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Evaluation of Traffic Operation at Selected Zone of Roadway Network in Kerbala City

A thesis Submitted to the Department of Civil Engineering, College of Engineering University of Kerbala in Partial Fulfillment of the Requirements for the Degree of Master of Science in Civil Engineering (Infrastructure Engineering)

by

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بسم الله الرحمن الرحيم

﴿ يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنْكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ ﴾

صدق الله العلي العظيم

الايه 11 من سورة المجادله

DEDICATION

To my family

ABSTRACT

Under local traffic conditions, traffic system is difficult to be analyzed and optimized because it is a complex system with random and dynamic in nature. Holy Karbala is an important city in Iraq because of its place in the Islamic world. The increased number of pilgrims, the rapid growth of population, and the increased number of car ownership, in addition to the flourish of shopping centers, cafes and others activities, cause an increase in number of daily trips on most streets and intersections especially during peak hours.

This study deals with evaluation of traffic performance at selected zone in roadway network. This was done through the evaluation of intersections performance and urban streets performance at selected network, this is followed by suggestions of some improvement proposals, which varied from geometric improvement, to change intersection type completely.

The study area composed of five intersections associated with various urban streets. To carry out the above objective, traffic data is collected at the network in Karbala city. The video recording technique from Karbala police was used to collect the traffic data for (Sayed Jawda intersection, Al-Safeena roundabout, and Police central Al-Hussein neighborhood intersection). These data are abstracted from video films by hand calculations. While, the traffic data for (Saif Saad and Stadium intersection) were collected manually. Three program used in this study include (VISSIM10, SIDRA 7, HCS+7FT). VISSIM software was used for the evaluation of the signalized, unsignalized intersections, and roundabouts. SIDRA INTERSECTION software was used for the evaluation and analysis of unsignalized intersections, signalized intersections and roundabouts. Highway Capacity Software (HCS+7FT) was used for the evaluation and analysis of signalized and unsignalized intersections and urban streets.

The output showed that Sayed Jawda, Police Central and Saif Saad intersections have warrants of traffic signal. The most of intersections as well as street segments operate with level of service (LOS F).

Some improvements were suggested to get an acceptable LOS. These proposal improvements varied from widening and adding a new lane for each approach for Al- Safeena roundabout to pavement remarking in addition to adding a new lane for (north and east) approach for Sayed Jawda intersection. The intersections (Police Central, Saif Saad and the Stadium) were improved by pavement widening.

The urban streets have been evaluated based on the new delay value after the improvements for the through movements, then improved to the acceptable level of service.

ACKNOWLEDGMENT

First and foremost, all thanks to Allah for giving me the strength, determination, and courage to implement this goal. I would like to express deep gratitude to my supervisors Prof. Dr. Hussein Ali Ewadh and *Dr. Raid R. A. Almuhanna* for their keen encouragement and significant suggestions, which improved this work. So, I feel deeply indebted and grateful to them.

Thanks also are due to the head and staff of Department of Civil Engineering and all those who stood with me to finish this work. Thanks are presented to my husband, my father, my mother my brothers and my sisters for their care, patience and encouragement throughout the research period. Finally, I would like to express my love and appreciation to everyone who encouraged me, no word can express my gratitude to them.

Contacts

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ABBREVIATIONS/ACRONYMS

A.M	Ante Merdiem
AASHTO	American Association of State Highway and Transportation Officials.
C	Cycle length
c	Capacity (Veh/Hr)
Co	optimum cycle length
FFS	Free Flow Speed
FHWA	Federal Highway Administration
g	Effective Green Time (Sec)
G	Green Time (Sec)
g/c	Green Ratio
GIS	Geographic Information System
HCM	Highway Capacity Manual
HCS	Highway Capacity Software
ID	Island Diameter (M)
LOS	Level Of Service
NACTO	National Associations of City Transportation Officials
NCHRP	National Cooperative Highway Research Program
P.M.	Post Merdiem
PCU	Passenger Car Unit
tc	Critical Gap
tf	Move-Up or Follow-Up Time
V/C	Volume to Capacity Ratio
Wc	Circulating Width (m)
We	Entry Width (m)

Chapter One
Introduction

Chapter One
Introduction

1.1 General

The transportation system is the engine of the economic activities in all urban communities all over the world, and consequently sustains livelihood of the people living in them. Typical urban transportation facilities include railways, waterways, airways and roads. Among these, the big proportion consists of roads. Logically, most planning and research efforts have focused on the road system. In recent times, many cities have seen a large increase in road traffic and transport demand, which has consequently lead to deterioration in capacity and inefficient performance of traffic systems (Chiguma, 2007).

The reason of transportation system is to give an instrument for the exchange of deliver people, goods, information, and support financial improvement for society. Transportation gives the way to go to the reasons for business, personal fulfillment or investigation and necessary for human activities, such as, business, recreation, and protection (Hoel, etal., 2011).

Global cities face rising traffic congestion. This situation is getting worse and becoming a major concern of the public. Traffic congestion is a condition of traffic delay, because the number of vehicles using a road exceeds the operational capacity of the network to handle (Boamah, 2010).

One of the negative effects of congestions is the increase in large amounts of fuel consumption that affects from financial terms on the car's owner and from productivity terms of the state that reflectes the economy in those areas. In addition, it contributes to the air pollution, which has a harmful effect on the quality of life, and reduces the investment attractiveness in the city by some global investors (Warid, 2004).

1.2 Statement of the Problem

The networks of urban roads suffer from many problems such as: low level of service, long increase in the time of travel, high congestion, low speed and increase accidents and mismanagement of the transport networks as a whole. Therefore, most traffic activities still deal with individual cases that get without technical and comprehensive approach to transport.

Locally, these problems are keep continue and it may be worsening in the future because of the rapid growth of the number of vehicles owner ship in Karbala city. Sub-standard geometric design and poor road planning of most of the intersections inside the selected network have a significant effect on traffic flow and traffic congestion. Therefore, it is necessary to evaluate and improve the traffic performance for a suitable traffic operation, and to give a clear view to the planners and traffic engineers who involved in the design and operation of traffic.

1.3 The Object of the Study

The primary objectives for the study are the following

1. Determinating the LOS for the intersections and segment street for selected zone in Karbala city by using HCS+7FT (Highway Capacity software), SIDRA intersection program, and VISSIM 10.
2. Propose engineering and traffic solutions to reduce the congestion in the specified area.
3. Evaluation of the level of service for proposal suggested in this study. Selecting the best proposal for intersections in which that gives the best level of service.

1.4 Structure of the Thesis

The thesis consists of five chapters including the present one: -

1. The first chapter deals with the introduction with a brief idea, Statement of the Problem, and the objective of this study.
2. Chapter two reviews the literature which is related to previous works. A description of urban streets, intersections, roundabouts and the selected computer programs SIDRA INTERSECTION 7, VISSIM 10, HCS+7FT were included in this chapter.
3. Chapter three illustrates the study area and the data collection, statistical data and the abstraction to be used for the three selected software.
4. Chapter four presents results analysis, discussion, and improvement strategies.
5. Chapter five contains conclusions, recommendations, and suggestions for further research.

Chapter Two

LITERATURE REVIEW

Chapter Two
Literature Review

2.1 General

This chapter displays the literature in several areas which is related to previous works. It also describes urban streets, intersections, and roundabouts. Furthermore, the selected computer programs SIDRA 7, VISSIM 10, HCS+7FT (Highway Capacity Software).

2.2 Urban Street

The urban street system is the major part of the cities. It has many functions including traffic, street landscape, free-barrier route for accessible entrances, and road/street signs, etc. Urban street systems play an important ecological and landscape function in cities. Especially street landscape, free barrier accessibilities and street signs have received increasing attention over the past decade as a valid option for establishing healthy sustainable urban modernization (Qi, et. al., 2011).

Urban arterials carry large traffic volumes within and through urban areas. The principal objective for an urban arterial should be mobility with limited or restricted service to local development. Urban arterials are capable of providing some access to abutting property. Such access service should, however, be only incidental to the arterial’s primary function of serving major traffic movements (AASHTO, 2004).

Streets are critical arteries for transporting goods and people, but they are also the places where we live, work, and play and interact. The design and management of an urban street must reflect and accommodate these diverse and competing uses. The layout and operation of streets can prioritize and enhance particular uses for the benefit of all (NACTO, 2012).

The hierarchy for the road transportation facilities, urban streets (including collectors and arterials) are positioned between the local streets and the multi-lanes suburban and the rural highways. This differences are determined chiefly by control conditions, street functions, and the intensity and pattern of the roadside developments (TRB, 2005).

The degree of mobility provided by urban street is assessed in terms of travel speed for the through traffic stream. This speed is affected by three factors according to highway capacity manual (TRB, 2005) as follows:

1. The street environment includes the geometric characteristics of the facility, the character of roadside activity, and adjacent land uses.
2. The interaction among vehicles is determined by traffic density, the proportion of trucks and buses, and turning movements
3. Traffic control (including signals and signs) forces a portion of all vehicles to slow or stop. As a result, this factors also influence the quality nature of service.

All parameter of urban street mentioned in HCM.

2.2.1 Urban Street Class

Urban street classification system is somewhat different from that used by the American Association of State Highway and Transportation Officials (AASHTO). The AASHTO classified the urban street class functionally into principal arterial and minor arterial. These classifications are based on mileage, travel volume, and features of the service which the urban streets are meant to provide (AASHTO, 2004).

1. Principal arterial that serves the main through direction movements between substantial centers of activities in a metropolitan zone and an important part of trips that enter and coming out the area. In smaller cities (population under 50,000), its significance derived from the service provided to traffic going through the urban area. It also links freeways with major traffic generators. Service to abutting land is subordinate to the function of Moving through traffic.

2. Minor arterials that links and enhance the principal arterial system. The system of minor arterials does trips of moderate length and distributes travel to geographical areas smaller than those served by the principal arterial. Though its major function is traffic mobility, it carries out this function at a lower grade or level and places more focus on the area access than does the principal arterial. The urban streets are furthermore classified by its design.

A second classification step was added by the Highway Capacity Manual (HCM 2000) to calculate the proper and right design categories for the arterial streets. The design categories depend on the signal density, access point density/driveway, speed limit, and other design characteristics. The design component is separated into four categories: high-speed, suburban, intermediate, and urban.

1. High-speed design represents an urban street with a very low driveway/access-point density, separate left-turn lanes, and no parking. It may be multilane divided or undivided or a two-lane facility with shoulders. Signals are infrequent and spaced at long distances. Roadside development is low density. The speed limit is typically 75 to 90 km/h.
2. Suburban design illustrates a street with an access-point density/low driveway, separated the left-turn lanes, and prohibit parking. It could be multi-lanes divided or un-divided or a two-lane facility with shoulders. The roadside development is low to medium density. Signals are spaced for good progressive movement (up to three signals per kilometer). The speed limits are generally 65 to 75 km/h.
3. Intermediate design illustrates an urban street with a moderate driveway/access-point density. It has a higher intensity of roadside development than the normal suburban design and has two to six signals per kilometer. It could be a two-lane, a multi-lane divided or an un-divided one-way. Speed limits are typically 50-to 65 km/h.

4. Urban design illustrates an urban street with a high driveway/access point density. The parking is usually permitted. It frequently is two-way facility with two or more lanes or an undivided one-way. It generally possesses four to eight signals per kilometer. In general, there are some pedestrian interference is present and few separate left-turn lanes. Speed limits range from 40 to 55 km/h. The roadside development is dense with commercial uses

2.2.2 Flow Characteristics

The vehicles speed on the urban streets is affected by three primary factors: interaction among vehicles, street environments, and traffic control, which are also influence service quality. The street environments include the geometric countenance of the facility, the countenance of the roadside actions and actives, and adjacent area uses. So, the environmental condition reflects the width and number of lanes, access point density/driveway, type of median, empty spacing between the signalized intersections, presence of parking, scale of pedestrian activity, and speed limitations. The interaction among vehicles can be determined by density of traffic, the ratio of buses and trucks, and turning movements. This interaction influences the vehicles operation at the intersections and, to a less range, between the signals. Traffic control (including signs and signals) impose a part of all vehicles for stopping or decelerating. The speed changes and delays caused by the traffic control devices decrease the vehicle speeds; however, such controls are needed to build up right-of-way (HCM, 2000).

2.2.2.1 Free Flow Speed

The desired average speed adopted by the driver when not restricted by other vehicles in the stream under given set of road conditions is called the free flow speed (HCM, 2010). The existence of traffic signals or other traffic control devices makes the traffic flow on urban street interrupted. Therefore, free-flow speed on urban streets depends on two principal factors: running time over urban street segments, and control delay at signalized intersections (TRB 2010).

Free flow speed represents the average running speed of automobiles traveling along a segment when volume condition is low and not delayed by traffic control devices or other vehicles. It reflects the effect of the street environment on driver speed choice element s of street environment that influence this choice under free flow condition include speed limit, access point density, lane width median type, curb presence and segment length (TRB, 2000).

2.2.2.2 Running Time

The total time spent by the driver of a vehicle on a segment of an urban road is divided into two main parts, which are running time and control delay at signalized intersections. Classification of street, segment length of street, and free flow speed of street are a very important to compute the running time for a segment. Arterial running time can be obtained through time delay, intersections, travel time studies and information from local data on operating times.

2.2.2.3 Travel Speed

Travel time is defined as “the time necessary to traverse a route between any two points of interest”. Travel time can be directly measured by traversing the route(s) that connects any two or more points of interest. Travel time is composed of running time, or time in which the mode of transport is in motion, and stopped delay time, or time in which the mode of transport is stopped (or moving sufficiently slow as to be stopped, i.e., typically, less than 8 mph, or 5 mph) (FHWA, 1998).

The vehicle speeds reduce below the average running speed when traffic control is existent on a street segment. The speed characteristic that captures the effect of traffic control is the average travel speed. This speed is computed as the length of segment divided by the average travel time. The travel time is the time taken to traverse the street segment, inclusive of any stop-time delay (TRB, 2000).

2.2.2.4 Level of Service

According to HCM, (2000) level of service is a quality measure describing the operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience. Some factors influence level of service for the urban streets like number of signals a segment have per kilometer and control delay at intersections. Some other influencing factors such as poor progression, increasing traffic flow, and inappropriate signal timing can reduce the LOS significantly. Urban streets having more than one signal per kilometer means streets with medium to high signal densities are more vulnerable to the above factors, and may lead to observation of poor LOS even before notable problems occur.

Level of service in urban area or controlled sections is totally different from that in rural areas or uncontrolled areas. The level of service in arterial roads within urban areas is affected by flow conditions, average overall travel speed, load-factor at intersections, peak-hour factor, and service volume capacity ratio. (Robin, etal, 2016).

HCM describes six LOS based on different operating conditions. Six level of service described in HCM are from LOS. (A) to LOS (F), road with LOS A signifies the best operating conditions among all level of services and road having LOS F is the worst of all defined LOS.

LOS for Automobile Urban Street shown in Table (2-1).

Table (2-1) LOS for Automobile Urban Street (HCM, 2010).

Travel Speed as a Percentage of Base Free Flow Speed (%)	LOS by Critical Volume to Capacity Ratio
>85	A
>67-85	B
>50-67	C
>40-50	D
>30-40	E
<=30	F

2.3 Intersection

An area shared by two or more roads is called intersection. The goal that led efficiently to the design of the intersection is to turn the direction of the cars in to any different directions to reach the intended destination. Traffic intersection is a complex location because the moving vehicles in different directions try to occupy the space at the same time in addition, the pedestrians try to look at the same area to cross. Therefore, drivers have to make split second decision at an intersection by considering the route, intersection geometry, speed and direction of other vehicles etc. An intersection is very critical so any small error in judgment can cause severe accidents. It also causes delay and it depends on the type, geometry, and control. The performance of the intersections up on the overall traffic. It also affects the capacity of the road. Therefore, both from the accident perspective and the capacity perspective, the study of intersections very is important for the traffic engineers especially in the case of urban scenario (Tom, 2007).

An intersection is any place where different users mix and compete for time within the same space. Intersections take many forms and shapes, ranging from complex junctions to driveways to the meeting of two paths. They are often defined by their layout and operations: traffic signals, roundabouts, T-junctions. Simplicity, compactness, low speed and eye contact are favored in intersection design (NACTO, 2012).

2.4 Signalized Intersection

The Traffic signal is considered as important device to control the traffic of vehicles and pedestrians when fully used properly. It allocates the right-of-way to the different traffic movements, and therefore deeply influences on the traffic flow.

The traffic control signal that actually located, operated, designed, and maintained will have many advantages and as following (FHWA, 2009):

1. The conflicting that occurs between the movement is eliminated.

2. The capacity of traffic that an intersection handling is Increases if:

A-The physical layout is correct and the control measure is recorded.

B -Reviewing and updating of signal operational parameters (if necessary) on a regular base (the engineering judgment decides that the significant traffic flow and/or land use changes have happened) to increase the capability of the traffic control signals to satisfy the demands of the current traffic.

3. Minimize the severity and frequency of specific types of crashes, specially the right-angle collision.

4. Using coordinated signals provides continuous or nearly continuous movements of the traffic at a specified speed along a given way under favorable conditions.

5. It is used to interrupt the heavy traffic at periods to permit other traffic, pedestrians or vehicles to cross.

Traffic control signals, even when justified by traffic and roadway conditions, can be ill-designed, ineffectively placed, improperly operated, or poorly maintained. Improper or unjustified traffic control signals may result in one or more of the following disadvantages (FHWA, 2009):

1. Excessive delay.
2. Excessive disobedience of the signal indications.
3. Increase the use of less adequate routes as road users attempt to avoid the traffic control signals.
4. The collisions recur greatly (especially rear-end collisions).

Intersection that carries large vehicular volumes cannot be controlled safely and satisfactorily without traffic signals. The installation of power operated traffic signals at an intersection can separate effectively all or most conflicting flow, bringing about a degree of orderliness and safety that would otherwise be impossible at higher traffic volumes. (Warid, 2004).

2.4.1 Traffic Signal Warrant

A traffic signal is a device which contains one or more lights to warn of an impending hazard or right-of-way change. Traffic signals, are commonly called stoplights, stop-and-go lights, semaphores, or flashers. The largest percentage of traffic signals are intersection traffic control signals. Most signals are installed to respond to high vehicle and/or pedestrian volumes, or a high number of correctable crashes. A justified signal, properly designed, installed, operated and maintained, is an asset to the traveling public. A traffic signal that is unjustified, poorly designed, installed, operated, or maintained may decrease the safety or the efficiency of an intersection. The decision to install a traffic signal should be made after an engineering study is performed for the intersection. The engineering study provides data for warrant analysis. If a signal for the intersection is warranted and justified, a design using the latest standards will result in a safe operation. The signal is installed according to the plans and special provisions. After a signal is installed, it must be maintained to ensure safe operation (TEM, 2007).

The Manual of Uniform Traffic Control Device (MUTCD) defines the traffic control signal as any highway traffic signal by which traffic is alternately directed to stop and permit to proceed (FHWA, 2009).

Chapter 4 in MUTCD presents the traffic signal warrant. These warrants specify the minimum standards that are most likely to be considered to install traffic signal.

2.5 Interchange (Grade Separate Intersection)

The interchange can be defined as a bridge when using it, the crossing conflict is eliminated by vertical separation of roadway in space. The another name for interchange is grade separation.

In grade separation intersection the delay and hazards are less than that occur when grade separated intersections is used. Route transfer at grade separations is accommodated by interchange facilities consisting of ramps. Interchange ramps are classified as direct, semi-direct and indirect. Interchanges are described by the patterns of the various turning roadways or ramps. The interchange configurations are designed in such a way to accommodate economically the traffic requirements of flow, operation on the crossing facilities, physical requirements of the topography, adjoining land use, type of controls, right of-way and direction of movements (Tom ,2014)

Intersections at grade can be eliminated by the use of grade-separation structures that permit the cross flow of traffic at different levels without interruption. The advantage of such separation is the freedom from cross interference with resultant saving of time and increase in safety for traffic movements (Rogers, 2008). Grade separations and interchanges may be warranted (Rogers, 2008):

1. As part of an express highway system designed to carry volumes of traffic.
2. To eliminate bottlenecks.
3. To prevent accidents.
4. Where the topography is such that other types of design are not feasible
5. Where the volumes to be catered for would require the design of an intersection at grade of unreasonable size.
6. Where the road user benefit of reducing delays at an at-grade intersection exceeds the cost of the improvement.

2.6 Saturation Flow Rate

Saturation flow is a mean to measure the performance of the maximum rate of flow of traffic. It is used to design and control the signalized intersection extensively. Saturation flow characterized the number of passenger car units (pcu) in a dense flow of traffic for a specific intersection lane group. In other words, if a signal for approach of intersection remains green for an entire hour and the flow of traffic through this intersection is as dense as could be expected, the saturation flow rate would be the amount of passenger car units that passes through this intersection during that hour" (Bester et.al ,2007).

Saturation flow rate (SFR) is the most important parameter to find the capacity of the intersection and level of service. According to Webster and Cobbe, (1966), the saturation flow rate is the flow which would be obtained if there was a constant queue of vehicles and they were given a 100 percent green time. It is generally expressed in vehicles per hour of green (vphg).

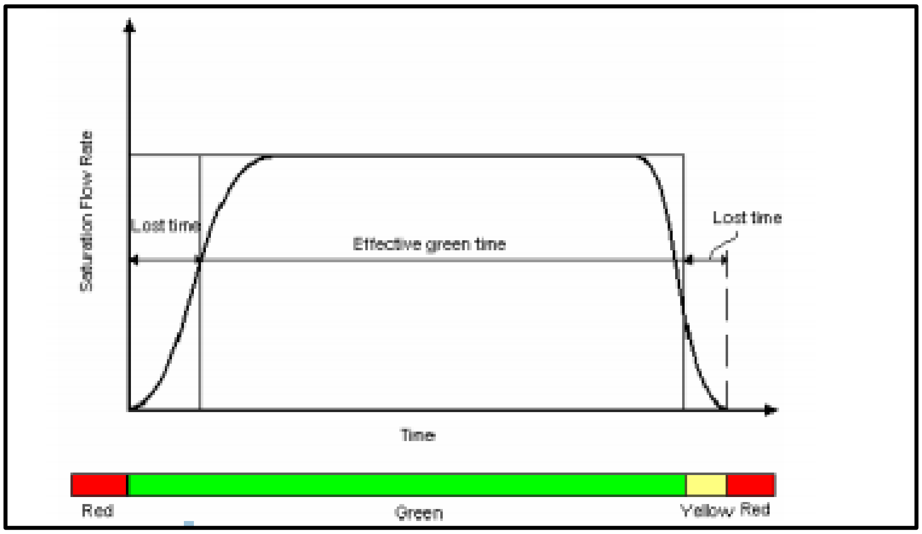


Figure (2-1) Variation with Time of Discharge Rate of Queue in A Fully Saturated Green Period (Webster and Cobbe, 1966).

The conventional graphical representation of the saturation flow is shown in Figure (2-1). The solid line in the figure shows the traditional concept, which assumes after a few seconds following the beginning of the green time, traffic discharges at a constant rate (the saturation flow rate) until the queue is discharged, when a sharp decrease in the flow occurs. The departure rate is lower during the first few seconds, while vehicles accelerate to normal running speed, and after the end of the green interval, as the flow of vehicles declines.

Through decades, the term of saturation flow was changed by different researchers. The Highway Capacity Manual (HCM), (2010) describes the saturation flow rate as the flow, in vehicles per hour per lane, that can be accommodated by the lane assuming that the green phase is always available to the approach. The Canadian Capacity Guide for Signalized Intersections (CCG), (2008) defines saturation flow as the rate of queue discharge from the stop line of an approach lane, expressed in passenger-car units per hour of green (pcu/hr green). Australian Road Research

Board (ARRB), (1981) defines saturation flow as the maximum constant departure rate from the queue during the green period, expressed in through car units per hour (tcu/hr).

2.7 Major Parameters for Evaluating Intersection Operations

Capacity, delay and level of service are the main parameters to evaluate the operation of intersections.

2.7.1 Capacity

Capacity is defined as the maximum number of vehicles and passengers each time unit that the road can take under certain conditions. Capacity is independent of the demand. It expresses the physical number of passengers and vehicles that the road can bear. It depends on several factors, the most important are the engineering design of the road and the traffic situation, so it does not depend on the total number of service required for vehicles. Capacity is expressed in terms of units of some specific thing (car, people, etc.), so it also depends on the traffic composition. In addition, the capacity analysis depends on the environmental conditions. It is a probabilistic measure and it varies with respect to time and position. Hence it is not always possible to completely derive the capacity analytically. In most cases it is obtained from field observations (Tom, 2014).

The capacity at a signalized intersection is given for each lane group and is defined as the maximum range of flow for the subject lane groups that can pass through the intersections under prevailing traffic conditions, signalized conditions, and roadway. Capacity units are given in vehicles per hour (veh/h) but is based on the flow during a peak of 15-minute period (Garber and Hoel, 2009).

