**An-Najah National University**
**Faculty of Graduate Studies**

# Compliance of Access Management Techniques on Urban Arterials in Nablus City

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***Submitted in Partial Fulfillment of the Requirements for the Degree of Master in Transportation Engineering, Faculty of Graduate Studies, at An-Najah National University, Nablus, Palestine***

**2006**

جامعة النجاح الوطنية
كلية الدراسات العليا
نابلس - فلسطين

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# DEDICATION

All thanks from my heart for people provided me with there support to achieve this thesis successfully. I dedicate my simple work for the dearest people to me: my father, my mother, my brother, my sisters, and all my friends. I dedicate this work also to my teachers who did all there bests in helping me to finish this thesis.

# ACKNOWLEDGMENT

First of all, I thanks Allah for all the blessings, he bestowed on me and continues to bestow on me. I'd like to provide my appreciation to my instructors in An-Najah National University, especially my supervisor Dr. Khaled Al-Sahili whose support and encouragement was a great factor for my success.

My thanks to the discussion committee instructors Dr. Osama Abaza and Dr. Khaled Zeidan who honored me in their valuable discussion from which I benefit much. Finally, thanks to all my students who did their best to help me in this project.

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**Compliance of Access Management Techniques on Urban Arterials in Nablus City**

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## Abstract

Transportation services provided in Palestine are inadequate to satisfy both the current and increasing demand for transportation. Due to the increasing limitation of spaces and resources in most cities, there has been a growing trend in the management of the existing traffic system rather than building new facilities. Traffic management is a low cost improvement while constructing new facilities is capital-intensive and may be faced with the limitations of space and financial resources.

The objective of this project is to evaluate the applicability and effectiveness of some access management measures on two urban arterials in Nablus City. Proper evaluation was performed for Rafidia-Yaser Arafat Street and Faisal-Haifa Street. The methodology of this research is based on the following items:

i) Review existing international access management processes
ii) Explain the functions and the importance of access management measures
iii) Collect the related access management data about the studied streets
iv) Select the steps, techniques, and adopt access management standards which suite the Palestinian cities
v) Evaluate the effect of these techniques on the street network.

vi) Survey the public's opinions on drivers, pedestrians, and business owners on the two studied arterials, by doing face-to-face interviews with these groups

The access management measures that will be discussed in this research address the following areas: intersection spacing, driveway spacing, median treatments and median openings, turning lanes and auxiliary lanes, street connections, and parking management.

The main results of this study were:

- There are no specific guidelines or standards that are universally adopted for some access management measures.
- The level of compliance of the arterials in Nablus City with access management measures is relatively acceptable.
- It is difficult to apply access management measures on urban arterials, especially near the CBD area, where space is limited and the need for accessibility is high, while it is much easier on rural arterials.
- Closing some driveways and openings or prohibiting some movements improved traffic movements and level of service, and reduce delay on the main arterial streets in Nablus City.
- LOS for signalized intersections was improved from (D-F) to (C-E). The unsignalized intersections, which operate at LOS (F) were improved to LOS (C).

After the discussion of the applicability of access management strategies, it is concluded that these measures can be applied on Nablus arterials. For the two studied streets, some measures are easily applied, others can be applied with limited geometric improvements, and some measures could not be applied because they need large space.

# CHAPTER ONE

# INTRODUCTION

## 1.1 Background

Due to the increasing limitation of spaces and resources in most cities, there has been a growing trend in the management of the existing traffic system rather than building new facilities. Traffic management is a low cost improvement while constructing new facilities is capital-intensive and may be faced with the limitations of space and financial resources. This is a global issue and not restricted to Palestine.

In the past, road improvements were frequently made on an ad hoc basis. They were based on predicted future traffic growth and looked at one problem area rather than the whole route. This piecemeal approach can have the effect of shunting traffic problems further along a road corridor.

Transportation management focuses on reducing corridor congestion and improving overall mobility on the existing facility. This alternative includes an integrated package of transportation management strategies that maximize the operational efficiency and person-moving capacity of the corridor by better balancing the demand for travel with the capacity to handle travel demand. Many of these strategies rely heavily on public-private partnerships to achieve desired results.

Transportation management includes the coordinated implementation of transportation demand management (TDM), transportation systems management (TSM), and intelligent transportation systems (ITS) strategies.

Transportation management strategies generally exclude extensive infrastructure investments aimed at expanding roadway capacity. Instead, these strategies focus on:

1. Management of travel demand to reduce the severity and duration of circumstances where travel demand exceeds existing roadway capacity. Modifications to travel demand can include adjustments to travel time (by time-of-day and/or day-of-week), travel route, trip distance (through changes in trip origins and destinations), and vehicle occupancy.

2. Management of existing corridor capacity to address locations where relatively minor improvements to the roadway network or highway operations will help address temporary or long-term capacity bottlenecks. Temporary bottlenecks include those caused by incidents, weather, and construction factors.

The traffic management can be divided into two main scales: streets and intersection control. This thesis discusses traffic management in terms of use of streets especially arterials and major corridors. This embraces solutions for existing arterials. New developments can also be part of this category; however, the focus should be on low cost improvements.

Highways serve the principal functions of providing mobility for the movement of through traffic and providing access to adjoining land. The function of any particular road can be related to the degree that it provides to these two services. The entire concept of functional classification is based on certain key characteristics, which can be used to differentiate between kinds of highways.

## 1.2 Highway Functional Classification

Highway functional classification means classifying highways with respect to the amount of access or movement they are to provide, and then designing and managing each facility to perform that function.

There are no definite dividing lines between each of the classes or rigid rules defining what makes a street a local, collector, or arterial. The three basic functional classes represent a continuum of facilities that range from unrestricted access to complete access control.

Arterial streets are the major elements of the road network and the highest order of streets in the West Bank and Gaza. They carry high traffic volumes, with high speed, and high percentage of heavy vehicles. Trip length is longer than trips on the other road classes and land access is a secondary consideration.

The roadways can have 2 to 6 traffic lanes. The designated truck routes are usually arterial streets. Therefore, special attention should be paid to these streets and thus should be well managed. Traffic operations and road design along these streets should be continuously improved. Parking organization and enforcement is necessary.

## 1.3 Arterial Management

An arterial is a highway or major street whose primary purpose is to provide safe and efficient long distance travel. Providing local access is a secondary function.

Typically, almost all roadways will fall into one of three classifications: arterial streets, collector streets, or local streets. The difference between the classifications depends on the trade-off between providing mobility to through traffic with higher speeds and traffic volumes and the level of land access that is permitted.

The functional integrity of the street/highway system is the effectiveness or reliability with which it provides personal mobility, freight delivery, cargo transport, and access to land use activities.

Figure (1.1) shows the variation of mobility and accessibility for the various highway classes.

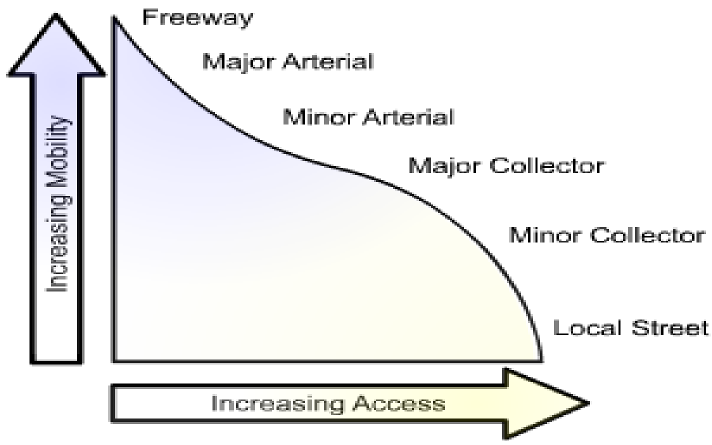



**Figure 1.1** Variation of Mobility and Accessibility
Source: Redrawn from Khisty and Lall, 2002

The priority on arterial streets is to provide mobility to through traffic, while the priority on local streets is to provide access. Collector streets fall in between, with the mobility and access functions sharing the priority equally.

The arterial streets and highways are keys to maintaining the utility of the highway systems with their primary responsibility to provide for mobility, capacity, reasonable speeds, and safety; they have limited responsibility to provide access.

The design geometrics of each of these facility classes are matched to the functional requirements; that is, the speed, capacity, and operational characteristics.

Arterial management also continues into the operation phase, which this thesis focus on, including the reallocation of space as need, and the enforcement of all policies related to preserving the arterial function and to encouraging efficient movement of through traffic.

Arterials that carry large volumes of traffic are attractive locations for strip development. Residential and commercial developments locate along the arterial over time until strip development becomes the predominant land use pattern. The ability of the arterial to move traffic then becomes seriously compromised, resulting in increased traffic congestion and reduced safety.

## 1.4 Definition of Access Management

Access is the ability to enter or leave a public street from or at an adjacent driveway or another public street. Based on New York State Department of Transportation, 1996, access management is defined as the control of driveways and intersections to maintain safety at a roadway's full traffic carrying capacity. It is also defined as "the process that provides access to land development while simultaneously preserving the flow of traffic on the surrounding system in terms of safety, capacity, and speed" (Maine Department of Transportation, 1994). In practical terms, it means managing the number of driveways that a vehicle may encounter without hampering reasonable access to a property and removing slower, turning vehicles from the arterial as efficiently as possible.

The following points should be considered in analyzing the thesis subject:

- Access management deals with traffic problems that are caused by unmanaged development.
- Access management addresses how land is accessed along arterials.
- Access management focuses on mitigating traffic problems arising from development and increased traffic volume attempting to utilize these developments.
- Access management calls upon local planning and zoning to address overall patterns of growth and the aesthetic issues arising from development.

Access control is a very important feature in preserving road capacity and reducing accidents. Ideally, arterials should have few, if any conflict points other than at intersections. Continuous access for adjacent development should not be permitted nor should be extensive on-street parking.

It is desired to restrict access on rural roads, but when these roads pass through cities, the municipalities must agree to allow access to a business or residence.

The application of access management treatments may be long-term when planning or designing the facility, or short-term when evaluating operation and control strategies.

Consequently, the level of service criteria used must be consistent with the timeframe in which it applies. Therefore, for long-term or planning decisions, the design level of service criterion is typically used. The operating level of service criteria may be used for short-term or existing conditions for access management decisions that are not irreversible, that is, where the traffic control, the design, or topographic and land use features can be altered in the future with acceptable costs and property owner reaction.

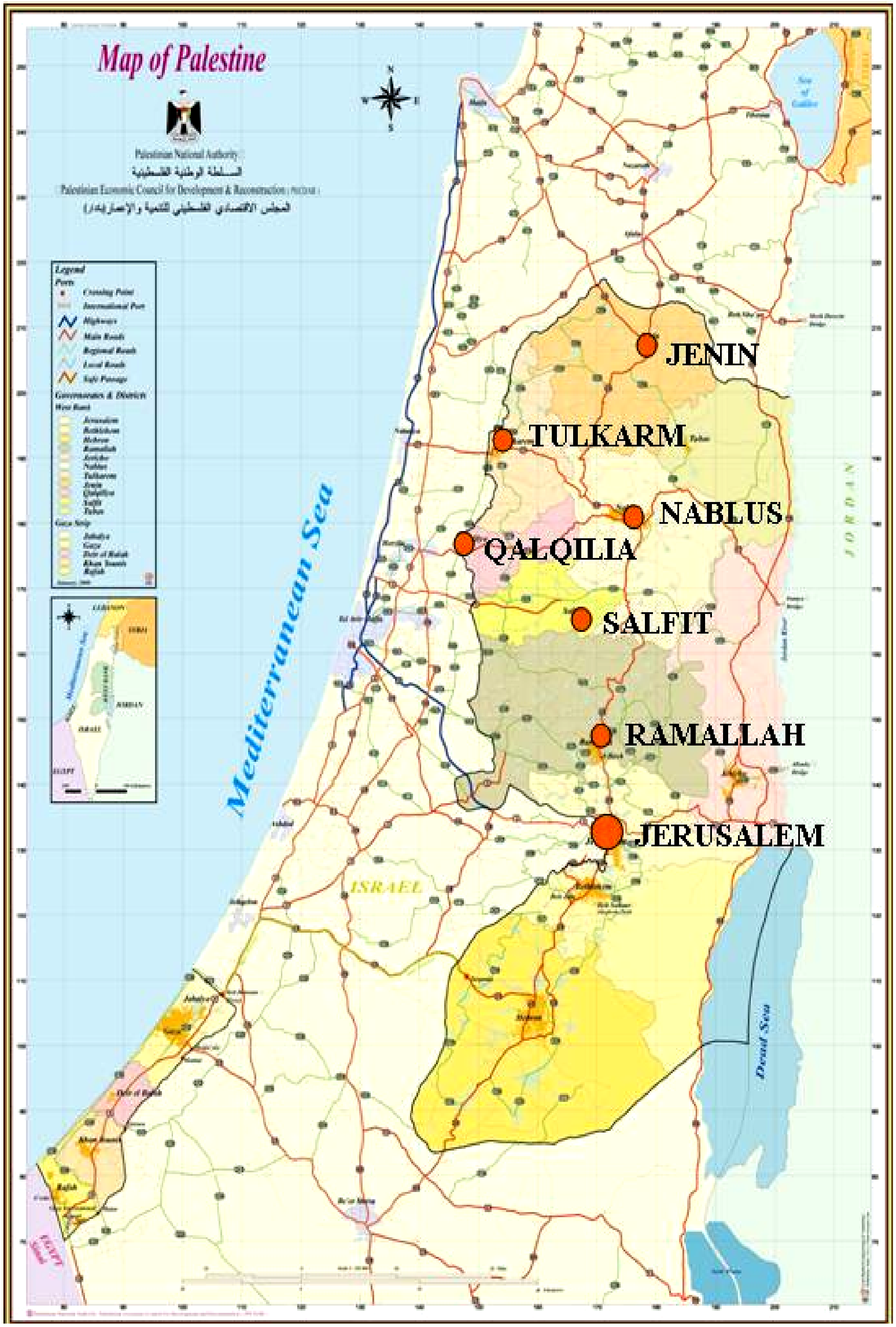
## 1.5 Objectives of the Study

There are no studies that have been done before with the specific objectives of streets management in the Palestinian cities except the studies of traffic systems management (TSM), for several Palestinian cities, which aimed at the general management of traffic (Abu-Eisheh, S. and Al-Sahili, K, 2000; Dornier Systems Consult & Universal Group, 1998). So it is important to do this study for the arterial streets, then consider the concepts and apply it on other streets.

The main objectives of this project are to evaluate and explore the various measures of access management, to evaluate the applicability and effectiveness of some of these measures on two arterial streets in Nablus City, and compare measures of effectiveness (capacity, LOS, delay, and speed) before and after applying these management measures.

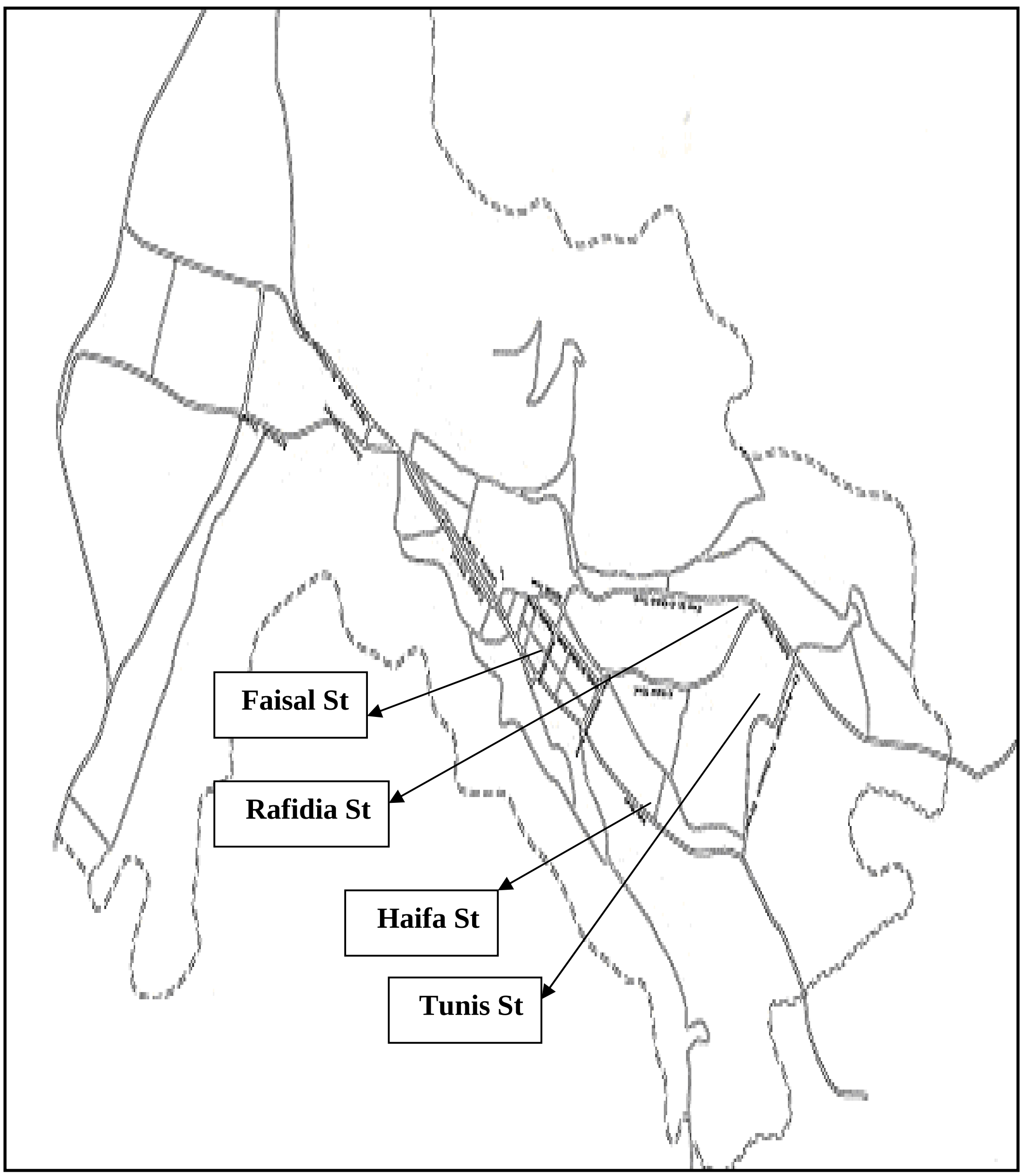
## 1.6 Study Area

Palestine is a typical developing country located in a central location in the Middle East. Its significance is represented by its geographic location. Nablus is a major city located in the northern part of the West Bank. The location of the city is shown in Map (1.1).




