight trucks and trailers.	Normal-size vehicles
Arterial lanes	Prohibit on-street parking on arterials during peak periods, to increase traffic lanes.	Vehicle traffic over parking.
abandoned vehicles	Have a system to identify and remove abandoned vehicles from public parking facilities.	Operating vehicles.

iii. Reduce Residential Street Width Requirements

Most jurisdictions require wide residential streets in order to provide on-street parking. This practice is not justified for safety or by consumer demands, since many households would not choose to pay for parking if it were unbundled, and so represents a hidden subsidy of automobile ownership and use (Guo, et al. 2012). Reducing minimum residential street widths in municipal zoning codes and development policies allows developers to build new urbanist communities with narrower streets and less parking, and rely more on efficient parking management.

iv. Parking Maximums

Parking Maximums means that an upper limit is placed on parking supply, either at individual sites or in an area. Area-wide limits are called Parking Caps. These can be in addition to or instead of minimum parking requirements. Excessive parking supply can also be discouraged by reducing public parking supplies, imposing a special parking tax, and by enforcing regulations that limit temporary parking facilities. Maximums often apply only to certain types of parking, such as long-term, single-use, free, or surface parking, depending on planning objectives.

v. Remote Parking and Shuttle Service

Remote Parking (also called Satellite Parking) refers to the use of off-site parking facilities. This often involves shared facilities, such as office workers parking at a restaurant parking lot during the day, in exchange for restaurant employees using the office parking lot evenings and weekends. It can involve use of public facilities, such as commercial parking lots. Remote parking can also involve use of parking facilities located at the periphery of a business district or other activity center, and use of overflow parking during a special event that attracts large crowds. Special shuttle buses or free transit service may be provided to connect destinations with remote parking facilities, allowing them to be farther apart than would otherwise be acceptable. Another type of remote parking is use of Park & Ride facilities, often located at the urban fringe where parking is free or significantly less expensive than in urban centers.

Remote parking requires providing adequate use information and incentives to encourage motorists to use more distant facilities. For example, signs and maps should indicate the location of peripheral parking facilities, and they should be significantly cheaper to use than in the core. Without such incentives, peripheral parking facilities are often underused while core parking is congested.

vi. Smart Growth

Smart growth (also called New Urbanism, Location Efficient Development and Transit Oriented Development) is a general term for development policies that result in more efficient transportation and land use patterns, by creating more compact, development with multi-modal transportation systems (“Smart Growth,” VTPI, 2005).

Smart growth supports and is supported by parking management. Parking management reduces the amount of land required for parking facilities, reduces automobile use and increases infill affordability. These land use patterns, in turn, tend to reduce vehicle ownership and use, and so reduce parking requirements. They allow more sharing of parking facilities, shifts to alternative modes, and various types of parking pricing. Smart growth usually incorporates specific parking management strategies, as indicated in Table 2.4. Effective parking management is a key component of smart growth.

Table 2.4: Conventional and Smart Growth Parking Policies

Conventional Parking Policies	Smart Growth Parking Policies
Managed only for motorist convenience Maximum parking supply Prefers free parking Dedicated parking facilities Favors lower-density, dispersed development	Managed for transport system efficiency Optimal parking supply (not too little, not too much) Prefers priced parking (user pays directly) Shared parking facilities Favors compact development.

vii. Increase Capacity of Existing Parking Facilities

Increase capacity of existing parking facilities means that parking supply increases without using more land or major construction. There are various ways to do this:

- ✓ Use currently wasted areas (corners, edges, undeveloped land, etc.). This can be particularly appropriate for small car spaces, motorcycle and bicycle parking.
- ✓ Where there is adequate street width, change from parallel to angled on-street parking.
- ✓ Maximize the number of on-street parking spaces, for example, by using a curb lane for parking rather than traffic during off-peak periods, and designating undersized spaces for small cars or motorcycles.
- ✓ Provide special, small parking spaces for motorcycles. Allow and encourage motorcycles to share parking spaces when possible.
- ✓ Reduce parking space size. Shorter-term parking requires larger spaces, but employee and residential parking spaces can be somewhat smaller. A portion of spaces can be sized for compact vehicles, which require about 20% less space than full-size stalls.
- ✓ Use car stackers and mechanical garages. These can significantly increase the number of vehicles parked in an area. However, they are only suitable for certain applications. They generally require an attendant to move lower-level vehicles when needed to access upper-level vehicles, and stackers may be unable to accommodate larger vehicles such as SUV, vans and trucks.

- ✓ Use valet parking, particularly during busy periods. This can increase parking capacity by 20-40% compared with users parking their vehicles. Commercial lots often have attendants park vehicles during busy periods, but not off-peak.
- ✓ Remove or consolidate non-operating vehicles, equipment, material and junk stored in parking facilities, particularly in prime locations.

viii. Mobility Management

Mobility Management (also called Transportation Demand Management or TDM) is a general term for strategies that increase transportation system efficiency by changing travel behavior (VTPI, 2005). It may affect travel frequency, mode, destination or timing (for example, shifting from peak to off-peak).

Mobility management both supports and is supported by parking management. Mobility management programs often reduce parking demand, and many parking management strategies help reduce vehicle traffic create more accessible land use patterns or support other mobility management objectives.

ix. Parking Pricing

Parking Pricing means that motorists pay directly for using parking facilities (“Parking Pricing,” VTPI, 2005; Shoup 2005). This may be implemented as a parking management strategy (to reduce parking problems), as a mobility management strategy (to reduce transport problems), to recover parking facility costs, or to raise revenue for any purpose (such as funding local transport programs or downtown improvements). It is often intended to achieve a combination of objectives.

Currently, most parking is inefficiently priced; it is provided free, significantly subsidized, or bundled (automatically included) with building purchases and rents, forcing consumers to pay for parking facilities regardless of whether or not they want it. When motorists do pay directly for parking, it is often a flat annual or monthly fee, providing little incentive to use an alternative mode occasionally. Rates should be set to optimize parking facility use, called performance-based pricing, which means that about 15% of parking spaces are vacant and available at any time (Shoup, 2006 and 2008).

x. Regulate parking use

Parking use should be regulated that aimed to use parking spaces and travel efficiently. Discount for residents parking and limit parking duration according to land-use type, and traffic volume, expected to increase the parking turnover rate and it favors shorter-term users or parking duration for deliveries and shopping. Regarding this, (Victoria Transport Provision Institution, 2015) discussed the feature of good parking use that minimizes congestion as follows: Limit on-street

parking of large vehicles (e.g. vehicles over 22 feet long) that obstacle the traffic movement, prohibit on-street parking on certain routes (arterials roads), during rush hour so as to maintain the smooth traffic flow traffic, and special parking regulation to favor priority vehicles, like emergency, service, etc.

Obviously, in reducing congestion, it is important to eliminate or minimize free parking in a specific place (Seattle Urban Mobility plan, 2008; Environment pollution).variable-rates parking price has a great role in reducing parking demand when compared with free parking, like higher rates during peak periods on-street spaces is more effective in reducing peak use.

The empirical studies have supported the above concept. For instance, a case study by Weinberger, et al., (2010),carried in Japan shows a positive change after formulation and effective implementation of a new on-street parking regulation (high price with time variable-rates) sinceJune,2006 on major cities in Japan. Three months later, it is reported that nearly 74% and 73.3% decline in illegal on-street parking in Tokyo and Osaka respectively which reduced the traffic congestion level on main roads from 27% to 23% at 2 pm to 4 pm than the previous time. The same to Japan, (Weinberger, et al., 2010), have stated that, in USA variable pricing policy on-street parking in peak hours also encouraged the short stays, high turnover rate and faster deliveries.

2.5 Perception of parking problems

In a study about parking problems in American central business districts (Ligocki and Zonn, 1984) discovered that the respondents define parking problems according to their needs. In other words that problems are defended according to the own perception. This implies that a different parking situation may be problematic for one group but not for another group.

Despite the need to address congestion and spillover parking problems related to a constrained supply, off-street parking has many costs that are usually ignored. Problems include the environment, aesthetics, safety, land use, development patterns, cost, economic development, affordable housing, and sprawl

Environmentally, parking lots themselves seem rather benign. However, surface parking creates some of the most polluted run-off water that communities are faced with (ULI, 2000)

Rainwater has to flow somewhere, and in nature it usually soaks into the ground where it is absorbed by plants or filters through to the groundwater table. It also flows into streams and rivers or simply evaporates. However, when a natural open area is covered with an impermeable surface such as a parking lot, rainwater flows into a gutter and is then deposited directly into a stream, river or lake. On its way, the rainwater takes with it dust, oil, antifreeze, tire rub-off, litter, yard or pet waste, and other elements that it finds in its way and brings it very efficiently to the nearest waterway without being filtered by a single mechanism, either mechanical or natural.

In addition, many communities are finding that surface parking lots are heating up run-off water, disrupting temperatures in streams, and in some cases making them unlivable for many species.

(Dane Co., Wisconsin, was the first community in the country to include temperature effect in measuring run-off pollution because of the abundance of trout streams and trout fishermen who enjoy them.)

As far as urban landscape is concerned, parking has many serious consequences. Underground parking, which usually connects the driver with his desired building via internal elevator or indoor stairway, empties sidewalks of potential pedestrians. These pedestrians could be customers of nearby shops, eyes on the street, neighbors, etc. who are effectively eliminated because they were afforded the luxury of not having to park on the street. This leaves the streetscape empty, as Donald Shoup states, and creates the perception that they are —threatening (Shoup, 2005).

Parking garages and surface parking lots, in addition to being extremely expensive, are often built in or near downtown or pedestrian-friendly areas at the expense of other buildings (Hass-Klau, 1992). In many cases, these buildings are older and in need of repair, and the owner finds it more cost effective or profitable to raze them and replace them with parking spaces, especially in areas with little parking supply like downtowns where a fee can be charged. However, the potential for renovating these older buildings, thus economically enhancing the community, serving as historical landmarks, providing property taxes and potential places for human interaction, are all denied in the name of automobile access to the few buildings that have escaped the parking demolition ball.

Parking can also threaten the safety of users of other modes. On-street parking creates potential hazards for bicycles, 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. In addition, driveways to off-street parking garages and lots increase the perceived danger to pedestrians from cars pulling in and out.

Every motorized trip ends in a parking situation. Truly, when one arrives at a destination by any motor vehicle one of the first experiences is of parking (Bendtsen, 1967) Particularly in the cities and the big towns there is a problem where the supply-demand ratio makes parking a problem for parking space providers, the motorists or both. According to (Monroe country department of planning and development, 2007), these are just the many solutions available:

- Increase parking supply
- Establish minimum parking requirements
- Increase on-street/curbside parking provision

- Increasing on-street parking
- Subsidizing off-street parking
- Adding overflow facilities
- Maximizing parking spaces in existing facilities
- Use of mechanization

2.6 Parking surveys

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

2.6.1 In-out survey

In this survey, the occupancy count in the selected parking lot is taken at the beginning. Then the number of vehicles that enter the parking lot for a particular time interval is counted. The number of vehicles that leave the parking lot is also taken. The final occupancy in the parking lot is also taken. Here the labor required is very less. Only one person may be enough. But we won't get any data regarding the time duration for which a particular vehicle used that parking lot. Parking duration and turnover is not obtained. Hence we cannot estimate the parking fare from this survey.

2.6.2 Fixed period sampling

For quick survey purposes a fixed period sampling can also be done. This is almost similar to in-out survey. All vehicles are counted at the beginning of the survey. Then after a fixed time interval that may vary between 15 minutes to 1 hour, the count is again taken. Here there are chances of missing the number of vehicles that were parked for a short duration.

2.6.3 License plate method of survey

This results 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. (Kadlyali, D, 2010).

2.7 Impact of parking

Parking has some effects like congestion, accidents, pollution, obstruction to fire-fighting operations etc.

1. 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.
2. 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.
3. 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.
4. Obstruction to firefighting operations Parked vehicles may obstruct the movement of firefighting vehicles. Sometimes they block access to hydrants and access to buildings.

2.8 Parking Space Dimensions

According to country of San Diego, parking design manual, 2013 each required parking space shall be at least 9' wide by 18' long, with adequate provisions for ingress and egress by a standard full size passenger vehicle.

Parking spaces in parking lots shall comply with the minimum dimension requirements in Table 2.5 and as illustrated in Figure 2.7

Table 2.5 parking space dimensions

Figure 3Label	Design Component	Parking Angle				
		0°(Parallel)	30°	45°	60°	90°
A	Stall Width	9'(8') ¹	9'	9'	9'	9'
B	Stall Length	22'	18'	18'	18'	18'
C	Stall Width Parallel to Aisle	N/A	18'-0"	12'-9"	10'-5"	9'-0"
D	Stall Depth to Curb or Wall	N/A	16'-10"	19'-1"	20'-1"	18'-0"
E	Stall Depth to Interlock	N/A	12'-11"	15'-11"	17'-10"	18'-0"
F	One-Way Aisle Width ²	13	14'	16'	19'	N/A
	Two-way	24'	22'	24'	24'	26'

G	Module Width	One-Way Aisle	N/A	43'-9"	51'-0"	46'-11"	N/A
	Wall/Curb to Interlock	Two-Way Aisle	N/A	51'-9"	59'-0"	61'-11"	62'-0"
H	Module Width	One-Way Aisle	N/A	39'-10"	47'-10"	54'-8"	N/A
	Interlock to Aisle Interlock	Two-Way	N/A	47'-10"	55'-10"	59'-8"	62'-0"
not shown in Figure	Module Width	One-Way Aisle	31'-0"	47'-8"	54'-2"	59'-2"	N/A
	Wall/Curb to Wall/Curb	Two-Way Aisle	42'-0"	55'-8"	62'-2"	64'-2"	62'-0"
I	Cross Aisle Width ²	One-Way	15'	15'	15'	15'	15
		Two-Way	22'	22'	22'	22'	22'

1. 8' width applies to on-street parking stalls

2. The Director may require greater aisle width due to emergency San Diego County Fire Authority equipment access needs. Aisles less than 24' shall not be designated as Fire Access.

N/A – Not Applicable

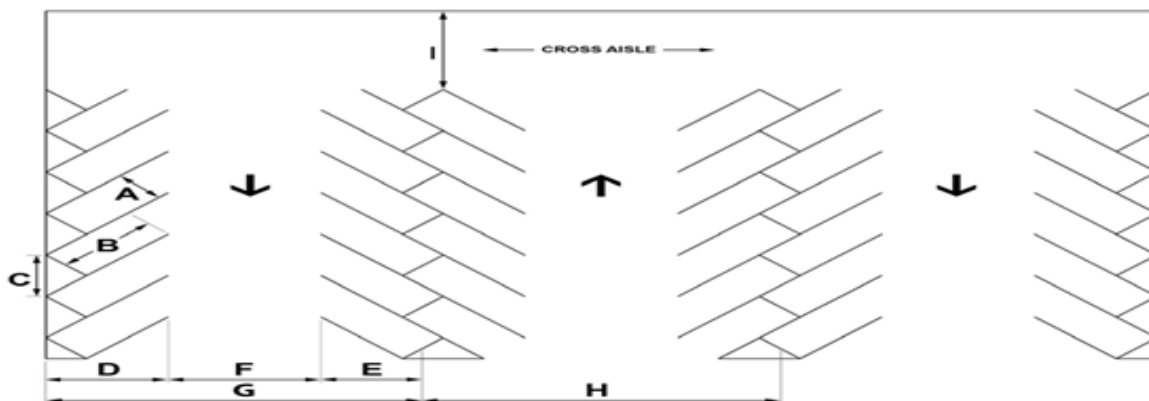


Figure 2.7: Reference Drawing for Minimum Parking Dimensions

Minimum parking dimensions for common parking layouts are illustrated in Figure 8.

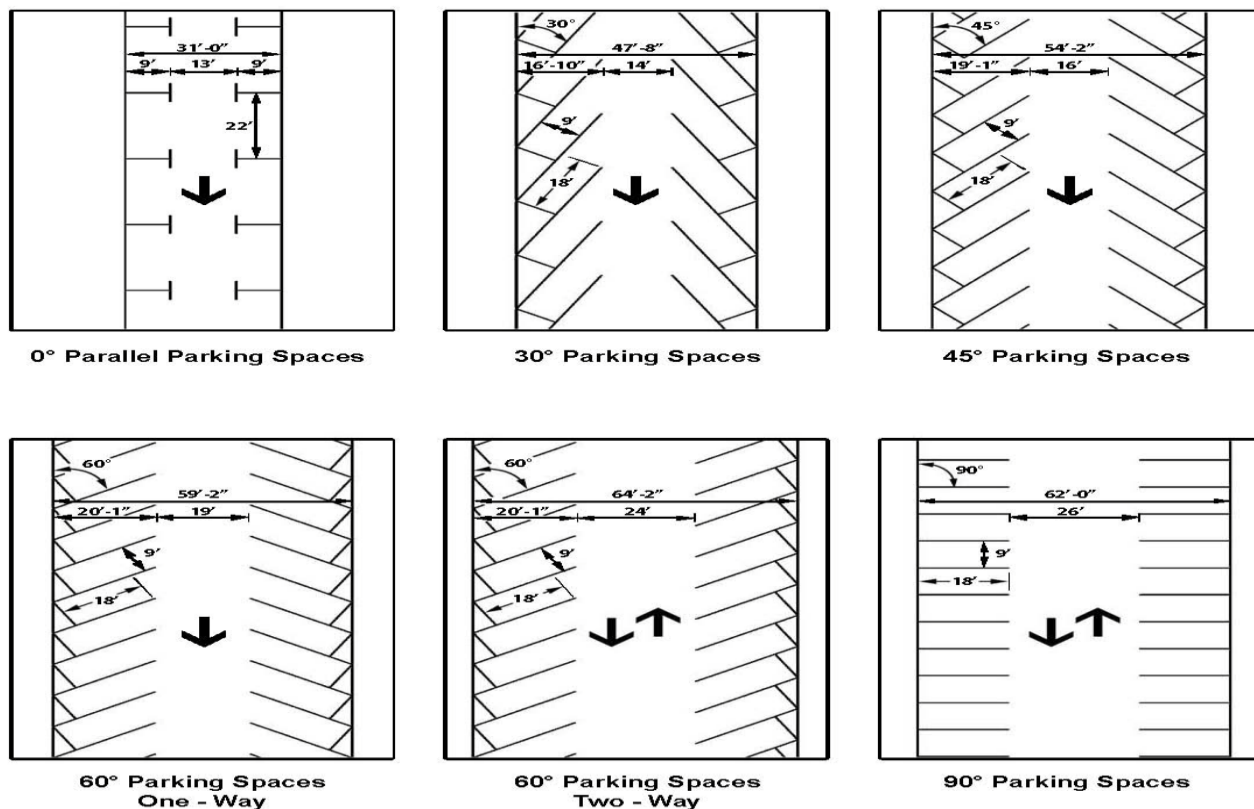


Figure 2.8: Minimum Dimensions for Common Parking Lot Layouts

2.9 Regulatory Measures for on Street Parking

1. Though on-street parking is an extravagant use of the precious street space, it cannot entirely be prohibited. A judicious application of appropriate traffic management measures will help to mitigate some of the ill-effects of on-street parking. Those measures should be part of the comprehensive parking policy for the town, formulated after a careful survey of the situation. The regulatory measures range from waiting restrictions in a street to the comprehensive control over an extended area, laying down where vehicles may or may not park, what should be the waiting time and what charges should be levied for parking. The measures should be periodically reviewed and altered, if necessary. The regulatory measures are generally of two types, one where the use of parking space is authorized for certain periods free or for payment and the other where parking is prohibited but which allows waiting for picking up or setting down goods and passengers'.

2. When a controlled parking scheme is planned, the zone boundaries should be clearly delineated and suitable traffic signs installed. Natural boundaries a river or a railway line could be advantageously adopted. The carriageway should be adequately marked.
3. **Prohibited parking**; it is desirable to prohibit parking at certain locations and for a period to ensure safety and convenience. Such locations are:
 - i. **Near intersections.** The capacity of an intersection is greatly reduced if vehicles are allowed to park on the approaches. Visibility is also adversely affected and safety is reduced. It is the general practice to prohibit parking for a distance of about 50m on the approaches to a major intersection.
 - ii. **Narrow streets.** Narrow streets with heavy traffic require that all possible measures should be taken to remove obstacles to traffic flow. Prohibition of parking can have a salutary effect on traffic flow and congestion. In busy streets of the central area, it is generally desirable to prohibit parking on two-way street less than 5.75m wide and one-way streets less than 4m wide.
 - iii. **Pedestrian crossings.** As already mentioned, parking maneuvers cause accidents, and pedestrians are the worst sufferers. Parked cars obstruct the visibility at pedestrian crossings. For these reasons, it is desirable to prohibit parking within about 8m from the pedestrian crossing.
 - iv. **Structures.** Structures such as bridges, tunnels and underpasses generally have a roadways width less than the highway and for this reason it is desirable to prohibit parking on them.
 - v. **Entrance driveways.** Vehicle should be prohibited from parking in front of entrance driveways leading to houses and buildings.

(SANFRANCISCO COUNTY TRANSPORTATION AUTHORITY, 2009)

2.10 Modelling innovations

No single model has emerged as the preferred choice for parking research. Much economic analysis has used stated preference or similar techniques while hypothetical approaches have also been used, especially by academics.

Some studies have developed new models to understand parking behavior. For example, TRAM – Traffic Restraint Analysis Model was developed for Bristol as part of a much larger project 199. This allowed a wide range of responses to transport changes. An External Forecasting model (EFM) provided input into transport for both demand and supply sides. The EFM generates the demand matrices. The model uses two land-use change indicators:

- Change of use; and
- Location/ intensity of activities.

The model was used to forecast the impacts of four do-maximum scenarios:

- A large fall in the supply of PNR in central Bristol;
- The application of large parking charges;
- Increased charges for short stay parking applied; and
- Enforcement regime changes.

In Truro an activity-based parking model was developed, linking to a traditional four-stage transport model²⁰⁰. Monte Carlo techniques were applied to select individual car parking spaces while choice co-efficient were derived from Stated Preference experiments. The authors claimed that this type of model can be used to test a very wide range of policies e.g. closing/opening car parks, changing the type of car park and charges, and access/ egress arrangements etc. It can also to predict their impact on traveler behavior.

2.11 Forecasting Space Availability

(Smith et al., 2005) indicates: “Even a perfectly accurate parking occupancy detection system will only indicate the number of spaces available at a particular point in time. What the drivers need, however, is an indication of whether spaces will be available at the time he or she arrives at the truck stop or rest area.” The study lists the following quoted approaches to deal with this problem:

- “Furnish information to the driver just before the entry to the rest area or truck stop. With a less than 1-minute lag, the actual occupancy number is not likely to change significantly. However, this does not help a driver to choose among rest locations, since some of them may be many miles down the road” (Smith et al., 2005).
- “Furnish information on the number of spaces occupied and the number of spaces available and let drivers do their own estimating as to whether spaces will be available when they arrive. This may be sufficient for a driver who is familiar with the corridor, but may not be helpful to an unfamiliar driver” (Smith et al., 2005).
- “Provide a forecast of space availability, based on historical information.” For example: if 20 spaces are open now at 7:00 PM, the lot will likely be full by 8:00 PM (Smith et al. 2005).
- “Allow drivers to send an inquiry or request for parking to the parking management system, and incorporate this request along with requests from other drivers into the forecasts” (Smith et al. 2005).

Chapter 3 Research Methodology

This section outlines the approach that used to undertook the research phase of the study.

3.1. Condition survey

Condition survey was performed for different sub-cities of the capital Addis in order to select the study area. The Arada sub-city has been selected for this research as it is the center of old and most of the buildings are running out of service. Within this sub-city Arat kilo to piazza road has been selected as a representatives of all streets as it is center of movement and contain varies services.

3.2. Site investigations

Site visits were undertaken throughout the selected streets various times across the day in order to observe peak versus non-peak conditions, parking hotspots and signage and controls. Notes and photos were recorded with a geographical reference. The parking occupancies of different parking areas within one hour intervals for the selected week and weekend days were recorded.

The data were then plotted on the graph in order to determine the peak and non-peak hour occupancy of the day. It is important to determine which variables are to be observed and what their level of importance is to the research. A field observation procedure and protocol were determined so that the manner in which the team performed the observations remained constant. The aim of both of these subtasks was to improve the data quality from the field work so that the results will maintain a high level of validity.

Within the peak occupancy time interval and by using the license plate survey method parking terms like turnover rate, accumulation, occupancy, average turnover, parking volume, average duration and average occupancy were calculated as follows:

Note: To be more accurate a 15 minutes interval license plate survey method was applied.

3.2 Primary and secondary data collections

Primary data were collected from the different road users by using techniques like interviewing, questionnaires and actual site survey. Secondary data like traffic volumes, capacity of the parking lots, and other related data were collected from different city traffic bureaus.

The data collection methods that would be used to evaluate issue validity and perceptions to the City are presented. Analyzing data related to each issue results in a set of recommendations that can satisfy several diverse sets of stakeholders including the City, downtown business-owners, shoppers, office workers, residents, and, faculty, and staff and for the foreseeable future or until conditions change enough to warrant a new approach.

The data collections for this thesis were originated from four main sources:

- ✓ Original data collected by the City;
- ✓ Data obtained from other sources during a literature review;
- ✓ Data gathered from the online and printed parking survey; and
- ✓ Data obtained in the field.

A small numbers of intercept surveys were conducted during the site investigation phase. These consist of asking people who are leaving or approaching their parked car a small number of questions designed to understand why they were parking in that location, whether the parking bay/location met their needs and their overall impression of parking in street. Time constraints limit the number of intercept surveys completed.

Generally two data collection methods were applied the first one is field survey and the second one is google map software.

Field survey

A field survey consists in going in the field (in the chosen sector) to conduct a comprehensive survey of data related to the calculation of parking capacity. Data collection by field survey was made for two types of parking, for on-street and off-street parking.

- ✓ On-street parking data collection: all information related to parking were noted, among others the lengths of street sections, the number of permanent equipment (driveways, bus stops , etc..), the information provided by regulatory signs (including the strict prohibitions of parking at any time) and parking availability by type (public, private, reserved, paid, free, funded ...)
- ✓ Off-street parking data collection: information were collected about the areas of parking spaces, the types of parking available and the information provided by the regulation governing the parking (which has less variation than for on-street parking).

The advantage of this method is that it is very accurate and provides detailed information. However, in addition to being expensive and dependent on weather constraints, this method has many logistical constraints, such as: The determination of the lengths of segments during field trips is relatively difficult. Since, this requires the use of measurement instruments, which can be cumbersome. Because of the large amount of information to be collected in this study, the choice was made to determine the distance from a google map software using Open Street Map.

Data extraction from Google map software

This method does not require a field trip: it uses google map layers and tools to extract data. Recent advances in the world of geographic information helps to provide a lot of public data.

