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EVALUATION OF TRAFFIC OPERATION AT KUFA – NAJAF ROADWAY

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٢٠٠٧

بسم الله الرحمن الرحيم

وأن ليس للإنسان إلا ما سعى ۝ وأن سعيه سوف يرى ۝ ثم

يجزاه الجزاء الأوفى ۝

صدق الله العلي العظيم

النجم

(٣٩ - ٤٠)

TO ALL

WHOM

I LOVE

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MANAR

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NOTATIONS

A.M. : Ante Meridian .

HCM ٢٠٠٠ : Highway Capacity Manual ٢٠٠٠ .

FHWA : Federal Highway Administration .

L.O.S : Level of Service .

M.O.Es : Measures of effectiveness .

SPSS : Statistical Package for Social Sciences .

ANOVA : Analysis of Variances .

TRANSYT : Traffic Network System Tool .

ARTSD : Arterial or section average travel speed, in (mph) .

C : Cycle time, in (sec) .

c : Capacity, in (veh/hr) .

d : Control delay, in (sec/veh) .

d ١ : Uniform delay, in (sec/veh) .

d ٢ : Incremental delay, in (sec/veh) .

d ٣ : Residual demand delay to account for over-saturation queues that may have existed before the analysis period, in (sec/veh) .

d_o : Total delay by TRANSYT-٧F model, in (veh-hr/hr) .

d_u : Uniform delay by TRANSYT-F model, in (veh-hr/hr) .

d_{rs} : Random and saturation delay by TRANSYT-٧F model, in (veh-hr/hr) .

D : intersection approach delay, in (sec/veh) .

DHV : Design hourly volume, in (pcu) .

f_p: Supplemental adjustment factor when the platoon arriving during the green .

g : Effective green time, in (sec) .

G : Green time, in (sec) .

h : Average discharge headway of all queued vehicles beginning with third vehicles, in (sec) .

I : Upstream filtering / metering adjustment factor .

K : Incremental delay factor dependent on signal controller setting .

k : Density, in (veh/km) .

L : Length of the highway segment, in (km) .

l : Number of lanes .

m_t : Queue length during step t .

n : Number of steps in the cycle .

N : Number of observations .

PF : Progression adjustment factor .

P : Proportion of vehicles arriving during the green interval .

PCU's : Passenger car equivalent factor .

q_t : Number of vehicles arriving in interval t .

q : Flow, in (veh/ hr) .

Rp : Platoon ratio .

R : Total number of vehicles in the queue .

S : Saturation flow rate, in (vphg) .

S_t : Number of vehicles allowed to leave in interval t .

T : Duration of analysis, in (hrs) .

t_i : Travel time of the ith vehicle to traverse the section, in (hr) .

t_r : The time required to discharge the queued vehicle starting with fourth vehicle, in (sec) .

u : Speed, in (km/hr) .

u_i : Spot speed of vehicle i, in (km/hr) .

***u_s*:** Space mean speed, in (km/hr) .

u_t : Time mean speed, in (km/hr) .

v : Rate of flow, in (veh/hr) .

V : The one-half peak hourly volume multiplied by two, in (vph) .

***V_i*:** Volume on the link .

X : Degree of saturation $= v/c$.

Y : Yellow interval, in (sec) .

y_i : Initial queue at the start of the analysis period .

$\sum$ ***TIAD*** : Summation of the total of the approach delay at all intersection along the arterial or section, in (sec) .

σ_s : The variance about the space mean speed .

% Truck : Percentage of trucks .

CHAPTER ONE

INTRODUCTION

١.١: Introduction

Arterials in any city, especially in religious tourism cities like Najaf and Kufa, are considered as important channels for transportation. Kufa-Najaf arterial was selected for this study which was suffering from traffic congestion that is one of the major problems in Iraq especially after ٩ April ٢٠٠٣; where many thousands of vehicles have been imported to Iraq without any evaluation studies for roads and intersections .

The arterials are the main features of the transport networks. They are defined as facilities with signalized intersections that serve the through movements and provide access to the abutting properties **[Everett & Wolfgang, ١٩٧٨]**. The traffic condition and geometric characteristics of the arterial restrict the motion of the vehicle along the arterials. Traffic flow interference may be caused by weather conditions, cross traffic, an accident, or other marginal conditions. Interference to traffic flow by one or more of these conditions causes reduction in speed, closer vehicle spacing, and greater density **[Pignataro, ١٩٧٣].**

Geometric characteristics, traffic composition, free flow speed, type of terrain, weather conditions, etc. are the main factors influencing speed-flow relationship **[AASHTO, ١٩٩٤]**. The geometric characteristics of the arterial are very important. The existence and number of signalized intersections along the arterial are important factors, which restricted the motion of the vehicle. The signal timing and sequence phasing of the signalized intersection will affect the entering traffic volume of the arterial.

