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Parking Problems in Khartoum Center

مشاكل أماكن الوقوف بوسط الخرطوم

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الآية الكريمة

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

"وَيَسْأَلُونَكَ عَنِ الرُّوحِ ۗ قُلِ الرُّوحُ مِنْ أَمْرِ رَبِّي وَمَا أُوتِيتُمْ مِنَ الْعِلْمِ إِلَّا قَلِيلًا"

صدق الله العظيم

"سورة الإسراء الآية (85) "

Dedication

To my dear mother and father, lovely wife, beautiful kids, brothers and sisters, friends, teachers, for always supporting, helping, and Standing with me.

Author

Acknowledgment

Firstly, I would like to express my sincere gratitude to my advisor Dr. Abdel Aziz Hassan for the continuous support of my study and research, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis.

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Abstract

Lack of parking policy has become one of the most important aspects of transportation. The parking issue is trending all around the world especially in Central Business District (CBD). Metropolitan cities are affected mainly by this problem. Khartoum is one of metropolitan cities in Sudan which is also affected by the parking problems. Insufficient off-street parking facilities and tendency to park the vehicles near to the destination lead to high parking demand. The vehicle ownership and the poor quality of transit system are also the reasons for increase in demand. These factors result in reduction of the main carriageway width, decrease in flow speed and creates unnecessary congestion to traffic flow which creates cruising of parking. Proper parking design and management policy should be implemented to control the demand.

In this research, parking demand in Khartoum CBD have been studied in order to estimate the availability of parking spaces by measuring the length of the road, the width of the road, the number of major intersections and their type control, kerb height, physical obstructions and forbidden areas and the general traffic characteristics of each road that govern the selection of reasonable type of on-street parking.

Forty seven (47) streets in Khartoum CBD have been selected as the case study, four of them were fully observed as a pilot zone, these are Elbaladyah Street, Elgamhoryah Street, Alqasr Street and Abdulmuniem Street. Some field works were conducted like survey works with real coordinates include full plan of the street, kerb height, intersection details, existing Off-street parking and Photographs representing its condition.

The analysis, calculations, design and drawings were carried out in addition to conclusion and recommendations of parking regulation as a tool of Traffic Management policy in Khartoum CBD were mentioned at the end chapter of this thesis.

المستخلص

مواقف السيارات أصبحت من أكثر المشاكل التي تواجه مهندسي النقل والمرور وذلك لعدم وجود سياسات واضحة في هذا المجال وخاصة في المدن والأماكن الحضرية وبشكل أكبر في أواسط المدن حيث تتركز المرافق التعليمية والتجارية والصحية.

ولاية الخرطوم كمنطقة حضرية وعاصمة البلاد مثلها مثل العواصم الأخرى في أنحاء العالم تعاني من هذه المشكلة وبشكل رئيس في أواسط المدن الثلاث، حيث أن عدم وجود المساحات الكافية وعدم إنتظام الحركة يؤدي إلى ضيق مسار المركبات والوقوف المتكرر ومن ثم إرتفاع الطلب على مواقف السيارات وتقليل مستوى الخدمة. لذلك يجب تنفيذ سياسة تصميم وإدارة مناسبة لمواقف السيارات للحد من هذه المشكلة للتحكم في الطلب. في هذا البحث تم دراسة وتقدير أماكن وقوف السيارات في الشوارع في منطقة وسط الخرطوم وذلك عن طريق قياس طول الشارع، عرض الشارع، عدد التقاطعات بالشارع ونوعية تحكم حركة المرور لكل تقاطع، العوائق الفيزيائية، المناطق المحظورة من التوقف والخصائص العامة لحركة المرور والتي تحكم وبشكل رئيسي نوع وعدد المواقف المناسبة لكل شارع.

أجريت الدراسة لمنطقة وسط الخرطوم وذلك بإختيار سبعة وأربعون (47) شارع لتحديد نوع وعدد المواقف المناسبة لكل شارع متضمنة أربعة شوارع تمت دراستها بالتفصيل بالإضافة الى التصميم الهندسي للمواقف كنموذج لمنطقة الدراسة وهي شارع البلدية، شارع الجمهورية، شارع القصر وشارع عبدالمنعم، هذا وتم تحليل البيانات وإعداد التصميم الهندسي المناسب ومن ثم تلخيص التوصيات اللازمة لحل مشكلة المواقف كواحدة من أهم الطرق لنظم إدارة حركة المرور في منطقة وسط الخرطوم .

TABLE OF CONTENTS

| ITEM | PAGE |
|---|-----------|
| Dedication | II |
| Acknowledgements | III |
| Abstract | IV |
| Table of Contents | VI |
| List of Tables | VIII |
| List of Figures | IX |
| List of plates | X |
| List of symbols/Abbreviations | XI |
| List of Appendixes | XII |
| 1 | 1 |
| CHAPTER ONE : INTRODUCTION | |
| 1.1 Background | 2 |
| 1.2 Objectives | 3 |
| 1.3 Problem Statement | 3 |
| 1.4 Study Area | 3 |
| 1.5 Structure of the Dissertation | 4 |
| 2 | 5 |
| CHAPTER TWO : LITERATURE REVIEW | |
| 2.1 Overview | 6 |
| 2.2 Type of Parking | 6 |
| 2.2.1 On street parking | 6 |
| 2.2.2 Off street parking | 9 |
| 2.2.3 Multistory Parking | 10 |
| 2.3 Effect of Parking. | 11 |
| 2.4 Parking Statistics. | 12 |
| 2.4.1 Parking Accumulation. | 12 |
| 2.4.2 Parking Volume. | 13 |
| 2.4.3 Parking Load. | 13 |
| 2.4.4 Average Parking Duration. | 13 |
| 2.4.5 Parking Turn Over (PTO). | 14 |
| 2.4.6 Parking Index. | 14 |
| 2.5 Parking Survey. | 14 |
| 2.5.1 Introduction. | 14 |
| 2.5.2 Choosing When to Survey. | 15 |
| 2.5.3 Supply Survey. | 16 |
| 2.5.4 Occupancy Survey. | 17 |
| 2.5.5 Beat Survey. | 18 |
| 2.5.6 Continuous Observation survey Techniques. | 23 |
| 2.5.7 Recording Number Plates. | 24 |
| 2.6 Parking Control. | 25 |
| 2.7 Parking Design. | 26 |
| 2.7.1 Introduction. | 26 |
| 2.7.2 On-Street Parking. | 27 |
| 2.7.3 Off-Street Parking. | 30 |
| 3 | 38 |
| CHAPTER THREE : RESEARCH METHODOLOGY | |
| 3.1 General. | 39 |
| 3.2 Mechanism of Research. | 41 |

| | | |
|----------|---|-----------|
| 3.3 | Technical Methodology. | 45 |
| 3.3.1 | Data Collection. | 45 |
| 3.3.2 | Data Process. | 48 |
| 4 | CHAPTER FOUR: PARKING CONDITION IN CBD | 50 |
| 4.1 | Over view | 51 |
| 4.2 | Khartoum CBD. | 54 |
| 4.3 | Parking Condition. | 55 |
| 4.3.1 | On-Street Parking. | 55 |
| 4.3.2 | Institutional Parking. | 57 |
| 4.3.3 | Parking in Service Areas. | 57 |
| 4.3.4 | Parking Control. | 59 |
| 5 | CHAPTER FIVE: DESIGN OF PARKING | 60 |
| 5.1 | Study Zone. | 61 |
| 5.2 | Design Assumptions. | 62 |
| 5.3 | Design Requirements. | 63 |
| 5.4 | Parking Calculations. | 63 |
| 5.5 | Analysis & Results. | 64 |
| 5.6 | Pilot Zone. | 66 |
| 5.6.1 | Concept. | 66 |
| 5.6.2 | Methodology. | 67 |
| 5.6.3 | Finding and Output. | 67 |
| 6 | CHAPTER SIX : CONCLUSION & RECOMMENDATIONS | 76 |
| 6.1 | Conclusion | 77 |
| 6.2 | Recommendations | 78 |
| | REFERENCES | 80 |
| | APPENDIXES | 81 |

LIST OF TABLES

| TABLE NO | ITEM | PAGE |
|----------|---|------|
| 2.1 | Level of under-counting with a 30 minutes beat survey. | 22 |
| 2.2 | Illustrate Wheel Stop Distances | 35 |
| 4.1 | Shows the population of Khartoum metropolitan | 48 |
| 4.2 | 2-way traffic volume between the three provinces of Khartoum state. | 49 |
| 4.3 | Parking Demand Ratios | 50 |
| 5.1 | Shows the Name of Studied Roads. | 56 |
| 5.2 | Shows Summary of Design Assumption. | 58 |
| 5.3 | Shows the Calculated Number of Parking Spaces. | 59 |

LIST OF FIGURES

| FIGURE NO. | ITEM | PAGE |
|-------------------|---|-------------|
| 1.1 | Shows the study area in Khartoum CBD. | 4 |
| 2.1 | Illustration of Parallel parking. | 7 |
| 2.2 | Illustration of 30° parking. | 7 |
| 2.3 | Illustration of 45° parking. | 8 |
| 2.4 | Illustration of 60° parking. | 8 |
| 2.5 | Illustration of 90° parking. | 9 |
| 2.6 | Illustration of off street parking. | 9 |
| 2.7 | Types and System of Multistory Parking. | 11 |
| 2.8 | Shows Parking Accumulation. | 13 |
| 2.9 | Example of car park beat survey route. | 19 |
| 2.10 | Survey design for street parking. | 20 |
| 2.11 | Shows on/off street Parking design parameters. | 29 |
| 2.12 | Example of an Off-Street Car Park. | 31 |
| 2.13 | Location of Wheel Stop. | 36 |
| 3.1 | Digital map of studied Roads. | 46 |
| 3.2 | Shows the Pilot Zone of Study Area. | 47 |
| 4.1 | Map Shows Sudan Country and the location of Khartoum State. | 51 |
| 4.2 | Map shows Entrance of Khartoum CBD. | 52 |
| 4.3 | Limit of Khartoum CBD. | 54 |

LIST OF PLATES

| PLATE NO | ITEM | PAGE |
|-----------------|---------------------------------------|-------------|
| 1 | Multi Story Parking | 10 |
| 2 | On Street Car Parking. | 51 |
| 3 | On Street Parking in Khartoum Centre. | 51 |
| 4 | Basement Parking. | 52 |
| 5 | Parking in Service Area. | 53 |

LIST OF SYMBOLS/ABBREVIATIONS

| | |
|--------|---|
| CBD | Central of Business District. |
| LRT | Railway Station. |
| PTO | Parking Turn Over. |
| PI | Parking Index. |
| IHT | Institute of Highway and Transportation. |
| PCU | Passenger Car Unit. |
| KTMMMP | Khartoum Transportation and Mobility Master Plan. |
| PST | Payment Technologies. |
| TMS | Traffic Management System. |
| IRC | Indian Roads Congress. |

LIST OF APPENDICES

| APPENDIX NO. | ITEM | PAGE |
|-----------------|--|------|
| 1 | Lay out Plan of a pilot Zone. | 82 |
| 2 | Lay out plan of Elbaladyah Street. | 83 |
| 2.1 | Section one: From Ali Abdulateef to Abdulmuniem Street. | 84 |
| 2.2 | Section Two: From Abdulmuniem Street to Algasr Street. | 85 |
| 2.3 | Section Thee: From Algasr Street to Maknimir Street. | 86 |
| 2.4 | Section Four: From Maknimir Street to Tabyah Street. | 87 |
| 3 | Lay out plan of Elgamhoryah Street. | 88 |
| 3.1 | Section one: From Ali Abdulateef to Abdulmuniem Street. | 89 |
| 3.2 | Section Two: From Abdulmuniem Street to Algasr Street. | 90 |
| 3.3 | Section Three: Algasr Street to Maknimir Street. | 91 |
| 3.4 | Section Four: Maknimir Street to Osman Dignah. | 92 |
| 4 | Lay out plan of Algasr Street. | 93 |
| 4.1 | Section one: From Eljamah Street to Elgamhoryah Street. | 94 |
| 4.2 | Section Two: From Elgamhoryah Street to Elbaladyah Street. | 95 |
| 4.3 | Section Three: From Elbaladyah Street to Elsyed Abdurahman Street. | 96 |
| 4.4 | Section Four: From Elsyed Abdurahman Street to Eltabyah Street. | 97 |
| 5 | Lay out plan of Abdulmuniem Street. | 98 |
| 5.1 | Section one: From Nile Street to Elgamhoryah Street. | 99 |
| 5.2 | Section Two: From Elgamhoryah Street to Elbaladyah Street. | 100 |
| 5.3 | Section Three: From Elbaladyah Street to Elsyed Abdurahman Street. | 101 |
| 5.4 | Section Four: From Elsyed Abdurahman Street to Eltabyah Street. | 102 |

CHAPTER ONE
INTRODUCTION

CHAPTER ONE

INTRODUCTION

1.1 Background

Effective downtown parking management is vital to the economic success, urban form, and cultural vibrancy of any downtown area and is an essential component to successful transportation systems. Vehicles need a parking space at each destination. Parking facilities, whether on-street or off-street, are significant types of land uses. Parking facility and infrastructure design both influence the physical character of each adjacent land use and greatly impact how a person views a building and how they interact with urban spaces. Parking is often one of the last interactions a resident or visitor has with a destination; this illustrates how parking management can greatly impact their overall experience.

Khartoum centre as a Central of Business District (CBD) is a dynamic and thriving community - a city of government, education and commerce. While experience significant growth and prosperity, the city is faced with many of the problems of modern day living, including parking problems. The availability of central area parking is a significant issue for many cities. Parking problems are often a sign of the successes of a central area. The demand for parking is directly correlated to growth or decline in the availability of business, employment, shopping and dining opportunities. Due to the efforts and investments of the government, property owners, merchants and the municipality, the Khartoum central are continues as a vibrant economic core city.

1.2 Objectives

The main objectives of this research are to:

1. Design of On-Street parking in Khartoum Centre in order to improve traffic flow and to reduce congestion as well as environmental impact and air pollution.
2. Encourage off-street and Multi-Story parking with application of parking Paid policy as a tool of Traffic Management System (TMS) in Central of Business District (CBD).

1.3 Problem Statement

Parking is one of the major problems that are created by the increasing road traffic. It is an impact of transport development. The availability of less space in urban areas has increased the demand for parking space especially in areas like Central Business Districts (CBD). This affects the mode choice also. This has a great economical impact.

1.4 Study Area

The area of study locates on Khartoum centre, specifically the area which is bordered by Nile Street at the north, Eltabyah Street at the south, White Nile in the west and military bridge in the east, as shown clearly in Fig (1.1) below.

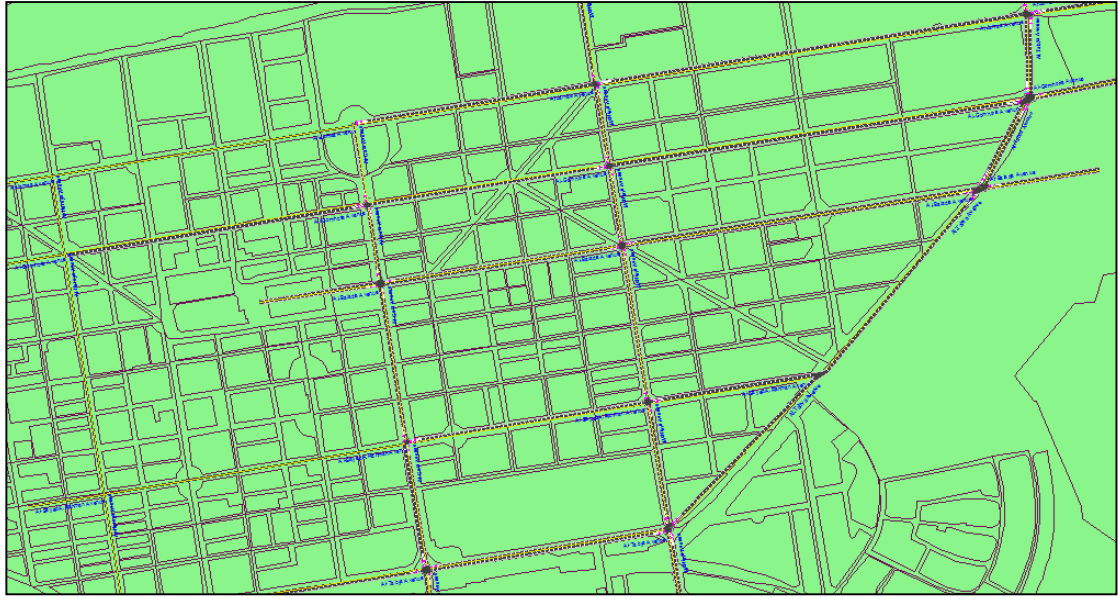


FIG 1.1 shows the study area in Khartoum CBD.

1.5 Structure of the Dissertation

The research include six chapters, these are:

Chapter one : Introduction.

Chapter two : Literatures Review.

Chapter three: Research Methodology.

Chapter Four: Parking Condition in Khartoum CBD.

Chapter Five: Design of parking and

Chapter six : Conclusion and Recommendations.

CHAPTER TWO
LITERATURE REVIEW

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

Parking is one of the serious problems that confront the urban planner and traffic engineer. Before taking any measures for the betterment of conditions, data regarding availability of parking space, extent of its usage and parking demand is essential. It is also required to estimate the parking fares also. Parking surveys are intended to provide all these information. Since the duration of parking varies with different vehicles, several statistics are used to access the parking need.

2.2 Type of Parking

2.2.1 on - Street Parking

On street parking means the vehicles are parked on the sides of the street itself. This will be usually controlled by government agencies itself. Common types of on-street parking are as listed below. This classification is based on the angle in which the vehicles are parked with respect to the road alignment. As per IRC (The Code of Practice for Road Markings st "First Revision" IRC: 35-1997 published by Indian Roads Congress) the standard dimensions of a car is taken as 5× 2.5 meters and that for a truck is 3.75× 7.5 meters.¹

1. Parallel parking: The vehicles are parked along the length of the road. Here there is no backward movement involved while parking or unparking the vehicle. Hence, it is the safest parking from the accident perspective. However, it consumes the maximum curb length and therefore only a minimum number of vehicles can be parked for a given kerb length. This method of parking produces least obstruction to the on-going traffic on the road since least road width is used. Parallel parking of cars is shown in figure 2.1 below, the length available to park N number of vehicles,

$$L = N/ 5.9..... (2-1)$$

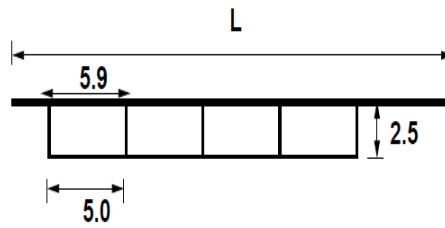


Fig 2.1: Illustration of Parallel parking

Resource: Transportation System Engineering (2014)

2. 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. An example is shown in figure 2.2. From the figure,

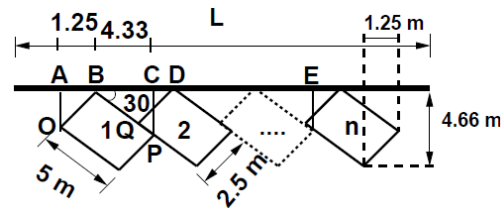


Fig 2.2: Illustration of 30° parking

Resource: Transportation System Engineering (2014)

$$AB = OB \sin 30^\circ = 1.25$$

$$BC = OP \cos 30^\circ = 4.33$$

$$BD = DQ \cos 60^\circ = 5.0$$

$$CD = BD - BC = 5 - 4.3 = 0.67.$$

$$AB + BC = 1.25 + 4.33 = 5.58.$$

$$\text{For } N \text{ vehicles, } L = AC + (N-1) CE = 5.58 + (N-1)5$$

$$L = 0.58 + 5N..... (2-2)$$

3. 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 2.3, length of parking space available for parking N number of vehicles in a given kerb is

$$L = 3.54 N + 1.77 \dots (2-3)$$

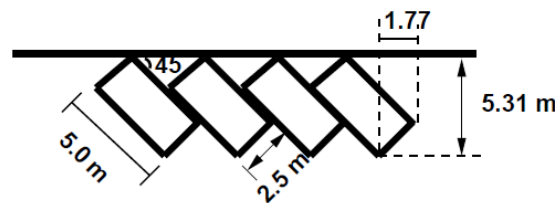


Fig 2.3: Illustration of 45° parking

Resource: Transportation System Engineering (2014)

4. 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 2.4, length available for parking N vehicles:

$$L = 2.89N + 2.16 \dots (2-4)$$

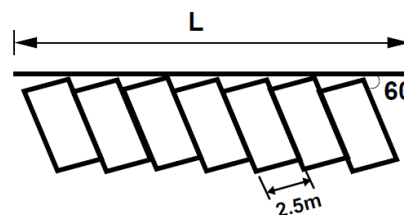


Fig 2.4: Illustration of 60° parking

Resource: Transportation System Engineering (2014)

5. Right angle parking 90°: In right angle parking or 90° parking, the vehicles are parked perpendicular to the direction of the road. Although it consumes maximum width kerb 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 kerb length. An example is shown in figure 2.5. Length available for parking N number of vehicles is

$$L = 2.5N \dots (2-5)$$

¹ Transportation System Engineering (2014).

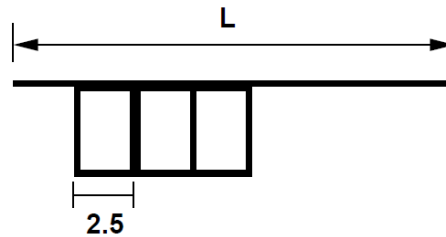


Fig 2.5: Illustration of 90° parking

Resource: Transportation System Engineering (2014)

2.2.2 Off street parking

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. ¹

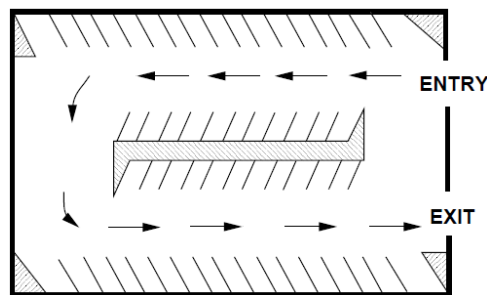


Fig 2.6: Illustration of off street parking

Resource: Parking Measures and Policies (2005)

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.

Here are some of the examples of Off Street Parking:

- Parking lots.
- Bypass road.
- Multistory Building Garage.
- Parking Lane

There are some minimum parking requirements for different types of building. For residential plot area less than 300 sq.m require only

community parking space. For residential plot area from 500 to 1000 sq.m, minimum one-fourth of the open area should be reserved for parking.

Offices may require at least one space for every 70 sq.m as parking area. One parking space is enough for 10 seats in a restaurant where as theatres and cinema halls need to keep only 1 parking space for 20 seats. Thus, the parking requirements are different for different land use zones.

2.2.3 Multistory Parking

A multi-story car park or a parking garage is a building (or part thereof) which is designed specifically to be for automobile parking and where there are a number of floors or levels on which parking takes place, It is essentially a stacked parking lot and limited to 5 till 6 stories with the total capacity up to 500 cars per lot. These types of parking apply multiple access



Plate 1: Multi Story Parking

Resource: Traffic Engineering and Transportation Planning

and exit system to avoid traffic congestion in and out. There are different types of multistory car parking:

(i) Basement parking: Appropriate for residential area, apartment, commercial complex, office complex and for area around airport that has building high control limit.

(ii) Podium parking: For medium and high density residential area, plus, office complex. Ground level until level 4 is used for the parking area, while residential units, office and other functional spaces are located above the parking level.

(iii) Independent building for multi storey car parking: For all building types that have large and adequate area for parking, such as low cost apartment, trade and city center, park and ride system at LRT station or railway station, bus station, institution, sport complex and mosque. Normally built separately if the building function is different.

(v) Roof top parking: Appropriate for shopping complex (less than 5 stories) because it saves cost compared to basement parking.