**Map 1.1** Location of Nablus in the West Bank

The structure of the roadway network of Nablus is affected by the nature of the city and its topography as presented in Map (1.2). The location of the city in a valley between two large mountains pushed towards a linear type of development of the city. Rafidia/Yaser Arafat Street and Faisal/Haifa Street are the two streets that this project will apply the concepts of access management on.




**Map 1.2** Street Network of the City of Nablus

## 1.7 Thesis Outline

This thesis contains seven chapters, which are summarized as follows:-

Chapter one presents the introduction, background, objectives, and study area.

Chapter two is the literature review.

Chapter three discusses the methodology.

Chapter four summarizes the adopted access management standards on this thesis.

Chapter five presents the compliance of access management measures on the studied Streets.

Chapter six illustrates measures of effectiveness that are used to evaluate the compliance

Chapter seven provides conclusions and recommendations of this study.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Introduction

Development of any country now is related to the strength of the transportation sector. Although the level of technology in transportation varies and the needs and demands are expressed differently, the movement of people and goods is essential for human activities and production. Living in any place without streets that connect cities with other cities or villages is impossible. Use of any transportation modes is necessary to facilitate the accessibility. Therefore, transportation has to be treated as an integral and basic component of any comprehensive development plan.

Access management is a key element in any development plan. There are no international standards to be adopted in any access management project. Historically, some of such projects are done in many countries, and each project is differing from the other according to many factors such as the topography of the area, traffic volume, turning traffic, and public acceptance.

## 2.2 Access Management

In the literature, access management measures were used to reduce accidents and congestion, to manage the movement in streets, and to maintain an acceptable capacity and level of service. In the following sections, brief historical explanations of some access management measures are presented. Access Management should address the following areas:

- Traffic signal spacing and coordination
- Corner clearance
- Two-way-left-turn lanes
- Median treatments and median openings

- Frontage and backage roads
- Dedicated turning lanes
- Driveway related
- Quadrant roadways
- Parking management
- Street connections
- Other measures

**2.2.1 Traffic Signal Spacing and Coordination**

Traffic signal coordination is one of the most widely used traffic management measures. The signals at two or more adjacent junctions are coordinated (linked) on a common cycle time and the relative timings set so that the traffic that leaves one junction arrives at the downstream junction when the signals are green. The optimal cycle length and splits (green time allocation for each phase) are first calculated.

To achieve smooth flow in an urban arterial system, especially where signals are closely spaced, it is desirable to coordinate the traffic signals to provide uninterrupted vehicular flow. For a well-designed coordinated signal system, vehicles flow without having to stop at every intersection. MUTCD, 2000 recommends that signals within 0.5 mile (0.8Km) of each other be coordinated on major streets.

Intersection spacing is an important measure of access management. As the number of intersections per mile increases, the opportunity for crashes increases. The existence of too many intersections per mile also increases delay and congestion. The optimum spacing of signals is dependent on the speed, cycle length, traffic volumes and efficiency of signal progression.

Many tools and techniques can be used to improve traffic signal performance. Traffic signals can be improved by the following actions:

- Physically improved intersections
- Coordinating signal timing for arterial roadways
- Computerizing area wide signal coordination in downtown grid networks
- Television monitoring of traffic

Colorado and Florida require ½ mile signal spacing on principal arterials. Studies in these two states have shown that accident rates are approximately 40 percent higher when signals are spaced at ¼ mile intervals as opposed to ½ mile intervals. Closely or irregularly spaced signals affect the efficiency of progression on the arterial. Signals spaced at ¼ mile intervals can provide progression at speeds of 26 to 30 mph with 60 to 70 sec cycle lengths (City of Florida and Colorado Regional Government, 1996).

The above study in the two states considered that intersection spacing along major (arterial) urban and suburban streets should follow the pattern given in Table (2.1).

**Table 2.1** Recommended Intersection Spacing

| Main Roadway | Intersecting Minor Roadway | Recommended Intersection Spacing |
|---|---|---|
| Freeway | Arterial | 1 to 2 miles minimum |
| Arterial | Arterial | 1 mile or greater |
| Arterial | Collector | 0.5 mile or greater |

Source: City of Florida and Colorado Regional Government (1996).

### 2.2.2 Corner Clearance

Corner clearance distance is the minimum distance required between an intersection and an adjacent driveway along an arterial road or collector street (see Figure 2.1).

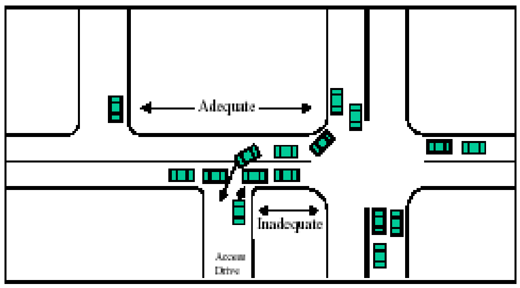



**Figure 2.1** Corner Clearance

Corner clearance is important because inadequate corner clearance results in traffic flow and safety problems, including:

- Traffic blocked by vehicles waiting to enter driveways
- Right or left turns out of driveways being blocked
- Rear-end and broadside collisions caused by inadequate time for motorists to react to vehicles entering and exiting the driveway
- Driver confusion about where it is permissible to enter and exit the driveway

Corner clearance standards vary greatly from city to city and from one street to another, it also depends on the speed limit on that arterial. For instance, the standard in Florida State ranges from 75 feet (23m) (about five car lengths) to 250 feet (76m) (about 16 car lengths) in urban areas. The 250-feet correspond to the minimum distance required to stop a car traveling 35 miles per hour (56kph) (Williams, Kristine M., and Marshall, Margaret A. 1996).

Corner clearance is even more important to maintain in rural areas because travel speeds are higher. Ideally, corner clearances on major roadways should be the same as driveway spacing requirements. When this cannot be achieved because of a lack of frontage, the upstream corner clearance should be longer than the longest expected queue at the adjacent intersection.

### 2.2.3 Continuous Two-Way Left-Turn Lanes

Continuous two-way-left-turn lanes (TWLTL) are a common access management treatment when combined with driveway consolidation and corner clearance. TWLTLs simultaneously provide a separate lane for left turning vehicles and property access.

Typically, they are used as the center lane of a five-lane roadway. A less common design involves three lanes, a TWLTL in the center for left turns and one lane in each direction for through traffic (see Figure 4.2).

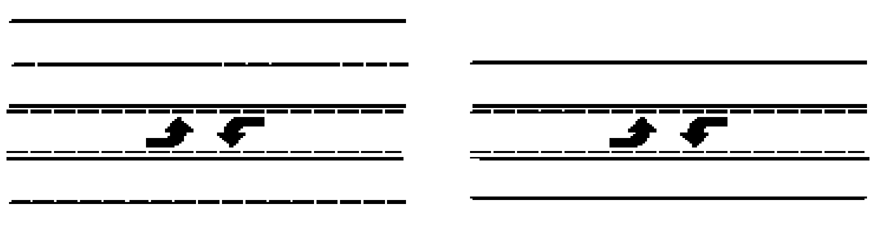


**Figure 2.2** TWLTL for: 5-Lane cross-section and 3-Lane cross-section

Many arterial roads in Palestinian Cities were constructed with either two lanes or four lanes and no turn lanes or medians. Since all lanes served both through traffic and turning traffic, these roads began to operate less efficiently and safely as the volume of turning traffic grew.

In many cases, this may have been caused by unmanaged development and access along the roadway. When such roads experience a considerable amount of left-turning traffic, congestion delays and crashes increase. Types of crashes most associated with turning vehicles include rear-end and broadside collisions. Because TWLTLs separate left-turning traffic from through traffic, they can help solve some of these problems.

Caution must be used when designating the two-way left turn lanes on Palestinian cities arterials. It should not be used for high turning traffic volumes, as it may be hazardous causing head-on collisions, especially that such lanes are not familiar to Palestinian drivers, and they may violate traffic laws and use it as passing lane. So it is difficult to apply this measure on the Palestinian streets in the existing situation. Therefore, using such techniques may require heavy police enforcement. It is not recommended to use such measures at the percent; however, it is recommended that such measure be studied in details.

**2.2.4 Raised Medians at Intersections**

Raised medians at intersections may be most effective in retrofit situations where high volumes of turning vehicles have degraded operations and safety, and where more extensive approaches would be too expensive because of limited right-of-way and the constraints of the built environment. Because raised medians limit property access to right turns only, they should be used in conjunction with efforts to provide alternative access ways and promote driveway spacing objectives.

Design considerations of raised medians at intersections should be taken into account, based on AASHTO (2001), as follows:

- The length of the turn/deceleration lane. Turn lanes must be long enough to allow safe deceleration and provide storage for turning vehicles—that is, prevent queuing vehicles from backing up into the travel lanes.

- The minimum width of the median at the "nose." Very narrow median noses are difficult to see, especially at night and in inclement weather.
- Visibility of the median. Carefully selected landscaping may be the most effective way to provide excellent visibility of the median, especially where the median islands begin. Reflective paint tends to wear and lose its reflectivity because of weather.
- The length of taper, or the portion of the median opening that begins the transition to the turn lane, is generally based on the approach speed: the faster the speed, the longer the taper.
- Related issues include continuous raised median, comparison of raised medians and two-way left-turn lanes, functional areas of intersections, dedicated left and right turning lanes, speed differential between turning vehicles and through traffic, and corner clearance.

### 2.2.5 Continuous Raised Medians

Continuous raised medians with well-designed median openings are among the most important features for managing access to create a safe and efficient highway system. Continuous raised medians are most effective on roadways with high traffic volumes and high driveway densities.

Physical medians prevent accidents caused by crossover traffic, reduce headlight glare distraction, reduce fuel consumption, and separate left-turning traffic from through lanes when combined with left-turn lanes. The raised median prohibits left turns into and out of driveways that may be located too close to the functional area of the intersection.

Continuous raised medians tend to limit property access and may force motorists to make circuitous routes to reach minor destinations, thereby increasing their travel time. Continuous raised medians may concentrate left turns and increase the frequency of U-turns. Roadways with continuous raised medians also require a wider right-of-way than do undivided roadways.

Because of such limitations, businesses and land owners oppose a raised median project if they believe it will limit access to their property, especially if they perceive it will block customers trying to make left turns into their property. Therefore, it is important to involve all major stakeholders in key design and construction decisions especially when retrofitting existing roadways. Raised medians do not necessarily hurt business vitality.

When medians extend the full length of a road, the spacing of intersections and median breaks are crucial to providing access to properties on both sides of the road. Median breaks should generally only be provided at public road intersections or at driveways shared by several businesses. They should generally not be provided for access to individual businesses or residences. The number of median breaks should be kept to a minimum since they add conflict points and detract from safety.

The directional median break allows for left turns onto the side street, the median prevents vehicles from crossing the arterial and making left turns from side streets onto the arterial, as (Figure 2.3) shows.

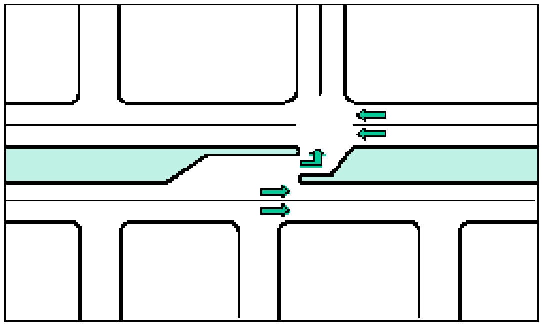


**Figure 2.3** Directional Median

Florida Department of Transportation (1997) recommended one-half mile (0.8Km) spacing between full median openings and one-quarter mile (0.4Km) spacing between directional median openings on major arterials. On minor arterials, it is recommended that one-quarter mile (0.4Km) spacing between full median openings (for posted speed limits under 45 miles per hour (72kph)), and one-eight mile (0.2Km) spacing between directional openings. Median openings should never be built into the functional areas of other median openings or intersections.

**2.2.6 Median Openings**

The basic concept used in median opening location and design is avoidance of unnecessary conflicts, which result in crashes. When properly designed, it will have an auxiliary lane allowing the left turning vehicles to decelerate without interfering with the through movements of the leftmost through lane. This means that the potential of high-speed crashes is the greatest there. Before any design of this area can be done, it is important to know what speed, maneuvering distances, and storage requirements you should design for.

Based on AASHTO (2001) the minimum length of opening depends on the width of the median at the intersection and the shape of median end, as (Table 2.2) shows.

**Table 2.2** Minimum Median Opening Length

| Metric | | | US Customary | | |
|---|---|---|---|---|---|
| M Width of median (m) | L = Minimum length of median opening (m) | | M Width of median (ft) | L = Minimum length of median opening (ft) | |
| | Semicircular | Bullet nose | | Semicircular | Bullet nose |
| 1.2 | 28.8 | 28.8 | 4 | 96 | 96 |
| 1.8 | 28.2 | 22.8 | 6 | 94 | 76 |
| 2.4 | 27.6 | 20.4 | 8 | 92 | 68 |
| 3.0 | 27.0 | 18.6 | 10 | 90 | 62 |
| 3.6 | 26.4 | 17.4 | 12 | 88 | 58 |
| 4.2 | 25.8 | 15.9 | 14 | 86 | 53 |
| 4.8 | 25.2 | 15.0 | 16 | 84 | 50 |
| 6.0 | 24.0 | 13.2 | 20 | 80 | 44 |
| 7.2 | 22.8 | 12.0 min | 24 | 76 | 40 min |
| 8.4 | 21.6 | 12.0 min | 28 | 72 | 40 min |
| 9.6 | 20.4 | 12.0 min | 32 | 68 | 40 min |
| 10.8 | 19.2 | 12.0 min | 36 | 64 | 40 min |
| 12.0 | 18.0 | 12.0 min | 40 | 60 | 40 min |
| 15.0 | 15.0 | 12.0 min | 50 | 50 | 40 min |
| 18.0 | 12.0 min | 12.0 min | 60 | 40 min | 40 min |
| 21.0 | 12.0 min | 12.0 min | 70 | 40 min | 40 min |

Source: AASHTO, 2001

Notes:

- The lengths on Table (2.2) are for right angle intersection, two-way movement crossroad, and design vehicle as single unit truck with 15m turning radii.
- There is no difference between opening at intersection or for U-turn. Openings for one-way driveways should be more than half the above values.
- For medians about 1.2m wide there is no difference between the two forms of median end. For median width of 3.0m or more the bullet nose is superior to the semicircular end.

- For any one median width with semicircular ends and skew of 20 degrees and 40 degrees, the openings are about one-third and two-thirds longer, respectively, than that for a 90 degree. Likewise, the bullet nose ends give lengths of openings for a 20 degree skew that are about one and one-half times, and for a 40 degree skew about two times, the lengths for a 90 degree.

All the following concepts of median opening placement principles are based on (Bowman and Vecellio, 1994). A median opening within the physical length of a left-turn bay or across right turn lanes is potentially dangerous, as illustrated in (Figures 2.4/2.5).

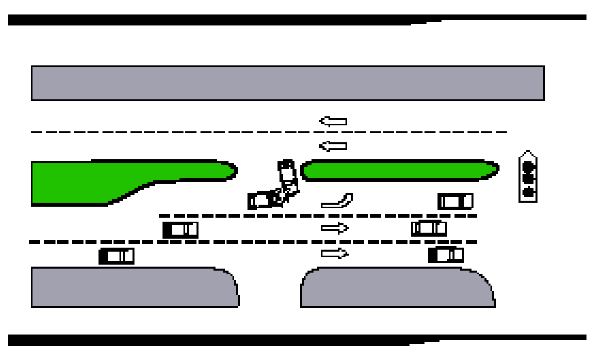


**Figure 2.4** Dangerous Median Opening

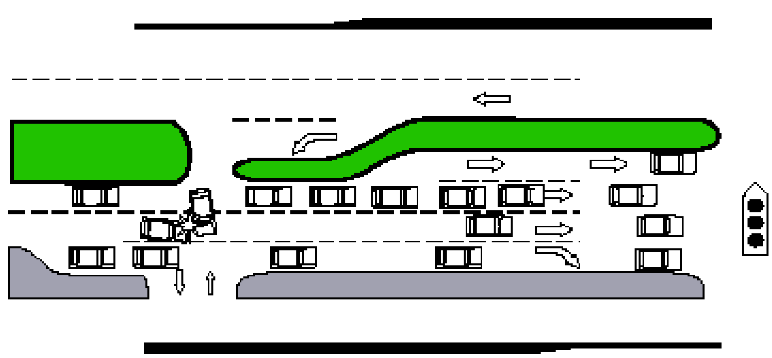


**Figure 2.5** Median Openings across Right Turn Lanes

When the queue in the through traffic lane spills past the left-turn bay, turning vehicles are trapped in the queue, as illustrated in (Figure 2.6). The left turning vehicles are not able to move into the turn bay until the queue advances. Dual left turn lanes are more prone to this problem.

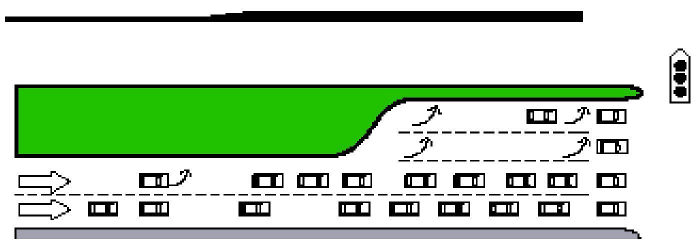


**Figure 2.6** Inadequate Space for Left Turn Storage

### 2.2.7 Frontage and Backage Roads

Frontage and backage roads run parallel the mainline route and provide alternative access to property (see Figures 2.7). Property access is provided along the frontage or backage road, which accesses the arterial via a cross road (with a traffic signal if necessary). This reduces the number and density of conflict points associated with strip development. These roads are generally applicable to commercial development.