١.٢: Research Objectives

The main objectives of this work are evaluating the measures of effectiveness of the selected roadway using TRANSYT-٧F (٢٠٠٢) and HCS (٢٠٠٠) software programs and make alternatives to improve its performance.

١.٣: Methodology

The following methodology was adopted through the research:

***Step ١*:** Selection of the suitable method for data collection.

Step ٢: Comprehensive survey to determine the peak hours to collect the necessary field data (speed and volume) during the selected observation intervals.

Step ٣: Determine the percentage of heavy vehicles (minibus & truck).

Step ٤: Select the suitable passenger car equivalent factors (PCU's), depending on level terrain, for two types of vehicles (minibus & truck) which commonly used in the chosen arterial.

Step ٥: Reduction and analysis of the collected data.

Step ٦: Evaluation the level of service of the selected arterial by using HCS (٢٠٠٠) and TRANSYT-٧F (٢٠٠٢) software packages and make six alternatives to improve the measures of effectiveness of the arterial.

١.٤: Research Structure

This study is conducted in a number of stages, which are described in the chapters of this thesis. This research is structured as follows:

Chapter one: Introduction.

This chapter contains the objectives of the study, the methodology and the structure of the research.

Chapter Two: Literature Review.

Description of some models for estimating delay at both signalized intersection and arterial, and various types of simulation software that used in this study are presented in this chapter.

Chapter Three: Data Collection.

This chapter is concerned with the selection of survey sites, study sections, and methods for the collection and abstraction of the required data.

Chapter Four: Data Reduction and Analysis.

The operations performed on the raw data to obtain a set that was considered suitable for analysis, and the evaluation of the selected arterial by TRANSYT-٧F (٢٠٠٢) and HCS (٢٠٠٠) software have been presented in this chapter.

Chapter Five: Conclusions

The overall research conclusions are reported in this chapter.

CHAPTER TWO

LITERATURE REVIEW

٢.١: Introduction

This chapter is consisted of two sections. The first section includes the description of some models for estimating delay at both signalized intersections and arterials. This presentation is followed by an overview of various types of simulation models that will be used in the evaluating the measures of effectiveness of the arterial under study and other adopted programs.

٢.٢: Delay Estimation Models

Delay time is a major factor in the analysis of congestion **[Drew, ١٩٦٧]**. It could be defined as the lost travel time because of traffic frictions and traffic control devices. The delay time consists of two components, the first is the fixed delay which is caused by traffic control devices (traffic signals, stops signs, yield signs, and railroad crossings) and the second is the operational delay which is caused by interference between components of traffic **[Pignataro, ١٩٧٣]** .

٢.٢.١: Delay Estimation Models at Isolated Signalized Intersection

The delays experienced on the arterials are mainly associated with the signalized intersection where conflicting movements are separated and controlled by traffic signals. Delay is a key parameter in computing the level of service provided to motorists at signalized intersection.

Average stopped delay can be defined as the total stopped delay experienced by all vehicles arriving during a designated period divided by the total volume of vehicles arriving during the same period. The stopped delay is the time an individual vehicle spends stopped in a queue while waiting to enter an intersection **[Everett & Wolfgang, ١٩٧٨]**.

Delay at an intersection is categorized as uniform, random, and oversaturated delays **[Kimber & Hollies, ١٩٧٨]**. If demand is less than capacity and vehicles arrive uniformly at a constant rate, this type of delay is referred to as uniform delay. The random delay is accounted for the randomness in arrivals between cycles because the arrival patterns of traffic flow are more likely to be random. The over-saturation delay is accounted for the delay when the demand exceeds capacity over along time interval.

٢.٢.١.١: HCM Model (٢٠٠٠)

After release of the Highway Capacity Manual (١٩٩٤), numerous researches has been undertaken to assess the changes that were made in the delay estimated model with respect to the (١٩٨٥) version of the manual. Fambro and Rouphail proposed a generalized delay model that corrected some of the problems found in the HCM model (١٩٩٤) **[Fambro & Rouphail, ١٩٩٧]**.