Multistory parking is divided mainly in to mechanical elevator/Automated parking and Conventional parking (self parking). The self parking system classified in to Ramps system, layout and floor system, Figure 2.7 below shows the types and system of multistory parking:

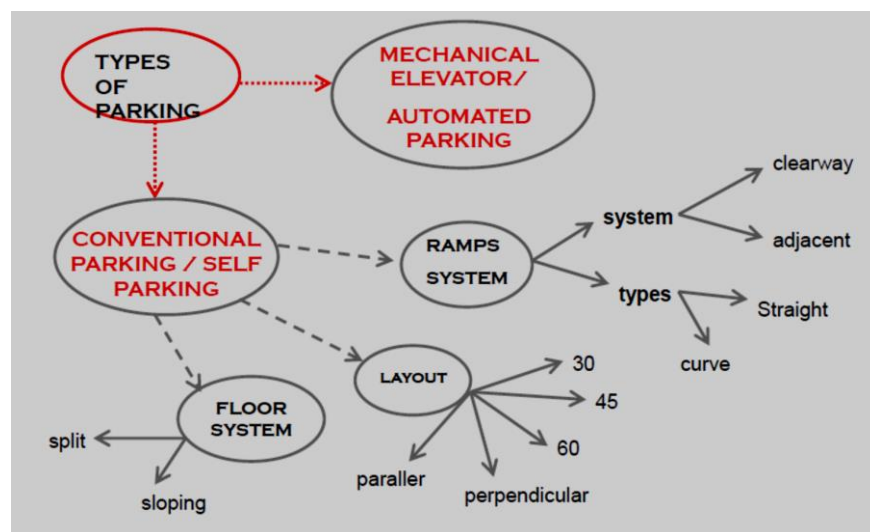


FIG 2.7: Types and System of Multistory Parking

Resource: Traffic Engineering and Transportation Planning (1987)

2.3 Effect of Parking

Parking has some ill-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. ¹
2. Accidents: Careless maneuvering of parking and unparking 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 stop- ping and starting of vehicles while parking and unparking results in noise and fumes. They also affect the aesthetic beauty of the buildings because cars parked at every available space create a feeling that building rises from a plinth of cars.

2.4 Parking Statistics

Before taking any measures for the betterment of conditions, data regarding availability of parking space, extent of its usage and parking demand is essential. It is also required to estimate the parking fares also. Parking surveys are intended to provide all these information. Since the duration of parking varies with different vehicles, several statistics are used to access the parking need. The following parking statistics are normally important.

2.4.1 Parking Accumulation

It is defined as the number of vehicles parked at a given instant of time. Normally this is expressed by accumulation curve. Accumulation curve is the graph obtained by plotting the number of bays occupied with respect to time. As shown in fig (2.8) below:

¹. Parking Measures and Policies (2005)

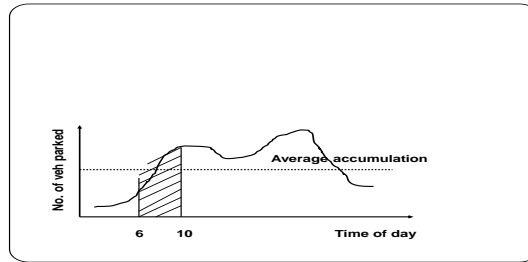


FIG 2.8: Shows Parking Accumulation
 Parking Measures and Policies (2005)

2.4. 2 Parking Volume

Parking volume is the total number of vehicles parked at a given duration of time. This does not account for repetition of vehicles. The actual volume of vehicles entered in the area is recorded.

2.4. 3 Parking Load

Parking load gives the area under the accumulation curve. It can also be obtained by simply multiplying the number of vehicles occupying the parking area at each time interval with the time interval. It is expressed as vehicle hours.

2.4.4 Average parking duration

It is the ratio of total vehicle hours to the number of vehicles parked.

$$\text{Parking Duration} = \frac{\text{Parking Load}}{\text{Parking Volume}} \dots (2 - 6)$$

2.4.5 Parking Turn-Over (PTO)

It is the ratio of number of vehicles parked in duration to the number of parking bays available. This can be expressed as number of vehicles per bay per time duration.

$$\text{Parking Turnover} = \frac{\text{Parking Volume}}{\text{no of bays available}} \dots (2-7)$$

2.4.6 Parking Index

Percentage of the theoretically available number of parking bays actually occupied by parked vehicles.

$$\text{Parking Index} = \frac{\text{No. of bays occupied} * 100}{\text{Theoretical no. of bays available}} \dots (2-8)$$

2.5 Parking Survey

2.5.1 Introduction

Every trip by a vehicle results in a parking act at the end of the trip. The importance of parking can perhaps be illustrated by the fact that, on average, a car in the UK is parked for about 23 hours a day. The vehicle may be parked on the street or off-street in a car/lorry/cycle park, or in a private garage. How vehicles arrive and depart from these parking places, how long they stay and under what circumstances define vehicular traffic and indeed some pedestrian traffic on the roads and help to determine what measures are required to meet or manage the demand. Therefore, it is very important to obtain an objective and unbiased understanding of this activity by properly constructed and conducted surveys. To allow us to understand the parking behavior, there are multitudes of parking survey techniques, which have been developed, each aimed at measuring something slightly different. Each technique is discussed below, in terms of the order of complexity.¹

¹. Traffic Engineering Design (2005)

2.5.2 Choosing when to survey

Activity will vary from day to day and season to season, and theoretical statisticians would no doubt expect any survey to be repeated for a representative number of days or periods in order to ensure a completely unbiased and representative sample, or to attach levels of uncertainty to the outcomes of surveys if collected on a single day. Unfortunately, traffic engineers seldom have the luxury of either the time or resources necessary to undertake multiple repeat surveys and have to make hard decisions based on the data they have. Therefore, we usually have to compromise with a survey on a single day and make decisions based on the results obtained, tempered by experience and common sense. In order to get the best value for money out of such a survey, it is important to take maximum advantage of any pre-existing knowledge or information. Thus, for example, if one wishes to understand 'normal' peak demand in a shopping area one might have traffic flow data which showed the busiest day of the week. Typically, traffic activity increases slightly from Monday to Friday, but shopping activity might be greatest on a Saturday and local retailers might be able to provide guidance on this. Similarly, it is clear that sales periods and the pre-Christmas rush is very busy but abnormal in that the situation only occurs for a few days a year and unless one were seeking to plan for these exceptional events, such surveys would not provide an understanding of normal conditions.

We might also reasonably believe that shopping activity would be lower during school holiday periods when people are more likely to go on holiday or to spend time with their children on other activities, although, of course, the converse would be true in areas where there is a high level of tourist activity. From the above we can see that we have begun to identify, from other information, a target time slot for a shopper parking survey which:

- Excludes school holidays and periods of abnormal demand.
- Tends towards the end rather than the beginning of the week, probably favouring Friday or Saturday. Thus we can begin to select a preferred time for our survey and with limited resources target one or two days which are more likely to give us a measure of what we are trying to understand.

2.5.3 Supply surveys

To understand existing parking behaviour, and the potential for accommodating additional parking, it is essential to have a sensible estimate of the amount of parking available in a given location. This is not always as simple as it may sound, since cars and other vehicles can be parked in many different places. On the street, in controlled parking areas, street parking is explicitly marked either as individual parking bays or as lengths of street where parking is allowed. The bays can be counted explicitly; for lengths of road where parking is allowed, it is reasonable to use an estimate of 5 meters of kerb space for each car parking space. The figure of 5 meters is derived empirically from observations in many surveys. When undertaking a survey of the spaces available on-street, it is important to remember that restrictions may only apply part of the time. This means that the supply of available parking space could vary, according to the time of day or day of the week.

Off-street, land and structures which are designed to be used as parking are often marked out with car parking spaces, which can be counted explicitly. However, it is commonplace to see yards, service roads and other areas, which were never intended as formal parking, used for parking on a regular basis. These can make a significant contribution to total parking supply. For example, in central London, a 1977 Census survey, where all the places regularly used for car parking were recorded, identified some 57 000 car parking spaces. A place was recorded if there was a vehicle parked or there was evidence, such as oil stains or exhaust marks which gave evidence of regular car parking. A later study, based on planning records,¹ suggested that there were about 34000 spaces in the same area. This is a 40% difference which is largely explained by the many places regularly used to park cars which were not formally identified as being for that purpose. More recent experience from other surveys suggests that a 25% difference between 'formal' and 'actual' parking capacities might be typical. Therefore, in order to understand parking behavior the first step is to accurately measure the amount of parking available in the study area, and experience suggests that the only reliable way of doing this is to actually

walk through the streets and count the spaces, as formal records can be a quite unreliable estimate of the true situation.

2.5.4. Occupancy surveys

The simplest parking activity survey is an occupancy survey, where the numbers of vehicles parked on a street, in a car park or parking area are periodically counted. A surveyor passes round the parking spaces at pre-determined intervals and simply counts the number of vehicles in the parking place. The surveyor may record:

- The total number of vehicles;
- The number of vehicles in each street or length of street;
- The numbers of each type of vehicle, by street or street length.

This survey technique tells us little about the vehicles, in terms of their arrival, departure and duration of stay; however, it does allow us to gauge the adequacy of the car parking available, when compared with parking demand. The surveys also tell us how busy the parking is at different times of the day or week. This survey technique is appropriate where the data is being collected to give either a broad understanding of the adequacy of the parking supply or an understanding of changes in demand over time. Thus, for example, if a car park operator wished to ensure that he always had enough parking available to be sure that a driver could always expect to find a place to park, he might set a threshold of 85% occupancy and, when demand reached this level, he would either increase supply or make the parking less attractive, by, for example, raising charges, so that demand was kept below the threshold.

The technique allows a large amount of parking to be surveyed quickly and so requires fewer survey resources than the other, more precise, methods described below. It provides us with good information about gross levels of activity but tells us nothing about the behavior of drivers.

2.5.5 Beat surveys

If we wish to have more details about the behaviour of individual vehicles, and hence an aggregate picture of parker behaviour, not just the gross level of parking demand, we can use a beat survey.

In a beat survey the surveyor visits, in turn, a pre-determined number of parking spaces and records details of the vehicles that are observed parking in each space. Typically, the surveyor would record:

- Time;
- Parking space location, this is required to allow successive observations to be compared;
- Vehicle type;
- Partial vehicle registration number (described below).

Normally, a beat survey is undertaken at regular intervals and so the time is recorded to an appropriate time block. Thus if the survey were hourly, the time would be recorded as the hour in which the survey round took place, and so on. The beat frequency will be determined by the purpose of the survey. If an area were used mostly by residents, who tend to park all day, or by workers who arrive in the morning and leave at the end of the working day, then a survey may only be required every 2 hours. However, if the survey were in a high street, where vehicles are coming and going every few minutes then a 15-minute beat might be more appropriate. More commonly, however, the survey technique is used to understand patterns of arrival and departure and duration of stay within a single day or part of the day. It can be used to distinguish between all-day and short-stay parking activity. If one wished to identify the number of long-stay parkers, three or four visits a day would allow an unambiguous quantification of long-stay parking; however, it could considerably under-count short-stay numbers. We return to discuss this issue in greater detail later.

Where it is important to identify short-stay parking, then the beat frequency needs to be much higher, possibly as often as four times an hour. Even this can under-count very short duration acts.

The methods that can be adopted to address this problem are discussed later.

If data are to be compared between succeeding beats, to see if a vehicles has moved, it is very important that the parking act being observed can be located exactly to a particular parking space. If this is not done, we could have the situation where the act observed in space ‘a’ on one pass of the surveyor is compared with an act observed in space ‘b’ in the next round. It is also very important to ensure that the surveyor passes round the beat in the same order at each visit, to avoid distortion of the results. The reason for this can be explained with a simple illustration. Figure 3.2 shows the path a surveyor is expected to follow round a car park for a 30-minute beat survey, starting at S and ending at F. If the survey takes 25 minutes to complete, with a 5-minute break at the end of each pass, then successive observations at each bay will be about 30 minutes apart. If, however, after completing a beat in the correct order the surveyor was to retrace his steps, visiting the parking bays in reverse order, then the two observations of the last bay would be only 5 minutes apart, while the two observations of the first bay would be separated by an hour.

Beat surveys can be used for surveys on the street or in a parking area. In either case careful planning is needed to ensure that each parking place can be recognized, to allow correct comparison of data between successive beats.

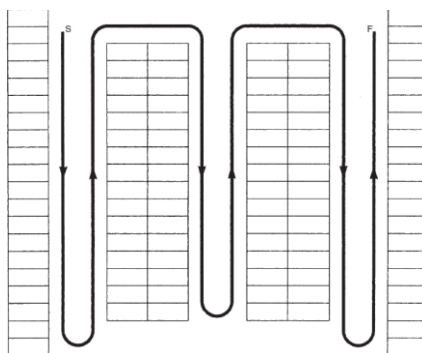


FIG 2.9: Example of car park beat survey route.

Source: Traffic Engineering Design (2005)

In most car parks the bays are marked and so location can be explicitly identified, provided the same route round the car park is followed. In a street, where there may be no markings, location is less clear and can be confusing. To avoid this, the street should be divided into nominal parking bays at the planning stage of the survey (Figure 2.10). On the day of the survey the bay limits could be marked on the kerb with chalk, or some other non-permanent marker, to aid the surveyors.

Obviously in a street with no markings drivers will not neatly park in the nominal survey bays. Any parked vehicle should be allocated to the bay it most nearly sits in. This should not cause confusion as, if a vehicle straddles two bays, it should be allocated to the bay it occupies most of. Clearly until the first vehicle leaves, a second vehicle cannot occupy the same space, so no confusion should occur.

If the purpose of the survey is to understand both the type and number of vehicles parked, then the type of vehicle seen should be recorded. Even if this information is not required, it can still be a useful way of checking data quality and helping to clarify uncertainties about the survey results.

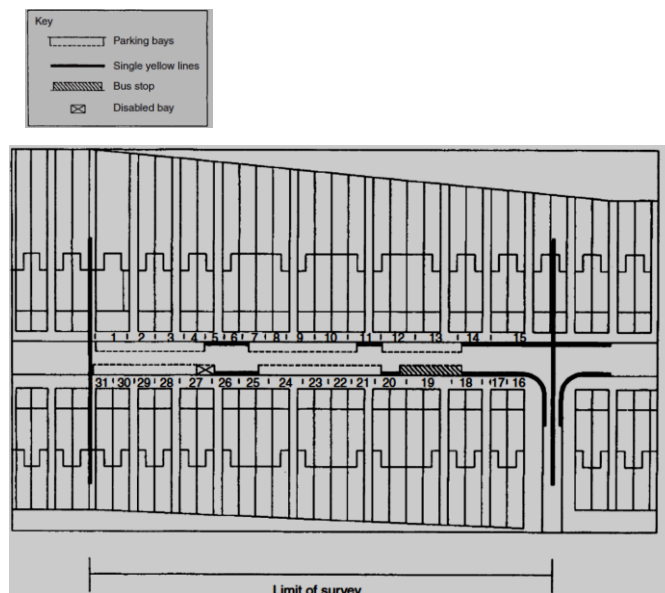


FIG 2.10: Survey design for street parking.

Source: Traffic Engineering Design (2005)

The complexity of vehicle types recorded will depend on the use to be made of the survey results. A minimum might be 'cars' and 'other vehicles'; however, if one wishes to gain a more detailed understanding of activity, 'cars' could be sub-divided into car, taxi and blue badge holder, and 'other' might be split into motorcycle, buses and various sub-categories of commercial vehicle. Figure 2.7 shows the standard vehicle classification used by the Department for Transport, and if this is used it will allow a consistency between surveys.

Whatever the categorization adopted, it is clearly important to ensure that surveyors are fully and unambiguously briefed on how to identify the types of vehicle to be used for the particular survey.

Such a survey could also be used to identify vehicles that regularly park in the same place, for example commuters who park in the same street or streets every day. In this case the survey could take place just once a day, over say a week. One would be trying to track vehicles that would move location from day to day, but stay in the same general area. The exact location would not be so important but it would be necessary to record the full registration mark so that the comparison can be made reliably.

Beat surveys compare a series of snapshots of activity and we can explain the parking behaviour of the vehicles in the area being studied by identifying the change between the snapshots. However, because the survey only observes the vehicles intermittently, we do not have a completely accurate picture of the behaviour we are observing. The survey technique suffers from two main types of inaccuracy. These are described below.

2.5.5.1 Timing Accuracy

When a vehicle is first seen on a beat the observer does not know exactly when it arrived, only that it arrived after his last visit and before the present one. Similarly, when the vehicle leaves the observer does not know the exact time of departure. It can be seen that if the beat frequency is once every t minutes then, at one extreme, the vehicle could have been parked for up to $2t$ minutes longer than the observer has logged. At the other extreme the vehicle could have arrived just as the observer reached the parking place on

one pass and left just as he/she left the parking place on another pass, in which case there would have been a zero error on the time recorded. It follows that the average error of observation is t , the beat frequency, and so when calculating length of stay all observations should have this amount added to give an unbiased estimate of duration of stay, that is if a vehicle is recorded n times, then the best estimate of its duration of stay is nt minutes.

2.5.5.2 Under Counting

With a beat survey a certain number of vehicles will arrive and depart between successive passes of the surveyor without being seen. Thus short-stay parking acts, that is those with duration of stay less than the beat frequency, will always be under-counted on a beat survey. The scale of under-counting and its importance will depend upon the specification and purpose of the survey. For example, in a long-stay car park, where the purpose of the survey is to measure the amount of long-stay parking, the fact that short-stay acts have been under-represented will be of relatively little importance. However, in a survey aimed at recording short-stay illegal parking in a restricted street, a beat could significantly under-count the number of such acts.

This factor was first recognised explicitly as a potential major error in the mid-1970s when it became clear that central London suffered from extensive illegal parking and yet standard beat surveys were failing to satisfactorily explain this behaviour. In 1977 the Greater London Council undertook a comprehensive survey of parking in central London. As part of this study the vehicles observed in a 30-minute beat survey were compared with the actual number of vehicles parking recorded by continuously observing the same streets. The results are shown in Table 2.1.

Table 2.1: Level of under-counting with a 30 minutes beat survey

| Parking type | Acts observed (%) |
|--------------------|-------------------|
| Two hour metres | 89 |
| Four hour metres | 93 |
| Residents' bays | 90 |
| Single yellow line | 41 |

Table 2.1 clearly shows that, although the under-counting on the longer-stay (compared with the beat frequency) parking is around 10%, for the short-stay (illegal) parking the survey only recorded about two in every five acts. Clearly, if the beat data had been used as a basis for judging the level of illegal parking, the scale of the problem would have been massively understated and any conclusions based on the results would have been invalid.

Recognition of this deficiency led to the development of the continuous observation street survey technique described below.

2.5.6 Continuous observation survey techniques

If we do not need to know where within a larger car park a particular car has parked, it may be more efficient to simply record the vehicles as they enter and leave the car park. In this case, the time of arrival, vehicle type and registration are recorded on entry and again on exit from the car park. The two data sets are then compared to establish how long each vehicle was parked.

This technique is more accurate than a beat survey as the duration of stay is known exactly, within the accuracy with which the data is recorded. With this type of survey, often a large car park can be observed with just two or three people. This task can also be undertaken by using video cameras to observe the entry and exit points, with analysis carried out in the office.

The data can be recorded on a form "represent Car park name, Site Number, Surveyors Name, Date, Vehicle Registration, Type, Time in and Time out." Alternatively at a very busy car park, the surveyor could record the data using a tape recorder, for later transcription and analysis. However, tape recorders should be used with care, as they introduce a whole different set of risks such as, flat batteries, reaching the end of the tape at an inopportune moment, or being unable to hear the surveyor over background noise.

The accuracy of an entry/exit survey in a car park can be transferred to observing parking in the street with a continuous observation survey. With this type of survey, each surveyor is limited to watching just a few parking

places, as many as can be seen from one location. Typically, this would be 30–40 spaces.

The surveyor is able to exactly record the arrival and departure time of each vehicle and, if appropriate, can also record other relevant information, such as:

- Whether or not the vehicle was loading;
- Whether the vehicle was illegally parked;
- If the parking was paid for and, if so, when the payment expired.

The surveyor can also record details, such as enforcement activity, if this is required. Although such continuous observation techniques should provide a very detailed understanding of parking behaviour, albeit in a relatively small area, one must recognise that the presence of a large number of survey staff with clipboards and wearing high visibility jackets could have an impact on driver behaviour, particularly those who were intending to park illegally. To overcome this, one might use remote observation using a strategically positioned video camera to observe parking behaviour in a less conspicuous way.

In 1982, the Transport Research Laboratory (TRL) developed a computer package specifically designed to undertake this type of survey called PARC.^{2,3} However, this package is no longer available, and so anyone wishing to undertake such surveys would have to develop their own analysis system.

In the parking activity survey techniques discussed above, there is generally a trade-off between coverage and depth of detail. Thus, with a very simple occupancy survey, a surveyor can cover a very large area in a given time period whereas, at the other extreme, for a continuous observation survey, using the same resources, the surveyor can only cover the spaces that can be seen from a fixed location.

2.5.7 Recording Number Plates

The discussion above suggests that in most cases time can be saved by recording a partial number plate, on the assumption that the chances of two vehicles having the same partial index and being in the same survey area is

sufficiently small not to be a concern. UK number plates have made several evolutions over the years viz:

ABC 123 prior to 1963

ABC 123 D 1963 to 1984

A 123 BCD from 1984 to 2001

AB 12 BCD from 2001

One should note, however, that with the latest evolution of the UK number plate system the first two characters represent the geographical area in which the vehicle is registered and the two numbers represent the half-year. Therefore, if one were to record the first four characters there would be a significantly higher chance of having two vehicles with the same first four characters than if one were to record the last four.

Summary

To summarize, the engineer wishing to survey parking supply or activity has a wide range of techniques to call on. The method chosen will depend upon the rationale for the survey. It is important to understand which survey is appropriate for the information required and to ensure that the correct technique is selected.

2.6 Parking Control

Parking control aimed at reducing traffic demand by controlling the supply of parking spaces and the parking fees in order to reduce the level of search traffic for empty parking spaces.

Limiting the supply of parking spaces can be an effective measure of traffic restraint, e.g. in the city center. It may however lead to long-term negative effects such as decreased turn-over for some commercial sectors. Another problem is that it is difficult to control the amount of already available private parking facilities, which may constitute the larger share of the parking supply in the area. Increased parking fees, which are another popular traffic restraint measure, may be less effective for the same reason.

Improved guidance to free parking facilities in order to reduce the amount of “search traffic” is another measure which has been tried with some success.

Location of parking spaces close to an arterial ring route in combination with shuttle services with buses to the city center is another traffic restraint measure aimed at reducing car traffic in the inner city. See also park-and-ride facilities below.

Park-and-ride facilities are parking spaces placed in the immediate vicinity of train stations or bus terminals for easy access to public transport to the city. The walking distance from the parking space should preferably not exceed 300m, and the parking fee must be very low, preferably 0. These requirements limit the extent of park-and-ride facilities provided because of the shortage of space and high land values in such locations.

The success of park-and-ride facilities depends on the following factors:

- The location and supply of parking spaces.
- Parking fee.
- Frequency of public transport departures.
- Travel time by car and public transport to the city.
- Supply and charges for parking in the city.

2.7 Parking Design

2.7.1 Introduction

The traffic engineer will need to know how best to provide parking, and how to control parking facilities, both on- and off-street, both in surface sites and structures. In this part of the research we describe the key factors that need to be considered. We also talk briefly about the need to ensure that any off-street car park is maintained in an appropriate state.

Parking provision on the highway in Great Britain is constrained by legislation. Government rules and guidelines determine where parking can be provided, the methods of control and the design standards to be used. Separate legislation applies in Northern Ireland.¹

1. Impact of Parking Supply & Demand Management on Central Business District (CBD) (2012).

Off-street car parks are provided to meet a variety of needs and the type of need can affect the design of the car park. It is widely accepted, although one has to admit without any hard evidence, that drivers will have fewer problems using lower standard car park that they are familiar with, and so car parks used by the same parkers day after day can be designed to a lower standard than one would otherwise expect. For example, it is often argued that an office car park could be designed to a lower standard than would be considered necessary for a public car park, as most of the users will be familiar with the geometry of the car park. Also if, for example, cars are parked too close together, a work colleague can usually be found and asked to move his/her vehicle with reasonable ease.