Figure (2-2) shows that the average rate of flow which is lower during the first few seconds (while vehicles are accelerating to normal running speed) and also during the amber period (as some vehicles decided to stop and others continue to move on). It is convenient to replace the green and amber periods by an "effective green" period, during which the flow is assumed to take place at the saturation rate, combined with a "lost" time during which no flow takes place.

$$c = s * (g/C) \quad (2\text{-}1)$$

where:

c: Capacity of lane group (vph)

s: Saturation flow for lane group (vph)

g: Effective green time for lane group, C: Cycle length.

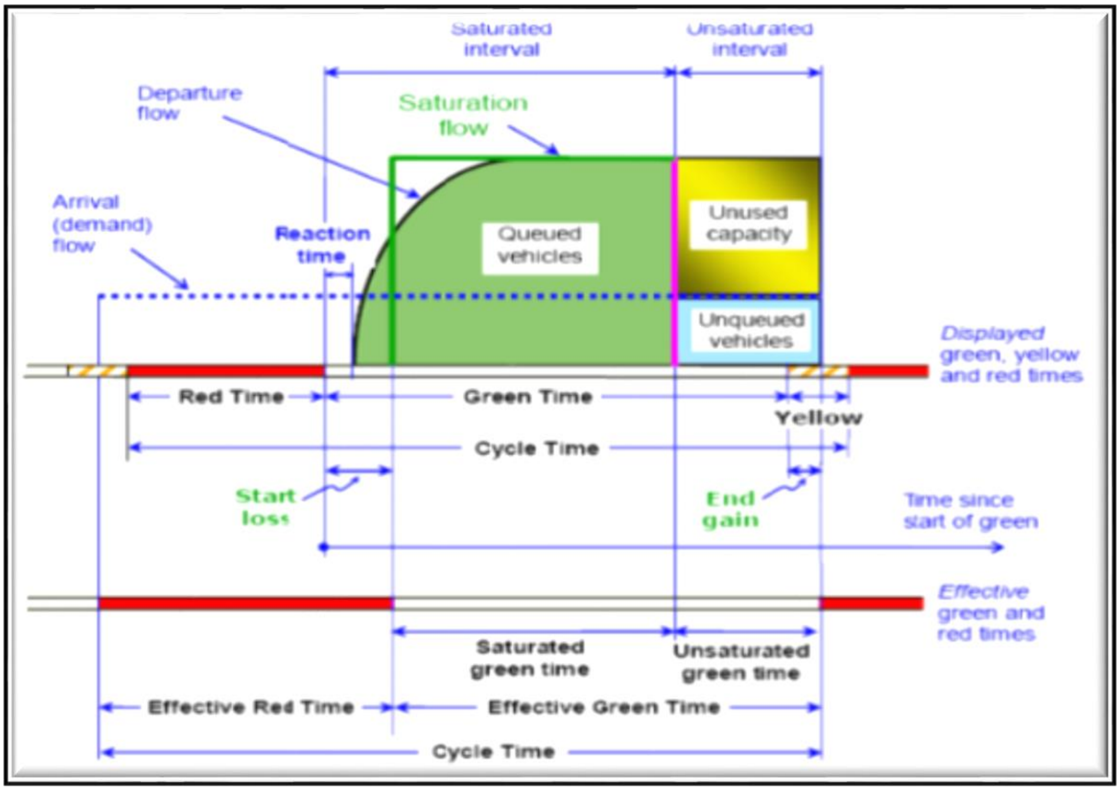


Figure (2-2) The Saturation Flow and the Parameters of Related Signal Timing (Akcelik, 2009 b)

2.7.2 Level of Service and Control Delay

In Highway Capacity Manual (HCM, 2010), Level of Service (LOS) is defined as "a quantitative stratification of a performance measure or measures that represent quality of service". The performance measure that used to evaluate LOS for signalized intersection is an average control delay per vehicle. When control delay increases the Level of Service worsens. The LOS for a signalized intersection are shown in Table (2-2).

Control delay is used to define the level of service at signalized intersections, since delay not only indicates the amount of lost travel time and fuel consumption but it is also a measure of the frustration and discomfort of motorists. Control or signal delay, which is that portion of total delay that is attributed to the control facility, is computed to define the level of service at the signalized intersection. This includes the delay due to the initial deceleration, queue move up time, final acceleration and stopped time. Reasonable levels of service can therefore be obtained for short cycle lengths, even though the (v/c) ratio is as high as 0.9. To the extent that signal coordination reduces delay, different levels of service may also be obtained for the same (v/c) ratio when the effect of signal coordination changes (Garber and Hoel, 2009).

Table (2-2) LOS for Signalized Intersection **(**HCM, 2010).

Control delay(s/veh)	**LOS by volume to capacity ratio**	
	≤1.0	>1.0
<10	A	F
>10-20	B	F
>20-35	C	F
>35-55	D	F
>55-80	E	F
>80	F	F

Highway Capacity Manual (HCM) 2010 suggested the method in order to determine control delay, which is based on direct observation of vehicle in queue counts at the intersection. The delay that experienced by all vehicles that arrive during the analysis period is represents as an average control delay as shown in Equation (2-3)

$$d = d1 + d2 + d3 \quad (2\text{-}3)$$

where d = control delay (s/vet), d1 = uniform delay (s/vet); d2 = incremental delay (s/vet), and d3 = initial queue delay (s/veh). These delay components are discussed briefly below, while their formulae are presented in Table (2-3).

Table (2-3) Delay Component and Variables (HCM, 2010).

Delay Component	Variables
$d_1 = \frac{0.5C(1-\frac{g}{c})^2}{1-[\min(1,X)g/C]}$ (2-4)	C=cycle length (second) g=effective green time for lane group (second) X=v/c ratio for lane group
$d_2 = 900T\left[(X-1) + \sqrt[2]{(X-1)^2 + \frac{8KIX}{cT}}\right]$ (2-5)	T=duration of analysis period (hour), K=delay adjustment factor that is dependent on signal controller mode, I=upstream filtering/metering adjustment factor, C=lane group capacity (vet/hr.), X=v/c ratio for lane group.
$d_3 = \frac{3600}{vT}(t_A \frac{Q_b+Q_e-Q_{eo}}{2} + \frac{{Q_e}^2+{Q_{eo}}^2}{2C_e} - \frac{{Q_b}^2}{2C_e})$ (2-6) $Q_e = Q_b + t_A(v - C_A)$ $Q_{eo} = T(v - C_A)$ $t_A = T$ $Q_{eo} = 0.0$ $t_A = Q_b/(C_A - v) \leq T$	T=duration of analysis period (hour) V=demand flow rate (veh/h) t_A=adjustment duration of un-met demand in the analysis period (hour). C_A=average lane group capacity (veh/h), Q_b=initial queue at the start of the analysis period Q_e= initial queue at the end of the analysis period Q_{eo}= initial queue at the end of the analysis period when v>C_A and Q_b = 0.0

2.8 Roundabout

Roundabout is an intersection with a generally circular shape, characterized by yield on entry and circulation around a central island. Roundabouts have been used successfully throughout the world and are being used increasingly in the United states, especially since 1990. (HCM, 2000).

Modern roundabouts are a type of intersection that characterized by a generally circular shape, yield control on entry, and geometric features that create a low-speed environment. Modern roundabouts have been constructed safety, operational, and other benefits when compared to other types of intersections. On projects that construct new or improved intersections, the modern roundabout should be examined as an alternative. (FHWA, 2000).

Modern roundabouts are near-circular intersections at grade. They are an effective intersection type with fewer conflict points and lower speeds, and they provide easier decision making than other intersection types. They also require less maintenance than traffic signals. Well-designed roundabouts have been found to reduce crashes (especially fatal and severe injury collisions), traffic delays, fuel consumption, and air pollution. They also have a traffic-calming effect by reducing the vehicles speeds by using a geometric design rather than relying solely on traffic control devices (WISDOT, 2017). Table (2-7) show the advantage and disadvantage of roundabout.

Table (2-7) Advantage and Disadvantage of Roundabouts (UDOT, 2005).

Category	Advantage	Disadvantage
Safety	• It has a reduced number of conflict points compared to uncontrolled intersections. • Slower operational speeds yield less severe and fewer accidents. • Slower through speeds because of deflection reduce accidents on legs.	• Since roundabouts are unfamiliar to average driver, there is likely to be an initial period where accidents increase. • Signalized intersections can prompt control for emergency vehicle, but roundabouts may not be able to.
Capacity	Traffic yields rather than stops, often resulting in the acceptance of smaller gaps. • Roundabouts should give higher capacity/lane than signalized intersections due to the omission of lost time. • Intersections with a high volume of left turns are better handled by a roundabout.	• Where a coordinated signal network can be used, a signalized intersection will increase the overall capacity of the network. • Signals may be preferred at intersections that periodically operate at higher than designed capacities.
Delay	• Overall delay will probably be less than for an equivalent volume signalized intersection (not for higher LOS). • During the off-peak, signalized intersections with no retiming produce unnecessary delays to stopped traffic when gaps on the other flow are available.	• Drivers may not like the geometric delays that force them to divert their cars from straight paths. • When queuing develops, entering drivers tend to force into the circulating streams with shorter gaps.

Table (2-7) continued

Category	Advantage	Disadvantage
Cost	• Less right-of-way is required. • Roundabout maintenance includes only landscape, illumination, and occasional sign replacement. • Accident costs are low due to the low number and severity of accidents..	• Roundabout construction costs may be higher than for four-way stop locations. •In some locations, roundabouts may require more illumination, increasing costs.

2.8.1 Capacity of Roundabout

The capacity of a roundabout is defined as the sum of capacities of all entering approaches. The capacity of each entry approach is the maximum rate of vehicles that can reasonably be predicted to enter the roundabout from an approach through a given time under prevailing (roadway) geometric and traffic conditions (Aty and Hosni, 2001). The expression of the "prevailing conditions" is very important when the capacity of roundabout is not constant value, but differs as a functions of traffic flow levels. Modern roundabouts usually operate under the off-side priority rule; in this case, the entry capacity for an approach leg depends on the circulating flow on the roundabout that conflicts with the entry flow, and the geometric elements of the roundabout (FHWA, 2000).

Capacity is the main factor of performance measures such as delay, queue length and stop rate. It represents the service rate (queue clearance rate) in the performance (delay, queue length, stop rate) functions, and therefore is relevant to both under-saturated and oversaturated conditions. Conceptually, this is different from the maximum volume that the intersection can handle which is the practical capacity (based on a target degree of saturation) under increased demand volumes, not the capacity under prevailing conditions (Akcelik, 2005).

2.8.2 Roundabout Delay

It could be defined the roundabouts delay separately for each entry approach. The delay value for any entry approach is composed of two distinct components: geometric delay and queuing. Geometric delay creates from slowing down of vehicles, when crossing the roundabouts. Queuing delay results when the motorists are waiting for a suitable gap in the circulating traffic (Hummody, 2007).

Definition of control delay is given by the HCM 2000 at a time which the drivers spend decelerating to a queue, queuing, waiting for a suitable gap in the circulating flow when at front of the queue, and accelerating out of the queue (TRB, 2005).

There are many types of the delay, however the control delay is an interval of time that the driver spends in queuing and waits for a suitable gap in the circulating flow while at front of the queue. Increasing of control delay exponentially based on the traffic volumes while approaching capacity. As a result, any small changes in the traffic volumes cause an important impact on delay value [Robinson and Rodegerdts, 2001].

Control delay can be considered to be the overall time loss that includes all delays experienced in traveling through an intersection with reference to approach and exit cruise speeds (including all acceleration and deceleration delays, delay due to cruise at a lower speed, and stopped delay). Geometric delay is the delay experienced by a vehicle going through (negotiating) the intersection in the absence of any other vehicles (Akcelik, 2009 b).

Figure (2-3) shows the definition of control delay, geometric delay, stopped delay, and stop-line delay, experienced by the turning vehicle at the intersections, Figure (2-4) shows geometric delay for a left-turn movement. The systems analysis of the roadway networks might contain a geometric delay because of the slower vehicles path required for a turning throughout the intersections (NCHRP, 2010). For example, a speed profile is shown in Figure (2-3) to explain the decreasing of speed that occurs from the geometric delay at a roundabout. Delay estimated by traffic models is usually the average for all vehicles, queued and un-queued. At roundabouts, all un-queued vehicles experience the geometric delay. Un-queued through movements at signals (arriving and departing during the green period) experience zero delay. These are taken into account in the average delay to all vehicles.

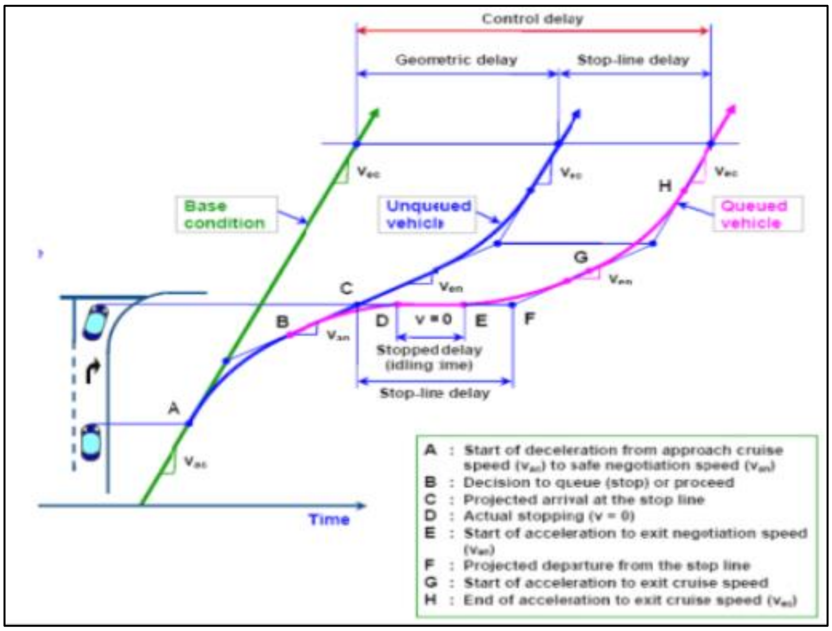


Figure (2-3) Various Delay Definition (Akcelik, 2009 b)

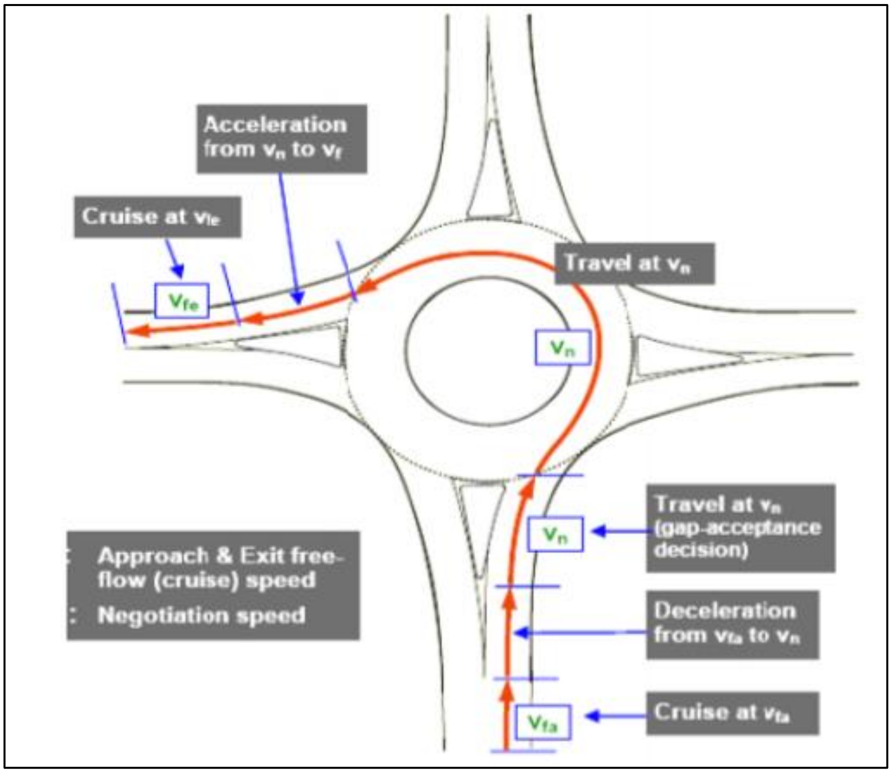


Figure (2-4) Geometric Delay Parameters (Akcelik, 2009 b)

When a comparison is made between a roundabout operation and that of a traffic signal, it is necessary to realize that outside the intersections peak hour (i.e., traffic demand is lower), the roundabout produces less delay to the drivers, while a signal will always give more delay, even under in the extreme low flow. This was confirmed by other researchers too. (Sisiopiku and Oh, 2001) compared the performance of roundabouts with other control types for various traffic conditions using SIDRA package. Such conditions include variations in volume levels, turning volume, number of approach lanes, and lane widths. The results from the analysis show that roundabouts are the best alternative designs for intersections with two lane approaches that carry heavy through and/or left traffic turning volumes. The roundabouts performance is compared well to the performance of signalized intersections with one-lane approaches and heavy traffic volumes. Roundabout capacity is found higher than the capacity of signal controlled intersection with two and three lane approaches for any proportion of left turning traffic volume. This is emphasis also by (Mishra, 2009).

2.8.3 Level of Service of Roundabout

It is a qualitative measure to express the operating conditions of the traffic flow and it is understanding by passengers. The parameters that the criteria of level of service supports for traffic flow are delay, speed, safety, travel time, and comfort. (Taylor, 2012).

The level of service(LOS) criteria for automobile in roundabout are given in table (2-8). LOS F is assigned if the volume-to-capacity ratio of a lane exceeds 1.0 regardless of the control delay. For assessment of LOS at an approach and intersection levels, LOS is based solely on control delay.

The level of service at a roundabout is determined by calculating or measuring the control delay of each movement on the minor street. As a result of different conditions and driver's perception, level of service is different at the signalized and unsignalized intersections (HCM,2000).

Table (2-8) LOS for Roundabout **(**HCM, 2010**).**

Control Delay (s/veh)	LOS by Volume to Capacity Ratio	
	$v/c \leq 1.0$	$v/c > 1.0$
0-10	A	F
>10-15	B	F
>15-25	C	F
>25-35	D	F
>35-50	E	F
>50	F	F

2.9 Traffic Analysis Tools

Understanding the consequences of a highway or traffic operations improvement before project implementation is essential to traffic engineers and planners. Decision makers are hesitant to invest in highway projects that promise to improve safety and reduce congestion without some evidence that these promises are realizable.

Experimenting with the transportation system can be costly, dangerous, and impractical. Engineers have been able to avoid such experiments by turning to computer software for a comparatively low-cost method of analyzing transportation projects. Traffic software has been developed for applications at every level of planning and traffic analysis. Depending on the objectives of a given study, any of a variety of tools may be appropriate. In some cases, one tool might be capable of a particular analysis, but not as well suited as another that has been designed especially for that purpose. Traffic software can be divided to analytical model and simulation models. Analytical model can be defined by HCM (TRB, 2005) as a model that relates system components using theoretical considerations tempered, validated, and calibrated by field data. And simulation model as a computer program that uses mathematical models to conduct experiments with traffic events on a transportation facility or system over extended periods of time.

Each model can be classified according to different basis. They can be classified according to Abu Olba, (2007), Turley, (2007):

- Typical applications to transportation planning, transportation design, transportation safety, or traffic operation.
- The level of aggregation to microscopic, mesoscopic and macroscopic. A fourth level of detail, called nanoscopic has emerged.

Traffic simulation models can be also classified according to:

- The uncertainty content as the deterministic or stochastic.
- The manner their systems are updated to continuous or discrete (discrete time and discrete event).
- Objective as descriptive or normative models

Nyong, (2003) compared the delay and LOS results obtained by the analysis of nine intersections by using HCS, VISSIM, SYNCHRO, TRANSYT-7F and CORSIM in term of their capability for corridor optimization. The conclusion was that software had the capability of simulation and/or optimization in actuated intersections even though the methodology and basic assumptions are not equal with each other.

2-10 Traffic Improvement Studies

The overviews of traffic improvement studies use computer program tools and experimental studies. This section provides a summary of some evaluation comparisons, and experimental studies of the computer programs.

2.10.1 Karbala, Iraq

Al-Haydari, (2011) studied the improvement of traffic flow on arterials, signalized, and un-signalized intersections, by using SIDRA and SYNCHRO programs for performance analysis and evaluation of three signalized intersections (Al-Hakeem, Fatima Bridge, Al-Sayed Jawda) and four roundabouts (Abtal Al-Taf , Al-Mizan, Al-Zahraa) through the development of three statistical models (linear with 95% confidence level, linear with 50% confidence level and polynomial) for the estimation of roundabout delay. Two alternatives were recommended to solve the current and future problems. The first was by Signal Timing Optimization and Coordination and the second by suggestion some geometric improvements.

2.10.2 Samawa, Iraq

Al-Dahhan, (2016) studied the Flow Improvements for Samawa Downtown Transportation Network. The study area composed of ten intersections; one unsignalized intersection, five signalized intersections, and the other four are roundabouts. SYNCHRO 8 software was used for the evaluation and analysis of the signalized and unsignalized intersections. SIDRA INTERSECTION 5.1 software was used for the evaluation and analysis of signalized intersections, unsignalized intersections and roundabouts. HIGHWAY CAPACITY SOFTWARE (HCS) 2010 was used for the evaluation and analysis of urban streets. The results of the evaluation process showed that most of the intersections and street segments operate with level of service (LOS F). Some improvements were suggested to get an acceptable LOS. The intersection (Al-Jesr) has improved by phases sequences and intersection (Al-Warda) by coordination process, while intersection (Al-Ameer) has improved by suggestion an overpass, and intersection (Al bani and Ali Werwar) has improved by pavement widening. Improvement of roundabout (Kathem Hussain Abood) by island shifting with pavement widening, and roundabout (Al-Ghadeer) by widening the entry width. The urban streets have been evaluated based on the new delay value after the improvements for the through movements, where 9 of 15 segments have improved to the acceptable level of service.

2.10.3 Samara, Iraq

HCS traffic program was used for the purpose of traffic analysis process in Improving of traffic capacity for Stadium intersection in Al-Samara city.in this study five proposal suggested to improve this intersection. First proposal included improvement of intersection by adding some parameters to enhance LOS of this proposal. These Parameters were:

1. Adding another left lane for both approaches of Baghdad-Samara Street.

2. Changing phasing time for the intersection and the LOS in this proposal remains F.

Second proposal included improvement of proposal No.1 by adding some parameters to enhance LOS of this proposal such as execution of flyover along Stadium-Al-zwaid Street approaches. The results of the analysis showed that the average delay was (70.9) sec/veh, and the intersection will operate at LOS (E). Third proposal included the execution of flyover along Baghdad-Samara street, and it will operate at LOS (C). Forth proposal included the execution of flyover along Stadium-Alzwaid Street approaches and remove the current access point. This proposal also included adding at least two U-turn in the study area. And LOS improved to D. Fifth proposal included adding at least four U-turn in the study area additional to the forth proposal. This proposal also includes adding two loops one of them on stadium area and the other on Al-zwaid area and LOS improved to (C). It has been concluded that Street (Proposal No.5) wass the best proposal to improve the operation ability of Stadium intersection.

2.10.4 Fallujah, Iraq

Thaer S. Mahmood, Hamid A. Awad (2014) studied the improvement level of service for congested intersection in CBD area of Fallujah city. HCS program was used for the purpose of traffic analysis process. This study included analysis and evaluation of the level of service and traffic operation of Al- Abasse intersection in the CBD of Fallujah city. Al-Abasse intersection is a four-leg intersection type, located in an important location,which connects between main directions. The high traffic volume at this intersection highly effects on the traffic flow especially through traffic. This study improved the LOS of this intersection by suggesting two proposals. First proposal contained changing phasing time for the intersection. The expected average delay at Al-Abasse intersection would be (84.9) sec/veh, which means the intersection, would be in LOS (F).

Second proposal contains improvement of intersection by adding some parameter to enhance LOS of this proposal. These Parameters were:

1. Changing phasing time for the intersection.
2. Execution of flyover along New street – Al– Kamaleat intersection approaches.

It has been concluded that the second proposal was the best to enhanced the LOS of intersection.

2.11 Summary

In this chapter, the urban street and its flow characteristics were reviewed. Furthemore, the intersection (signaliazed intersection and roundabout) and major parameters for evaluating it were presented. The traffic analysis tools explined in this chapter. In addition an overview local traffic studies.

Chapter Three

Methodology and Data Collection

Chapter Three
Methodology and Data Collection

3.1 General

This chapter presents the study area characterization, the methods that applied to collect the data, abstraction, and processing. In addition, the main input data required for the selected software programs are identified.

3-2 Study Area Description

The area of the study consists of one roundabout and four intersections with different urban street. The presence of various entertainment places in addition to the large number of schools, government buildings and shopping centers have increased the traffic and thus increased the traffic congestion ,the study area shown in Figure (3-1). The intersections names, codes, and the type of traffic control are shown in Table (3-1).

Table (3-1) Intersections Names, Codes, and Traffic Control Types.