Data was collected in google map by going (virtually) in every street, alley and other parking spaces available and the area of each land use by identifying any data related to the calculation of the parking supply, as done in field.

3.3 Determination of parking demand

The procedure for estimating parking demand is complex. It involves many factors, including project size, type of zoning, type and number of persons expected to visit the site, availability of alternative transportation modes, and the time frame of the analysis.

Basically two methods of parking demand estimations are mostly used:

1. Based on specific land uses/regression model.
2. Analytical approach.

Because of the land use analysis takes the parking utilization data one step further by relating it to surrounding land uses and national standards to determine the demand and supply analysis, it is more accurate and easy. Therefore on this thesis the first method were applied.

3.3.1 Parking demand estimation based on specific land uses

Parking demand were estimated based on specific land uses. The land uses that were identified actually are listed as shown below:

- ✓ Government office
- ✓ General office
- ✓ Bank
- ✓ Restaurant/clubs
- ✓ Residential units
- ✓ Hotel units
- ✓ Commercial centers
- ✓ Miscellaneous land use including library ,convention center, youth hostel, theatre

Land use totals by sub-area for each category are then provided in table.

For each land use a peak rate were identified. The rates for each land uses were derived from the actual data collected during site investigation and parking survey counts. And the derived peak demand rates were compared with the available national transportation parking industry standards. The most widely used standards in the industry is from the institute of transportation engineers (ITE).

And then parking demand was calculated based on the land use analysis for both cases as follow:

Parking demands of each land use=peak rates*land use
--

3.4. Determination of parking supply

For the supply survey, existing data that were provided by the City, recent aerial photography and on-the ground reconnaissance and verification were utilized to establish, as accurately as possible. For each numbered block all on-street parking spaces within each block's respective street faces, as well as all private or public parking lots spaces interior to each block (referred to as "off-street" parking), were counted as available spaces.

The on-street parking supply estimation is based upon the curb length of each zone minus areas where parking restrictions or dropped curbs and junctions prevent parking. The parking length is then divided by 5.9m, which is the standard car dimension plus a certain gap from both side of the vehicle (5+0.9) to convert the length into an approximate number of parking spaces.

Chapter 4 Result and Analysis

4.1 Inventory of Existing Parking Facilities

Introduction

The Arat kilo-piazza road is a 1.7 km long which starts near Meseret cafe around Arat-kilo round about and ends at piazza square near the corner of Anbessa shoes. The parking demand and supply analysis include both side of the road and the on-street, off-street and building parking supplies that passes along the main road. The road contains 25 parking lots of which 7 are on-street 15 are off-street and the remaining 3 are a combination of on-street, off-street and building parking facilities. The parking fees are ranges from 0.5birr to 3:00birr with related to the purpose of the service for 30 minutes of duration. Within this road segment there are different residential and commercial buildings, community commercial centers, shops, bar and restaurants. The study area is only main road and didn't include minor roads; along the road segment parking is allowed according to parking allowance signal. But there are considerably illegal parking's due to shortage of parking spaces mainly on the right side of the road around Cinema Empire and near Ras Mekonen Bridge. Double line parking around Cinema Empire shows inadequacy of parking spaces in that area. The road from Cinema Empire to Ras Mekonnen Bridge is the longest one sided parking space and the other side is completely restricted for parking due to inadequacy of road width. But there are many vehicles parked on this restricted places due to shortage of parking spaces which is considered to be illegal parking.

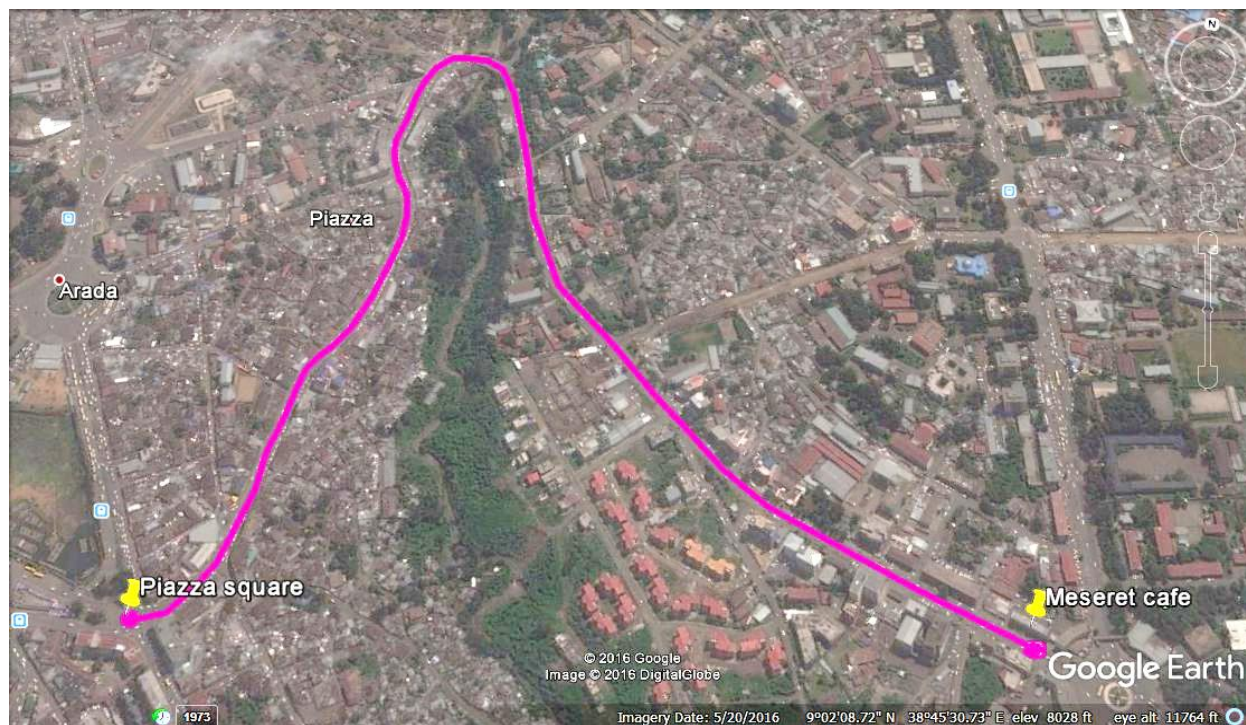


Figure 4.1 location of the study area from google maps

The inventory of existing parking facilities that includes detailed listing of the location and all other relevant characteristics of each legal parking facility, private and public, in the study area are listed below:





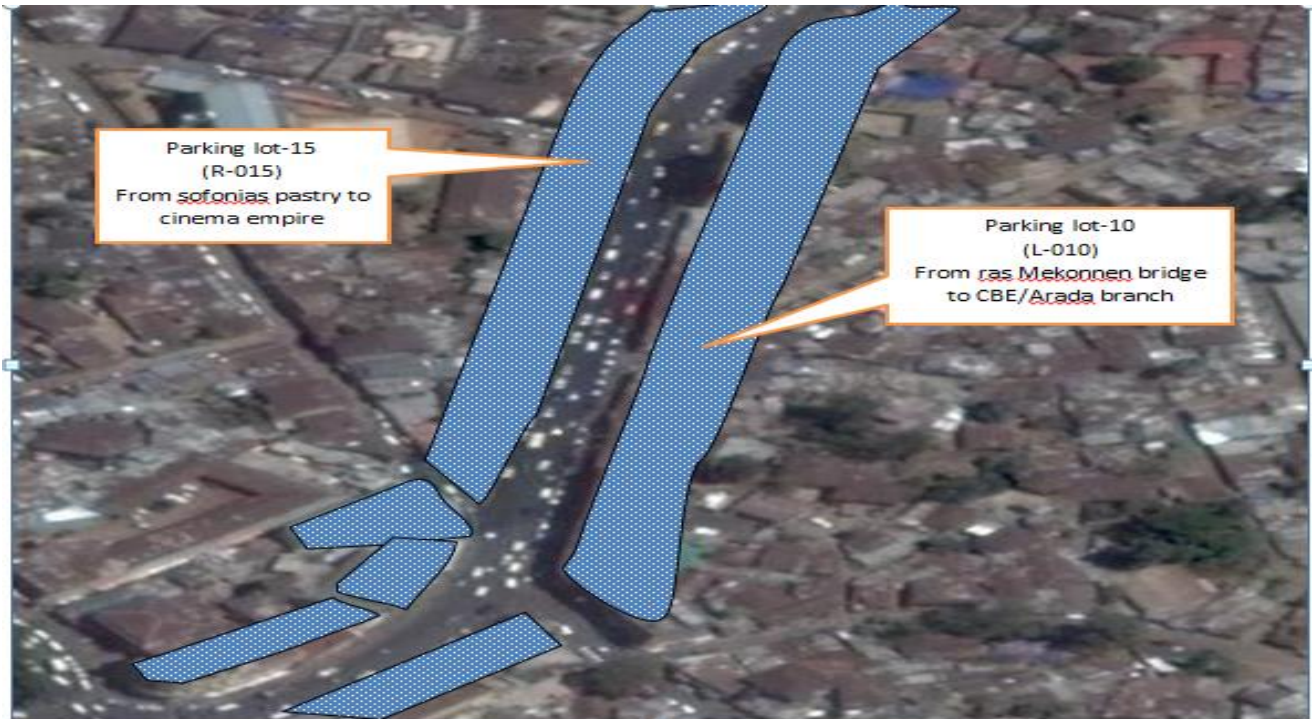








Figure 4.2 parking lot locations at the right and the left side of the main road.

Legend

-  Multi-purpose building
-  Hotel
-  Commercial
-  Bar & restaurant
-  Office
-  Bank

1. At the right side of the road

Parking lot-1: R-001 (at Meseret café)

- ✚ It is a multi-purpose building which contains café and restaurants, commercial centers, business centers and residential apartment.
- ✚ Located at 9°02'00"N and 38°45'45.4"E
- ✚ Has a gross square footage area of 28881 with 12 off-street parking capacities.
- ✚ Angular parking facility

Parking lot-2: R-002(at Yomik fashion)

- ✚ A small commercial center
- ✚ Located at 9°02'0.6"N and 38°45'44.1"E
- ✚ Has a gross square footage area of 1824 with an off-street Parking capacity of 5.
- ✚ Perpendicular parking facility

Parking lot-3: R-003 (at Seble restaurant)

- ✚ A multi-purpose building which contains café and restaurants, commercial centers, and business centers
- ✚ Located at 9°02'1.7"N and 38°45'42.1"E
- ✚ Has a gross square footage area of 29988 with an off-street Parking capacity of 20.
- ✚ Angular parking facility

Parking lot-4: R-004(at Awash bank)

- ✚ A business and office building
- ✚ Located at 9°02'2.5"N and 38°45'39.8"E
- ✚ Has a gross square footage area of 7703 with an off-street parking capacity of-12.
- ✚ Perpendicular parking facility

Parking lot-5: R-005 (at Birhanina selam printing press and Habesha cinema)

- ✚ Business, restaurant and cinema area
- ✚ Located at 9°02'3.5"N and 38°45'37.8"E
- ✚ Has a gross square footage area of 37769.08 with an On-street parking capacity of 10.
- ✚ Parallel parking facility

Parking lot-6: R-006 (at Kaldis coffee)

- ✚ Café and business zone
- ✚ Located at 9°02'5.1"N and 38°45'35.9"E
- ✚ Has a gross square footage area of 11327 with Off-street parking capacity of 10 and an under-ground parking garage of 6.
- ✚ Perpendicular parking facility

Parking lot-7 R-007 (at Buna international bank /Diber bldg.)

- ✚ Business and commercial area
- ✚ Located at 9°02'5.3"N and 38°45'34.8"E
- ✚ Has a gross square footage area of 33307 with 10 off-street, 8 on-street and 12 building Parking capacities.
- ✚ Angular, perpendicular and parallel parking facilities

Parking lot-8: R-008(at Denver cafe)

- ✚ Business and commercial center
- ✚ Located at 9°02'7.2"N and 38°45'33.8"E
- ✚ Has a gross square footage area of 16581 with an off-street Parking capacity of 8.
- ✚ Perpendicular parking facility

Parking lot-9: R-009 (At Book light)

- ✚ Commercial and bank area
- ✚ Located at 9°02'08"N and 38°45'33"E
- ✚ Has a gross square footage area of 12365 with an Off-street parking capacity of 8.
- ✚ Perpendicular parking facility

Parking lot-10: R-010 (At Gera furniture)

- ✚ A small Commercial place
- ✚ Located at 9°02'09"N and 38°45'30"E
- ✚ Has a gross square footage area of 1500 but has no any parking facility but a maximum of 4 vehicles parks using internal facility road daily.

Parking lot-11: R-011 (at Yegna guada bar and restaurant)

- ✚ Bar and restaurant and a small commercial place
- ✚ Located at 9°02'14"N and 38°45'27"E
- ✚ Has a gross square footage area of 1785 with an On-street parking capacity of-8.
- ✚ Parallel parking facility

Parking lot-12: R-012 (Sheger pastry)

- ✚ Café zone
- ✚ Located at 9°02'17"N and 38°45'26"E
- ✚ Has a gross square footage area of 3424 and has an On-street Parking capacity of 8.
- ✚ Parallel parking facility

Parking lot-13 R-013 (Licha zone)

- ✚ Café and residential building
- ✚ Located at 9°02'22"N and 38°45'20"E
- ✚ Has a gross square footage area of 17702 with an off-street Parking capacity of 5.
- ✚ Perpendicular parking facility

Parking lot-14 R-014 (Ethiopian household and office furniture)

- ✚ A commercial and office area
- ✚ Located at 9°02'20"N and 38°45'19"E
- ✚ Has a gross square footage area of 17340 with an Off-street parking capacity of 10.
- ✚ Angular parking facility

Parking lot-15 R-015 (From Sofonias pastry to cinema Empire)

- ✚ Café, restaurant, commercial and cinema area
- ✚ Located at 9°02'18"N and 38°45'19"E to 9°01'59"N and 38°45'16"E
- ✚ Has a gross square footage area of 17154, the cinema has 805 seats and the road side is restricted for parking.
- ✚ Angular, parallel and perpendicular parking facility

2. At the left side of the road

Parking lot-1 L-001(CBE/Arat Kilo branch)

- ✚ Bank area
- ✚ Located at $9^{\circ} 1' 59.2644''$ N and $38^{\circ} 45' 45.1836''$ E
- ✚ Has a gross square footage area of 3079 with an off-street parking capacity of 6.
- ✚ Perpendicular parking facility

Parking lot-2 L-002(at Tourist hotel)

- ✚ Hotel and recreational area
- ✚ Located at $9^{\circ} 1' 59.7792''$ N and $38^{\circ} 45' 43.7436''$ E
- ✚ Has a gross square footage area of 2985 with 66 numbers of rooms and an off-street parking capacity of 7.
- ✚ Angular parking facility

Parking lot-3 L-003(at near to Total gas station)

- ✚ Under construction building
- ✚ Located at $9^{\circ} 1' 59.7036''$ N and $38^{\circ} 45' 42.7032''$ E
- ✚ Has a gross square footage area of 7500 with an off-street parking capacity of 11.
- ✚ Perpendicular parking facility

Parking lot-4 L-004 (at Dink Sira complex)

- ✚ A business and office building
- ✚ Located at $9^{\circ} 2' 1.4604''$ N and $38^{\circ} 45' 39.7944''$ E
- ✚ Has a gross square footage area of 7516.25 with an off-street of 8 and a building parking of 16 capacities.
- ✚ Perpendicular parking facility

Parking lot-5 L-005(at Ethiopian press agency)

- ✚ Business and office area
- ✚ Located at $9^{\circ} 2' 1.9248''$ N and $38^{\circ} 45' 38.9376''$ E
- ✚ Has a gross square footage area of 3325 with an off-street parking capacity of 12.
- ✚ Angular parking facility

Parking lot-6 L-006(at Bilo's pastry)

- ✚ Café and office building
- ✚ Located at $9^{\circ} 2' 2.8032''$ N and $38^{\circ} 45' 36.4752''$ E
- ✚ Has a gross square footage area of 4925 with an off-street parking capacity of 13.
- ✚ Angular parking facility

Parking lot-7 L-007(at Arada sub-city land development and management office /ASLDMO)

- ✚ Government office
- ✚ Located at $9^{\circ} 2' 7.2384''$ N $38^{\circ} 45' 30.564''$ E
- ✚ Has a gross square footage area of 6599 with an off-street parking capacity of 14.
- ✚ Perpendicular parking facility

Parking lot-8 L-008(at Mega books)

- ✚ Commercial center
- ✚ Located at $9^{\circ} 2' 12.9408''$ N and $38^{\circ} 45' 25.9596''$ E
- ✚ Has a gross square footage area of 4377 with an off-street parking capacity of 10.
- ✚ Perpendicular parking facility
- ✚ Angular parking facility

Parking lot-9 L-009(at channel five)

- ✚ Bar and restaurant zone
- ✚ Located at $9^{\circ} 2' 21.3216''$ N and $38^{\circ} 45' 23.544''$ E
- ✚ Has a gross square footage area of 2011 with an off-street parking capacity of 12.
- ✚ Perpendicular parking facility

Parking-lot 10 L-010(from Ras Mekonnen Bridge to CBE /Piazza branch)

- ✚ A commercial places where mostly jewelries and boutiques are found
- ✚ Located from $9^{\circ} 2' 22.0344''$ N and $38^{\circ} 45' 20.7''$ E to $9^{\circ} 1' 59.9484''$ N and $38^{\circ} 45' 17.3412''$ E
- ✚ Has a gross square footage area of 105964 with an on-street parking capacity of 145.
- ✚ Parallel parking facility

4.2 Summary of existing Parking supply

A. On the right side of the road

1. On-street parking supply

Table 4.1 on-street parking supply at the right side of the road

Street name and well known places	Existing parking spaces
Habesha cinema	10
Buna bank (Diber bldg.)	8
Yegna guada bar and restaurant	8
Sheger pastry	8
Total	34

2. Off-street parking supply

Table 4.2 off-street parking supply at the right side of the road

Street name and well known places	Existing parking spaces
Meseret cafe	12
Yomik fashion	5
Seble restaurant	20
Awash bank	12
Kaldis coffee	10
Buna bank (Diber bldg.)	10
Denver cafe	8
Book light	8
Licha zone	5
Ethiopian household and office furniture	10
Total	100

3. Building parking supply

Table 4.3 building parking supply at the right side of the road

Building name	Existing parking spaces
Kaldis coffee	6
Buna bank (Diber bldg.)	12
Total	18

Total supply =on-street + off-street + building supply

$$=34+100+18=152 \text{ parking spaces}$$

B. At the left side of the road

1. On-street parking supply

Table 4.4 on-street parking supply at the left side of the road

Street name and well known places	Existing parking spaces
Mega books	8
Channel five	12
Ras Mekonen bridge-CBE(Piazza branch)	145
Total	165

2. Off-street parking supply

Table 4.5 off-street parking supply at the left side of the road

Street name and well known places	Existing parking spaces
CBE(Arat Kilo branch)	5
Tourist Hotel	7
Near Total	11
Dink Sira complex	8
Ethiopian Press Agency	12
Bilo's pastry	13
Arada Sub-city land administration	14
Mega Books	10
Total	80

3. Building parking supply

Table 4.6 building parking supply at the left side of the road

Building name	Existing parking spaces
Dink Sira complex	16
Total	16

$$\begin{aligned} \text{Total supply} &= \text{on-street} + \text{off-street} + \text{Building supply} \\ &= 165 + 80 + 16 = 261 \text{ parking spaces} \end{aligned}$$

Table 4.7 Total parking supply at the right and left side of the road

Direction of parking spaces	On-street parking	Off-street parking	Building parking	Total
At the right side of the road	34	100	18	152
At the left side of the road	165	80	16	261
Total	199	180	34	413

- Generally the street has a total of $152+261=413$ parking spaces which is the sum of parking spaces at the right and at the left of the street.

4.3 Survey data and Analysis

A summary of results from the parking surveys of on-street, off-street and building parking lots at the right and at the left side of the road are summarized below:

4.3.1 At the right side of the road

Parking lot-1: R-001/Meseret café

The number of vehicles parked at an hourly interval on July 11th 2016 for R-001(at Meseret café) is realized as shown in the chart below:

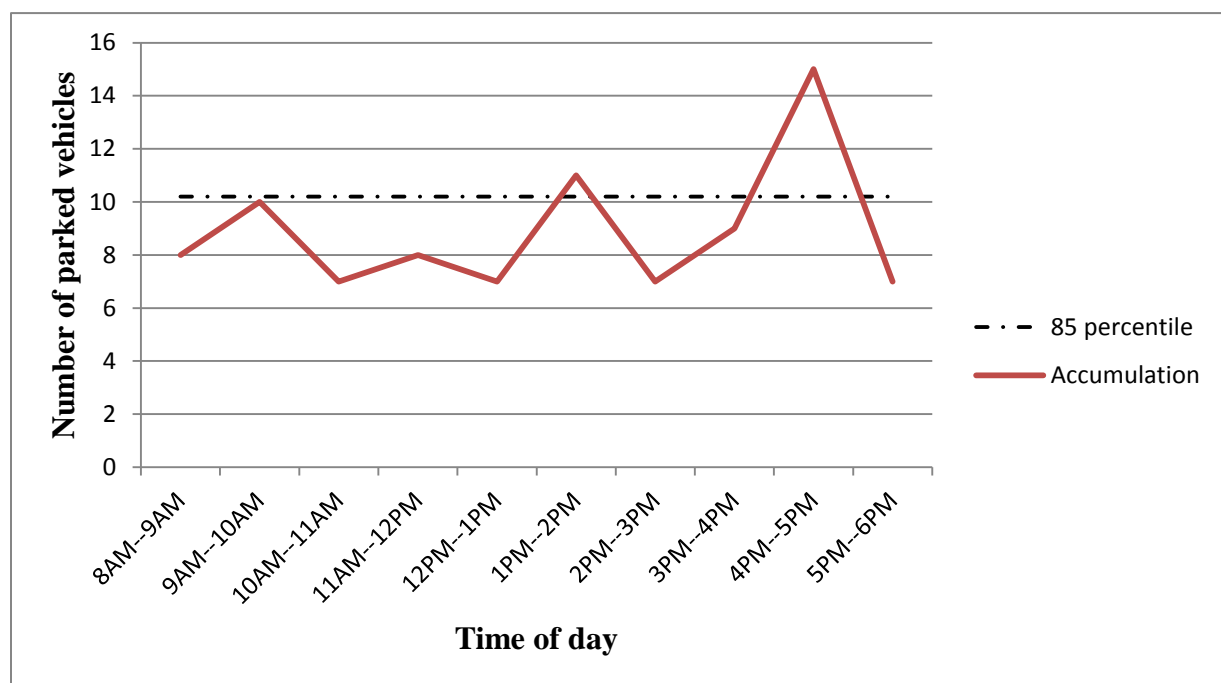


Figure 4.3: Accumulation curve, R-001 at Meseret café, July 11, 2016.

It shows the maximum demand is on the time interval between 4:00pm to 5:00pm. This is due to most customers are free from their work and park their vehicles within this time interval to get access for café, internet services and photo shops.

Recognizing the accumulation curve of the off- street parking spaces, are being utilized with in the allowable limit or capacity the whole day, except from 1:00pm to 2:00pm and 4:00pm to 5:00pm which is the peak flow more than the capacity of the streets.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Procedure of analysis is tabulated only for parking lot-1, result of other site are presented by table to ignore redundancy of procedure.

Table 4.8: license plate survey data result, R-001 on Monday July 11, 2016 from 4:00PM-5:00PM

Date:- Monday July 11/2016					Recording time:-4:00PM-5:00PM				
Weather:- sunny					Location :-R-001/Meseret café				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	A73637	A73637	A73637	A73637	1	1	1	1	1
2	-	-	-	-	0	0	0	0	0
3	-	19640	19640	19640	0	1	1	1	1
4	A26117	A26117	A26117	A26117	1	1	1	1	1
5	75323	-	73372	73372	1	0	1	1	2
6	A04891	92856	A22573	A04891	1	1	1	1	3
7	A30534	01728	01728	-	1	1	1	0	2
8	-	-	-	-	0	0	0	0	0
9	00903	00903	00903	-	1	1	1	0	1
10	12304	12304	A63952	A63952	1	1	1	1	2
11	A48426	A48426	A48426	A48426	1	1	1	1	1
12	91846	178977	A56100	A56100	1	1	1	1	3
Accumulation					9	9	10	8	17
Occupancy					75	75	83.3	66.67	

		Unit
Average turn over	1.42	Vehicles/hr.
Parking volume	17	Vehicles
Average duration	31.8	Minute/vehicles
Average occupancy	75	%
Parking load	9	Vehicles hours
Parking capacity	12	Vehicles hours

Columns 1 to 5 are the input data. The parking status in every bay is coded first. If a vehicle occupies that bay for that time interval, then it has a code 1. This is shown in columns 6,7,8 and 9 of the table corresponding to the time intervals 15,30,45 and 60 seconds.

- Turnover is computed as the number of vehicles present in that bay for that particular hour. For the 6th bay, it is counted as 3. similarly, for the first bay, one vehicle is present throughout that hour and hence turnover is 1 itself. This is being tabulated in column 10 of the table. Average turnover =sum of turnover/total number of bays=1.42.
- Accumulation for a time interval is the total of number of vehicles in the bays 1 to 12 for that time interval. Accumulation for first time interval of 15 minutes=1+0+0+1+1+1+1+0+1+1+1+1=9

- Parking volume= sum of the turnover in all the bays=17 vehicles
- Average duration is the average time for which the parking lot was used by the vehicles. it can be calculated as sum of the accumulation for each time interval \times time interval divided by the parking volume=
$$\frac{(9+9+10+8) \times 15}{17} = 31.8 \text{ minutes/vehicle.}$$
- Occupancy for that time interval is accumulation in that particular interval divided by total number of bays. For first time interval of 15 minutes, occupancy=
$$(9 \times 100) / 12 = 75\%.$$
 Average occupancy is found out as the average of total number of vehicles occupying the bay for each time interval. it is expressed in percentage.
Average occupancy=
$$\frac{(0.75+0.75+0.833+0.6667) \times 100}{4} = 75\%.$$
- Parking capacity = number of bays \times number of hours=12*1=12 vehicles hours.
- Parking load=total number of vehicles accumulated at the end of each time interval*time=
$$\frac{(9+9+10+8) \times 15}{60} = 9 \text{ vehicles hours.}$$
- Efficiency=
$$\frac{\text{parking load}}{\text{total number of bays}} = \frac{9 \times 100}{12} = 75\%.$$

From the result average parking duration of 31.8 minute/vehicles indicates most vehicles are parked for long period of time, it shows that almost two vehicle is parked within an hour. From the turnover result of 1.42vehicles/hour, it is possible to say that the rate of usage of parking space is poor or the frequency of space availability is low.