Although off-street car park design is not governed by legislation in the same way as parking on the highway, the operation of a public car park can be subject to regulation using statutory powers. Further, with the growth in concerns about safety in car parks there are new constraints that affect the design and aftercare of car parking structures.

Car parking control equipment is becoming increasingly more sophisticated, and the advent of microprocessor-based systems has allowed parking control systems to become more flexible, to meet the varied demands of users more closely. However, just as the availability of increasingly sophisticated control systems has affected the way parking is controlled off-street, on-street parking controls have seen a different kind of revolution. This has allowed more flexibility, to better meet users' needs, through the use of both high-tech and very low-tech control equipments.

2.7.2 On-Street Parking

Most roads, in most places, are not subject to any form of parking control; and it is widely believed that there is a right to park where no controls are present. This is not true. There is a right to pass along (travel) on a Road but no absolute right to stop.

Generally speaking, a vehicle parked at the kerbside, providing it is not parked dangerously or blocking traffic, will not attract police action

although, in theory, the driver could be prosecuted for causing a highway obstruction.

Formal parking on the highway can be provided for general use, or for particular groups of users. For example, kerbside parking could be set aside for a particular class of vehicles; this could include:

- All vehicles below a certain size (i.e. excluding heavy commercial vehicles)
- Solo motorcycles
- Taxis
- Buses
- Vehicles belonging to registered disabled
- Local residents' vehicles
- Local businesses
- Doctors
- Diplomats
- Police vehicles or
- Specialist vehicles, such as a mobile library.

The provision can be made all the time (at any time), on certain days or at certain times of day, and the provision can be free or be charged for. Thus, generally speaking, a taxi stand is available only to taxis at any time. However, other facilities may only operate part time.

For example, parking for residents in a city centre may only be protected during the working day, typically 08.30–18.30 hours, Saturday–Thursday, although the increasing tendency for late night opens and the introduction of Sunday trading means that the timing of many of these regulations will increasingly be rethought to be 24-hour restrictions.

Where activity is intermittent, for example, near a football stadium, restrictions may not be appropriate all the time and may only apply on match days. This type of restriction is increasingly common in areas where a local community requires occasional protection from a short-lived sudden influx of parkers associated with activity such as a sports stadium.

2.7.2.2 Parking Project Elements

- Assess Existing and Future Parking Supply and Demand.
- Review Parking Policies, Procedures and Standards.
- Develop Operational Criteria, Procedures and Strategies for Managing Parking Supply.
- Assess Potential Locations and Methods for Expansion of Parking Capacity.
- Prepare Central City Parking Master Plan.

2.7.3 Off-street car parking

2.7.3.1 General

The design of a car park structure is a complex exercise requiring a detailed understanding of many factors.

The layout of a surface car park will be greatly influenced by the shape and form of the land over which it is constructed. Obviously a flat, square site offers an easier design problem than a steeply sloping irregularly shaped one. As a rule of thumb, to estimate the number of cars that can be accommodated on a site, each car space requires about 25 square metres of space.

The basic element in a car park is a rectangular parking space, which would typically be of the order of 4.8 metres x 2.4–5 metres. However, bays could be as small as 4.6 metres x 2.2 metres, where space is at a premium, and widths could be up to 3.6 metres or more, for disabled parking.

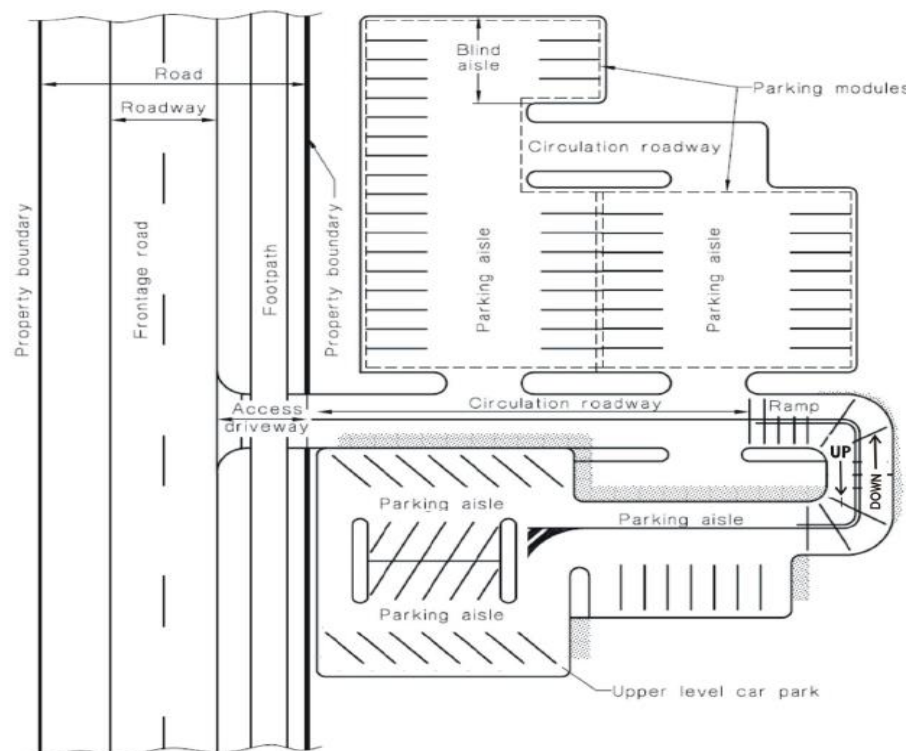
Generally speaking, short-stay car parking, where there is a constant coming and going operates more efficiently with wide bays and the Institution of Highways and Transportation (IHT) recommend a 2.5 metres bay width for short-stay car parking.⁵ Studies over time have shown that as car design has developed vehicle doors have tended to get thicker. A typical 1960s car would consist of little more than two sheets of metal with a window in between. By comparison the 21st century vehicle door also contains crash bars, airbags, electric motors speakers and storage bins. The same studies

show that, overall cars are not getting significantly longer. However, with the increasing popularity of off-road four-wheel drive vehicles, headroom requirements are also increasing. Parking bays are grouped together in rows and parking places at 90° tend to provide the most efficient use of a site, although, if the car park shape is irregular, echelon parking may be desirable to use the space more efficiently. Echelon parking may also be desirable in situations of very short-stay parking where dynamic capacity, being the maximum flow of traffic along aisles, is more important than static capacity.

2.7.3.2 Design of Parking Modules, Circulation Roadways and Ramps

1. Concept

This Section gives requirements and recommendations to be used in the design of parking modules and circulation roadways within off-street car parking facilities.



NOTE: A proportion of parking spaces for people with disabilities is required to be located near the accessible entrance to the development the car park serves.

FIG 2.12 Example of an Off-Street Car Par

Fig 2.12 above shows an example of an off-street car park illustrating the various elements which make up the parking modules and access paths, together with the terms used to describe each of the elements.

2. Preliminary Design Considerations

a. Design coordination

The layout design of an off-street car park shall consider the entire facility, including parking modules, circulation roadways, access driveways and if necessary, frontage road access as an integrated and co-ordinated design. Provision for traffic within a parking facility shall take into account the following:

- (i) The need for traffic to move to and from the frontage road with minimum disruption to through traffic and maximum pedestrian safety.
- (ii) Provision of adequate capacity in circulation roadways and parking aisles to handle peak period movements.
- (iii) Arrangement of internal roadways to avoid, as far as practicable, conflicts between intersecting streams of circulating traffic.
- (v) Provision of minimum length travel paths between entry/exit points and parking spaces.
- (vi) Safe treatment of points of conflict with pedestrians and other road users.
- (vii) Provision of parking spaces and accessible pedestrian paths for people with disabilities.

b. Parking angle

Parking angles used in off-street car parks are divided in to the followings:

- (i) 90 degree angle parking: Parking aisles for 90 degree parking shall be designed for two-way movement even though one-way movement may need to be imposed in some instances.

Note: 90 degree parking will in most cases be found to be the most efficient use of space in a large area.

(ii) 30, 45 or 60 degree angle parking: Where space is limited or does not lend itself to 90 degree parking, 30, 45 or 60 degree parking may be used instead. Aisles serving such spaces shall be one-way (except where parallel parking is allowed on one side) with forward entry into the spaces only.

Note: Such arrangements can have advantages for high turnover parking provided drivers are discouraged from entering aisles the wrong way and reversing into parking spaces.

(iii) Parallel parking.

c. Parking aisle length

If a parking aisle exceeds 100 m in length, (i.e. more than about 40 × 90 degree parking spaces on either side) traffic control devices such as speed humps, shall be placed along the parking aisle to control vehicle speeds. Where vehicle negotiation of such devices may lead to structural damage, compliance with this requirement may be waived.

d. Physical Control

The need for the following physical controls shall be considered:

(i) Kerbs—on one or more sides of a parking space to protect pedestrian walkways, landscaped areas, and any other non-trafficable areas generally at or just above pavement level, from encroachment.

(ii) Barriers—to contain vehicles at the edges of platforms or decks, or to prevent encroachment onto pedestrian facilities.

(iii) Wheel stops—to limit the travel of vehicles when manoeuvring into a parking space.

(d) Other protective devices—to prevent damage to structural elements or other unwanted vehicle encroachment.

Physical controls shall not obstruct accessible travel paths for people with disabilities.

All kerbs, wheel stops, low barriers and other obstructions that could be a tripping hazard to pedestrians shall be surfaced in a color contrasting with their surroundings.

(i) Kerbs:

Vehicles may be allowed to park overhanging a kerb at the rear of a parking space, provided that:

- The kerb is not more than 150 mm high;
- The area up to 1.2 m behind the kerb does not slope up from the kerb; and
- The walkway behind the kerb would not be obstructed.

If overhang cannot be tolerated, wheel stops shall be provided. Kerbs in vulnerable locations may require additional devices such as bollards to make them visible to car drivers.

(ii) Barriers:

Barriers shall be constructed to prevent vehicles from running over the edge of a raised platform or deck of a multi-storey car park including the perimeter of all decks above ground level. They are required wherever the drop from the edge of the deck to a lower level exceeds 600 mm. At drops between 150 mm and 600 mm, wheel stops shall be provided.

Barriers shall comply with the following requirements:

- (1) They shall be designed structurally to satisfy the relevant loading requirements.
- (2) If at the end of a parking space, they shall be at least 1.3 m high so that drivers of cars backing into the space can see the barrier above the rear of the car.
- (3) They shall not be made from brickwork, unreinforced concrete or other materials likely to shatter on impact.

(iii) Wheel stops

Wheel stops may be provided where it is considered necessary to limit the travel of a vehicle into a parking space. If used they shall meet the requirements given below.

NOTES:

1. Typical uses of wheel stops are as follows:

(a) Control of kerb overhang where inconvenient or hazardous for pedestrians.

(b) Inhibiting contact with an end barrier or high kerb.

(c) Inhibiting encroachment into an opposing parking space.

2. Wheel stops should be avoided in any situation where they may be in the path of pedestrians moving to or from parked vehicles, or crossing a car park for any other purpose.

Wheel stops shall be between 90 and 100 mm in height, and 1650 ±50 mm in width.

Where reverse-in parking is unlikely, e.g. at 30, 45 and 60 degree angle parking Modules with one-way aisles, or where occasional minor encroachment (up to about 400 mm) by a reverse-in vehicle can be tolerated, e.g. over a kerb, wheel stop positions shall be set at the front-in position.

If reverse-in parking is likely and encroachment over the end of the parking space cannot be tolerated, wheel stop positions shall be set at the rear-in position and all vehicles required to back in. Location of wheel stops with respect to the front of parking spaces is given in Table 2.2 and illustrated in Figure 2.10. If wheel stops are provided to restrain vehicle contact with a kerb higher than 150 mm or a wall, a further 200 mm shall be added to the wheel stop distance to cater for a Large vehicle, as illustrated in Figure 2.10 (c) and (d).

Table 2.2: Illustrate Wheel Stop Distances

| millimetres | | | | |
|-------------------|---|-----|-----------------------------------|------|
| Parking direction | Wheel stop distance to front of parking space | | | |
| | Parking to kerb ≤150 high | | Parking to kerb >150 high or wall | |
| | Wheel stop height | | Wheel stop height | |
| | 90 | 100 | 90 | 100 |
| Front-in | 630 | 620 | 830 | 820 |
| Rear-in | 910 | 900 | 1110 | 1100 |

Source: Impact of Parking Supply & Demand Management On Central Business District (2012).

(v) Other protective devices:

Protective devices shall be provided as necessary to protect parts of the building or other fixed objects or equipment from damage by vehicles. Such protection shall include devices to prevent vehicle encroachment into pedestrian ways, stairs, doorways, lifts and the like. Appropriately located bollards are suitable for these purposes. Protective devices shall be clearly visible to drivers when in their normal driving position.

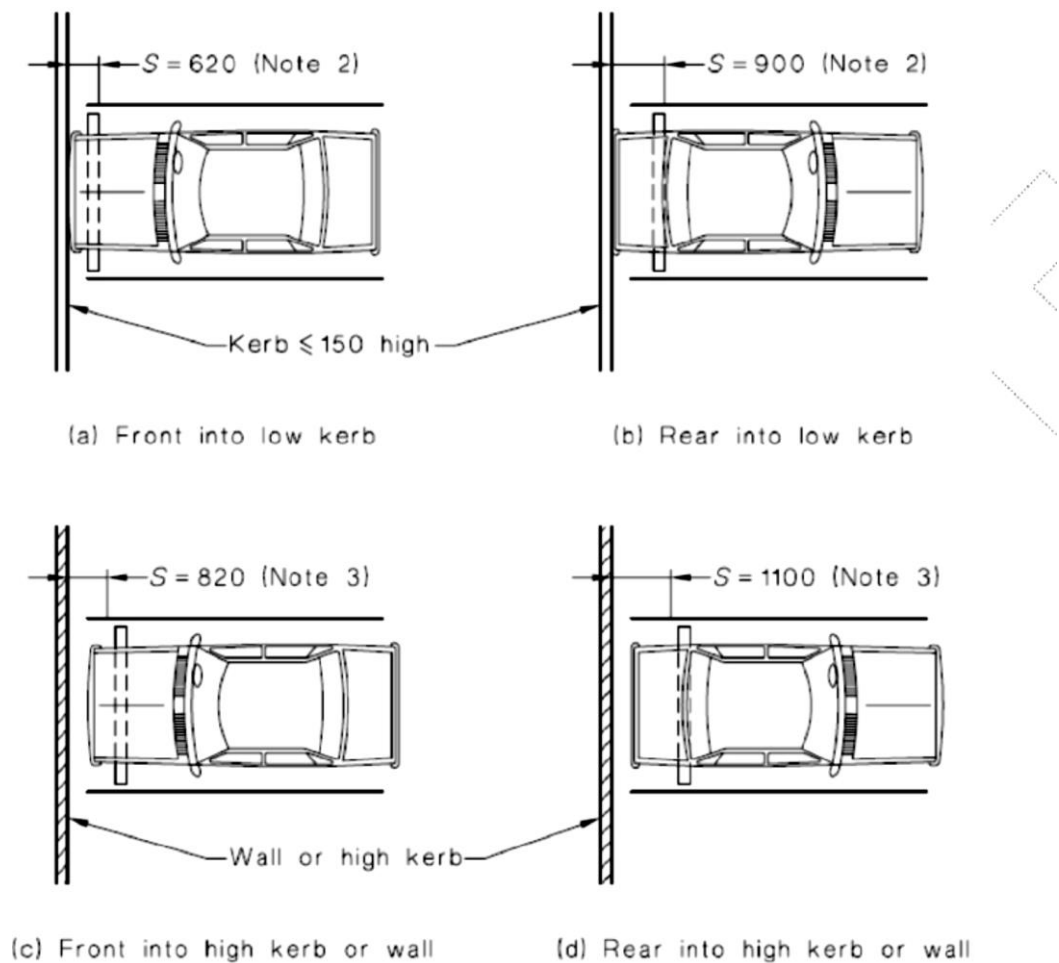


FIG 2.13 Location of Wheel Stop

Impact of Parking Supply & Demand Management On Central Business District (2012).

NOTES:

1. Wheel stop distances shown in this Figure are for 100 mm high wheel stops (see also Table 2.1).
2. Wheel stop distances are set for the Medium vehicle. Some kerb overlap may occur if either a longer vehicle or, in the case of an occasional reverse-in vehicle, uses the space.
3. Wheel stop distances are set to allow 200 mm clearance to the wall for the Medium vehicle. The clearance will be almost zero for the large vehicle.

CHAPTER THREE
RESEARCH METHODOLOGY

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 General

Khartoum state is the most developed state in Sudan and it is the capital of the country. It has three main cities (Omdurman, Khartoum North and Khartoum). With the most updated technologies applied in Khartoum, it is attractive for the public and most of the peoples from other states prefer to live in it, which makes a lot of city extensions. This result in deterioration in the services and the big effect appear in the transportation sector which affect all the social and cultural activities. Also the increases in the population result in more demand for both the private and public transportation, Increase the commercial and industrial activities in the state of Khartoum and the need for more education, all good schools and universities are placed in Khartoum, which leads to increase in the number of schools, universities and other collogues.

Khartoum CBD is composed of very homogeneous activities which most of them is commercial activities surrounds by a belt of mixed activities. There are about ten different activities happening there, the land area of the CBD is almost about 430.7 hectare where administrative and services activities are dominating (70%), with very low percentages of residential activities. Khartoum is city of 4,000,000 inhabitants, most of them live in the periphery, this phenomenon of living away from the CBD make it a place that is active only during daytime, and this fact has been reflected directly to the riverside activities.

General observation indicates that the need for parking in different zones of Khartoum urban area increasing at an alarming rate. In fact some of the reasons of road congestion especially at the city centers are the parking use of sustainable parts of the road for car parking in single and sometimes double lines, many patterns of parking are observed in Khartoum such as street parking “mainly for private cars”, It is most appreciable in the town

centers in Khartoum, Omdurman and Khartoum North. It is found on main streets as well as side roads. It is characterized by whimsical car orientation, protrusion into the street itself and mixes of inclined and parallel parking. The duration is long; 7-8 hours while in the more commercial and trading areas they may be as short as 30 minutes for shoppers and as long as 12 hours for shop owners. The pattern varies between morning, midday, afternoon, early evening and late evening. The most competitive parking time is midday and early afternoon.

The second type of parking needed especially in Khartoum center is Institutional parking; this type of parking is becoming a common feature/practice in recent years. It is related to governmental and international bodies where limited parking lots are provided within the site/compound as well as on the abutting streets.

Recently built commercial, office and hotels are required to provide a certain floor ratio/park places for their cars and those of their visitors. In this context the practice of basement parking facilities is becoming more and more common and ranges between 1-2 basement parking zones.

Parking problem result mainly from concentration of higher education facilities and main health/medical services have created major attraction points for users and generated increasing need for medium term parking but within specific time space of the day and evening. This feature, however, extends to newly established private health facilities in residential areas and mostly converted from existing buildings. In the majority of cases the locations are abutting on main streets with absolutely no attention to parking demand and sometimes ambulant parking.

Khartoum is generally characterized by a low car ownership ratio. At the residential level the low density of the city allows for a wider area spread of individual family car/s with possible provisions of parking within plot boundary. The recent developments aiming at higher residential densities in the form of 3-7 story apartment blocks have created new parking situation and lead to congestions in specific areas, zones and streets. The general

policy here is that developers must provide within plot parking areas at the rate of parking lot per 60m² of built floor area. This specification is not always met.

Parking control is generally undertaken by the traffic police authority who exercises their regulatory powers through a set of legal interventions. Both the parking activity and the interventions are not compatible with the need for parking regulation. On the one hand the parking zone/areas are neither conspicuously defined nor respected. Penalties are rarely imposed and supervision is thinly practiced. Overall it can be said that the parking policy for Khartoum especially at town centers is practically limited in scope and implementation.

All these aspects leads to bad **traffic jam** especially during the day time. There are so many reasons for the traffic jam which are:-

- The main airport is located in Khartoum which makes it as a collection point for the people from other states.
- The roads still the old ones; it is not updated to meet the huge increase in the number of vehicles.
- Lack of fly over and very rare entrance and exits.
- Lack of **parking areas** in the big buildings which lead the drivers to park in the roads randomly, and
- The location of the main public transportation stations in the center of the state.

3.2 Mechanism of Research

Parking have been a problem in most cities in the world, one of the cities attributes in which the vehicle of transportation is, especially in areas where accumulate various activities and uses, and represents a parking one of the

basic land uses forms in the cities, so it must be taken into account to allocate areas when planning.

This study aims to highlight the problem of parking in the center of Khartoum, as a case study in general, and the study area in particular, in an attempt to find scientific solutions, providing positions in crowded areas where land prices rise, reversing a civilized image of the city, and designed the study to the possibility of benefiting from the return physical positions paid, and contribute to the awareness of members of the community, to reduce reliance on private cars, and reduce the demand for the positions, and use them in an effective and civilized way.

In order to achieve the intended objectives of the research, the study is based on both theoretical and practical aspects, the theoretical side profile theory for parking and definition, types and standards of planning and design as well as clarify the causes of the problem, in addition to overview the previous studies that carried out by consultants, ministry of infra structures and others. But the practical side based on the descriptive and analytical study, collecting data and design after determining the study area.

3.2.1 Previous studies of Interrelated Authorities

1. Khartoum Transport and Mobility Master Plan (KTMMMP)

This study is carried out by MEFIT Co. Ltd (Sudan Branch) and presents the Strategy elaborated to adjust the urban transport system of Khartoum to the current and future needs of the population.

The Consultants proposed a strategy for road network and pedestrian traffic, public transport (i.e. road transport, rail transport, river Nile transport and freight transport).

The overall policy of Transport & Traffic projects in Khartoum state by adopting:

- Policy of financing transport projects.
- Plan for solution of traffic jam in Khartoum state and increase Level Of Service (LOS) for the roads by improve parking areas using latest technology.
- Plan for environmental and socio-economic solutions and
- Plan for increased level of safety in transportation system.

The main objective of plan for transportation system is to develop many systems of transport by encouraging public transport and reducing as possible the private transport as well as high cost and environmental impact specially at the centers of Khartoum state. These include the followings:

A. Comprehensive Plan of Transport Systems

The comprehensive plan of transport include many tools and policies aims to develop traffic and transportation in Khartoum metropolitan by encouraging users to use public transport and reduce private transport specially at the centers of the city in order to deduct high cost of transportation and to improve environment. These systems include the followings:

- Transit Bus System.
- Side country Train System.
- Tram and Metro System.
- River Nile system.

B. Control of Traffic Demand

Control of traffic demand is consider one of the main tools in Traffic Management System (TMS), the plan uses two main systems in order to control high traffic demand specially at the city centers, these are:

(i) Cycle Lane Network project

The plan of this mode of transport aims to create multi model of transport for the short distances of trips (ie. Universities, commercial areas..etc) to the main stations of transport in order to reduce pedestrians between bus stations and final destination in the center of the city as well as traffic congestion.

- Park and ride policy and
- Pay and go policy in the centers of Khartoum state.

2. Study & Design of Parking in Khartoum CBD

Many studies and designs were carried out by Khartoum municipality through Elwathba for Integrated Solutions company for on street parking, off street parking and transportation parking in different locations at

Khartoum center; the on street parking include only five roads, these are Abdulmuniem mohamed road, Elbaladiah road, Eljamhariah road, hospital road, Elsyed Abdurhman road and Elgasr road. The off street parking study includes two locations; east of Elawaha mall Area and Abujenzeer lot. Also three locations were selected for transportation parking named Jabrah transportation, Elailafoon transportation and Elsoog Elmahali.