Intersection code	Intersection name	Control type
1	Al-Safeena	Roundabout .
2	Al- Sayed Jawda Tomb.	Un signalized intersection controlled By traffic police, so it`s considered as fully actuated intersection.
3	Police Central Al-Hussein Neighborhood.	Signalized intersection.
4	Saif Saad intersection.	Signalized intersection with over-pass for through traffic(east-west) and under-pass for left turn traffic in north direction.
5	Al-Stadium intersection.	Interchange

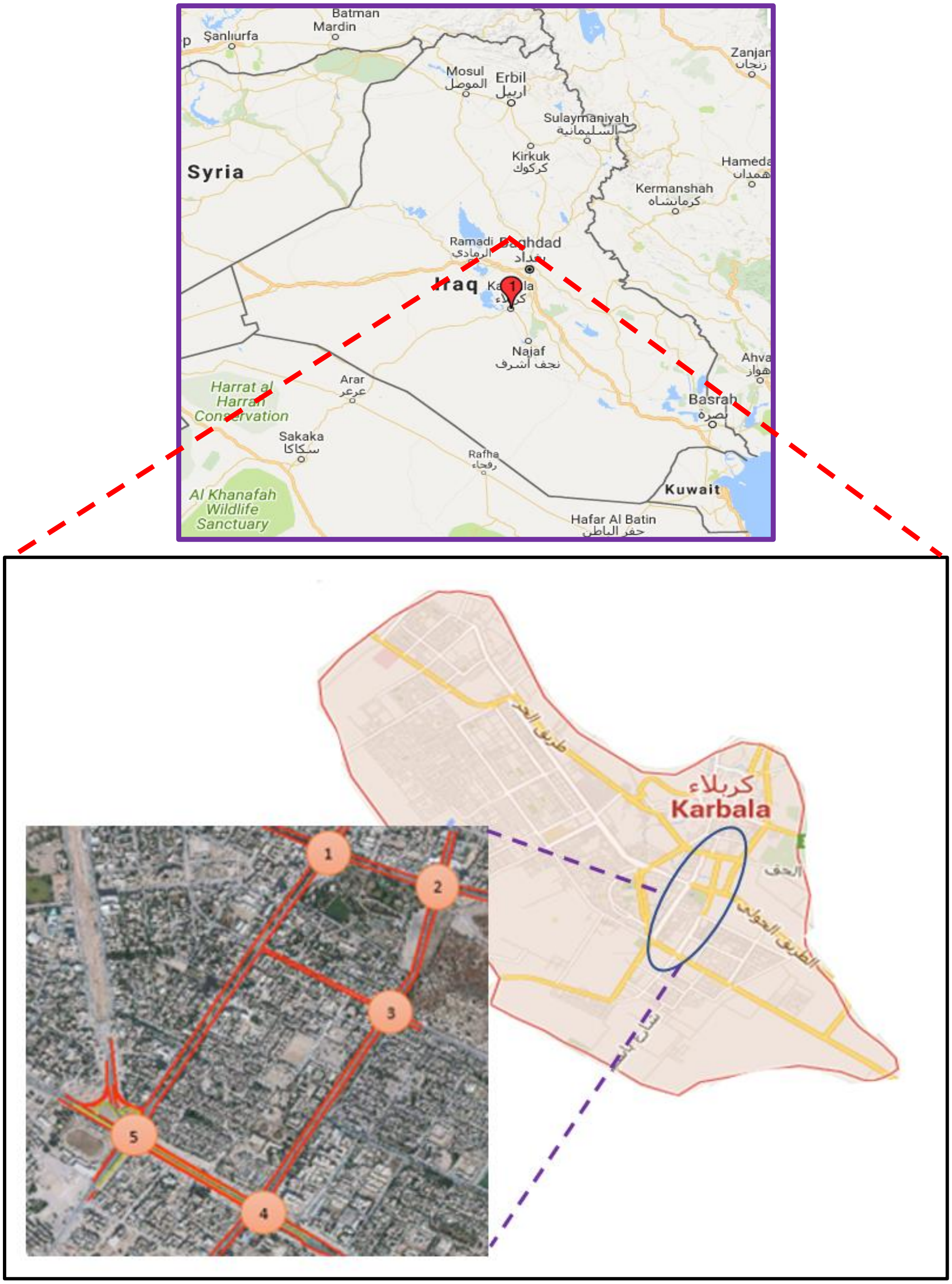


Figure (3-1) The Selected Network in Karbala

1. Al-Safeena Roundabout Intersection: Al-Safeena intersection is a four-leg roundabout intersection. This roundabout suffered from congestion due to the connection between two major streets, Fatima Al-Zahraa Street with Al-Iskan street. Geometric layout is shown in Figure (3-2).

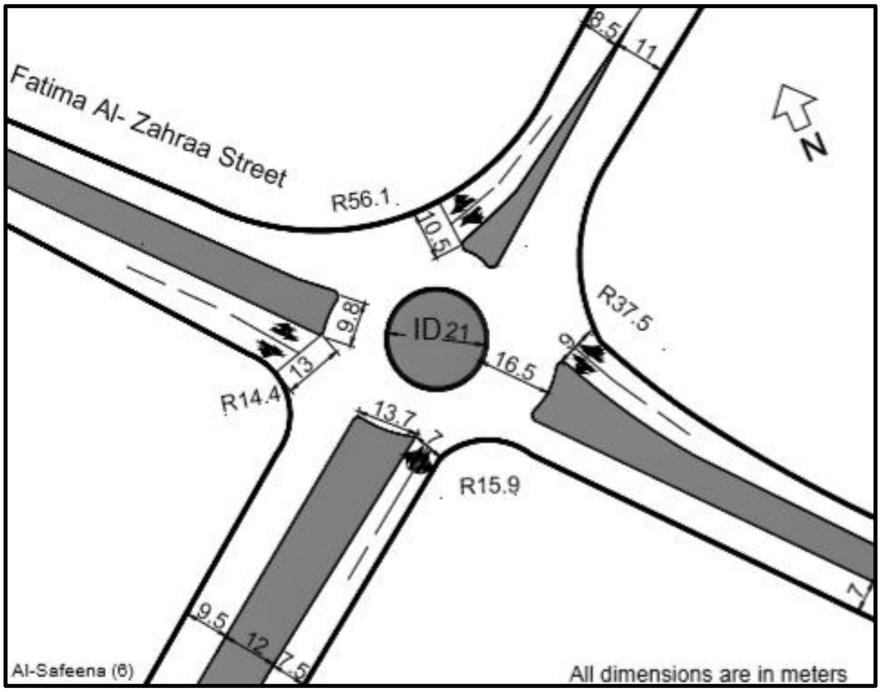


Figure (3-2) Al-Safenaa Roundabout Layout.

2. Sayed Jawda Tomb Intersection: It is a four leg unsignalized intersection. It is controlled by traffic policeman, so it was analyzed as fully actuated signalized intersection. It represents one of the main important intersections in Karbala city which suffered from congestion. The geometric layout is shown in Figure (3-3).
3. Police Central Al-Hussein Neighborhood: It is a four signalized intersection controlled by traffic signal. Geometric layout is shown in Figure (3-4).
4. Saif Saad Intersection: It is a signalized intersection with over-pass for through traffic in dire ion (east-west) and under-pass for left turn traffic in north direction. The layout of Saif Saad Intersection is shown in Figure (3-5)
5. Al-Stadium Neighborhood Intersection: It is an interchange intersection. The layout of Al-stadium intersection shown in Figure (3-6)

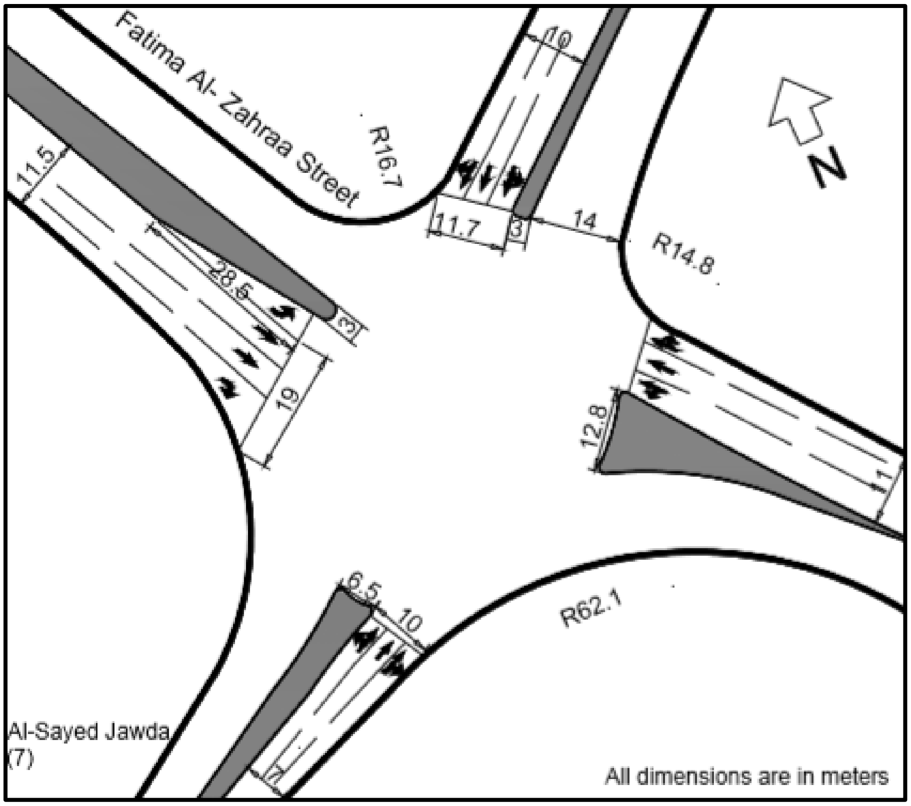


Figure (3-3) Sayed Jawda Intersection Layout

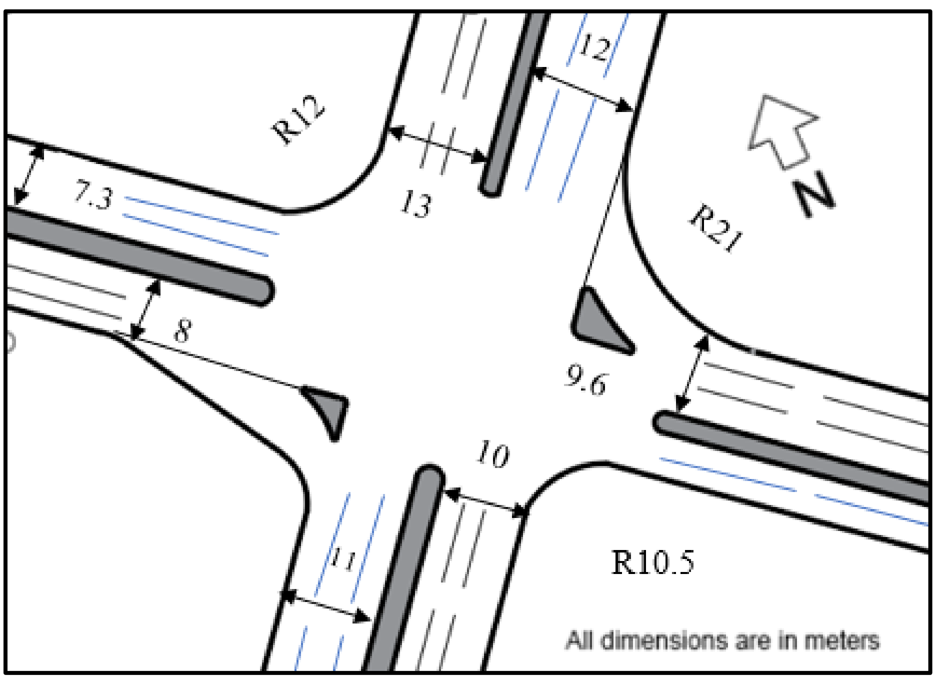


Figure (3-4) Police Central Al-Hussein Neighborhood Layout.

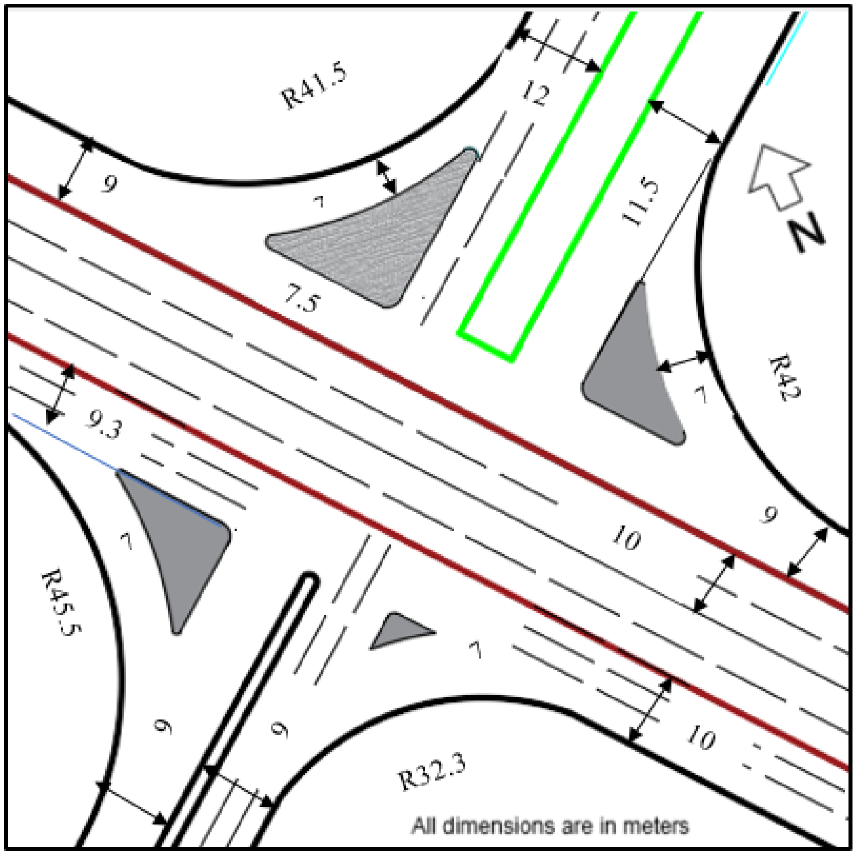


Figure (3-5) Saif Saad Intersection Layout.

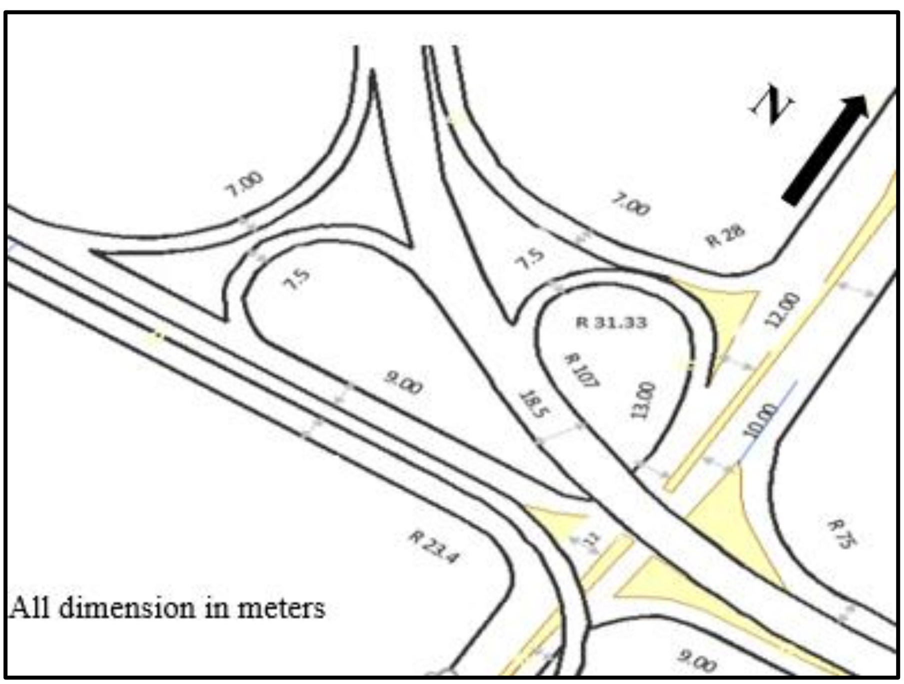


Figure (3-6) Al-stadium Neighborhood Intersection Layout.

3.3 Data Collection Methodology

To obtain the study objectives, it was necessary to follow a designed procedure to collect the required data. The procedure can be summarizing by four steps:

1. Defining the limits of the study area.
2. Determining the peak period for each intersection in the traffic network
3. Identifying the specific input information for the selected programs.
4. 4Checking, coding, and preparing the collected data to be used in the selected software programs.

The data collection stage was aimed to gather all data that would be necessary to show the conditions of traffic flow at the study area. After precise study, the kinds of data to be gathered were chosen to contain:

1. Geometric features (e.g., lane width for each approach, no. of lane per approach, circulating width, entry radius, island diameter, and so on).
2. Data of traffic flow which included; traffic volume of vehicles at peak period, vehicles classification (passenger car, bus, motor cycle), and turning movements.
3. Traffic control information like; the type of signal control that used in the intersection and the type of traffic control, signal cycle length, phases information, existing signs and markings.
4. The land use data and projected changes in land uses.
5. The speed data represented by free-flow speed at each internal link in the network.

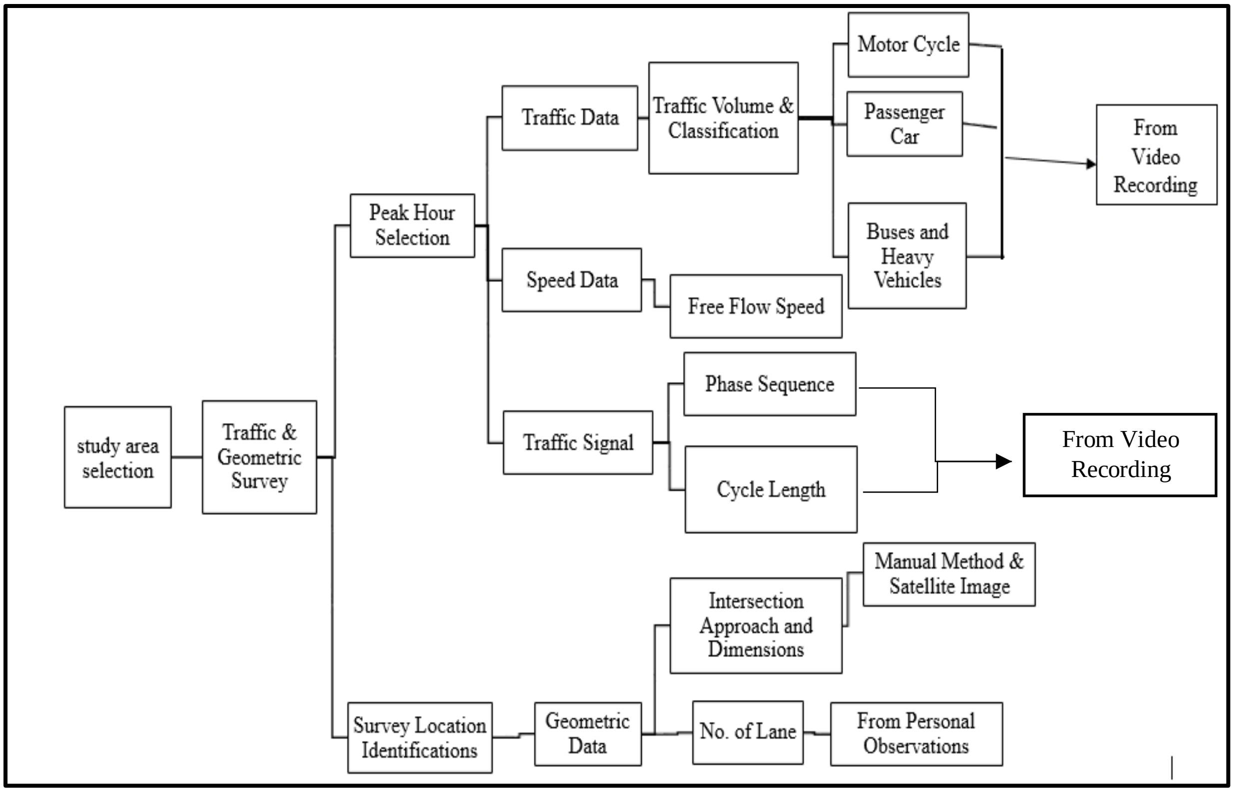


Figure (3-7) Data Collection Methodology

3.4 Geometric Data

GIS tools in map measurements were used to calculate the geometric data like intersection spacing, right of way depending on the available satellite photographs for Karbala city with accuracy of 0.6m, updated to 2016 . Another geometric data such as no. of lines per approach, lane width, median width, splitter island width was calculated by field measurement by using measuring tape .In addition, some of geometric features for roundabouts, which were difficult to be measured at the field like entry and exit radius, island diameter, circulating width, and so on ,were taken from Municipality department of Karbala city. Field survey was used to obtain the geometric features that could not be drawn from satellite image due to the un availability of updated one. Also most of the intersections geometric layouts were unavailable in Karbala municipality. The main geometric features of the selected intersections are shown in Table (3-2).

Table (3-2) The Main Geometric Features of the Selected Intersection.

Code Intersection	Approach	Entry width	No. of entry lane	Exit width	Entry radius	Entry angle	Effective flare length	Circulating width	No. of circulating lane	Splitter island width	Inscribed circle diameter	Central Island diameter
Al-Safeena roundabout	N	8.8	2	14.5	36	30	0	16	2	11	53	21
	S	8.8	2	14.5	36	30	0	16	2	11	53	21
	E	11	2	10	30	30	0	16	2	11.7	53	21
	W	11	2	10	30	30	0	16	2	11.7	53	21
Sayed Jawda intersection	N	11	3	12.8	16	----	----	----	----	4.8	----	----
	S	11	3	12.8	16	----	----	----	----	4.8	----	----
	E	12	4	12.8	24.5	----	----	----	----	7.9	-----	----
	W	12	3	12.8	24.5	----	--	----	----	7.9	-----	----
Saif saad intersection	N	10	3	9.6	41.4	----	----	----	----	----	----	----
	S	10	3	12.5	38	----	----	----	----	----	----	----
	E	9.5	3	9	56.5	----	----	----	----	----	----	----
	W	9	3	9	43.8	----	----	----	----	----	----	----
Police central Al-Hussein neighborhood:	N	13	3	13.8	6.1	----	----	----	----	1.5	----	----
	S	10	3	12.3	5.5	----	----	----	----	1.7	----	----
	E	10	4	10.6	40.1	----	----	----	----	2.3	----	----
	W	7.5	2	9	6.2	----	----	----	----	1.5	----	----
Stadium intersection.	N	13	4	10	107	----	----	----	----	11	----	----
	S	9	3	17.3	30	----	----	----	----	----	----	----
	E	11	3	11.4	68	----	----	----	----	----	----	----
	W	9	3	9	23	----	----	----	----	----	----	----

3.5 Determination of Peak Hour Periods

The most congested period for traffic data collection predicted by different individual observations and survey was achieved in the selected area. Also many personal interviews were done with many concerned people such as; policemen, owners of shops and offices at the study area and different road users. These observation and survey showed that there were two peak periods (A.M.) peak period of (7:30-9:30) and P.M. peak period of (1:30-4:30) for typical weekdays (Sunday, Tuesday, Thursday and Friday). Some of data was collected by a video from the police of Karbala (Sayed Jawda intersection, Al Safeena roundabout, police central al-Hussein neighborhood),which showed that the intersection had morning peak hour (7:30-8:30). In addition, the traffic volume data for stadium and Saif Saad intersections was collected by field measurement, where that data showed that the intersections had morning peak hour (7:30-8:30).

3.6 Method of Data Collection

The traffic flow data for (Sayed Jawda intersection, Al-Safeena roundabout, Police central Al-Hussein neighborhood) were collected by using a video camera from Karbala police. The traffic flow data for (Saif Saad intersection and stadium intersection) were collected by field measurement.

3.7 Traffic Data

The traffic data that have been collected are as follows:

3.7.1 Traffic Volume Data for Intersections

This data includes counting the traffic volumes abstracted from a video recording or by field survey for each approach at the intersections in the selected network, also ,traffic composition (heavy vehicle, passenger car, bus, private car and motorcycle), and the volume of turning movements (right, though, left and U-turn).

The network traffic volume was converted to (PCU) after multiplying every vehicle type by its factor according to (HCM, 2010).

Turning movement traffic volumes were an important part of the analysis of any intersection. To measure turning movement traffic volumes, vehicles had to followed through the intersection from their approach leg to their exit leg. This should be done easily with signalized intersections because of closeness of approach arms (enter and exit), one observer can without much effort collect the turning movement.

3.7.2 Traffic Volume Data for Roundabouts

The estimation of roundabouts turning movement was derived from the gathered traffic volume data as recommended in the Federal Highway Administration (FHWA, 2000). The procedure of FHWA requires the circulating, entering, exiting, and right turns for each leg of the traffic circle. Traffic passing ‘through’ the roundabout and ‘left turning’ vehicles were determined from Equations, (3-1) and (3-2), respectively (FHWA, 2000), (NCHRP, 2010).