Occupancy of 75% and parking load of 9 vehicles hours shows the parking space coverage of the area is considered to be ideal, since the parking space is used effectively.

Parking lot-2: R-002(At Yomik fashion)

The number of vehicles parked at an hourly interval on July 11, 2016 for R-002(at Yomic fashion) is realized as shown in the chart below:

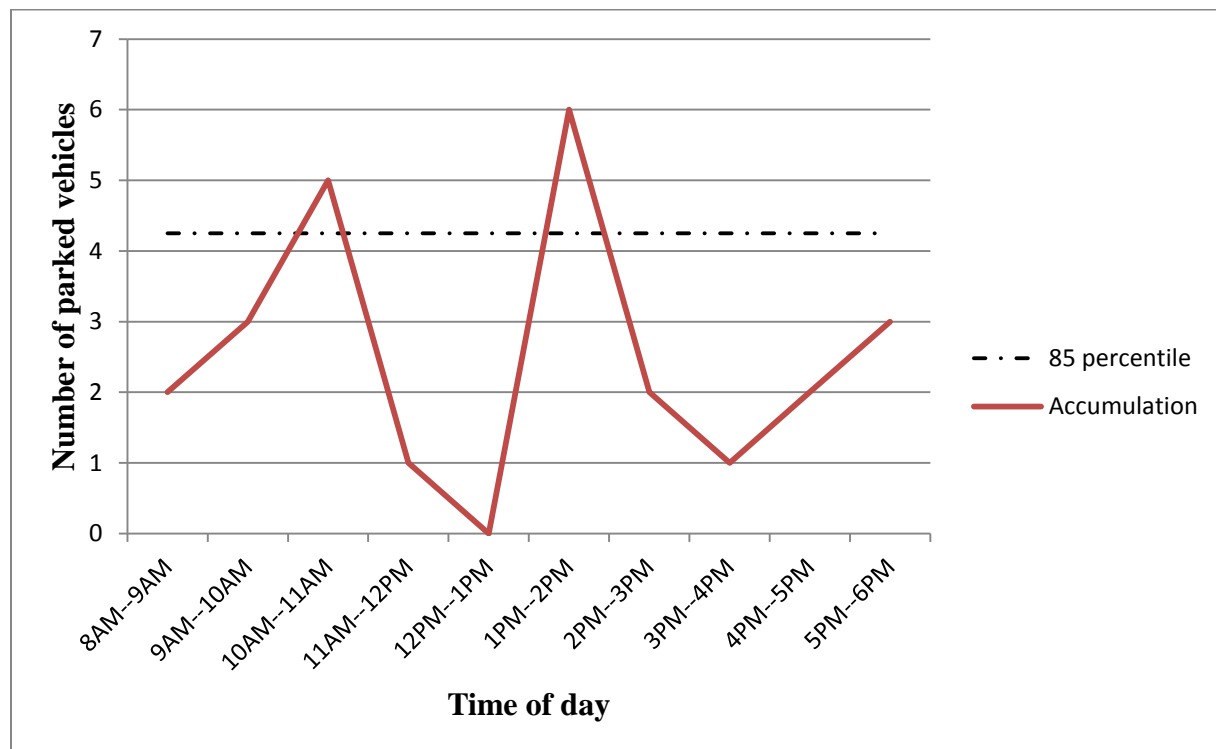


Figure 4.4: Accumulation curve, R-002 at Yomik fashion, July 11, 2016.

It shows the maximum demand is on the time interval between 1:00pm to 2:00pm. As the place is a small commercial center the peak demand may vary within the day hour.

The high vehicle accumulation on the parking lot is identified from 10:00am to 11:00am, and 1:00p.m to 2:00p.m, which is more than the allowable space capacity of the parking lot or the 85 percentile.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.9: license plate survey data result on Monday July 11, 2016 from 1:00PM-2:00PM

Date: Monday July 11/2016 Weather: sunny					Recording time:1:00pm-2:00pm Location: R-002/Yomic fashion				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	29449	29449	-	-	1	1	0	0	1
2	A89371	89724	20335	01509	1	1	1	1	4
3	A80129	-	73990	78815	1	0	1	1	3
4	-	51031	67545	-	0	1	1	0	2
5	A20126	A20126	-	47147	1	1	0	1	2
Accumulation					4	4	3	3	12
Occupancy					80	80	60	60	

		Unit
Average turn over	2.4	Vehicles/hr.
Parking volume	12	Vehicles
Average duration	17.5	Minute/vehicles
Average occupancy	70	%
Parking load	3.5	Vehicles hours
Parking capacity	5	Vehicles hours

From the result average parking duration of 17.5 minute/vehicles indicates most vehicles are parked for medium period of time, it shows that almost four vehicles are parked within an hour. From the turnover result of 2.4vehicles/hour, it is possible to say that the rate of usage of parking space or the frequency of space availability is good.

Occupancy of 84.38% and parking load of 3.5 vehicles hours shows the parking space coverage of the area is considered to be ideal, since the parking space is used effectively.

Parking lot-3: R-003 (At Seble restaurant)

The number of vehicles parked at an hourly interval on July 13/2016 R-003(At seble restaurant) is realized as shown in the chart below:

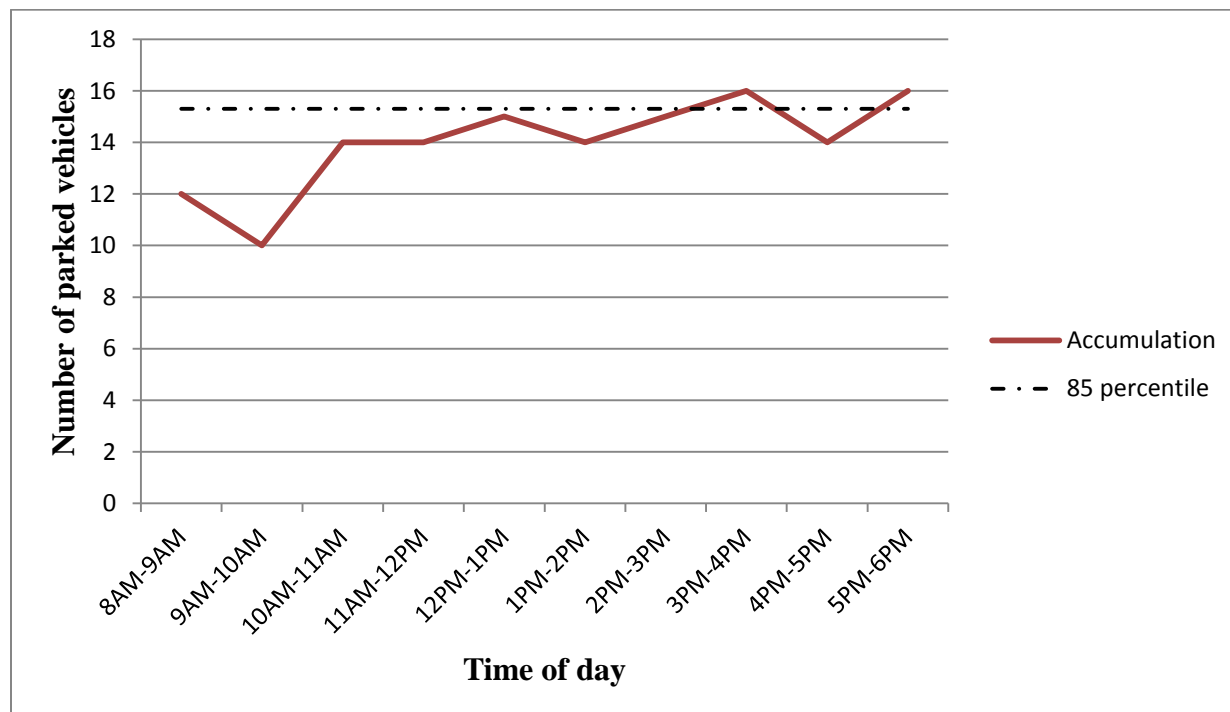


Figure 4.5: Accumulation curve, R-003 at sable restaurant, July 13, 2016.

The maximum demand as shown in the above graph is on the time interval between 3:00pm to 4:00pm and 5pm to 6pm and slightly increase between the lunch times 12pm to 1pm. The reason for this is that as the place is a multi-purpose building where cafes, restaurants, coffee rooms and stationary shops are found, the customers are able to use easily within the above listed hours.

Recognizing the accumulation curve of the off- street parking spaces, are being utilized with in the allowable limit or capacity/the 85 percentile the whole day, except from 3:00 pm to 4:00 pm and 5:00pm to 6:00pm which is the peak flow more than the capacity of the streets.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.10: license plate survey data result, R-003, on Monday July 13, 2016 from 5:00PM-6:00PM

Date :Wednesday July 13/2016 Weather :cloudy					Recording time:3:00PM-4:00PM Location:R-003/seble restaurant				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	A33012	A54879	A23514	A23514	1	1	1	1	3
2	28585	A79457	A79457	A79457	1	1	1	1	2
3	-	73990	73990	73990	0	1	1	1	1
4	67545	67545	-	17678	1	1	0	1	2
5	17676	05309	11658	11658	1	1	1	1	3
6	-	A38224	A38224	05309	0	1	1	1	2
7	A38224	A38224	A38224	A38224	1	1	1	1	1
8	79027	40941	40941	40941	1	1	1	1	2
9	A08106	A08106	28137	79027	1	1	1	1	3
10	69297	69297	69297	62297	1	1	1	1	2
11	32242	32242	A08106	A08106	1	1	1	1	2
12	-	35-462	35-462	-	0	1	1	0	1
13	78815	A34400	A34400	-	1	1	1	0	2
14	-	A56775	-	77854	0	1	0	1	2
15	22321	22321	22321	-	1	1	1	0	1
16	A52954	A52954	-	77844	1	1	0	1	2
17	02955	02955	02955	68615	0	1	1	1	2
18	A20309	-	27079	27079	1	0	1	1	2
19	18531	18531	-	18531	1	1	0	1	1
20	A64451	A64451	A64451	A64451	1	1	1	1	1
Accumulation					15	19	16	17	37
Occupancy					75	95	80	85	

		Unit
Average turn over	1.85	Vehicles/hr.
Parking volume	37	Vehicles
Average duration	27.2	Minute/vehicles
Average occupancy	83.75	%
Parking load	16.75	Vehicles hours
Parking capacity	20	Vehicles hours

Average parking duration of 27.2 minute/vehicles indicates most vehicles are parked for a medium period of time, it shows that almost two to three vehicles are parked within an hour. From the turnover result of 1.85vehicles/hour, it is possible to say that the rate of usage of parking space or the frequency of space availability is also medium.

Occupancy of 83.75% and parking load of 16.75 vehicles hours shows the parking space coverage of the area is considered to be ideal, since the parking space is used effectively.

Parking lot-4: R-004(At Awash bank)

The number of vehicles parked at an hourly interval on July 13/2016 R-003(Awash bank) building is realized as shown in the chart below:

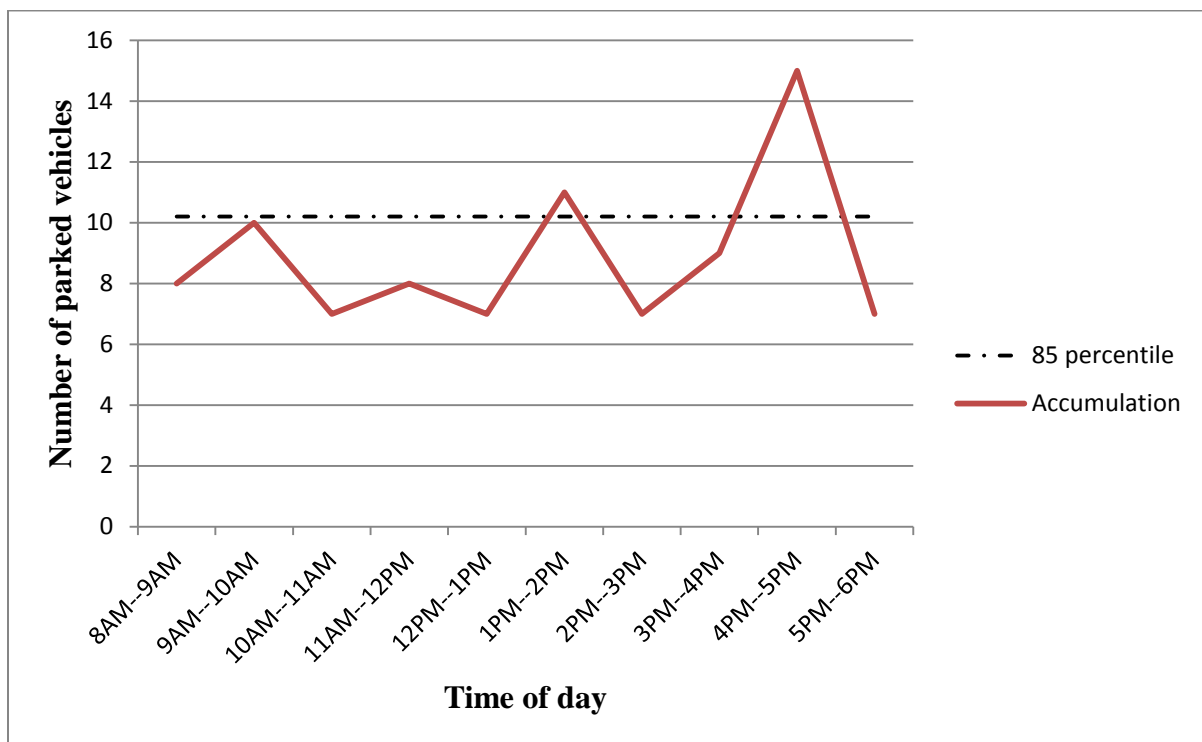


Figure 4.6: Accumulation curve, R-004 at Awash Bank, July 13, 2016.

It shows the maximum demand is on the time interval between 4:00pm to 5:00pm. This indicates that the parking users are trying to use their free time to for banking.

Recognizing the accumulation curve of the off- street parking spaces are being utilized with in the allowable limit or capacity the whole day, except from 1:00 pm to 2:00 pm and 4:00pm to 5:00pm which is the peak flow more than the capacity of the streets.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.11: license plate survey data result, R-004, on Monday July 13, 2016 from 4:00PM-5:00PM

Date: Monday July 13/2016 Weather: Cloudy					Recording time: 4:00PM-5:00PM Location: R-004/Awash Bank				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	4761	8955	4257	6658	1	1	1	1	4
2	6176	9907	9907	4898	1	1	1	1	3
3	1322	2788	2135	2135	1	1	1	1	3
4	8336	4443	672	2935	1	1	1	1	4
5	2935	2935	9384	1728	1	1	1	1	3
6	3721	-	1217	1217	1	0	1	1	2
7	9397	-	3139	3139	1	0	1	1	2
8	4152	4271	5343	9397	1	1	1	1	4
9	-	4152	-	9552	0	1	0	1	2
10	3477	1961	1105	3113	1	1	1	1	4
11	8191	1737	1535	1112	1	1	1	1	4
12	3527	3527	3527	3527	1	1	1	1	1
	Accumulation				11	10	11	12	36
	Occupancy				91.7	83.3	91.7	100	

		Unit
Average turn over	3.0	Vehicles/hr.
Parking volume	36	Vehicles
Average duration	18.3	Minute/vehicles
Average occupancy	91.7	%
Parking load	11	Vehicles hours
Parking capacity	12	Vehicles hours

Average parking duration of 18.3 minute/vehicles indicates most vehicles are parked for short period of time, it shows that almost three vehicles are parked within an hour. From the turnover result of 3.0 Vehicles/hour, it is possible to say that the rate of usage of parking space or the frequency of space availability is good.

Occupancy of 91.7% and parking load of 11 vehicles hours shows the parking space coverage of the area is high and considered to be full, since someone looking for a space will not find an empty one easily and may need to circle as few times before one becomes available.

Parking lot-5: R-005 (At Birhanina selam printing press and Habesha cinema)

The number of vehicles parked at an hourly interval on August 8/2016 R-005(At Birhanina selam printing press and Habesha cinema) is realized as shown in the chart below:

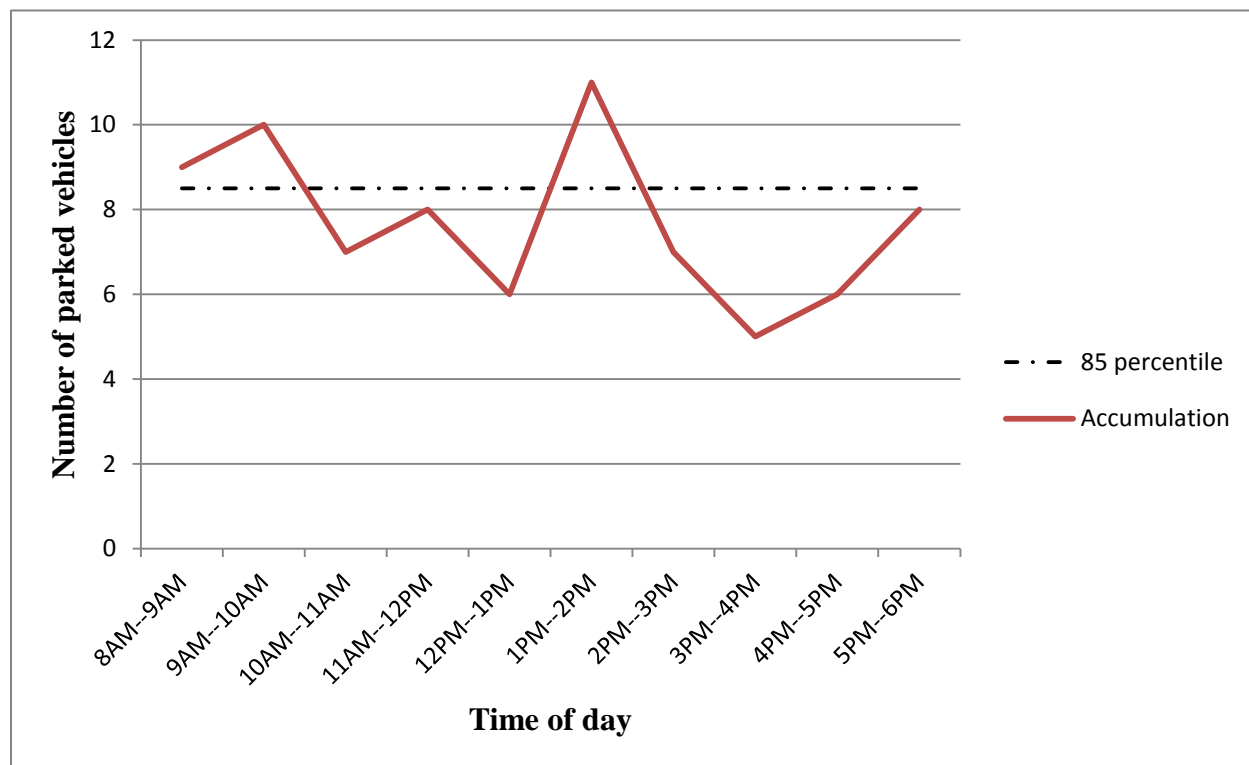


Figure 4.7: Accumulation curve, R-005 at Birhanina selam printing press and Habesha cinema, August 8, 2016.

It shows the maximum demand is on the time interval between 1:00pm to 2:00pm. The reason for this is that since there is a restaurant inside the area, most customers’ park to use the service within the lunch time.

Recognizing the accumulation curve of the off- street parking spaces are being utilized with in the allowable limit or capacity the whole day, except from 3:00 pm to 4:00 pm and 5:00pm to 6:00pm which is the peak flow more than the capacity of the streets.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.12: license plate survey data result, R-004, on Monday August 8, 2016 from 1:00PM-2:00PM

Date: Monday August 8/2016 Weather: Cloudy					Recording time: 1:00PM-2:00PM Location: R-005/Birhanina selam printing				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	22178	-	20702	A49334	1	0	1	1	3
2	81379	81379	81379	20306	1	1	1	1	2
3	-	-	86425	81379	0	0	1	1	2
4	06024	06024	01337	06024	1	1	1	1	2
5	A64897	A64897	A64897	A64897	1	1	1	1	1
6	27058	27058	06024	A00151	1	1	1	1	3
7	27535	-	00151	18531	1	0	1	1	3
8	18531	18531	18531	07640	1	1	1	1	2
9	28434	-	-	76330	1	0	0	1	2
10	07640	07640	07640	28434	1	1	1	1	2
Accumulation					9	6	9	10	22
Occupancy					90	60	90	100	

		Unit
Average turn over	2.2	Vehicles/hr.
Parking volume	22	Vehicles
Average duration	23.2	Minute/vehicles
Average occupancy	85	%
Parking load	8.5	Vehicles hours
Parking capacity	10	Vehicles hours

From the result average parking duration of 23.2 minute/vehicles indicates the vehicles are parked for medium period of time, it shows that almost two vehicles are parked within an hour. From the turnover result of 2.2 Vehicles/hour, it is possible to say that the rate of usage of parking space or the frequency of space availability is good.

Occupancies of 85% and parking load of 8.5 vehicles hours shows the parking space coverage of the area is high and considered to be full, since someone looking for a space will not find an empty one easily and may need to circle as few times before one becomes available.

Parking lot-6: R-006 (At Kaldis coffee)

The number of vehicles parked at an hourly interval on August 8/2016 R-006/ kaldis coffee is realized as shown in the chart below:

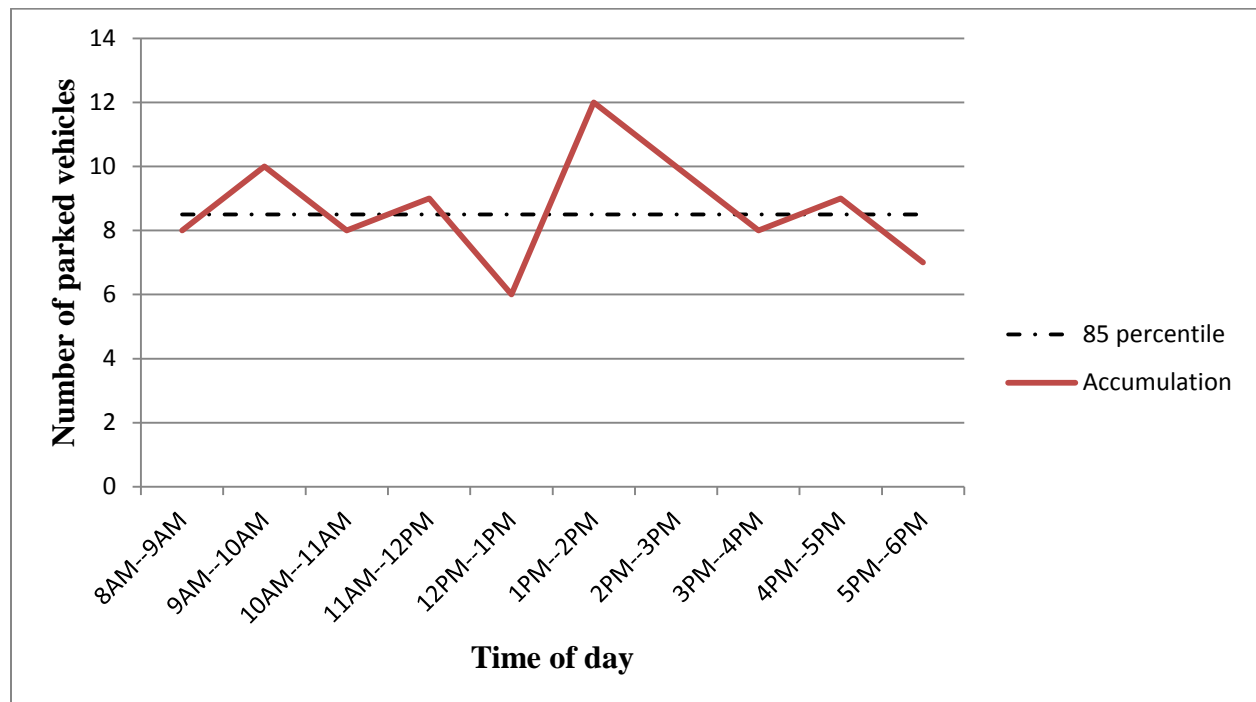


Figure 4.8: Accumulation curve, R-006 at Kaldis coffee, August 8, 2016.

The maximum demand is on the time interval between 1:00pm to 2:00pm during the lunch time.

Recognizing the accumulation curve of the off- street parking spaces are being utilized with in the allowable limit or capacity from 8:00am to 9:00am, 10:00am to 11:00am,12:00pm to 1:00pm,3:00pm to 4:00pm and 5:00pm to 6:00pm and out of the allowable limit or capacity from 9:00am to 10:00am,11:00am to 12:00pm,1:00pm to 2:00pm and 4:00pm to 5:00pm which is the peak flow more than the capacity of the streets.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.13: license plate survey data result, R-006, on Monday August 8, 2016 from 1:00PM-2:00PM

Date: Monday August 8/2016 Weather: sunny					Recording time:1:00pm-2:00pm Location: R-006/kaldis coffee				
	Time(min)				Time(min)				Turn over
Bay No.	0-15	15-30	30-45	45-60	15	30	45	60	
1	47147	47147	47147	-	1	1	1	0	1
2	72343	72343	A61424	A61424	1	1	1	1	2
3	A05430	A05430	A05430	A05430	1	1	1	1	1
4	A58038	-	A58038	A58038	1	0	1	1	1
5	A20819	A20819	A20819	A20819	1	1	1	1	1
6	A5542	A5542	A5542	A5542	1	1	1	1	1
7	-	53949	53949	53949	0	1	1	1	1
8	A61090	A61090	86571	86571	1	1	1	1	2
9	A2399	A2399	A2399	A2399	1	1	1	1	1
10	A27499	A27499	A27499	A27499	1	1	1	1	1
	Accumulation				9	9	10	9	12
	Occupancy				90	90	100	90	

		Unit
Average turn over	1.2	Vehicles/hr.
Parking volume	12	Vehicles
Average duration	46.25	Minute/vehicles
Average occupancy	92.5	%
Parking load	9.25	Vehicles hours
Parking capacity	10	Vehicles hours

From the result average parking duration of 46.25 minute/vehicles indicates most vehicles are parked for long period of time, it shows that almost one vehicle is parked within an hour. From the turnover result of 1.2 vehicles/hour, it is possible to say that the rate of usage of parking space or the frequency of space availability is low.

Occupancy of 92.5% and parking load of 9.25 vehicles hours shows the parking space coverage of the area is high and considered to be full, since someone looking for a space will not find an empty one easily and may need to circle as few times before one becomes available.

Parking lot-7 R-007 (At Buna international bank /Diber bldg.)