3. Khartoum Paid Parking Study

On street paid parking study was carried out by ministry of infrastructure and transportation based on Khartoum transport and mobility master plan in order to solve parking problems and to reduce traffic congestion in centers of Khartoum state, one of these centers is Khartoum CBD.

The implementation plan of this study is divided in to two stages; short term plan including the followings:

- Application of on street parking project on a pilot zone of study area.
- Development of all intersections and traffic geometric design, street furniture design, application of parking infrastructure (marking, signs...etc).
- Application of payment machines and selected technology system.
- Development of parking by laws & operational regulations (legalization authorization).
- Develop a continuous advertising campaign to introduce the project to users.

And long term plan which is include the followings:

- Completions of on street parking project in Khartoum CBD and start it in Omdurman & Bahary city center.
- Set a consultant for the project.
- Re design of Off street parking project with highly coordination with the seven (7) local municipalities in Khartoum state (feasibility study and technical design the available open spaces for such parking types by a consultant).
- Establishing the multi-story parking building and encouraging private sector investment.

- Determining the parking demand for the entire city especially areas with high density of population.
- Public transportation policies to encourage more people to park and ride.

3.3 Technical Methodology

This research concerned with parking problems & regulation in Khartoum Central Business District (CBD) by collecting data of previous studies, investigates the existing situation, land use, analyzes and design of on street parking for the proposed roads inside study area.

This chapter represents the detailed methodology which is carried out to get appropriate solution of parking regulation as a main tool of traffic management policy for such areas in order to solve the problem of traffic jam and high congestion in CBD area. The data collections, evaluation of existing parking situation, method of analysis and data process have been discussed in details below.

3.3.1 Data Collection

The first hand data was collected from interrelated authorities such as Ministry of Infra Structure - Roads and Bridges Corporation, municipality of Khartoum, Elwathba For integrated Solution and others, where the second hand data was collected from site investigation, survey data and field works. In general Digital map with real coordinates system processed in (Auto CAD) format of the study area was prepared, this contain of forty seven (47) roads represents the study area in addition to off street parking and transportation parking as shown in Fig (3.1) below,

Survey data include full plan of the study area contain building lines, travel way, kerb line, services, open spaces for off street parking, fore bidden areas and any physical features.

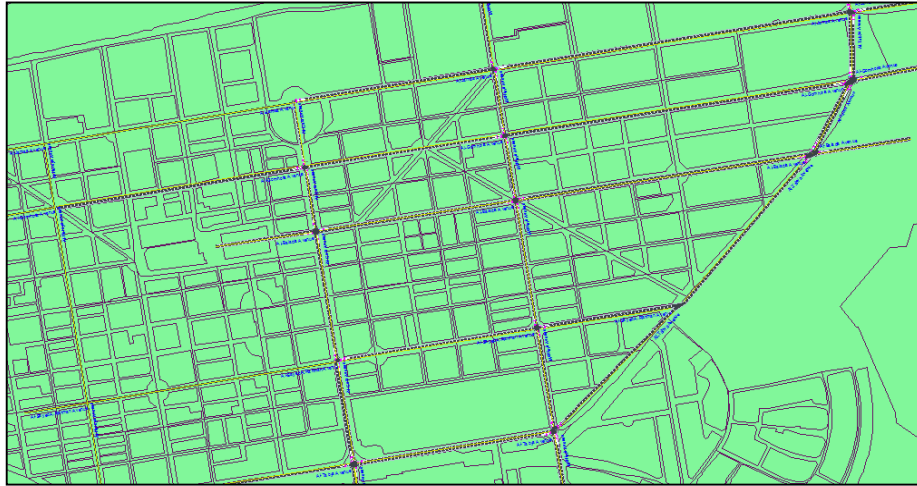


FIG 3.1 Digital map of studied Roads.

The estimation of available number of parking spaces for each road of the study area shall be calculated depending upon the width of carriageway, the number and type of junctions that cross the road, traffic properties, existing physical obstructions, land use and forbidden areas.

The names of these roads are clearly shown in chapter five (table 5.1).

From site investigation and field works; selection of a pilot zone was adopted for detailed engineering study and design as a model for the entire study area of Central Business District (CBD).

The pilot zone consists of four main roads, two of them extend from west to east direction named Elbaladyah Street and Elgamhoryah Street, and the others extend from south to north direction named Algasr Street and Abdulmuniem Street.

3.3.2 Data Process

1. Study Area

From the digital map of study area, forty seven (47) roads were selected in order to calculate all parameters that effect on the selection of reasonable type and number of parking for each Street, these contain length of the road, width of the road, number of junctions and length of forbidden areas (if any), then the estimation of available length of parking, allowed parking side and parking spaces shall be calculated for each Street as shown clearly in chapter five Table (5.3).

2. Pilot Zone

The pilot zone was adopted after analysis and evaluation of exiting parking situation on the study area, where main four roads were selected and it locates at the centre of this area with variations in its carriageway widths, traffic characteristics, land use and high demand of car parking. The detailed study zone and as mentioned above includes Elbaladyah Street, Elgamhoryah Street, Algasr Street and Abdulmuniem Street. The field works were conducted include detailed survey works, observation of carriage way condition, photographs, kerb height and traffic characteristics. Accordingly each Street of the pilot zone was divided in to four sub sectors as followings:

Elbaladyah Street: The first section is locate between Ali Abdulateef Street and Abdulmuniem Street, the second sector connect between Abdulmuniem Street and Algasr Street, the third sector is from Algasr Street to Maknimir Street and the last sector is locate between Maknimir Street to Eltabyah East Street.

Elgamhoryah Street: The first section is locate between Ali Abdulateef Street and Abdulmuniem Street, the second sector connect between Abdulmuniem Street and Algasr Street, the third sector is from Algasr Street

to Maknimir Street and the last sector is locate between Maknimir Street to Osman Dignah Street.

Algasr Street: The first section is locate between Eljamah Street and Elgamhoryah Street, the second sector connect between Elgamhoryah Street and Elbaladyah Street, the third sector is from Elbaladyah Street to Elsyed Abdurahman Street and the last sector is locate between Elsyed Abdurahman Street to Eltabyah South Street.

Abdulmuniem Street: The first section is locate between Nile Street and Elgamhoryah Street, the second sector connect between Elgamhoryah Street and Elbaladyah Street, the third sector is from Elbaladyah Street to Elsyed Abdurahman Street and the last sector is locate between Elsyed Abdurahman Street to Eltabyah South Street.

The geometric design of parking for each subsector was carried out by using Auto CAD format as shown clearly in appendix A.

CHAPTER FOUR
PARKING CONDITION IN KHARTOUM (CBD)

CHAPTER FOUR

PARKING CONDITION IN KHARTOUM (CBD)

4.1 Overview

Traffic congestion has been an ongoing problem in all major metropolitan areas during the past several years. The increase in traffic began as a result of the migration from the suburb to major cities as a result of the industrial revolution which began in the 1970's, since then metropolitan areas has doubled in areas, population, and endured major delays. This problem is clear happen for most capitals of the world as well as capital of Sudan; Khartoum state.

Khartoum state lies between longitudes 31.5 to 34 °E and latitudes 15 to 16 °N. It is surrounded by River Nile State in the north-east, in the north-west by the Northern State, in the east and southeast by the states of Kassala, Gedaref, Gezira and White Nile State, and in the west by North Kurdufan.



FIG 4.1 Map Shows Sudan Country and the location of Khartoum State

The city as shown in fig 4.1 consist of three main provinces named Omdurman, Khartoum north (Bahary) and Khartoum. These provinces suffer from traffic congestion specifically at the centre of each one.

An interesting fact about Khartoum CBD is that it contains the safest riverside edge along the city. In general, Khartoum CBD is composed of very homogeneous activities that are dominated by commercial, business and services functions. A belt of mixed-multi-functional activities surrounds those functions. Ten types activities are traced within Khartoum CBD which covers about 430, 7 hectare and has a very low residential activity and up to 70% of its functions are allocated for commercial services and business activities.

Khartoum city as the capital of Sudan has serious traffic problems as a result of urban population increase, rapid growth in car ownership, and the movement to suburban areas. So high density of vehicles in roads come out and makes the streets overloaded.

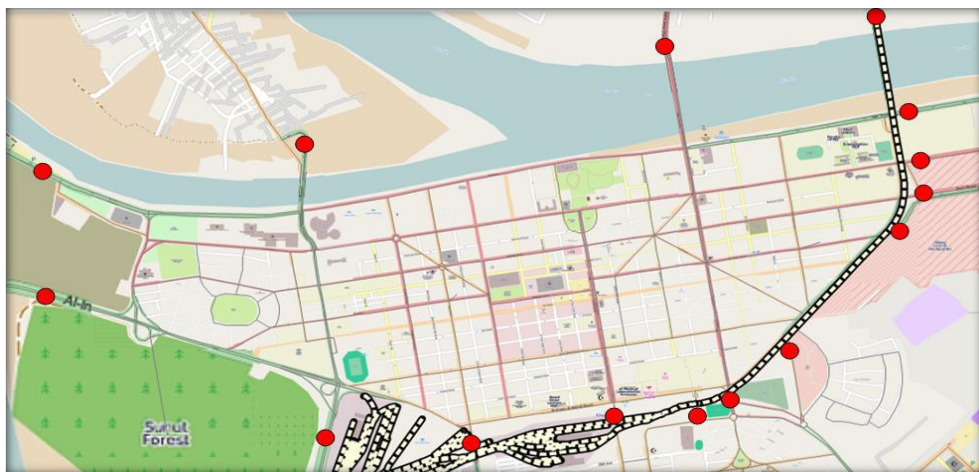


FIG 4.2 Map shows Entrance of Khartoum CBD.

More over the lack of car parking facilities complicates the situation by on-street parking. Thus, traffic congestion, slow movements and pollution appear as symptom of the problem.

The surface of the Khartoum metropolitan Area (province Al-Khartoum) is equal to 22,142Km². Population of the Khartoum metropolitan Area in 2007 is about 8,400,000 divided in table 4.1 as follows: ¹

¹. Khartoum Transport Mobility Master Plan. (2011)

Table 4.1 Shows the Population of Khartoum Metropolitan

| Province | Population 2007 (calculation) |
|------------------------------------|--|
| Khartoum Center | 168,000 |
| Khartoum South-West | 1,680,000 |
| Khartoum South-East | 1,680,000 |
| Omdurman North | 924,000 |
| Omdurman Center | 168,000 |
| Omdurman South-West | 1,344,000 |
| Khartoum-North (Bahry West) | 588,000 |
| Khartoum-North (Bahry East) | 1,848,000 |
| TOTAL | 8,400,000 |

Resource: Khartoum Transport Mobility Master Plan. (2011)

Location at the confluence of the White Nile and the Blue Nile creates three separates traffic districts divided by the river creeks.

Public transport consists of Busses, mini-busses and tuc-tucs only.

Low level of motorization and public transport offers creates a high portion of pedestrian traffic.

Traffic count survey's results in 2002 [Ref8] gave similar high dimensions of traffic impact for the five Nile bridges included:

- Main roads networks inside the metropolitan area have high traffic impact especially in Khartoum centre (CBD).

- High impact of pedestrian traffic, especially in Khartoum centre (CBD).

- The traffic Volumes in passengers (PCU) per working day between provinces of Khartoum state is illustrated in table 4.2 below:

Table 4.2 shows: 2-way traffic volume between the three provinces of Khartoum state.

| Province | Q PCU/day(2way) |
|----------------------------|-----------------|
| Khartoum - Omdurman | 290,000 |
| Khartoum - Bahary | 260,000 |
| Omdurman - Bahary | 120,000 |

Resource: Khartoum Transport Mobility Master Plan. (2011)

4.2 Khartoum (CBD)

This area has the largest demand on parking in Khartoum state with more than 40000 parking lots per day and expected to increase to reach about 110000 parking lots per day. Many studies of on-off street parking were carried out by inter related authorities "such as General Administration of Transportation , Ministry of Infra Structures and consultants" based on Khartoum Transportation and Mobility Master Plan (KTMMP).



FIG 4.3 Limit of Khartoum CBD

The parking demand was determined according to the current land uses and in the future on Khartoum CBD. The land uses inventories and their demand used was as below

Table (4.3) Parking Demand Ratios

| Land Use | Ratio per 100 m2 |
|-----------------|-------------------------|
| Residential | 0.33 |
| Private Offices | 1 |
| Commercial | 2.5 |
| Public | 1.5 |
| Medical | 2.0 |
| Semi-Public | 0.75 |
| Recreational | 0.5 |
| Vacant Space | 0 |

Source: Khartoum Transport Mobility Master Plan. (2011)

4.3 Parking Condition

General observation indicates that the need for parking in different zones of Khartoum urban area increasing at an alarming rate. In fact some of the reasons of road congestion especially at the city centers (CBD) are the parking use of sustainable parts of the road for car parking in single and sometimes double lines. The following patterns of parking are observed in Khartoum:

4.3.1 On- Street parking

This is mainly for private cars. It is most appreciable in the town centers in Khartoum, Omdurman and Khartoum North. It is found on main streets as well as side roads. It is characterized by whimsical car orientation,



Plate 4.1: On Street Parking in Khartoum Centre
Source (Researcher)

Protrusion into the street itself and mixes of inclined and parallel parking as shown in plate 2 below.

The duration is long; 7-8 hours while in the more commercial and trading areas they may be as short as 30 minutes for shoppers and as long as 12 hours for shop owners. The pattern varies between morning, midday, afternoon, early evening and late evening. The most competitive parking time is midday and early afternoon.



Plate 4.2: On Street Parking in Khartoum
Source (Researcher)

4.3.2 Institutional parking

Institutional parking is becoming a common feature/practice in recent years. It is related to governmental and international bodies where limited parking lots are provided within the site/compound as well as on the abutting streets.

Recently built commercial, office and hotels are required to provide a certain floor ratio/park places for their cars and those of their visitors. In this context the practice of basement parking facilities is becoming more and more common and ranges between 1-2 basement parking zones. In general; observations indicate that the study area suffer from lack of high building with parking basement except some locations such as Elwaha mall , Elbarakha Tower and LG co Building . Plate 4.3 below shows the sample of basement parking. ¹

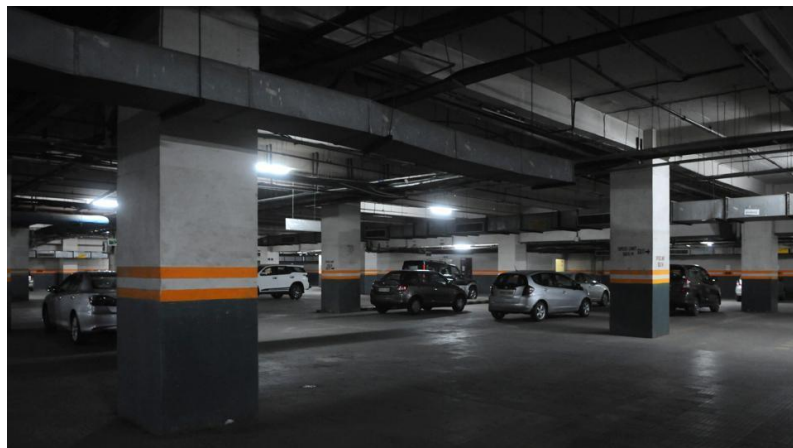


Plate 4.3: Basement Parking

Source: Technical Requirements for Car Parking.

<http://www.ar.momra.gov.sa>.

4.3.3 Parking in service areas

Here again the town centers exhibit special parking problems. The concentration of higher education facilities and main health/medical services have created major attraction points for users and generated increasing need.

¹Technical Requirements for Car Parking. <http://www.ar.momra.gov.sa>.



Plate 4.4: Parking in Service Area

Source (Researcher)

For medium term parking but within specific time space of the day and evening. This feature, however, extends to newly established private health facilities in residential areas and mostly converted from existing buildings. In the majority of cases the locations are abutting on main streets with absolutely no attention to parking demand and sometimes ambulant parking.

Khartoum is generally characterized by a low car ownership ratio. At the residential level the low density of the city allows for a wider area spread of individual family car/s with possible provisions of parking within plot boundary. The recent developments aiming at higher residential densities in the form of 3-7 story apartment blocks have created new parking situation and lead to congestions in specific areas, zones and streets. The general policy here is that developers must provide within plot parking areas at the rate of parking lot per 60m² of built floor area. This specification is not always met.

4.3.4 Parking Control

Parking control is generally undertaken by the traffic police authority who exercises their regulatory powers through a set of legal interventions. Both the parking activity and the interventions are not compatible with the need for parking regulation. On the one hand the parking zone/areas are neither conspicuously defined nor respected. Penalties are rarely imposed and supervision is thinly practiced. Overall it can be said that the parking policy for Khartoum especially at town centers (CBD) is practically limited in scope and implementation.

CHAPTER FIVE
DESIGN OF PARKING

CHAPTER FIVE

DESIGN OF PARKING

5.1 Study Zone

The study area consist of forty seven (47) streets locate on Khartoum CBD as shown in figure 1.1 (chapter 1). The selected roads differ in dimensions, traffic characteristics, land use, kerb height, number of major intersections and control type, existing parking condition and physical obstructions. in general the names of these roads are shown in table 5.1 as follows:

Table 5.1 Shows the Name of Studied Roads

| Item | Name of The Road |
|------|---------------------------|
| 1 | Algamhoryah street |
| 2 | Alneel Street |
| 3 | Assayed Abdruhman Street. |
| 4 | Algama Street |
| 5 | Elbaladia Street |
| 6 | Almek Nimir Street. |
| 7 | Algasr Street |
| 8 | Abu Garga street |
| 9 | A.Alnogomi Street. |
| 10 | Alhurya Street. |
| 11 | Al-Imam Almahdi street |
| 12 | CAPT Zulfo Street. |
| 13 | Abdula anor Street. |
| 14 | Ali Dinar Street. |
| 15 | Abd Almuneim Street. |
| 16 | Atbara Street |
| 17 | Babiker Badri street |
| 18 | Altigani Almahi street |
| 19 | Mohd Abdulrahim Street. |
| 20 | 21st October street |
| 21 | Salih Pasha Almuk street |
| 22 | Eltayar Gamiel street |
| 23 | Terhaga Street |
| 24 | Senkat Street |
| 25 | Alshareef Alhindi street |
| 26 | Alamatonj Street |
| 27 | Aljami Alkabir street |
| 28 | Albrir Street |
| 29 | Cap. Murad Street |

| | |
|----|--------------------------|
| 30 | Eltayar Izz edeen street |
| 31 | M.C Street |
| 32 | Abid Haj Alamin Street |
| 33 | Albrlman Street |
| 34 | Slaiman Kasha st |
| 35 | Ali Abdulatif street |
| 36 | Arbab Alagaied Street |
| 37 | Abu Sin Street |
| 38 | Cont Mokhlis Street |
| 39 | Karoma Street |
| 40 | Alkhalifah Street |
| 41 | Osman Dignah Street |
| 42 | Alzubair pasha street |
| 43 | Alisbtalya Street |
| 44 | Hisham Bia Street |
| 45 | Wad Haboba Street |
| 46 | Almoutamar Street |
| 47 | Meherah Bit Abood Street |

5.2 Design Assumptions

Many assumptions were adopted in order to design and calculate the reasonable on-street parking for the study area; these are shown below:

1. For the road width equal to 15.0 m. or less, the parallel parking will be adopted for one side and the required distance for a car is 6.1 m.
2. For the road width ranging between 20 - 30 m, forty five degree (45°) parking will be adopted for two sides and the required distances for a car is equal to 2.5m.
3. For the road width more than 30.0m, the sixty degree (60o) of parking will be adopted for two sides and required distance for a car is equal to 2.5m.
4. The open yards are depending on space availability, table (5.2) below give summary of design assumptions.¹

¹. Parking Measures and Policies (2010).

Table (5.2) Shows Summary of Design Assumption

| Road Width | Parking Type | Required Distance for a Car (m) | Allowed Sides for Parking |
|----------------|------------------------------|---------------------------------|---------------------------|
| 15 m or less | Parallel Parking | 6.1 | One Side |
| 20 m - 30 m | 45° Degree | 2.5 | Two Sides |
| More Than 30 m | 60° Degree | 2.5 | Two Sides |
| Open Yards | Depend on space Availability | - | Two Sides |

5.3 Design Requirements

1. For Parallel parking, the minimum length for no parking is 15 meter after and before the intersection.
2. For degree parking, the minimum length is 12 meter on the beginning and 9 meter at the end, with consideration of the intersection geometric design.

5.4 Parking Calculations

The following equations represent the method of calculation was done as below:

$$\text{The Available No. of parking for any street} = \frac{\text{Available Length for parking} * \text{No of sides}}{\text{Distance required for one Car}} \dots\dots\dots(5-1).$$

$$\text{The Available Length of parking} = \text{Road Length} - (60 * \text{No. of Intersection}) - \text{No parking length} \dots\dots(5-2).$$

5.5 Analysis & Results

The type of parking, available length for parking, allowed parking sides and parking space for each road were determined based on the equations No (9) and (10). The study area consists of forty seven (47) streets with different lengths and widths. The measures and calculation was carried out for each street from the map of study area (Khartoum CBD) with real coordinates considering the following parameters:

1. The Road Width.
2. Road Length.
3. Number of Intersections.
4. Distance required for one car and
5. No parking length for each section of the road.