Equation (3-1) shows the through movement flow rate for the eastbound approach as a function of the entry flow rate for that approach, the exit flow rate for the opposing approach, the right turn flow rate for the subject approach, the right turn flow rate for the approach on the right, and the circulating flow rate for the approach on the right. Other through movement flow rates can be estimated by using a similar relationship.

$$V_{EB,TH} = V_{EB,entry} + V_{WB,exit} - V_{EB,RT} - V_{NB,RT} - V_{NB,circ} \quad (3\text{-}1)$$

The left turn flow rate for an approach is a function of the entry flow rate, the through flow rate, and the right turn flow rate for that same approach, as shown in Equation (3-2). Again, other movements’ flows were estimated by using similar equations.

$$V_{EB,LT} = V_{EB,entry} - V_{EB,TH} - V_{EB,RT} \quad (3\text{-}2)$$

The accuracy of the aforementioned procedure was tested and tried by Dixon, et. al., (2007**)** and was found to be satisfactory, acceptable, less complicated and similarly calculated as compared with other methods, where they all would require one observer per approach. This numerical method (Algebraic Solution Procedure) was also checked with the method mentioned in **(**NCHRP, 2010**)**. This method named live recording of turning movement patterns using field observation. This only Could be used under low traffic volume conditions, where the entire roundabout is visible from one location. The traffic volume for Al- Safeena , Sayed Jawda, Police Central , Saif Saad and stadium intersections shown in Figures (3-8, 3-9, 3-10, 3-11, and3-12). Equations (3-1),(3-2) not used in calculation the traffic volume in this study.

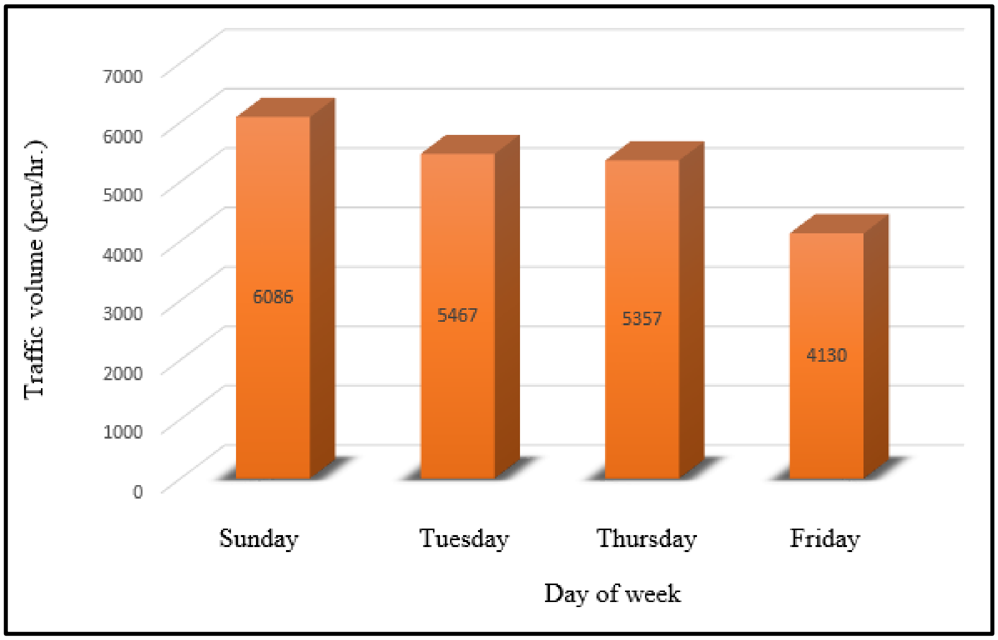
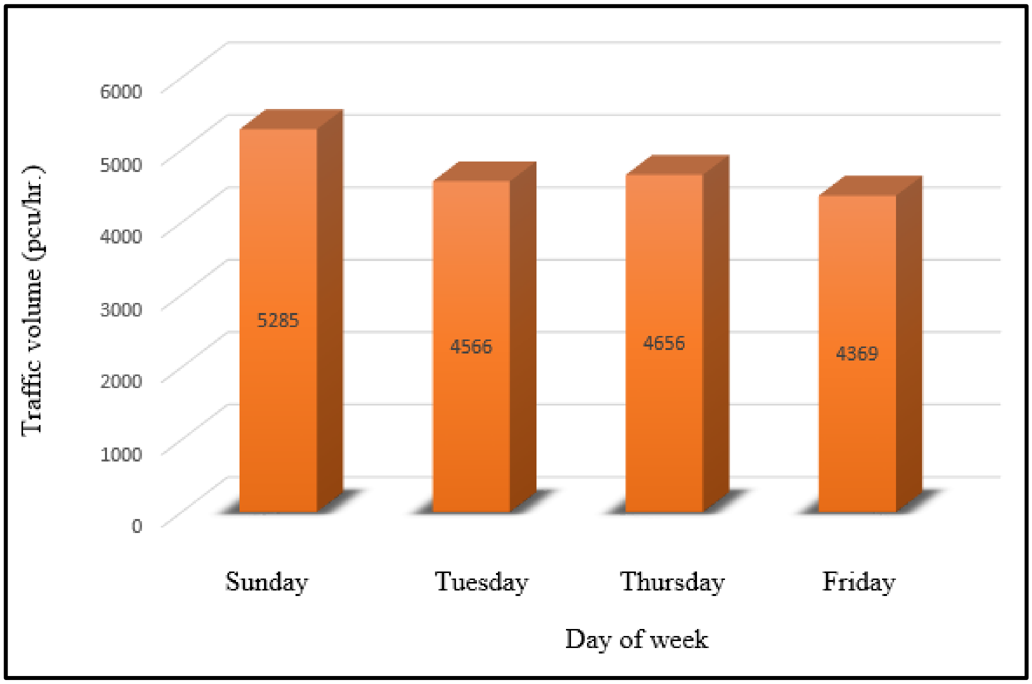


Figure (3-8) Total Traffic Volume Al-Safeena Intersection.



(3-9) Traffic Volume for Sayed Jawda Intersection.

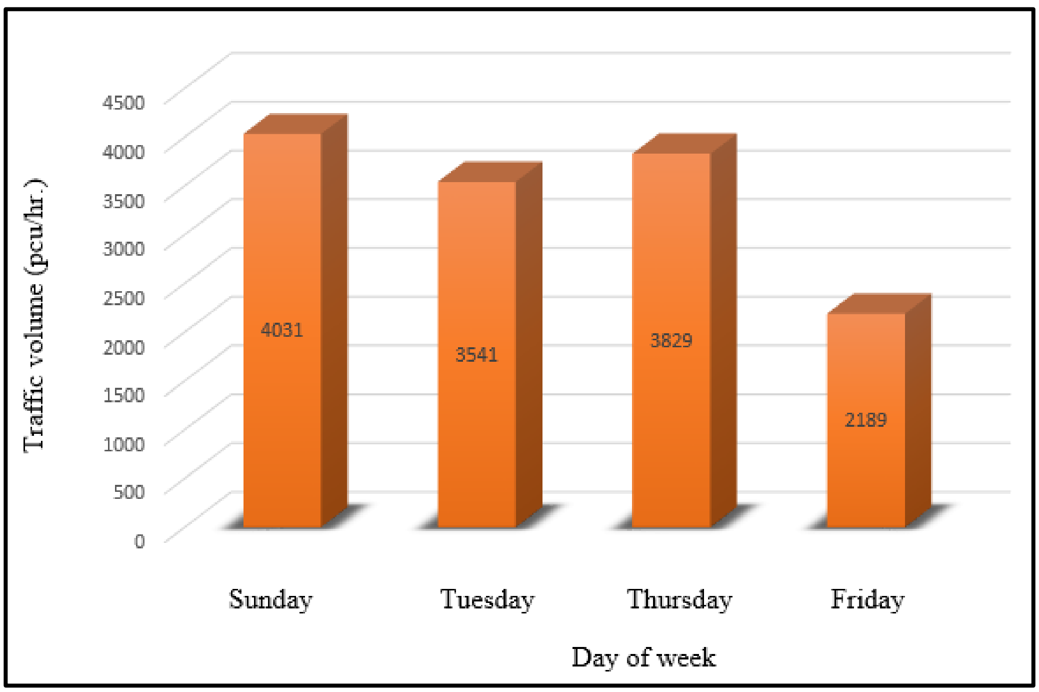


Figure (3-10) Total Traffic Volume at Police Central Al-Hussein Neighborhood

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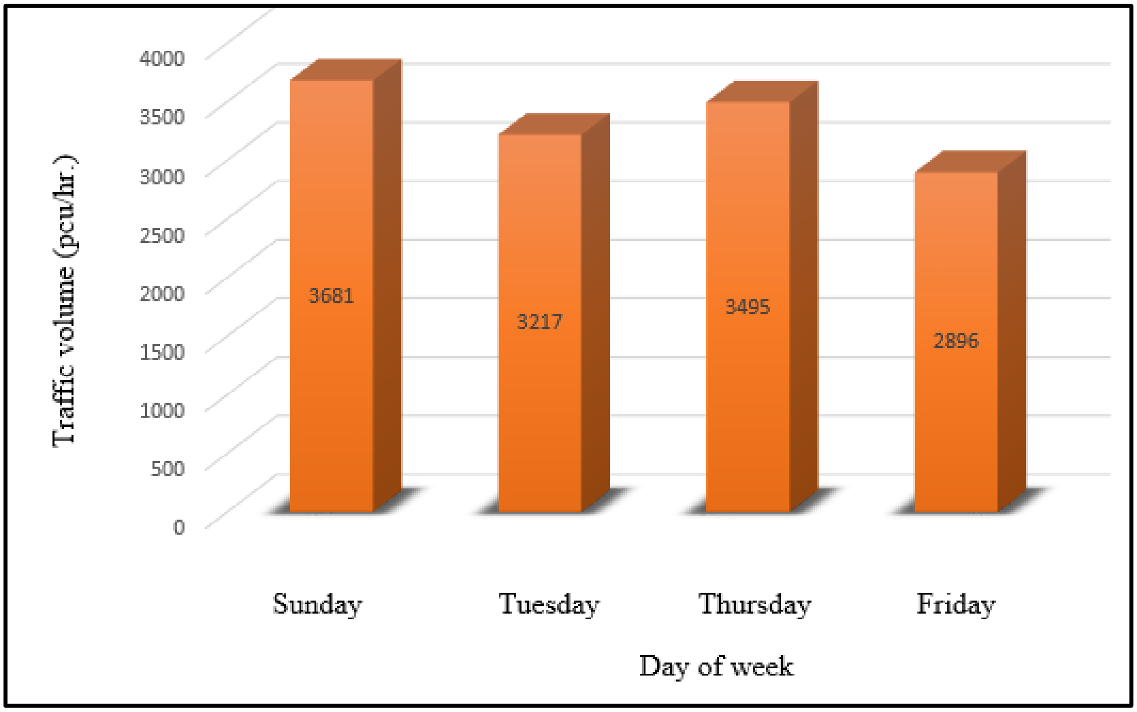


Figure (3-11) Traffic Volume for Saif Saad Intersection.

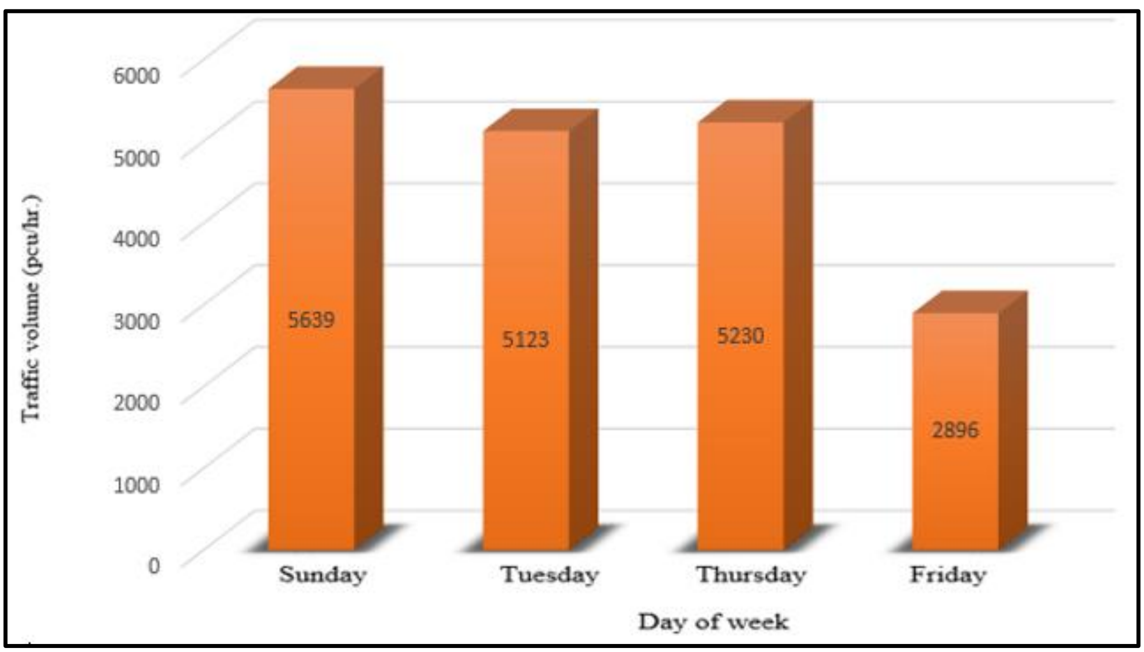


Figure (3-12) Traffic Volume for Stadium Intersection.

3.7.3 Traffic Data Collection for Segment Urban Street

3.7.3.1 Segment Distance

The distance between two adjacent intersections is called the segment distance. According to the highway capacity manual (HCM, 2000), the segment distance calculated in the travel direction from the away corner of the first intersection to the away corner of the second intersection. The segment distance were calculated by using the the distance tools in GIS program for the entire study reviewing.

3.7.3.2 Free Flow Speed

It is important to be determined carefully in the field because this parameter plays an important role in the models used in planning, operational analysis, and performance evaluation of transportation systems. There are several methods for computing the necessary speed data. In this study, free flow speed was calculated by measuring the running time for each segment and then using the equation (3-3).

$$FFS = \frac{3600L}{5280(TR)} \qquad (3\text{-}3)$$

FFS: the free-flow speed that includes the impact of intersection delay (mph)

L: Segment length (feet).

T R: The time to traverse a segment(second).

Before collecting the free flow speed data, it was needed to know the time period, during which the traffic volume would be less than or equal 200 vehicles per lane per hour. It was found that the free flow traffic condition (less than 200 veh/ln/hr.) was approaching after12 A.M. Data of free flow speed for all segments was collected during the off-peak period at whole week once a day at selected speed rate for these days for the purposes of analysis.

3.8 Traffic Signal Data

For signalized intersections, the cycle length, phase length, green time and all red time are measured from video films, as shown in Table (3-3).

Cycle length: Is the total time for the signal to complete one cycle, measured in second.

Phase length: Is the part of the cycle allocated to any combination of the traffic movement receiving the right-of-way simultaneously during one or more interval.

Yellow time: Is the amount of time for the yellow interval, normally, the value should be set to between 3 to 5 seconds, depending on the approach speed, the cross street width, and the local standard.

All red time: Is the amount of time for all red intervals that follow the yellow intervals.

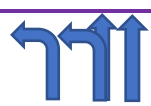
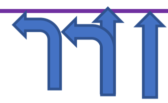
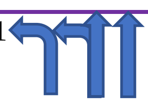
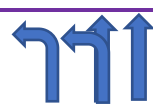
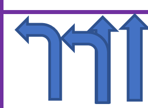
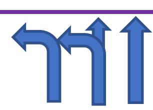
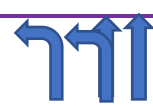
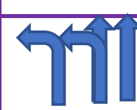
Intersection name	**Phase length**				**Cycle length**
	North	**South**	**East**	West	
	G +Y+AR	**G+Y+AR**	**G+Y+AR**	**G+Y+AR**	
Sayed Jawda					134
	45+3+1	35+3+1	21+3+1	20+3+1	
Police Central	`1 				128
	35+3+1	40+3+1	19+3+1	19+3+1	
Saif Saad					134
	23+3+1	38+3+1	26+3+1	36+3+1	

Table (3-3) Traffic Signal Data (at peak hour).

3.9 Saturation Flow Data for Signalized Intersection

To find the saturation flow rate exactly, the start up lost time should be taken in to respect and sensed. The principle of start-up lost time (Bester and Varndell, 2002) can be described as follows: When the light signal turns to green and the vehicles start moving and crossing the intersection then the headway , which can be defined as the time period elapsed between the successive cars and that the first headway is calculated when the rear wheels of the first vehicle pass the stop line and that the second headway will be the time between crossing the rear wheels of the first vehicle and crossing the rear wheels of the second vehicle the stop line . The first headway is the longer than the second headway. Thus, the first driver standing at the beginning of the queue requires him to observe and react with the change of light signal to the green color. After observing the signal, he must begin to accelerate through the intersection of the stationary position, Performs the same process except.The process of the reaction and acceleration is done in the period initiated by the first driver movement, so the second driver has the length of an additional vehicle to work acceleration vehicle. This process go on until the headway become constant and the effect of the acceleration and start up reaction on the headway reduce . This headway called is called saturation headway .The saturation headway starts between third and sixth vehicle in the queue . Figure (3-13),(3-14) and(3-15) illustrates the relationship between headway and vehicle queue at Sayed Jawda,Police Central and Saif Saad intersections

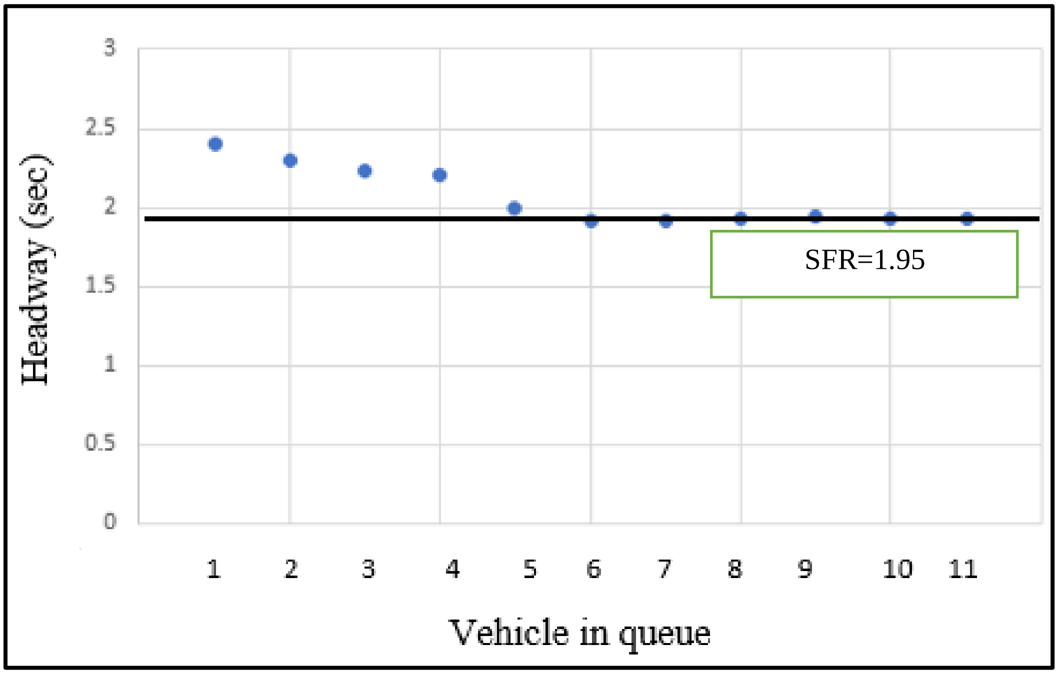


Figure (3-13) Relationship Between Headway and Vehicle Queue

at Sayed Jawda Intersection.

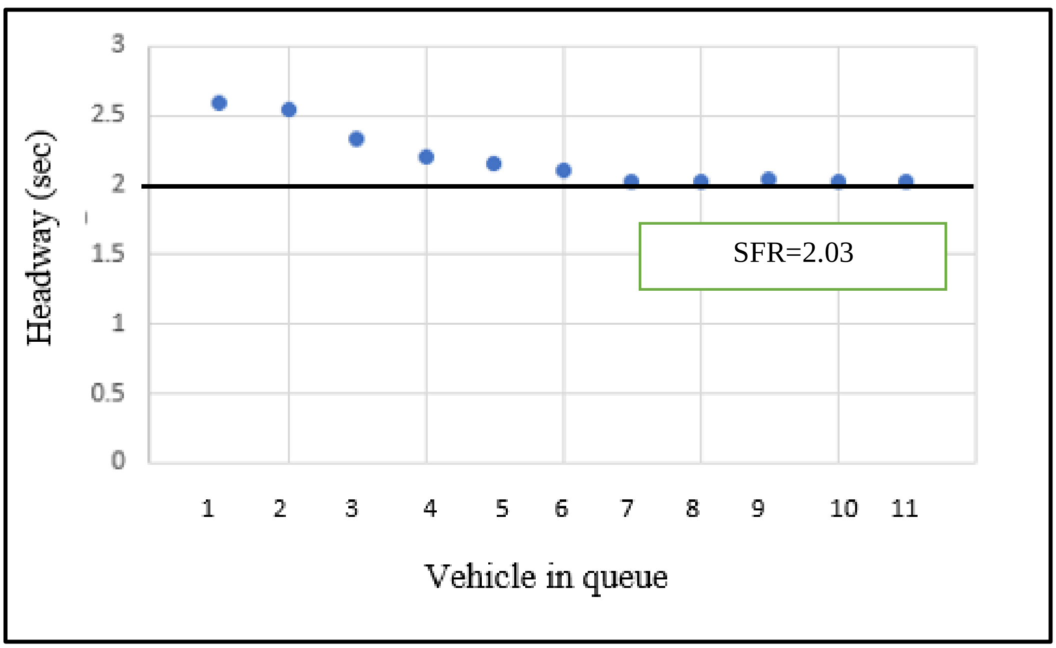


Figure (3-14) Relationship Between Headway and Vehicle Queue

at Police Central.

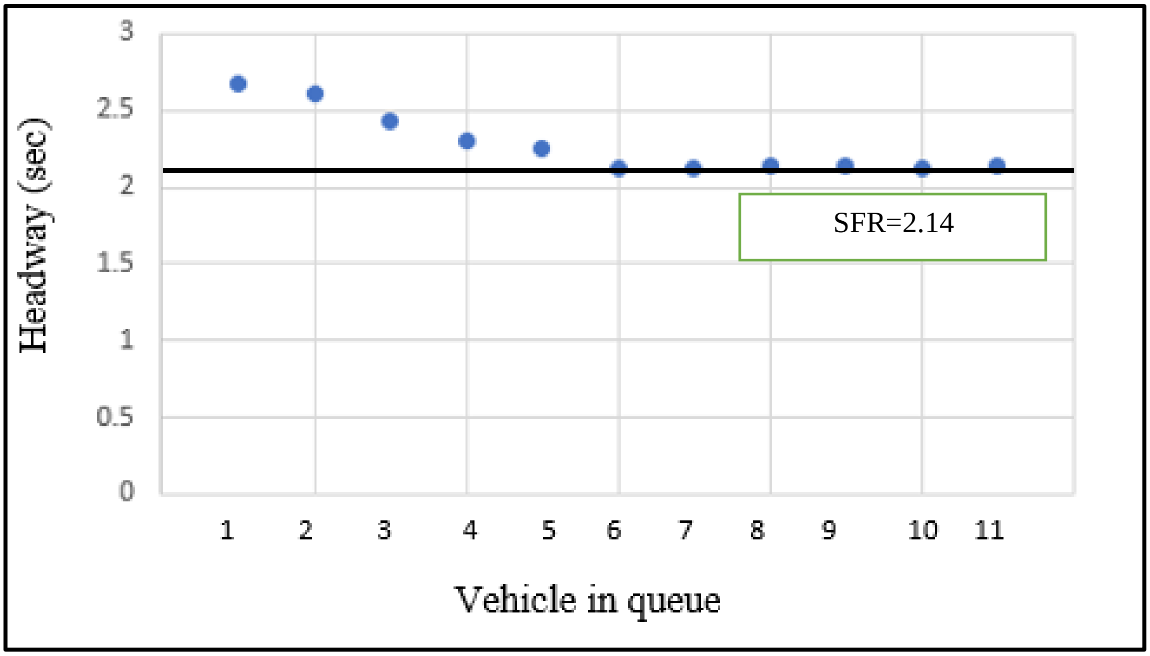


Figure (3-15) Relationship Between Headway and Vehicle Queue at Saif Saad Intersection.

3.10 Relation Between Cycle Length and Delay

Traffic signal control is one of the most efficient methods to reduce the impact of traffic congestion. The cycle length is selected to optimize the intersection performance. One of the most commonly used performance measures is the delay due to its direct relation to what drivers experience while attempting to cross an intersection (F. Viti,2006), (R. van Katwijk,2008).