The number of vehicles parked at an hourly interval on July 15/2016 R-007/Diber building is realized as shown in the chart below:

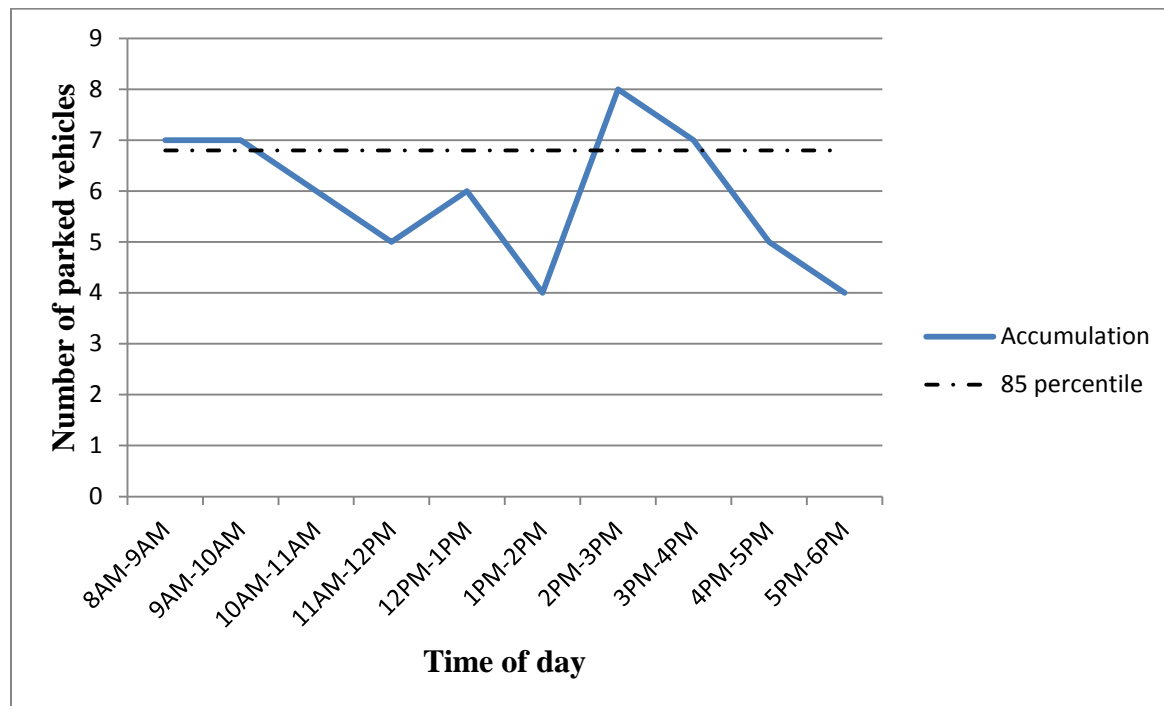


Figure 4.9: Accumulation curve, R-007 at Diber bldg., July 15, 2016.

The maximum demand is on the time interval between 2:00pm to 3:00pm.

Recognizing the accumulation curve of the off- street parking spaces are being utilized with in the allowable limit or capacity the whole day except from 8:00am to9:00am, 9:00am to10:00am and 2:00pm to 3:00pm which is the peak flow more than the capacity of the streets.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.14: license plate survey data result, R-007, on Friday July 15, 2016 from 2:00PM-3:00PM

Date: Friday July15/2016 Weather: cloudy					Recording time:2:00PM-3:00PM Location:R-007/ Denver bldg.				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	65472	09483	A30319	A30319	1	1	1	1	3
2	95594	95594	95594	95594	1	1	1	1	1
3	37765	37501	A34625	A34625	1	1	1	1	3
4	A19610	30009	30009	30009	1	1	1	1	2
5	71930	A61424	A61424	A61424	1	1	1	1	2
6	29535	29535	A61006	A61006	1	1	1	1	2
7	-	-	-	-	0	0	0	0	0
8	04223	04223	-	96294	1	1	0	1	2
Accumulation					7	7	6	7	
Occupancy					87.5	87.5	75	87.5	

		Unit
Average turn over	1.88	Vehicles/hr.
Parking volume	15	Vehicles
Average duration	27	Minute/vehicles
Average occupancy	84.38	%
Parking load	6.75	Vehicles hours
Parking capacity	8	Vehicles hours

From the result average parking duration of 27 minute/vehicles indicates most vehicles are parked for long period of time, it shows that almost two vehicles are parked within an hour. From the turnover result of 1.88vehicles/hour, it is possible to say that the rate of usage of parking space or the frequency of space availability is low.

Occupancy of 84.38% and parking load of 6.75 vehicles hours shows the parking space coverage of the area is considered to be ideal, , since the parking space is used effectively.

Parking lot-8: R-008(At Denver cafe)

The number of vehicles parked at an hourly interval on August 8/2016 R-008(at Denver café) is realized as shown in the chart below:

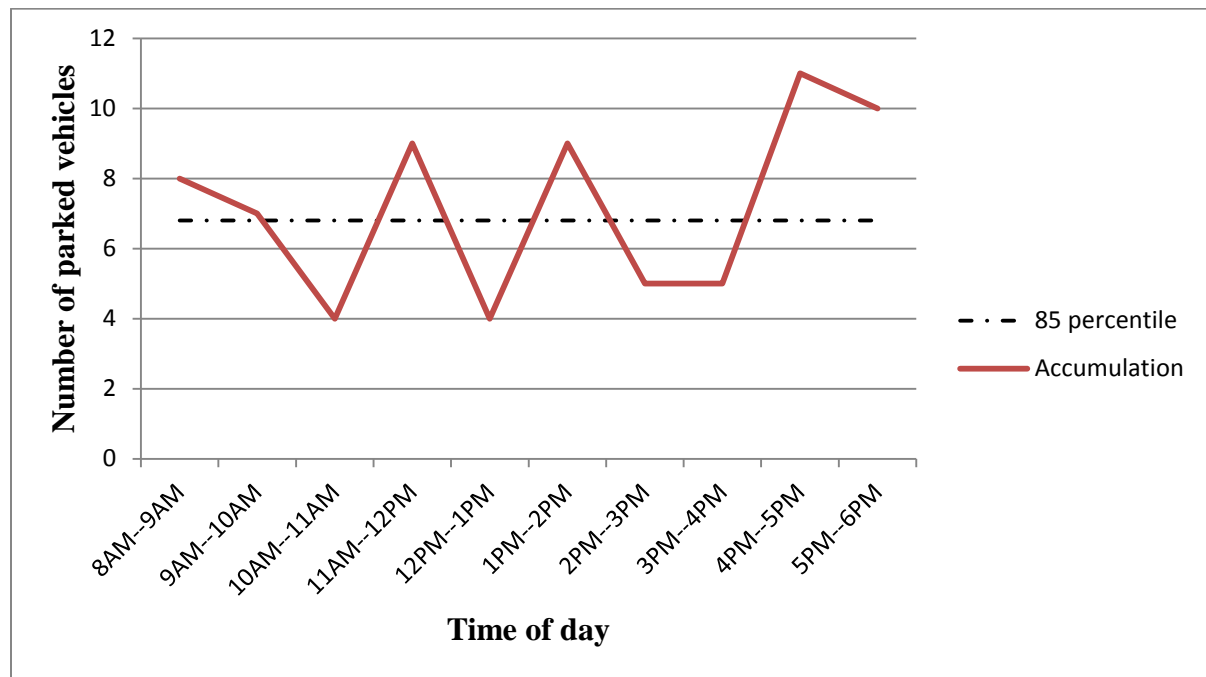


Figure 4.10: Accumulation curve, R-008 at Denver cafe, August 8, 2016.

It shows the maximum demand is on the time interval between 4:00pm to 5:00pm. As the place is a multi-purpose area the peak period is observed at varies time of the day.

Recognizing the accumulation curve of the off- street parking spaces are being utilized with in the allowable limit or capacity from 10:00am to 11:00am, 12:00pm to 1:00pm, 2:00pm to 3:00pm and 3:00pm to 4:00pm and out of the allowable limit or capacity from 8:00am to 9:00am, 11:00am to 12:00pm, 1:00pm to 2:00pm, 4:00pm to 5:00pm and 5:00pm to 6:00pm which is the peak flow more than the capacity of the streets.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.15: license plate survey data result, R-008, on Monday August 8, 2016 from 4:00PM-5:00PM

Date: Monday August 8/2016 Weather: sunny					Recording time:4:00pm-5:00pm Location: R-008/Denver bldg.				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	-	-	4563	4563	0	0	1	1	1
2	2114	6346	6346	-	1	1	1	0	2
3	3721	3721	-	1217	1	1	0	1	2
4	9397	9397	9397	9397	1	1	1	1	1
5	5343	3785	3785	0176	1	1	1	1	3
6	5190	5190	9386	9386	1	1	1	1	2
7	4152	9552	5721	5721	1	1	1	1	3
8	6911	6911	1094	1094	1	1	1	1	2
	Accumulation				7	7	7	7	16
	Occupancy				87.5	87.5	87.5	87.5	

		Unit
Average turn over	2	Vehicles/hr.
Parking volume	16	Vehicles
Average duration	26.25	Minute/vehicles
Average occupancy	87.5	%
Parking load	7	Vehicles hours
Parking capacity	8	Vehicles hours

From the result average parking duration of 26.25 minute/vehicles indicates most vehicles are parked for a medium period of time, it shows that almost two vehicles are parked within an hour. From the turnover result of 2 vehicles/hr., it is possible to say that the rate of usage of parking space is fair or the frequency of space availability is somewhat easy.

Occupancy of 87.5% and parking load of 7 vehicles hours shows the parking space coverage of the area is high and considered to be full, since someone looking for a space will not find an empty one easily and may need to circle as few times before one becomes available.

Parking lot-9: R-009 (At Book light)

The number of vehicles parked at an hourly interval on August 8/2016 R-009(at book light) is realized as shown in the chart below:

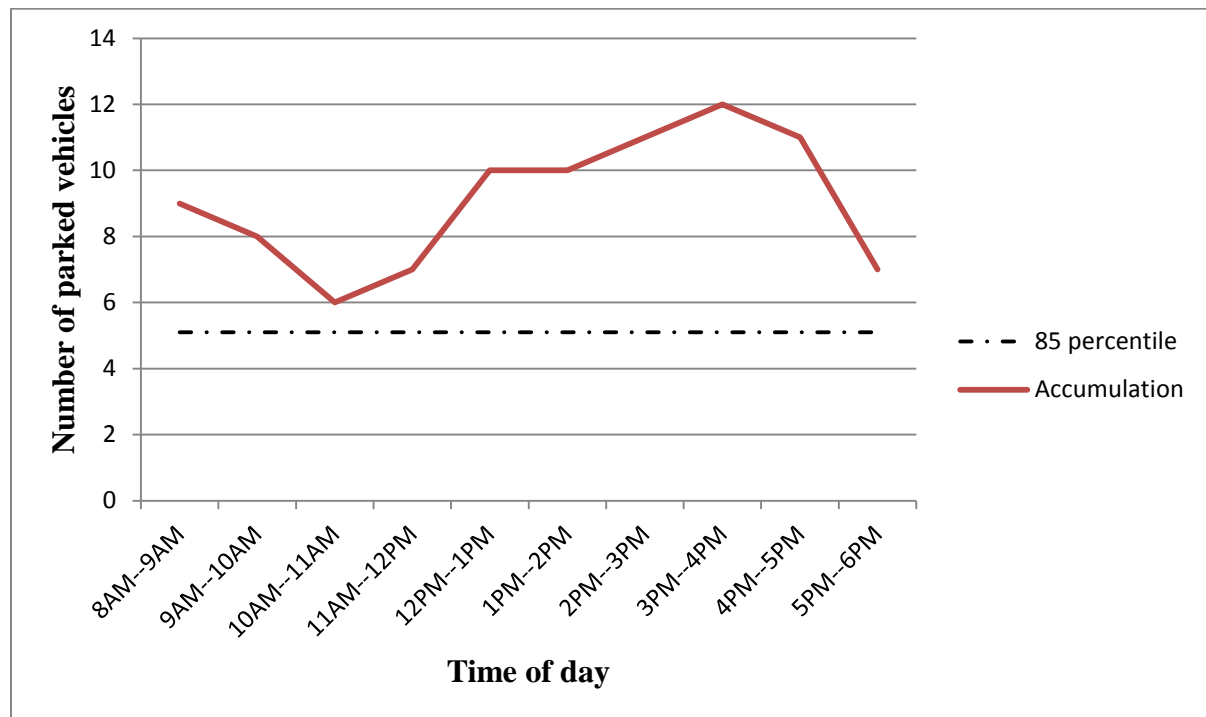


Figure 4.11: Accumulation curve, R-009 at book light, August 8, 2016.

It shows the maximum demand is on the time interval between 3:00pm to 4:00pm.

Recognizing the accumulation curve of the off- street parking spaces are being utilized out of the allowable limit or capacity the whole day. It indicates the place needs

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.16: license plate survey data result, R-009, on Monday August 8, 2016 from 3:00PM-4:00PM

Date: Monday August 8/2016 Weather: sunny					Recording time:3:00pm-4:00pm Location:R-009/Book light				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	A18049	A18049	3982	3437	1	1	1	1	3
2	A25603	A25603	-	2550	1	1	0	1	2
3	A80129	-	7964	6770	1	0	1	1	3
4	A74230	A74230	6667	1845	1	1	1	1	3
5	A20126	0736	3436	2237	1	1	1	1	4
6	A04364	8956	7627	3327	1	1	1	1	4
7	49655	49655	6850	6155	1	1	1	1	3
8	38410	-	9904	7589	1	0	1	1	3
	Accumulation				8	6	7	8	25
	Occupancy				100	75	87.5	100	

		Unit
Average turn over	3.13	Vehicles/hr.
Parking volume	25	Vehicles
Average duration	17.4	Minute/vehicles
Average occupancy	90.63	%
Parking load	7.25	Vehicles hours
Parking capacity	8	Vehicles hours

From the result average parking duration of 17.4 minute/vehicles indicates most vehicles are parked for a medium period of time, it shows that almost four vehicles are parked within an hour. From the turnover result of 3.13vehicles/hr., it is possible to say that the rate of usage of parking space is good or the frequency of space availability is high.

Occupancy of 90.63% and parking load of 7.25 vehicles hours shows the parking space coverage of the area is high and considered to be full, since someone looking for a space will not find an empty one easily and may need to circle as few times before one becomes available.

Parking lot-10: R-010 (At Gera furniture)

The number of vehicles parked illegally at an hourly interval on August 8/2016 R-010(at Gera furniture) is realized as shown in the chart below:

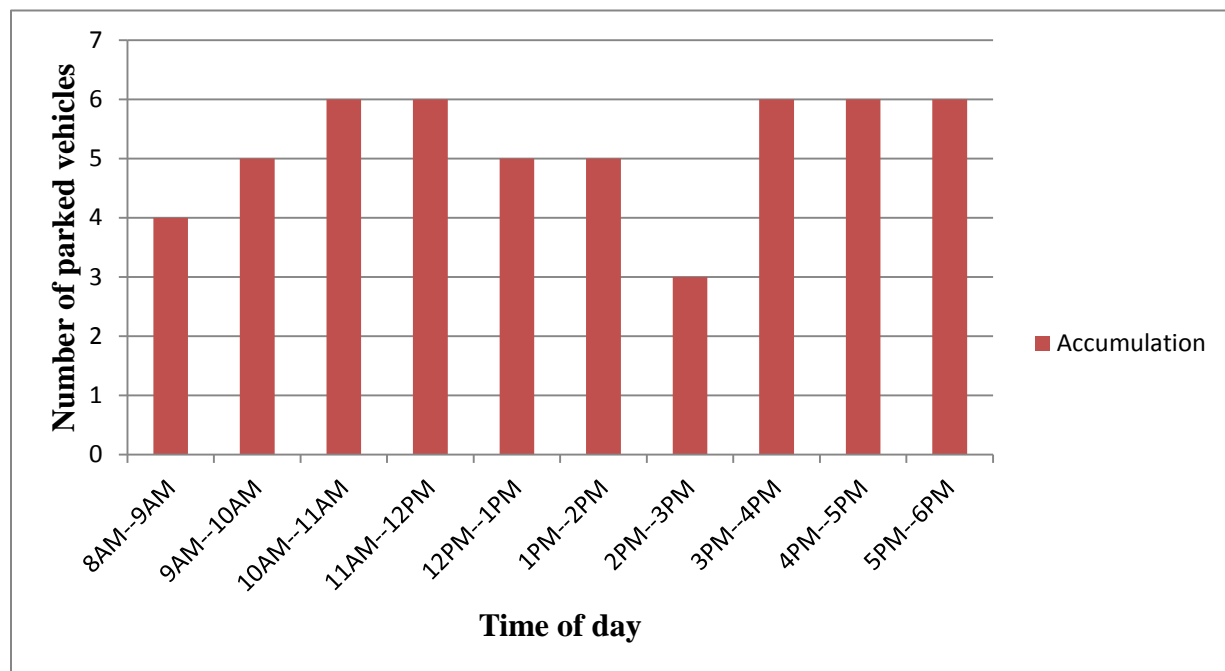


Figure 4.12: Illegally parked vehicles, R-010 at Gera furniture, August 8, 2016.

The area has no any parking facility but as it shows on the graph a maximum of 6 Vehicles Park at most of the time interval illegally by using internal facility road.

Parking lot-11: R-011/Yegna guada bar and restaurant

The number of vehicles parked at an hourly interval on August 11/2016 R-011(at Yegna guada bar and restaurant) is realized as shown in the chart below:

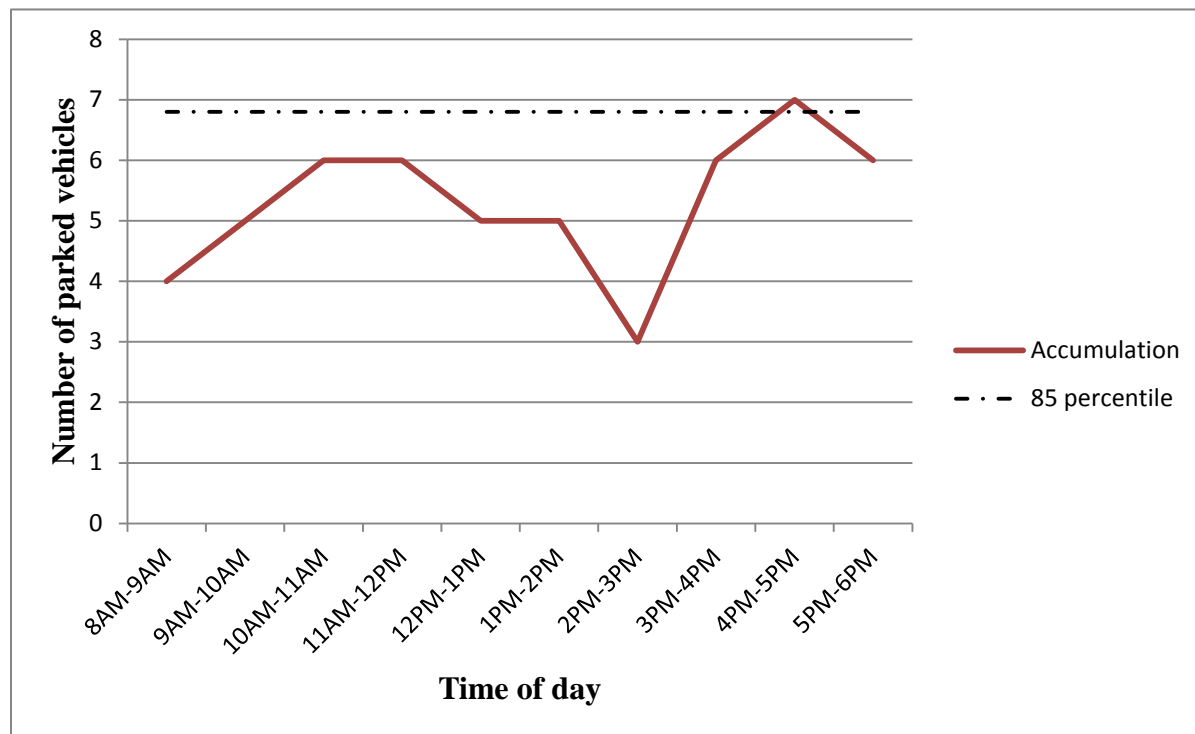


Figure 4.13: Accumulation curve, R-011 at Yegna guada bar and restaurant, August 11, 2016.

The maximum demand is on the time interval between 4:00pm to 5:00pm.

Recognizing the accumulation curve, the off- street parking spaces are being utilized within the allowable limit or capacity the whole day except from 4:00pm-5:00pm.

Remark: The vehicles park illegally on the edge of the road and the pedestrian walk way due to insufficient road width as shown below:



Figure 4.14: Illegal parking on the edge of the road and pedestrian walk way due to narrow road width, R-011 at Yegna guada bar and restaurant

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.17: license plate survey data result, R-011, on Thursday August 11, 2016 from 4:00PM-5:00PM

Date: Thursday August 11/2016					Recording time:4:00PM-5:00PM				
Weather: sunny					Location:R-011/near yegna guada				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	68042	68042	68042	68042	1	1	1	1	1
2	86571	86571	86571	86571	1	1	1	1	1
3	25363	25363	25363	25363	1	1	1	1	1
4	35995	35995	35995	35995	1	1	1	1	1
5	A50950	A50950	A50950	A50950	1	1	1	1	1
6	82518	82518	82518	82518	1	1	1	1	1
7	-	-	-	-	0	0	0	0	0
8	A01403	A01403	A01403	A01403	1	1	1	1	1
	Accumulation				7	7	7	7	
	Occupancy				87.5	87.5	87.5	87.5	
									Unit
Average turn over						0.88	Vehicles/hr.		
Parking volume						7	Vehicles		
Average duration						52.5	Minute/vehicles		
Average occupancy						87.5	%		
Parking load						7	Vehicles hours		
Parking capacity						8	Vehicles hours		

From the result average parking duration of 52.5 minute/vehicles indicates most vehicles are parked for a longer period of time, it shows that almost one vehicle is parked within an hour. From the turnover result of 0.88 vehicles/hr., it is possible to say that the rate of usage of parking space is low or the frequency of space availability is low.

Occupancy of 87.5% and parking load of 7 vehicles hours shows the parking space coverage of the area is high and considered to be full.

Parking lot-12: R-012 (Sheger pastry)

The number of vehicles parked at an hourly interval on August 8/2016 R-012/sheger pastry is realized as shown in the chart below:

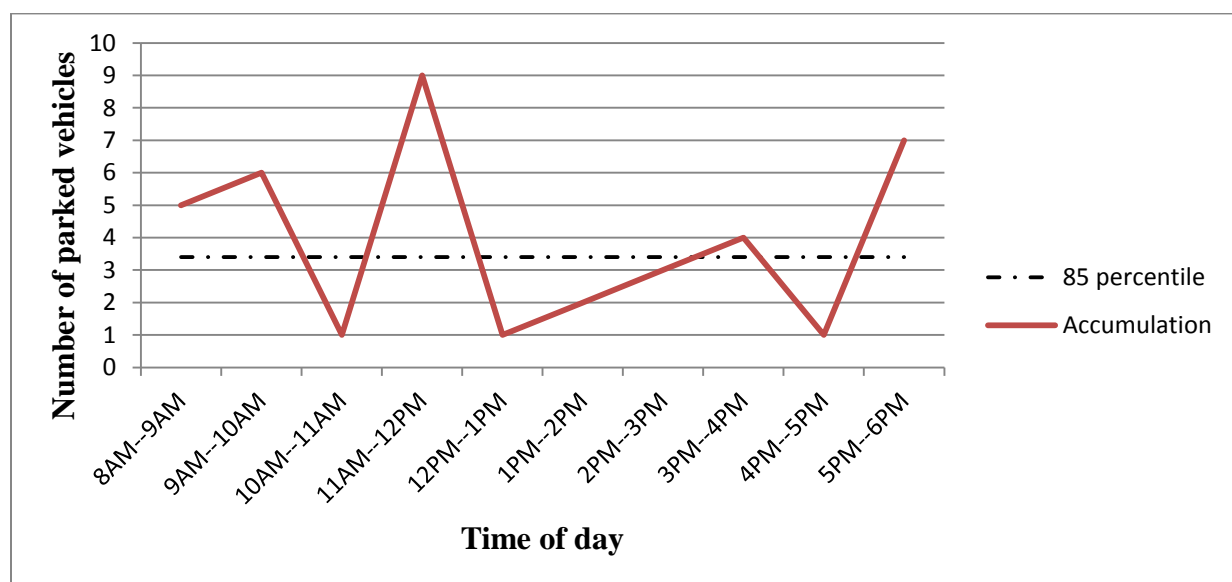


Figure 4.15: Accumulation curve, R-012 at Sheger pastry, August 8, 2016.

The maximum demand is on the time interval between 11:00am to 12:00pm.

Recognizing the accumulation curve of the off- street parking spaces are being utilized with in the allowable limit or capacity from 10:00am to 11:00am, 12:00pm to 1:00pm and 4:00pm to 5:00pm and out of the allowable limit or capacity from 8:00am to 9:00am, 9:00am to 10:00am, 11:00am to 12:00pm, 3:00pm to 4:00pm and 5:00pm to 6:00pm which is the peak flow more than the capacity of the streets.

Remark: The vehicles park illegally on the edge of the road and the pedestrian walk way due to insufficient road width.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.18: license plate survey data result, R-012, on Thursday August 8, 2016 from 1:00PM-2:00PM

Date: Monday August 8/2016					Recording time:11:00am-12:00pm				
Weather: sunny					Location:R-012/sheger pastry				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	4761	-	2186	-	1	0	1	0	2
2	8955	8955	1048	1048	1	1	1	1	2
3	4211	4211	-	9861	1	1	0	1	2
4	3437	-	-	-	1	0	0	0	1
5	8214	-	1737	-	1	0	1	0	2
6	-	-	-	1535	0	0	0	1	1
7	-	5470	1431	1431	0	1	1	1	2
8	6171	-	-	9154	1	0	0	1	2
	Accumulation				6	3	4	5	14
	Occupancy				75	37.5	50	62.5	

		Unit
Average turn over	1.75	Vehicles/hr.
Parking volume	14	Vehicles
Average duration	19.3	Minute/vehicles
Average occupancy	56.3	%
Parking load	4.5	Vehicles hours
Parking capacity	8	Vehicles hours

From the result average parking duration of 19.3 minute/vehicles indicates most vehicles are parked for a short period of time, it shows that almost three vehicles are parked within an hour. From the turnover result of 1.75 vehicles/hr., it is possible to say that the rate of usage of parking space is fair or the frequency of space availability is medium.

Occupancy of 56.3 % and parking load of 4.5 vehicles hours shows the parking space coverage of the area is low.