The results are shown clearly in table (5.3) below:

Table (5.3) Shows the Calculated Number of Parking Spaces

| It | Street Name | Road Width (m) | Road Length (m) | No. of Intersections | Type of parking | No parking length (if any) | Available length for parking | Allowed parking sides | Parking Spaces |
|----|---------------------------|----------------|-----------------|----------------------|-----------------|----------------------------|------------------------------|-----------------------|----------------|
| 1 | Algamhoria street | 20 | 4447.8 | 26 | 45° | 150 | 2738 | 2 | 2190 |
| 2 | Alneel Street | 20 | 5624.5 | | 45° | 2225 | 3400 | 2 | 2720 |
| 3 | Assayed Abdruhman Street. | 20 | 2643 | 20 | 45° | 110 | 1333 | 2 | 1066 |
| 4 | Algama Street | 20 | 5125 | 27 | 45° | 750 | 2755 | 2 | 2204 |
| 5 | Elbaldya Str. | 20 | 3316.3 | 26 | 45° | | 1756 | 2 | 1404 |
| 6 | Mk Nimir s | 20 | 1215 | 12 | parallel | | 495 | 2 | 162 |
| 7 | Algasr Str. | 40 | 1219.5 | 13 | 60° | | 440 | 2 | 352 |
| 8 | Abu Garga str. | 10 | 882.3 | 11 | parallel | | 222 | 1 | 36 |
| 9 | A.Alnogomi Str. | 20 | 985.5 | 7 | 45° | | 565 | 2 | 452 |
| 10 | Alhurya Str. | 20 | 1466 | 14 | parallel | 265 | 361 | 2 | 118 |

| | | | | | | | | | |
|----|-----------------------------|----|--------|----|----------|------|------|---|------|
| 11 | Al-Imam Almahdi str. | 40 | 6543.4 | | 60° | 2800 | 3743 | 2 | 2994 |
| 12 | CAPT Zulfo Str. | 10 | 877 | 12 | parallel | | 157 | 1 | 25 |
| 13 | Abdula A.str | 15 | 1070 | 10 | parallel | | 470 | 1 | 77 |
| 14 | Ali Dinar Str. | 10 | 1137 | 10 | parallel | | 537 | 1 | 88 |
| 15 | Abd Almuneim Str. | 30 | 1515 | 16 | 60° | | 556 | 2 | 444 |
| 16 | Atbara Street | 15 | 678 | 5 | parallel | | 378 | 1 | 61 |
| 17 | Babiker Badri str. | 10 | 876 | 11 | parallel | | 216 | 1 | 35 |
| 18 | Altigani Almahi str. | 10 | 3482 | 28 | parallel | | 1803 | 1 | 295 |
| 19 | Mohd Abdulrahi m Str. | 20 | 578 | 5 | 45° | | 279 | 2 | 222 |
| 20 | 21st October str. | 10 | 2361 | 20 | parallel | | 1161 | 1 | 190 |
| 21 | Salih Pasha Almuk str. | 10 | 1188 | 14 | parallel | | 348 | 1 | 57 |
| 22 | Eltayar Gamiel str. | 15 | 1220 | 14 | parallel | | 381 | 1 | 62 |
| 23 | Terhaga Str. | 15 | 506 | 4 | parallel | | 266 | 1 | 43 |
| 24 | Senkat Str. | 20 | 610 | 5 | 45° | | 311 | 2 | 248 |
| 25 | Alshareef Alhindi str. | 15 | 2960 | 24 | parallel | | 1519 | 1 | 249 |
| 26 | Alamatonj Str. | 15 | 300 | 4 | parallel | | 60 | 1 | 9 |
| 27 | Aljami Alkabir str. | 30 | 730 | 10 | 60° | | 130 | 2 | 104 |
| 28 | Albrir Str. | 20 | 365 | 5 | 45° | | 65 | 2 | 52 |
| 29 | Cap. Murad Str. | 20 | 665 | 8 | 45° | | 184 | 2 | 146 |
| 30 | Eltayar Izz Edeen str. | 10 | 600 | 10 | parallel | | 0 | 1 | 0 |
| 31 | M.C Street | 10 | 960 | 10 | parallel | | 359 | 1 | 58 |
| 32 | Abid Haj Alamin Str. | 10 | 603 | 6 | parallel | | 244 | 1 | 40 |
| 33 | Albrlman Str. | 10 | 3050 | 22 | parallel | | 1732 | 1 | 283 |
| 34 | Slaiman K.sstr. | 20 | 940 | 10 | 45° | | 340 | 2 | 272 |
| 35 | Ali Abdultif | 15 | 1322 | 15 | parallel | | 422 | 1 | 69 |
| 36 | Arbab Alagaied | 20 | 850 | 8 | 45° | | 368 | 2 | 294 |

| | Str. | | | | | | | | |
|----|-----------------------|----|------|----|----------|--|------|---|-----|
| 37 | Abu Sin Str. | 10 | 1305 | 12 | parallel | | 585 | 1 | 95 |
| 38 | Cont Mokhlis Str. | 15 | 1000 | 12 | parallel | | 282 | 1 | 46 |
| 39 | Karoma Str. | 15 | 366 | 5 | 45° | | 66 | 1 | 26 |
| 40 | Alkhalifah Str. | 20 | 668 | 8 | 45° | | 188 | 2 | 150 |
| 41 | Osman Dignah Str. | 10 | 1113 | 10 | parallel | | 514 | 1 | 84 |
| 42 | Alzubair pasha str. | 10 | 3329 | 26 | parallel | | 1769 | 1 | 290 |
| 43 | Alisbtalya Street | 10 | 2245 | 20 | parallel | | 1045 | 1 | 171 |
| 44 | Hisham Bia Str. | 10 | 730 | 12 | parallel | | 10 | 1 | 1 |
| 45 | Wad Haboba Str. | 10 | 537 | 7 | parallel | | 117 | 1 | 19 |
| 46 | Almoutamar Str. | 10 | 315 | 4 | parallel | | 75 | 1 | 12 |
| 47 | Meherah Bit Abood St. | 20 | 441 | | 45° | | 141 | 2 | 112 |

The Number of available spaces of On-Street parking in study area was found about 17000 parking.

5.6 Pilot Zone

5.6.1 Concept

The pilot zone of study area was selected as a complete model for design and redesign of on-street parking. Four main roads were adopted in the centre of the study area, two of them extend from west to eastern direction and the other extends from south to northern direction. The selection was depending on the location of these roads, variation of carriageway widths and high demand of car parking. The detailed study zone includes Elbaladyah Street, Elgamhoryah Street, Algasr Street and Abdulmuniem Street. The field works were conducted include detailed survey works, observation of carriage way condition for each sector of the road, photographs, kerb height and traffic characteristics.

5.6.2 Methodology

Lay out plan of a pilot zone was clearly prepared in reasonable scale with real coordinates, this include all existing details such as:

- Asphalt edges.
- Kerb Lines.
- Existing Median.
- Existing car Parking.
- Building Lines.
- Existing Fence (If any).
- Existing Trees.
- Existing Traffic signal.
- Green Areas (if any) and
- Exiting electric and lighting pools.

Then detailed geometric design of parking was carried out for each road of the pilot zone after dividing it in to four subsectors, these were adopted depending on condition of existing carriageway, existing spaces of On or Off street parking, land use and traffic properties.

5.6.3 Finding and Out put

As mentioned above the pilot zone consist of four streets. Survey works were carried out in order to create layout plan after processing the data by using AUTO CAD software program as shown clearly in appendix A.

The design of each road was conducted as follows:

1. Elbaladyah Street:

Layout plan of this road was prepared in separate sheet; the start point is from Ali Abdulateef and the end point at Eltabyah East Street.

The road was divided in to four sub sectors; the characteristics of each section are shown below:

Section 1.1:

This section is start from Ali Abdulateef road to Abdulmuniem Street, the length of this section is 465 m while the average width of the carriageway is 20 m with exiting raised curbstone and interlock tiles in both sides. The Aisle width is equal to 12.5 m according to the proposed design.

The direction of traffic is from west to eastern direction (one way traffic). This section has three minor cross intersections with right angle approximately. Forty five (45) degree angle of parking for both sides is adopted for design taking in to consideration that the minimum distance between intersection point and parking area is 15m.

The designed parking areas should be repaved with clear road marking and traffic Signs for parking as per standards.

Section 1.2:

This section is start from Abdulmuniem Street to Algasr Street; the length of this sector of the road is equal to 600m while the average width of the carriageway is 38 m with exiting raised curbstone and interlock tiles in its both sides. The Aisle width is equal to 15 m according to the proposed design. The direction of traffic is from west to eastern direction (one way traffic). Many types of parking were found in this section as shown below:

- a. Underground parking for Elwha mall.
- b. Existing parking on the west bound of Elwaha Mall, above the kerb stone.

c. Off-Street parking: Two locations of parking were found in this section, the first one locates directly on the eastern bound of Elwaha Mall, with paid system operation. The area of this parking is equal to 5150 square meter. The second one is open area named Abojenzeer parking with area equal to 4180 square meter.

Ninety (90) degree angle of parking for both sides is adopted for design with repainting the road marking of existing locations and new road marking for the proposed locations as shown clearly on the Appendix A (sheet No 2.2).

Section 1.3:

This section is start from Algasr Street to Maknimir Street, the length of this section is 670 m while the average width of the carriageway is 27 m with exiting raised curbstone and interlock tiles in both sides. The Aisle width is equal to 20 m approximately according to the proposed design. the vehicles trafficked two way in this section of the road, this part of the road have four cross intersections with right angle approximately. Forty five (45) degree angle of parking for both sides is adopted for design taking in to consideration that the minimum distance between intersection point and parking area is 15m.

The designed parking areas should be repaved with clear road marking and traffic signs for parking as per standards.

Section 1.4:

The last section of this road starts from Maknimir Street to Eltabyah East Street with length equal to 550 m while the average width of the carriageway equal to 27.5 m with exiting raised curbstone and interlock tiles in both sides. The Aisle width is equal to 18.5 m approximately according to the proposed design. The vehicles trafficked two ways in this section of the road. This part of the road have four cross intersections with right angle approximately. Forty five (45) degree angle of parking for both sides is adopted for design taking in to consideration that the minimum distance between intersection point and parking area is 15m.

2. Elgamhoryah Street:

Layout plan of this road was prepared in separate sheet; the start point is from Ali Abdulateef and the end point at Osman Dignah Street.

The road was divided in to four sub sectors; the characteristics of each section are shown below:

Section 2.1:

This section is start from Ali Abdulateef road to Abdulmuniem Street, the length of this section is 485 m while the average width of the carriageway is 25 m with exiting raised curbstone and interlock tiles in both sides. The Aisle width is equal to 15 m according to the proposed design.

The direction of traffic is from west to eastern direction (one way traffic). This section have three intersections, two of them with right angle approximately and one major junction with five leg.

Forty five (45) degree angle of parking for both sides is adopted for design taking in to consideration that the minimum distance between intersection point and parking area is 15m.

The designed parking areas should be re paved with clear road marking and traffic Signs for parking as per standards.

Section 2.2:

This sector of the road locates on commercial area and characterize by high demand of parking, while it is start from Abdulmuniem Street to Algasr Street.

The length of this section is 600 m and the average width of the carriageway is 20 m. The Aisle width is equal to 13 m according to the proposed design which is adopted as forty five (45) degree angle of parking for both sides. This section has five cross intersections with right angle approximately. Road marking and parking signs is highly recommended for this section.

Section 2.3:

This section is start from Algasr Street to Maknimir street, the length of this section is 670 m with average width of the carriageway equal to 22 m. The Aisle width is equal to 13 m approximately according to the proposed design. The direction of traffic is from west to eastern direction (one way traffic), this part of the road has four intersections, three of them cross intersection with right angle approximately and one major junction with six legs as shown clearly in appendix A. Forty five (45) degree angle of parking for both sides of the road is adopted for design taking in to consideration that the minimum distance between intersection point and parking area equal to 15m. Road marking and parking signs is highly recommended for this section.

Section 2.4:

The last section of this road starts from Maknimir Street to Osman Dignah Street. The length of this road is equal to 550 m with average width of the carriageway equal to 28 m and exiting raised curbstone and interlock tiles in its both sides. The Aisle width is equal to 16.5 m approximately according to the proposed design. The direction of traffic is from west to eastern direction (one way traffic). Forty five (45) degree angle of parking for both sides is adopted for design taking in to consideration that the minimum distance between intersection point and parking area is 15m.

3. Algasr Street:

Layout plan of this road was prepared in separate sheet in Appendix A (named sheet No 4). The start point of this road is from Eljamah and the end point at Eltabyah Street.

The total length of the road is divided by physical median with three major traffic signalized intersections; these are Elgamhoryah, Elbaladyah and Elsyed Abdurrahman.

The road was divided in to four sub sectors; the characteristics of each section are shown below:

Section 3.1:

This section is start from Eljamah Street to Elgamhoryah Street, the length of this section is equal to 230 m while the average width of the carriageway is equal to 30 m with exiting raised curbstone and interlock tiles in both sides. This section and as shown in Appendix A divided by median, the vehicles trafficked two ways in this section of the road. One cross junction intersects this part of the road.

Sixty (60) degree angle of parking for both sides is adopted for design taking in to consideration that the minimum distance between intersection point and parking area is 15m.

The designed parking areas in the northern bound of cross junction "the intersection between this part of the sector and Meharah Bitabood road" should be repaved with clear road marking and traffic signs for parking and road marking above the existing interlock tiles in the southern bound of this junction should be done as shown in the Appendix A (sheet No 4-1).

Section 3.2:

This section is start from Elgamhoryah road to Elbaladyah Street, the length of this section is equal to 230 m while the average width of the carriageway is equal to 30 m with exiting raised curbstone and interlock tiles in its both sides. This section and as shown in Appendix A divided by median also, the

vehicles trafficked two ways in this section of the road. One cross junction intersects this part of the road and the other closed by median so it consider as a T junction for each sides of the road. forbidden parking areas is adopted for the western bound of this sector as shown clearly in Appendix A (sheet No 4-2).

Sixty (60) degree angle of parking for both sides of the road is adopted for design taking in to consideration that the minimum distance between intersection point and parking area is 15m.

Road marking for the selected angle of parking should be done above the existing raised areas of interlock tiles.

Section 3.3:

This section fall between two major cross intersections in addition to cross three minor junctions. The start point of this sector is from Elbaladyah street and the end point at Elsyed Abdurahman street. The length of this section is equal to 450 m while the average width of the carriageway is equal to 30 m with exiting raised curbstone and interlock tiles in its both sides. Sixty (60) degree angle of parking for both sides of the road is adopted for design taking in to consideration that the minimum distance between intersection point and parking area is 15m.

Road marking for the selected angle of parking should be done above the existing raised areas of interlock tiles. Also traffic signs should be fixed as per standards.

Section 3.4:

This section is start from Elsyed Abdurahman road to Eltabyah Street, the length of this section is equal to 350 m while the average width of the carriageway is equal to 30 m with exiting raised curbstone and interlock tiles in its both sides. This section and as shown in Appendix A divided by median also, and it characterize by high traffic demand because it falls on medical area and educational areas. Sixty (60) degree angle of parking for

both sides of the road is adopted for design taking in to consideration that the minimum distance between intersection point and parking area is 15m.

Road marking for the selected angle of parking should be done above the existing raised areas of interlock tiles.

4. Abdulmuniem Street

This road connects between Nile Street and Eltabyah Street, the total length of this road is equal to... m and it divided in to four subsectors differ in traffic characteristics and land use. Layout plan of this road was prepared in separate sheet as shown in appendix A. the characteristics of each section are shown below:

Section 4.1:

This section is start from Nile Street to Elgamhoryah Street, the length of this section is equal to 485 m while the average width of the carriageway is equal to 27 m with exiting raised curbstone and interlock tiles in both sides. This section and as shown in Appendix A cross Eljamah road with signalized junction then it divided by median. The first part of this sector "which is fall on the northern bound of the junction"; vehicles are trafficked two ways while it trafficked from north to the southern direction to the end point at Eltabyah road.

Sixty (60) degree angle of parking for both sides is adopted for design taking in to consideration that the minimum distance between intersection point and parking area is 15m.

Road marking and traffic signs should be fixed as per standards.

Section 4.2:

This section is start from Elgamhoryah road to Elbaladyah Street, the length of this section is equal to 280 m while the average width of the carriageway is equal to 30 m. This section and as shown in Appendix A divided by median also, but the vehicles trafficked one way to the end point at Eltabyah road.

Sixty (60) degree angle of parking for both sides of the road is adopted except the length of existing designed parking that falls on the western bound of Elwaha mall. The design taking in to consideration that the minimum distance between intersection point and parking area is 15m, also Road marking for the selected angle of parking and traffic signs should be fixed as per standards.

Section 4.3:

This sector of the road connects between Elbaladyah Street and Elsyed Abdurahman road and cross four minor intersections. The length of this section is equal to 400 m with average width of carriageway equal to 30 m. This sector of the road characterized by high traffic demand and parking needs because it falls on commercial areas.

Sixty (60) degree angle of parking for both sides of the road is adopted for design taking in to consideration that the minimum distance between intersection point and parking area is 15m.

Road marking and traffic signs for the selected angle of parking should be fixed as per standards.

Section 4.4:

This section is start from Elsyed Abdurahman road and end at Eltabyah street and cross three minor junctions, the length of this section is equal to 360 m with average width of the carriageway equal to 30 m. Sixty (60) degree angle of parking for both sides of the road is adopted for design taking in to consideration that the minimum distance between intersection point and parking area is 15m.

Road marking and traffic signs for the selected angle of parking should be fixed as per standards.

CHAPTER SIX
CONCLUSION & RECOMMENDATIONS

CHAPTER SIX

CONCLUSION & RECOMMENDATIONS

6.1 Conclusion

Khartoum state as a capital of Sudan suffers from high traffic jam resulting from development of the city. This thesis intend to present a study of parking in the Central of Khartoum (CBD) – capital of the Sudan, were most of the public services are found, many studies of on-off street parking were carried out by inter related authorities "such as General Administration of transportation, ministry of Infra Structures and consultants" based on Khartoum Transportation and Mobility Master Plan (KTMMP).

The term of Khartoum (CBD) is for the area which is bordered by Nile Street at the north, Eltabyah Street at the south, White Nile in the west and military bridge in the east.

General observation indicates that the need for parking in different zones of Khartoum urban area increasing at an alarming rate. In fact some of the reasons of road congestion especially at the city centers (CBD) are the parking use of sustainable parts of the road for car parking in single and sometimes double lines.

This area has the largest demand on parking with more than 40000 parking lots per day and expected to increase to reach about 110000 parking lots per day.

The study area consists of Forty seven (47) streets include full details of parking geometric design for main four roads considered as a pilot zone of the studied area. The number of available spaces of On-street parking in study area was found 17000 parking.

6.1 Recommendations

After evaluation, analysis and design of existing parking, the following recommendations should be addressed:

- On-street parking required continues monitoring & variety of strategies to support policy and provide parking with good condition
- Development of all intersection and traffic geometric & street furniture design.
- Redesign of Off-Street parking project with highly coordination with interrelated authorities in Khartoum state.
- Increase short- term parking - Assign more existing spaces or create new spaces as two-hour maximum parking spaces for short duration visit to particular destinations in the centre.
- Establish Public transportation policies to encourage people to park and ride.
- Encourage Payment System Technologies (PST) of on street parking space for the Centers of Khartoum state; system can be integrated with multiple methods such as automated payment machine or smart phone.
- More traffic studies and researches should be continued in Khartoum CBD and such areas in order to solve traffic congestion and to increase Level Of Service (LOS).

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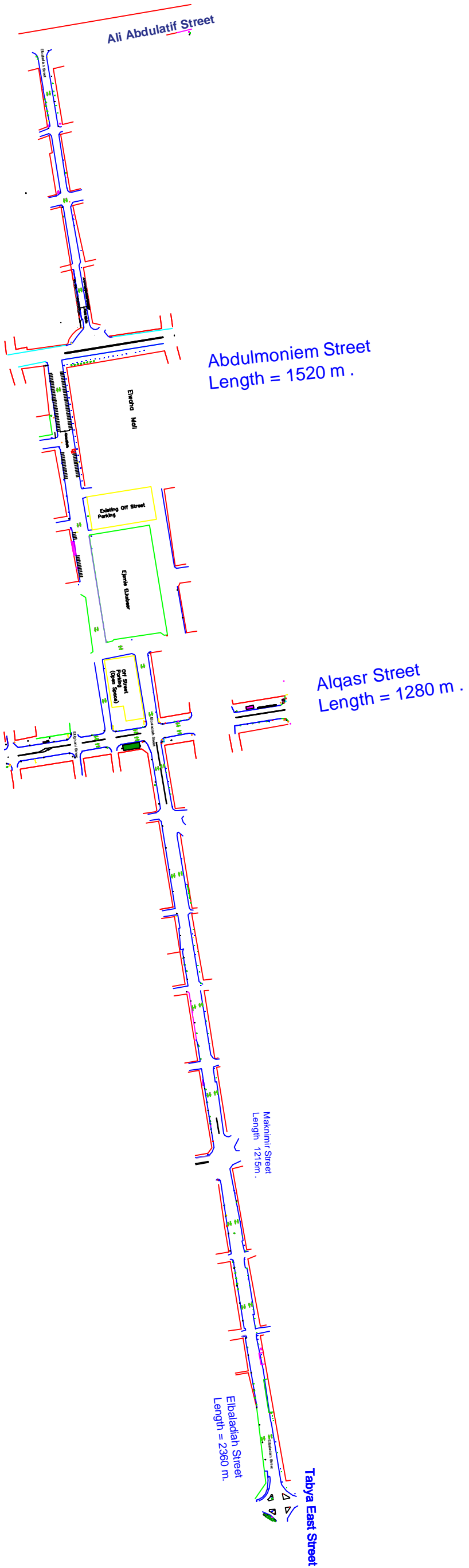
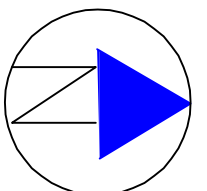
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**APPENDIX A: PARKING GEOMETRIC DESIGN
PILOT ZONE**



| Key | |
|-----|----------------|
| ● | Sudatel Pool |
| ● | Traffic Signal |
| ● | Electric Pool |
| ● | Tree |
| ● | Lighting Pool |
| — | Curb Line |
| — | Asphalt |
| — | Car Parking |
| — | Green Area |
| — | Fence |
| — | Median |
| — | Building Line |

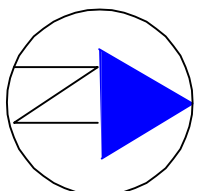
CHAPTER FIVE

PARKING DESIGN

APPENDIX A

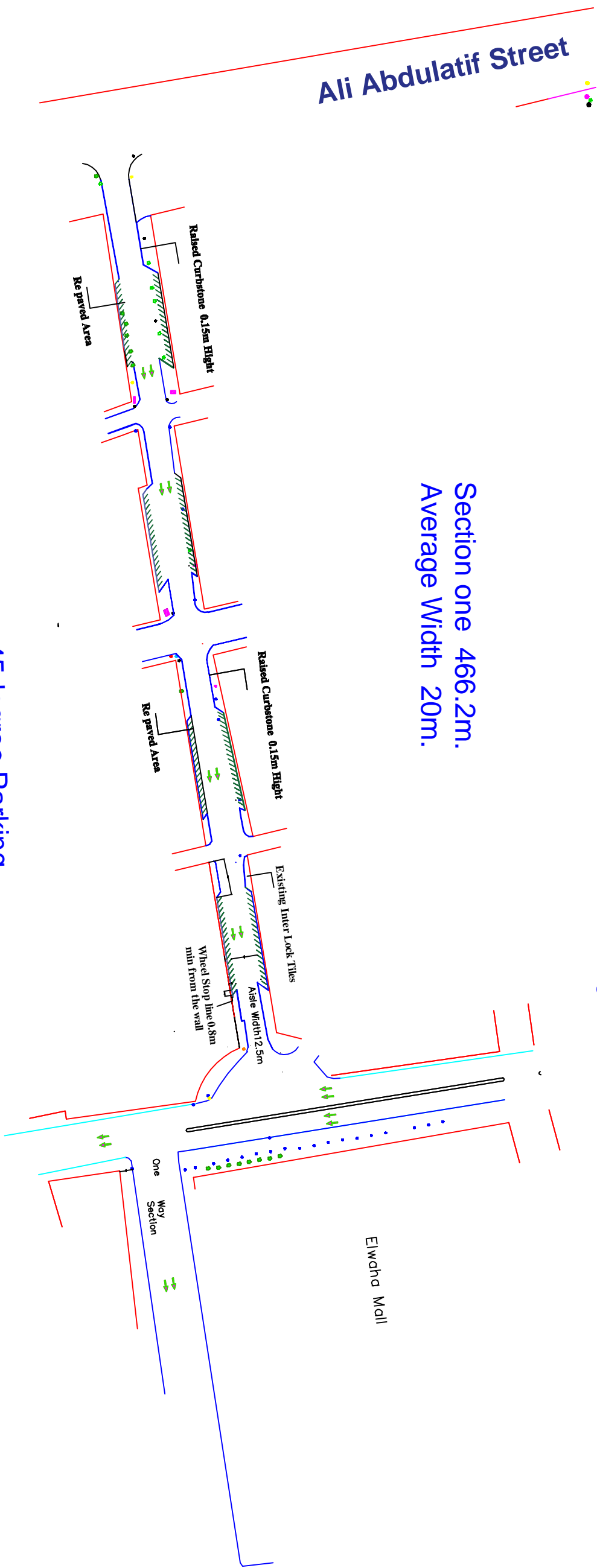
DRAWING TITLE:
ALBALADYAH STREET PLAN

SHEET NO 2
Pd. 83

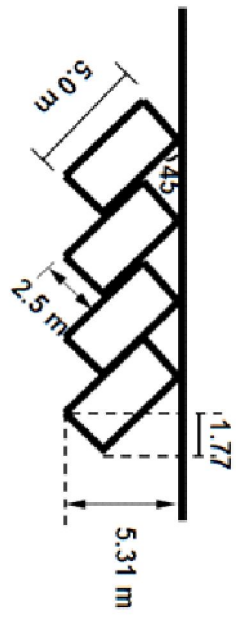


Abdulmoniem Street
Length 1520m.

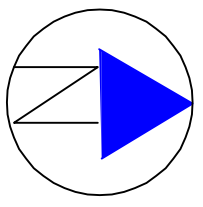
Section one 466.2m.
Average Width 20m.