Once you know the total cycle length, you can subtract the length of the amber and all-red periods from the total cycle length and end up with the total time available for green signal indications. Efficiency dictates that the cycle length should be long enough to serve all of the critical movements. If the cycle is too short, there will be so many phase changes during the hour that the time lost, so that due to these changes will be high compared to the usable green time. But if the cycle is too long, delays will be lengthened, as vehicles wait for their turn to discharge through the

intersection.
(http://webpages.uidaho.edu/niatt_labmanual/chapters/signaltimingdesign/theoryandconcepts/CycleLengthDetermination.htm)

Webster's equation, which minimizes intersection delay, gives the optimum cycle length as a function of the lost time and the critical flow ratios. Many design manuals use Webster's equation as the basis for their design and only make minor adjustments to suit their purposes. Webster's equation is shown below(NIATT,2014)

$$\frac{1.5L+5}{1-Y} \tag{3-4}$$

Where:

Co = Optimum cycle length (sec).

L = Sum of the lost time for all phases, usually taken as the sum of the intergreen periods (sec).

Y = Ratio of the design flow rate to the saturation flow rate for the critical approach or lane in each phase.

3.11 Data abstraction

Data abstraction was based on sessions of 15 minute periods of recorded data. The choice of a 15-minute period was depended on these considerations:

1. To guarantee that the sample is adequate to give meaningful results.

2. The traffic flow should be effectively constant during the period without incidents.

3. Decreasing of observer fatigue and subsequent mistakes which may result from the continuously watching for the video recordings.

To get the required data from a video film, it was important to play back the film a few times. To guarantee that the video film begins at the same point in time, a clock is shown on the screen to check this point.

Table (3-4) Summary of Abstracted Data

Major Category	Data Type
Traffic volume data	Through and turning traffic volume counts Vehicle Classification
Driver performance characteristics data	Headways and saturation flow rate Signal timing control
Signal timing control	Cycle length Phase sequence
Data used in comparison with simulated results	Delay

3.12 Software Used for Data Analysis

For the analysis and evaluation of traffic performance at the selected road network, the abstracted and processed traffic and geometric data, collected from the site, has been used as inputs into three software packages. Highway capacity software (HCS +7F), SIDRA INTERSECTION 7, and VISSM 10 have been used. The functions of each software are described in this paragraph.

3-12-1 HIGHWAY CAPACITY SOFTWARE (HCS+7FT)

The highway capacity software was setup by FHWA and considered in transportation as the center for microcomputer (McTrans). In the university of Florida, the McTrans center was advanced the Highway Capacity as a typical windows installation. The access to TRANSYT-7F to become seamless McTrans latest software development upgrades HCS+, the professions most powerful signal timing optimization in HCS+T7F. This new combined software package was provides for the advanced signal timing optimization for intersections, arterials or networks using TRANSYT-7F. HCS+ was also upgraded to version 5.3 to include the new Interchange Ramp Terminals module automating the recently approved HCM Chapter 26 procedures .The steps existing in the highway capacity manual(HCM) closely carried out by HCS+ including all approved changes to date for signalized intersections, unsignalized intersections, urban streets, multilane and two-lane highways, freeway sections, weaving areas and ramp junctions. HCS+ also includes Warrants (Auburn university, 2007)

3-12-2 SIDRA Intersection 7

SIDRA INTERSECTION 7 was released in July 2009 (First released in 1984). This software was developed by ARRB Transport Research, Ltd., and modified by Akcelik and associates in Australia.

The following points briefly provide an overview of SIDRA (Akcelik, 2009 b).

• It is an advanced micro-analytical tool for evaluation of alternative intersection designs.

• It is used for as an aid for design and evaluation of signalized intersections, pedestrian crossings, single point interchanges, roundabouts, roundabout metering, , and give-way /yield sign-control.

• It can be calibrated for local conditions.

The parameters used for calibration are saturation flow rate, and lane utilization factor for signalized intersections, and environment factor, and entry/circulating flow for roundabouts.

• Analyze many design alternatives to optimize the intersection geometry, signal phasing and timings specifying different strategies for optimization.

• Carry out a design life analysis to assess impact of traffic growth.

• Carry out a parameter sensitivity analysis for calibration, optimization, evaluation and geometric design purposes.

• Analyze oversaturated conditions making use of the time-dependent delay, queue length and stop rate models

• It implements NASAAR 1986 (National Association of Australian State Road Authorities), HCM2000, and ICU2003 procedures for capacity and delay calculations of signalized intersections, and FHWA2000, NCHRP 2007, TRL1981 for roundabouts.

• In the USA, it is recognized by the US Highway Capacity Manual, FHWA Roundabout Guide, NCHRP Report 572, and various local roundabout guides. In Australia and New Zealand, it endorsed the Guide to Traffic Engineering Practice, a major publication of AUSTROADS (the Association of Australian State, Territory and Federal Road and Transport Authorities).

Operations of SIDRA INTERSECTION system can be presented in Figure (3-16) in term of available models, main functions, input, processing, output, data summary, and printing.

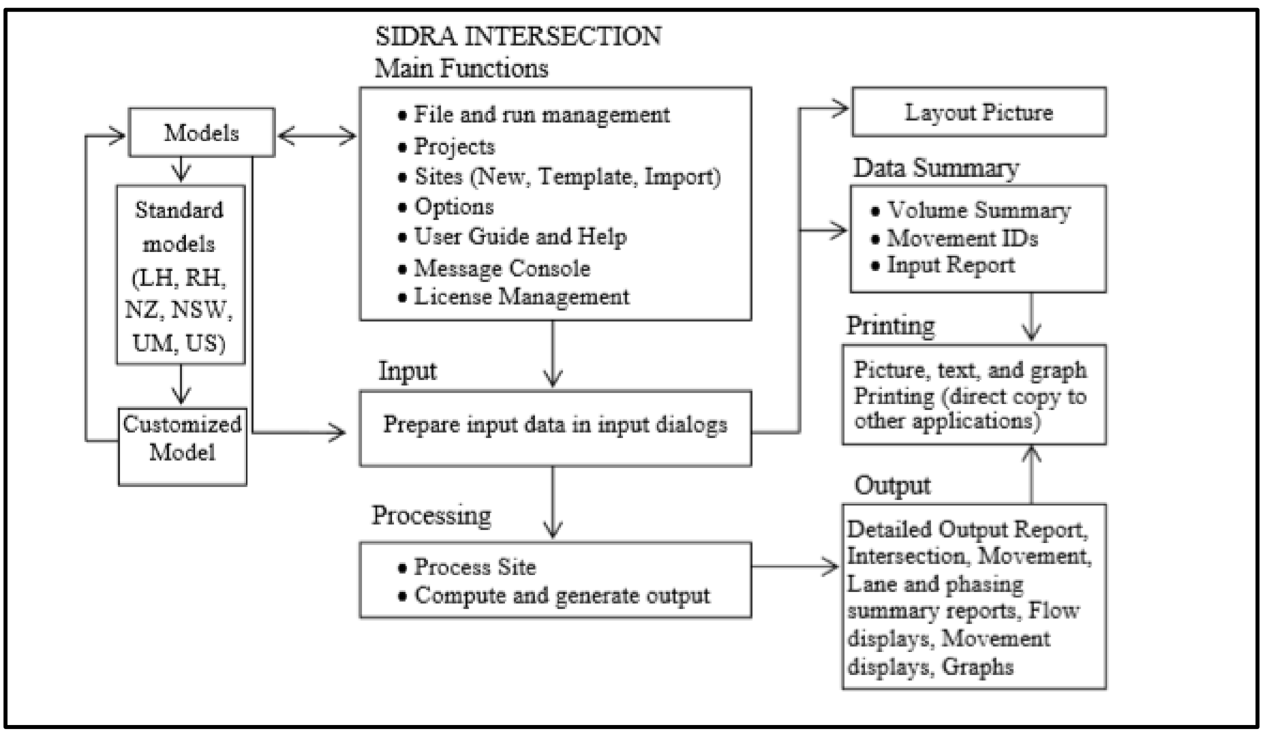


Figure (3-16) Operation of SIDRA Intersection System (Akcelik, 2009 b)

3-12-3 VISSM 10

VISSIM has been used to analyze networks of all sizes ranging from individual intersections to entire metropolitan areas. Within these transportation networks, VISSIM was able to model all roadway functional classifications from freeways (motorways) to driveways. VISSIM's breadth of network applications also includes transit, bicycle and pedestrian facilities. Many common, as well as unique, geometric and operational conditions exist throughout the transportation system that VISSIM can simulate (PTV, 2005).

Gai, (2005) indicates that VISSIM is the most advanced and widely used microscopic traffic simulation software. He introduced the modules, function and application field of VISSIM, and suggested extending its application in China.

VISSIM is a program with abilities to display and visualize complex traffic flow in a graphical way. It is able to cope with the analyses of various traffic and transit operations under various conditions and aid the assessment of traffic impacts of physical and operational alternatives in transportation planning. VISSIM itself can be considered as a difficult program to handle due to its complexity and brief explanation in the manual (Koh S.Y Doina and Chin H.C, 2009).

3.13 Summary

This chapter explained the methodology for data collection , which included (defining the limits of the study area, determining the peak period for each intersection in the traffic network, Identifying the specific input information for the selected programs, and preparing the collected data to be used in the selected software programs) . The data collection stage was aimed to gather all data that would be necessary to show the conditions of traffic flow at the study area,the kinds of data contain (Geometric features, Data of traffic flow, Traffic control information, The Land use data and projected changes in land uses and the speed data). Furthemore, explained software used for data analysis .

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Chapter Four

Data Presentation and Analysis

Chapter Four
Data Presentation and Analysis

4.1 General

In this chapter the collected data was analyzed, many improvement suggestions were introduced and then evaluated by using the calibrated software. This chapter is divided into five parts:

- The first part includes the result of traffic signal warrant for Sayed Jawda ,Saif Saad and Police Central intersections by theotecaly method based on (MUTCD) and by highway capacity software (HCS+7FT).
- The second part involves the result of saturation flow rate for Sayed Jawda, Police Central and Saif Saad intersections.
- Third part involves the result of the optimum cycle length for signalized intersection by highway capacity software (HCS+7FT) and by Webster equation.
- The forth part includes the application of software (HCS+7FT and SIDRA Intersection 7 and VISSIM 10) to simulate the traffic operations at isolated intersections in the study area, and applying Highway Capacity Software (HCS+T7F) to evaluate and analyses the urban streets.
- The fifth part includes the evaluation of the suggested improvements and the alternatives to enhance the performance of traffic flow at the study area network.

4.2 Traffic Signal Warrants

4.2.1 Traffic Volume

The traffic flow data for (Sayed Jawda intersection ,Al-Safeena roundabout Police central Al-Hussein neighborhood) were collected by using a video camera from Karbala police. The traffic flow data for (Saif Saad intersection) were collected by field measurement. The peak traffic volume for the mentioned intersections are shown in Tables (4-6, 4-7, and 4-8).

The traffic volume for minor and major street for five hour for (Sayed Jawda ,Saif Saad ,Police Central ,Al-Safeena)intersections shown in Tables (4-1, 4-2, 4-3, 4-4, and 4-5) .

Table (4-1) The Traffic Volume for Minor and Major Street for (Sayed Jawda ,Saif Saad ,Police Central ,Al-Safeena)Intersection at (7:30-8:30) .

Intersection name	Approach	Traffic volume
Sayed Jawda int.	East (minor)	1604
	West(minor)	926
	North (major)	1176
	South (major)	1279
Police Central int.	East (minor)	608
	West(minor)	557
	North (major)	1318
	South (major)	1304
Saif Saad int.	East (minor)	754
	West(minor)	674
	North (major)	1120
	South (major)	987
Al- Safeena roundabout	East (minor)	1520
	West(minor)	1190
	North (major)	1537
	South (major)	1836

Table (4-2)The Traffic Volume for Minor and Major Street for (Sayed Jawda ,Saif Saad ,Police Central ,Al-Safeena)Intersection at (8:30-9:30) .

Intersection name	Approach	Traffic volume
Sayed Jawda int.	East (minor)	1257
	West(minor)	808
	North (major)	1155
	South (major)	1344
Police Central int.	East (minor)	537
	West(minor)	704
	North (major)	1149
	South (major)	1150
Saif Saad int.	East (minor)	554
	West(minor)	574
	North (major)	898
	South (major)	754
Al- Safeena roundabout	East (minor)	1018
	West(minor)	472
	North (major)	1327
	South (major)	1859

Table (4-3) The Traffic Volume for Minor and Major Street for (Sayed Jawda ,Saif Saad ,Police Central ,Al-Safeena)Intersection at (13:30-14:30) .

Intersection name	Approach	Traffic volume
Sayed Jawda int.	East (minor)	1490
	West(minor)	669
	North (major)	1258
	South (major)	1248
Police Central int.	East (minor)	643
	West(minor)	654
	North (major)	1213
	South (major)	1167
Saif Saad int.	East (minor)	554
	West(minor)	574
	North (major)	898
	South (major)	754
Al- Safeena roundabout	East (minor)	1005
	West(minor)	574
	North (major)	1206
	South (major)	1865

Table (4-4) The Traffic Volume for Minor and Major Street for (Sayed Jawda ,Saif Saad ,Police Central ,Al-Safeena)Intersection at (14:30-15:30) .

Intersection name	Approach	Traffic volume
Sayed Jawda int.	East (minor)	1305
	West(minor)	579
	North (major)	1282
	South (major)	1049
Police Central int.	East (minor)	643
	West(minor)	673
	North (major)	1219
	South (major)	1163
Saif Saad int.	East (minor)	554
	West(minor)	574
	North (major)	898
	South (major)	754
Al- Safeena roundabout	East (major)	1115
	West(major)	1656
	North (minor)	1206
	South (minor)	1378

Table (4-5) The Traffic Volume for Minor and Major Street for (Sayed Jawda ,Saif Saad ,Police Central ,Al-Safeena)Intersection at (15:30-16:30) .

Intersection name	Approach	Traffic volume
Sayed Jawda int.	East (minor)	788
	West(minor)	612
	North (major)	1236
	South (major)	1167
Police Central int.	East (minor)	731
	West(minor)	670
	North (major)	1237
	South (major)	1191
Saif Saad int.	East (minor)	554
	West(minor)	574
	North (major)	898
	South (major)	754
Al- Safeena roundabout	east (major)	1074
	west(major)	1328
	north (minor)	873
	south (minorr)	1092

4.2.2 Calculation of the PHF (Peak Hour Factor):

The peak hour factor is defined as the ratio of total hourly volume to the maximum 15- min rate of flow within the hour as following equation (4-1) (HCM, 2010):

$$PHF = \frac{Hourly\ volume}{peak\ rate\ of\ flow\ (within\ hour)} \quad (4\text{-}1)$$

$$PHF = \frac{Hourly\ volume}{4 * V15}$$

Where: -

PHF= Peak-hour factor

V_{15}= Volume during the peak 15 min of the peak hour, on veh/15min

Table (4-6) PHF Values at Al-Safeena Rundabout

Direction	PHF
E	0.95
W	0.85
N	0.87
S	0.87

Table (4-7) PHF Values at Sayed Jawda Intersection

Direction	PHF
E	0.88
W	0.92
N	0.85
S	0.87

Table (4-8) PHF Values at Police Central Intersection

Direction	PHF
E	0.87
W	0.93
N	0.9
S	0.92

Table (4-9) PHF Values at Saif Saad Intersection

Direction	PHF
E	0.89
W	0.91
N	0.88
S	0.87

Table (4-10) PHF Values at Stadium Intersection

Direction	PHF
E	0.91
W	0.88
N	0.87
S	0.89

4.2.3 Results of Traffic Signal Warrant

Traffic signal warrants applied for four intersections in Kerbala city these intersections are Sayed Jawda, Police Central, Saif Saad, and Al-Safeena intersections. The results shown that three warrants of traffic signal satisfied for these intersections ,these warrants are (four hour vehicular volume, peak hour and network system).In four hour vehicular warrant for each hour of any 4 hours of an average day, the plotted points that representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) all fall above the applicable curve in Figure (4-1) for the existing combination of approach lanes. In peak hour warrant the plotted points for 1 hour (any four consecutive 15-minute periods) of an average day falls above the applicable curve in Figure(4-2) for the existing combination of approach lanes so this warrant was satisfied .The results of traffic signal warrants for the three intersections are shown in Tables (4-4),(4-5) and (4-6) .

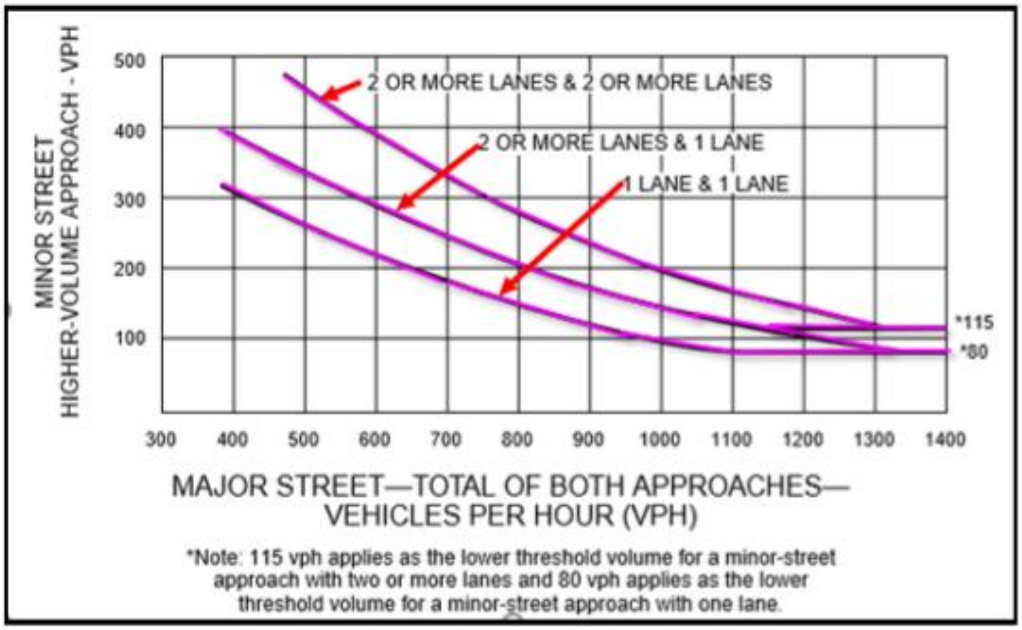


Figure (4-1) Warrant 2 Four-Hour Vehicular Volume (MUTCD,2006)

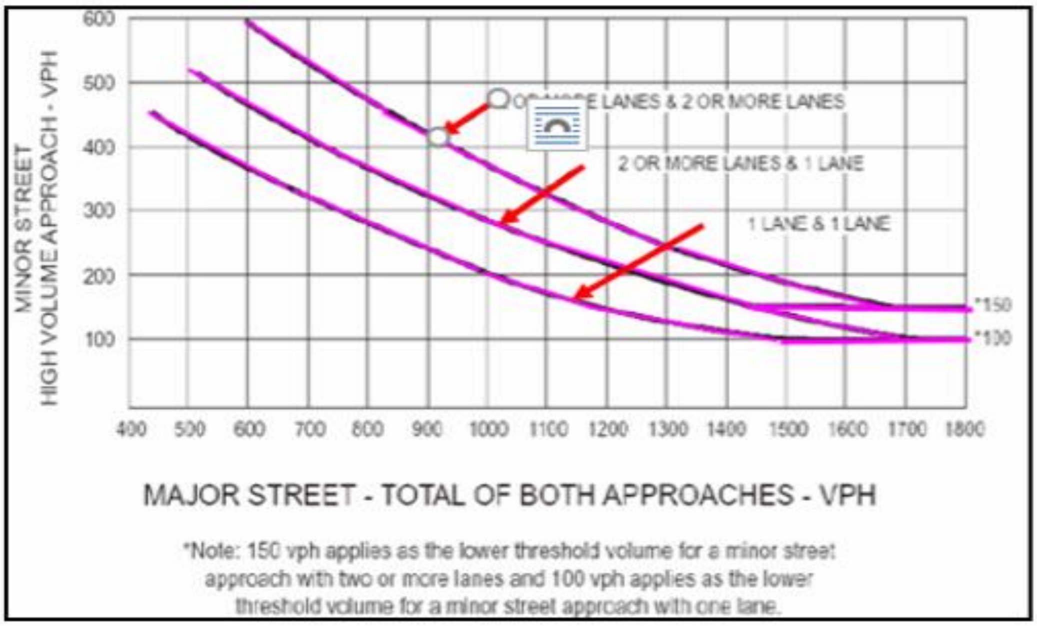


Figure (4-2) warrant 3 peak hour volume (MUTCD,2006).

Table (4-11) Peak Traffic Volume for Sayed Jawda Intersection.

Approach	Direction	Peak Traffic Volume
East	Through	526
	Left	195
	Right	202
	U-turn	62
West	Through	784
	Left	279
	Right	277
	U-turn	52
North	Through	660
	Left	`422
	Right	305
	U-turn	44
South	Through	472
	Left	232
	Right	346
	U-turn	56

Table (4-12) Peak Traffic Volume for Police Central Intersection.

Approach	Direction	Peak traffic volume
East	Through	206
	Left	176
	Right	224
	U-turn	46
West	Through	187
	Left	229
	Right	157
	U-turn	43
North	Through	626
	Left	457
	Right	203
	U-turn	46
South	Through	753
	Left	181
	Right	141
	U-turn	55

Table (4-13) Peak Traffic Volume for Saif Saad Intersection.

Approach	Direction	Peak traffic volume
East	Through	290
	Left	221
	Right	144
	U-turn	87
West	Through	201
	Left	225
	Right	177
	U-turn	48
North	Through	305
	Left	146
	Right	234
	U-turn	105
South	Through	601
	Left	402
	Right	194
	U-turn	7

Table (4-14) Result of Traffic Signal Warrant for Sayed Jawda Intersection.

Warrants	Results
1- Eight-Hour Vehicular Volume	Not. Satisfied
2- Four-Hour Vehicular Volume	Satisfied
3- Peak Hour	Satisfied
4- Pedestrian Volume	Not satisfied
5- School Crossing	Not Satisfied
6- Coordinated Signal System	Not satisfied
7- Crash Experience	Not satisfied
8- Roadway Network	Satisfied
9- Intersection Near a Grade Crossing	Not satisfied

Table (4-15) Result of Traffic Signal Warrant for Police Central Intersection.

Warrants	Results
1- Eight-Hour Vehicular Volume	Not. Satisfied
2- Four-Hour Vehicular Volume	Satisfied
3- Peak Hour	Satisfied
4- Pedestrian Volume	Not satisfied
5- School Crossing	Not Satisfied
6- Coordinated Signal System	Not satisfied
7- Crash Experience	Not satisfied
8- Roadway Network	Satisfied
9- Intersection Near a Grade Crossing	Not satisfied

Table (4-16) Result of Traffic Signal Warrant for Saif Saad Intersection.

Warrants	Results
1- Eight-Hour Vehicular Volume	Not. Satisfied
2- Four-Hour Vehicular Volume	Satisfied
3- Peak Hour	Satisfied
4- Pedestrian Volume	Not satisfied
5- School Crossing	Not Satisfied
6- Coordinated Signal System	Not satisfied
7- Crash Experience	Not satisfied
8- Roadway Network	Satisfied
9- Intersection Near a Grade Crossing	Not satisfied

4.3 Relationship Between Cycle Length and Delay

The cycle length was selected to optimize the intersection performance. One of the most commonly used performance measures was the delay due to its direct relation to what drivers experience while attempting to cross an intersection.

Two methods were used to calculate the optimum cycle length.

4.3.1-By Highway Capacity Software (HCS+7FT)

Highway capacity software (HCS+7FT) was used to calculate the optimum cycle length for Sayed Jawd ,Police Central and Saif Saad intersection. The results of this program shown in Figures (4-4, 4-5, 4-6).