Parking lot-13 R-013 (Licha zone)

The number of vehicles parked at an hourly interval on August 11/2016 R-013/Licha zone is realized as shown in the chart below:

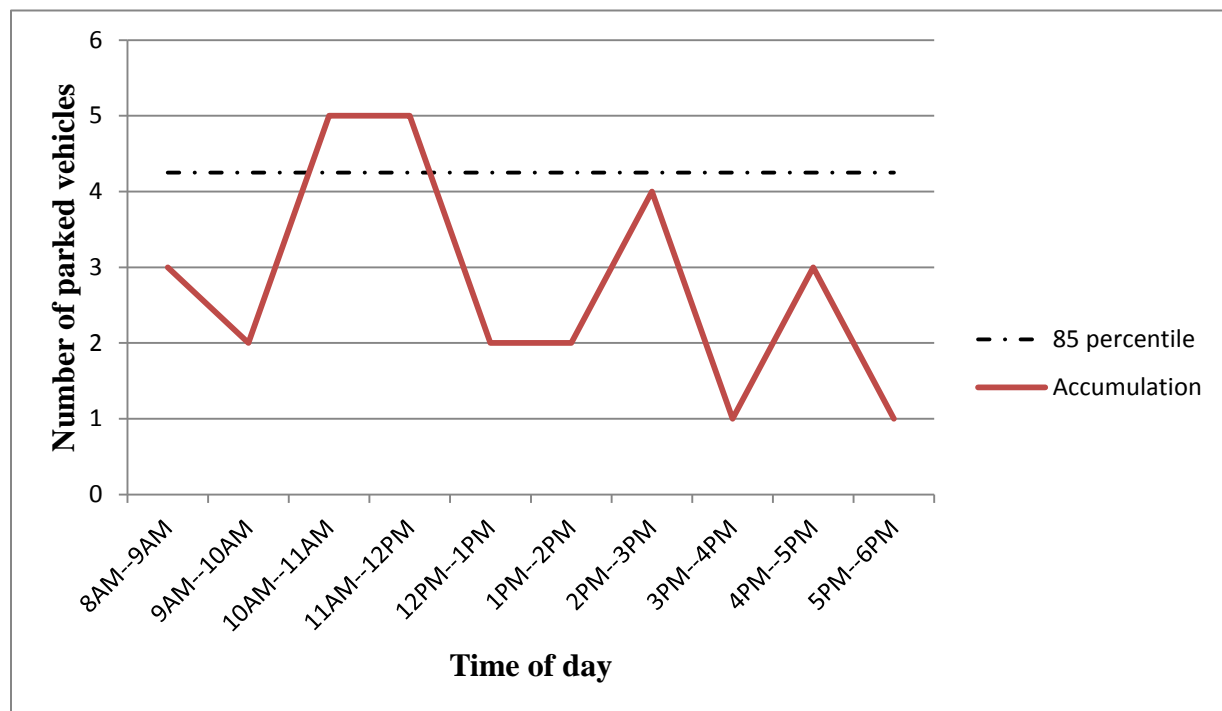


Figure 4.16: Accumulation curve, R-013 at Licha zone, August 11, 2016.

It shows the maximum demand is on the time interval between 10:00am to 11:00am and 11:00am to 12pm.

Recognizing the accumulation curve of the off- street parking spaces are being utilized with in the allowable limit or capacity except from 10:00am to 11:00am and 11:00am to 12:00pm which is the peak flow more than the capacity of the streets.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.19: license plate survey data result, R-013, on Thursday August 11, 2016 from 10:00AM-11:00AM

Date: Thursday August 11/2016					Recording time:10:00am-11:00am				
Weather: sunny					Location:R-013/licha zone				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	6658	6658	7970	4643	1	1	1	1	3
2	5721	-	5721	5721	1	0	1	1	1
3	-	3531	3531	5208	0	1	1	1	2
4	8514	8514	8514	8514	1	1	1	1	1
5	1393	1393	1393	1393	1	1	1	1	4
	Accumulation				4	4	5	5	11
	Occupancy				80	80	100	100	

		Unit
Average turn over	2.2	Vehicles/hr.
Parking volume	11	Vehicles
Average duration	24.5	Minute/vehicles
Average occupancy	90	%
Parking load	4.5	Vehicles hours
Parking capacity	5	Vehicles hours

From the result average parking duration of 24.5 minute/vehicles indicates most vehicles are parked for a medium period of time, it shows that almost two vehicles are parked within an hour. From the turnover result of 2.2 vehicles/hr., it is possible to say that the rate of usage of parking space is good or the frequency of space availability is high.

Occupancy of 90 % and parking load of 4.5 vehicles hours shows the parking space coverage of the area is high and considered to be full. Since someone looking for a space will not find an empty one easily and may need to circle as few times before one becomes available.

Parking lot-14 R-014 (Ethiopian household and office furniture)

The number of vehicles parked at an hourly interval on August 8/2016 R-013(Ethiopian household and office furniture) is realized as shown in the chart below:

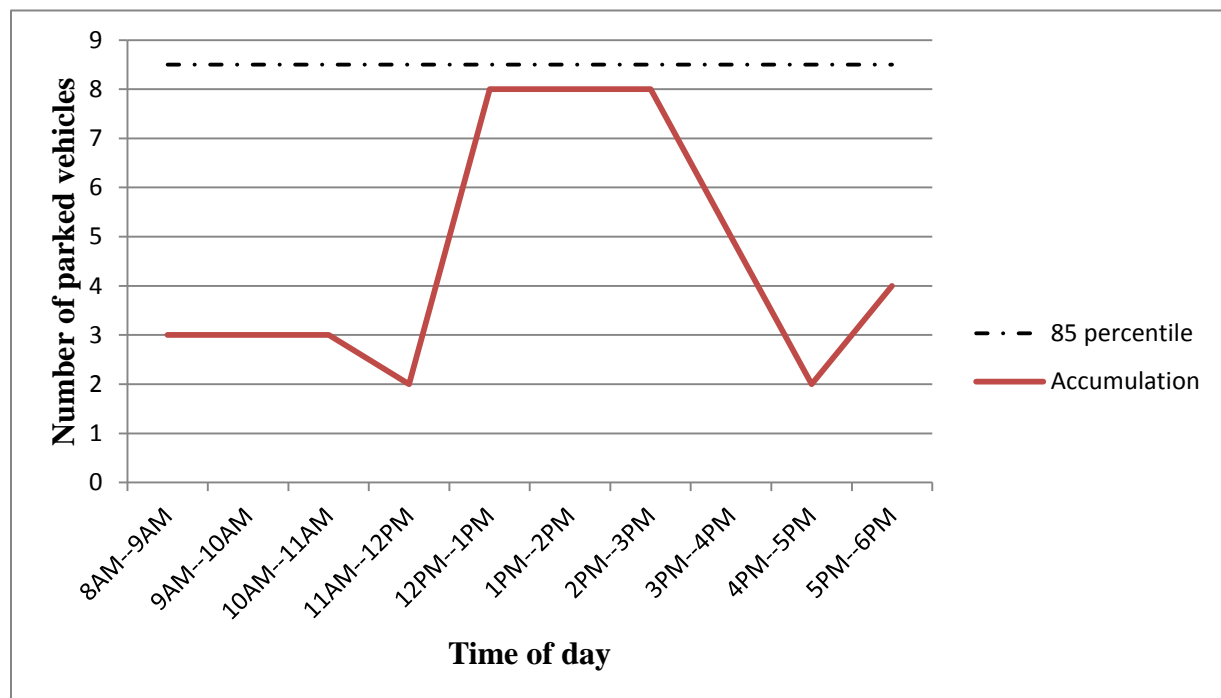


Figure 4.17: Accumulation curve, R-014 at Ethiopian household and office furniture, August 8, 2016.

It shows the maximum demand is on the time interval between 12:00pm to 1:00pm and 1:00pm to 2:00pm and 2:00pm-3:00pm.

Recognizing the accumulation curve of the off- street parking spaces are being utilized with in the allowable limit or capacity the whole day.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.20: license plate survey data result, R-009, on Thursday August 11, 2016 from 1:00PM-2:00PM

Date: Monday August 8/2016 Weather: sunny					Recording time:1:00pm-2:00pm Location:R-013/licha zone				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	4950	-	2551	6850	1	0	1	1	3
2	6850	9768	-	-	1	1	0	0	2
3	3428	3428	3428	-	1	1	1	0	1
4	-	3113	3113	9177	0	1	1	1	2
5	6419	6419	6419	6419	1	1	1	1	1
6	5109	5109	5109	5109	1	1	1	1	1
7	4522	-	-	9907	1	0	0	1	2
8	1393	1393	1682	1682	1	1	1	1	2
9	5527	-	8514	3421	1	0	1	1	3
10	1322	1322	1322	1322	1	1	1	1	1
	Accumulation				9	7	8	8	18
	Occupancy				90	70	80	80	

		Unit
Average turn over	1.8	Vehicles/hr.
Parking volume	18	Vehicles
Average duration	26.7	Minute/vehicles
Average occupancy	80	%
Parking load	8	Vehicles hours
Parking capacity	10	Vehicles hours

From the result average parking duration of 26.7 minute/vehicles indicates most vehicles are parked for a medium period of time, it shows that almost two vehicles are parked within an hour. From the turnover result of 1.8 vehicles/hr., it is possible to say that the rate of usage of parking space is fair or the frequency of space availability is moderate.

Occupancy of 80 and parking load of 8 vehicles hours shows the parking space coverage of the area is considered to be ideal and the parking space is used effectively.

Parking lot-15 R-015 (From Sofonias pastry-cinema Empire)

The number of vehicles parked at an hourly interval on August 8/2016 R-015(from sofonias pastry-cinema Empire) is realized as shown in the chart below:

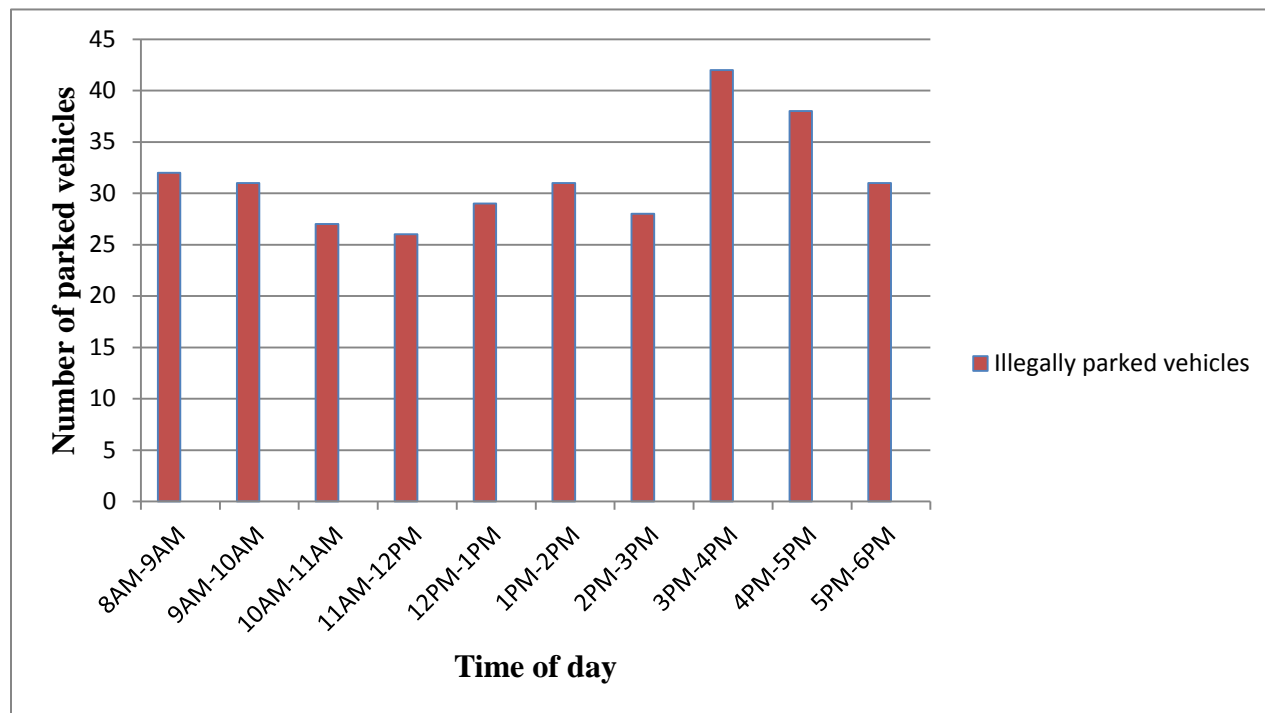


Figure 4.18: Illegally parked vehicles, R-015 from sofonias pastry to Cinema Empire, August 8, 2016.

It shows the maximum demand is on the time interval between 9:00pm to 10:00pm and somewhat less between 10:00pm to 11:00pm.

Remark: The road side is restricted for parking due to the narrow road width but an average of 35 vehicles parks daily.

4.3.2 At the left side of the road

Parking lot-1 L-001/CBE (Arat Kilo branch)

The number of vehicles parked at an hourly interval on August 8/2016 L-001(CBE/Arat kilo branch) is realized as shown in the chart below:

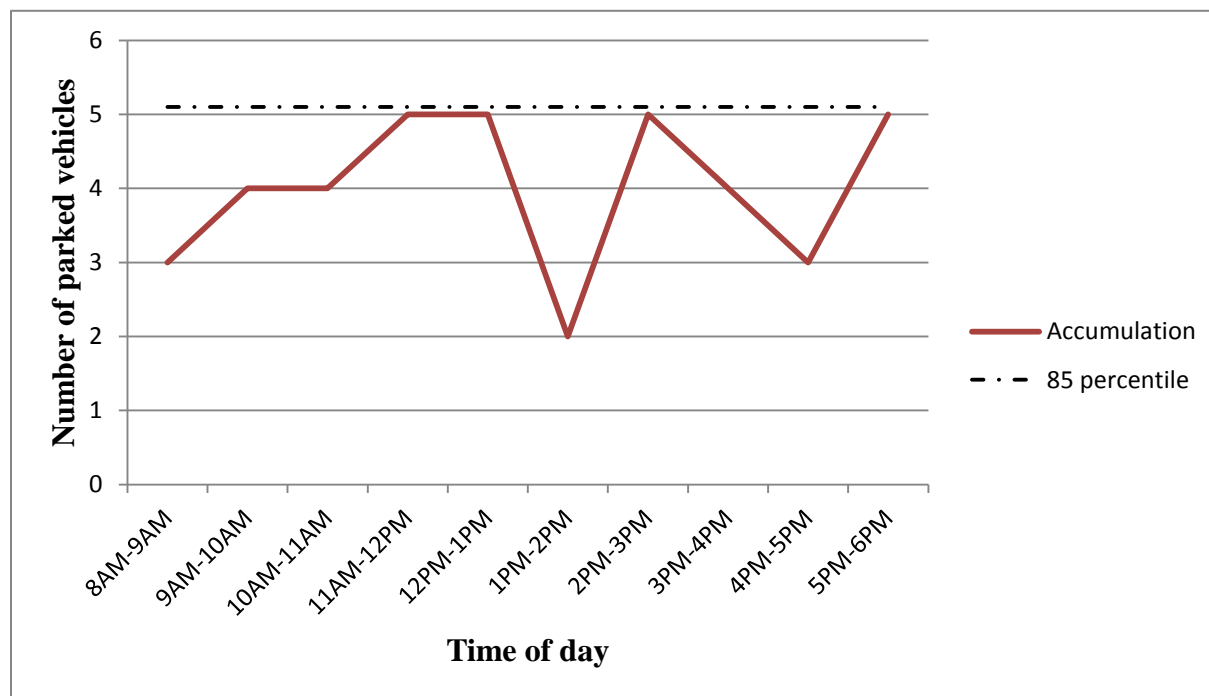


Figure 4.19: Accumulation curve, L-001 at Arat Kilo branch, August 8, 2016.

It shows the maximum demand is on the time interval between 11:00am to 12:00pm, 12:00pm to 1:00pm, 2:00pm to 3:00pm and 5:00pm-6:00pm.

Recognizing the accumulation curve of the off- street parking spaces are being utilized with in the allowable limit or capacity the whole day.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.21: license plate survey data result, L-001, on Monday August 8, 2016 from 11:00AM-12:00PM

Date: Monday August 8/2016 Weather: sunny					Recording time: 11:00am-12:00pm Location: L-001/CBE(Arat-kilo branch)				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	A58697	A58697	-	2551	1	1	0	1	2
2	A33506	9316	9316	4950	1	1	1	1	3
3	03806	03806	2103	7627	1	1	1	1	3
4	12314	6389	4774	3376	1	1	1	1	4
5	02603	8418	8728	9575	1	1	1	1	4
6	34071	3421	8514	9184	1	1	1	1	4
Accumulation					6	6	5	6	20
Occupancy					100	100	83.3	100	

		Unit
Average turn over	3.33	Vehicles/hr.
Parking volume	20	Vehicles
Average duration	17.25	Minute/vehicles
Average occupancy	95.83	%
Parking load	5.75	Vehicles hours
Parking capacity	6	Vehicles hours

From the result average parking duration of 17.25 minute/vehicles indicates most vehicles are parked for short period of time,; it shows that almost three vehicle is parked within an hour. From the turnover result of 3.33vehicles/hour, it is possible to say that the rate of usage of parking space is good or the frequency of space availability is high.

Occupancy of 95.83% and parking load of 5.75 vehicles hours shows the parking space coverage of the area is high and considered to be full.

Parking lot-2 L-002 Tourist hotel

The number of vehicles parked at an hourly interval on August 11/2016 L-002(Tourist hotel) is realized as shown in the chart below:

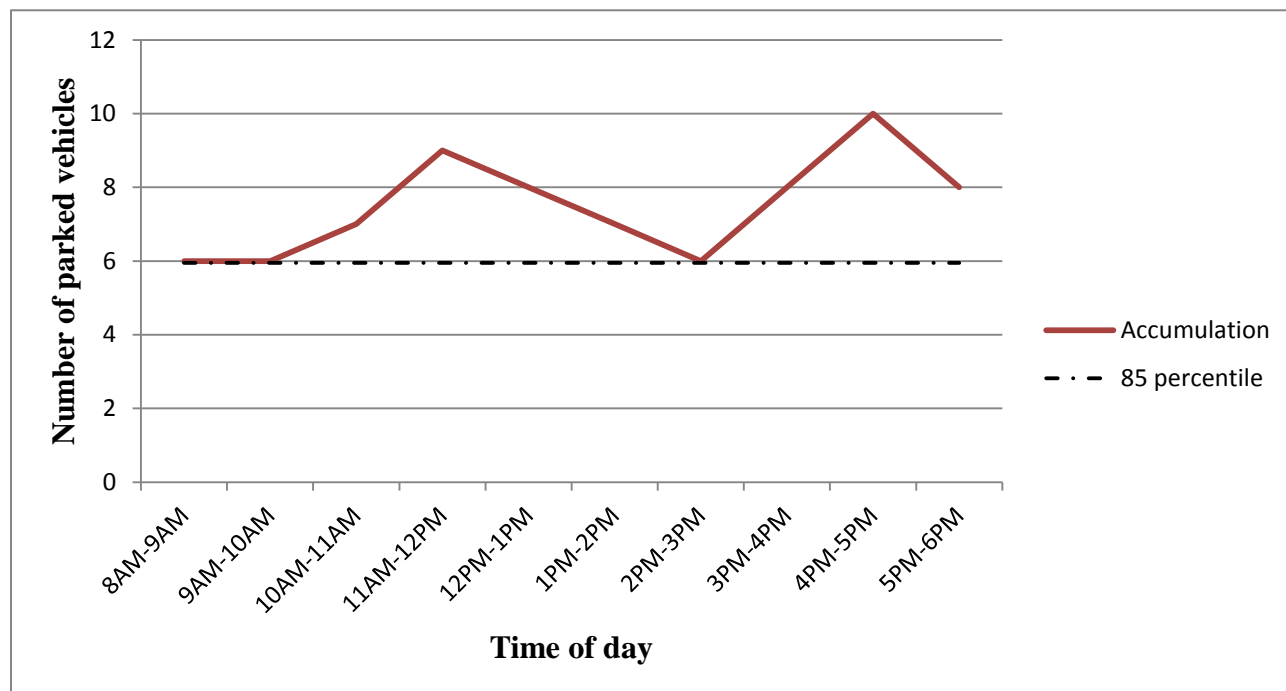


Figure 4.20: Accumulation curve, L-002 at Tourist Hotel, August 11, 2016.

It shows the maximum demand is on the time interval between 4:00pm to 5:00pm.

Recognizing the accumulation curve of the off- street parking spaces are being utilized out of the allowable limit or capacity the whole day.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.22: license plate survey data result, L-002, on Thursday August 11, 2016 from 4:00PM-5:00PM

Date: Thursday August 11/2016					Recording time:4:00pm-5:00pm				
Weather: sunny					Location:L-002/Tourist hotel				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	2970	2970	2970	2970	1	1	1	1	1
2	66606	66606	66606	66606	1	1	1	1	1
3	52307	52307	52307	52307	1	1	1	1	1
4	81122	81122	81122	81122	1	1	1	1	1
5	16076	16076	16076	16076	1	1	1	1	1
6	26681	26681	26681	26681	1	1	1	1	1
7	72395	72395	72395	72395	1	1	1	1	1
Accumulation					7	7	7	7	
Occupancy					100	100	100	100	

		Unit
Average turn over	1.0	Vehicles/hr.
Parking volume	7	Vehicles
Average duration	60	Minute/vehicles
Average occupancy	100	%
Parking load	7	Vehicles hours
Parking capacity	7	Vehicles hours

From the result average parking duration of 60 minute/vehicles indicates most vehicles are parked for long period of time, it shows that one vehicle is parked within an hour. From the turnover result of 1.0 vehicles/hour, it is possible to say that the rate of usage of parking space is poor or the frequency of space availability is low.

Occupancy of 100 % and parking load of 7 vehicles hours shows the parking space coverage of the area is high or all the parking space is full and the parking lot needs no more vehicles.

Parking lot-3 L-003 under construction building

The number of vehicles parked at an hourly interval on August 8/2016 L-003(under construction bldg.) is realized as shown in the chart below:

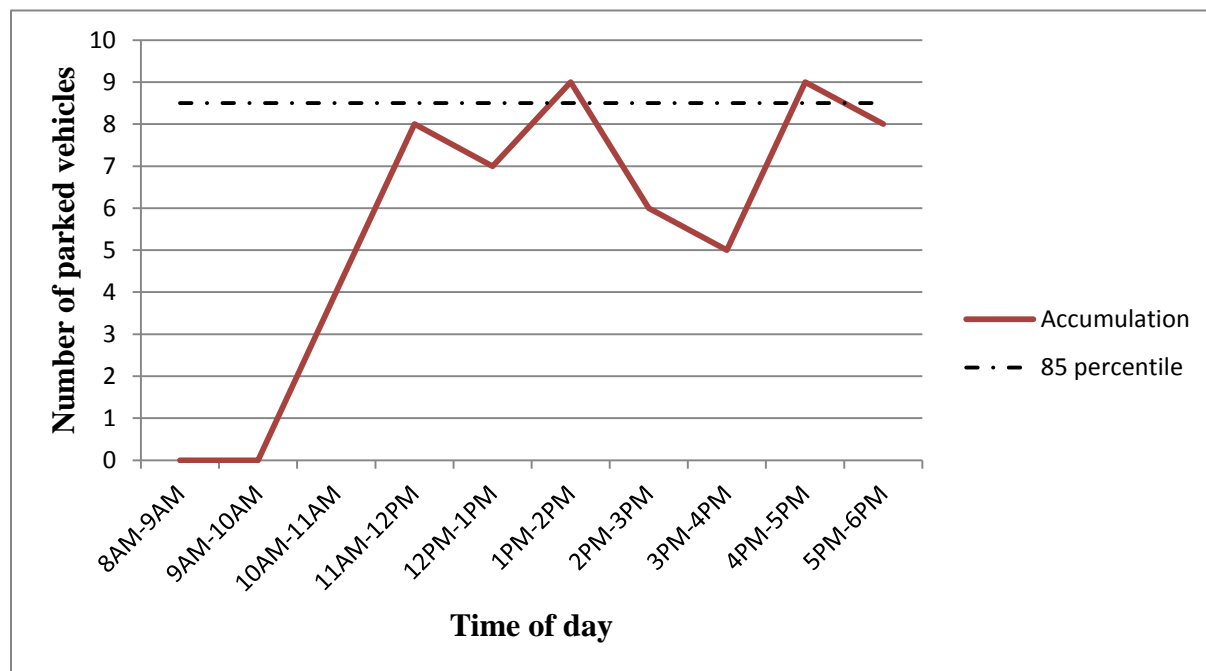


Figure 4.21: Accumulation curve, L-003 at under construction bldg., August 8, 2016.

It shows no demand is seen between 8:00am to 9:00am and 9:00am to 10:00am and the maximum demand is on the time interval between 1:00pm to 2:00pm and 4:00pm to 5:00pm.

Recognizing the accumulation curve of the off- street parking spaces are being utilized within the allowable limit or capacity the whole day except from 1:00pm to 2:00pm and 4:00pm to 5:00pm.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.23: license plate survey data result, L-003, on Monday August 8, 2016 from 4:00PM-5:00PM

Date: Monday August 8/2016					Recording time:4:00pm-5:00pm				
Weather: sunny					Location:L-003/under construction bldg.				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	51031	51031	1645	1645	1	1	1	1	2
2	47827	47827	47827	9423	1	1	1	1	2
3	96196	96196	2232	2232	1	1	1	1	2
4	A64219	A64219	A64219	A64219	1	1	1	1	1
5	32161	32161	2551	-	1	1	1	0	2
6	62599	8941	8941	4470	1	1	1	1	3
7	31557	31557	5807	5807	1	1	1	1	2
8	72547	8239	2237	8778	1	1	1	1	4
9	-	6389	6389	9177	0	1	1	1	2
10	82692	82692	-	2186	1	1	0	1	2
11	A37624	A37624	-	3531	1	1	0	1	2
	Accumulation				10	11	9	10	24
	Occupancy				90.9	100	81.8	90.9	

		Unit
Average turn over	2.18	Vehicles/hr.
Parking volume	24	Vehicles
Average duration	54.5	Minute/vehicles
Average occupancy	90.9	%
Parking load	10	Vehicles hours
Parking capacity	11	Vehicles hours

From the result average parking duration of 54.5 minute/vehicles indicates most vehicles are parked for longer period of time, it shows that almost one vehicle is parked within an hour. From the turnover result of 2.18vehicles/hour, it is possible to say that the rate of usage of parking space is fair or the frequency of space availability is moderate.

Occupancy of 90.9 % and parking load of 10 vehicles hours shows the parking space coverage of the area is high and considered to be full.