In the HCM (٢٠٠٠), the average delay per vehicle for a lane group is given by the following Equations:

$$d = d_1 \times PF + d_2 + d_3 \quad \text{...........} \ (٢.١)$$

$$d_1 = 0.5C \frac{\left(1-\frac{g}{C}\right)^2}{\left(1-Min(1,X)\frac{g}{C}\right)} \quad \text{.............} \ (٢.٢)$$

$$d_2 = 900T\left[(X-1)+\sqrt{(X-1)^2+\frac{8KIX}{cT}}\right] \ \text{........} \ (٢.٣)$$

The progression adjustment factor (PF), applies to all coordinated lane groups, whether the control is pretimed or no actuated in a semi actuated system. Progression primarily affects uniform delay; for this reason, the adjustment is applied only to d_1. The value of PF may be determined by the following Equation:

$$PF = \frac{(1-P)f_p}{1-\frac{g}{C}} \quad \text{.........} \ (٢.٤)$$

Where

d = control delay, in (sec/veh);

d_1 = uniform delay, in (sec/veh);

d_2 = incremental delay, in (sec/veh);

d_3 = residual demand delay to account for over-saturation queues that may have existed before the analysis period, in (sec/veh);

C = cycle time, in (sec);

g = effective green time, in (sec);

X = degree of saturation, (v/c);

v = rate of flow, in (veh/hr);

c = capacity for lane group; in (veh/hr);

PF = progression adjustment factor;

K = incremental delay factor dependent on signal controller setting (٠.٥٠ for pretimed signals; vary between ٠.٠٤ to ٠.٥٠ for actuated controllers);

I = upstream filtering/metering adjustment factor (١.٠ for an isolated intersection);

T = duration of analysis period, in (hr);

P = proportion of vehicles arriving during the green interval; and

f_p =supplemental adjustment factor when the platoon arriving during the green, taken from Table (٢.١).

Five arrival types were defined based on the platoon ratio (Rp) which was the ratio of percent vehicles arriving on green to the green ratio of the movement. According to Table (٢.١), the platoon ratio (Rp) ranges from ٠.٣٣٣ to ٢.٠٠٠, increasing in platoon ratios or increasing arrival type number indicates a decrease in the progression. The arrival type number was derived on the basis of whether the front of the platoon arrived during the first, middle, or the last third of the green or red periods.

There are three cases for estimating the term d٣:

١) d٣= ٠ …………..(٢.٥)

If there is no over-saturation queue exists at the start analysis periods.

٢) $$d_3 = \left[\frac{3600\, y_i}{c}\right]\left[\frac{0.5\, y_i}{Tc}\,(1-X)\right]$$ ……… (٢.٦)

If an over-saturation queue is presented at the start, but not at the end of the analysis period.

٣) $d_3 = \left[\frac{3600\, y_i}{c}\right] - 1800T\left[1 - Min(X,1)\right]$...... (٢.٧)

If an over-saturation exists at both start and end of the analysis period.

y_i = initial queue at the start of the analysis period .

Table (٢.١): Progression Adjustment Factors for Uniform Delay Calculation [HCM, ٢٠٠٠]

PROGRESSION ADJUSTMENT FACTOR (*PF*)						
Green Ratio	Arrival Type (AT)					
	AT-١	AT-٢	AT-٣	AT-٤	AT-٥	AT-٦
٠.٢٠	١.١٦٧	١.٠٠٧	١.٠٠٠	١.٠٠٠	٠.٨٣٣	٠.٧٥٠
٠.٣٠	١.٢٨٦	١.٠٦٣	١.٠٠٠	٠.٩٨٦	٠.٧١٤	٠.٥٧١
٠.٤٠	١.٤٤٥	١.١٣٦	١.٠٠٠	٠.٨٩٥	٠.٥٥٥	٠.٣٣٣
٠.٥٠	١.٦٦٧	١.٢٤٠	١.٠٠٠	٠.٧٦٧	٠.٣٣٣	٠.٠٠٠
٠.٦٠	٢.٠٠١	١.٣٩٥	١.٠٠٠	٠.٥٧٦	٠.٠٠٠	٠.٠٠٠
٠.٧٠	٢.٥٥٦	١.٦٥٣	١.٠٠٠	٠.٢٥٦	٠.٠٠٠	٠.٠٠٠
Default *fp*	١.٠٠	٠.٩٣	١.٠٠	١.١٥	١.٠٠	١.٠٠
Default Rp	٠.٣٣٣	٠.٦٦٧	١.٠٠٠	١.٣٣٣	١.٦٦٧	٢.٠٠