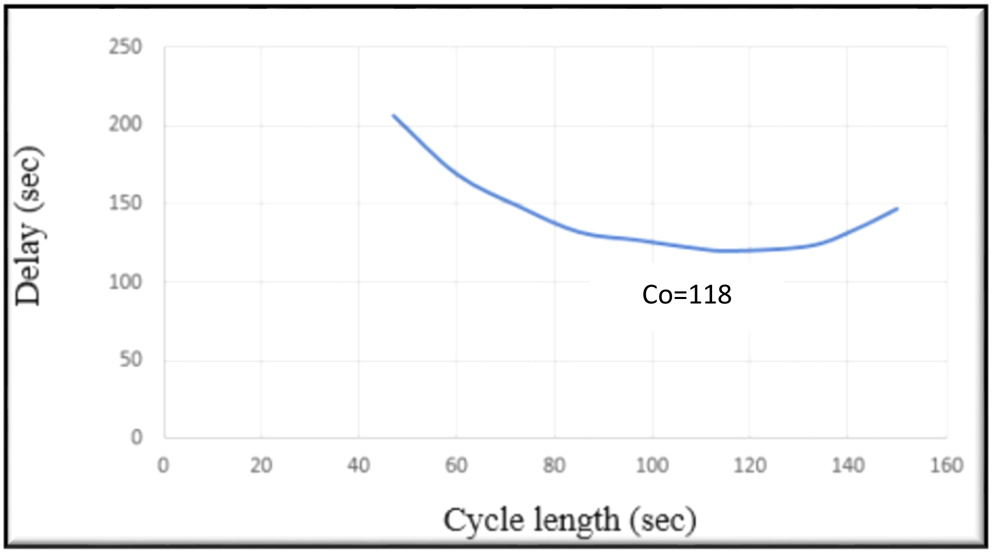


Figure (4-4) Relationship Between Cycle Length and Delay for Sayd Jawda Intersection

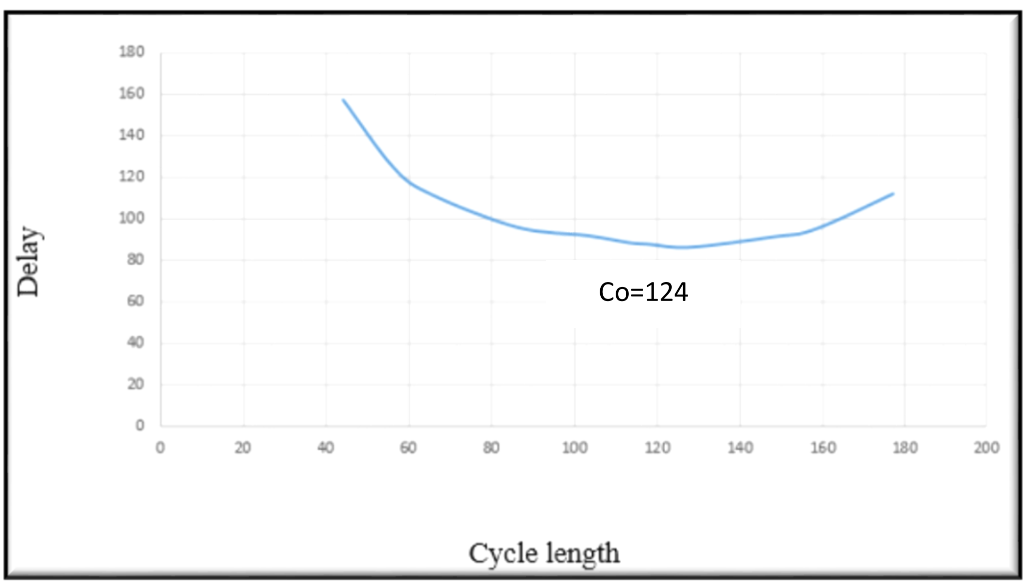


Figure (4-5) Relationship Between Cycle Length and Delay for Police Central Intersection.

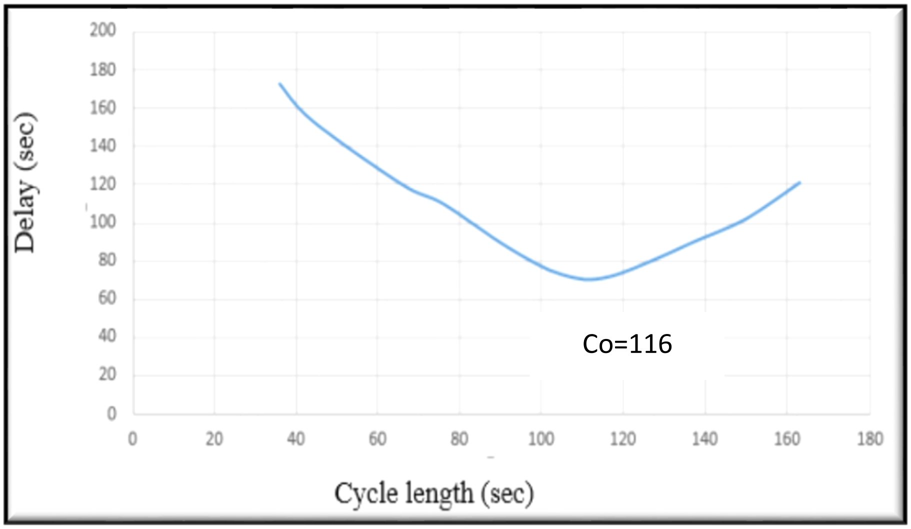


Figure (4-6) Relationship Between Cycle Length and Delay for Saif Saad Intersection.

4.3.2-By Webster Equation

The Webster Equation made the length of the cycle optimal as a function of the critical flow ratios and lost times. The Webster Equation is considered as the basis for the design of many design brochures.

The results of Websters equation are shown in Tables (4-17, 4-18, 4-19).

Table (4-17) Flow, Saturation Flow ,Y for Sayed Jawda Intersection.

Direction	Flow	Saturation flow	v/c
West approach ,through and left	317	2191	0.144
West approach , left	179	2165	0.0826
West approach ,through	287	2017	0.142
West approach ,through and left	489	2168	0.225
West approach , left	239	2045	0.116
West approach ,through	426	1895	0.224
North approach ,through and left	462	2031	0.227
North approach , left	350	1956	0.178
North approach ,through	358	1914	0.187
South approach ,through and left	317	1925	0.164
South approach , left	230	1855	0.123
South approach ,through	292	1823	0.167

The obtimum cycle length for Sayed Jawda intersection is 119 sec.

Table (4-18)flow, saturation flow and y for Police Central intersection.

Direction	Flow	Saturation flow	v/c
East approach ,through and left	135	1875	0.072
East approach , left	164	1915	0.086
East approach ,through	135	1800	0.075
West approach ,through and left	109	1867	0.058
West approach , left	193	1894	0.101
West approach ,through	102	1914	0.053
North approach ,through and left	501	1936	0.258
North approach , left	372	1894	.194
North approach ,through	476	1912	0.248
South approach ,through and left	395	1922	0.217
South approach , left	140	1773	0.078
South approach ,through	588	1912	0.307

The obtimum cycle length for Police Central intersection is 117.

Table (4-19) Flow, Saturation Flow and y for Saif Saad Intersection.

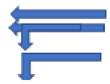
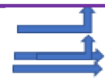
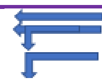
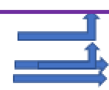
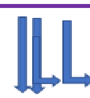
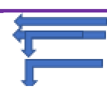
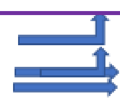
Direction	Flow	Saturation flow	v/c
North approach ,through and left	305	1722	0.133
North approach , left	230	1698	0.068
North approach ,through	116	1814	0.064
South approach ,through and left	303	1951	0.155
South approach , left	350	1923	0.182
South approach ,through	302	1821	0.165
East approach ,through and left	259	1830	0.141
East approach , left	163	1822	0.089
East approach ,through	426	1806	0.235
West approach ,ahead and left	220	1830	0.120
West approach , left	137	1806	0.075
West approach ,through	329	1858	0.177

Optimum cycle length for Saif Saad intersection is 109.

4.4 Saturation Flow Rate

The saturation flow rate is a fundamental parameter to measure the intersection capacity, the results of the saturation flow rate are shown in Table (4-10).

Table (4-20) Saturation Flow Rate.

Intersection name	Direction	Lane group	Saturation headway(sec)	Saturation flow rate (vph)
Sayed Jawda	E		1.64	2195
	W		1.69	2135
	N		1.72	2093
	S		1.8	2000
Police Central Al-Hussein Neighborhood	E		1.85	1945
	W		1.88	1914
	N		1.82	1978
	S		1.86	1935
Saif Saad	E		1.79	2011
	W		1.82	1978
	N		1.84	1956
	S		1.89	1904

4.5 Evaluation of Existing Traffic Flow

To discuss the current conditions of sketch of traffic operation and geometry on traffic flow performance, the actuall movement is required. These have been done by applying three software programs as follows:

4.5.1 Application of SIDRA Software Program

The SIDRA software is a micro-analytical tool for evaluation of an intersection performance. The SIDRA software can be used as an aid for the design and evaluation of signalized intersections, roundabouts, stop control, give-way control, and signalized pedestrian crossings. SIDRA output includes LOS results based on the concept described in the US Highway Capacity Manual (HCM) and delay and degree of saturation. The results by the SIDRA in current condition for Al- Safeena roundabout, Sayed Jawda, Police Central, Saif Saad intersections are shown in Figures (4-11, 4-12, 4-13, and4-14).

Table (4-21): Analysis of the Results by SIDRA for Al-Safeena Roundabout.

Direction	Approach		Intersection	
	Delay (sec)	LOS	Delay(sec)	LOS
Northbound	178	F	120	F
Eastbound	78	F		
Southbound	154	F		
Westbound	60	F		

Table (4-22): Analysis of Result by SIDRA for Sayed Jawda Intersections.

Direction	Approach		Intersection	
	Delay (sec)	LOS	Delay(sec)	LOS
Northbound	110	F	114.9	F
Eastbound	147	F		
Southbound	92	F		
Westbound	147	F		

Table (4-23): Analysis of Result by SIDRA for Police Central intersections.

Direction	Approach		Intersection	
	Delay (sec)	LOS	Delay(sec)	LOS
Northbound	87.7	F	84.3	F
Eastbound	75.8	E		
Southbound	97.6	F		
Westbound	49.5	D		

Table (4-24): Analysis of Result by SIDRA for Saif Saad Intersection.

Direction	Approach		Intersection	
	Delay (sec)	LOS	Delay(sec)	LOS
Northbound	96.5	F	72.9	E
Eastbound	46.8	D		
Southbound	55.8	E		
Westbound	68.5	E		

4.5.2 Application of VISSM

This software enables an extensive assortment of urban and highway applications and integrates the public and private transport as well as pedestrians into the model. By incorporating the possibility of simulating different transportation means, PTV VISSIM can replicate complex traffic situations, such as roundabouts and intersections, where numerous conflicts between modes of transport exist. Table (4-25),(4-26),(4-27),(4-28) show the results obtained by VISSIM for Sayed Jawda intersection and Al-Safeena rounabout and Saif Saad intersection and Stadium intersection.

Table (4-25): Analysis of Result by VISSIM for Al- Safeena Roundabout.

Direction	Approach		Intersection	
	Delay (sec)	LOS	Delay(sec)	LOS
Northbound	23	C	116	F
Eastbound	152	F		
Southbound	209	F		
Westbound	78	E		

Table (4-26): Analysis of Result by VISSIM for Sayed Jawda intersection.

Direction	Approach		Intersection	
	Delay (sec)	LOS	Delay(sec)	LOS
Northbound	75	E	109	F
Eastbound	94	F		
Southbound	189	F		
Westbound	78	E		

Table (4-27): Analysis of Result by VISSIM for Police Central Intersections.

Direction	Approach		Intersection	
	Delay (sec)	LOS	Delay(sec)	LOS
Northbound	77	F	78	F
Eastbound	93	F		
Southbound	48	D		
Westbound	95	F		

Table (4-28): Analysis of Result by VISSIM for Saif Saad intersections.

Direction	Approach		Intersection	
	Delay (sec)	LOS	Delay(sec)	LOS
Northbound	46	D	71.95	F
Eastbound	50.83	D		
Southbound	104	F		
Westbound	87	F		

Table (4-29): Analysis of Result by VISSIM for Stadium Intersections.

Direction	Approach		Intersection	
	Delay (sec)	LOS	Delay(sec)	LOS
Northbound	33.5	D	32.25	D
Eastbound	85	F		
Southbound	2	B		
Westbound	10.16	B		

4.5.3 Application of Highway Capacity Software (HCS+T7F) for Intersection

The abstracted and collected data required for this software were fed to the program for each intersection alone. Many runs were implemented to exclude the bias data. HCS+7FT software was used to analyze the existing traffic flow patterns for intersections as isolated at the study area. Tables (4-30, 4-31, 4-32) indicates the output results of simulation runs which include total delay, and level of service for each intersection in the study area .

Table (4-30): Analysis of Result by HCS for Sayed Jawda Intersections.

Direction	Approach		Intersection	
	Delay (sec)	LOS	Delay(sec)	LOS
Northbound	54.7	E	115.2	F
Eastbound	227	F		
Southbound	41.5	D		
Westbound	185	F		

Table (4-31): Analysis of Result by HCS for Police Central Intersections.

Direction	Approach		Intersection	
	Delay (sec)	LOS	Delay(sec)	LOS
Northbound	55.9	F	86.5	F
Eastbound	123.6	F		
Southbound	99.8	F		
Westbound	91.9	F		

Table (4-32): Analysis of Result by HCS for Saif Saad intersections.

Direction	Approach		Intersection	
	Delay (sec)	LOS	Delay(sec)	LOS
Northbound	87.7	F	75.3	E
Eastbound	75.8	E		
Southbound	97.6	F		
Westbound	49.5	D		

4.5.4 Application of Highway Capacity Software (HCS+T7F) for Urban Street.

The first step for an operational (LOS) was to determine the free flow speed, length of street segment and street class. The free flow speed and length of street segment were determined in the previous chapter, whereas the street class was found according to the free flow speed.

The running time was computed for each segment directly from the HCS, along with the control delay for the through movement at each intersection which was computed by using the simulation programs (SIDRA INTERSECTION 7) as previously mentioned. Based on total travel time and total travel speed, the level of service (LOS) for urban street directions was estimated . The results are shown in Table (4-33).

Table (4-33) The Result of Analysis for Urban Streets Segments.

	Segment name	Average free flow speed(km/hr)	Segment length(m)	Street class	Running time (sec)	Control delay(sec)	Travel speed (km/hr.)	Travel time(sec)	LOS
1	From Al-Safeena to Sayed Jawda	51	411	3	31	153	7.88	184.5	F
2	From Sayed Jawda to Police central Al-Hussein neighborhood.	47	546	3	40.8	40.7	24.1	81.5	D
3	From Police Central Central Al-Hussein neighborhood to Saif Saad.	56	941	3	59.7	55	29.28	114	F
4	From Saif Saad to stadium.	34	520	2	34.9	71	17.5	105.9	F
5	From Al-Safeena to Al-Aslah	49	1370	3	100	58.1	35.4	131	F
6	From police central to Sayed Jawda	46.6	551	3	42.5	107	7.3	142,5	F
7	From saif saad to police central	55	945	3	57.3	90.7	20.1	154	E
8	From Sayed Jawda to Al-Safeena roundabout	51	412	3	31.4	60	15.6	91.5	E

4.6 Improvement of Intersections

In this part the improvement that happened for the traffic flow in the zone selected in kerbala city presents by (SIDRA 7, HCS+7FT).

4.6.1 Geometric Improvement

The improvement strategies will be as follows:

1- Re-marking of pavement.

2- Pavement widening.

3- Change the intersection type.

At the improvement process, the degree of saturation (v/c) or level of service (LOS) was used as an indicator for diagnosing the oversaturated cases. Intersections having v/c ratios equal or greater than 0.9 or level of service (LOS D, E, or F), need to be improved at the first stage. The previous Tables show that most of the intersections in the study area operate at saturated conditions.

Pavement remarking at Al-Safeena intersection (intersection6) results in lower delay times, fuel consumption, stops, and P.I. this with an increase value of v/c. So the widening of the south approach is necessary to add an extra lane. For the north approach adding 2.5 m to the circulating width to be 12m was applied. The entry radius for the east, south, and west approach is increased. The increase in entry radius is recommended to increase flare length, and entry width and consequently increase approach capacity , this intersection enhanced to (C),as shown in Figure (4-7) .This mean the MOE enhanced to78%.

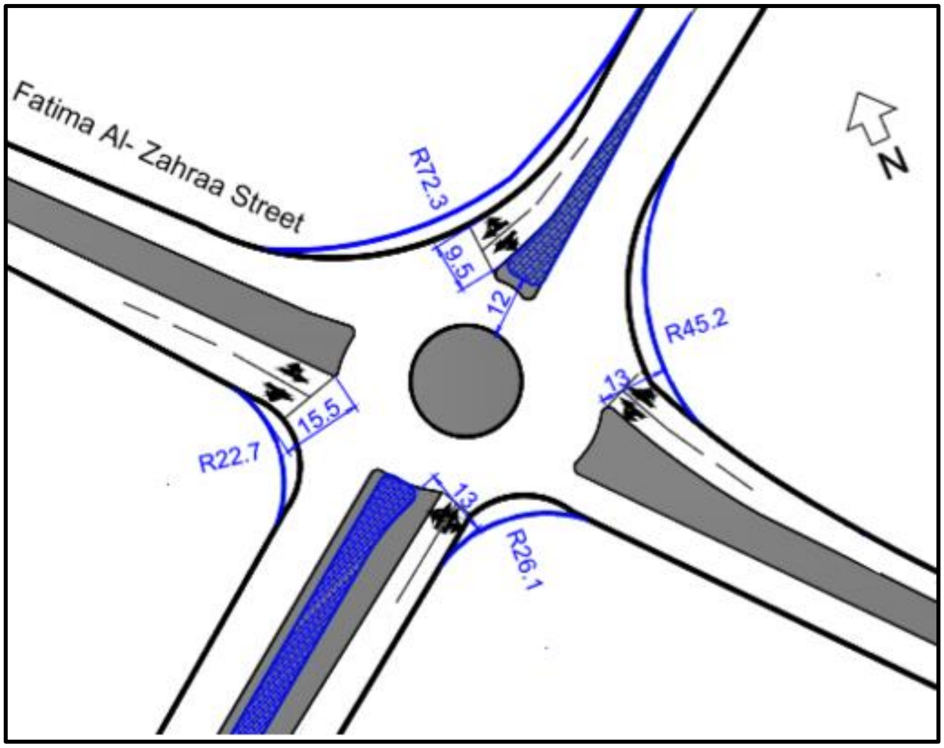


Figure (4-7) Improvement Proposal for Al- Safeena Roundabout.

The traffic problem at Al-Sayed Jawda intersection is solved by dividing the approach width into four lanes; each lane has its exclusive movement. The traffic lanes that have low traffic volume are assigned to be shared. After the optimization process is applied, the optimum cycle length is set to be 119 sec and v/c is 0.87. So the intersection is under-saturated condition. The entry radius for the east, south, and north approach is increased. The increase in entry radius is recommended to increase entry width and consequently increase approach capacity , this intersection enhanced to (C),.This mean the MOE enhanced to72.5%.

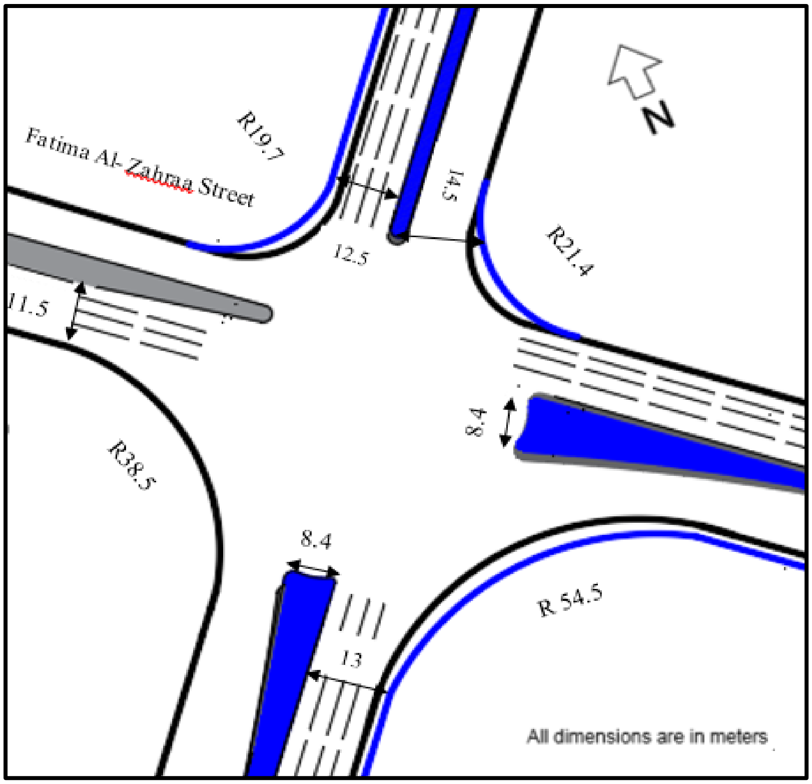


Figure (4-8) Improvement Proposal for Sayed Jawda Intersection .

The problem in police central was solved by adding new lane in the east , north and south directions. This reduced v/c drastically to 0.8, and the LOS to C, as can be seen in Figure (4-9).

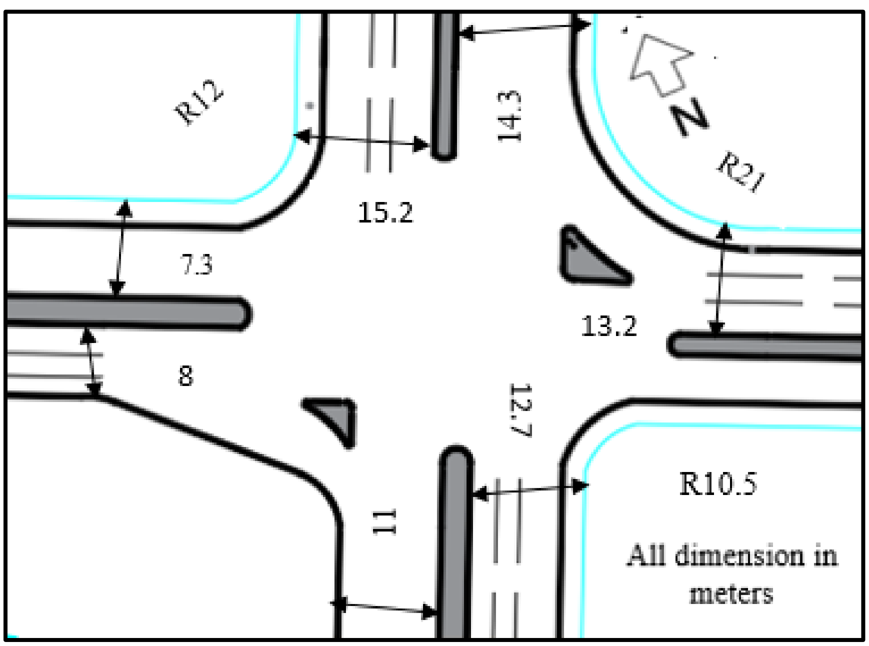


Figure (4-9) Improvement Proposal for Police Central Intersection.

For Saif Sayd intersection the problem solved by add new lane for east and and north approach and make optimum cycle length by SIDRA 110 sec the v/c reduce to value 0.7 and the value of average delay reduce to C.

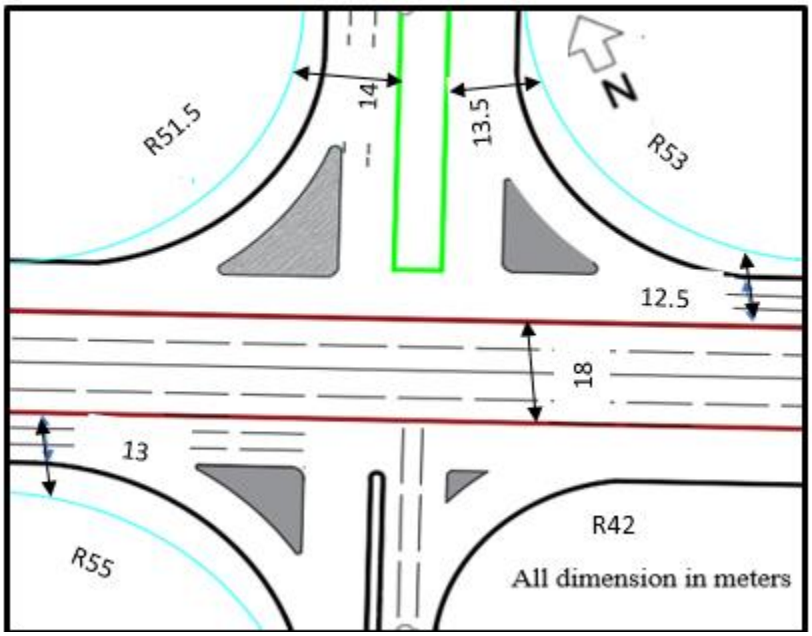


Figure (4-10) Improvement Proposal for Saif Saad Intersection.

The problem in Al-Stadium intersection was solved by remarking pavement of the west direction (left movement) from two to three lanes and this reduced the LOS to C.

4.7 Urban Streets Improvements

Level of service (LOS) was determined by the average travel speed of vehicles that travel straight in the urban street . The travel speed along a segment, section, or entire length of an urban street was dependent on the running speed between signalized intersections and the amount of control delay incurred at signalized intersections.

The selected area in this study consisted of rotations and intersections with light signals ,intersections without light signals and urban streets. Therefore, the delay was calculated by using the SIDRA INTERSECTION 7 and the geometric delay that was already connected to the roundabout.in this way by using (HCS+7FT) all the street that connected by roundabout could be evaluated and analyzed .The major inputs for the analysis of the urban street were the class of the street ,length of the street, the free flow speed and the value of average delay to through movement.

The process of adding a new lane or extending the pavement can be used to enhanced the level of service of urban streets ,but not all the streets have enough space to widen. As mentioned above, the purpose is to improve all the street sections, so using the value of the new delay which obtained after applying the improvement methods will be used as a common input for all the urban street segments for the purpose of prediction the amount of improvements. The whole results are illustrated in table (4-34).

Table (4-34) The Improvements for Urban Segments.