Parking lot-4 L-004 Dink sira complex

The number of vehicles parked at an hourly interval on July 15/2016 off-street and Building parking supply of L-004(Dink sira complex) is realized as shown in the chart below:

i. Off-street parking

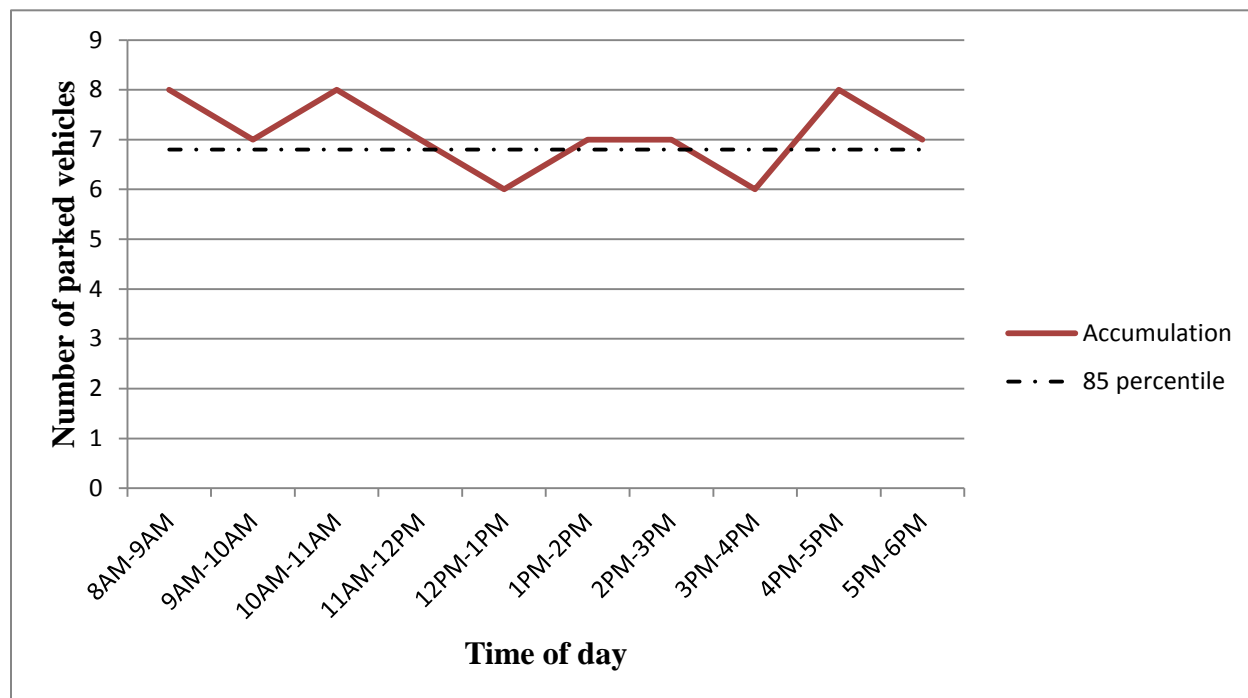


Figure 4.22: Accumulation curve, L-004 at Dink Sira complex, off-street parking, July 15, 2016.

It shows the maximum demand is on the time interval between 10:00am to 11:00am and 4:00pm to 5:00pm.

Recognizing the accumulation curve of the off- street parking spaces are being utilized out of the allowable limit or capacity the whole day except from 12:00pm to 1:00pm and 3:00pm to 4:00pm.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.24: license plate survey data result, L-004, on Thursday August 15, 2016 from 4:00PM-5:00PM

Date: Thursday August 15/2016					Recording time:4:00pm-5:00pm				
Weather: sunny					Location: L-004 dink sira bldg.(off-street)				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	A61549	A61549	-	-	1	1	0	0	1
2	02454	02454	02454	02454	1	1	1	1	1
3	-	A08313	A08313	A08313	0	1	1	1	1
4	A24619	A24619	A24619	A24619	1	1	1	1	1
5	90372	90372	90372	90372	1	1	1	1	1
6	58306	58306	58306	-	1	1	1	0	1
7	02474	02474	02474	02474	1	1	1	1	1
8	A40001	-	A44434	A44434	1	0	1	1	2
Accumulation					7	7	7	6	9
Occupancy					87.5	87.5	87.5	75	

		Unit
Average turn over	1.13	Vehicles/hr.
Parking volume	9	Vehicles
Average duration	45	Minute/vehicles
Average occupancy	84.4	%
Parking load	6.75	Vehicles hours
Parking capacity	8	Vehicles hours

From the result average parking duration of 45 minute/vehicles indicates most vehicles are parked for long period of time, it shows that one vehicle is parked within an hour. From the turnover result of 1.13vehicles/hour, it is possible to say that the rate of usage of parking space is poor or the frequency of space availability is low.

Occupancy of 84.4 % and parking load of 6.75 vehicles hours shows the parking space coverage of the area is considered to be ideal, since the parking space is used effectively.

ii. Building parking

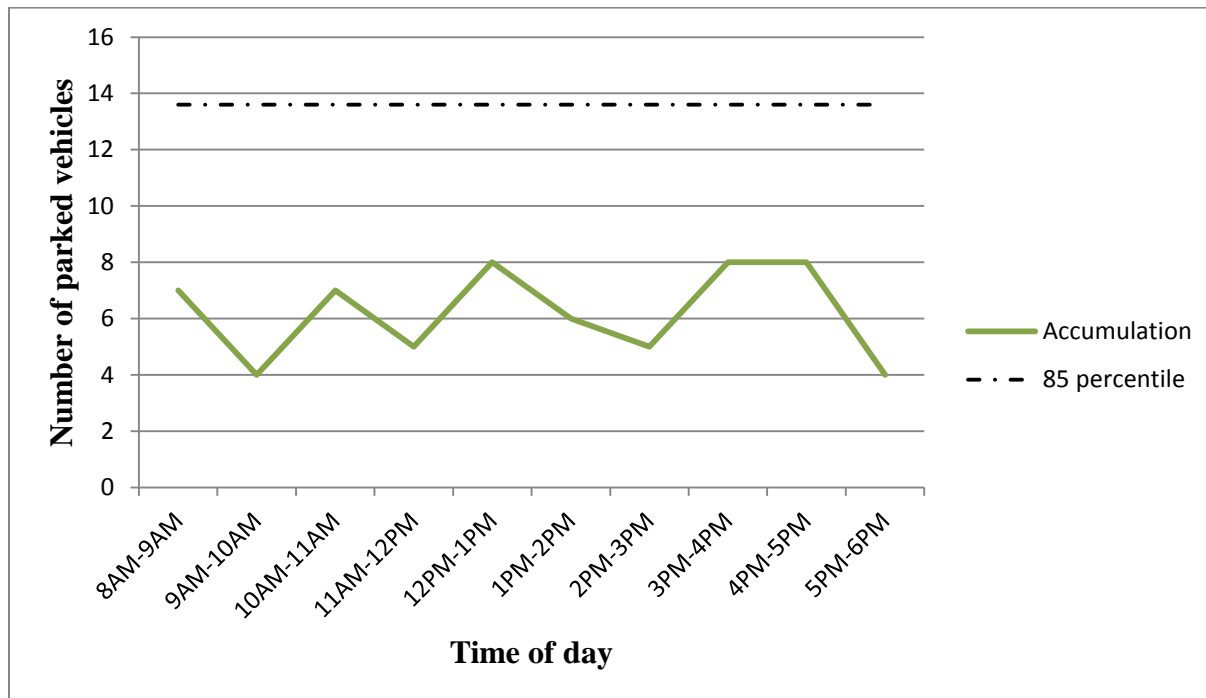


Figure 4.23: Accumulation curve, L-004 at Dink Sira complex, Building parking, August 11, 2016.

It shows the maximum demand is on the time interval between 12:00pm to 1:00pm, 3:00pm to 4:00pm and 4pm-5pm.

Recognizing the accumulation curve of the building parking spaces the 85 percentile is very far from the accumulation curve or the parking spaces are being utilized within the allowable limit or capacity the whole day. This indicates that the shared parking strategy is needed to balance the parking usage of the area.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.25: license plate survey data result, L-004, on Friday August 11, 2016 from 12:00PM-1:00PM

Date: Thursday August 11/2016					Recording time:12:00pm-1:00pm				
Weather: sunny					Location: L-004 dink sira bldg.(Building parking)				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	02019	02019	02019	02019	1	1	1	1	1
2	48433	48433	48433	48433	1	1	1	1	1
3	02959	02959	02959	02959	1	1	1	1	1
4	A62764	A62764	A62764	A62764	1	1	1	1	1
5	A32052	A32052	A32052	A32052	1	1	1	1	1
6	-	-	-	-	0	0	0	0	0
7	-	-	-	-	0	0	0	0	0
8	-	-	-	-	0	0	0	0	0
9	-	-	-	-	0	0	0	0	0
10	-	-	-	-	0	0	0	0	0
11	-	-	-	-	0	0	0	0	0
12	27924	27924	27924	27924	1	1	1	1	1
13	A19772	A19772	A19772	A19772	1	1	1	1	1
14	A19794	A19794	A19794	A19794	1	1	1	1	1
15	A47428	A47428	A47428	A47428	1	1	1	1	1
16	A74082	A74082	A74082	A74082	1	1	1	1	1
	Accumulation				10	10	10	10	10
	Occupancy				62.5	62.5	62.5	62.5	

		Unit
Average turn over	0.63	Vehicles/hr.
Parking volume	10	Vehicles
Average duration	60	Minute/vehicles
Average occupancy	62.5	%
Parking load	10	Vehicles hours
Parking capacity	16	Vehicles hours

From the result average parking duration of 60 minute/vehicles indicates most vehicles are parked for long period of time, it shows that one vehicle is parked within an hour. This is due to most vehicles parked in the building garage are office workers within the building. From the turnover result of 0.63vehicles/hour, it is possible to say that the rate of usage of parking space is poor or the frequency of space availability is very low.

Occupancy of 62.5 % and parking load of 10 vehicles hours shows the parking space coverage of the area is low and considered to be ideal, since the parking space is used effectively.

Parking lot-5 L-005 Ethiopian press agency

The number of vehicles parked at an hourly interval on July 15/2016 off-street and Building parking supply of L-005(Ethiopian press agency) is realized as shown in the chart below:

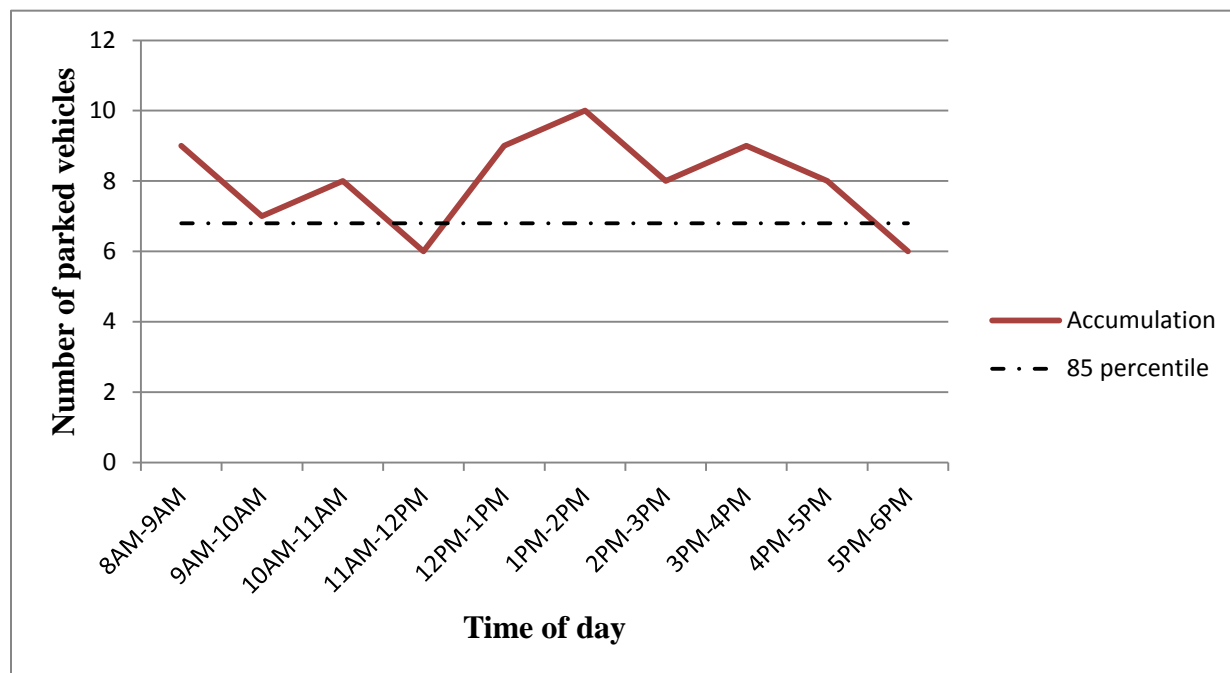


Figure 4.24: Accumulation curve, L-005 at Ethiopian Press Agency, July 15, 2016.

It shows the maximum demand is on the time interval between 1:00pm to 2:00pm.

Recognizing the accumulation curve, the off-street parking spaces are being utilized without the allowable limit or capacity the whole day except from 11:00am to 12:00pm and 5:00pm to 6:00pm.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.26: license plate survey data result, L-005, on Friday July 15, 2016 from 1:00PM-2:00PM

Date: Friday July 15/2016					Recording time: 1:00pm-2:00pm				
Weather: sunny					Location: L-005/Ethiopian press agency				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	A4281	31480	8078	9831	1	1	1	1	4
2	01509	29449	-	8955	1	1	0	1	3
3	28236	A89371	-	-	1	1	0	0	2
4	20335	20335	2186	2186	1	1	1	1	2
5	A63990	A63990	-	7163	1	1	0	1	2
6	A24481	A24481	1048	1048	1	1	1	1	2
7	92781	92781	-	4211	1	1	0	1	2
8	21844	21844	6658	6658	1	1	1	1	2
9	A09860	A09860	1105	1105	1	1	1	1	2
10	81450	81450	4761	-	1	1	1	0	2
11	00341	00341	3982	3982	1	1	1	1	2
12	05853	05853	9238	9238	1	1	1	1	2
Accumulation					12	12	8	10	27
Occupancy					100	100	66.7	83.3	

		Unit
Average turn over	2.25	Vehicles/hr.
Parking volume	27	Vehicles
Average duration	23.3	Minute/vehicles
Average occupancy	87.5	%
Parking load	10.5	Vehicles hours
Parking capacity	12	Vehicles hours

From the result average parking duration of 23.3 minute/vehicles indicates most vehicles are parked for medium period of time, it shows that almost two vehicles are parked within an hour. From the turnover result of 2.25vehicles/hour, it is possible to say that the rate of usage of parking space is fair or the frequency of space availability is moderate.

Occupancy of 87.5 % and parking load of 10.5 vehicles hours shows the parking space coverage of the area is high and considered to be full.

Parking lot-6 L-006 Bilo's pastry

The number of vehicles parked at an hourly interval on July 15/2016 L-006/Bilo's pastry is realized as shown in the chart below:

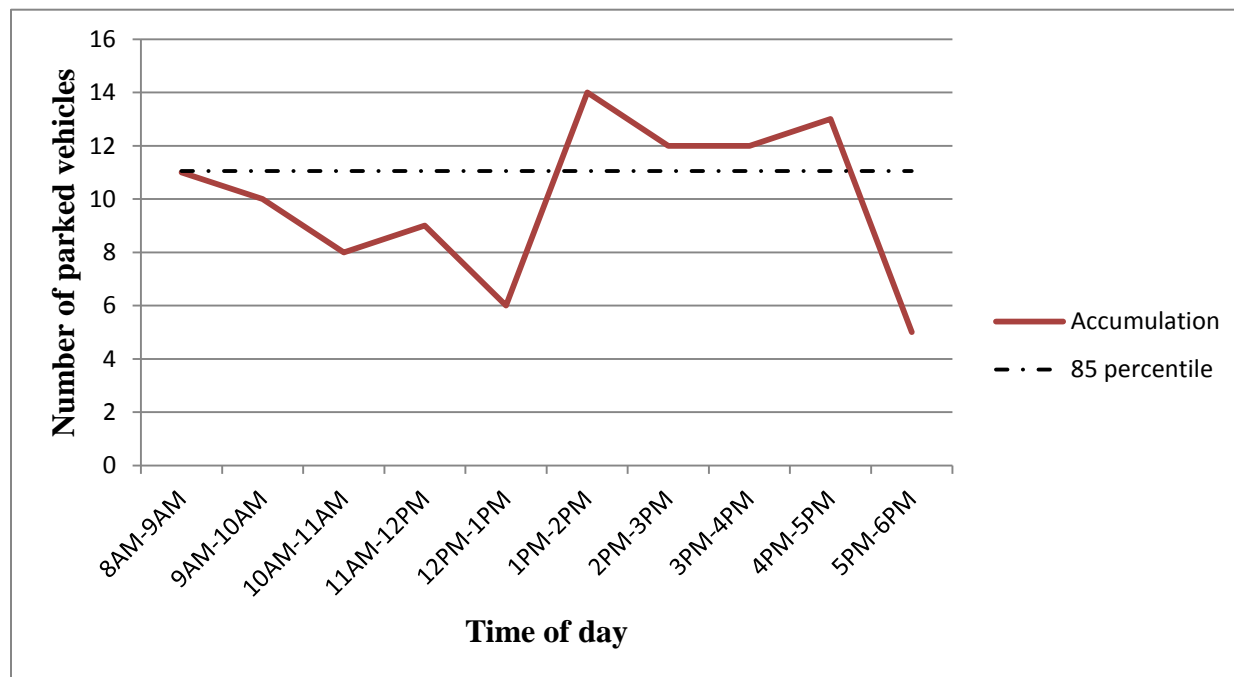


Figure 4.25: Accumulation curve, L-006 at Bilo's Pastry, July 15, 2016.

It shows the maximum demand is on the time interval between 1:00pm to 2:00pm.

Recognizing the accumulation curve of the off- street parking spaces are being utilized within the allowable limit or capacity the whole day except from 1:00pm to 2:00pm, 2:00pm to 3:00pm, 3:00pm to 4:00pm and 4:00pm to 5:00pm.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.27: license plate survey data result, L-006, on Friday July 15, 2016 from 1:00PM-2:00PM

Date: Friday July 15/2016 Weather :sunny					Recording time:1:00PM-2:00PM Location: L-006/Bilo's pastry				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	08667	08667	08667	08667	1	1	1	1	1
2	-	-	-	-	0	0	0	0	0
3	97848	97848	-	-	1	1	0	0	1
4	90740	90740	90740	90740	1	1	1	1	1
5	75193	75193	75193	75193	1	1	1	1	1
6	A32159	A32159	A32159	A32159	1	1	1	1	1
7	A29274	A29274	A29274	A29274	1	1	1	1	1
8	A22226	A22226	A22226	A22226	1	1	1	1	1
9	A31423	A31423	A31423	A31423	1	1	1	1	1
10	A08518	A08518	A08518	A08518	1	1	1	1	1
11	19492	19492	19492	19492	1	1	1	1	1
12	78252	78252	78252	78252	1	1	1	1	1
13	A54678	A54678	A54678	-	1	1	1	0	1
	Accumulation				12	12	11	10	
	Occupancy				92.3	92.3	84.6	76.92	

		Unit
Average turn over	0.92	Vehicles/hr.
Parking volume	12	Vehicles
Average duration	56.25	Minute/vehicles
Average occupancy	86.53	%
Parking load	11.25	Vehicles hours
Parking capacity	13	Vehicles hours

From the result average parking duration of 56.25 minute/vehicles indicates most vehicles are parked for long period of time, it shows that almost one vehicle is parked within an hour. From the turnover result of 0.92vehicles/hour, it is possible to say that the rate of usage of parking space is poor or the frequency of space availability is weak.

Occupancy of 86.53 % and parking load of 11.25 vehicles hours shows the parking space coverage of the area is high and considered to be full.

Parking lot-7 L-007/Arada sub-city land development and management office (ASLDMO)

The number of vehicles parked at an hourly interval on July 15/2016 L-007/ASLDM is realized as shown in the chart below:

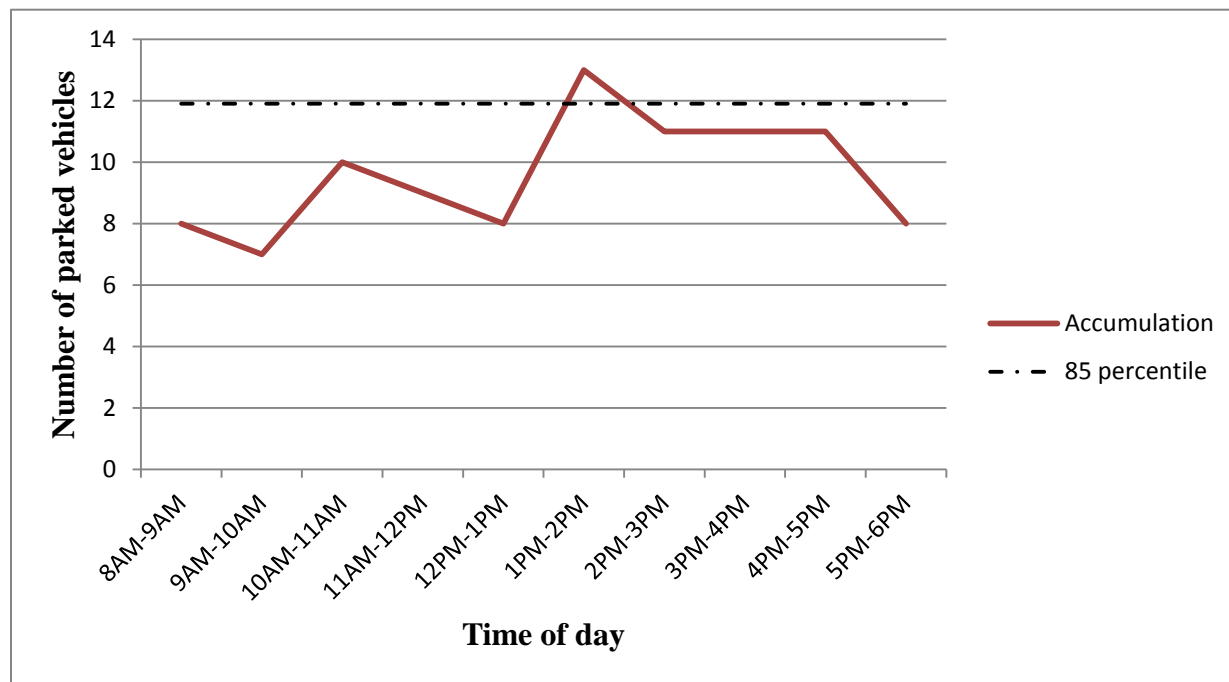


Figure 4.26: Accumulation curve, L-007 at ASLDMO, July 15, 2016.

It shows the maximum demand is on the time interval between 1:00pm to 2:00pm.

Recognizing the accumulation curve of the off-street parking spaces are being utilized within the allowable limit or capacity the whole day except from 1:00pm to 2:00pm which is over the capacity of the parking supply.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.28: license plate survey data result, L-007, on Friday July 15, 2016 from 1:00PM-2:00PM

Date: Friday July 15/2016 Weather :sunny					Recording time:1:00PM-2:00PM Location: L-007/ASLDM				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	A17443	A17443	A17443	A17443	1	1	1	1	1
2	-	66536	66536	66536	0	1	1	1	1
3	79924	79924	79924	79924	1	1	1	1	1
4	A32562	A32562	A32562	A32562	1	1	1	1	1
5	A56640	A56640	-	A56640	1	1	0	1	1
6	54898	54898	54898	54898	1	1	1	1	1
7	A16800	A16800	A16800	A16800	1	1	1	1	1
8	89724	89724	89724	89724	1	1	1	1	1
9	52714	52714	52714	52714	1	1	1	1	1
10	A16046	A16046	A16046	A16046	1	1	1	1	1
11	8778	-	-	4214	1	0	0	1	2
12	-	-	3428	1845	0	0	1	1	2
13	2071	-	-	-	1	0	0	0	1
14	-	7841	-	1653	0	1	0	1	2
Accumulation					11	11	10	13	17
Occupancy					78.6	78.6	71.43	92.9	

		Unit
Average turn over	1.21	Vehicles/hr.
Parking volume	17	Vehicles
Average duration	39.7	Minute/vehicles
Average occupancy	80.38	%
Parking load	11.25	Vehicles hours
Parking capacity	14	Vehicles hours

As the parking lot is in the government office and then the result average parking duration of 39.7 minute/vehicles indicates most vehicles are parked for long period of time, it shows that almost one vehicle is parked within an hour. From the turnover result of 1.21 vehicles/hour, it is possible to say that the rate of usage of parking space is poor or the frequency of space availability is weak.

Occupancy of 80.38 % and parking load of 11.25 vehicles hours shows the parking space coverage of the area is considered to be ideal and the parking space is used effectively.

Parking lot-8 L-008/Mega books

The number of vehicles parked at an hourly interval on July 15/2016 L-008/Mega books is realized as shown in the chart below:

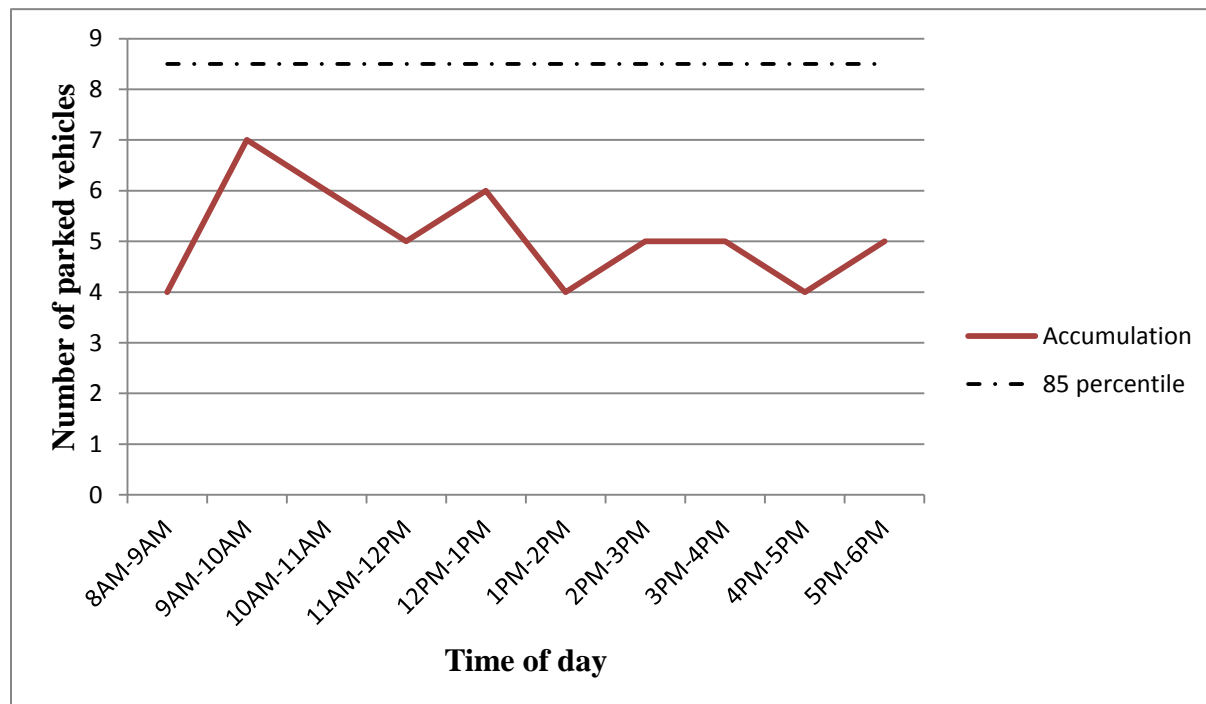


Figure 4.27: Accumulation curve, L-008 at Mega books, July 15, 2016.