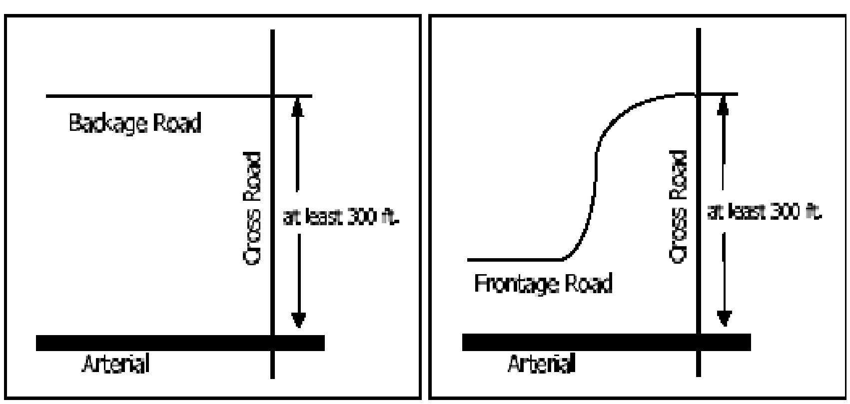



**Figure 2.7** Frontage and backage roads

Frontage roads near arterials may cause more problems than they solve if they are not set far enough back from an arterial. If frontage road outlets are set back only one or a few car lengths from the arterial, cars exiting the frontage road enter the functional area of the arterial intersection, creating conflict points with other vehicles.

This situation can worsen as further development occurs along the frontage road. The recommended separation of at least 300 feet (90m) between frontage road outlets and intersections between cross streets and arterials (New York State Department of Transportation, 1996). This should be considered a bare minimum and should be higher if possible. In rural areas, higher operating speeds dictate longer separations.

In comparison to frontage roads, backage roads with development along both sides are preferable to frontage roads because they allow for greater distance between the connection to the cross street and the intersection with the arterial. Backage roads provide access to a greater number of individual properties (assuming development along both sides of the road). This increases the value of the land and reduces road construction costs for individual properties. The frontage road system should be visible on both sides of the main roadway.

**2.2.8 Dedicated Left and Right Turning Lanes**

One of the major concerns of transportation engineers and planners in cities and suburban areas is keeping through traffic moving at a smooth and even pace. When traffic can’t move at an even pace, delays and congestion are the result. This frustrates motorists and creates opportunities for crashes. One of the simplest ways to accomplish smooth and even traffic is to remove the turning traffic from the through traffic flow at road intersections and near busy driveways (see Figure 2.8). Often, dedicated turning lanes are provided to serve that purpose.

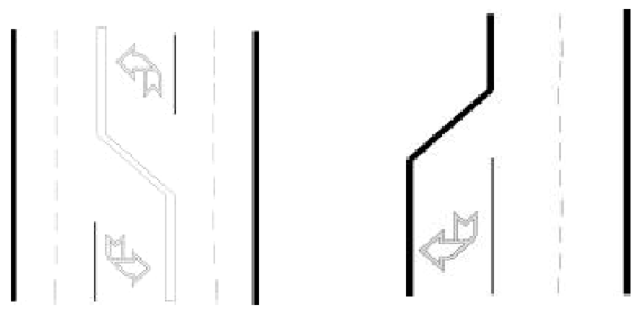


**Figure 2.8** Left Turn Lanes and Right Turn Lane

Here are the main benefits of turn lanes:

- Improved traffic safety
- Increased travel speed
- Reduced delay
- Reduced congestion

Two studies were reviewed; one of them was conducted in San Francisco, and showed that accidents at four intersections in this city dropped 52 to 38 percent after turn restrictions were implemented. The other study showed that the use of a continuous raised median to restrict left turns between intersections in Wichita, Kansas resulted in a reduction in accidents of 69 to 43 percent, (Jonathan Reid, 2000).

### 2.2.9 Driveway Related

#### 2.2.9.1 Driveway spacing

Maintaining an adequate spacing between commercial driveways is one of the most critical aspects of access management. Motorists turn left and right into and out of driveways when permitted. Traffic turning into and out of driveways moves more slowly than through traffic. This speed difference produces conflicts that may lead to broadside and rear-end collisions between vehicles. It is known that roadways with a large number of closely spaced driveways are always less safe than similar roads where driveway access is more limited.

Spacing requirements may be based, among other factors, on posted speed limits, acceleration requirements the classification of the roadway, or the amount of traffic generated by a development. Spacing requirements should reflect a balance between traffic and engineering conditions and needs, local development objectives, and existing land-use characteristics (such as lot sizes, land-use type, and frontage requirements). There are no hard and fast guidelines for driveway spacing, and spacing requirements vary considerably from place to place. However, Table (2.3) is used by two local governments in Florida and Ohio (Tallahassee, and Cincinnati Regional Governments, 1996). As the posted speed limit rises, the recommended spacing between driveways increases, and the number of driveways per mile or block falls to accommodate the increased spacing.

**Table 2.3** Florida and Ohio Standards for Driveway Spacing of the Highway Systems

| Posted Speed on Arterial Street (mph) | Centerline to Centerline Driveway Spacing (feet) | Approximate Number of Driveways per 500-foot Block Face |
|---|---|---|
| 20 | 85 | About 6 |
| 25 | 105 | 5 |
| 30 | 125 | 4 |
| 35 | 150 | 3 |
| 40 | 185 | 3 |
| 45 | 230 | 2 |
| 50 | 275 | Fewer than 2 |

Source: City of Tallahassee, Florida (1996), and OKI Regional Government, Cincinnati, Ohio (1996).

In rural areas, the posted speed is usually at or above 55 miles per hour (88 kph). The higher speeds mean that driveway spacing in rural areas must be longer to provide for a safe driving environment, as Table (2.4) shows.

**Table 2.4** Kansas's Standards for Driveway Spacing of the Highway Systems

| State Highway Route Type | Minimum Spacing between Driveways (feet) | Approximate Number of Driveways per Mile |
|---|---|---|
| **Major Arterial (National Highway System)** | 2,640 | 2 |
| **Other Major Arterial** | 1,320 | 4 |
| **Minor Arterial** | 660 | 8 |
| **(Collector, etc.)** | 500 | 10 |

Source: Kansas Department of Transportation (1996).

On county roads, the spacing standard should also depend on the nature of the road (e.g., how important the road is to through traffic). Even the lowest functional levels require driveway spacing standards for traffic safety, as shown in Table (2.5).

**Table 2.5** Wisconsin Standards for Driveway Spacing of the County Highway Systems

| County Road Route Type | Minimum Spacing between Driveways (feet) | Number of Driveways per Mile |
|---|---|---|
| **Minor arterials** | 600 | 9 |
| **Collectors** | 300 | 18 |
| **Local traffic service** | 75 | 70 |

Source: Waushara County, Wisconsin (1996).

### 2.2.9.2 Driveway Grade

Along older urban arterial streets, it is common to find rather steep driveways. Driveways with steep grades were often constructed to allow the driveway and connecting parking lots to drain more efficiently and to save earth-moving costs. On the other hand, more recently constructed arterials typically feature very gentle driveway grades.

Driveway grade is important because it affects speed differential. The steeper the driveway, the greater the reduction in speed required to prevent "bottoming out." (Table 2.6) shows typical driveway entry speeds for varying degrees of driveway grade.

**Table 2.6** Variation of Driveway Entry Speed with Its Grade

| **Driveway Grade Change (percent)** | **Typical Driveway Entry Speed (mph)** |
|---|---|
| Greater than 15 | Less than 8 |
| 14-15 | 8 |
| 12-13 | 9 |
| 10-11 | 10 |
| 8-9 | 11 |
| 6-7 | 12 |
| 4-5 | 13 |
| 2-3 | 14 |
| 0-2 | Approximately 15 |

Source: Oregon State University, 1998.

The (ITE Guidelines for Driveway Location and Design, 1987) recommends the following initial driveway grade angles (Table 2.7) (these grades were all chosen to keep the speed differential at or below 20 miles per hour (32kph):

**Table 2.7** Change of Grade According to Roadway Type

| **Roadway Classification** | **Desirable Change in Grade (percent)** | **Maximum Change in Grade (percent)** |
|---|---|---|
| **Major Arterial** | Less than 3 | 5 |
| **Minor Arterial** | Less than 4 | 5 |
| **Collector** | Less than 5 | 6 |
| **Local** | Less than 6 | 8 |

Source: ITE Guidelines for Driveway Location and Design, 1987.

Steep driveways are not ideal under any circumstances; however, they are more easily tolerated on local streets and roads that carry little or no through traffic. Steep driveways are also more tolerable at residential properties than at retail businesses because residences generate much less traffic. Reducing driveway grade is a very important consideration along roadways that

- carry considerable through traffic volumes
- have relatively high travel speeds (say, 35-40 miles per hour (56-64 kph) or more)
- have commercial land uses along them, especially retail and service businesses that generate high volumes of automobile trips

**2.2.9.3 Driveway Width**

Along older urban arterial streets, it is common to find many narrow driveways. These driveways will safely accommodate only one vehicle at a time, either an entering or an exiting vehicle, so vehicles must wait for others to exit the driveway before entering. This can create a dangerous situation of left-turning or right-turning vehicles stopped in a through traffic lane.

Another common problem is driveways in urban and rural areas that are too wide. In some cases, the driveway may have no discernable boundaries or curbs. Both situations create operational and safety concerns and may create confusion for motorists and to pedestrians, who will have a greater distance of pavement to cross. A properly designed driveway helps turning traffic move off the roadway more quickly and reduces the likelihood of crashes.

Driveway width is important because it affects speed differential. The more a turning vehicle must slow to enter a driveway, the greater the speed differential. In general, vehicles must slow to a greater extent to negotiate narrower driveways than wider driveways although the use of longer turn radii and/or tapers will improve operating performance.

Commercial driveways may vary in size depending on the number of lanes needed. The optimal width for a one-way in or out driveway is 14-16 feet (4.3-4.8m). Maximum width driveways usually have two inbound and three outbound lanes, with each lane being at least 11 feet (3.3m) wide. Where more than one inbound and outbound lane is provided, a median divider is generally desirable. This median should be at least 4 feet (1.2m) wide; however, median widths of 10-16 feet (3-4.8m) are preferable because they improve driver maneuvering and provide opportunities for landscaping. Median widths over 16 feet (4.8m) are undesirable because they create turning problems and greatly expand the intersection size (National Cooperative Highway Research Program (NCHRP), 1987).

Many different combinations of turn radius and driveway width provide the same level of driveway operations. For a given level of service, shorter radii require wider driveways than longer radii.

#### 2.2.9.4 Driveway Turn Radius

Turn radius refers to the extent that the edge of a commercial driveway is "rounded" to permit easier entry and exit by turning vehicles. Driveway entrances with longer turn radii help slower, turning traffic move off the arterial more quickly. They also help traffic leaving a driveway turn and enter the stream of traffic more efficiently.

Longer turn radii allow vehicles to turn into and out of driveways at a higher speed (see Figure 2.9). They also prevent turning vehicles from encroaching upon oncoming traffic or traffic in adjacent lanes.

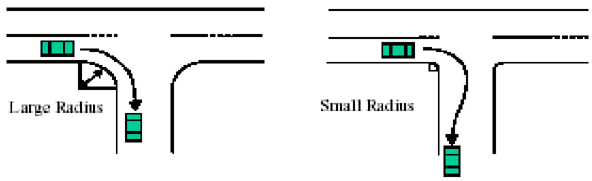



**Figure 2.9** Large and Small Turning Radiuses

Longer radii are most desirable in situations where vehicles are exiting from a higher speed roadway or when a high volume of driveway traffic is expected.

It is recommended a minimum 25 feet (7.6m) turn radius in urban areas, although a 35 feet (10.7m) radius may be needed to accommodate buses and single unit trucks. In most suburban settings, 25-50 feet (7.6-15.2m) radii are desirable; however, longer radii are desirable where turning islands or dual turning lanes are provided. A minimum 15 feet (4.6m) radius is recommended in areas of heavy pedestrian traffic such as business districts and school crossings. Shorter radii are recommended only for residential drives from low-speed roadways, (Oregon State University, 1998).

The use of longer turning radii should also consider the impact on pedestrian safety. A tradeoff may be involved where pedestrian safety is a key concern. Longer turning radii increase the distance of the pedestrian crossing and allow for higher vehicle speeds. Solutions include shortening the turning radii or introducing a pedestrian refuge island in the driveway.

### 2.2.9.5 Driveway Density and Driveway Consolidation

Driveway density is the number of driveways per block or per mile or Km. Driveway consolidation is the process of reducing the density of driveways along a major roadway by closing driveways, creating alternative access ways, creating shared driveways, relocating entrances to side streets, or promoting cross access.

The Institute of Transportation Engineers (ITE) recommends a maximum number of driveways per commercial property as presented in (Table 2.8).

**Table 2.8** Maximum Number of Driveways per Commercial Property

| Property Frontage (feet) | Number of Driveways |
|---|---|
| 0-50 | 1 |
| 50-165 | 2 |
| 165-500 | 3 |
| Over 500 | 4 |

Source: ITE Guidelines for Driveway Location and Design, 1987.

Driveway density is important because accident rates increase dramatically as the number of driveways per mile increases along urban arterial roadways (see Table 2.9).

**Table 2.9** Effect of Driveway Density on Accident Rates

| Driveways per Mile | Number of Driveways per 500-foot Block | Representative Accident Rate for A multilane, undivided roadway | Increase in Accidents Associated with Higher Driveway Density |
|---|---|---|---|
| Under 20 | Under 2 | 3.4 | --- |
| 20-40 | 2-4 | 5.9 | +74% |
| 40-60 | 4-6 | 7.4 | +118% |
| Over 60 | Over 6 | 9.2 | +171% |

Source: National Cooperative Highway Research Program Report 3-52, 1987.

Driveway densities should be even lower if the posted speed limit is higher or if the roadway is functionally important to through traffic. Driveway densities can safely be higher if they serve residential properties. This is because residences generate far fewer trips per hour than commercial or industrial properties. However, driveways should never be located on or close to corners of intersections. They should also never be located within the functional area of an intersection.

Spacing between driveways and/or farm-field entrances is especially critical in rural areas because travel speeds are high. Higher vehicle speeds mean that driver reaction and stopping distances are longer. In rural areas, a maximum driveway density standard of about 4 access points per mile (2.5 per Km) per roadway side is appropriate on many arterial roads. This assumes that driveways on opposite sites of the road are lined up. However, where stopping sight distances are restricted by curves or hilly terrain, this number should be lower, (ITE Guidelines for Driveway Location and Design, 1987).

Different states and localities in the U.S.A have adopted various driveway density standards for urban and suburban arterial streets. However, several of them recommend 20 to 30 driveways per mile as a maximum driveway density standard. This translates into a desired standard of only two or three driveways per 500-foot city block face (Kansas, and Iowa Departments of Transportation, 1996).

Driveway consolidation can be applied as an individual access management strategy, but it is most often done in conjunction with the installation of medians, two-way-left-turn lanes, and/or frontage or backage roads.

#### 2.2.9.6 Driveway Throat Length

The throat length of a driveway is the distance between the street and the end of the driveway inside the land development. Throat length can also be defined as the distance parallel to the centerline of a driveway to the first on-site location at which a driver can make a right or left turn, measured from the edge of the mainline roadway. (Table 2.10) provides recommended throat lengths.

**Table 2.10** Recommended Throat Lengths

| Commercial Development Type | Recommended Driveway Throat Length |
|---|---|
| Large and medium shopping centers with greater than 200,000 gross leaseable square feet in floor area | 200-250 feet (about 15 car lengths) |
| Small commercial developments with signalized access driveways | 80-90 feet (five to six car lengths) |
| Small commercial developments with unsignalized commercial driveways | 30-50 feet (two to three car lengths) |

Source: Florida Department of Transportation, 1997.

Inadequate driveway throat length is the number one problem that occurs when internal land development circulation is poorly designed. Most commercial developments do not include a two to three car length driveway. This can lead to situations in which traffic circulation within the commercial development is chaotic. It can also lead to situations in which traffic turning into a development queues on the arterial roadway while waiting for vehicles to clear the short driveway. This is unsafe and may cause accidents.

Adequate throat length allows stacking or queuing to occur on site. This reduces driver confusion, traffic problems, and unsafe conditions as seen in (Figure 2.10).

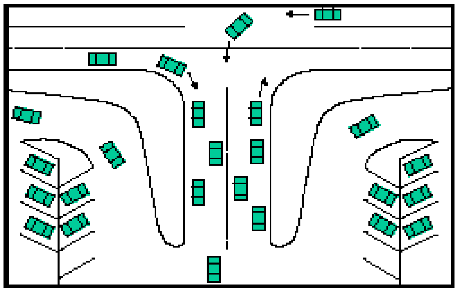


**Figure 2.10** Adequate Throat Length

Insufficient throat length and poor site planning can cause unsafe conditions and result in vehicles backing out onto the arterial, interrupting traffic flow as shown in (Figure 2.11).

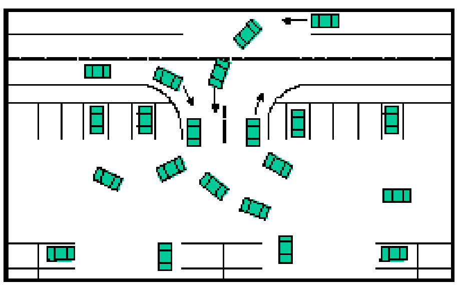


**Figure 2.11** Insufficient Throat Length

**2.2.9.7 Driveway-Related Crashes**

Much of access management involves managing traffic movements into and out of commercial driveways. The reason for this is that driveway traffic generates a large number of crashes on major roads and streets—arterials and collectors.

The nature of traffic accidents that occur at driveways is related to the turning movement either left-turning vehicle: entering or exiting driveways, and this has a high percent of total crashes at commercial driveways, or right-turning vehicles: entering or exiting driveways, and this has a low percent of total crashes at commercial driveways.