Segment Name	Average Free Flow Speed(k/hr)	Segment Length(m)	Street Class	Running Time(sec)	Control Delay(sec)	Travel Speed (Km/hr.)	Travel Time(sec)	LOS
From Al-Safeena to Sayed Jawda.	51	411	3	31	23.1	27.3	54.1	C
From Sayed Jawda to Police Central .	47	546	3	40.8	23.9	30.8	63.7	C
From Police Central Central to Saif Saad.	56	941	3	59.7	42.3	33.2	102	D
From Saif Saad to Stadium Interchange.	34	520	2	34.9	33	27.5	67.9	C
From Al-Safeena to Al-Satdium interchange.	49	1370	3	78	33.1	44.3	111.1	C
From police central to Sayed Jawda	46.6	551	3	31.4	18.2	29.12	49.5	C
From Sayed Jawda to Al-Safeena roundabout	51	412	3	31.4	31.2	23.2	62.6	C
From saif saad to police central	55	945	3	62	38	35	96	C

4.8 Summary

This chapter includes utilizes software (SIDRA 7,HCS+7FT,VISSIM 10) to evaluate the intersections and urban street , the results showed that the most intersection and urban street operate in worse LOS. Also this chapter include finding the the optimum cycle length for signalized intersection ,the result of optimum cycle showed that the signalized intersection operater in cycle length longer than the optimum cycle length .furthermore in this chapter the traffic signal warrant studies for intersections .

Chapter Five
Conclusions &
Recommendations

Chapter Five
Conclusions and Recommendations

5.1 Conclusions

Up on the geometric features and traffic limits of the study area ,the conclusions of this research are shown as follow :

1. By (HCS+7TF) computer program results showed that Sayed Jawda intersection needs traffic signal because more than one warrant satisfied.
2. The signalized intersection work in cycle length higher than the optimum cycle length.
3. Saturation flow rate for the Sayed Jawda intersection is 1976 vph ,for police central intersection is 1873 vphpg ,and for saif saad intersection is 1831vph.
4. Most intersection and roundabout suffered from high traffic volume and operate in worse LOS (F) this mean that have high delay.
5. The level of service (LOS) for street segments that result by computer software (HCS+7FT) showed that the most street segments operate at level of service (F).
6. The high delay in (Al-Safeena roundabout) enhanced by adding a new lane in each approach ,The performance of roundabout enhanced by an average of 78%.
7. In predicting of delay time at roundabout, circulating traffic volume, and entry radius have the most significant impact on total delay among other traffic and geometric parameters.
8. The increase of traffic volume cause increase in delay time. While, the increase in the geometric features dimension (width of circulatory road and the length weaving section) reduce the delay time, except entry radius which cause increase in delay time.

9. Changing the signalized intersection (Sayed Jawda) to roundabout in addition to pavement marking have given a great result.Pavement remarking enhanced the performance of intersection by 32 %. Changing the signalized intersection to roundabout enhanced the performance by an average of 72.5%.
10. Pavement widening, in addition to pavement marking improve MOE of the(police central and Saif Saad) intersections by an average of 62% and 80%.
11. When improve the intersection the urban street level of service improves and give a good result showed in (HCS+7TF).

5.2 Recommendations

1. The process of converting the the four leg signalized intersection to roundabout in urban area is necessary as in intersection (Sayed Jawda) because this type of control makes the speed low without stop .This point in urban street is very important to enhance the safety and aesthetic issue.
2. Use the local basic saturation flow instead of the basic saturation flow recommended by HCM
3. Make the signalized intersection works in optimum cycle length.

5.3 Recommendations for Future Research

1. Study of the traffic flow on the same study area after applying the improvement proposals, in order to get full-scale studies.
2. A planning study for Kerbala city, it is necessary to encourage more studies. This can be achieved by supporting researchers in terms of modern equipment supply that requires less manpower and provide data on different parameters of traffic engineering.
3. Using SIDRA NETWORK UPGRADE software to evaluate and analyze the street segments along with SIDRA INTERSECTION 7 to evaluate and analyze the intersections .

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APPENDIX-A-

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Sample of Traffic Volume Data

Sample of Traffic Volume Data

Sample of traffic volume data for Al-Safeena roundabout.

East	**Total**	**455**	**384**	**364**	**395**	**266**	**365**	**322**	**298**
	U-turn	13	9	7	11	5	7	8	12
	Left	71	71	60	62	27	32	36	25
	Through	288	220	215	242	135	246	191	180
	Right	83	84	82	80	99	80	87	81
West	**Total**	**198**	**240**	**223**	**258**	**157**	**146**	**139**	**143**
	U-turn	6	7	11	7	12	8	7	8
	Left	33	49	50	61	19	29	22	22
	Through	104	131	131	141	90	80	90	80
	Right	55	53	31	49	36	29	20	33
North	**Total**	**378**	**402**	**361**	**363**	**287**	**301**	**287**	**267**
	U-turn	8	11	9	9	13	14	9	11
	Left	43	68	57	62	42	62	61	91
	Through	116	127	115	113	98	113	116	110
	Right	211	196	180	179	134	112	101	55
South	**Total**	**388**	**304**	**285**	**296**	**393**	**329**	**310**	**307**
	U-turn	8	11	7	9	13	9	10	13
	Left	110	103	88	104	138	90	91	81
	Through	224	147	144	133	201	180	172	170
	Right	46	43	46	50	41	50	37	43
time		**7:30-7:45**	**7:45-8:00**	**8:00-8:15**	**8:15-8:30**	**8:30-8:45**	**8:45-9:00**	**9:00-9:15**	**9:15-9:30**

East	**Total**	**389**	**375**	**389**	**372**	**342**	**326**	**324**	**288**	**269**	**296**	**330**	**308**
	U-turn	12	11	8	11	11	13	7	8	9	12	13	8
	Left	68	56	69	68	76	57	64	41	33	68	75	77
	Through	242	230	243	231	207	197	193	182	196	173	201	187
	Right	67	78	69	62	48	59	60	57	31	43	41	36
West	**Total**	**184**	**153**	**158**	**151**	**143**	**156**	**185**	**170**	**161**	**129**	**177**	**189**
	U-turn	10	4	6	10	7	3	5	5	8	4	7	9
	Left	48	38	35	31	35	34	58	51	43	25	53	58
	Through	82	75	85	79	67	78	68	67	79	63	70	68
	Right	44	36	32	31	34	41	54	47	31	37	47	54
North	**Total**	**303**	**437**	**182**	**320**	**316**	**345**	**317**	**306**	**300**	**310**	**316**	**332**
	U-turn	9	8	11	7	11	17	13	8	9	8	7	7
	Left	36	35	47	41	78	79	69	68	47	53	63	77
	Through	72	93	83	88	62	76	68	58	81	82	72	74
	Right	186	301	41	184	165	173	167	172	163	167	174	174
South	**Total**	**345**	**320**	**307**	**279**	**262**	**257**	**233**	**236**	**248**	**320**	**307**	**315**
	U-turn	9	10	7	12	11	9	6	3	8	6	7	4
	Left	93	80	71	63	52	61	57	55	49	93	80	81
	Through	202	191	187	201	168	158	153	141	162	192	181	183
	Right	41	39	44	37	31	29	17	37	29	30	39	47
time		**13:30-13:45**	**13:45-14:00**	**14:00-14:15**	**14:15-14:30**	**14:30-14:45**	**14:45-15:00**	**15:00-15:15**	**15:15-15:30**	**15:30-15:45**	**15:45-16:00**	**16:00-16:15**	**16:15-16:30**

APPENDIX-B-

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Sample of Average Free Flow Speed for

Urban Street

Sample of Computed Average Free Flow Speed

Vehicle no.	First day	Second day	Third day	Forth day	Fifth day	Sixth day	Seventh day	Average day
1	50.89	49.32	51.33	53.54	47.55	51.32	49.33	50.45
2	44.35	50.22	45.33	49.43	52.33	53.34	55.65	50.11
3	51.23	48.46	49.36	52.67	53.87	46.89	51.66	50.59
4	55.34	49.38	51.59	52.49	45.61	53.19	53.46	51.58
5	47.38	51.96	52.93	50.12	50.59	52.45	52.39	51.11
6	52.48	50.67	48.73	50.28	47.29	47.54	49.17	49.39
7	51.39	48.48	50.29	51.36	51.97	50.36	51.94	50.827
8	50.88	52.85	47.92	51.16	52.13	53.45	48.93	51.04
9	48.23	52.19	48.32	53.31	48.29	49.99	52.89	50.46
10	52.12	49.71	51.62	48.94	57.12	42.18	53.41	50.62
11	54.27	51.76	47.32	52.22	49.37	51.38	49.47	50.82
12	53.78	46.87	51.45	51.38	48.98	47.32	52.49	50.324
13	52.45	52.11	47.43	53.39	45.98	50.48	50.17	50.28
14	58.31	52.59	51.2	52.2	51.36	47.32	54.78	52.53
15	52.43	55.41	47.32	44.38	46.49	49.32	49.59	49.27
16	57.32	54.46	51.44	48.82	57.71	52.19	51.39	53.33
17	48.29	53.26	46.39	46.89	45.39	49.51	51.34	48.724
18	55.45	51.49	48.21	48.91	47.74	51.2	58.7	51.67
19	49.52	51.32	54.34	56.33	51.34	48.29	55.83	52.377
20	48.54	45.32	53.21	52.18	51.89	50.54	49.32	50.077

APPENDIX-C-

Sample of SIDRA INTERSECTION 7 Output

Sample of SIDRA INTERSECTION 7 Output

SIDRA INTERSECTION software provides different output results in graphical and in tabular form. The main output for a sample used in present study for

1-Al-Safeena roundabout

MOVEMENT SUMMARY

Site: 101 [Site1]

Al-Safeena Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: RoadName											
3	L2	355	0.0	1.325	178.9	LOS F	79.4	603.7	1.00	4.43	15.7
8	T1	872	0.0	1.325	177.0	LOS F	79.4	603.7	1.00	4.28	15.6
18	R2	386	0.0	1.325	181.6	LOS F	68.1	517.5	1.00	4.07	15.2
Approach		1613	0.0	1.325	178.1	LOS F	79.4	603.7	1.00	4.27	15.5
East: RoadName											
1	L2	190	0.0	1.006	59.7	LOS F	22.3	169.1	1.00	2.19	31.0
6	T1	852	0.0	1.006	59.3	LOS F	22.3	169.1	1.00	2.16	30.6
16	R2	326	0.0	1.006	63.5	LOS F	20.3	154.1	1.00	2.12	29.5
Approach		1368	0.0	1.006	60.3	LOS F	22.3	169.1	1.00	2.15	30.4
North: RoadName											
7	L2	186	0.0	1.267	154.6	LOS F	69.8	530.3	1.00	4.26	17.6
4	T1	968	0.0	1.267	152.1	LOS F	69.8	530.3	1.00	4.10	17.4
14	R2	391	0.0	1.267	159.9	LOS F	55.1	418.7	1.00	3.71	16.7
Approach		1545	0.0	1.267	154.4	LOS F	69.8	530.3	1.00	4.02	17.2
West: RoadName											
5	L2	402	0.0	1.070	78.6	LOS F	35.6	270.5	1.00	2.72	27.0
2	T1	717	0.0	1.070	78.5	LOS F	35.6	270.5	1.00	2.66	26.6
12	R2	381	0.0	1.070	82.4	LOS F	30.7	233.5	1.00	2.57	25.6
Approach		1500	0.0	1.070	79.0	LOS F	35.6	270.5	1.00	2.65	26.5
All Vehicles		6026	0.0	1.325	120.4	LOS F	79.4	603.7	1.00	3.32	20.4

INTERSECTION SUMMARY

Site: 101 [Site1]

Al-Safeena

Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	20.4 km/h	20.4 km/h
Travel Distance (Total)	6264.8 veh-km/h	7517.7 pers-km/h
Travel Time (Total)	306.8 veh-h/h	368.1 pers-h/h
Demand Flows (Total)	6026 veh/h	7231 pers/h
Percent Heavy Vehicles (Demand)	0.0 %	
Degree of Saturation	1.326	
Practical Spare Capacity	-35.9 %	
Effective Intersection Capacity	4547 veh/h	
Control Delay (Total)	201.47 veh-h/h	241.77 pers-h/h
Control Delay (Average)	120.4 sec	120.4 sec
Control Delay (Worst Lane)	180.3 sec	
Control Delay (Worst Movement)	181.6 sec	181.6 sec
Geometric Delay (Average)	0.0 sec	
Stop-Line Delay (Average)	120.4 sec	
Idling Time (Average)	71.2 sec	
Intersection Level of Service (LOS)	LOS F	
95% Back of Queue - Vehicles (Worst Lane)	79.4 veh	
95% Back of Queue - Distance (Worst Lane)	603.7 m	
Queue Storage Ratio (Worst Lane)	0.49	
Total Effective Stops	20015 veh/h	24017 pers/h
Effective Stop Rate	3.32 per veh	3.32 per pers
Proportion Queued	1.00	1.00
Performance Index	641.1	641.1
Cost (Total)	4460.16 $/h	4460.16 $/h
Fuel Consumption (Total)	844.3 L/h	
Carbon Dioxide (Total)	1984.1 kg/h	
Hydrocarbons (Total)	0.203 kg/h	
Carbon Monoxide (Total)	2.114 kg/h	
NOx (Total)	0.606 kg/h	

LANE SUMMARY

Site: 101 [Site1]

Al-Safeena

Roundabout

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: RoadName													
Lane 1	874	0.0	659	1.325	100	176.2	LOS F	79.4	603.7	Full	500	0.0	10.9
Lane 2	739	0.0	558	1.325	100	180.3	LOS F	68.1	517.5	Full	500	0.0	6.0
Approach	1613	0.0		1.325		178.1	LOS F	79.4	603.7				
East: RoadName													
Lane 1	730	0.0	726	1.006	100	58.5	LOS F	22.3	169.1	Full	500	0.0	0.0
Lane 2	639	0.0	635	1.006	100	62.4	LOS F	20.3	154.1	Full	500	0.0	0.0
Approach	1368	0.0		1.006		60.3	LOS F	22.3	169.1				
North: RoadName													
Lane 1	872	0.0	689	1.267	100	151.4	LOS F	69.8	530.3	Full	500	0.0	6.8
Lane 2	672	0.0	531	1.267	100	158.2	LOS F	55.1	418.7	Full	500	0.0	0.0
Approach	1545	0.0		1.267		154.4	LOS F	69.8	530.3				
West: RoadName													
Lane 1	818	0.0	765	1.070	100	75.6	LOS F	35.6	270.5	Full	500	0.0	0.0
Lane 2	681	0.0	637	1.070	100	80.9	LOS F	30.7	233.5	Full	500	0.0	0.0
Approach	1500	0.0		1.070		78.0	LOS F	35.6	270.5				
Intersection	6026	0.0		1.325		120.4	LOS F	79.4	603.7				

2-Police Central intersection

MOVEMENT SUMMARY

Site: 101 [Site1]

New Site
Signals - Fixed Time Isolated Cycle Time = 128 seconds (User-Given Cycle Time)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: RoadName											
3u	U	59	0.0	0.582	43.2	LOS D	14.5	110.3	0.93	0.79	20.2
3	L2	193	0.0	0.582	43.2	LOS D	14.5	110.3	0.93	0.79	28.4
8	T1	917	0.0	1.056	103.8	LOS F	45.5	346.0	1.00	1.24	17.8
Approach		1169	0.0	1.056	90.7	LOS F	45.5	346.0	0.98	1.15	19.1
East: RoadName											
1u	U	49	0.0	0.421	45.1	LOS D	7.8	59.0	0.92	0.75	33.3
1	L2	187	0.0	0.421	45.0	LOS D	8.8	67.0	0.92	0.75	28.4
6	T1	222	0.0	0.421	45.0	LOS D	9.1	69.1	0.92	0.75	35.9
Approach		458	0.0	0.421	45.0	LOS D	9.1	69.1	0.92	0.75	32.8
North: RoadName											
7u	U	46	0.0	1.057	111.7	LOS F	30.6	232.3	1.00	1.09	20.5
7	L2	486	0.0	1.057	111.2	LOS F	32.2	244.6	1.00	1.13	20.8
4	T1	675	0.0	1.057	104.7	LOS F	44.6	338.6	1.00	1.24	17.6
Approach		1208	0.0	1.057	107.6	LOS F	44.6	338.6	1.00	1.19	19.1
West: RoadName											
5u	U	47	0.0	0.875	70.9	LOS E	21.4	162.6	1.00	0.94	27.0
5	L2	246	0.0	0.875	70.9	LOS E	21.4	162.6	1.00	0.94	27.2
2	T1	186	0.0	0.482	45.8	LOS D	10.7	81.0	0.93	0.77	36.0
Approach		479	0.0	0.875	61.1	LOS E	21.4	162.6	0.97	0.87	30.0
All Vehicles		3314	0.0	1.057	86.3	LOS F	45.5	346.0	0.98	1.07	21.9

INTERSECTION SUMMARY

Site: 101 [Site1]

New Site
Signals - Fixed Time Isolated   Cycle Time = 128 seconds (User-Given Cycle Time)

Intersection Performance - Hourly Values

Performance Measure	Vehicles	Pedestrians	Persons
Travel Speed (Average)	21.9 km/h	1.8 km/h	21.0 km/h
Travel Distance (Total)	2763.0 veh-km/h	13.2 ped-km/h	3328.8 pers-km/h
Travel Time (Total)	126.4 veh-h/h	7.2 ped-h/h	158.8 pers-h/h
Demand Flows (Total)	3314 veh/h	306 ped/h	4283 pers/h
Percent Heavy Vehicles (Demand)	0.0 %		
Degree of Saturation	1.057	0.105	
Practical Spare Capacity	-14.8 %		
Effective Intersection Capacity	3136 veh/h		
Control Delay (Total)	79.42 veh-h/h	4.37 ped-h/h	99.68 pers-h/h
Control Delay (Average)	86.3 sec	51.4 sec	83.8 sec
Control Delay (Worst Lane)	111.7 sec		
Control Delay (Worst Movement)	111.7 sec	55.5 sec	111.7 sec
Geometric Delay (Average)	0.0 sec		
Stop-Line Delay (Average)	86.3 sec		
Idling Time (Average)	80.5 sec		
Intersection Level of Service (LOS)	LOS F	LOS E	
95% Back of Queue - Vehicles (Worst Lane)	45.5 veh		
95% Back of Queue - Distance (Worst Lane)	346.0 m		
Queue Storage Ratio (Worst Lane)	1.06		
Total Effective Stops	3541 veh/h	275 ped/h	4524 pers/h
Effective Stop Rate	1.07 per veh	0.90 per ped	1.06 per pers
Proportion Queued	0.98	0.90	0.97
Performance Index	296.0	8.7	304.7
Cost (Total)	1832.10 $/h	74.81 $/h	1906.91 $/h
Fuel Consumption (Total)	360.4 L/h		
Carbon Dioxide (Total)	847.1 kg/h		
Hydrocarbons (Total)	0.087 kg/h		
Carbon Monoxide (Total)	0.949 kg/h		
NOx (Total)	0.258 kg/h		

LANE SUMMARY

Site: 101 [Site1]

New Site
Signals - Fixed Time Isolated   Cycle Time = 134 seconds (User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: RoadName													
Lane 1	296	0.4	252 [1]	1.174	100	159.7	LOS F	31.2	237.8	Short	60	0.0	NA
Lane 2	241	0.0	276 [1]	0.873	100	78.3	LOS E	18.3	139.0	Full	500	0.0	0.0
Lane 3	272	0.0	312	0.873	100	77.1	LOS E	20.9	158.6	Full	500	0.0	0.0
Approach	809	0.2		1.174		107.7	LOS F	31.2	237.8				
East: RoadName													
Lane 1	268	3.0	234 [1]	1.148	100	153.9	LOS F	27.7	215.6	Short	60	0.0	NA
Lane 2	262	3.0	245 [1]	1.070	100	130.1	LOS F	24.9	194.2	Full	500	0.0	0.0
Lane 3	309	3.0	289	1.070	100	125.6	LOS F	29.2	227.6	Full	500	0.0	0.0
Approach	840	3.0		1.148		136.1	LOS F	29.2	227.6				
North: RoadName													
Lane 1	507	3.0	426 [1]	1.189	100	144.7	LOS F	53.4	416.1	Short	60	0.0	NA
Lane 2	298	3.0	421 [1]	0.709	100	42.0	LOS D	17.6	137.0	Full	500	0.0	0.0
Lane 3	419	3.0	592	0.709	100	43.7	LOS D	26.1	203.7	Full	500	0.0	0.0
Approach	1224	3.0		1.189		85.1	LOS F	53.4	416.1				
West: RoadName													
Lane 1	360	3.0	308 [1]	1.168	100	148.7	LOS F	37.5	292.2	Short	60	0.0	NA
Lane 2	357	3.0	317 [1]	1.124	100	133.8	LOS F	35.5	276.8	Full	500	0.0	0.0
Lane 3	495	3.0	441	1.124	100	126.7	LOS F	48.8	380.0	Full	500	0.0	0.0
Approach	1212	3.0		1.168		135.3	LOS F	48.8	380.0				
Intersection	4085	2.4		1.189		114.9	LOS F	53.4	416.1				

3-Sayed Jawda intersection

INTERSECTION SUMMARY

Site: 101 [Site1]

New Site
Signals - Fixed Time Isolated   Cycle Time = 134 seconds (User-Given Cycle Time)

Intersection Performance - Hourly Values			
Performance Measure	**Vehicles**	**Pedestrians**	**Persons**
Travel Speed (Average)	20.6 km/h	1.8 km/h	20.2 km/h
Travel Distance (Total)	4170.1 veh-km/h	9.1 ped-km/h	5013.3 pers-km/h
Travel Time (Total)	202.7 veh-h/h	5.1 ped-h/h	248.4 pers-h/h
Demand Flows (Total)	4085 veh/h	217 ped/h	5119 pers/h
Percent Heavy Vehicles (Demand)	2.4 %		
Degree of Saturation	1.189	0.067	
Practical Spare Capacity	-24.3 %		
Effective Intersection Capacity	3434 veh/h		
Control Delay (Total)	130.42 veh-h/h	3.17 ped-h/h	159.67 pers-h/h
Control Delay (Average)	114.9 sec	52.5 sec	112.3 sec
Control Delay (Worst Lane)	159.7 sec		
Control Delay (Worst Movement)	159.7 sec	58.4 sec	159.7 sec
Geometric Delay (Average)	0.0 sec		
Stop-Line Delay (Average)	114.9 sec		
Idling Time (Average)	111.5 sec		
Intersection Level of Service (LOS)	LOS F	LOS E	
95% Back of Queue - Vehicles (Worst Lane)	53.4 veh		
95% Back of Queue - Distance (Worst Lane)	416.1 m		
Queue Storage Ratio (Worst Lane)	0.47		
Total Effective Stops	4555 veh/h	192 ped/h	5658 pers/h
Effective Stop Rate	1.12 per veh	0.88 per ped	1.11 per pers
Proportion Queued	0.98	0.88	0.98
Performance Index	693.9	6.2	700.1
Cost (Total)	2968.35 $/h	53.27 $/h	3021.63 $/h
Fuel Consumption (Total)	583.4 L/h		
Carbon Dioxide (Total)	1378.3 kg/h		
Hydrocarbons (Total)	0.143 kg/h		
Carbon Monoxide (Total)	1.531 kg/h		

MOVEMENT SUMMARY

Site: 101 [Site1]

New Site
Signals - Fixed Time Isolated   Cycle Time = 134 seconds (User-Given Cycle Time)

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: RoadName											
3u	U	43	3.0	1.174	159.7	LOS F	31.2	237.8	1.00	1.16	15.7
3	L2	252	0.0	1.174	159.7	LOS F	31.2	237.8	1.00	1.16	15.8
8	T1	513	0.0	0.873	77.7	LOS E	20.9	158.6	1.00	0.97	27.4
Approach		809	0.2	1.174	107.7	LOS F	31.2	237.8	1.00	1.04	21.6
East: RoadName											
1u	U	57	3.0	1.148	153.9	LOS F	27.7	215.6	1.00	1.14	16.2
1	L2	212	3.0	1.148	153.9	LOS F	27.7	215.6	1.00	1.14	16.2
6	T1	572	3.0	1.070	127.7	LOS F	29.2	227.6	1.00	1.19	19.6
Approach		840	3.0	1.148	136.1	LOS F	29.2	227.6	1.00	1.18	18.4
North: RoadName											
7u	U	48	3.0	1.189	144.7	LOS F	53.4	416.1	1.00	1.20	16.9
7	L2	459	3.0	1.189	144.7	LOS F	53.4	416.1	1.00	1.20	17.0
4	T1	717	3.0	0.709	43.0	LOS D	26.1	203.7	0.91	0.79	38.9
Approach		1224	3.0	1.189	85.1	LOS F	53.4	416.1	0.95	0.96	24.8
West: RoadName											
5u	U	57	3.0	1.168	148.7	LOS F	37.5	292.2	1.00	1.17	16.6
5	L2	303	3.0	1.168	148.7	LOS F	37.5	292.2	1.00	1.17	16.6
2	T1	852	3.0	1.124	129.7	LOS F	48.8	380.0	1.00	1.32	19.2
Approach		1212	3.0	1.168	135.3	LOS F	48.8	380.0	1.00	1.28	18.3
All Vehicles		4085	2.4	1.189	114.9	LOS F	53.4	416.1	0.98	1.12	20.6