It shows the maximum demand is on the time interval between 9:00am to 10:00am.

Recognizing the accumulation curve of the off-street parking spaces are being utilized within the allowable limit or capacity the whole day.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.29: license plate survey data result, L-008, on Friday July 15, 2016 from 9:00AM-10:00AM

Date: Friday July 15/2016 Weather :sunny					Recording time:9:00AM-10:00AM Location: L-008/Mega Books				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	1645	1645	9423	4442	1	1	1	1	3
2	-	-	2232	2232	0	0	1	1	1
3	1374	-	1374	9316	1	0	1	1	2
4	2551	2551	-	-	1	1	0	0	1
5	2103	2103	2103	2103	1	1	1	1	1
6	6389	3428	3428	2867	1	1	1	1	3
7	2237	-	8778	8778	1	0	1	1	2
8	8514	4522	-	5527	1	1	0	1	3
9	-	9184	9184	9907	0	1	1	1	2
10	1825	1825	5127	5127	1	1	1	1	2
	Accumulation				8	7	8	9	20
	Occupancy				80	70	80	90	

		Unit
Average turn over	2	Vehicles/hr.
Parking volume	20	Vehicles
Average duration	24	Minute/vehicles
Average occupancy	80	%
Parking load	8	Vehicles hours
Parking capacity	10	Vehicles hours

From the result average parking duration of 24 minute/vehicles indicates most vehicles are parked for medium period of time, it shows that almost two vehicles are parked within an hour. From the turnover result of 2vehicles/hour, it is possible to say that the rate of usage of parking space is fair or the frequency of space availability is moderate.

Occupancy of 80 % and parking load of 8 vehicles hours shows the parking space coverage of the area is considered to be ideal and the parking space is used effectively.

Parking lot-9 L-009/channel five

The number of vehicles parked at an hourly interval on July 16/2016 L-009/channel five is realized as shown in the chart below:

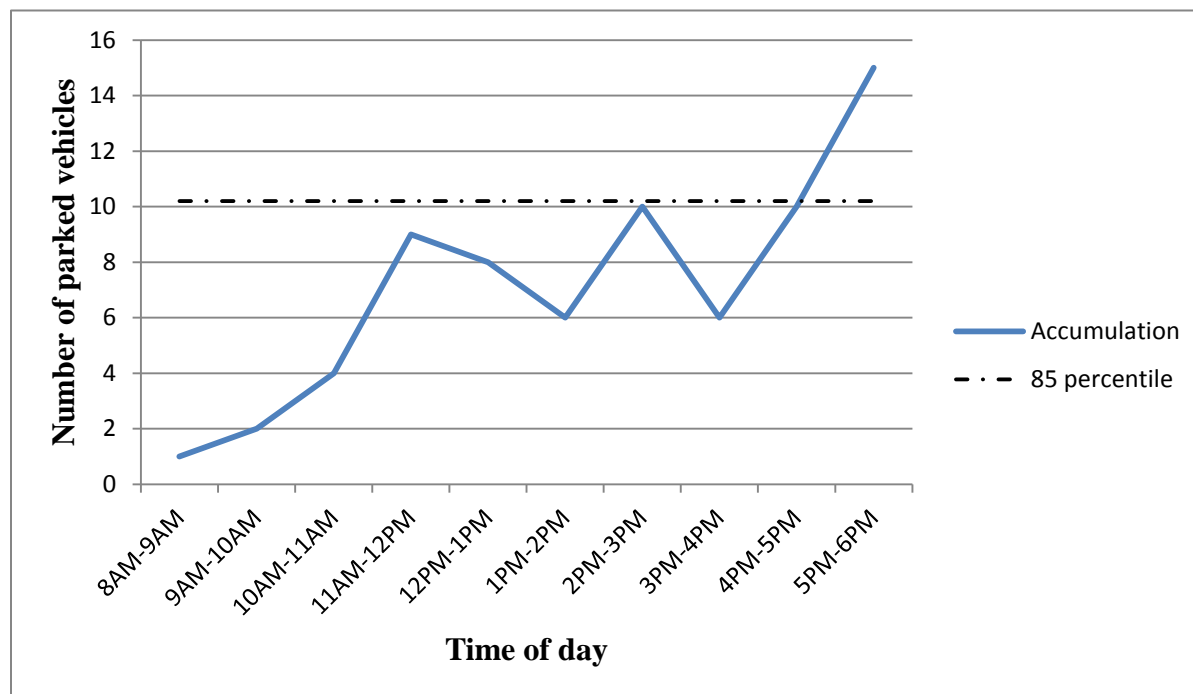


Figure 4.28: Accumulation curve, L-009 at Channel Five, July 16, 2016.

It shows the maximum demand is on the time interval between 5:00pm to 6:00pm. The reason for this is that as the place is bar and restaurant as well as a night club, the demand is showing continuous increase between the time interval and even more above.

Recognizing the accumulation curve of the off-street parking spaces are being utilized within the allowable limit or capacity the whole day except from 5:00pm to 6:00pm which is over the capacity of the parking supply.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.30: license plate survey data result, L-009, on Saturday July 15, 2016 from 5:00PM-6:00PM

Date: Saturday July 15/2016 Weather :sunny					Recording time:5:00PM-6:00PM Location: L-009/channel five				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	2358	4563	4563	6346	1	1	1	1	3
2	-	4443	1728	1728	0	1	1	1	2
3	8336	-	7553	7553	1	0	1	1	2
4	A37424	A37424	A64219	A64219	1	1	1	1	2
5	28236	-	9724	9724	1	0	1	1	2
6	9552	9552	9552	9552	1	1	1	1	1
7	1961	1961	1961	1961	1	1	1	1	1
8	3477	9558	6623	8239	1	1	1	1	4
9	9768	9768	7841	7841	1	1	1	1	2
10	1682	1682	1682	1682	1	1	1	1	1
11	5127	5127	5127	5127	1	1	1	1	1
12	3421	3421	3421	3421	1	1	1	1	1
	Accumulation				11	11	12	12	22
	Occupancy				91.7	91.7	100	100	

		Unit
Average turn over	1.83	Vehicles/hr.
Parking volume	22	Vehicles
Average duration	31.36	Minute/vehicles
Average occupancy	95.85	%
Parking load	11.5	Vehicles hours
Parking capacity	12	Vehicles hours

From the result average parking duration of 31.36 minute/vehicles indicates most vehicles are parked for medium period of time, it shows that almost two vehicles are parked within an hour. From the turnover result of 1.83vehicles/hour, it is possible to say that the rate of usage of parking space is fair or the frequency of space availability is moderate.

Occupancy of 95.85 % and parking load of 11.5 vehicles hours shows the parking space coverage of the area is high and considered to be full.

Parking-lot 10 L-010(from Ras Mekonnen Bridge to CBE/Piazza branch)

The number of vehicles parked at an hourly interval on Wednesday September 14/2016 L-010/from Ras Mekonnen bridge to CBE/piazza branch road is realized as shown in the chart below:

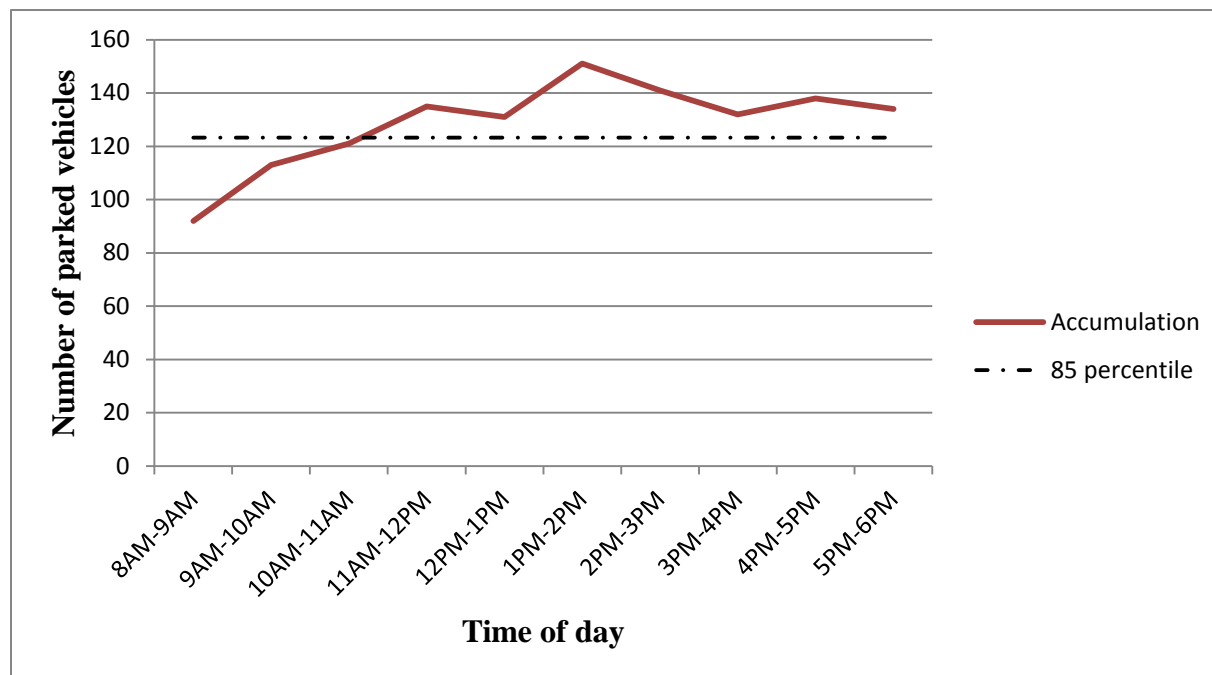


Figure 4.29: Accumulation curve, L-004 from Ras Mekonnen Bridge to CBE/piazza branch, September 14, 2016.

It shows the maximum demand is on the time interval between 1:00pm to 2:00pm.

Recognizing the accumulation curve of the off-street parking spaces is being utilized within the allowable limit or capacity the whole day except from 8:00am to 9:00am, 9:00am to 10:00am and 10:00am to 11:00am.

The statistical terms used to analyze the parking space supplies of the area at the peak hour of the day are presented below:

Table 4.31: license plate survey data result, L-010, on Wednesday September 14, 2016 from 1:00PM-2:00PM

Date: Wednesday September 14/2016 Weather: cloudy					Recording time:1:00PM-2:00PM Location: from Ras Mekonnen bridge- CBE/piazza branch				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1	05256	05256	03376	03376	1	1	1	1	2
2	03376	03376	07240	07240	1	1	1	1	2
3	A73467	-	A32969	A32969	1	0	1	1	2
4	A59692	A59692	A31440	A31440	1	1	1	1	2
5	10819	-	-	-	1	0	0	0	1
6	A61143	-	-	-	1	0	0	0	1
7	-	A00148	00856	00856	0	1	1	1	2
8	-	-	A50752	A50752	0	0	1	1	1
9	24092	24092	A38646	A38646	1	1	1	1	2
10	78281	78281	A75694	A75694	1	1	1	1	2
11	A50752	A50752	A26456	A26456	1	1	1	1	2
12	A38646	A38646	A83591	A83591	1	1	1	1	2
13	A30033	24285	A77852	A77852	1	1	1	1	3
14	28805	-	30210	30210	1	0	1	1	2
15	A14022	-	A10536	A10536	1	0	1	1	2
16	A67804	A67804	60999	60999	1	1	1	1	2
17	27627	27627	69098	69098	1	1	1	1	2
18	12078	12078	-	-	1	1	0	0	1
19	-	A65796	A48643	A48643	0	1	1	1	2
20	-	69098	08239	08239	0	1	1	1	2
21	69098	01937	01937	-	1	1	1	0	2
22	01937	-	A38134	A38134	1	0	1	1	2
23	08239	-	-	-	1	0	0	0	1
24	-	-	-	-	0	0	0	0	-
25	A07634	A07634	A07634	A07634	1	1	1	1	1
26	64993	64993	64993	64993	1	1	1	1	1
27	24214	24214	24214	24214	1	1	1	1	1
28	14930	14930	14930	14930	1	1	1	1	1
29	A05355	A05355	A05355	A05355	1	1	1	1	1
30	26618	26618	26618	26618	1	1	1	1	1
31	A72612	A72612	A72612	A72612	1	1	1	1	1
32	A24896	A24896	A24896	A24896	1	1	1	1	1
33	-	A13732	A13732	26066	0	1	1	1	2
34	A04470	A04470	A04470	A04470	1	1	1	1	1
35	89184	89184	89184	89184	1	1	1	1	1
36	A54467	A54467	A54467	A54467	1	1	1	1	1
37	A24227	A24227	A24227	A24227	1	1	1	1	1

38	A57646	A45262	A73852	A73852	1	1	1	1	3
39	73113	73113	73113	73113	1	1	1	1	1
40	A73219	A73219	A73219	A73219	1	1	1	1	1
41	A34027	40303	40303	40303	1	1	1	1	2
42	A26318	A26318	A26318	A26318	1	1	1	1	1
43	04050	04050	04050	04050	1	1	1	1	1
44	82494	82494	82494	82494	1	1	1	1	1
45	A55407	A55407	A55407	A55407	1	1	1	1	1
46	A12799	A12799	-	7597	1	1	0	1	2
47	32186	32186	32186	32186	1	1	1	1	1
48	90119	90119	90119	90119	1	1	1	1	1
49	A12898	A12898	A12898	A12898	1	1	1	1	1
50	A54266	A54266	75484	75484	1	1	1	1	2
51	A09539	19907	19907	19907	1	1	1	1	2
52	A794	A794	A794	A794	1	1	1	1	1
53	96748	96748	96748	20929	1	1	1	1	2
54	A64090	A64090	A64090	A64090	1	1	1	1	1
55	-	40770	04522	04522	0	1	1	1	2
56	A24570	A24570	88989	88989	1	1	1	1	2
57	A36752	A36752	A36752	A36752	1	1	1	1	1
58	A35404	A35404	A35404	A35404	1	1	1	1	1
59	27185	27185	27185	27185	1	1	1	1	1
60	A67364	28228	28228	28228	1	1	1	1	2
61	A32843	-	-	-	1	0	0	0	1
62	20971	20971	20971	20971	1	1	1	1	1
63	A45184	57572	A55877	A55877	1	1	1	1	3
64	52381	A74664	A74664	A74664	1	1	1	1	2
65	A05248	A05248	45768	45768	1	1	1	1	2
66	A07634	-	97872	97872	1	0	1	1	2
67	A12349	A12349	A10676	A10676	1	1	1	1	2
68	74635	74635	23301	23301	1	1	1	1	2
69	A1322	A1322	A1322	A1322	1	1	1	1	1
70	72957	72957	72957	57778	1	1	1	1	2
71	A36133	A36133	A36133	A36133	1	1	1	1	1
72	13426	A43926	A27960	A27960	1	1	1	1	3
73	04406	04406	57512	57512	1	1	1	1	2
74	98768	98768	31430	04406	1	1	1	1	3
75	62788	62788	62788	62788	1	1	1	1	1
76	06886	06886	06886	06886	1	1	1	1	1
77	A62046	-	-	-	1	0	0	0	1
78	A34630	A34630	A34630	A34630	1	1	1	1	1
79	A27219	A27219	A27219	A27219	1	1	1	1	1
80	A53685	A53685	A53685	A53685	1	1	1	1	1
81	58103	58103	58103	58103	1	1	1	1	1
82	14476	A77206	A77206	-	1	1	1	0	2

83	11727	11727	14476	04933	1	1	1	1	3
84	07240	07240	07240	07240	1	1	1	1	1
85	24337	12550	12550	12550	1	1	1	1	2
86	89484	A04662	A04662	A04662	1	1	1	1	2
87	76620	76620	76620	76620	1	1	1	1	1
88	30834	33982	33982	33982	1	1	1	1	2
89	66550	66550	66550	66550	1	1	1	1	1
90	A31326	A31326	A31326	A31326	1	1	1	1	1
91	A75903	A75903	A40479	A56960	1	1	1	1	3
92	08808	-	A79868	A79868	1	0	1	1	2
93	A73746	A73746	A73746	A73746	1	1	1	1	1
94	A05178	A05178	71013	A20583	1	1	1	1	3
95	73437	73437	73437	73437	1	1	1	1	1
96	A71176	A71176	A06108	A06108	1	1	1	1	2
97	A72612	A72612	A72612	A72612	1	1	1	1	1
98	A31212	A31212	A31212	A31212	1	1	1	1	1
99	70900	70900	70900	70900	1	1	1	1	1
100	13074	A15957	A15957	13074	1	1	1	1	2
101	06020	06020	41160	41160	1	1	1	1	2
102	28686	-	25842	28686	1	0	1	1	2
103	A22232	A22232	A22232	A22232	1	1	1	1	1
104	69655	69655	69655	69655	1	1	1	1	1
105	32358	32358	32358	32358	1	1	1	1	1
106	87121	87121	87121	87121	1	1	1	1	1
107	A72692	A72692	A72692	A72692	1	1	1	1	1
108	87138	87138	87138	87138	1	1	1	1	1
109	A3145	A3145	A3145	A3145	1	1	1	1	1
110	A72674	A72674	A72674	A72674	1	1	1	1	1
111	00313	00313	00313	00313	1	1	1	1	1
112	A46017	A46017	A46017	A46017	1	1	1	1	1
113	A57173	A68473	A68473	A68473	1	1	1	1	2
114	A54188	A54188	A54188	A54188	1	1	1	1	1
115	A75810	A75810	A75810	A75810	1	1	1	1	1
116	A09186	A09186	A09186	A09186	1	1	1	1	1
117	81535	81535	81535	81535	1	1	1	1	1
118	13213	00485	-	A40021	1	1	0	1	3
119	05350	05350	00485	00485	1	1	1	1	2
120	A44562	A44562	A44562	A39892	1	1	1	1	2
121	23037	-	13655	71086	1	0	1	1	3
122	29010	13655	63739	142655	1	1	1	1	4
123	91738	96279	-	19492	1	1	0	1	3
124	03376	03376	03376	03376	1	1	1	1	1
125	10-031	-	-	-	1	0	0	0	1
126	A26982	A26982	A20620	A20620	1	1	1	1	2
127	63457	30146	A26982	A26982	1	1	1	1	3

128	10819	10819	30146	30146	1	1	1	1	2
129	A18155	79021	10819	10819	1	1	1	1	3
130	A65194	24092	-	07240	1	1	0	1	3
131	97189	97189	24092	24092	1	1	1	1	2
132	92391	92391	-	A26695	1	1	0	1	2
133	A63038	5508	A31345	A50298	1	1	1	1	4
134	95218	26078	26078	26078	1	1	1	1	2
135	79076	79076	79076	79076	1	1	1	1	1
136	A69328	A69328	A69328	A69328	1	1	1	1	1
137	30959	30959	30959	30959	1	1	1	1	1
138	A39177	A39177	A39177	A39177	1	1	1	1	1
139	54260	54260	54260	54260	1	1	1	1	1
140	A22790	A22790	A22790	A22790	1	1	1	1	1
141	A45940	A45940	A45940	A45940	1	1	1	1	1
142	24745	24745	24745	24745	1	1	1	1	1
143	15768	15768	15768	15768	1	1	1	1	1
144	A27334	A27334	A27334	A27334	1	1	1	1	1
145	A27374	A27374	A27374	A27374	1	1	1	1	1
	Accumulation				138	129	132	135	228
	Occupancy				95	89	91	93	

		Unit
Average turn over	1.57	Vehicles/hr.
Parking volume	228	Vehicles
Average duration	55.24	Minute/vehicles
Average occupancy	92	%
Parking load	133.5	Vehicles hours
Parking capacity	145	Vehicles hours

From the result average parking duration of 55.24 minute/vehicles indicates most vehicles are parked for long period of time, it shows that almost one vehicle is parked within an hour. From the turnover result of 1.57vehicles/hour, it is possible to say that the rate of usage of parking space or the frequency of space availability is weak.

Occupancy of 92 % and parking load of 133.5 vehicles hours shows the parking space coverage of the area is high and considered to be full, since someone looking for a space will not find an empty one easily and may need to circle as few times before one becomes available.

4.4 Expected parking demand

4.4.1 Parking demand generators

Peoples move around this site uses parking spaces to get different facilities. These peoples are the parking generators that are another demand to the study area in addition of the usual demand like shop owners and residents. The parking generators on this site is peoples come to jewelry, people come to cinema house, for entertainment and governmental offices.

4.4.2 Actual versus ITE peak demand rates

The actual peak demand rates were calculated by determining the highest number of parked vehicles during an observation period and dividing this number by the GSF of each land use obtained by using online Google earth software as shown below for parking lot-1/Meseret café.



Area Output

894.400 m²
0.001 km²
0.221 Acres
0.089 Hectares
9627.240 Feet²

Figure 4.30 land use area output for parking-lot 1/Meseret cafe

From the above Google earth area output only surface area is obtained. To change it into Gross square footage it was multiplied by the number of stories. i.e.

$$9627.24 * 3 = 28881 \text{ft}^2.$$

The actual demand rate was calculated by the peak demand divided by the Gross square footage area of each land uses and expressed in terms of per one thousand rates.

$$\frac{13 * 1000}{28881} = 0.45/1000 \text{gsf}.$$

Results of other parking lots are presented by table Results of other actual peak demand rates at the right and left side of the road compared with the ITE standard peak demand rates are presented by table below to ignore redundancy of procedure.:

Table 4.32 Actual versus ITE peak demand rates at the right side of the road

Land uses	Land use type	Size	Unit	Actual demand rate	ITE demand rate	Actual vs ITE
R-001	Commercial	6906	GSF	0.45/1000gsf	2.84/1000gsf	Below
	Residential	6	Dwelling	0.83 per unit	1.23/unit	Below
R-002	Commercial	1824	GSF	2.19/1000gsf	2.84/1000gsf	Below
R-003	Commercial/Office	29988	GSF	0.53/1000gsf	2.84/1000gsf	Below
R-004	Bank	7703	GSF	1.95/1000gsf	4/1000gsf	Below
R-005	Cinema	250	Seats	0.044/seat	0.26/seat	Below
	Restaurant High-Turnover (Sit-Down) Family Restaurant (no bar/lounge)	18885	GSF	0.58/1000gsf	5.55/1000gsf	Below
	Commercial/Office	9443	GSF	1.16/1000gsf	2.84/1000gsf	
R-006	Restaurant	3775	GSF	4.2/1000gsf	5.55/1000gsf	Below
	Commercial/Office	7551	GSF	1.06/1000gsf	2.84/1000gsf	Below
R-007	Bank	11102	GSF	2.7/1000gsf	4/1000gsf	Below
	Commercial/Office	22205	GSF	1.35/1000gsf	2.84/1000gsf	Below
R-008	Commercial/Office	16581	GSF	0.66/1000gsf	2.84/1000gsf	Below
R-009	Commercial/Office	9892	GSF	1.2/1000gsf	2.84/1000gsf	Below
	Bank	2473	GSF	2.4/1000gsf	4/1000gsf	Below
R-010	Commercial/office	1500	GSF	2.6/1000gsf	2.84/1000gsf	Below
R-011	Restaurant	1785	GSF	2.8/1000gsf	5.55/1000gsf	Below
R-012	Restaurant	3424	GSF	2.63/1000gsf	>>	Below
R-013	Restaurant	4425	GSF	1.13/1000gsf	>>	Below
	Residential/apartment	24	Unit	0.2/unit	1.23/unit	Below
R-014	Commercial/office	17340	GSF	0.46/1000gsf	2.84/1000gsf	Below
R-015	Commercial/office	8584	GSF	2.44/1000gsf	2.84/1000gsf	Below

	Restaurant	8570	GSF	2.9/1000gsf	5.55/1000gsf	Below
	Cinema	805 seats	Seats	0.026/1000gsf	0.26/seat	Below

Table 4.33 Actual versus ITE peak demand rates at the left side of the road

Land uses	Land use type	Size	Unit	Actual demand rate	ITE demand rate	Actual vs ITE
L-001	Bank	3079	GSF	1.62/1000gsf	4/1000gsf	Below
L-002	Hotel	66	Room	0.15/room	0.89/room	Below
L-003	Commercial/Office	7500	GSF	1.2/1000gsf	2.84/1000gsf	Below
L-004	Commercial/Office	5368	GSF	1.49/1000gsf	2.84/1000gsf	Below
	Bar and restaurant	2147	GSF	3.26/1000gsf	15/1000gsf	Below
L-005	Commercial/Office	4000	GSF	2.5/1000gsf	2.84/1000gsf	Below
L-006	Commercial/Office	3283	GSF	2.13/1000gsf	2.84/1000gsf	Below
	Restaurant	1641	GSF	4.3/1000gsf	5.55/1000gsf	Below
L-007	Government office	6599	GSF	1.97/1000gsf	3.65/1000gsf	Below
L-008	Commercial/Office	4377	GSF	2.51/1000gsf	2.84/1000gsf	Below
L-009	Restaurant/club High-Turnover (Sitdown) Restaurant with bar/lounge	2100	GSF	2.6/1000gsf	16.3/1000gsf	Below
L-010	Commercial/Office	105964	GSF	1.42/1000gsf	2.84/1000gsf	Below

4.4.3 Parking demand calculations using actual and ITE peak demand rates

The Institute of Transportation Engineers (ITE) produces a periodic report titled Parking Generation, which is the accepted national standard in determining parking demand for a development. ITE standards are based on parking demand studies submitted to ITE by a variety of parties, including public agencies, developers and consulting firms.

The researcher includes the ITE rates as guidelines to benchmark how the study area existing supply compares to its land uses. While recognizing that every community's needs are different, below it shows what ITE would recommend as the number of spaces needed in the study area with adjustment for the areas mixed-use characteristics.