### 2.2.10 Quadrant Roadways

#### 2.2.10.1 Arterial Capacity Problems

The function of an arterial is efficient movement of large traffic volumes over a significant distance. As arterial traffic volumes approach roadways capacity, delays grow rapidly at signalize intersections with significant cross street volumes, diminishing the ability of the arterials to help traffic move effectively.

When conventional arterial intersections become over-saturated, a common traffic engineering "solution" to increase intersection capacity is to lengthen the signal cycle length. Longer cycle lengths reduce the impact of "lost time" between phases and allow longer through-movement phases. However, an undesirable product of a longer cycle length is increased intersection delay and queue lengths.

#### 2.2.10.2 Unconventional Roadway and Intersection Designs

In an attempt to overcome these short-comings associated with the conventional intersection design, transportation engineers have studied and implemented "unconventional" arterial roadway and intersection design alternatives. The commonality of unconventional arterial designs is the eliminations of direct left-turn movements at major arterial intersections through various geometric designs and traffic-control measures.

#### 2.2.10.3 The Quadrant Roadway Intersection Design

A new unconventional intersection design alternatives is proposed- the "quadrant roadways intersection" (QRI) design. The overall QRI concept is similar to the one-quadrant ramp interchange design. A typical QRI design example is illustrated in (Figure 2.12).

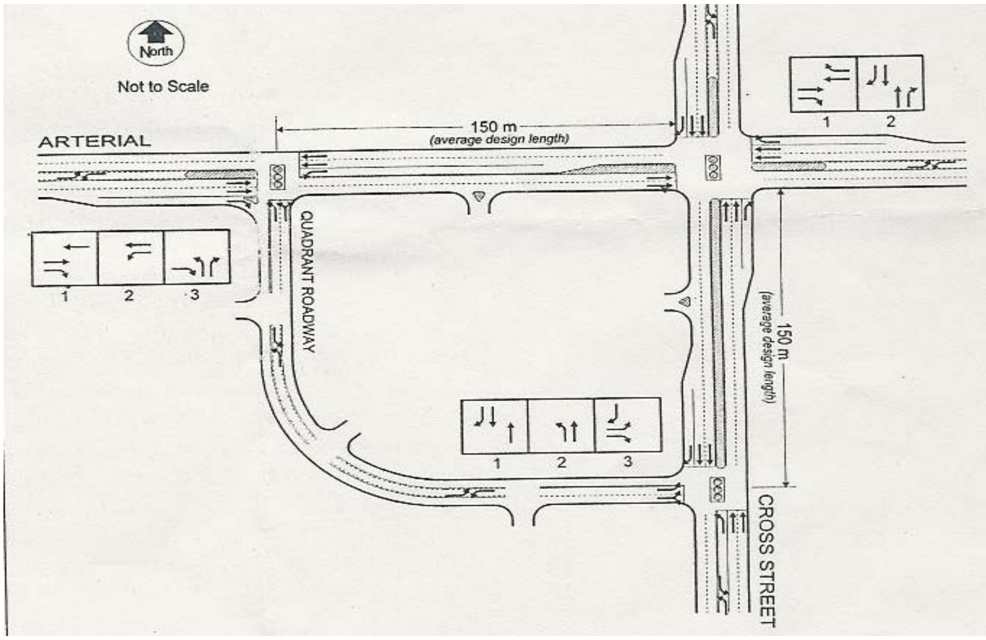
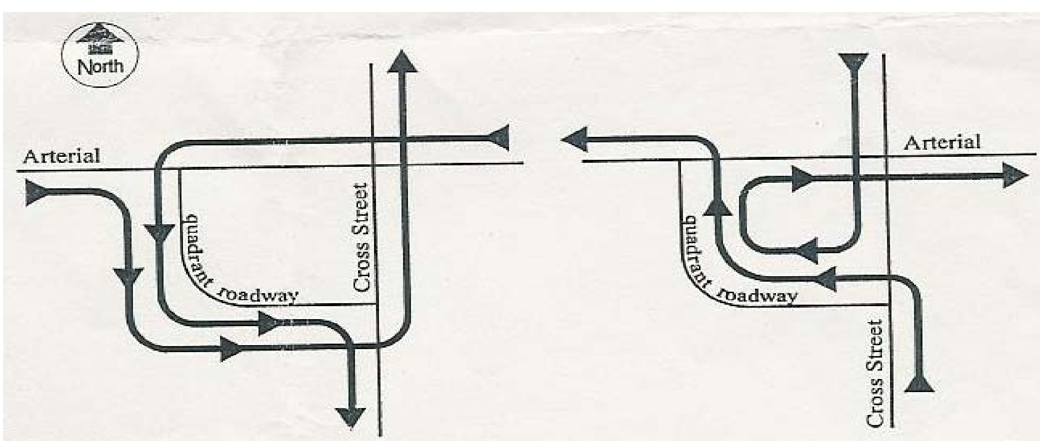



**Figure 2.12** QRI Design

The left-turn patterns for the arterial and cross street are shown in (Figure 2.13). Left-turn movements are not permitted at the main intersection. By routing all left-turn movements from the arterial and cross street to the quadrant roadways, the main arterial and cross-street intersection can operate with a simple two-phase signal.




A) Left-Turn Pattern from the Arterial B) Left-Turn Pattern from the Cross Street

**Figure 2.13** QRI Left-Turn Pattern

**2.2.10.4 Signal Operations**

The most important element of the QRI design is the signal operation at each intersection. The design requires that the three signalized be coordinated to serve as one interconnected, fixed-time, intersection-control system. As described earlier, the main intersection operates under a simple, two-phase cycle. The secondary intersections operate as three-phase signals; however, the offsets to the secondary intersection signals provide perfect progression through the main intersection. In (Figure 2.14), the phasing sequences and resultant progressive movements are presented for the QRI design.

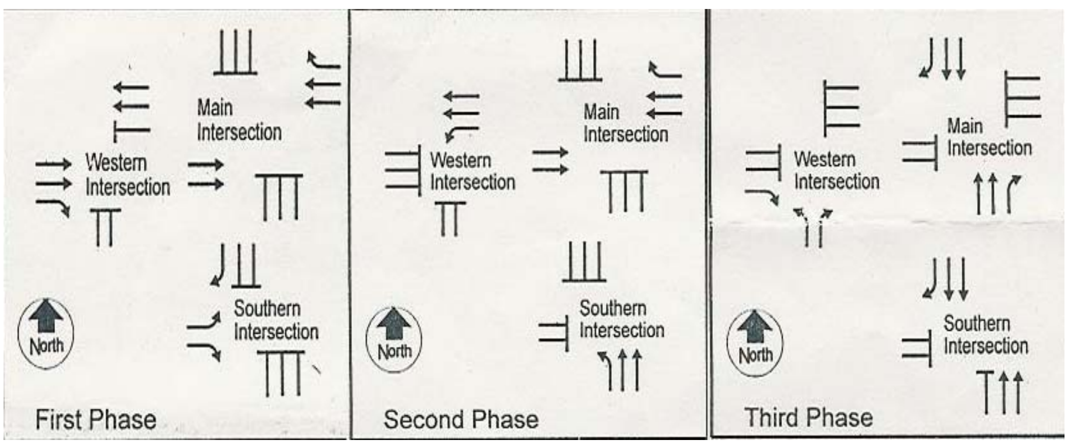



**Figure 2.14** QRI Design Signal-Phasing Sequence

**2.2.11 Parking Management**

Parking availability is a mean of regulating the flow of traffic. When parking becomes more scarce and expensive, the number of vehicles entering the area will be reduced. Some people will shift to transit or carpools; others will park at the periphery of the city, where space is available at more reasonable rates.

The road network in the main Palestinian cities has roadways of various widths constraining space for pedestrian, traffic flow, and parking that necessitates the need for many one-way streets. Complicating the space problem are various user attitudes, practices, and enforcement conditions. Some of common parking related problems in Palestinian cities include:

- There is no efficient management of curb space parking.
- People park in restricted areas and double park.
- Limited police enforcement.

Parking control and management in the Palestinian Territories are implemented through a variety of measures. These measures range from parking prohibition, establishing parking time limits, and charging for parking.

Car park control is generally believed to reduce congestion by limiting the total value of private traffic and also by improving traffic flow. Uncontrolled on-street parking can obstruct the free movement of traffic, particularly at road junctions. Commercial vehicles may be denied access to premises, buses are obstructed at stops and in bus lanes and there is an increased risk of accidents. On the other hand, parking control may increase local flows where traffic circulates looking for parking space. The magnitude of this effect is not known.

**2.2.12 Street Connections**

An important access management principle is that roads should not connect directly to another of a much higher classification. For instance, a local road may be connected to a major collector, and a major collector may be connected to a minor arterial, but a local road should not connect directly with a major arterial.

The problem appears when local streets connects with the arterial street (this is the common situation in Palestinian Streets). In this case, it is important to merge these small local streets in a major local street or collector street. The two concepts of driveway spacing and shared driveways may be used under this measure.

## 2.3 Other Measures

The following measures can affect access management plans in a second degree, these measures are:

- Incorporating aesthetics into access management
- Speed differential between turning vehicles and through traffic
- Internal circulation
- Sight distance

### 2.3.1 Incorporating Aesthetics into Access Management

Access management projects often involve widening existing roadways to add either an additional two-way-left-turn lane (TWLTL) or a raised median. Such projects can lead to a wide expanse of concrete and asphalt. An aesthetically pleasing treatment, however, does not need to run counter to sound access management practices. In fact, aesthetics can and should be incorporated into access management project plans. Access management projects are much more likely to be accepted by the public and by business owners of adjacent properties if they look good as well as improve safety and traffic flow.

In conjunction with access management improvements such as consolidating driveways, installing raised medians, or constructing TWLTLs, many aesthetic treatments are possible. These include

- Landscaping the raised median
- Adding pavement textures and designs to parking areas

- Adding well designed retaining walls where needed to prevent erosion
- Planting street trees and other vegetation outside the clear zone
- Removing signs from the clear zone and otherwise modifying commercial signs to make them less obtrusive
- Adding uniform, well designed street lights and other hardware
- Placing utility lines underground to eliminate them from view and reduce the need for utility poles

Such aesthetic treatments can, when combined with access management, create a much more attractive roadway corridor that is also highly functional and safer.

### 2.3.2 Speed Differential between Turning and Through Traffic

Speed differential is a simple yet important concept that forms the basis for many access management measures. Speed differential is the difference between the speed of vehicles that are continuing along the main roadway versus those that are entering and exiting the driveway.

When the speed differential is high, it is also more likely that crashes will be more severe, cause greater property damage, and result in more injuries and fatalities. Keeping the speed differential as low as possible is very important for safety reasons, as indicated by (Table 2.11). Many access management plans and standards strive to keep the differential at or below 20 miles per hour (32kph), (Oregon State University, 1998).

**Table 2.11** Likelihood of Crashes According to Speed Differential

| **Speed Differential Between Turning and Through Traffic** | **Likelihood of Crashes** |
|---|---|
| 10 miles per hour | Minimal |
| 20 mph | 3 times greater than at 10 mph |
| 30 mph | 23 times greater than at 10 mph |
| 35 mph | 90 times greater than at 10 mph |

Source: Oregon State University, 1998

In general, the following features will help decrease the speed differential between through and turning traffic:

- Larger turn radii
- Wider driveway throat widths
- Longer driveway throat lengths
- Smaller driveway slopes
- Dedicated turn lanes for both left and right turns
- Adequate sight distance at driveways
- Improved circulation within land developments

### 2.3.3 Internal Circulation

The internal circulation of a land development functions well when it is designed with respect to highway access point(s) rather than the building(s). Design should start from the outside in and finish with the parking and building. Very often, the opposite approach is taken. The circulation design of driveways and parking lots are done last. Here is the optimal internal circulation design approach:

1. Provide safe and reasonable access to and from the street to motorists and pedestrians.

2. Provide a reasonable transition between the access and the internal circulation, especially by making sure the driveways are wide and long enough.
3. Design the parking area and individual parking spaces.
4. Design the building footprint within the constraints of the internal circulation and the parking.

Complete on-site circulation allow vehicles to travel between adjacent businesses without having to re-enter the arterial as shown in (Figure 2.15).

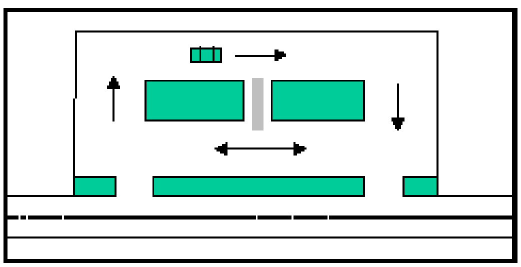


**Figure 2.15** Complete On-Site Circulation

**2.3.4 Sight Distance**

Guidelines for adequate sight distance are one of the most important and basic approaches a community can take in managing access to its roadways. Sight distance can help communities ensure that its arterials are safe for motorists and pedestrians. Sight distance can also help communities promote adequate spacing of residential and commercial driveways.

Sight distance is the length of highway visible to a driver. A safe sight distance is the distance needed by a driver on an arterial, or a driver exiting a driveway or street, to verify that the road is clear and avoid conflicts with other vehicles. Sight lines must be kept free of objects, which might interfere with the ability of drivers to see other vehicles (see Figures 2.16

and 2.17). Features such as hills, curves in the road, vegetation, other landscaping, signs, and buildings can reduce sight distance.

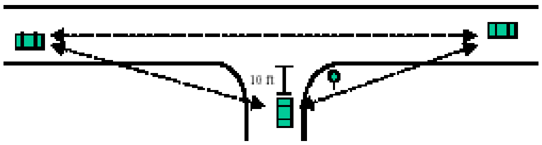



**Figure 2.16** Adequate Sight Distance

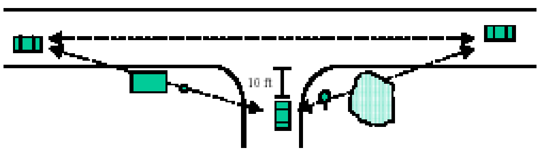



**Figure 2.17** Inadequate Sight Distance

## 2.4 Economic Impacts

Perceived impacts of access management on adjacent commercial businesses and landowners are often major impediments to projects moving forward. Business owners often are concerned that changes in access to their premises will have temporary or permanent impacts on their sales. They are concerned that changes in direct access to their property—such as consolidating driveways or installing raised medians—will lead to declines in patronage and sales.

Based on Iowa Department of Transportation, 1996, a study was conducted in Iowa State to see the effect of access management on business vitality; the results are as follows:

- Over 80 percent of all business owners indicated that their sales had been stable or increased following project completion. Negative impacts on commerce tended to be confined to a small number of individual businesses (five percent).

- Over 80 percent of business owners reported no customer complaints about access to their businesses. About 19 percent of businesses reported their customers complained or reported some difficulty in driving to their businesses after the completion of the access management project. About half of the businesses reporting complaints were the auto-oriented businesses, including gasoline filling stations, convenience stores, and fast- food restaurants.
- Two-way left-turn lanes generally received high levels of support from business owners and generated low levels of customer complaints. Medians at intersections generated similarly low levels of customer complaints, but appeared to receive lower levels of support from business owners.
- Auto-oriented businesses adjacent to raised medians at intersections tended to be least supportive of such projects. Continuous raised medians generated the most customer complaints regarding access; however, they also appeared to enjoy high levels of support from business owners.

### 2.5 In Palestine

There is no access management studies conducted for the Palestinian areas. There were few studies related to traffic system management, which are relatively related to access management. The following is a brief description of two studies that were done for Nablus City. A traffic system management study was done for Nablus City in 1998, by PECDAR (The Palestinian Economic Council for Development and Reconstruction).

First, this study summarized the present traffic conditions in Nablus city. Then, analyzing of existing traffic situation was done by analyzing road network and evaluating traffic characteristics. After that, suggested improvement to the network system were proposed either through geometric improvement or traffic improvement, such as, city center closure, new Faisal Street, relocation of public terminals, and construction of new mall in the city center (Dornier Systems Consult & Universal Group, 1998).

Traffic Systems Management-Concepts and Applications on Palestinian Cities, 2001, is another study that was done in this field. This study was applied on the Palestinian cities, which are Ramallah, Al-Bireh, Gaza, Bethelehem, Beit Jala, Beit Sahour, Nablus, Tulkarem, Jenin, and Qalqilya. Like the previous study, the existing situation was evaluated, the data was collected in several fields, traffic management concepts was studied on both streets and intersections, and management of public transportation and parking was also included (Abu-Eisheh, S. and Al-Sahili, K, 2000).

**In Summary**, some of these access management measures may be applicable to Palestinian cities, and city of Nablus arterials in particular. However, other measures are not applicable or need farther studying before they are recommended for use in Nablus or other Palestinian cities. The adoption and justification of specific access management measures for the studied arterials is discussed in Chapter Four.

# CHAPTER THREE

# METHODOLOGY

## 3.1 Introduction

The existing transportation infrastructure and poor transportation services provided in Palestine are inadequate to satisfy both the current and increasing demand for transportation and to facilitate the socio-economic development. Lack of proper transportation infrastructure facilities and services can be an obstacle to the development of the various economic sectors and may hinder the entire development efforts.

Based on the literature, better management of arterial access not only increased arterial and intersection capacity and reduced congestion and conflicting maneuvers, but also greatly increased safety. The objective of this project is to evaluate the compliance and effectiveness of some access management measures on two urban arterials in Nablus City.

The methodology of this research is based on the following items:

vii) Review existing international access management processes

viii) Explain the functions and the importance of access management measures

ix) Collect the related access management data about the studied streets

x) Select the steps, techniques, and adopting access management standards which suite the Palestinian cities

xi) Evaluate the effect of these techniques on the street network.

xii) Survey the public's opinions to (drivers, pedestrians, and business owners) on the two studied arterials, by doing face-to-face interviews with these groups

### 3.2 Literature Review

A brief explanation of some access management projects and its measures were described. Several studies listed various types of measures used in access management. The list of measures includes:

- Driveway Spacing
- Intersection Spacing
- Median Treatments and Median Openings
- Parking Management
- Turning Lanes and Auxiliary Lanes
- Economic Impacts

### 3.3 Data Collection

The required data for this project includes:

a) International data about access management measures (the applicability of specific items in these measures for Palestinian cities will be examined).

b) Maps of the selected corridors, which shows median opening, driveway spacing, continuous raised medians.

c) Traffic volumes and patterns, geometry, and traffic control data.

d) Review local regulations, if any, related to access management issues.