45degree Parking
Two Sides



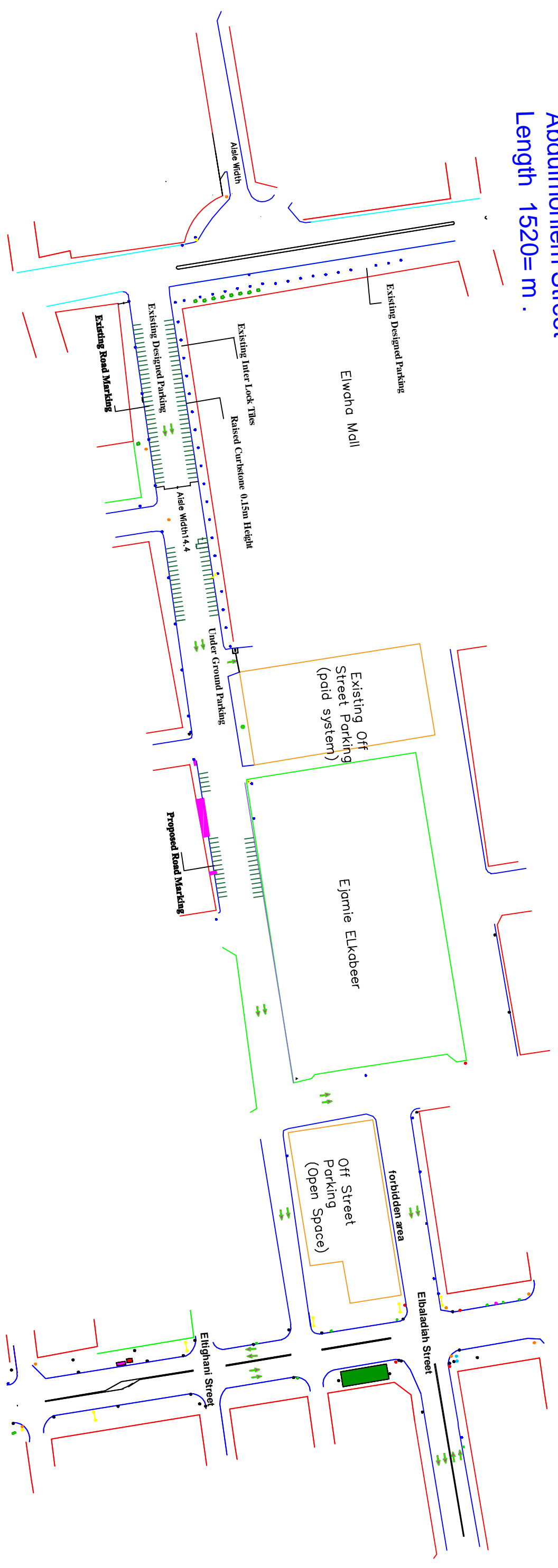
| Key | | | |
|-----|----------------|--|---------------|
| | Sudatel Pool | | Asphalt |
| | Traffic Signal | | Car Parking |
| | Electric Pool | | Green Area |
| | Tree | | Fence |
| | Lighting Pool | | Median |
| | Curb Line | | Building Line |



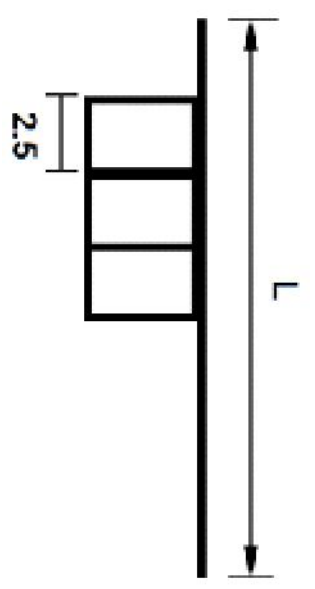
Abdulmuniem Street
Length 1520= m .

Section Two 600m.
Average Width 37.6m.

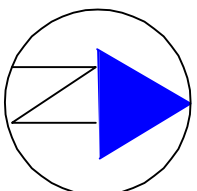
Alqasr Street
Length 1280= m .



90degree Parking
Two Sides



| Key | | | |
|-----|----------------|---|---------------|
| ● | Sudatel Pool | ■ | Asphalt |
| ● | Traffic Signal | ■ | Car Parking |
| ● | Electric Pool | ■ | Green Area |
| ● | Tree | ■ | Fence |
| ● | Lighting Pool | ■ | Median |
| — | Curb Line | — | Building Line |



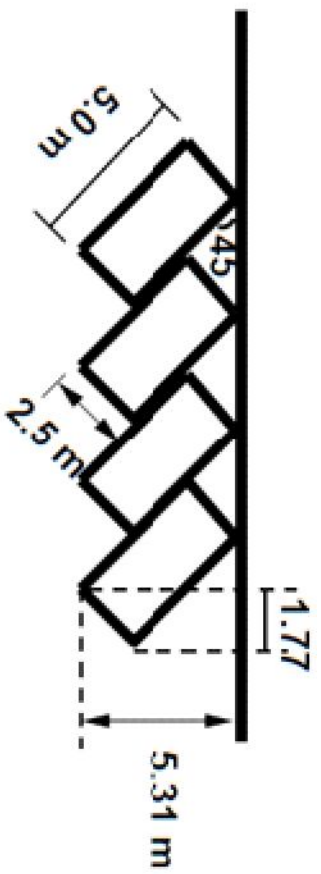
Section Three 671m.
Average Width 27.5m.

Maknimir Street
Length 1215m .

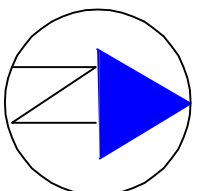
Alqasr Street
Length 1280= m .



45degree Parking
Two Sides



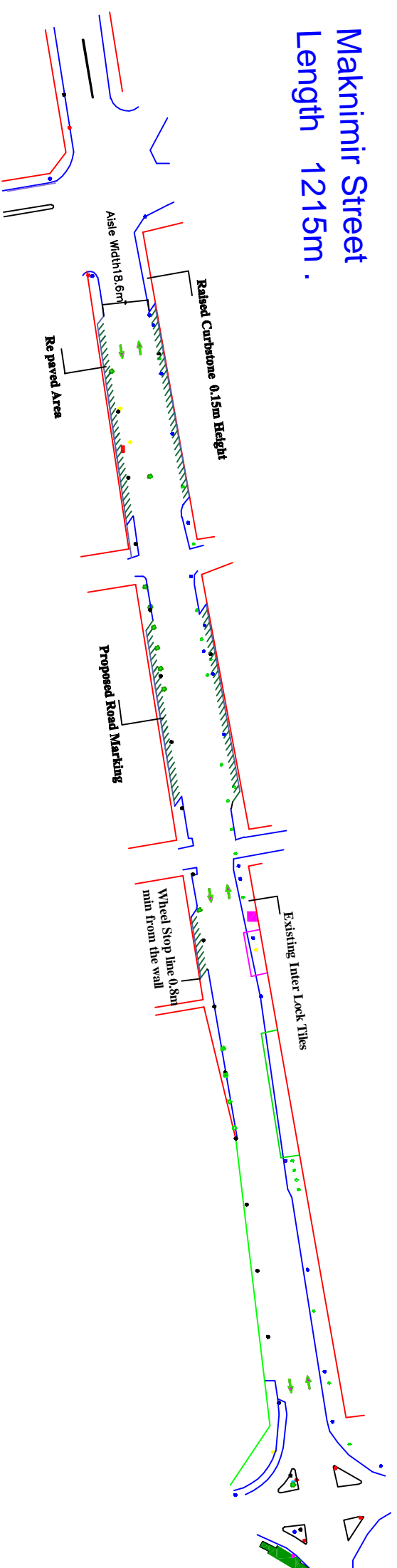
| Key | | | |
|-----|----------------|--|---------------|
| | Sudatel Pool | | Asphalt |
| | Traffic Signal | | Car Parking |
| | Electric Pool | | Green Area |
| | Tree | | Fence |
| | Lighting Pool | | Median |
| | Curb Line | | Building Line |



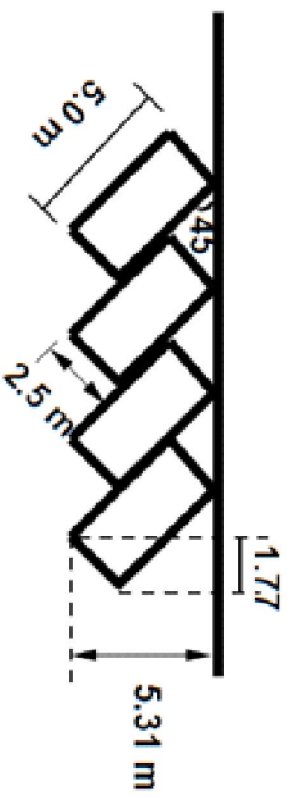
Section Four 550m.
Average Width 27.5m.

Tabya East Street

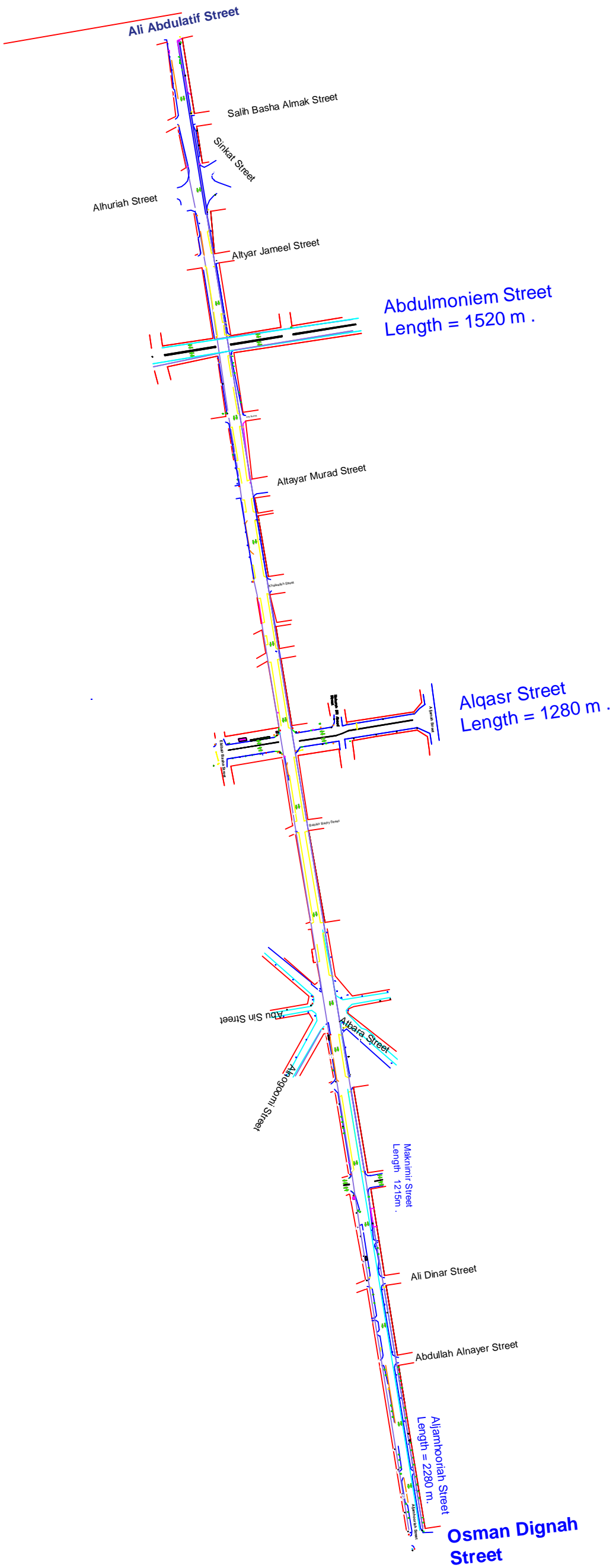
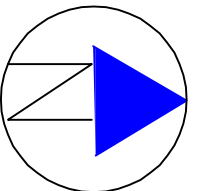
Maknimir Street
Length 1215m .



45degree Parking
Two Sides



| Key | |
|-----|----------------|
| | Sudatel Pool |
| | Traffic Signal |
| | Electric Pool |
| | Tree |
| | Lighting Pool |
| | Curb Line |
| | Asphalt |
| | Car Parking |
| | Green Area |
| | Fence |
| | Median |
| | Building Line |



| Key | |
|-----|----------------|
| ● | Sudatel Pool |
| ● | Traffic Signal |
| ● | Electric Pool |
| ● | Tree |
| ● | Lighting Pool |
| — | Curb Line |
| — | Asphalt |
| — | Car Parking |
| — | Green Area |
| — | Fence |
| — | Median |
| — | Building Line |

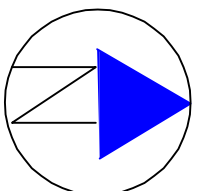
CHAPTER FIVE

PARKING DESIGN

APPENDIX A

DRAWING TITLE:
AIGAMHORAYAH STREET PLAN

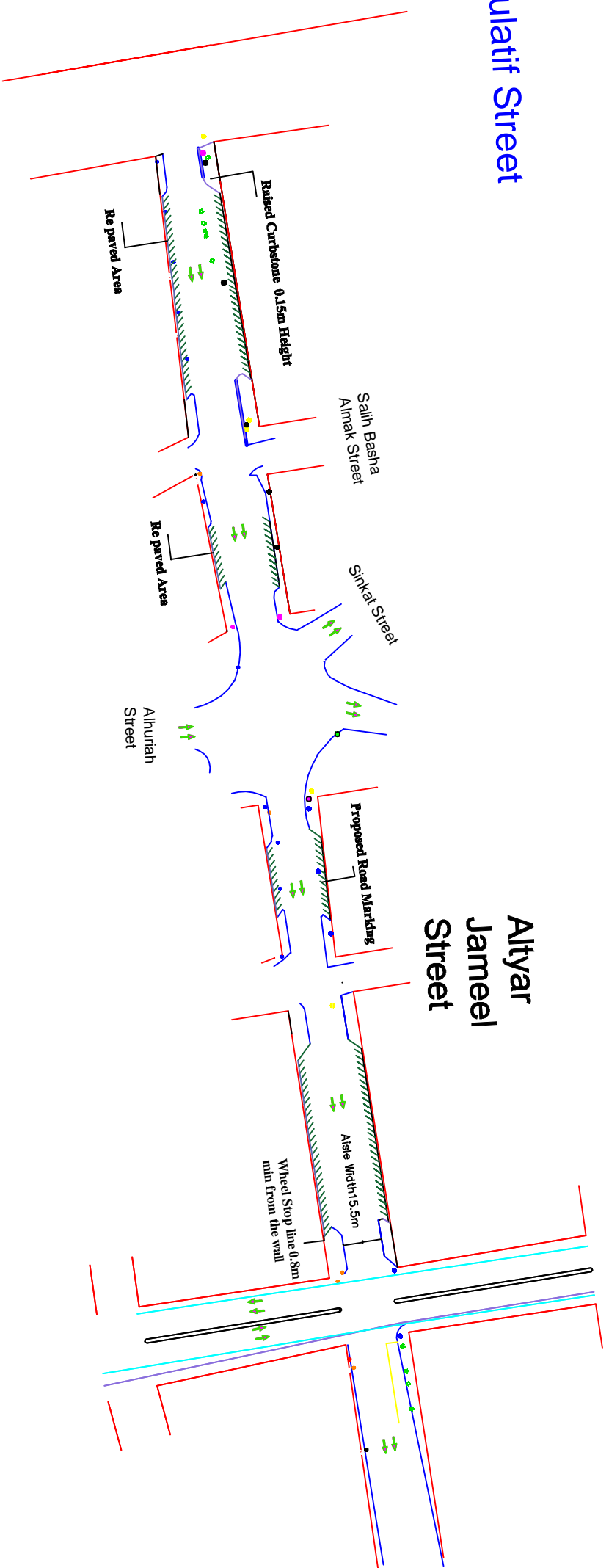
SHEET NO 3
Pa. 88



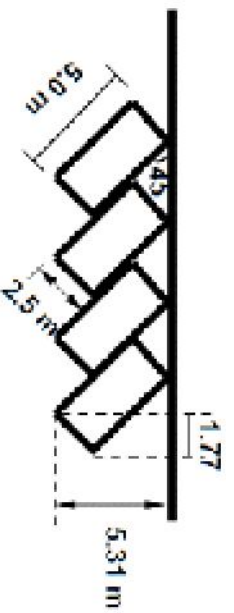
Section one 485m.
Average Width 25m.

Abdulmoniem Street
Length 1520= m .

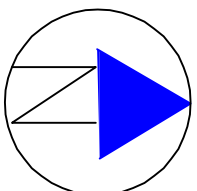
Ali Abdulatif Street



45degree Parking
Two Sides



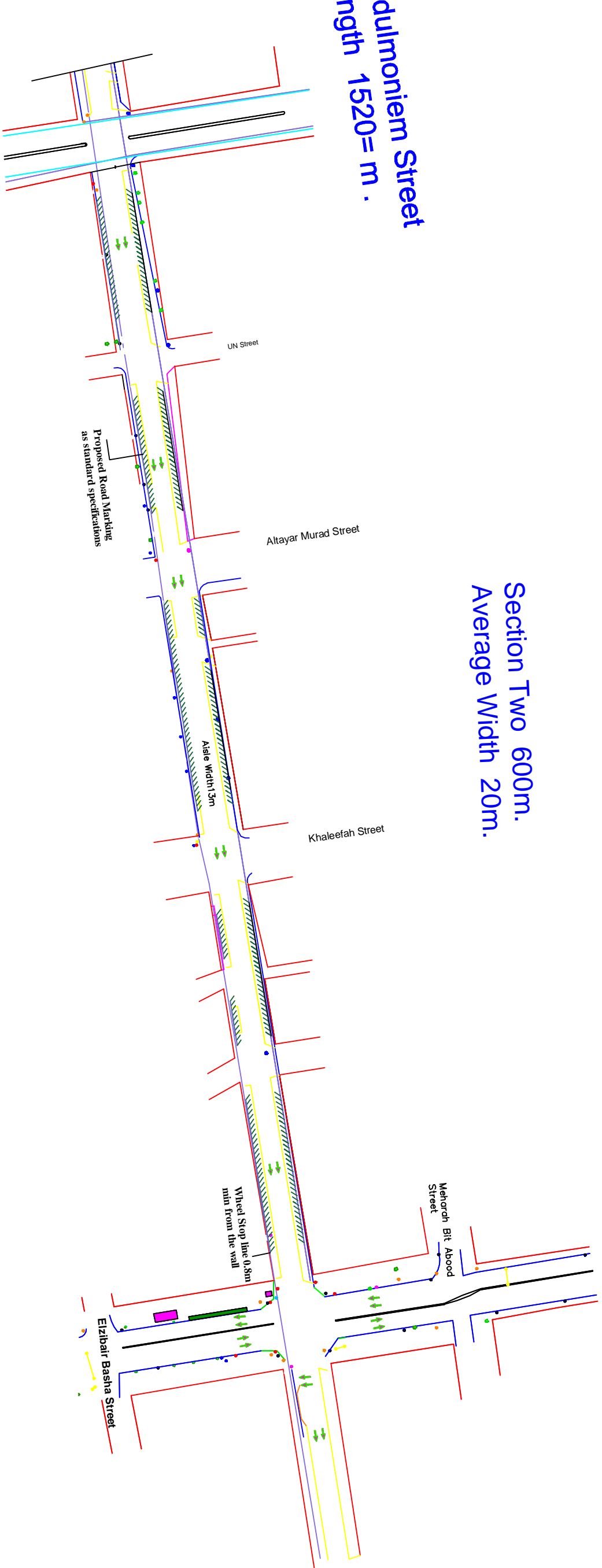
| Key | | | |
|-----|----------------|--|---------------|
| | Sudatel Pool | | Asphalt |
| | Traffic Signal | | Car Parking |
| | Electric Pool | | Green Area |
| | Tree | | Fence |
| | Lighting Pool | | Median |
| | Curb Line | | Building Line |



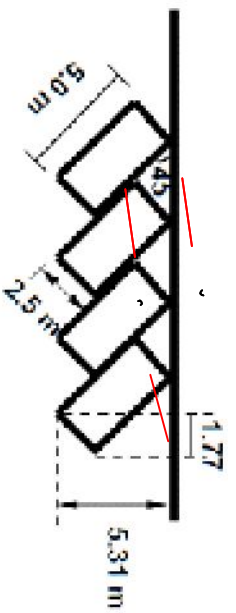
Alqasr Street
Length 1280 = m .

Section Two 600m.
Average Width 20m.

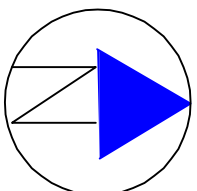
Abdulmuniem Street
Length 1520 = m .



45degree Parking
Two Sides



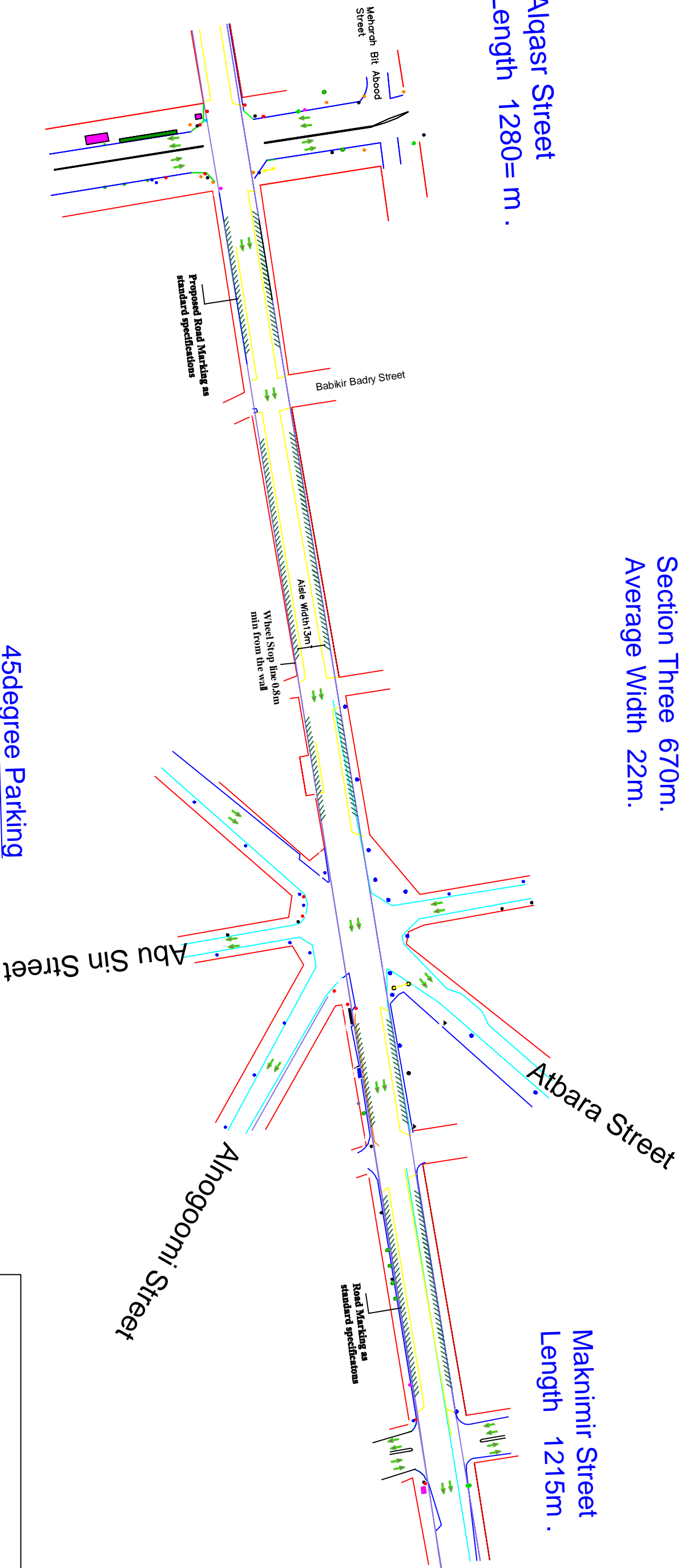
| Key | |
|-----|----------------|
| | Sudatel Pool |
| | Traffic Signal |
| | Electric Pool |
| | Tree |
| | Lighting Pool |
| | Curb Line |
| | Asphalt |
| | Car Parking |
| | Green Area |
| | Fence |
| | Median |
| | Building Line |



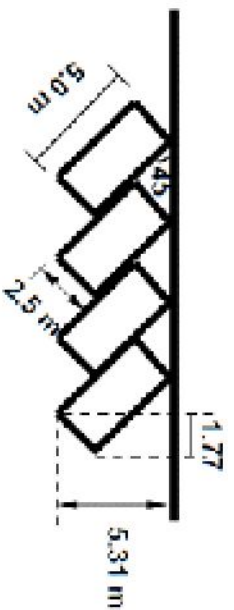
Section Three 670m.
Average Width 22m.