Rates from ITE are used to determine the average peak period parking demand. The average peak period demand is the parked cars observed at the peak period divided by the quantity of the independent variable, such as building area or employees, expressed as a rate. To estimate the average peak period demand in the study area, the researcher used the City's land use data from Google earth map to determine the square footage of each land use in Arat-kilo-piazza road, and

multiplied that square footage (or other independent variable, such as residential units or employees) by the actual and ITE average peak period demand.

Table 4.34 Actual and ITE parking demands at the right side of the road

Land uses	Land use type	Area	Actual peak rates	ITE peak rates	Actual demand	ITE demand
R-001	Commercial/Office	6906gsf	0.45/1000gsf	2.84/1000gsf	10	20
	Residential	6 units	0.83/ unit	1.23/unit	5	8
R-002	Commercial/Office	1824	2.19/1000gsf	2.84/1000gsf	4	5
R-003	Commercial/Office	19988	0.53/1000gsf	2.84/1000gsf	16	57
R-004	Bank	7703	1.95/1000gsf	4/1000gsf	15	31
R-005	Cinema	250 Seats	0.044/seat	0.26/seat	11	65
	Restaurant High-Turnover (Sit-Down) Family Restaurant (no bar/lounge)	11200	0.98/1000gsf	5.55/1000gsf	11	62
R-006	>>	3775	4.2/1000gsf	5.55/1000gsf	16	21
	Office	7551	1.06/1000gsf	2.84/1000gsf	8	21
R-007	Bank	11102	2.7/1000gsf	4/1000gsf	30	44
	Office	15000	2.0/1000gsf	2.84/1000gsf	30	43
R-008	Commercial/Office	11581	0.66/1000gsf	2.84/1000gsf	11	33
R-009	Commercial/Office	9892	1.2/1000gsf	2.84/1000gsf	12	28
	Bank	2473	2.4/1000gsf	4/1000gsf	6	10
R-010	Commercial/Office	1500	2.6/1000gsf	2.84/1000gsf	4	5
R-011	Restaurant	1785	2.8/1000gsf	5.55/1000gsf	5	10
R-012	Restaurant	3424	2.63/1000gsf	>>	9	19
R-013	Restaurant	4425	1.13/1000gsf	>>	5	25
	Residential/apartment	12	0.2/unit	1.23/unit	5	15
R-014	Commercial/Office	11340	0.46/1000gsf	2.84/1000gsf	8	32
R-015	Commercial/Office	8584	2.44/1000gsf	2.84/1000gsf	21	24
	Restaurant	8570	2.9/1000gsf	5.55/1000gsf	25	48
	Cinema	805 seats	0.026/1000gsf	0.26/seat	21	209
Total					288	835

Table 4.35 Actual and ITE parking demands at the left side of the road

Land use code	Land use type	Area	Actual peak rates	ITE peak rates	Actual demand	ITE demand
L-001	Bank	3079	1.62/1000gsf	4/1000gsf	5	12
L-002	Hotel	66	0.15/room	0.89/room	10	59
L-003	Commercial/Office	7500	1.2/1000gsf	2.84/1000gsf	9	21
L-004	Commercial/Office	5368	1.49/1000gsf	2.84/1000gsf	8	15
	Restaurant	2147	3.26/1000gsf	5.55/1000gsf	7	12
L-005	Commercial/Office	4000	2.5/1000gsf	2.84/1000gsf	10	12
L-006	Commercial/Office	3283	2.13/1000gsf	2.84/1000gsf	7	9
	Restaurant	1641	4.3/1000gsf	5.55/1000gsf	7	9
L-007	Government office	6599	1.97/1000gsf	3.65/1000gsf	13	24
L-008	Commercial/Office	4377	2.51/1000gsf	2.84/1000gsf	11	12
L-009	Restaurant/club High-Turnover(Sit down Restaurant with bar/lounge)	2100	7.1/1000gsf	16.3/1000gsf	15	34
L-010	Commercial	105964	1.42/1000gsf	2.84/1000gsf	150	301
Total					252	520

There for the study area has a total demand of $288+252=540$ by actual/observed peak demand rates and $835+520=1355$ by ITE peak demand rates which is the sum of both at the right and left side of the road.

4.4.4 Additional parking space required

The additional parking spaces required for each parking lot at the right and left side of the road is shown below:

Table 4.36 Additional parking required by Actual and ITE demands at the right side of the road

Codes	Name of Parking lots	Existing supply	Actual demand	ITE demand	Additional parking spaces required		Remarks
					Actual	ITE	
R-001	Meseret cafe	12	15	28	3	16	
R-002	Yomik fashion	5	4	5	-	-	
R-003	Seble restaurant	20	16	57	-	39	
R-004	Awash bank	12	15	31	3	19	
R-005	Birhanina selam printing press and Habesha cinema	10	22	127	12	117	
R-006	Kaldis coffee	16	24	42	8	26	

R-007	Buna international bank (Diber bldg.)	30	60	87	30	69	
R-008	Denver cafe	8	11	33	3	25	
R-009	Book light	8	18	38	10	32	
R-010	Gera furniture	-	4	5	4	5	Using of internal facility roads
R-011	Yegna guada bar and restaurant	8	5	10	-	2	
R-012	Sheger pastry	8	9	19	1	15	
R-013	Licha zone	5	10	40	5	35	
R-014	Ethiopian household and office furniture	10	8	32	-	22	
R-015	From Sofonias pastry-cinema Empire	-	67	281	67	281	Restricted road side for parking
	Total	152	288	835	146	703	

Table 4.37 Additional parking required by Actual and ITE demands at the left side of the road

Codes	Name of Parking lots	Existing supply	Actual demand	ITE demand	Additional parking spaces required		Remarks
					Actual	ITE	
L-001	CBE/Arat Kilo branch	5	5	12	-	6	
L-002	Tourist hotel	7	15	59	8	52	
L-003	Beside Total gas station	11	14	21	3	10	
L-004	Dink Sira complex	24	32	27	8	3	
L-005	Ethiopian press agency	12	14	12	2	-	
L-006	Bilo's pastry	13	14	18	1	5	
L-007	ASLDMO	14	13	24	-	10	
L-008	Mega books	18	11	12	-	2	
L-009	channel five	12	15	34	3	22	
L-010	from Ras Mekonnen Bridge to CBE /Piazza branch	145	160	301	15	156	
	Total	261	293	520	40	266	

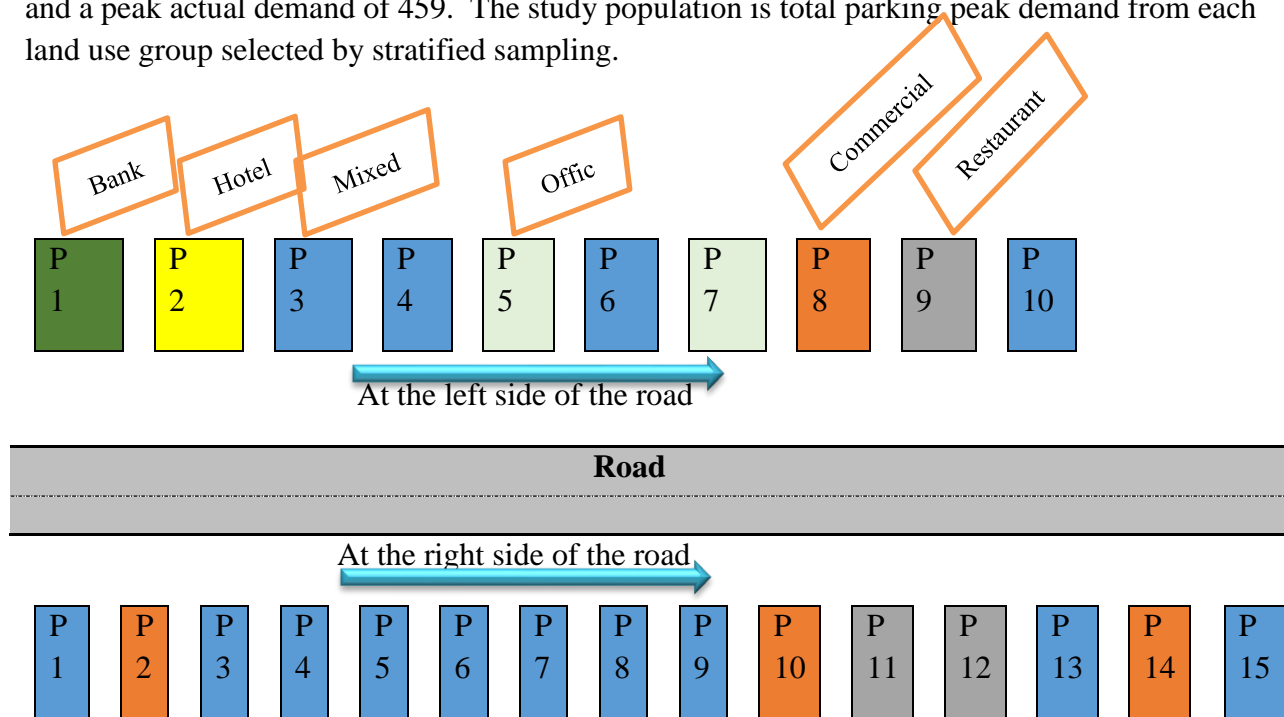
There for the current observed/actual demand requires a minimum of $146+40=186$ additional parking spaces where as the ITE standard recommends an additional parking space of $703+266=969$ which is the sum of parking spaces both at the right and left side of the road. By considering that the ITE is a high standard manual and it follows the high standard living style of

most developed countries, it may not be appropriate directly applying it in our country. So taking the average of the two /577 parking spaces are better.

4.5 Parking survey/questionnaire

4.5.1 Study population size

The study area has a total of 25 parking lots from which 13 are mixed-use building 4 commercial, 3 office, 1 bank, 2 café & restaurant and 1 hotel with a total of 413 parking spaces and a peak actual demand of 459. The study population is total parking peak demand from each land use group selected by stratified sampling.



- ✓ From the above parking lot-diagrams two from the right and one from the left mixed-use parking lots were selected by systematic random sampling considering the factors such as parking capacity, problems seen, location and purpose (i.e. parking-lot 3,15 and 6).
- ✓ From the commercial parking lots one from the right and one from the left side were selected (i.e. parking lot 10 and 8)
- ✓ From the café and restaurant parking lots one from the right was selected (i.e. parking lot-12)
- ✓ From office parking lots one from the left was selected (i.e. parking lot-5)
- ✓ From bank area one parking lot from the left was selected (i.e. parking lot-1)
- ✓ From hotel one parking lot from the left was selected (i.e. parking lot-2)

Study population size = sum of peak parking demands in each selected parking lots

$$= \text{Mixed use}(16+42+14) + \text{commercial}(6+7) + \text{café \& restaurant}(9) + \text{office}(11) + \text{bank}(5) + \text{hotel}(10)$$

$$= 120$$

4.5.2 Sample Size

The sample size was determined using the formula for population proportion.

$$n = \frac{\frac{Z^2 p(1-p)}{e^2}}{1 + \left(\frac{Z^2 p(1-p)}{e^2 N}\right)}$$

Where: Z = The Z- score corresponding to the 95% confidence level which is 1.96.

e = margin of error/confidence interval

N=population size

Assumption for calculating the sample size:

- Population size=120
- Confidence level = 95%
- 5% margin of error/confidence interval
- 50% proportion for general level of accuracy is appropriate.

Taking the above assumption 'n' becomes **100**.

4.5.3 Results and analysis of questionnaires

4.5.3.1 Demographics

Gender of the respondent

Approximately 85 percent of the survey respondents reported that they are male and about 15 percent reported they are female.

Age of respondent

About 6% of the respondent are the age between 18-25, 48% are 25-35, 38% are 35-45 and 8% are 45 and above.

4.5.3.2 Are you a resident, visitor, business man, or member of the student or worker?

Drivers were asked whether they are a resident, visitor, business man, or student/worker. About 49% of the respondents reported they are residents, 11% of them are visitors, 26% are business men and the remaining 14% are student or worker.

4.5.3.3 Which vehicle type do you mostly drive?

Drivers were asked which vehicle type they drive mostly. These questions, drivers were able to mark response choices. Public transportation: taxi, bus; Private car and Governmental organization transport. Overall, 27% of respondents indicated that they use public transport vehicles, 59% of respondents reported that they mostly use private cars and the remaining 14% use government organization transport.

4.5.3.4 How many times do you park in the area within a week?

Driver reported from the multiple choices how many times as they park in the area within a week. 10% of respondents reported that they park in the area 2-3 days, 24% reported 3-5 days, 47% reported 5-7 days and the remaining 19% reported sometimes.

4.5.3.5 Most of the time at which parking type do you park?

Drivers reported the type of parking places where they used to park at most of the time from the multiple choices. About 17% of the respondents reported private off-street parking; about 7% reported private building parking, about 10% reported public parking, about 61% reported on-street parking and the remaining 5% reported government organization parking.

4.5.3.6 How would you characterize your ability to find parking lots?

Drivers were asked how characterize they encounter finding available parking facilities. Among the overall sample, no one say it's easy to find parking spaces, 20% of the respondents reported its somewhat easy, 32% indicated that its somewhat difficult and 48% of the respondents reported its difficult.

4.5.3.7 Why do you park in the area most of the time?

Drivers were asked why they park in the area most of the time. About 4% of the respondents say for shopping, 8% of the respondents say to visit restaurants/bar, 42% say to visit personal services and 46% of the respondents say to work.

4.5.3.8 What do you estimate the average length of time you park in the area on a typical trip?

Drivers reported the average length of time they park in the area on a typical trip. 24% of the respondents reported less than one hour, 33% of the respondents reported one to two hours, 23% of the respondents reported two to four hours, 13% of the respondents reported four to eight hours and the remaining 7% respondents reported more than eight hours.

4.5.3.9 How do you characterize the parking fee in the area?

Drivers were asked how they characterize the parking fee in the area. 14% of the respondents say less than expected, 12% of the respondents say more than expected and 74% of the respondents say adequate.

4.5.3.10 Should the City administrator finance and build additional parking in the area?

Drivers were asked whether the city administrator finance and build additional parking in the area. 27% of the respondents say yes-on its own, 69% of the respondents say yes-in partnership with the private sectors and the remaining 4% say no.

4.5.3.11 Which parking type do you prefer if the City administrator finance and build?

Drivers were asked which parking type they prefer if the city administrator finance and build. 72% of the respondents reported building parking whereas the remaining 28% of the respondents reported on-street parking.

4.5.3.12 Are the ways finding signs in the area easy to follow and to get destinations?

Drivers were asked the way of finding parking signs in the area. 11% of the respondents say yes, 12% of the respondents say difficult to understand, 52% of the respondents say no parking signs at most of the places and 25% of the respondents say there are no any parking signs at all.

4.5.3.13 Which problem do you think is the main cause of parking problem in the area?

Drivers reported the main problem they think that causes parking problem in the area. About 60% of the respondents reported shortage of on-street and off-street parking facilities 11% of the respondents reported lack of knowledge in parking users and 29% of the respondents reported parking management policy problem.

4.5.3.14 If you have any suggestions or ideas to improve parking and way findings please write them in the space below:

Finally the drivers were asked to give their suggestions or ideas to improve the current parking supplies. Most of the respondents reported as there is a shortage of on-street and off-street parking supplies in the area, the city administrator should build additional parking facilities specially they prefer building and public parking facilities. They also suggests as the parking signs should be provided in the area in addition to parking policy preparation.

Analysis

From the questionnaires distribute to strength the parking demand of the area the following analysis are formulated:

Majority of the respondents were from the questionnaires collected majority of the respondents were male and young/ the age between 25 to 35 years. About half of the respondents were residents of the area and more than half of the respondents use private cars and parks in the area 5 to 7 days a week with average parking duration of one to two hours within a day in a certain parking lot. This indicates that as the customers uses the parking lots frequently for a long period

they need off-street parking facilities to afford for long-term usages. Majority of the respondents use on-street parking facilities due to lack of sufficient parking facilities and they say it's difficult to find parking spaces within the street. Even though the current parking fee is almost fair and appropriate, some of the drivers are not willing to pay it. In the future most of the drivers want for building parking rather than on-street parking facility.

Customers also reported that absence of parking marks and signs are creating inefficient utilization of parking spaces due to confusion of the availability of parking spaces and whether a certain parking space is restricted or not. In addition to these customers are also suggests the parking meter technology which enables to give information about the availability of parking spaces in each parking lot and makes parking fee simple by smart card system.

Chapter 5 Conclusions and Recommendations

5.1 Conclusions

This research sought to understand the parking demand and supply characteristics for Arat kilo to piazza road. The actual weekday and weekend site survey from the 8:00AM morning to 6:00PM afternoon was made to calculate the peak demand of the area in addition with some questionnaires distributed to support the demand. The license plate survey was also made to support the actual parking space supply of the area.

The study area has a total of 413 parking spaces from which 199 are on-street 180 are off-street and 34 are building parking spaces with average turnover of 1.82 vehicles/hr., average parking duration of 34.24 minute/vehicles and average occupancy of 86.4%.

From the result average parking duration of 34.24 minute/vehicles indicates most vehicles are parked for long period of time, it shows that almost two vehicles are parked within an hour. From the turnover result of 1.82vehicles/hour, it is possible to say that the rate of usage of parking space is fair or the frequency of space availability is moderate.

Average occupancy of 86.4% shows the parking space coverage of the area is high and considered to be full. Since someone looking for a space will not find an empty one easily and may need to circle as few times before one becomes available.

The peak demands vary along the day with respect to the purpose of the service. Mostly the peak demand is seen in the morning between 2:00AM to 3:00AM, in the lunch time between 6:00AM to 7:00 and in the afternoon between 10:00AM to 12:00PM.

Parking spaces within the area are used by shoppers, cinema house customers, café, bar and restaurant users, bank customers and government and private office workers, who at certain times will compete for the available spaces. The availability and parking fees of the area varies significantly between different roads within the study area based on the facility going on. And the parking fee is ranges from 0.5 birr to 2.00birr per 30 minutes time interval. Most of the parking lots serve parallel and perpendicular parking directions. Even if this type of parking is more scalable or requires little parking space than parallel and angular parking facilities, it causes obstruction and accident to the road traffic.

The demand estimation was done by land use analysis. The actual demand rate indicates the community around this area needs additional 186 parking spaces whereas the ITE standard recommends 969 parking spaces to afford the existing demand.

To support the current parking demand and supply of the area some questionnaires which contain 15 questions with a sample size of 100 was distributed to the drivers. From the questionnaires

collected majority of the respondents were male and the age between 25 to 35 years. About half of the respondents were residents of the area and more than half of the respondents use private cars and parks in the area 5 to 7 days a week with average parking duration of one to two hours within a day in a certain parking lot. Majority of the respondents use on-street parking facilities and they say it's difficult to find parking spaces within the street. Even though the current parking fee is almost fair and appropriate, some of the drivers are not willing to pay it. In the future most of the drivers want for building parking rather than on-street parking facility.

Generally the available parking spaces are not balanced with the current demand of the area this and the following other problems are observed in the study area

- Absence of constructed off-street parking facilities
- old buildings are running without installed parking spaces
- Lack of parking signs that guides the users easily to where parking space is available.
- Lack of parking policy and management.

5.2 Recommendations

The following measurements are recommended for the study:

- The government should develop parking policy and strategy in national level that used to improve the parking usage of the area and brings an effective and efficient usage of parking spaces.
- As new building development occurs, ensure that the parking needs are addressed according to the standards and the government should take appropriate measurements for those that are not constructed based on the standards.
- The government should construct and widely spreads smart parking facilities as being started in some selected areas of the city. This type of parking space is not located on road side, in which any member of the public can park. It should be constructed with the mandate of specific regulations (e.g. maximum stay hours or minutes, payment of fee etc) and can be operated by public or private sector or organization. This type of parking lot is best fitted at the road from parking lot-1(at Meseret café) to parking lot 13(at licha zone near Ras Mekonnen bridge) It promises to provide accessibility for people to visit downtown or any places within the city because the people are confidence of where to park.
- Working with parking stakeholders, it should be ensured that on-street and off-street parking options are well coordinated, quick turnover for retail/restaurant uses while off-street parking options are used for employee parking and other long-term needs.
- Develop a timeline and funding sources to upgrade parking meter technology and equipment, such as installing meters able to accept credit and debit cards, multi-space meters and other improvements to enhance the customer experience. This technology also allows for better monitoring of peak hour usage so rates can be adjusted to reflect demand and enforcement issues can be eased.
- Make the best use of all available spaces, using shared parking and limited use strategies. This includes using of parking spaces with the nearest available parking spaces whenever the current parking space supply is full.
- Continuously educate the public on availability and location of parking to meet the need for more information about parking options and to adapt angular parking facilities as it is the gentler turn allows easier and quicker parking, narrower aisles, and thus higher density than perpendicular parking.
- Develop a standardized parking signs and other information systems throughout the area that makes the drivers easy to find parking spaces and direct them to the parking supply available in the nearest location this finally facilitate the parking usages of the area.
- Off-street parking facilities/spaces should be provided at designated areas of the study area. Insufficient off-street parking facilities results in on-street parking which reduces the effective width of roads, thus leading to obstruction of traffic flow.

- Parking restrictions are to be enforced at Ras Mekonnen bridge to Piazza Round about where only one sided on-street parking is allowed, and traffic police will need to be empowered to do so

Future studies

- Derivation of parking demand rates in national level.
- Forecasting and analysis of future parking demand based upon possible development scenarios.
- Development of parking design manual and demand model.
- Impact assessment of smart parking in the case of Addis Ababa city.

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Appendix A-1

Data collection sheet: license plate survey

Date:					Recording time:				
Weather:					Location:				
Bay No.	Time(min)				Time(min)				Turn over
	0-15	15-30	30-45	45-60	15	30	45	60	
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
	Accumulation								
	Occupancy								

	Unit
Average turn over	Vehicles/hr.
Parking volume	Vehicles
Average duration	Minute/vehicles
Average occupancy	%
Parking load	Vehicles hours
Parking capacity	Vehicles hours

Appendix A-2

Parking volume at the right side of the road in each time interval of the day

Week-day	Hour starting																																						
	8am-9 am			9am-10 am			10am-11 am			11am-12pm			12pm-1pm			1pm-2pm			2pm-3pm			3pm-4pm			4pm-5pm			5pm-6pm											
	On-street	Off -street	Building	On-street	Off -street	Building	On-street	Off -street	Building	On-street	Off -street	Building	On-street	Off -street	Building	On-street	Off -street	Building	On-street	Off -street	Building	On-street	Off -street	Building	On-street	Off -street	Building	On-street	Off -street	Building									
1		12				7				11				9				10				5				8				8				13				9	
2		2				3				4				1				0				4				2				1				2				3	
3		12				10				14				14				15				14				15				16				12				16	
4		8				10				7				8				7				11				7				9				15				7	
5		9				10				7				8				6				11				7				5				6				8	
6		8	3			10	2			8	4			9	3			6	2			12	4			10	2			8	4			9	5			7	4
7	7	11	9	7		12	9	6		10	10	5		10	9	6		9	8	4		11	11	8		12	10	7		12	9	5		11	9	4		13	9
8		8				7				4				9				4				9				5				5				11				10	
9		9				8				6				7				10				10				11				12				11				5	
9.5		2				3				4				2				1				3				2				1				0				1	
10		4				5				6				6				5				5				3				6				6				6	
11		3				2				5				3				0				2				1				0				0				1	
12		5				6				1				9				1				2				3				4				1				7	
13		3				2				5				5				2				2				4				1				3				1	
14		3				3				3				2				8				8				8				5				2				4	
15		32*				31*				27*				26*				29*				31*				28*				42*				38*				31*	

Appendix A-3

Parking volume at the left side of the road in each time interval of the day

Week -day	Hour starting																													
	2-3 AM			3-4 AM			4-5 AM			5-6 AM			6-7 AM			7-8 AM			8-9 AM			9-10 AM			10-11 AM			11AM-12 PM		
	On -street	Off -street	Building	On -street	Off -street	Building	On -street	Off -street	Building	On -street	Off -street	Building	On -street	Off -street	Building	On -street	Off -street	Building	On -street	Off -street	Building	On -street	Off -street	Building	On -street	Off -street	Building			
1		3			4			4			5			5			2			5			4			3			5	
2		6			6			7			9			8			7			6			8			10			8	
3		0			0			4			8			7			9			6			5			9			8	
4		8	7		7	4		8	7		7	5		6	8		7	6		7	5		6	8		8	8		7	4
5		9			7			8			6			9			10			8			9			8			6	
6		11			1			8			9			6			14			12			12			13			5	
7		8			7			1			9			8			13			11			11			11			8	
8	4			7			6			5			6			4			5			5			4			5		
9	1			2			4			9			8			6			10			6			10			15		
10	92			113			121			135			131			151			141			132			138			134		

Appendix B

Questionnaire form

Raw public parking survey data were collected by the following questionnaires:

1. Gender
 - Male
 - Female
2. Age
 - 18-25
 - 25-35
 - 35-45
 - 45 and above
3. Are you a resident, visitor, business man, or member of the student, faculty, or staff?
4. Which vehicle type do you mostly use?
 - Public transportation: taxi, bus
 - Private car
 - Governmental organization transport
5. How many times do you park in the area within a week?
 - 2-3 days
 - 3-5 days
 - 5-7 days
 - Sometimes
6. Most of the time at which parking type do you park?
 - Private off-street parking
 - Private building parking
 - Public parking
 - On-street parking
 - Governmental organization parking
7. How would you characterize your ability to find parking lots?
 - Easy
 - Somewhat easy
 - Somewhat difficult
 - Difficult
8. Most of the time, why do you park in the city?
 - To shop
 - To visit restaurants/bars

- To visit personal services
 - To work
 - To go to school
9. What do you estimate is the average length of time you park in the city on a typical trip?
- Less than one hour
 - One to two hours
 - Two to four hours
 - Four to eight hours
 - More than eight hours
10. How do you characterize the parking fee in the area?
- Less than expected
 - More than expected
 - Appropriate/balanced
11. Should the City administrator finance and build additional parking in the area?
- Yes – on its own
 - Yes – in partnership with the private sector
 - No
12. Which parking type do you prefer if the City administrator finance and build?
- Off-street parking
 - On-street parking
13. Are the ways finding signs in the area easy to follow and to get destinations?
- Yes
 - Difficult to read and understand
 - There are no parking signs at most of the places
 - There are no parking signs at all.
14. Which problem do you think is the main cause of parking problem in the area?
- Shortage of on-street and off-street parking facility supplies.
 - Lack of skill in parking usage
 - Parking management and policy problem.
15. If you have any suggestions or ideas to improve parking and way findings please write them in the space below:

Appendix C

Pictures showing different activities and problem observed