LANE SUMMARY

Site: 101 [Site1]

New Site
Signals - Fixed Time Isolated Cycle Time = 128 seconds (User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: RoadName													
Lane 1	252	0.0	433	0.582	55[5]	43.2	LOS D	14.5	110.3	Short	60	0.0	NA
Lane 2	400	0.0	378[1]	1.056	100	106.9	LOS F	35.5	270.0	Full	200	0.0	32.4
Lane 3	518	0.0	490	1.056	100	101.4	LOS F	45.5	346.0	Full	200	0.0	55.5
Approach	1169	0.0		1.056		90.7	LOS F	45.5	346.0				
East: RoadName													
Lane 1	138	0.0	328	0.421	100	45.1	LOS D	7.8	59.0	Short	60	0.0	NA
Lane 2	158	0.0	374	0.421	100	45.0	LOS D	8.8	67.0	Full	500	0.0	0.0
Lane 3	162	0.0	386	0.421	100	45.0	LOS D	9.1	69.1	Full	500	0.0	0.0
Approach	458	0.0		0.421		45.0	LOS D	9.1	69.1				
North: RoadName													
Lane 1	342	0.0	323[1]	1.057	100	111.7	LOS F	30.6	232.3	Short	60	0.0	NA
Lane 2	360	0.0	341[1]	1.057	100	110.4	LOS F	32.2	244.6	Full	500	0.0	0.0
Lane 3	506	0.0	479	1.057	100	102.9	LOS F	44.6	338.6	Full	500	0.0	0.0
Approach	1208	0.0		1.057		107.6	LOS F	44.6	338.6				
West: RoadName													
Lane 1	293	0.0	335	0.875	100	70.9	LOS E	21.4	162.6	Full	500	0.0	0.0
Lane 2	186	0.0	386	0.482	55[5]	45.8	LOS D	10.7	81.0	Full	500	0.0	0.0
Approach	479	0.0		0.875		61.1	LOS E	21.4	162.6				
Intersection	3314	0.0		1.057		86.3	LOS F	45.5	346.0				

4-Saif Saad intersection

MOVEMENT SUMMARY

Site: 101 [Site1]

New Site
Signals - Fixed Time Isolated Cycle Time = 134 seconds (User-Given Cycle Time)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: RoadName											
3u	U	3	2.6	0.977	88.4	LOS F	25.6	199.1	0.97	0.99	23.9
3	L2	437	2.7	0.977	88.3	LOS F	25.8	201.8	0.97	1.02	24.2
8	T1	653	3.7	0.977	85.9	LOS F	37.5	293.6	0.99	1.11	25.7
Approach		1093	3.3	0.977	86.9	LOS F	37.5	293.6	0.98	1.08	25.0
East: RoadName											
1u	U	114	3.2	0.952	79.0	LOS E	27.9	218.3	1.00	0.99	25.3
1	L2	240	3.6	0.952	79.0	LOS E	27.9	218.3	1.00	0.99	25.5
6	T1	315	3.0	0.314	38.0	LOS D	8.2	64.0	0.83	0.69	38.9
Approach		670	3.2	0.952	59.7	LOS E	27.9	218.3	0.92	0.85	30.4
North: RoadName											
7u	U	114	2.9	0.758	66.6	LOS E	12.2	95.3	1.00	0.87	27.6
7	L2	159	3.2	0.758	65.1	LOS E	15.1	118.1	1.00	0.88	28.7
4	T1	332	3.9	0.758	64.1	LOS E	15.4	120.7	1.00	0.89	30.2
Approach		604	3.5	0.758	64.8	LOS E	15.4	120.7	1.00	0.88	29.3
West: RoadName											
5u	U	11	3.0	0.538	52.3	LOS D	9.6	74.5	0.96	0.79	31.2
5	L2	245	3.0	0.538	52.3	LOS D	9.9	77.5	0.96	0.79	31.6
2	T1	218	3.0	0.538	52.2	LOS D	10.3	79.9	0.96	0.79	33.5
Approach		474	3.0	0.538	52.2	LOS D	10.3	79.9	0.96	0.79	32.4
All Vehicles		2841	3.3	0.977	70.0	LOS E	37.5	293.6	0.97	0.93	28.1

INTERSECTION SUMMARY

Site: 101 [Site1]

New Site
Signals - Fixed Time Isolated   Cycle Time = 134 seconds (User-Given Cycle Time)

Intersection Performance - Hourly Values

Performance Measure	Vehicles	Pedestrians	Persons
Travel Speed (Average)	28.1 km/h	2.0 km/h	26.7 km/h
Travel Distance (Total)	2895.4 veh-km/h	13.7 ped-km/h	3488.2 pers-km/h
Travel Time (Total)	102.9 veh-h/h	7.0 ped-h/h	130.5 pers-h/h
Demand Flows (Total)	2841 veh/h	340 ped/h	3750 pers/h
Percent Heavy Vehicles (Demand)	3.3 %		
Degree of Saturation	0.977	0.105	
Practical Spare Capacity	-7.9 %		
Effective Intersection Capacity	2908 veh/h		
Control Delay (Total)	55.26 veh-h/h	4.05 ped-h/h	70.36 pers-h/h
Control Delay (Average)	70.0 sec	42.9 sec	67.5 sec
Control Delay (Worst Lane)	88.4 sec		
Control Delay (Worst Movement)	88.4 sec	58.5 sec	88.4 sec
Geometric Delay (Average)	0.0 sec		
Stop-Line Delay (Average)	70.0 sec		
Idling Time (Average)	64.4 sec		
Intersection Level of Service (LOS)	LOS E	LOS E	
95% Back of Queue - Vehicles (Worst Lane)	37.5 veh		
95% Back of Queue - Distance (Worst Lane)	293.6 m		
Queue Storage Ratio (Worst Lane)	0.36		
Total Effective Stops	2651 veh/h	286 ped/h	3468 pers/h
Effective Stop Rate	0.93 per veh	0.84 per ped	0.92 per pers
Proportion Queued	0.97	0.84	0.96
Performance Index	384.4	8.6	392.9
Cost (Total)	1509.54 $/h	72.54 $/h	1582.08 $/h
Fuel Consumption (Total)	363.6 L/h		
Carbon Dioxide (Total)	860.7 kg/h		
Hydrocarbons (Total)	0.085 kg/h		
Carbon Monoxide (Total)	1.002 kg/h		
NOx (Total)	1.302 kg/h		

LANE SUMMARY

Site: 101 [Site1]

New Site
Signals - Fixed Time Isolated   Cycle Time = 134 seconds (User-Given Cycle Time)

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: RoadName													
Lane 1	320	2.7	328 [1]	0.977	100	88.4	LOS F	25.6	199.1	Short	60	0.0	NA
Lane 2	324	3.3	332 [1]	0.977	100	88.0	LOS F	25.8	201.8	Full	500	0.0	0.0
Lane 3	449	3.7	459	0.977	100	85.0	LOS F	37.5	293.6	Full	500	0.0	0.0
Approach	1093	3.3		0.977		86.9	LOS F	37.5	293.6				
East: RoadName													
Lane 1	354	3.5	372 [1]	0.952	100	79.0	LOS E	27.9	218.3	Short	60	0.0	NA
Lane 2	158	3.0	502	0.314	100	38.0	LOS D	8.2	64.0	Full	500	0.0	0.0
Lane 3	158	3.0	502	0.314	100	38.0	LOS D	8.2	64.0	Full	500	0.0	0.0
Approach	670	3.2		0.952		59.7	LOS E	27.9	218.3				
North: RoadName													
Lane 1	172	3.0	227	0.758	100	66.6	LOS E	12.2	95.3	Short	60	0.0	NA
Lane 2	214	3.6	283	0.758	100	64.2	LOS E	15.1	118.1	Full	500	0.0	0.0
Lane 3	218	3.9	288	0.758	100	64.0	LOS E	15.4	120.7	Full	500	0.0	0.0
Approach	604	3.5		0.758		64.8	LOS E	15.4	120.7				
West: RoadName													
Lane 1	152	3.0	283	0.538	100	52.3	LOS D	9.6	74.5	Short	60	0.0	NA
Lane 2	158	3.0	294	0.538	100	52.2	LOS D	9.9	77.5	Full	500	0.0	0.0
Lane 3	163	3.0	304	0.538	100	52.2	LOS D	10.3	79.9	Full	500	0.0	0.0
Approach	474	3.0		0.538		52.2	LOS D	10.3	79.9				
Intersection	2841	3.3		0.977		70.0	LOS E	37.5	293.6				

APPENDIX-D-

.

Sample of (HCS+7FT) output

Sample of (HCS+7FT) output for

1-Al-Sayed Jawda intersection

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
L	1.07	0.17	55.5	1.000	280	0.50	74.0	0.0	129.5	F		
LT	1.42	0.17	55.5	1.000	598	0.50	200.8	0.0	256.3	F	223.2	F
Westbound												
L	0.86	0.15	55.7	1.000	243	0.50	31.2	0.0	86.9	F		
LT	1.09	0.15	57.0	1.000	521	0.50	65.5	0.0	122.5	F	112.9	F
Northbound												
L	0.61	0.26	43.5	1.000	408	0.50	6.7	0.0	50.2	D		
LT	0.55	0.26	42.7	1.000	925	0.50	2.3	0.0	45.0	D	46.7	D
Southbound												
L	0.96	0.33	44.1	1.000	474	0.50	32.1	0.0	76.2	E		
LT	0.61	0.33	37.8	1.000	1160	0.50	2.4	0.0	40.2	D	54.2	D

Intersection delay = 115.2 (sec/veh) Intersection LOS = F

2-Police Central intersection

Cycle Length: 128.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
LT	436	3103	1.09	0.14	123.6	F	123.6	F
Westbound								
L	216	1534	1.05	0.14	130.3	F		
LT	444	3344	0.56	0.13	57.1	E	91.9	F
Northbound								
L	360	1152	0.75	0.31	52.7	D		
LT	1059	3477	0.92	0.30	56.8	E	55.9	E
Southbound								
L	499	1637	1.24	0.30	168.1	F		
LT	1163	3916	0.62	0.30	41.2	D	99.8	F

Intersection Delay = 86.5 (sec/veh) Intersection LOS = F

3-Saif Saad intersection

Cycle Length: 134.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
L	287	1671	0.88	0.17	84.1	F		
LT	483	2813	0.90	0.17	77.2	E	79.7	E
Westbound								
L	496	1703	0.63	0.29	47.0	D		
LT	882	3029	0.61	0.29	44.1	D	45.2	D
Northbound								
L	453	1687	0.98	0.27	85.2	F		
LT	779	2901	0.99	0.27	78.4	E	80.9	F
Southbound								
L	297	1656	0.54	0.18	56.8	E		
LT	515	2877	1.05	0.18	109.8	F	97.7	F

Intersection Delay = 75.3 (sec/veh) Intersection LOS = E

APPENDIX-E-

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Sample of VISSIM 10 Outputs

Sample of VISSIM 10 Output

VISSIM 10 software provides different output results in graphical and in tabular form. The main output for a sample used in present study for

1-Al-Safeena Roundabout

Count: 1	SimRun	TimeInt	Movement	QLen	QLenMax	Vehs(All)	Pers(All)	LOS(All)	LOSVal(All)	VehDelay(All)	PersDelay(All)	StopDelay(All)	Stops(All)	EmissionsCO	EmissionsNOx	EmissionsVOC
1	142	0-3600	1 - 1: south	25.10	67.41	73	73	LOS_C	3	22.25	22.25	16.82	0.34	56.392	10.972	13.069
2	142	0-3600	1 - 1: south	27.97	91.43	131	131	LOS_C	3	23.08	23.08	17.49	0.39	99.929	19.442	23.159
3	142	0-3600	1 - 3: east@	52.52	151.71	31	31	LOS_E	5	78.12	78.12	63.17	1.26	62.015	12.066	14.372
4	142	0-3600	1 - 3: east@	61.85	105.45	86	86	LOS_D	4	48.83	48.83	43.27	0.48	102.398	19.923	23.732
5	142	0-3600	1 - 3: east@	47.23	77.99	30	30	LOS_C	3	26.20	26.20	16.83	0.60	26.122	5.082	6.054
6	142	0-3600	1 - 5: west	62.16	91.94	44	44	LOS_D	4	49.34	49.34	44.51	0.36	50.010	9.730	11.590
7	142	0-3600	1 - 5: west	62.16	91.94	28	28	LOS_F	6	152.29	152.29	137.19	1.54	89.051	17.326	20.638
8	142	0-3600	1 - 8: north	49.57	56.65	9	9	LOS_F	6	209.42	209.42	185.75	2.78	40.362	7.853	9.354
9	142	0-3600	1 - 8: north	49.57	56.65	20	20	LOS_F	6	92.01	92.01	80.90	1.30	42.364	8.242	9.818

2-Sayed Jawda intersection

1 - 1: weast	79.00	107.97	0	0	LOS_A									
1 - 1: weast	79.00	107.97	138	138	LOS_F	6	93.66	93.66	80.22	0.91	284.427	55.339	65.919	4.069
1 - 3: east t	50.95	113.33	104	104	LOS_D	4	53.51	53.51	50.72	0.28	123.113	23.953	28.533	1.761
1 - 3: east t	50.95	113.33	35	35	LOS_E	5	78.08	78.08	73.42	0.46	56.516	10.996	13.098	0.809
1 - 5: sa@7	0.12	15.45	156	156	LOS_A	1	4.46	4.46	0.11	0.15	56.035	10.902	12.987	0.802
1 - 6: south	62.68	85.81	36	36	LOS_E	5	73.31	73.31	69.65	0.36	52.780	10.269	12.232	0.755
1 - 6: south	62.68	85.81	68	68	LOS_E	5	75.38	75.38	70.63	0.51	105.547	20.536	24.462	1.510
1 - 7@57.0	0.00	0.00	107	107	LOS_A	1	0.08	0.08	0.00	0.00	19.680	3.829	4.561	0.282
1 - 9@78.1	0.00	0.00	158	158	LOS_A	1	0.12	0.12	0.00	0.00	35.044	6.818	8.122	0.501
1 - 10: nort	49.16	56.55	29	29	LOS_F	6	140.83	140.83	128.30	1.31	83.235	16.195	19.291	1.191
1 - 10: nort	49.16	56.55	11	11	LOS_F	6	189.11	189.11	175.80	1.27	38.832	7.555	9.000	0.556

3-Police Central intersection

Count: 17	SimRun	TimeInt	Movement	QLen	QLenMax	Vehs(All)	Pers(All)	LOS(All)	LOSVal(All)	VehDelay(All)	PersDelay(All)	StopDelay(All)	Stops(All)	EmissionsCO	EmissionsNOx
1	31	0-3600	1 - 1: NORTH@53.1 -	27.44	70.09	11	11	LOS_D	4	48.13	48.13	37.69	1.27	15.684	3.052
2	31	0-3600	1 - 1: NORTH@53.1 -	27.44	70.09	64	64	LOS_C	3	29.30	29.30	22.75	0.63	58.418	11.366
3	31	0-3600	1 - 1: NORTH@53.1 -	27.44	70.09	11	11	LOS_C	3	30.11	30.11	24.57	0.73	10.002	1.946
4	31	0-3600	1 - 1: NORTH@53.1 -	27.44	70.09	118	118	LOS_C	3	31.75	31.75	24.37	0.71	117.351	22.832
5	31	0-3600	1 - 4: south@80.2 - 2	46.90	92.68	123	123	LOS_E	5	60.90	60.90	52.37	0.85	185.918	36.173
6	31	0-3600	1 - 4: south@80.2 - 6	46.90	92.68	12	12	LOS_E	5	77.76	77.76	67.15	1.17	22.362	4.351
7	31	0-3600	1 - 4: south@80.2 - 7	46.90	92.68	24	24	LOS_E	5	55.76	55.76	48.23	0.83	34.026	6.620
8	31	0-3600	1 - 5@85.8 - 11@15.	0.00	0.00	64	64	LOS_A	1	0.08	0.08	0.00	0.00	13.115	2.552
9	31	0-3600	1 - 8: west@49.1 - 2	44.72	69.70	66	66	LOS_E	5	64.44	64.44	57.35	0.77	98.092	19.085
10	31	0-3600	1 - 8: west@49.1 - 7	44.72	69.70	4	4	LOS_F	6	93.50	93.50	84.60	1.00	7.782	1.514
11	31	0-3600	1 - 8: west@49.1 - 1	44.72	69.70	44	44	LOS_E	5	62.04	62.04	55.82	0.70	61.498	11.965
12	31	0-3600	1 - 9: east@55.6 - 6	31.32	71.39	45	45	LOS_E	5	66.51	66.51	57.99	0.89	70.787	13.773
13	31	0-3600	1 - 9: east@55.6 - 7	31.32	71.39	55	55	LOS_E	5	61.32	61.32	53.36	0.87	81.258	15.810
14	31	0-3600	1 - 9: east@55.6 - 11	31.32	71.39	3	3	LOS_F	6	95.83	95.83	86.97	1.00	5.935	1.155

4-Saif Saad intersection

2	0-3600	1 - 3: east@66.0 - 2@40.3	54.53	104.04	1	1	LOS_F	6	87.32	87.32	77.19	1.00	2.023	0.394	0.469	0.029
3	0-3600	1 - 3: east@66.0 - 5@31.3	54.53	104.04	103	103	LOS_D	4	47.56	47.56	41.17	0.69	134.006	26.073	31.057	1.917
4	0-3600	1 - 3: east@66.0 - 7@39.9	54.53	104.04	95	95	LOS_D	4	40.19	40.19	34.82	0.58	107.975	21.008	25.024	1.545
5	0-3600	1 - 4: south@73.2 - 5@31.3	56.52	104.19	4	4	LOS_D	4	49.77	49.77	41.53	0.75	5.223	1.016	1.211	0.075
6	0-3600	1 - 4: south@73.2 - 7@39.9	56.52	104.19	79	79	LOS_D	4	46.93	46.93	40.67	0.71	102.175	19.879	23.680	1.462
7	0-3600	1 - 4: south@73.2 - 9@68.9	56.52	104.19	122	122	LOS_D	4	43.02	43.02	36.12	0.74	159.556	31.044	36.979	2.283
8	0-3600	1 - 6: weast@63.3 - 2@40.3	24.11	72.52	44	44	LOS_D	4	50.14	50.14	40.34	0.91	62.874	12.233	14.572	0.899
9	0-3600	1 - 6: weast@63.3 - 7@39.9	24.11	72.52	0	0	LOS_A									
10	0-3600	1 - 6: weast@63.3 - 9@68.9	24.11	72.52	26	26	LOS_D	4	50.83	50.83	41.02	0.92	39.436	7.673	9.140	0.564
11	0-3600	1 - 8: north@57.2 - 2@40.3	41.19	123.35	1	1	LOS_F	6	104.94	104.94	91.63	1.00	2.247	0.437	0.521	0.032
12	0-3600	1 - 8: north@57.2 - 5@31.3	41.19	123.35	96	96	LOS_D	4	52.14	52.14	43.25	0.88	141.478	27.527	32.789	2.024
13	0-3600	1 - 8: north@57.2 - 9@68.9	41.19	123.35	21	21	LOS_D	4	54.53	54.53	45.25	0.95	32.939	6.409	7.634	0.471

5-Satadium intersection

TimeInt	Movement	QLen	QLenMax	Vehs(All)	Pers(All)	LOS(All)	LOSVal(All)	VehDelay(All)	PersDelay(All)	StopDelay(All)	Stops(All)	EmissionsCO	EmissionsNOx	EmissionsVOC	FuelConsumption
0-3600	1 - 2: north th@50.	51.61	70.10	44	44	LOS_D	4	33.52	33.52	11.94	2.20	98.476	19.160	22.823	1.409
0-3600	1 - 2: north th@50.	51.61	70.10	52	52	LOS_D	4	32.46	32.46	12.27	2.15	84.010	16.345	19.470	1.202
0-3600	1 - 4: east@281.7 -	0.00	0.00	106	106	LOS_A	1	0.20	0.20	0.00	0.00	87.083	16.943	20.182	1.246
0-3600	1 - 4: east@281.7 -	0.00	0.00	0	0	LOS_A									
0-3600	1 - 4: east@281.7 -	0.00	0.00	55	55	LOS_B	2	10.16	10.16	2.76	0.84	81.195	15.798	18.818	1.162
0-3600	1 - 4: east@281.7 -	0.00	0.00	0	0	LOS_A									
0-3600	1 - 5@116.7 - 1@1	0.13	8.16	162	162	LOS_A	1	2.94	2.94	0.11	0.18	95.878	18.654	22.221	1.372
0-3600	1 - 8@22.5 - 8@41	0.00	0.00	93	93	LOS_A	1	0.09	0.09	0.00	0.00	65.361	12.717	15.148	0.935
0-3600	1 - 8@22.5 - 12@2	0.00	0.00	79	79	LOS_A	1	0.01	0.01	0.00	0.00	37.633	7.322	8.722	0.538
0-3600	1 - 9: west th@19.8	189.35	273.95	158	158	LOS_F	6	85.95	85.95	33.07	4.42	605.116	117.734	140.242	8.657
0-3600	1 - 10: south th@6	0.00	0.00	136	136	LOS_A	1	2.07	2.07	0.45	0.14	77.488	15.076	17.959	1.109
0-3600	1 - 10: south th@6	0.00	0.00	82	82	LOS_A	1	0.12	0.12	0.00	0.00	27.027	5.259	6.264	0.387
0-3600	1 - 10004@96.0 - 1	0.00	0.00	0	0	LOS_A									
0-3600	1	30.14	273.95	1207	1207	LOS_C	3	19.56	19.56	6.81	1.12	1644.952	320.048	381.234	23.533

الخلاصه

في ظل نظام حركة المرور المحليه ، يصعب تحليل النظام المرور وتحسينه لأنه نظام معقد ذو طبيعة عشوائية وديناميكية. ان مدينه كربلاء المقدسة هي مدينة مهمة في العراق لأنها مشهورة في العالم الإسلامي. مدينة كربلاء هي مركز محافظة كربلاء. تشتهر هذه المدينة بالعالم الإسلامي بسبب مظهرها الديني و ازدياد اعداد الزائرين الى مدينه كربلاء ، ونمو السكان المتزايد ، وزيادة عدد رحلات المركبات ، بالإضافة إلى ازدهار مراكز التسوق والمقاهي وغيرها من الأنشطة ، يتسبب في زيادة عدد الرحلات اليومية في معظم الشوارع والتقاطعات خاصة خلال ساعات الذروة . تهدف هذه الدراسة إلى تقييم الأداء المروري في منطقة مختارة في شبكة الطرق ، من خلال تقييم أداء التقاطعات وأداء الشوارع الحضرية وفقًا لشبكة مختارة. وكذلك تهدف الدراسه الى تطبيق معايير لمعرفه فيما اذا التقاطع يحتاج الى اشارة ضوئيه او لا بالاضافه الى ايجاد طول الدورة للاشارة الضوئيه التي تحقق اقل تاخير يلي ذلك بعض المقترحات لتحسين مستوى الخدمه ، والتي تختلف من التحسين الهندسي ، لتغيير نوع التقاطع بشكل كامل. تتكون منطقة الدراسة من أربعة تقاطعات ودوار واحد مرتبط بمختلف الشوارع الحضرية.

لتقييم التقاطعات ذات الاشارة الضوئيه وبدون لاشارة والدوارات تم استخدام برنامج VISSIM.

لتقييم وتحليل كل من التقاطعات و والدوارات تم استخدام برنامجSIDRA INTERSECTION.

لتقييم وتحليل التقاطعات والشوارع الحضرية تم استخدام برنامج2010 (HCS + 7FT).

تظهر النتائج أن معظم التقاطعات بالإضافة إلى قطاعات الشوارع تعمل بمستوى الخدمة(LOS F).

من خلال النتائج تبين بان تقاطع سيد جوده ومركز شرطه حي الحسين وسيف سعد تنطبق عليها المحددات لتنصيب اشارة ضوئيه.

لقد تم اقتراح عدة تحسينات لتحسن مستوى الخدمه تتباين المقترحات هذه من تعريض رصيف لفلكه السفينه .بينما تحسن التقاطع (2) عن طريق تغيير التقاطع إلى الدوران ، وتحسن التقاطع (3 ، 4 و 5) بتوسيع الأرصفة وقد تم تقييم الشوارع الحضرية على أساس قيمة التأخير الجديدة بعد التحسينات من خلال الحركات ، وتحسنت إلى مستوى الخدمة المقبولة.

جمهورية العراق
وزارة التعليم العالي والبحث العلمي
جامعة كربلاء / كلية الهندسة
قسم الهندسة المدنية

تقييم الاداء المروري لمنطقه مختارة من شبكه النقل في مدينه كربلاء

رسالة مقدمة الى

قسم الهندسة المدنية في كلية الهندسة/ جامعة كربلاء

كجزء من متطلبات نيل شهادة الماجستير في علوم الهندسة المدنية – هندسة البنى التحتية

من قبل :

هدى مجيد فتلاوي

(بكلوريوس في الهندسة المدنية – 2015)

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