٢.٢.١.٢ TRANSYT-٧F (٢٠٠٢)

TRANSYT-٧F (٢٠٠٢) estimates delay as follows :

$$d_o = d_u + d_{rs} \qquad \text{……………(٢.٨)}$$

Where

d_o = total delay, in (veh-hr/hr);

d_u = uniform delay, in (veh-hr/hr);

d_{rs} = random and saturation delay, in (veh-hr/hr).

$$d_u = \frac{C}{3600\,n^2}\sum_t^n m_t \qquad \text{…………….(٢.٩)}$$

$$m_t = \max\left[\left(m_{t-1} + q_t - s_t\right),(0)\right] \qquad \text{………(٢.١٠)}$$

Where

m_t = queue length during step t

n = number of steps in the cycle.

q_t = number of vehicles arriving in interval t;

s_t = number of vehicles allowed to leave in interval t.

TRANSYT computes the combine effect of random delay and saturation delay using an algorithm which is as follows :

$$d_{rs} = \left[\left(\frac{B_n}{B_d}\right)^2 + \frac{X^2}{B_d}\right]^{1/2} - \frac{B_n}{B_d} \qquad \text{…………(٢.١١)}$$

$$B_n = 2(1 - X) + XZ$$

…………………………….(٢.١٢)

$$B_d = 4Z - Z^2 \qquad \text{…………………(٢.١٣)}$$

$$Z = \frac{\left(2X/V_i\right) \times 60}{T} \qquad \text{………………….(٢.١٤)}$$

V_i = volume on the link;

T = period length, normally ٦٠ minutes.

It is important to note that the random and saturation delay is primarily a function of the degree of saturation and the period length. When the degree of saturation exceeds ١.٠ (١٠٠٪), the random and saturation delay increases very rapidly as the period length increases.

٢.٢.٢: Delay Estimation Models at Arterials

Urban and suburban arterials are defined as facilities with signalized intersections that primarily serve through traffic **[HCM, ٢٠٠٠]**. The length of the arterial should be at least (١.٥ km) in downtown areas and (٣ km) in other areas with a signalized intersections spacing of (٣ km) or less and the turning movement intersections should not exceed ٢٠٪ of the total traffic volumes **[HCM, ٢٠٠٠].**

٢.٢.٢.١: The Highway Capacity Manual (HCM ٢٠٠٠)

(HCM-٢٠٠٠) Divided the arterial into segments, each segment is one directional distance from one signalized intersection to the next. Some consecutive segments are combining into a section when they have the same arterial class, segment length, speed limit, general land use and activity. The average travel speed of all through vehicles on the arterial was used to measure the level of service (LOS) of the arterial. The average travel speed is computed as follows:

$$ARTSPD = \frac{3600 \times Length}{[(RunningTime) \times Length + \sum TIAD]} \text{ .... (٢.١٥)}$$

Where

ARTSPD =arterial or section average travel speed, in (mph);

Length =arterial or section length, in (miles);

Running Time =total of the running time per mile on all segments in the arterial or section, in (sec); and

$\sum TIAD$ =summation of the total of the approach delay at all intersections along the arterial or section, in (sec).

The intersection total approach delay was estimated using delay model for the isolated signalized intersection as follow:

$$D = ١.٣\, d \qquad \text{................. (٢.١٦)}$$

Where

D =intersection approach delay, in (sec/veh); and

The d is computed according to Equation (٢.١). The arterial is classified into functional and design categories to special criterions as shown in Table (٢.٢). Then according to those categories the arterial is further classified into principal and minor arterials as shown in Table (٢.٣).

The running time in Equation (٢.١٥) is estimated according to arterial class, segment length, and the free flow speed as shown in Table (٢.٤). The arterial level of service is based on average travel speed for all through vehicles on the arterial. The arterial classification (I, II, and III) is according to functional and design categories for the arterial, as illustrated in Tables (٢.٣) and (٢.٤). Six levels of service are defined as shown in Table (٢.٥).

Table (٢.٢): Aid in Establishing Arterial Classification.

[HCM, ٢٠٠٠]

Criterion	Functional Category	
	Principal Arterials	Minor Arterials
Mobility function	Very important	Important
Access function	Very minor	Substantial
Points connected	Freeways, important activity centers, major traffic generators.	Principal arterials
Predominant trips served	Relatively long trips between above points and through trips entering, leaving , and going through the city.	Trips of moderate length within relatively small geographical areas.