Necessary modifications will also be applied to make these standards suitable for Palestinian capabilities.

The main sources of these data are:

1- Nablus Municipality, the maps of the studied street and regulations.

2- Site visits to do some field measurements, and to make interviews with the people who work in the study area.

3- Previous studies.

4- International sources (some of these sources are listed in the references).

### 3.4 Evaluate the Compliance with Access Management and their Effectiveness

Techniques must be established to evaluate the effectiveness of these measures. Available techniques will be reviewed and the most appropriate ones (that can solve the problems and can be implemented in a short-time with low cost) will be identified. The application of the access management measures will be conducted at Rafidia-Yaser Arafat Street, and at Faisal-Haifa Street in Nablus City.

A set of conclusions and recommendations will be developed based on the above analysis.

# CHAPTER FOUR

# ADOPTED ACCESS MANAGEMENT STANDARDS

## 4.1 Introduction

It is noticed from the literature review that some standards used in the United States projects are not appropriate for the Palestinian projects because of the large difference in the geometric design and traffic volumes on the streets. So, the list of recommended access management standards to be applied on the Palestinian arterials is discussed in the following sections after analyzing the measures that will be applied on the studied streets.

## 4.2 Driveway Spacing

It is noticed that there are no guidelines for driveway spacing and spacing requirements vary considerably from place to place. The spacing standard depends on speed limit, functional classification of the road, and frontage area. As the speed limit rises, the recommended spacing between driveways increases, in rural areas spacing must be longer than urban areas, and local streets required larger number of driveways per mile while small number of driveways per mile is required for arterials.

It is also noticed that:

- Driveway densities can safely be higher if they serve residential properties. This is because residences generate far fewer trips per hour than commercial or industrial properties.
- Driveways should never be located on or close to corners of intersections. They should also never be located within the functional area of an intersection (e.g., along right-turn lanes provided at intersections).
- As number of driveways per mile increases, accident rates become unacceptably high. However, this thesis will not focus on accidents on the studied arterials.

- Spacing requirements should reflect a balance between traffic managing and existing land-use characteristics. Closing one of the two adjacent driveways is not a good solution if there are no alternative roads. So, driveways should be separated as possible, but also upto a certain limit.

Minimum stopping sight distance can be used to determine the spacing between driveways. Based on minimum stopping sight distance with 50mph (80kph) design speed on the studied streets, the adopted minimum driveway spacing is 422ft (130m). Comparing this result with the USA standards mentioned before, this value is appropriate and can be adopted. The effectiveness of this value will be discussed in the following chapters using proper effectiveness tools.

## 4.3 Traffic Signal Spacing and Coordination

It is indicated in the literature that intersection spacing on arterials has an impact on accident rates (as the number of intersections per mile increase, the opportunity for crashes increases) and delay (increasing intersection densities will increase delay and congestion). Travel speed has a great effect on spacing between signals and cycle lengths. Irregularly spaced signals affect the efficiency of progression on the arterial.

Same as the MUTCD (2000), 0.5 mile (0.8Km) between successive signals will be adopted for coordination. When greater distance between signals exist, the coordination becomes less effective, since in this case vehicles platooned between signals tend to spread out.

## 4.4 Median Opening

The evaluation of a median opening location and width will be based on traffic volumes and type of turning vehicles (design vehicle). An important factor in designing median openings is the path of the design vehicle making a minimum left-turn (turning radius). At intersections, the minimum width of median opening should be as great as the width of crossroad traveled plus shoulders or sidewalks, if exists.

The adopted standards for median openings along the studied streets will be based on AASHTO standards presented on (Table 2.2). A separate minimum width of each opening will be adopted according to the width of the median and the shape of the median end. Locations of opening will also be evaluated when these openings are closed or shifted.

## 4.5 Parking Management

On-street parking should not be permitted on arterials for safety reasons. However, if they are permitted, they should be started and finished at a minimum distance of 30m away from the entrance of any intersection. Curb parking restrictions will be applied in a number of cases: if the volume/capacity is exceeding unity, if the width of street is narrow (less than 3m), and if there exists accident hazards due to on-street parking (Khisty and Lall, 2002). On the studied streets on-street parking will be permitted if there are enough spaces and away from intersections.

Parking should be prohibited within at least 10m of a stop sign, yield sign, or a signal, and within 6m of a crosswalk at an intersection. Space for on-street parking use reaches as high as 30 percent of the total paved street space. The minimum width of parking lane is 2.4m, which is the width of one vehicle (Khisty and Lall, 2002).

## 4.6 Corner Clearance

Corner clearance analysis is the same as driveway spacing. Since corner clearance depends on speed limit, and the speed limit on the studied arterials is 50mph (80kph), so the minimum distance required to stop a car traveling at this speed is 422-feet (130m).

### 4.7 Medians at Intersections

Based on AASHTO (2001), median width should be (0.5-9.0m). The width of the deceleration lane should keep storage for one vehicle, this width should be at least 3m, and desirably should equal that of the through lanes. Deceleration length depends or (taper length and turning lane pocket length) is the distance required to stop the vehicle from the deceleration speed 20mph (32kph), which is 111-feet (34m). This length is equal to six vehicles lengths, which is approximately the maximum number of vehicles waiting to turn left or right in the studied streets. The width of median nose should be at least 1.2m, a width of 1.8-2.4m is preferable, to provide excellent visibility.

### 4.8 Driveway Related

In this thesis, if a new driveway will be constructed it is important to take the driveway relations in consideration. Very gentle driveway grades should be selected, with maximum change in grade of less than four for minor arterials, to keep smooth entrance to the arterial and for drainage (ITE, 1987).

A proper driveway width should be designed, neither narrow nor too wide. Driveways may vary in size depending on the number of lanes needed. Driveways in Palestinian streets can be either one-way in or out with optimal width of 14-16 feet (4.3-4.8m), or two-ways with one lane per direction, with each lane being at least 11 feet (3.3m) wide. Proper turning radii should be designed to accommodate the largest vehicle generally expected to use the driveway. The design vehicles that use the studied driveways are single unit trucks with 15m turning radii.

Recommended driveways throat lengths will be adopted based on the Florida Department of Transportation standard, which is suitable to apply on Palestinian street; to achieve smooth traffic circulation within land developments, and to prevent turning traffic from queuing on the arterial. This length is 30-50 feet (9-15m).

### 4.9 Frontage and Backage Roads

Since this project will be applied on urban arterial, the opportunities to construct access roads are generally restricted to locations where there is substantial spacing between intersecting roads, little if any existing development, and a development plan.

Frontage and backage roads should be set far enough back from an arterial. According to New York State Department of Transportation (1996), the recommended separation is at least 300 feet (90m) between frontage and backage roads outlets and intersections between cross streets and arterials. This spacing can be adapted to the Palestinian streets since minimum distance will cause safety problems. It is important to mention that frontage roads can be too close to the arterial, depending on the strip development along this street. This measure can be applied on new Palestinian streets, but it can not be applied on the two studied streets of this thesis.

### 4.10 Dedicated Left and Right Turning Lanes

Turning lanes separate slower turning vehicles from through traffic and provide a protected space for these vehicles to decelerate and turn. The discussion mentioned before about the deceleration lane length and width, and the taper length will be used in this thesis as standards for dedicated left-turn lanes.

### 4.11 Quadrant Roadways

The quadrant roadways are considered good measures, and can be applied on several arterial streets on Palestinian cities. But in this project, the studied streets have a few signalized intersections, there are no large open areas around these streets, and there are no close intersections (150m) from these main intersections. So the applicability of the quadrant roadway concept will not be meaningful in this project.

**Table 4.1** Summary of the Adopted Access Management Standards

| Access Measures | Adopted Standards | Reference |
|---|---|---|
| Traffic signal spacing for coordination | Less than 0.8Km | MUTCD |
| Corner clearance | 130m | Calculated based on stopping sight distance |
| Driveway spacing | 130m | Calculated based on stopping sight distance |
| Median width | 0.5-9.0m | AASHTO |
| Deceleration lane length | 34m | Calculated based on stopping sight distance |
| Deceleration lane width | At least 3m | AASHTO |
| Median opening width | As shown in Table 2.4 | AASHTO |
| Parking Management | *No parking within 30m from intersection<br>* No parking within 6m from crosswalk<br>* No parking within 10m from sign or signal | Weant, Mogren, and Levinson |

# CHAPTER FIVE
# COMPLIANCE WITH ACCESS MANAGEMENT TECHNIQUES ON THE STUDIED STREET

## 5.1 Introduction

Access management measures will be applied on two arterials in Nablus City; these arterials are described below.

The first street on which this study will evaluate the compliance of the concepts of access management is Rafidia-Yasar Arafat Street. This street is divided into two sections. The first section extends from Al-Salam Intersection to Rafidia Street/Omar Ibn Al-Kattab Street Intersection in the west. The other section extends from the intersection of Rafidia Street/Omar Ibn Al-Kattab Street to the new campus of An-Najah National University. This street is considered as an arterial that represents a western entrance and exit to/from Nablus.

The other street that this thesis will discuss is Faisal-Haifa Street. This street is divided into two sections. One section extends from the intersection of Tunis Street and Haifa Street in the west to Al-Salam Intersection in the east. The other section extends from Al-Salam Intersection in the west to the office of the Ministry of Education in the east. Faisal Street is a major urban arterial street in Nablus City. It connects the city with cities and villages around it such as Tulkarm.

## 5.2 Data Collection

The needed data to examine the applicability of access management measures on these streets are:

1- Maps of the studied streets

2- Intersection's traffic volume

3- Geometric field measurements

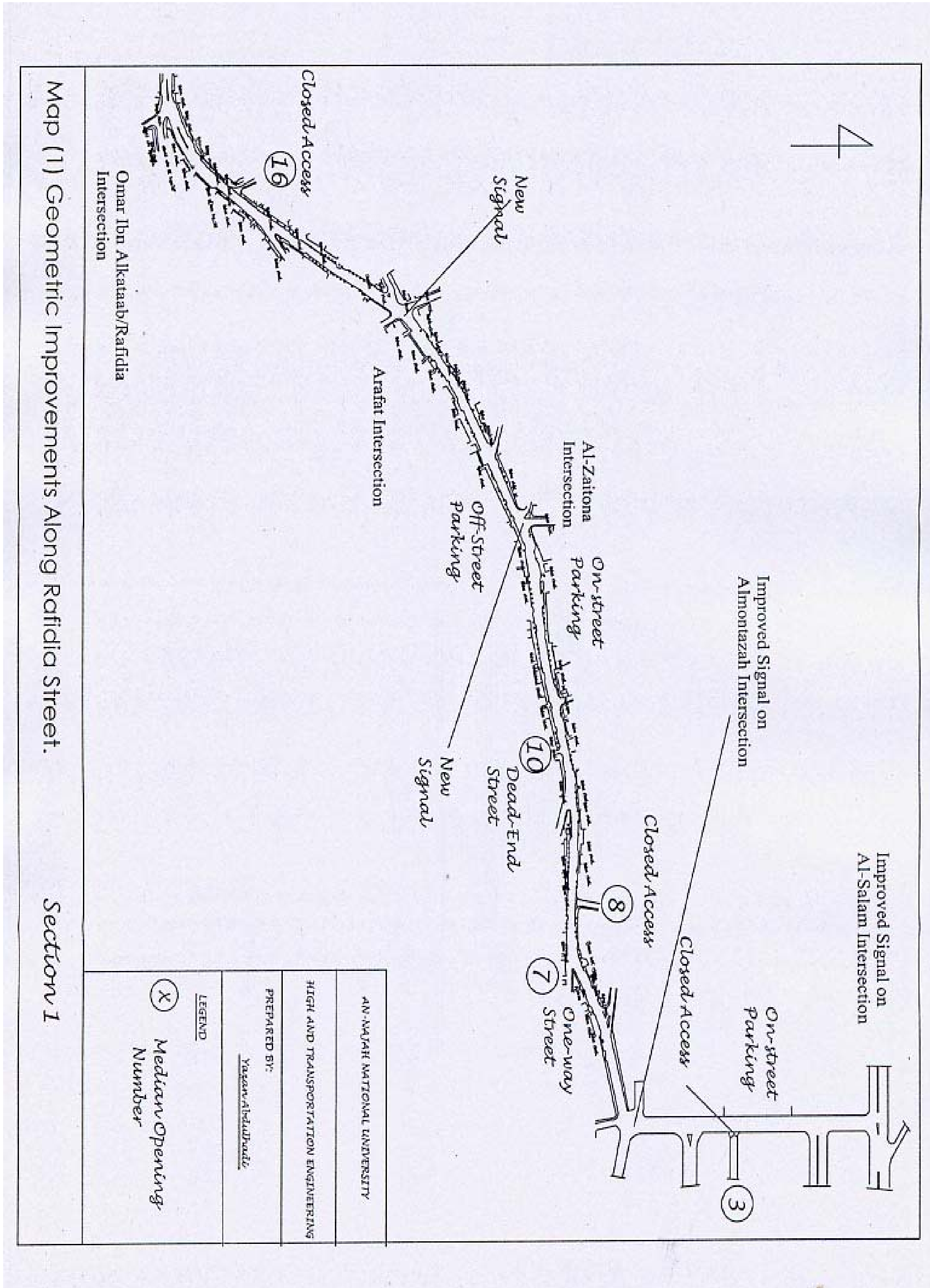
4- Signal timing and plans

### 5.2.1 Maps

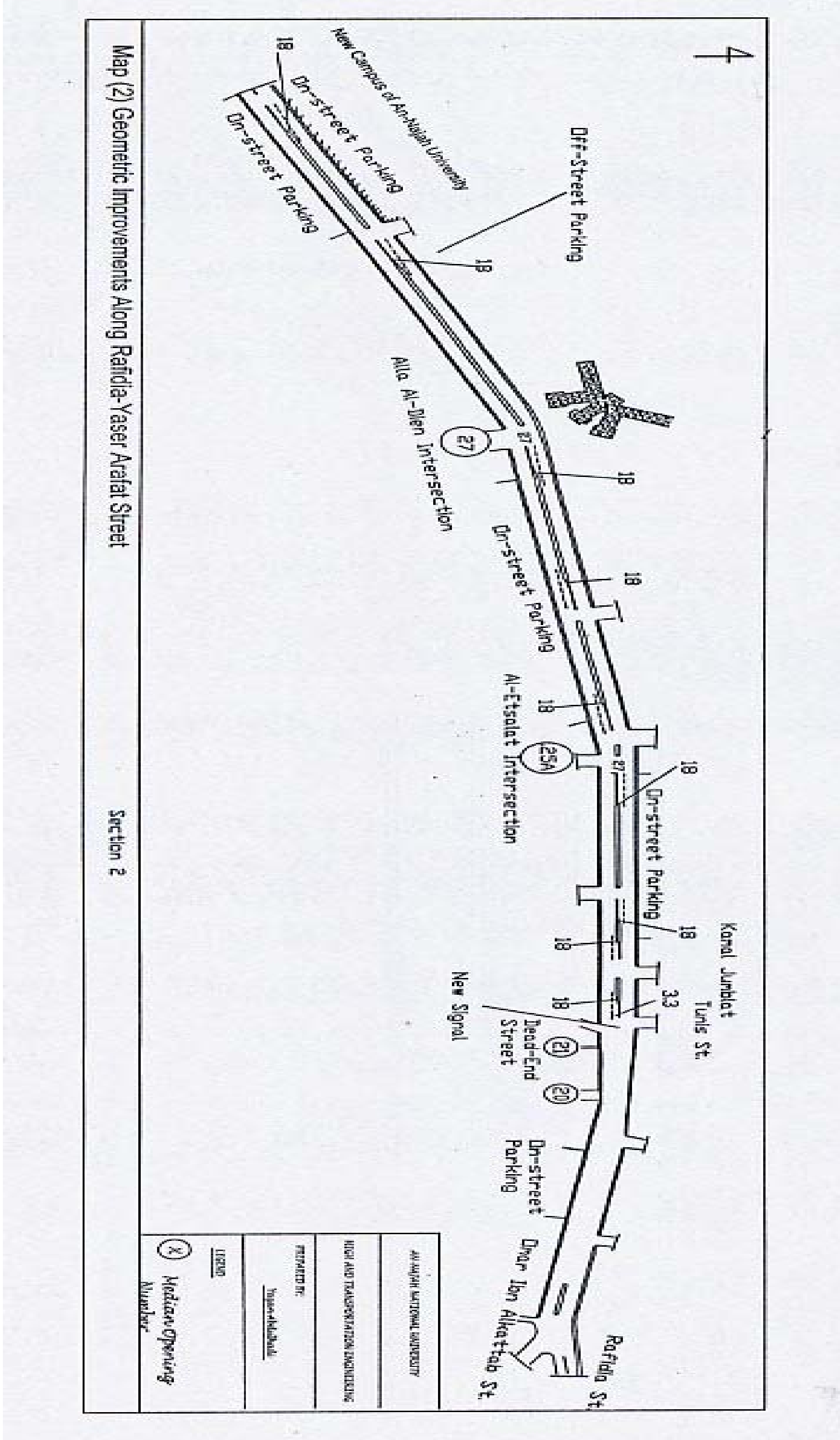
Several maps were used for these streets. These maps show a general view of the studied streets, the studied intersections, driveways, and median opening locations along these streets.