Algasr Street
Length 1280 = m .

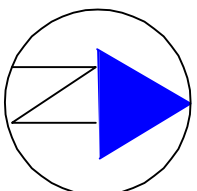
Maknimir Street
Length 1215m .



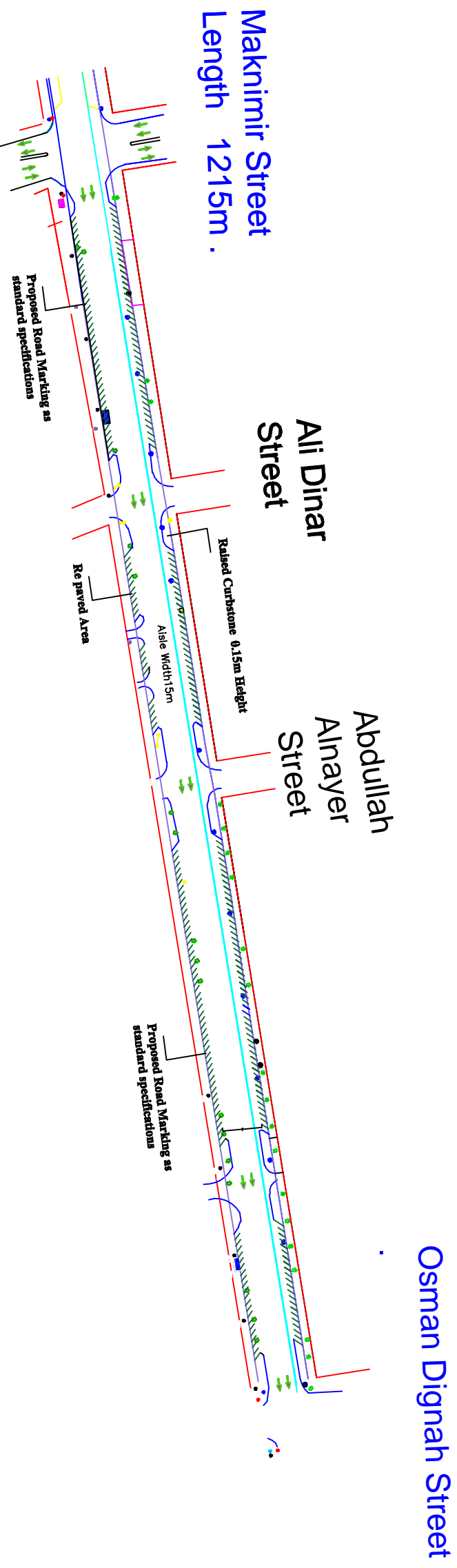
45degree Parking
Two Sides



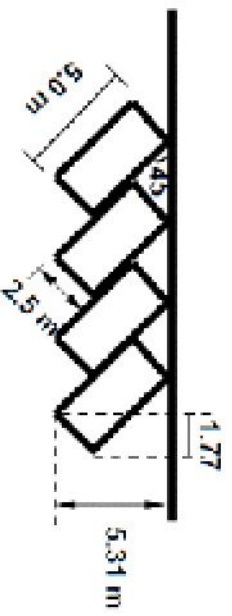
| Key | | | |
|-----|----------------|--|---------------|
| | Sudatel Pool | | Asphalt |
| | Traffic Signal | | Car Parking |
| | Electric Pool | | Green Area |
| | Tree | | Fence |
| | Lighting Pool | | Median |
| | Curb Line | | Building Line |



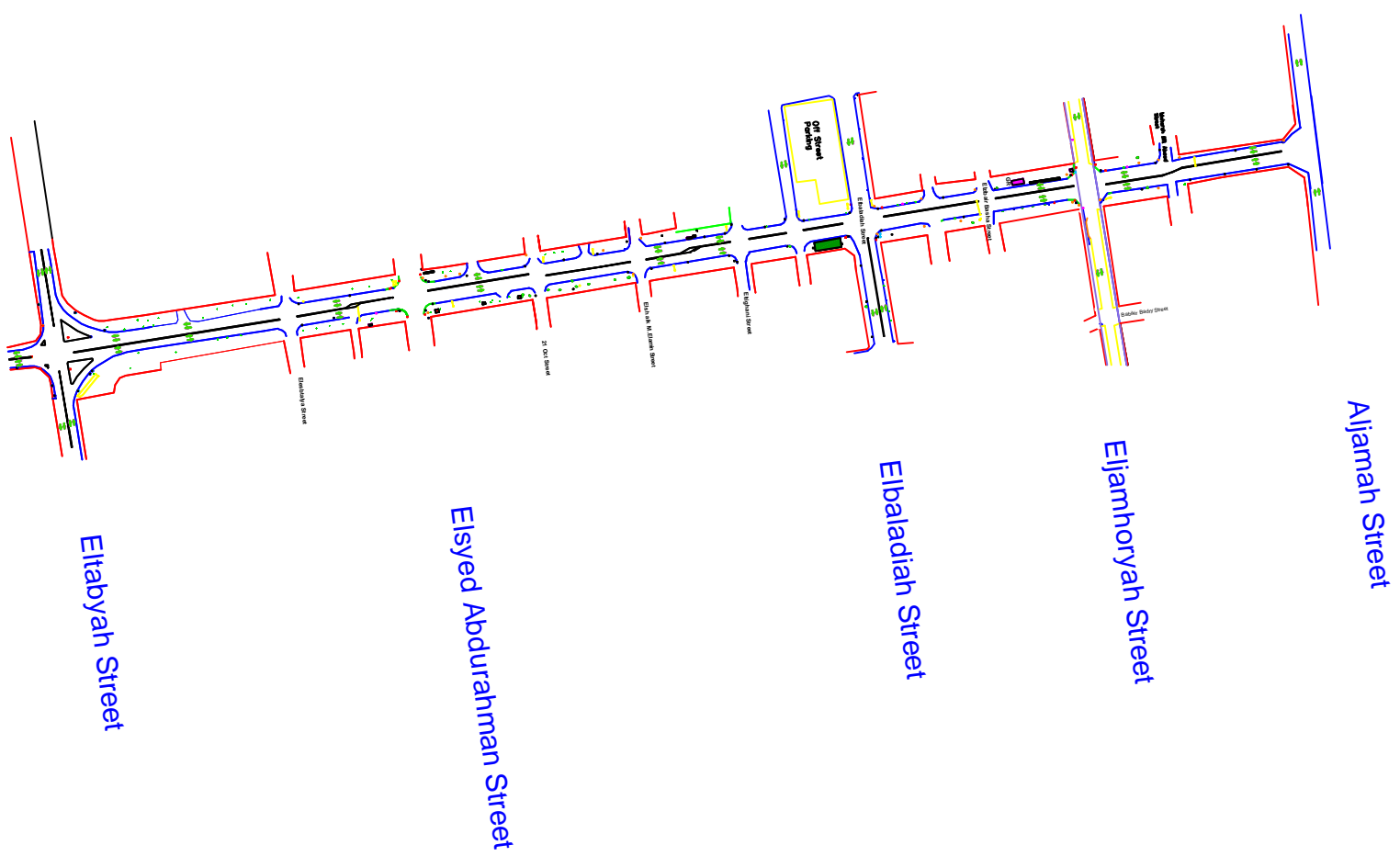
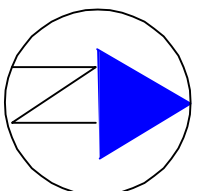
Section Four 550m.
Average Width 28m.



45degree Parking
Two Sides



| Key | | | |
|-----|----------------|--|---------------|
| | Sudatel Pool | | Asphalt |
| | Traffic Signal | | Car Parking |
| | Electric Pool | | Green Area |
| | Tree | | Fence |
| | Lighting Pool | | Median |
| | Curb Line | | Building Line |



| Key | | | |
|-----|----------------|---|---------------|
| ● | Sudatel Pool | ■ | Asphalt |
| ● | Traffic Signal | ■ | Car Parking |
| ● | Electric Pool | ■ | Green Area |
| ● | Tree | ■ | Fence |
| ● | Lighting Pool | ■ | Median |
| — | Curb Line | — | Building Line |

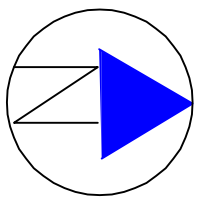
CHAPTER FIVE

PARKING DESIGN

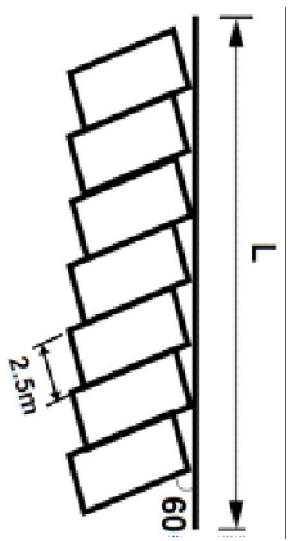
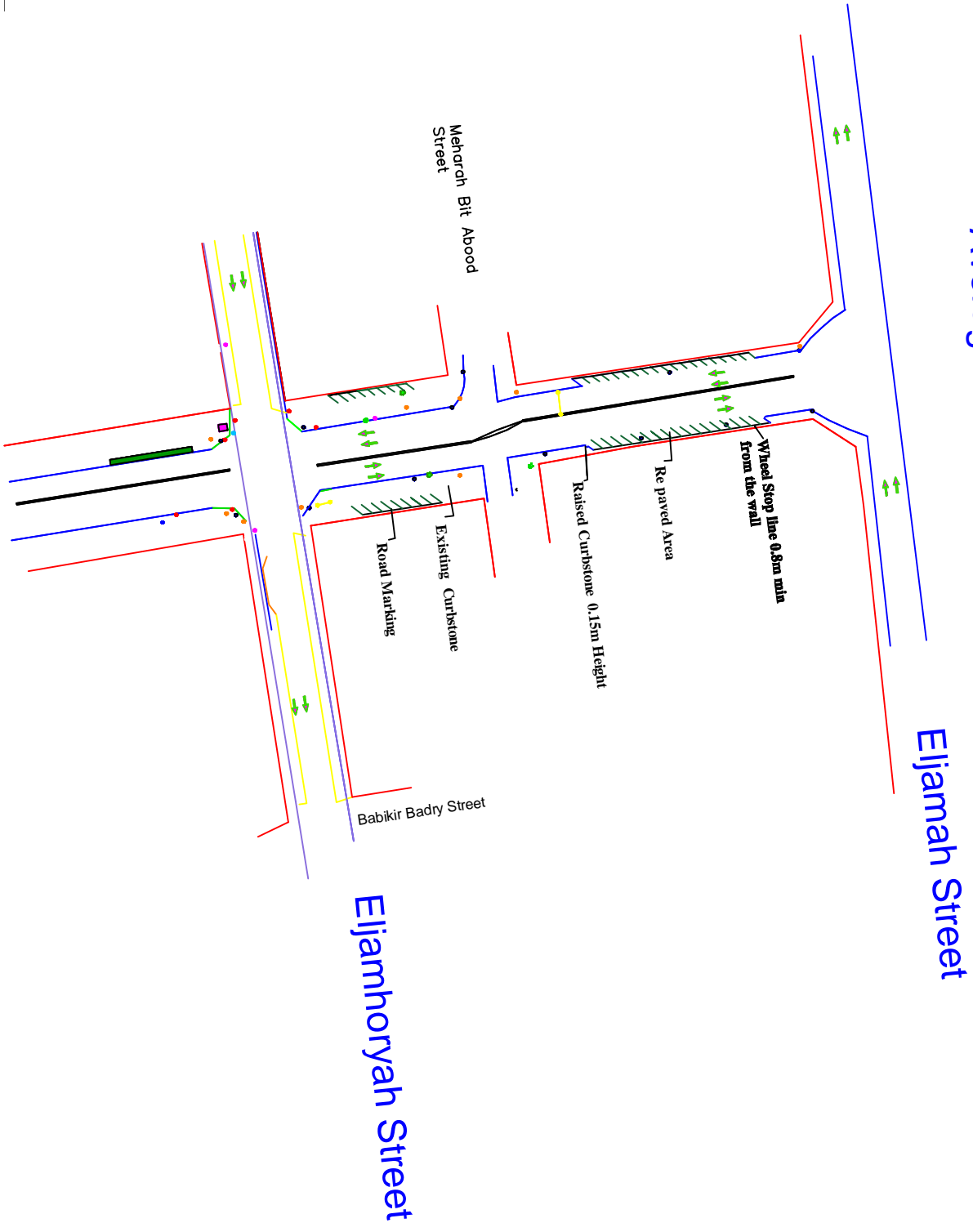
APPENDIX A

DRAWING TITLE:
AIGASR STREET PLAN

SHEET NO 4
Pa. No 93



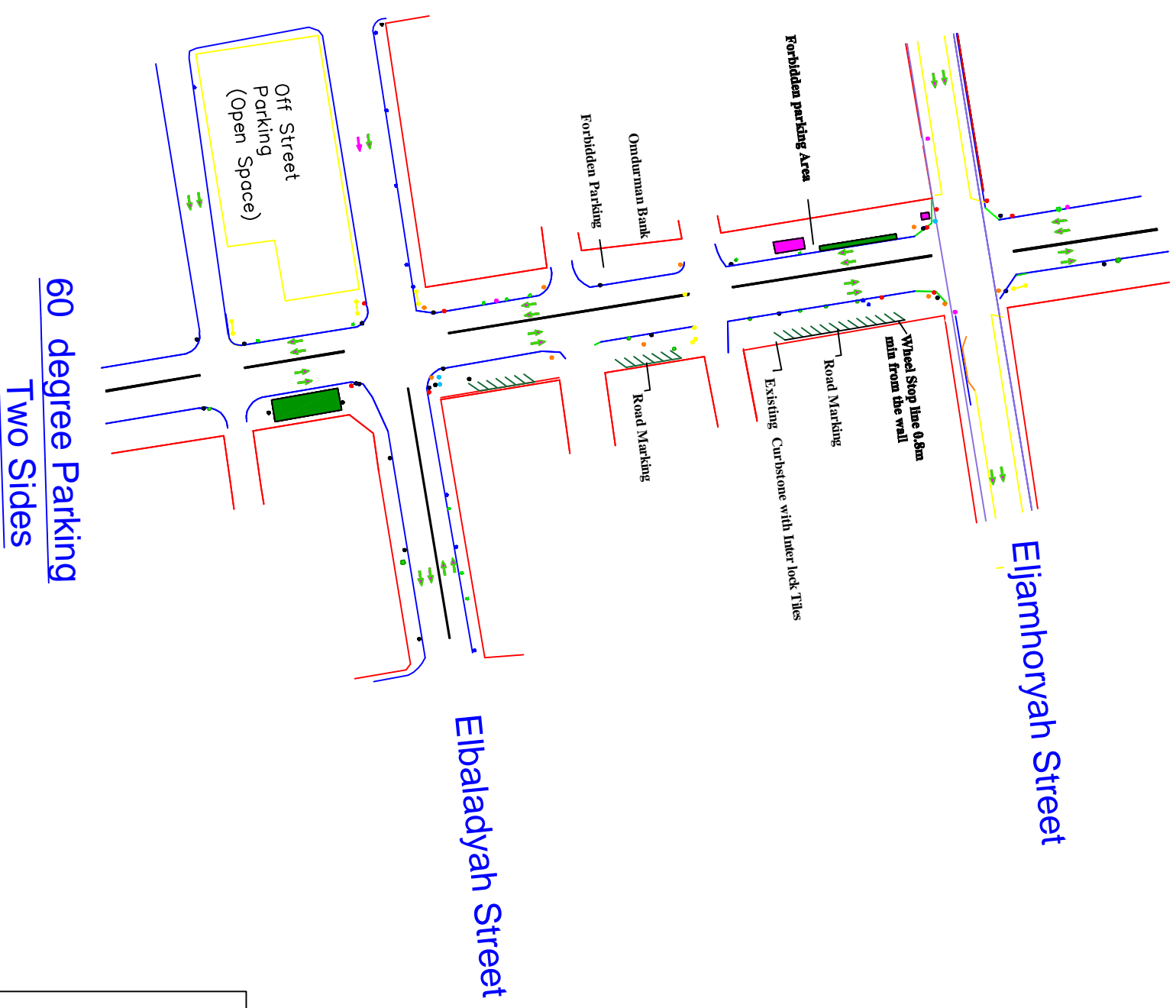
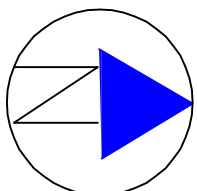
Section one 230 m.
Average Width 30 m.



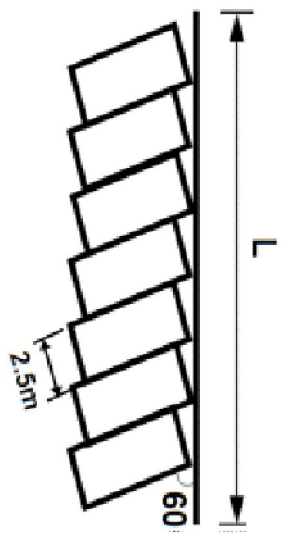
60 degree Parking
Two Sides

| Key | | | |
|-----|----------------|--|---------------|
| | Sudatel Pool | | Asphalt |
| | Traffic Signal | | Car Parking |
| | Electric Pool | | Green Area |
| | Tree | | Fence |
| | Lighting Pool | | Median |
| | Curb Line | | Building Line |

Section Two 230 m.
Average Width 30 m.

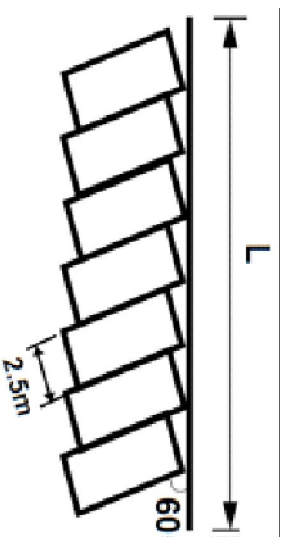
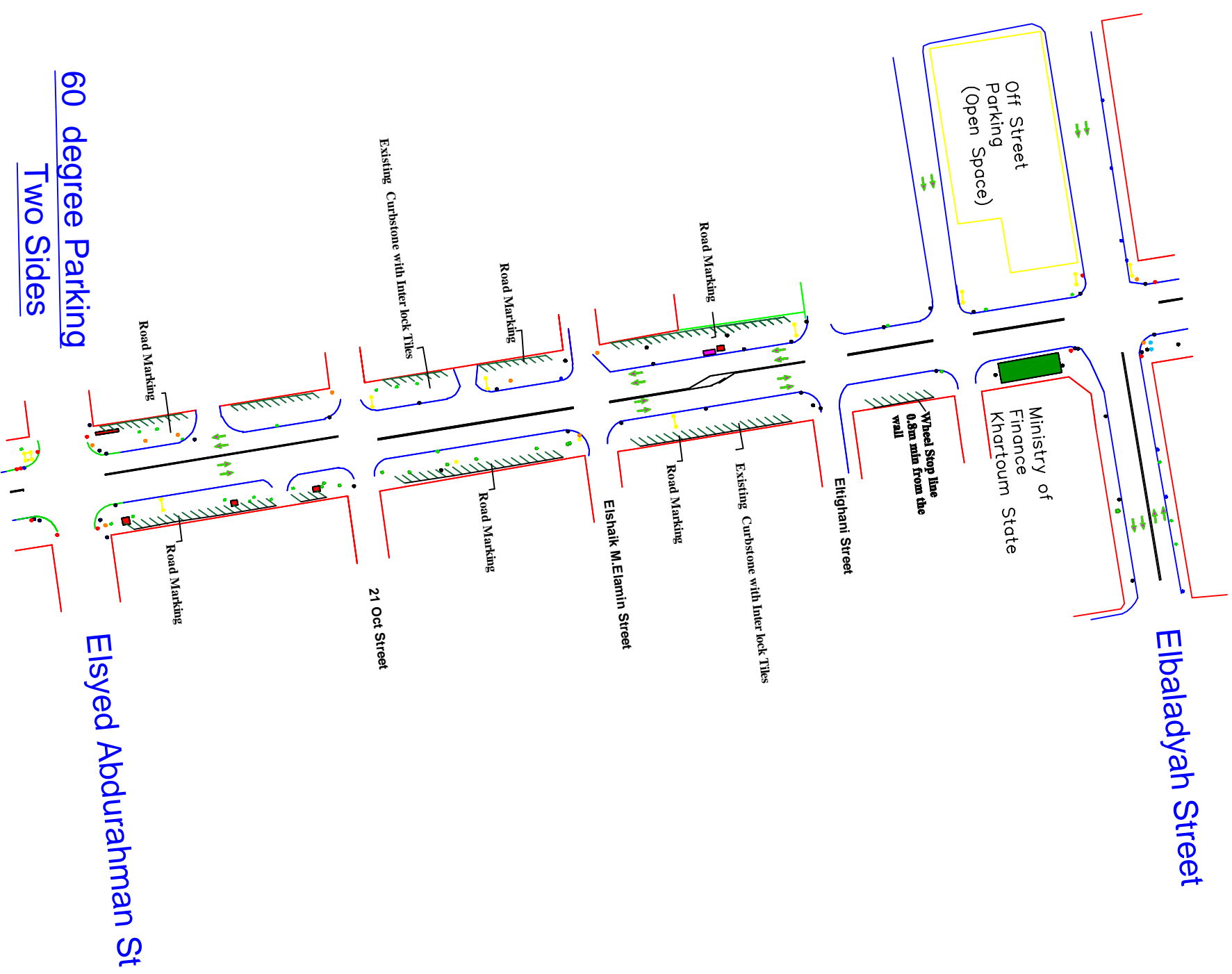
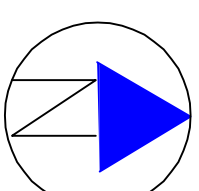


60 degree Parking
Two Sides



| Key | | | |
|-----|----------------|--|---------------|
| | Sudatel Pool | | Asphalt |
| | Traffic Signal | | Car Parking |
| | Electric Pool | | Green Area |
| | Tree | | Fence |
| | Lighting Pool | | Median |
| | Curb Line | | Building Line |

Section Three 450 m.
Average Width 30 m.