Criterion	Design Category		
	Suburban	Intermediate	Urban
Driveway access density	Low density	Moderate density	High density
Arterial type	Multilane divided: undivided or two-lane with shoulders.	Multilane divided or undivided: one way: two lanes.	Multilane one way: two ways, two or more lanes.
Parking	No	Some	Much
Separate left-turn lanes	Yes	Usually	Some
Signal per mile	١ to ٥	٤ to ٦	٦ to ١٢
Speed limit (mph)	٤٠ to ٤٥	٣٠ to ٤٠	٢٥ to ٣٥
Pedestrian-activity	Little	Some	Usually
Roadside-development	Low to medium	Medium/moderate	High density

	density	density	

Table (٢.٣): Arterial Classifications According to their Functional and Design Categories. [HCM, ٢٠٠٠]

Design Category	Functional Category	
	Principal Arterial	Minor Arterial
Typical suburban	I	II
Intermediate	II	II or III
Typical urban	II or III	III

Table (٢.٤): Segment Running Time per Mile. [HCM, ٢٠٠٠]

Arterial Classification	I			II		III		
Free Flow Speed (mph)	٤٥	٤٠	٣٥	٣٥	٣٠	٣٥	٣٠	٢٥
Average segment length, miles	Running time per mile (sec/mile)							
٠.٠٥							٢٢٧	٢٦٥
٠.١٠				١٤٥	١٥٥	١٦٥	١٨٠	٢٢٠
٠.١٥				١٣٥	١٤١	١٤٠	١٥٠	١٨٠
٠.٢٠	١٠٩	١١٥	١٢٥	١٢٨	١٣٤	١٣٠	١٥٠	١٦٥
٠.٢٥	١٠٤	١١٠	١١٩	١٢٠	١٢٧	١٢٢	١٣٢	١٥٣
٠.٣٠	٩٩	١٠٢	١١٠					
٠.٤٠	٩٤	٩٦	١٠٥					

٠.٥٠	٨٨	٩٣	١٠٣					
١.٨٠	٨٠	٩٠	١٠٣					

Table (٢.٥): The Level of Service for Arterial.

[HCM, ٢٠٠٠]

	Arterial Classification		
	I	**II**	**III**
Range of Free Flow Speed (mph)	٣٥-٤٥	٣٠-٣٥	٢٥-٣٥
Typical Free Flow Speeds (mph)	٤٠	٣٣	٢٧
Level of Service	**Average Travel Speed (mph)**		
A	≥٣٥	≥٣٠	≥٢٥
B	≥٢٨	≥٢٤	≥١٩
C	≥٢٢	≥١٨	≥١٣
D	≥١٧	≥١٤	≥٩
E	≥١٣	≥١٠	≥٧
F	<١٣	<١٠	<٧

٢.٣: Traffic Stream Descriptive Parameters

Numerous variables are used to characterize traffic streams. The three primary variables are:

- Speed;
- Volume or rate of flow;
- Density.

٢.٣.١: Speed

Speed expresses a rate of motion and is usually defined in terms of traveled distance per unit time. Because there is generally a wide range of individual speeds that may be observed in a traffic stream, an average travel speed reflecting the general characteristics of the traffic stream is often used in traffic studies in replacement of individual vehicle travel speeds.

To obtain the average speed of a traffic stream, two different calculations can be performed. In the first case, the average travel speed along a given roadway segment can be obtained by weighting the travel time of individual vehicles along the segment. This computation, which is expressed by Equation (٢.١٧), yields the space mean speed and the weighting of travel times effectively computes the average amount of time that each that each vehicle spends over a particular point in space **[HCM, ٢٠٠٠]** .

$$u_s = \frac{L}{\sum_{i=1}^{N} \frac{t_i}{N}} = \frac{NL}{\sum_{i=1}^{N} t_i} \quad \text{................ (٢.١٧)}$$

Where:

u_s = space mean speed, in (km/hr);

L = length of the highway segment, in (km);

t_i = travel time of the ith vehicle to traverse the section, in (hr); and

N = number of observations.

In the second case, the average travel time can be obtained by taking the arithmetic mean of the measured speeds of all vehicles passing a fixed roadside point during a given interval time. This use of spot speeds, as indicated in Equation (٢.١٨), yields the time mean speed **[HCM, ٢٠٠٠]**.

$$u_t = \frac{\sum_{i=1}^{N} u_i}{N} \quad \text{..................... (٢.١٨)}$$

Where:

u_t = time mean speed, in (km/hr);

u_i = spot speed of vehicles i, in (km/hr).