The general maps were obtained from the Municipality of Nablus. However, these maps were old and some information was missing. Therefore, missing information was drawn onto the maps using AutoCad. Field measurements were also done to be sure that all existing features match streets conditions shown on the map. Maps (5.1A/5.1B) show the following elements of Rafidia-Yaser Arafat Street, while maps (5.2A/5.2B) are for Faisal-Haifa Street:

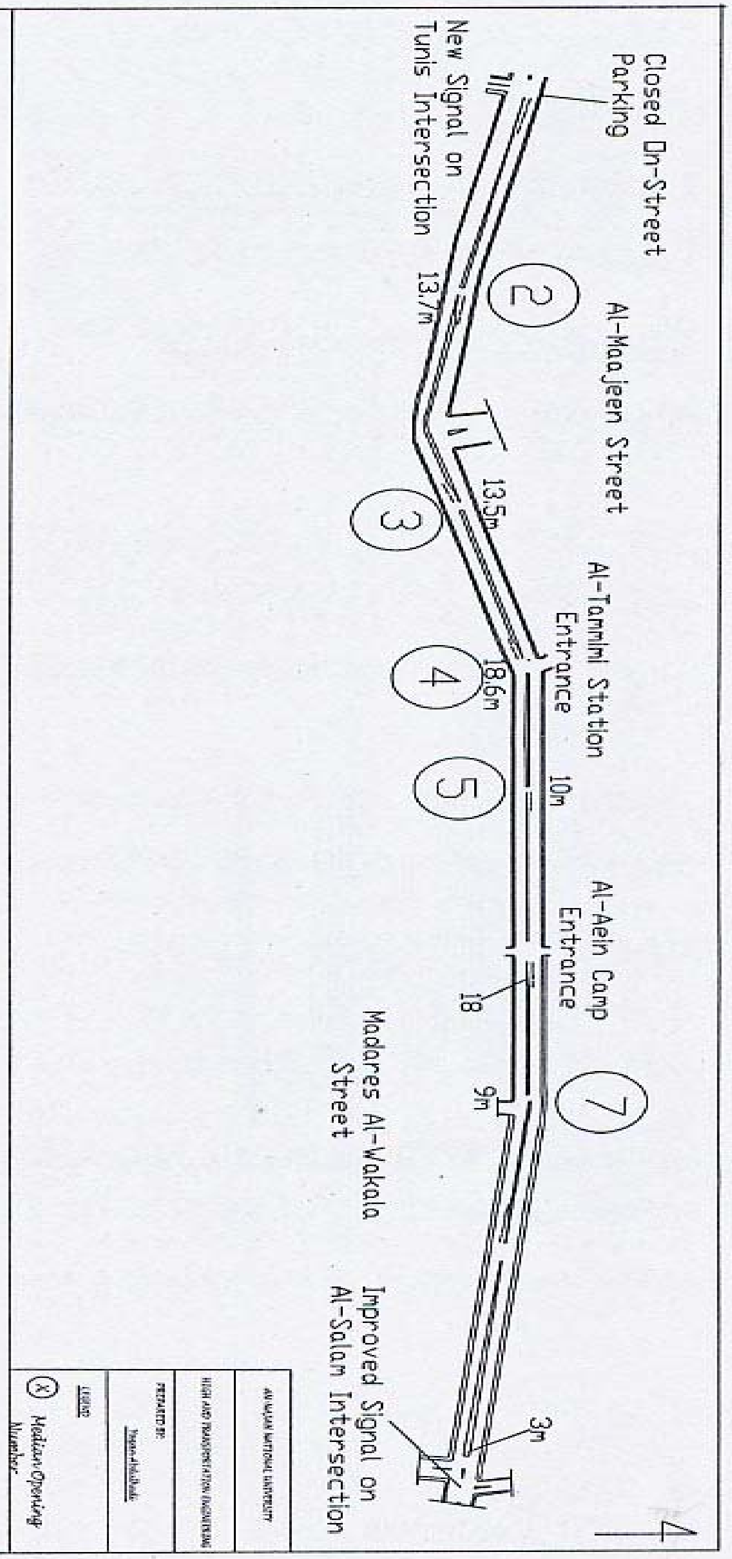
1) Right of way of the street
2) Continuous raised medians
3) Median opening
4) Driveways spacing
5) Existing parking on both sides




Map (1) Geometric Improvements Along Rafidia Street.

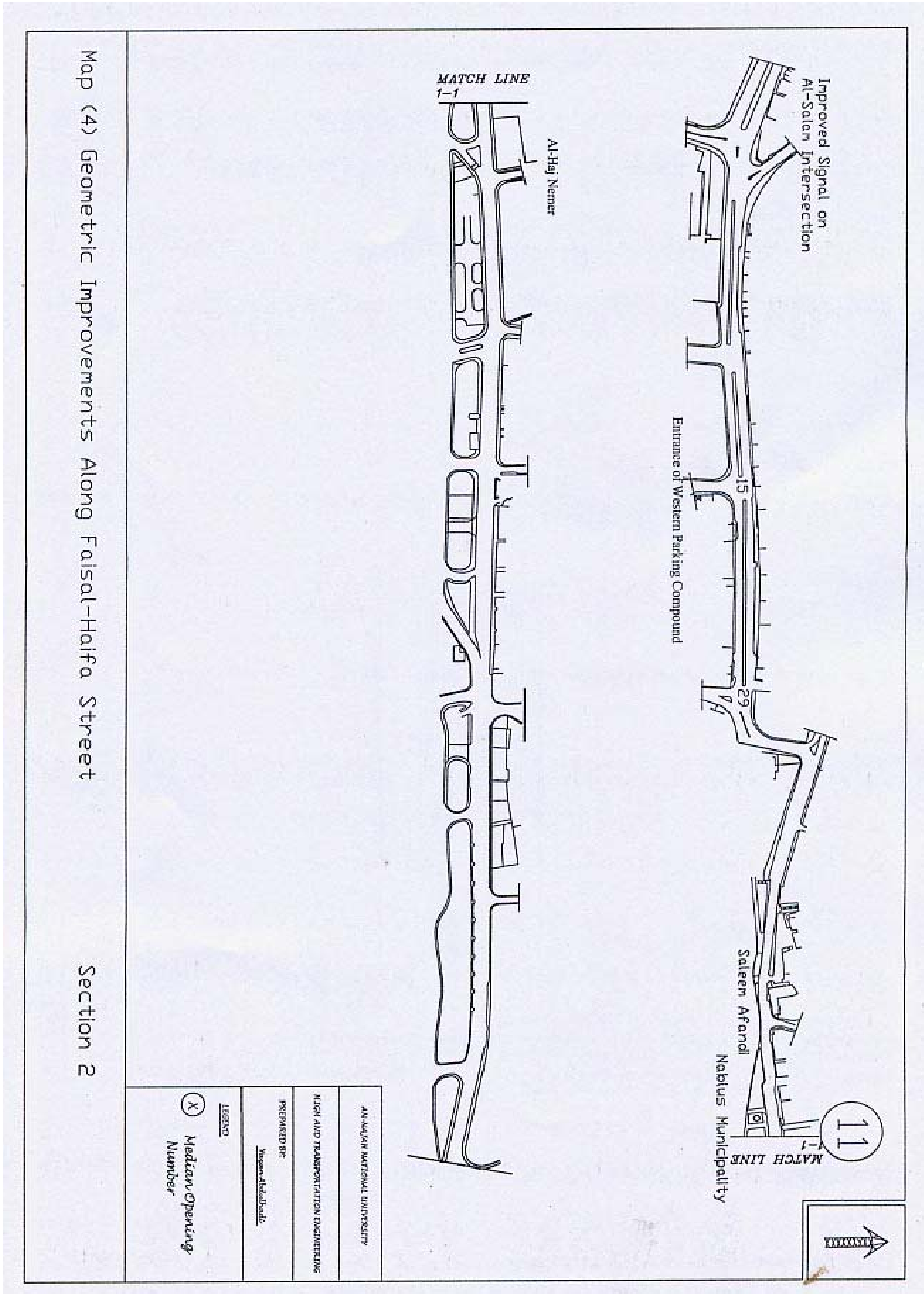



Map (2) Geometric Improvements Along Rafidia-Yaser Arafat Street




Map (3) Geometric Improvements Along Faisal-Haifa Street

Section 1




Map (4) Geometric Improvements Along Faisal-Haifa Street Section 2

### 5.2.2 Traffic Volume Studies

The main studied intersections along the studied arterial streets are presented in Tables (5.1/5.2).

**Table 5.1** Intersections along Rafidia-Yaser Arafat Street

| Intersection No. | Intersection Name |
|---|---|
| 1 | Al-Salam Mosque |
| 2 | AlShwatrih St and Rafidia St |
| 3 | Almraij St and Rafidia St |
| 4 | Akram Ziater St and Rafidia St |
| 5 | Omar Ibn AL-Khttab St and Rafidia St |
| 6 | Tunis St and Rafidia St |
| 7 | Kamal Jumblat St and Yaser Arafat St |
| 8 | Al-Etsalat St and Yaser Arafat St |
| 9 | Alla Al-Dein Intersection |
| 10 | New Campus of An-Najah University Entrance |

**Table 5.2** Intersections along Faisal-Haifa Street

| Intersection No. | Intersection Name |
|---|---|
| 1 | Tunis St and Haifa St |
| 2 | Al-Maajeen St and Haifa St |
| 3 | Al-Aien Camp St and Faisal St |
| 4 | Madares Al-Wakala St and Faisal St |
| 5 | Al-Salam Mosque Intersection |
| 6 | Al-Kendy Intersection |
| 7 | Saleem Afandi Intersection |
| 8 | Al-Haj Nemer Intersection |
| 9 | Al-Baloor Intersection |
| 10 | Ministry of Education Intersection |

The peak hour (PH), peak hour volume (PHV), and peak hour factor (PHF) for the studied intersections along Rafidia-Yaser Arafat Street, and the detailed traffic volume counts are shown in **Appendix (A).** A summary sheet for the traffic volume counts is shown in **Appendix (B).** The data of traffic volume counts for Faisal-Haifa Street are conducted manually, and shown in **Appendix (C).** A summary sheet for the traffic volume counts is shown in **Appendix (D).**

## 5.3 Compliance with Access Management Techniques

The compliance with the following access management measures on the studied arterial will be evaluated:

- Medians at Intersections
- Median Opening
- Driveway Spacing
- Parking Management
- Signal Coordination

### 5.3.1 Medians at Intersections

On Rafidia Street the continuous median extends from Tunis Intersection to the new campus of An-Najah Universeity. This median is in good condition and has approximately (2.3m) width. This width is in the range, which the AASHTO adopted (0.5-9m). It is difficult to construct a raised median on the other section of this street, because of the limited space. The raised median with left-turn lanes at intersections has (25-47m); deceleration lane length; most of these lengths are larger than the minimum length (34m), few are smaller, and need to be increased. The deceleration lane is (2m) width, this width is smaller than lane width

(2<3.3m), and it does not provide storage for turning vehicles. Therefore, it should be increased, and this is possible. The improved condition is shown in (**Appendix E**).

Along Faisal-Haifa Street, the continuous median in the first section has a width ranges from (0.5-5m). The large width (5m) appeared between Al-Salam Intersection and Madares Al-Wakala Intersection. Median at this location is wide. On the second section, the buildings which divide Faisal Street and Alhuria Street can be considered as a large continuous raised median, with good width.

The raised median at intersections has (15-23m); deceleration lane length; these lengths are smaller than the standard length, except for one location in the west of Al-Salam intersection, which has a length of (40m). The deceleration lane is (2m) width; this width is smaller than the standard width, but it can be increased easily. The improved condition is shown in (**Appendix E**).

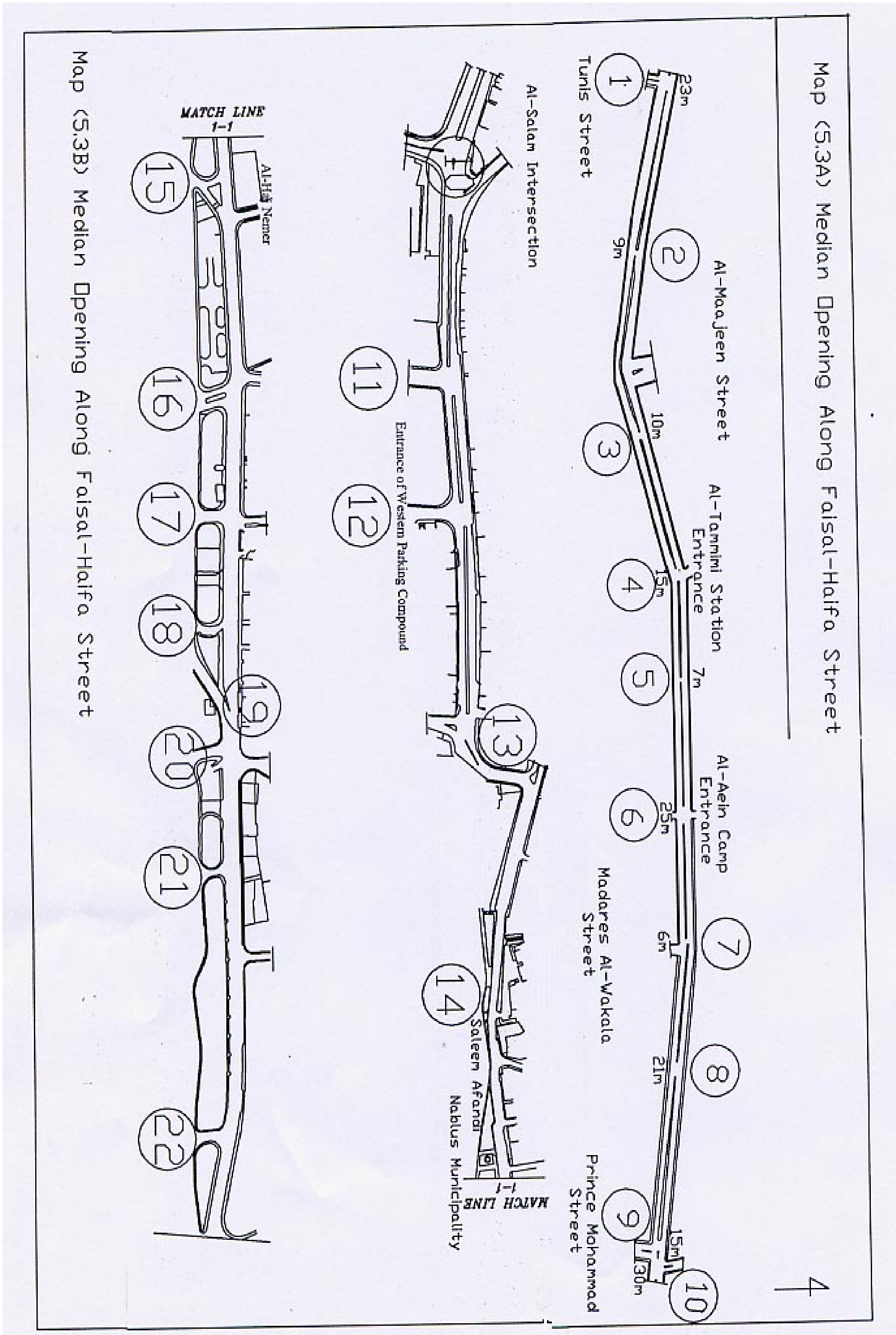
### 5.3.2 Median Opening

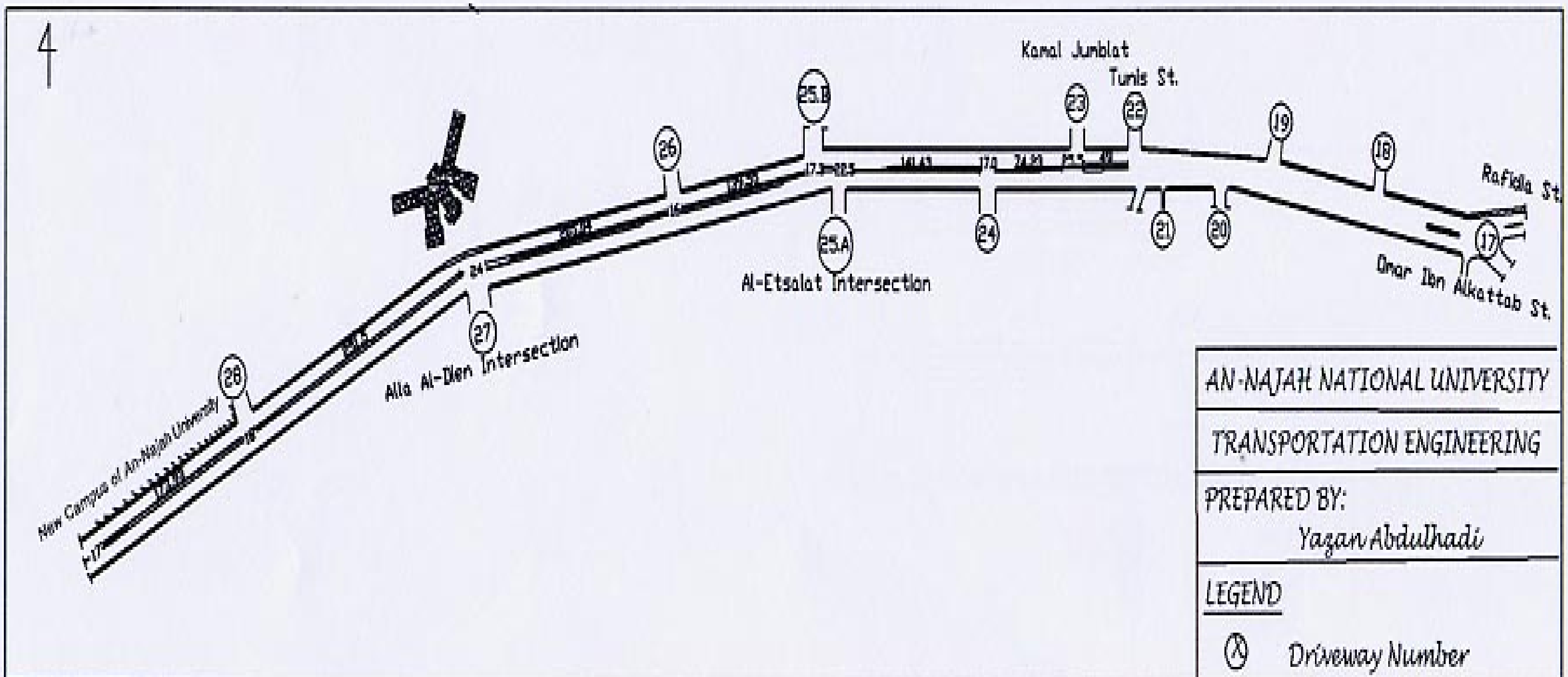
In the studied streets, median opening satisfied the basic guidelines for median opening placement principles, median breaks are provided at some road intersections, and there are few driveways that median do not have a break. Tables (5.3/5.4) present the width of median opening along the two streets. Note that minimum length of opening depends on the width of the median (m) and the shape of median end either semicircular (S.C) or bullet nose (B.N); the locations of medians opening are numbered according to (Maps 5.3A/5.3B) for Faisal-Haifa Street and (Map 5.1B) for Rafidia-Yaser Arafat Street.