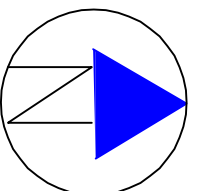


| Key | | | |
|-----|----------------|--|---------------|
| | Sudatel Pool | | Asphalt |
| | Traffic Signal | | Car Parking |
| | Electric Pool | | Green Area |
| | Tree | | Fence |
| | Lighting Pool | | Median |
| | Curb Line | | Building Line |

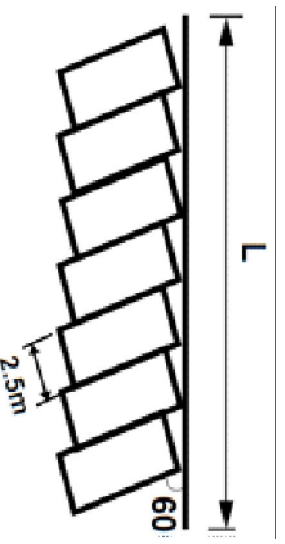
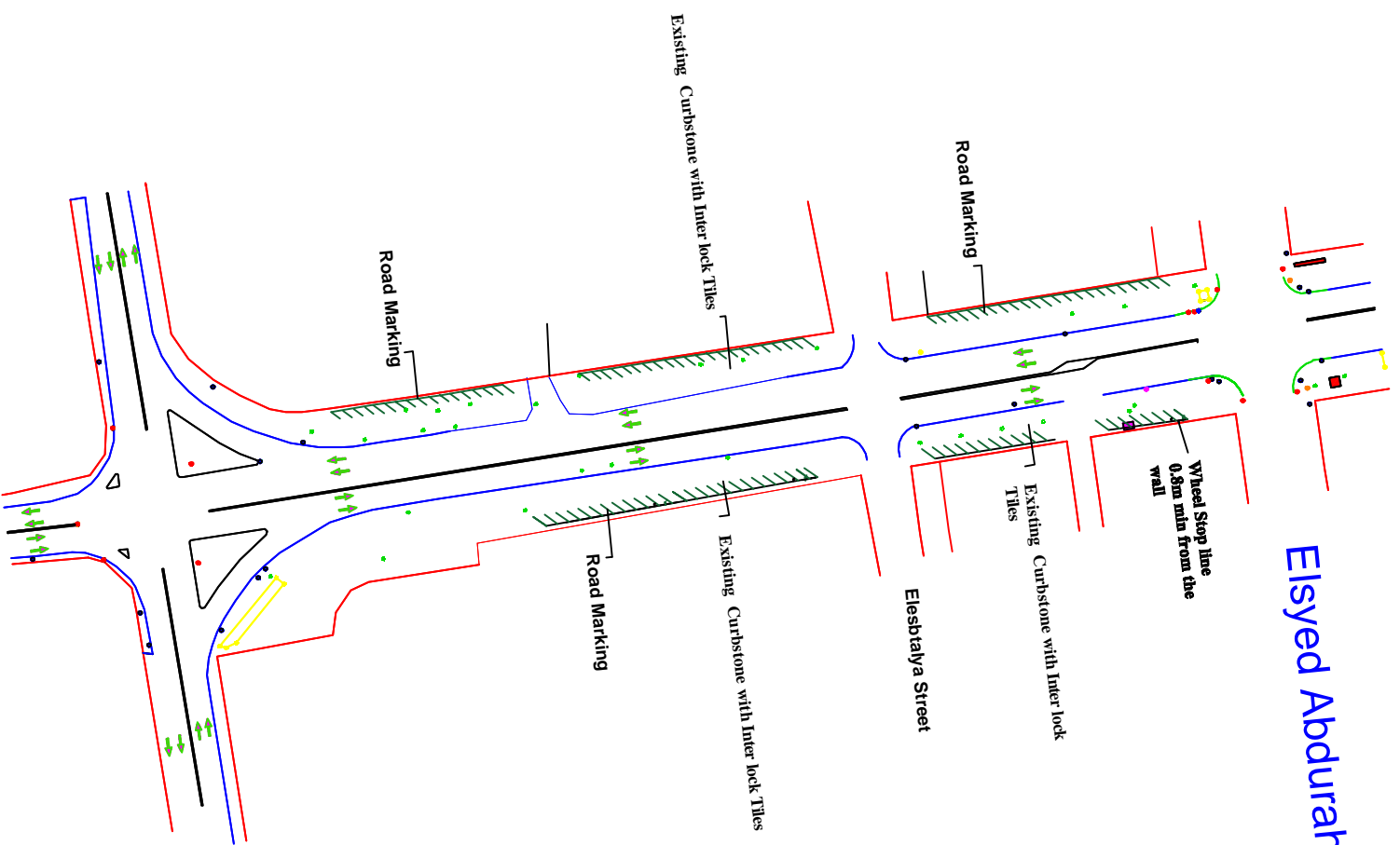
60 degree Parking

Two Sides

Section Four 350 m.
Average Width 30 m.



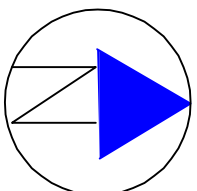
Elsyed Abdurahman St



60 degree Parking
Two Sides

Eltabyah Street

| Key | | | |
|-----|----------------|---|---------------|
| ● | Sudatel Pool | ■ | Asphalt |
| ● | Traffic Signal | ■ | Car Parking |
| ● | Electric Pool | ■ | Green Area |
| ● | Tree | ■ | Fence |
| ● | Lighting Pool | ■ | Median |
| — | Curb Line | — | Building Line |



Key

| | | | |
|--|----------------|--|---------------|
| | Sudatel Pool | | Asphalt |
| | Traffic Signal | | Car Parking |
| | Electric Pool | | Green Area |
| | Tree | | Fence |
| | Lighting Pool | | Median |
| | Curb Line | | Building Line |

CHAPTER FIVE

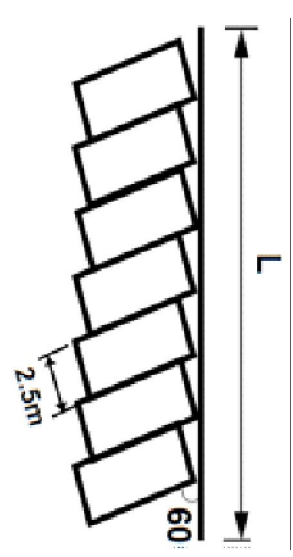
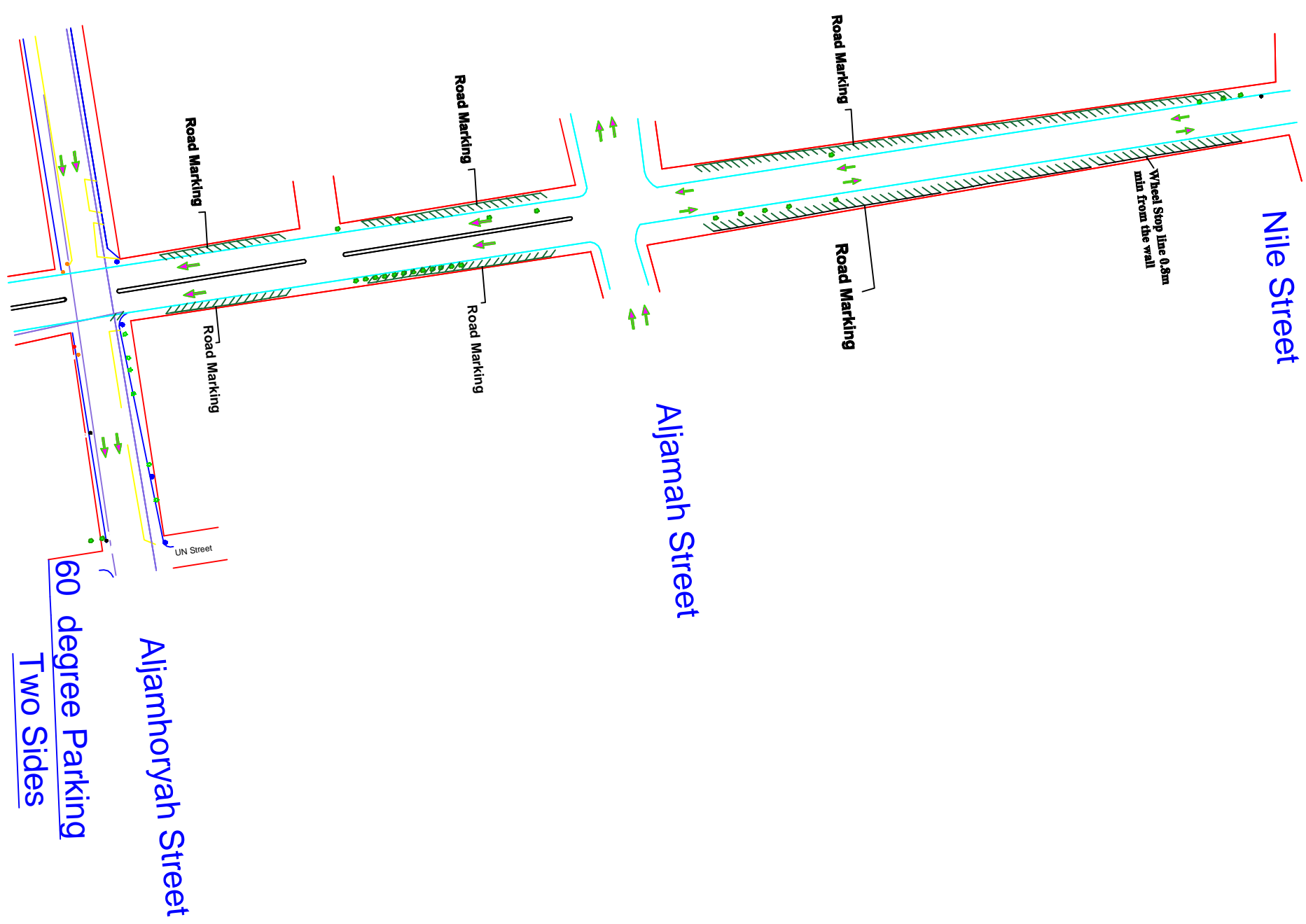
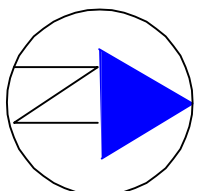
PARKING DESIGN

APPENDIX A

DRAWING TITLE:
Albulmoniemi Street Plan

SHEET NO 5
Pa. 98

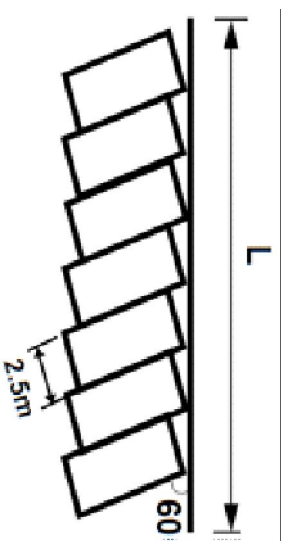
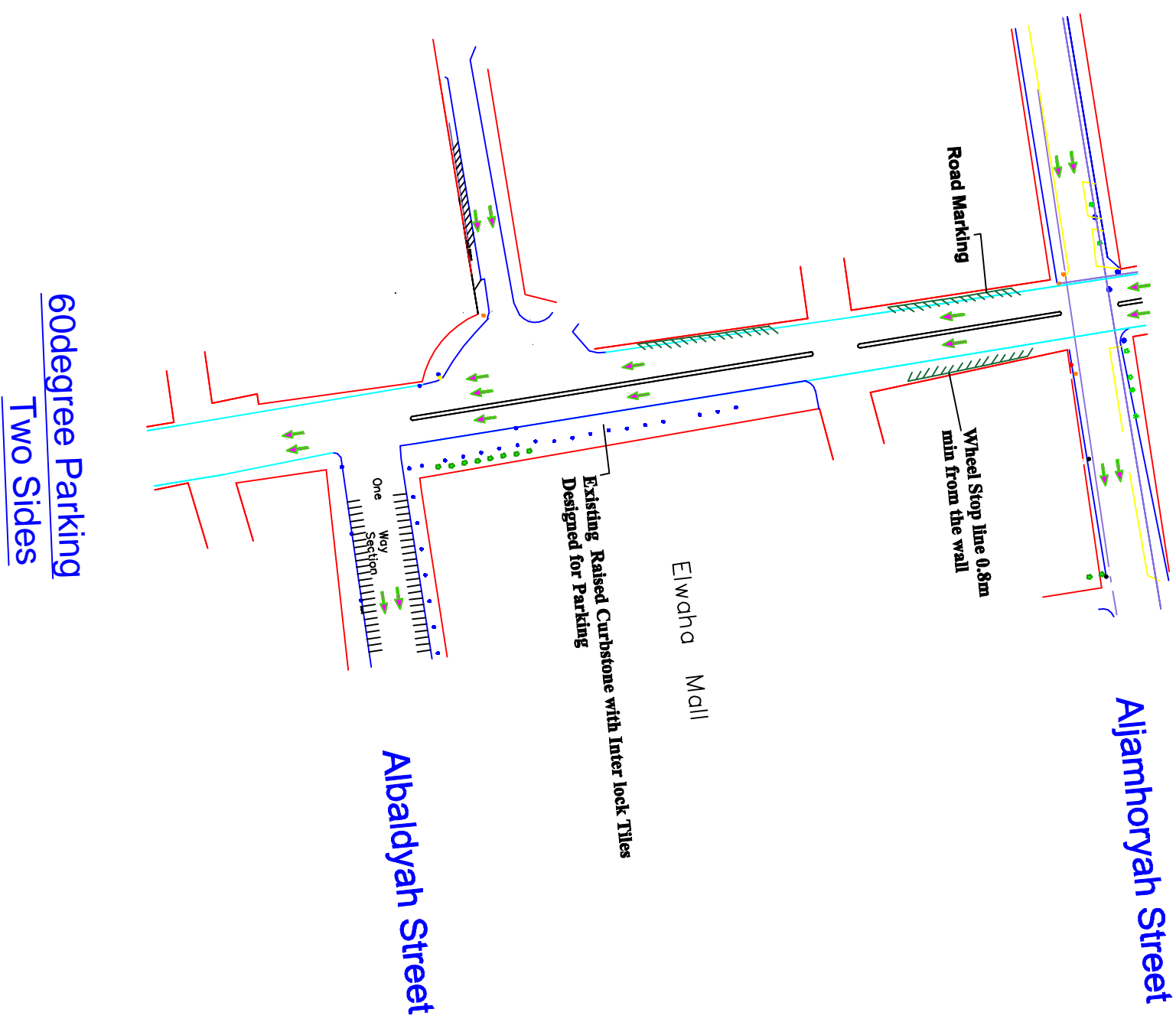
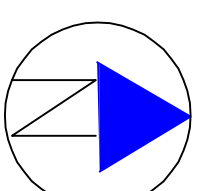
Section one 485 m.
Average Width 30m.



Key

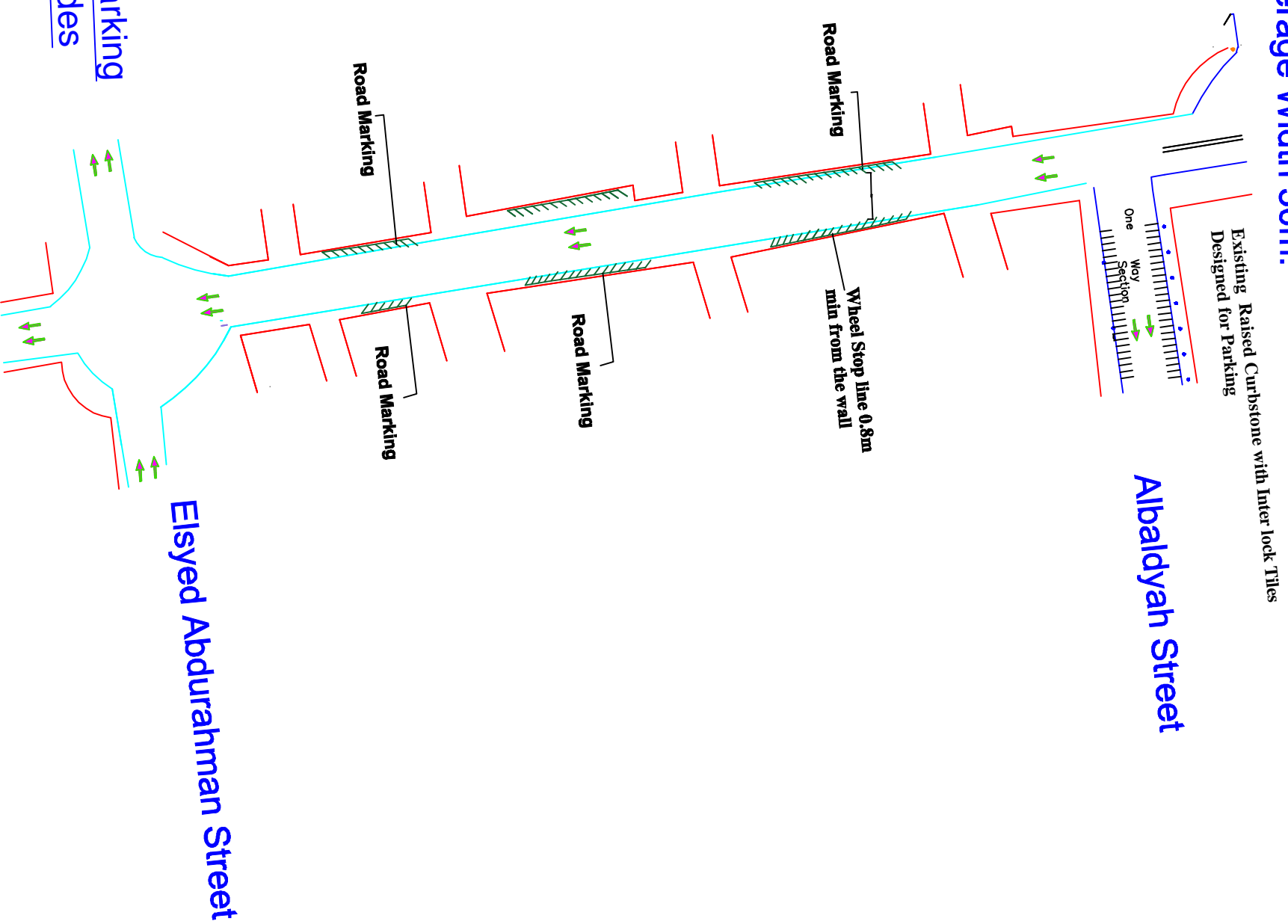
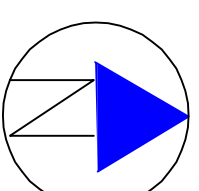
| | |
|------------------|-----------------|
| ● Sudanese Pool | ● Asphalt |
| ● Traffic Signal | ● Car Parking |
| ● Electric Pool | ● Green Area |
| ● Tree | ● Fence |
| ● Lighting Pool | ● Median |
| ● Curb Line | ● Building Line |

Section TWO 280 m.
Average Width 30 m.



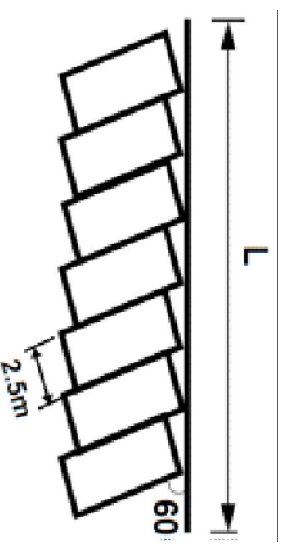
| Key | | | |
|-----|----------------|---|---------------|
| ● | Sudatel Pool | ■ | Asphalt |
| ● | Traffic Signal | ■ | Car Parking |
| ● | Electric Pool | ■ | Green Area |
| ● | Tree | ■ | Fence |
| ● | Lighting Pool | ■ | Median |
| — | Curb Line | — | Building Line |

Section Three 400 m.
Average Width 30m.

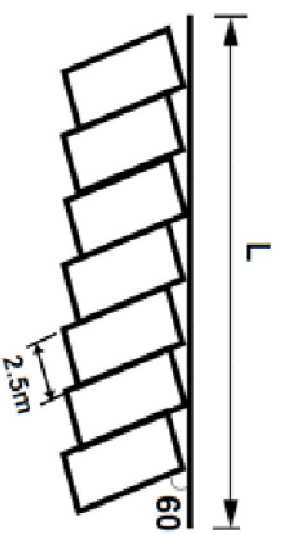
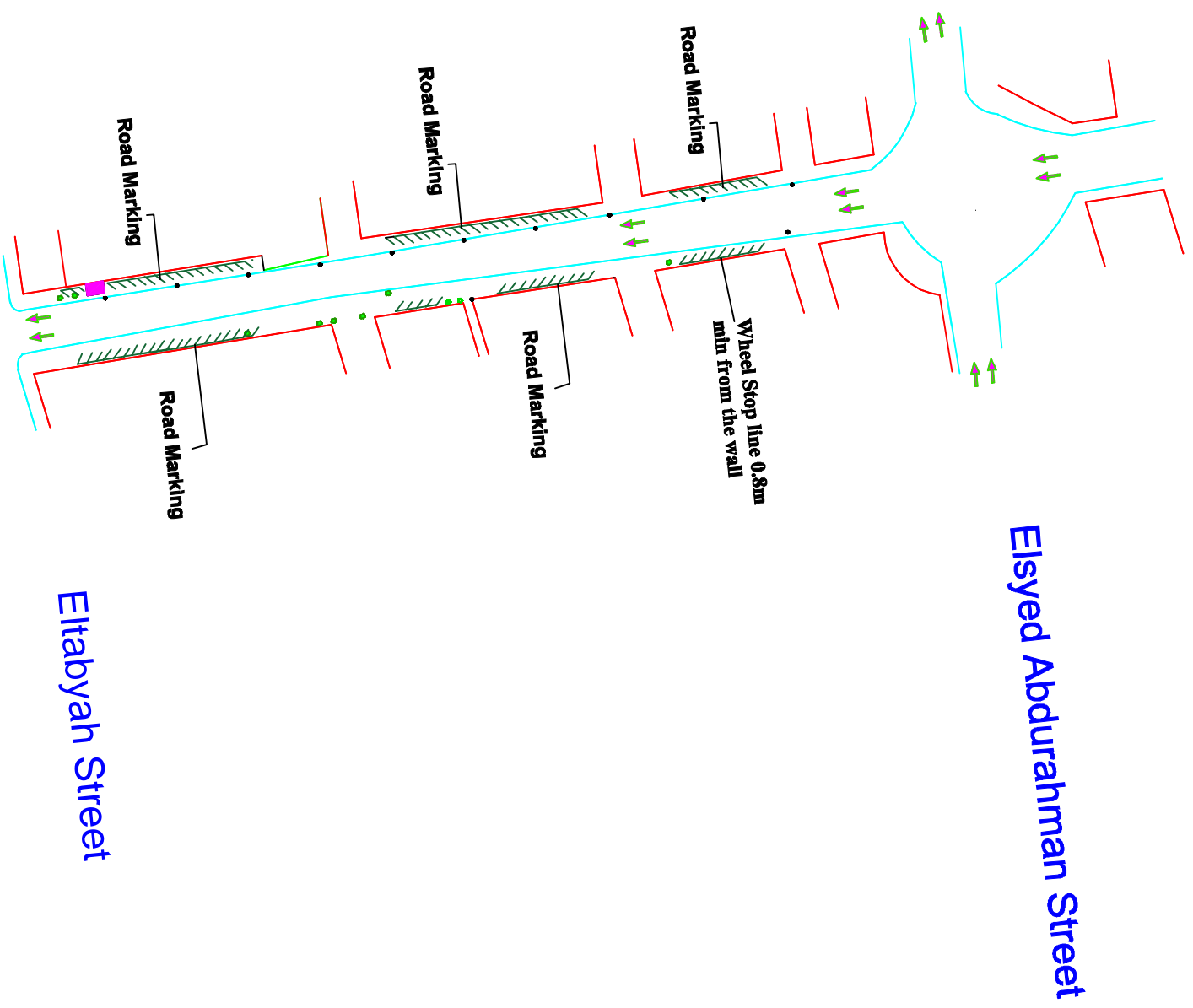
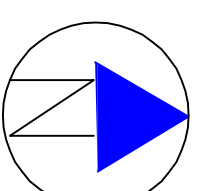


| Key | | | |
|-----|----------------|--|---------------|
| | Sudatel Pool | | Asphalt |
| | Traffic Signal | | Car Parking |
| | Electric Pool | | Green Area |
| | Tree | | Fence |
| | Lighting Pool | | Median |
| | Curb Line | | Building Line |

60 degree Parking
Two Sides



Section Three 360 m.
Average Width 30 m.



60degree Parking
Two Sides

| Key | | | |
|-----|----------------|--|---------------|
| | Sudatel Pool | | Asphalt |
| | Traffic Signal | | Car Parking |
| | Electric Pool | | Green Area |
| | Tree | | Fence |
| | Lighting Pool | | Median |
| | Curb Line | | Building Line |