**Table 5.3** Median Opening on Faisal-Haifa Street

| Opening # | Median Width | End Shape[a] | Minim. Required Opening Width (m) | Existing Opening Width (m) | Compli -ance |
|---|---|---|---|---|---|
| 1 | 2.0 | B.N | 21.0 | 23.0 | Yes |
| 2 | 2.5 | S.C | 13.7 | 9.0 | No |
| 3 | 3.0 | S.C | 13.5 | 10.0 | No |
| 4 | 3.0 | B.N | 18.6 | 15.0 | No |
| 5 | 2.5 | B.N | 10.0 | 7.0 | No |
| 6 | 3.0 | B.N | 18.6 | 25.0 | Yes |
| 7 | 2.8 | B.N | 9.0 | 6.0 | No |
| 8 | 4.5 | S.C | 7.7 | 21.0 | Yes |
| 9 | 5.0 | B.N | 14.5 | 15.0 | Yes |
| 10 | 2.0 | B.N | 21.0 | 30.0 | Yes |
| 11 | 1.0 | B.N | 14.4 | 15.7 | Yes |
| 12 | 1.0 | B.N | 14.4 | 14.0 | No |
| 13 | 1.0 | B.N | 28.8 | 13.0 | No |
| 14 | 2.0 | ---- | For Pedestrian | 5.0 | Yes |
| 15 | 20.0 | B.N | 12.0 | 14.0 | Yes |
| 16 | 20.0 | B.N | 12.0 | 18.5 | Yes |
| 17 | 20.0 | B.N | 6.0 | 12.3 | Yes |
| 18 | 20.0 | B.N | 6.0 | 7.5 | Yes |
| 19 | 20.0 | B.N | 6.0 | 11.3 | Yes |
| 20 | 20.0 | B.N | 6.0 | 9.3 | Yes |
| 21 | 20.0 | B.N | 6.0 | 9.5 | Yes |
| 22 | 20.0 | B.N | 6.0 | 10.5 | Yes |

[a] B.N: Bullet Nose; and S.C: Semicircular


Map (5.3A) Median Opening Along Faisal-Haifa Street
4
Tunis Street
Al-Maajeen Street
Al-Tammimi Station Entrance
Al-Aein Camp Entrance
Madares Al-Wakala Street
Prince Mohammad Street
23m
9m
10m
15m
7m
25m
6m
21m
15m
30m
1
2
3
4
5
6
7
8
9
10
Al-Salam Intersection
Entrance of Western Parking Compound
Saleem Afandi
Nablus Municipality
MATCH LINE 1-1
11
12
13
14
MATCH LINE 1-1
Al-Haj Nemer
15
16
17
18
19
20
21
22
Map (5.3B) Median Opening Along Faisal-Haifa Street




Map (5.1B) Driveway Spacing and Median Opening Along Rafidia-Yaser Arafat Street Section 2

Most of the openings satisfy the requirements, the other openings which do not satisfy the requirements should be widened a little more, and this can be done easily. Others should be closed to enhance traffic by allowing right turn (in-out) only, like opening number 11. The improved condition is shown in (**Appendix E**).

**Table 5.4** Median Opening on Rafidia-Yaser Arafat Street

| **Driveway #** | **Median Width** | **End Shape[a]** | **Minimum Opening Width** | **Existing Opening Width** | **Compliance** |
|---|---|---|---|---|---|
| 23 | 2.3 | S.C | 13.8 | 25.5 | Yes |
| 24 | 2.3 | S.C | 13.8 | 17.0 | Yes |
| 25.A | 2.3 | S.C | 27.6 | 22.5 | No |
| 25.B | 2.3 | S.C | 13.8 | 17.3 | Yes |
| 26 | 2.3 | S.C | 13.8 | 16.0 | Yes |
| 27 | 2.3 | S.C | 27.6 | 24.0 | No |
| 28 | 2.3 | S.C | 13.8 | 18.0 | Yes |

[a] S.C: Semicircular

The openings that do not satisfy the standards can be improved by making the end as bullet nose or it can be increased, and this is possible. One of the countermeasures of inappropriate location of median opening is to close it. The improved condition is shown in (**Appendix E**).

**5.3.3 Driveway Spacing**

The spacing between the adjacent driveways and the distances between the intersections and the next driveways are listed in Tables (5.5/5.6). The driveways are numbered as shown in (Maps 5.1A/5.1B) for Rafidia-Yaser Arafat Street, and (Maps 5.2A/5.2B) for Faisal-Haifa Street.

**Table 5.5** Driveway Spacing on Rafidia-Yaser Arafat Street

| Driveway Number | Spacing (m) | Compliance | Driveway Number | Spacing (m) | Compliance |
|---|---|---|---|---|---|
| 1-2 | 52.0 | No | 15-16 | 60.0 | No |
| 2-3 | 93.0 | No | 16-17 | 123.0 | No |
| 3-4 | 32.0 | No | 17-18 | 100.0 | No |
| 4-5 | 59.0 | No | 18-19 | 97.0 | No |
| 5-6 | 93.0 | No | 19-20 | 43.0 | No |
| 6-7 | 60.0 | No | 20-21 | 80.0 | No |
| 7-8 | 73.0 | No | 21-22 | 35.0 | No |
| 8-9 | 111.0 | No | 22-23 | 49.0 | No |
| 9-10 | 56.0 | No | 23-24 | 75.0 | No |
| 10-11 | 53.0 | No | 24-25 | 141.5 | Yes |
| 11-12 | 211.0 | Yes | 25-26 | 140.0 | Yes |
| 12-13 | 94.0 | No | 26-27 | 205.0 | Yes |
| 13-14 | 201.0 | Yes | 27-28 | 251.0 | Yes |
| 14-15 | 190.0 | Yes | | | |

According to the adopted standard for driveway spacing, the minimum spacing between driveways should be 422ft (130m). The spacing distances along this street generally do not conform to these standards. Closing some driveways or converting others to one-way in or exist driveways will solve most problems. Driveways (3, 8, and 16) should be closed with physical controls like (cul-de-sac, semi-diverter, chains, or barrels); there are several alternatives for people to use after closing these driveways. Driveway 7 is one-way out.

Driveways (10, 21) are dead end streets with light traffic volumes; they are used for parking by people living on these streets. It is a common problem in Palestinian Streets that these residential streets are connected directly to the arterials. Driveway 20 should also be closed, but this driveway is providing access to Al-Natoor Mosque and some residential buildings, so it is not recommended closing it until an alternative street is constructed. The spacings become larger for the areas located away from the CBD area. The improved condition is shown in (**Appendix E**).

**Table 5.6** Driveway Spacing on Faisal-Haifa Street

| Driveway Number | Spacing (m) | Compliance | Driveway Number | Spacing (m) | Compliance |
|---|---|---|---|---|---|
| 1-2 | 385.0 | Yes | 9-10 | 290.0 | Yes |
| 2-3 | 253.0 | Yes | 10-11 | 120.0 | No |
| 3-4 | 310.0 | Yes | 11-12 | 90.0 | No |
| 4-5 | 162.0 | Yes | 12-13 | 160.0 | Yes |
| 5-6 | 392.0 | Yes | 13-14 | 170.0 | Yes |
| 6-7 | 180.0 | Yes | 14-15 | 230.0 | Yes |
| 7-8 | 140.0 | Yes | 15-16 | 200.0 | Yes |
| 8-9 | 220.0 | Yes | 16-17 | 290.0 | Yes |

Along Faisal-Haifa Street, distances between driveways are greater than the minimum spacing between driveways 422ft (130m), distances between driveways 10/11 and 11/12 are less than the standard, but driveway number 11 can not be closed because it is for police station. The improved condition is shown in (**Appendix E**).

### 5.3.4 Parking Management

The parking facilities of the studied street are divided into two main parts; on-street and off-street parking. According to adopted standards listed in Chapter Four, it is not recommended to have on-street parking along arterial streets. However, because there are several commercial and educational facilities, lack of off-street parking, and streets are wide enough, on-street parking may be allowed on these streets, either on one side or on both sides of the street.

Parallel curb parking is preferred over other types of parking along Faisal-Haifa Street and Rafidia-Yaser Arafat Street, since this type of parking consumes minimum street width. On-street parking may cause problems on arterials. The municipalities should adopt a policy to control on-street parking, such as enforcing the regulations related to new construction to provide their parking requirements on site.

Along the two studied streets, there are several open areas, which can be used as off-street parking facility, like the space in front of Al-Zitona Building, the two open areas located beside the new campus of An-Najah University, and Nablus Commercial Development Center which will be used as off-street parking. The ownership of these areas is not investigated. However, parking management plan, which is beyond the scope of this thesis, is required for the two streets. Parking improvements are shown in (**Appendix E**).

**5.3.5 Survey of Users' Perspectives**

This survey was done to present users' trends about the subject of this thesis, and not to reach to final conclusions, since the sample size is not statistically representative. The form shown in **Appendix (F)** was prepared to measure people's perspective about access management measures. A sample size of 100 person was taken, and the form was distributed to drivers, pedestrians, and business owners on the two studied arterials.

Drivers at some taxi/bus garages like the one in front the new campus of the university, Asker and Balata garage, and the one near Al-Montazah were asked about there perspectives. Some forms were distributed to private vehicle drivers who were parking their vehicles near commercial centers. Pedestrians walking along the streets were asked about their opinions. Interviews were done with some business owners, whose business is near the studied streets. The interviews were done face-to-face with these groups; an Arabic clarification about these measures and the main goals of this study was explained, because it is not easy for the public to understand the form requirement.

### 5.3.5.1 Survey Results

The results of the drivers, pedestrians, and business owners are shown in Tables (5.7/5.8/5.9) respectively. The graphical explanations of the results are shown in **Appendix (F)**.

**Table 5.7** Drivers Trends towards Access Management

| # | Access Management Measure | Condition | | | |
|---|---|---|---|---|---|
| | | Appropriate | Need Adjustment | Not Appropriate | Don't Know |
| **1** | Location of Median Opening | 24% | 34% | 42% | 0% |
| **2** | Width of Median Opening | 82% | 13% | 0% | 5% |
| **3** | Driveways Spacing | 36% | 20% | 30% | 14% |
| **4** | Continuous Raised Medians | 56% | 26% | 13% | 5% |
| **5** | Pedestrian Safety Aspects | 12% | 32% | 56% | 0% |
| **6** | Parking Availability | 13% | 56% | 21% | 0% |
| **7** | Sidewalks Continuity | 13% | 67% | 20% | 0% |

*Sample size=40 drivers

**Table 5.8** Pedestrian Trends towards Access Management

| # | Access Management Measure | Condition | | | |
|---|---|---|---|---|---|
| | | Appropriate | Need Adjustment | Not Appropriate | Don’t Know |
| 1 | Location of Median Opening | 69% | 31% | 0% | 0% |
| 2 | Width of Median Opening | 44% | 37% | 13% | 6% |
| 3 | Driveways Spacing | 19% | 75% | 0% | 6% |
| 4 | Continuous Raised Medians | 56% | 19% | 19% | 6% |
| 5 | Pedestrian Safety Aspects | 13% | 81% | 6% | 0% |
| 6 | Parking Availability | 13% | 37% | 50% | 0% |
| 7 | Sidewalks Continuity | 25% | 44% | 19% | 12% |

*Sample size=30 pedestrians

**Table 5.9** Business Owners Trends towards Access Management

| # | Access Management Measure | Condition | | | |
|---|---|---|---|---|---|
| | | Appropriate | Need Adjustment | Not Appropriate | Don't Know |
| 1 | Location of Median Opening | 86% | 14% | 0% | 0% |
| 2 | Width of Median Opening | 82% | 18% | 0% | 0% |
| 3 | Driveways Spacing | 55% | 32% | 13% | 0% |
| 4 | Continuous Raised Medians | 27% | 55% | 9% | 9% |
| 5 | Pedestrian Safety Aspects | 9% | 59% | 32% | 0% |
| 6 | Parking Availability | 59% | 27% | 14% | 0% |
| 7 | Sidewalks Continuity | 5% | 59% | 36% | 0% |

*Sample size=30 business owners

#### 5.3.5.2 Discussion

This survey is done to compare users' perspective with the application of access management techniques on the two studied streets. It should be reiterated, that the objective of this survey was not to reach at conclusive results about the users' opinions. The sample size is not statistically representative. Therefore, it is intended only to get a general idea of how the public will react to applying such measures.

From Table (5.7) and based on the interviews, drivers suggest to increase the number of median opening, not closing any of the driveways at the street, and increase on-street parking. Drivers indicate that sidewalks need adjustment and pedestrian safety aspects are not appropriate.

From Table (5.8) and based on the interviews, pedestrians suggest increasing driveway spacing, limiting median opening, increasing safety measures for them and for the drivers, enhancing sidewalks continuity, and increasing sidewalk clear width.

From Table (5.9) and based on the interviews, business owners preferred to break the median in front of their shops and increase parking spaces. They indicated that median opening locations and widths are good. They also suggest enhancing sidewalks continuity and increasing safety measures for pedestrians.

Some public recommendations conform to the main objectives of this thesis, especially the pedestrian indications. Drivers' indications did not conform to the main goals of this thesis, since they are local drivers and need a high level of accessibility. Business owners' indications did not conform to the main goals of this thesis also; they are concerned that changes in direct access to their property, such as closing driveways or installing raised medians, will lead to declines in sales.

The limited education and knowledge of the benefits of some access management measures is expected to be the main reasons of drivers and business owners' indications. Therefore, in cases were the access management measures are to be applied, there should be public involvement and participative as well awareness program to accompany their implementation. This is expected to gain more public support for these projects. However, it should be mentioned that the issue of public perspectives should investigated in details and using a representative sample size.

# CHAPTER SIX
# EFFECTIVENESS OF APPLYING ACCESS MANAGEMENT ON STUDIED ARTERIALS

## 6.1 Introduction

To evaluate the effectiveness of the adopted access management on the studied arterials, two methods were used to measure delay, LOS, and speed before and after the proposed improvements are done. The Highway Capacity Method (HCM) was used to evaluate the measures of effectiveness on intersections and arterials. CORSIM Simulation program was used to evaluate the impact at the network or segments level. The following sections describes the results of these analysis

## 6.2 HCM Analysis

### 6.2.1 Existing Unsignalized Intersections

Using HCS (Highway Capacity Software version 2000) program for the unsignalized intersections on the studied streets, the results of existing level of service (LOS) are shown in Tables (6.1/6.2). Summary of HCS worksheets for existing unsignalized intersections on Rafidia-Yaser Arafat Street, and Faisal-Haifa Street are presented in **Appendices (G),** and **(H)**, respectively.

**Table 6.1** Existing LOS for the Unsignalized Intersections on Rafidia-Yaser Arafat Street

| **Intersection No.** | **Northbound** | | | **Southbound** | | | **Eastbound** | | | **Westbound** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | L | T | R | L | T | R | L | T | R | L | T | R |
| 3 | --- | --- | --- | --- | F | --- | B | --- | --- | --- | --- | --- |
| 4 | --- | --- | --- | F | --- | B | B | --- | --- | --- | --- | --- |
| 6 | --- | F | --- | --- | F | --- | B | --- | --- | B | --- | --- |
| 7 | --- | --- | --- | --- | --- | --- | B | --- | --- | --- | --- | --- |
| 8 | --- | B | --- | --- | E | --- | B | --- | --- | A | --- | --- |
| 9 | --- | C | --- | --- | --- | --- | --- | --- | --- | B | --- | --- |
| 10 | --- | --- | --- | --- | B | --- | A | --- | --- | --- | --- | --- |

L: left-turn movement / T: through movement / R: right-turn movement.

**Table 6.2** Existing LOS for the Unsignalized Intersections on Faisal-Haifa Street

| Intersection No. | Northbound | | | Southbound | | | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | L | T | R | L | T | R | L | T | R | L | T | R |
| 1 | F | --- | B | --- | --- | --- | --- | --- | --- | A | --- | --- |
| 2 | --- | --- | --- | --- | --- | B | --- | --- | --- | --- | --- | --- |
| 3 | --- | D | --- | --- | D | --- | A | --- | --- | A | --- | --- |
| 4 | --- | B | --- | --- | --- | --- | --- | --- | --- | A | --- | --- |
| 7 | --- | --- | --- | --- | --- | C | --- | --- | --- | --- | --- | --- |
| 9 | C | --- | --- | --- | --- | --- | --- | --- | --- | A | --- | --- |
| 10 | C | --- | --- | --- | --- | --- | --- | --- | --- | A | --- | --- |

L: left-turn movement / T: through movement / R: right-turn movement.

The unsignalized intersections on the two studied arterials operate at an acceptable LOS, except intersections number (3, 4, and 6) on Rafidia Street and intersections number (1) on Faisal-Haifa Street, which have (F) LOS, and these should be improved, as detailed later.

### 6.2.2 Existing Signalized Intersections

Using the HCS Program for the signalized intersections on the studied streets, the results of existing condition are shown in Tables (6.3/6.4). LOS analysis of signalized intersections was based on existing signal timing and phasing. Summary of HCS worksheets for existing signalized intersections on Rafidia-Yaser Arafat Street, and Faisal-Haifa Street are presented in **Appendices (G),** and **(H)**, respectively.

**Table 6.3** Existing LOS for the Signalized Intersections on Rafidia-Yaser Arafat Street

| Intersection No. | Intersection Name | NB | SB | EB | WB |
|---|---|---|---|---|---|
| 1 | Al-Salam Mosque | E | F | F | D |
| 2 | AlShwatrih/Rafidia | F | F | D | --- |
| 5 | Omar Ibn AL-Khttab/ Rafidia | D | F | F | F |

**Table 6.4** Existing LOS for the Signalized Intersections on Faisal-Haifa Street

| Intersection No. | Intersection Name | NB | SB | EB | WB |
|---|---|---|---|---|---|
| 5 | Al-Salam Mosque | E | F | F | D |
| 6 | Al-Kendy | --- | --- | E | C |
| 8 | Al-Haj Nemer | D | --- | --- | D |

The signalized intersections operate at unacceptable LOS (F), except Al-Haj Nemer Intersection and Al-Kendy Intersection.

### 6.2.3 Intersections Level of Service Improvements

Depending on traffic volume counts shown in **Appendices (B,** and **D)**, intersections (3 ,4, and 6) on Rafidia Street and intersection number (1) on Faisal-Haifa Street, which are controlled by stop sign, are warranted for signalization based on the Peak Hour Volume Warrant, (MUTCD, 2000) see (Figure 6.1).

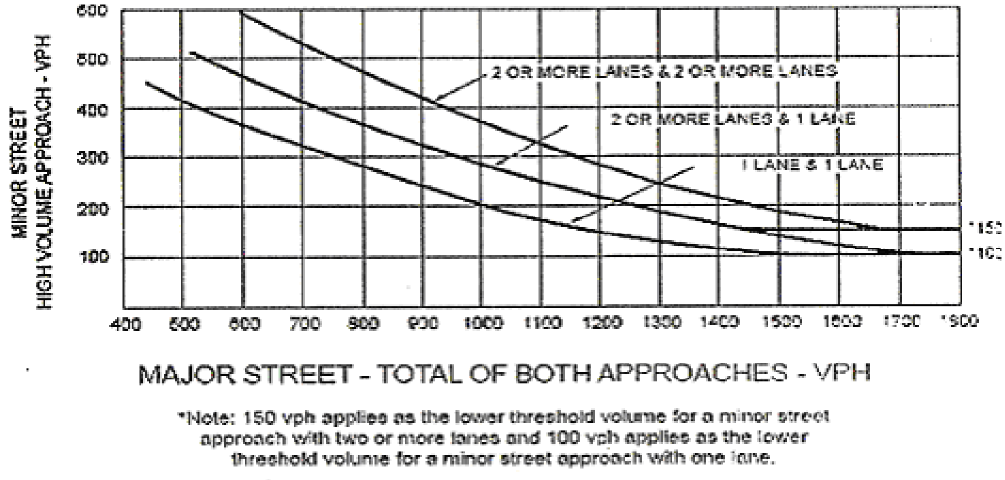



Figure 6.1 Peak Hour Volume Warrant

Source: MUTCD, 2000

The design of the suggested signals is done using (HCS). The result is shown in Table (6.5).

**Table 6.5** LOS for Improved Intersections Along Studied Arterials

| Intersection No. | Intersection Name | NB | SB | EB | WB |
|---|---|---|---|---|---|
| 3 | Almraij/Rafidia | --- | D | D | B |
| 4 | Rafidia Hospital/ Rafidia | D | C | B | C |
| 6 | Tunis/Rafidia | C | C | C | C |
| 1 | Tunis/ Haifa | C | --- | C | C |

Redesign for traffic signals on intersections, which operate at an un-acceptable LOS along Rafidia Street and Faisal Street was done to reach at better LOS. Table (6.6) shows these results.

**Table 6.6** LOS for Improved Signalized Intersections Along Studied Arterials

| Intersection No. | Intersection Name | NB | SB | EB | WB |
|---|---|---|---|---|---|
| 1 | Al-Salam Mosque | E | E | E | E |
| 2 | AlShwatrih/Rafidia | C | B | C | --- |

The details of new and improved unsignalized and signalized intersections results on Rafidia-Yaser Arafat Street and Faisal-Haifa Street are shown in **Appendices (I**, and **J)**, respectively.

### 6.2.4 Arterial Level of Service

Level of service on Faisal-Haifa Street and Yaser Arafat Street is conducted using HCM analysis for Muti-Lane Highway. For the section of Rafidia Street from Tunis Intersection to Al-Salam Intersection, level of service is conducted using HCM for Two-Lane Streets. Two-way and directional LOS are computed for Rafidia Street and were found to be (D and E), respectively. The resulted LOS for multi-lane highway on Yaser Arafat Street is (B, and A) for directions 1 and 2, respectively. Faisal-Hiafa Street is divided into two sections; the LOS is shown Table (6.7). The details are shown in **Appendix (K)**.

**Table 6.7** Existing LOS Analysis of Faisal-Haifa Street

| Section No./LOS | Direction 1 | Direction 2 |
|---|---|---|
| **1** | A | A |
| **2** | F | ---- |

Notes:-

*Section # (1):- From Tunis Intersection to Al-Salam Intersection.

*Section # (2):- Al-Salam Intersection to the office of the Ministry of Education Intersection.

## 6.3 CORSIM Simulation Analysis

To evaluate the effectiveness of applying some of the adopted access management measures at the network level CORSIM computer program was used. CORSIM is a comprehensive microscopic traffic simulation model; this program combines two simulation tools: FRESIM for freeways and NETSIM for surface streets. CORSIM uses the concept of nodes and links to define a traffic network. Links are streets or freeways, and nodes are usually the intersection of two or more links.

The network should be laid out using the distances between intersection, number of lanes, and other data that were obtained, so geometric pictures can be drawn such as maps. First, the existing network geometry and traffic were coded, and then the new improvements were added.

The analysis of the selected measures of effectiveness was done at the network level, as well at network sections (corridors) where access management improvements are applied. Results of measures of effectiveness are shown in Tables (6.8/6.9), for existing and improved network and corridors. The improvements include closing some of the driveways that do not conform with the standards, closing median openings, prohibiting some turn movements, and coordination of successive signals. All the improvements are described in Chapter Five and shown in Appendix (E).

The network segments that are described in Table (6.9) are the following:

*Segment one: Faisal Street from Al-Baloor Intersection to Al-Kindy Intersection (WB).

*Segment two: Faisal Street from Al-Kindy Intersection to Al-Baloor Intersection (EB).

*Segment three: Hiafa Street from Al-Salam Intersection to Al-Kindy Intersection (EB).

*Segment four: Hiafa Street from Al-Kindy Intersection to Al-Salam Intersection (WB).

*Segment five: Prince Mohammad Street from Al-Salam Intersection to Al-Montazah Intersection (SB).

*Segment six: Prince Mohammad Street from Al-Montazah Intersection to Al-Salam Intersection (NB).

**Table (6.8)** CORSIM Network Simulation Results

| | **Vehicles** | | **Average Delay Time** | **Fuel Consumption (M.P.G)**[1] | **CO Emission (grams/ mile)**[2] | **Speed (mph)** |
|---|---|---|---|---|---|---|
| | **Miles** | **Trips** | **Minutes/ vehicle-Trip** | | | |
| **Existing Network** | 369.5 | 603.0 | 3.04 | 4.15 | 19.23 | 6.4 |
| **Improved Network** | 603.5 | 866.0 | 2.76 | 5.95 | 18.24 | 8.0 |
| **% Change** | 63.0 | 43.0 | -9.0 | 43.0 | -5.0 | 25 |

**1**: Miles per gallon

**2**: Fuel consumption and CO emissions are for auto vehicles

The results from Table (6.8) show that vehicle-miles and vehicle-trips on the improved network increased compared to the existing network. Average delay time has decreased with approximately 9 percent. Closing a direct access will improve traffic flow and thus increase vehicle-miles and vehicle-trips, and reduce delay time. However, since the network is congested, the impacts of the improvements will not be great. Percent change between existing and improved network is limited, because the suggested improvements are also limited. The rate of fuel consumption has improved by 43 percent as a result of traffic improvement at the network level. Carbon-oxide emission has decreased by 5 percent. Speed of the network enhanced by 25 percent.

**Table 6.9** CORSIM Corridors Simulation Results

| Segment # | Measures of Effectiveness | Existing Condition | Improved Condition | % Change |
|---|---|---|---|---|
| 1 | Vehicle-trips | 1377.0 | 1551.0 | 12.6 |
| | Average travel time (minutes/vehicle-trip) | 19.2 | 26.8 | 39 |
| | Average speed (mph) | 10.0 | 6.8 | -32 |
| 2 | Vehicle-trips | 1212.0 | 1341.0 | 10.6 |
| | Average travel time (minutes/vehicle-trip) | 16.5 | 23.6 | 43 |
| | Average speed (mph) | 12.6 | 8.0 | -36.5 |
| 3 | Vehicle-trips | 326.0 | 312.0 | -4.3 |
| | Average travel time (minutes/vehicle-trip) | 18.2 | 17.9 | -1.6 |
| | Average speed (mph) | 19.3 | 19.7 | 2.1 |
| 4 | Vehicle-trips | 278.0 | 250.0 | -10.0 |
| | Average travel time (minutes/vehicle-trip) | 24.2 | 39.0 | 61.0 |
| | Average speed (mph) | 14.6 | 9.1 | -37.7 |
| 5 | Vehicle-trips | 79.0 | 185.0 | 134.0 |
| | Average travel time (minutes/vehicle-trip) | 38.1 | 105.7 | 177.0 |
| | Average speed (mph) | 4.7 | 1.5 | -68.0 |
| 6 | Vehicle-trips | 134.0 | 253.0 | 88.8 |
| | Average travel time (minutes/vehicle-trip) | 44.1 | 15.6 | -64.6 |
| | Average speed (mph) | 4.0 | 9.9 | 147.5 |

Since we are dealing with a network, solving the congestion on one street may transmit this problem to other streets. There were improvements on some segments, while traffic conditions on other segments got worse. Table (6.9) shows that some measures of effectiveness like average travel time and speed have improved for segments 3 and 6, a median and a driveway were closed. However, travel time has increased on other segments because the diverted traffic added congestion to an already congested network. Vehicle-trips decreased in segments 3 and 4, while increased on other segments. This is because some access management measures were applied on these two segments, like closing median opening and prohibiting some movements to these segments.

It is concluded that the proposed improvements produced good results on the network level. Therefore, it is recommended to adopt these improvements and apply them to the actual network. However, these results vary from one segment to another, depending on the improvement that was done on each segment, and the effect of such improvements on the related segments.

# CHAPTER SEVEN
# CONCLUSIONS AND RECOMMENDATIONS

## 7.1 Introduction

Arterials are designed and built with the intention of providing better service than is available on local roads and streets. One of the important considerations in arterial development is the amount of access control that can be acquired. Access management is usually not too difficult to obtain in a rural area where development is light. However, this becomes challenging in urban areas where the area is built-up and space is limited.

## 7.2 Conclusions and Recommendations

Based on the analysis presented in the thesis, several conclusions were reached. The conclusions are:

- There are no specific guidelines or standards that are universally adopted for some access management measures. Therefore, it was necessary to adopt criteria for the studied arterials to evaluate their compliance with access management.
- It is concluded that applying some access management measures on specific road segments, such as closing driveways and median openings or prohibiting resulted on limited improvements for that particular segment. However, the diverted traffic has resulted in increasing average travel time and reducing speed to other segments of the network.
- The level of compliance of the arterials in Nablus City with access management measures are relatively acceptable, as median opening, width and location, and driveway spacing conform to adopted standards.
- Access management measures can be applied on Nablus arterials. For the two studied streets, some measures are easily applied (such as driveway spacing and median opening), others can be applied with little geometric improvements (such as driveway related issues), and some measures

could not be applied (such as quadrant roadways and frontage and backage roads) because they need large space.

- It is difficult to apply access management measures on urban arterials, especially near the CBD area, where space is limited and the need for accessibility is high, while it is much easier on rural arterials.
- LOS for signalized intersections was improved from (D-F) to (C-E). The unsignalized intersections, which operate at LOS (F) were improved to LOS (C).
- Since few access management measures improvements were applied to the studied streets, little improvements are resulted on speed, delay, and LOS. Average delay time has decreased with approximately 9 vehicles-hours. Carbon-oxide emission is decreased by 5 percent. Speed of the network enhanced by 25 percent.
- Several factors should be taken into account before applying this study on other arterials in Palestine, especially traffic volume. This thesis results were based on the existing traffic volumes in Nablus City. Travel restriction, economical and political conditions in Nablus makes it a special case.

This study showed the importance of applying access management measures. As a result of this study, the following recommendations were depicted:

- It is concluded that the proposed improvements produced good results on the network level, therefore, it is recommended to adopt these improvements and apply them to the actual network.
- There is a lack of knowledge among Palestinian authorities in the road sector about access management and its applications. Therefore, it is

recommended that these officials consider the access management techniques listed in this thesis and evaluate it in other cities.

- The access management measures standards should be adopted by Palestinian Municipalities when constructing new arterials or evaluating the existing streets, considering the effect of the related variables.
- For roads, which have large adjacent open spaces, it is recommended to consider applying some important measures such as (QRI) and backage or frontage roads, and this is expected to solve some of the traffic conflict problems that might appear.
- Since this study focused on the general concepts of access management, it is recommended for other studies to discuss specific measures of access management in details and to explore establishing standards that is appropriate for Palestinian conditions.
- It is recommended to conduct traffic impact studies for future land developments including access management's projects, to mitigate resulted traffic impacts.
- It is recommended to conduct a comprehensive study about the public opinions and acceptance of applying access management techniques on urban arterials in Palestinian cities.
- Public involvement should be seriously considered when applying access management because they are impacted by these measures. Therefore, it is important to obtain their support in order for the project to succeed.

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# Appendices

Note: For detailed appendices please referee to the attached appendices folder on CD. The program used for data analysis is (HCS – Highway Capacity Software).

جامعة النجاح الوطنية
كلية الدراسات العليا

# تطابق تقنيات إدارة الدخول و الخروج على الشوارع الشريانية في مدينة نابلس

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قدمت هذه الاطروحة استكمالا لمتطلبات درجة الماجستير في هندسة الطرق و المواصلات بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين
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## الملخص

تزايدت الاتجاهات الداعية إلى إدارة أنظمة المرور الحالية بدلآ من بناء مرافق المواصلات الجديدة، بسبب المحدودية المتزايدة للمساحات الفارغة في معظم المدن. كما و إن إدارة أنظمة المرور تتميز بتكلفتها المنخفضة، بينما بناء مرافق المواصلات الجديدة تحتاج إلى تكلفة أكبر بكثير، وقد تواجه بتقييدات الفضاء (الفراغ) والمصادر المالية. إنّ الهدف الرئيسي لهذا البحث يكمن في دراسة وتقييم إمكانية تطبيق استراتيجيات إدارة الدخول و الخروج على الشوارع الشريانية في المدن الفلسطينيّة. و سيتم تطبيق هذه الدراسة على شارعين شريانيين داخل مدينة نابلس، هما: شارع رفيديا- ياسر عرفات وشارع فيصل-حيفا.

وتتلخص طريقة العمل في هذا البحث بالنقاط التالية:

- مراجعة عمليات وطرق إدارة و ضبط الدخول و الخروج على الشوارع الشريانية في المدن العالمية.
- توضيح استراتيجيات إدارة الدخول والخروج، من خلال تبيان مفهومها وأهميتها ووظيفتها في تحقيق مثل هذا الهدف. و تعتبر هذه الخطوة من أهم خطوات العمل، حيث أن التعرف على هذه الاستراتيجيات ضروري قبل البدء بتطبيقها.
- جمع المعلومات ذات العلاقة بموضوع إدارة الدخول والخروج عن الشوارع التي سيتم عمل الدراسة عليها.

- اختيار الخطوات والوسائل التي يتناسب تطبيقها مع الشوارع في المدن الفلسطينيّة، من خلال وضع معايير خاصة تتلاءم مع واقع شوارع فلسطين الشريانية.
- تقييّم تأثير هذه الوسائل على الشوارع المحلية.
- عمل استبيان يوضح آراء الناس (السائقين، المشاة، أصحاب المحال التجارية) ومقترحاتهم فيما يتعلق بموضوع البحث.

ومن أهم الإجراءات المتعلقة بضبط الدخول و الخروج على الشوارع الشريانية، والتي تمت مناقشتها في هذا البحث: الجزر على التقاطعات، و الجزر الممتدة على طول الشارع، و الفتحات في الجزر، وبعض الأمور المتعلقة بالممرات المفتوحة على الشارع الشرياني، وأماكن إيقاف المركبات، والمسافات بين التقاطعات، ومسارب الانعطاف.

وقد توصلت الدراسة إلى ما يلي:

- ليس هناك معايير متبناة عالميا لبعض إجراءات إدارة الدخول والخروج. لذا، كان من الضروري تبنّي معايير للشوارع المدروسة لتقييم مدى تطابقها مع هذه الإجراءات.
- إجراءات إدارة الدخول والخروج يمكن أن تطبّق على شوارع مدينة نابلس الشريانية.
- من الصعب تطبيق إجراءات إدارة الوصول على الشوارع داخل المدن، خصوصا قرب منطقة وسط البلد، بينما من السهل تطبيقها على الشوارع بين المدن.
- إغلاق بعض الممرات اوالفتحات في الجزر أو منع بعض الحركات حسّنت حركة المرور ومستوى الخدمة، وخفضت التأخير على الشوارع الشريانية الرئيسية في مدينة نابلس.
- عدّة عوامل يجب أن تؤخذ في الحسبان قبل تطبيق هذه الدراسة على شوارع شريانية أخرى في فلسطين، خصوصا الحجم المروري. لان نتائج هذه الأطروحة كانت مستندة على الحجم المروري الحالي في مدينة نابلس.

بعد مناقشة تطبيق إستراتيجيات إدارة وضبط الدخول و الخروج على الشوارع الشريانية، تم الاستنتاج بأنّ بعض هذه الإجراءات يمكن أن تطبّق على الشوارع الفلسطينية. وبالنسبة لشارع رفيديا- ياسرعرفات وشارع فيصل-حيفا موضوع الدراسة، فان بعض الإجراءات قابلة للتطبيق بسهولة، وبعضها آلاخر يمكن أن يطبّق بعمل بعض التحسينات، وهناك إجراءات أخرى لا يمكن أن تطبّق لأنها تحتاج إلى مساحات واسعة. وحتى يتم الاستفادة من هذه الدراسة بالشكل المطلوب، يجب أن يتم تبني التوصيات الواردة فيها من قبل الجهات المختصة.