The relationship for computing time mean speed from space mean speed was first recognized by Wardrop. His relationship is:

$$\bar{u}_t = \bar{u}_s + \sigma_s^2 / \bar{u}_s \quad \text{……….……….. (٢.١٩)}$$

Where бs is the variance about the space mean speed **[Gerlough& Huber, ١٩٧٥]** .

Time mean speed is always greater than space mean speed for a given sample of traffic flow, except when all vehicles are traveling at exactly the same speed. Travel or space mean speeds are determined by performing a travel time and delay study**[Pignataro, ١٩٧٣]**.

٢.٣.٢ :Volume or Rate of Flow

Two measures are often used to quantify the amount of traffic passing a point on a lane or roadway during a designated time interval. The first measure, volume, expresses the total number of vehicles that are observed or predicted to pass in front of an observation point during a given time interval. The second measure, rate of flow, expresses the same number of observed vehicles in terms of vehicle arrivals per unit time. The distinction between these two parameters is important because the flow rate is used to characterize the flow of traffic using the standard traffic flow relationships.

٢.٣.٢.١: Categories of Traffic Flows

Vehicle flow on transportation facilities may generally be classified into two categories:

- Uninterrupted flow; and
- Interrupted flow.

Uninterrupted flow occurs on facilities on which there are no external factors causing periodic interruptions to the traffic stream. As indicated in Table (٢.٦), such flows exist primarily on freeway and other limited-access facilities, where there are no traffic signals, stop or yield signs, or at-grade intersections to interrupt the continuous movement of vehicles. Such flows can also occur on long sections of highways between signalized intersections where the geometric and driving characteristics approach those usually found on a limited- access facility. On uninterrupted flow facilities, traffic flow conditions are thus primarily the result of the interactions among the vehicles within the stream and of the interactions between the vehicles and the geometric characteristics of the roadway. If congestion occurs, the breakdown of traffic flow then is strictly the results of internal frictions to the traffic stream and not the result of external causes.

Table (٢.٦): Types of Transportation Facilities

Uninterrupted Flow	Freeways
	Multilane highways
	Two-lane highways
Interrupted Flow	Signalized Streets
	Unsignalized Streets with Stop Signs
	Arterial
	Transits
	Pedestrian Walkways
	Bicycle Path

Interrupted flow occurs on transportation facilities that have fixed elements causing period interruptions to the traffic stream irrespective of existing traffic conditions. As indicated in Table (٢.٦), these flows occur on facilities on which traffic signals, stop signs, yield signs, and other types of control devices force motorists to interrupt their progression at specific locations. On these facilities, traffic flow characteristics thus not only depend on the interactions between the vehicles within the stream and with the roadway geometry, but also on the external factors causing the interruptions.

The principle device creating periodical interruptions to traffic flow in transportation networks is the traffic signal. Because these signals allow design movements to occur only part of the time, they cause traffic to flow in platoons. A platoon is usually defined as a group of vehicles traveling closely together along a facility **[HCM,٢٠٠٠]**. These platoons are formed during the red interval of a traffic signal, when vehicles are being queued upstream of the stop line, and are released at the beginning of a green interval. As platoon departs a signalized intersection, they tend to disperse. This dispersion is a function of the spacing between signalized intersections, driver behavior and traffic conditions along the roadway. When successive intersections are far enough apart, the extent of the dispersion may even become sufficient to assume that uninterrupted flow exists on some part of the roadway between them. As a general guide, a spacing of ٣.٢ kilometers between intersections is often thought as being sufficient for considering uninterrupted flow to exist at some points between signalized intersections **[McShane & Roess, ١٩٩٠].**

٢.٣.٣: Density

Traffic density, or concentration, is defined as the number of vehicles occupying a unit length of a lane or roadway at a particular instant, usually expressed as (veh/km) or (vpm) **[Khisty & Lall, ١٩٩٨]**. Direct measurement of this parameter in the field is difficult, requiring a vantage point from which significant lengths of highway can be photographed, videotaped, or observed, but when the average travel speed and the corresponding rate of flow are known, it is commonly calculated from the following Equation **[HCM, ٢٠٠٠]**:

$$q = u\,k \qquad \text{……………..} \ (٢.٢٠)$$

Where

q = flow, in (veh/hr);

u = speed, in (km/hr); and

k = density, in (veh/km).

This Equation is the fundamental relationship between the three principle traffic variables of flow, speed, and density. This relationship is illustrated in Figure (٢.١).

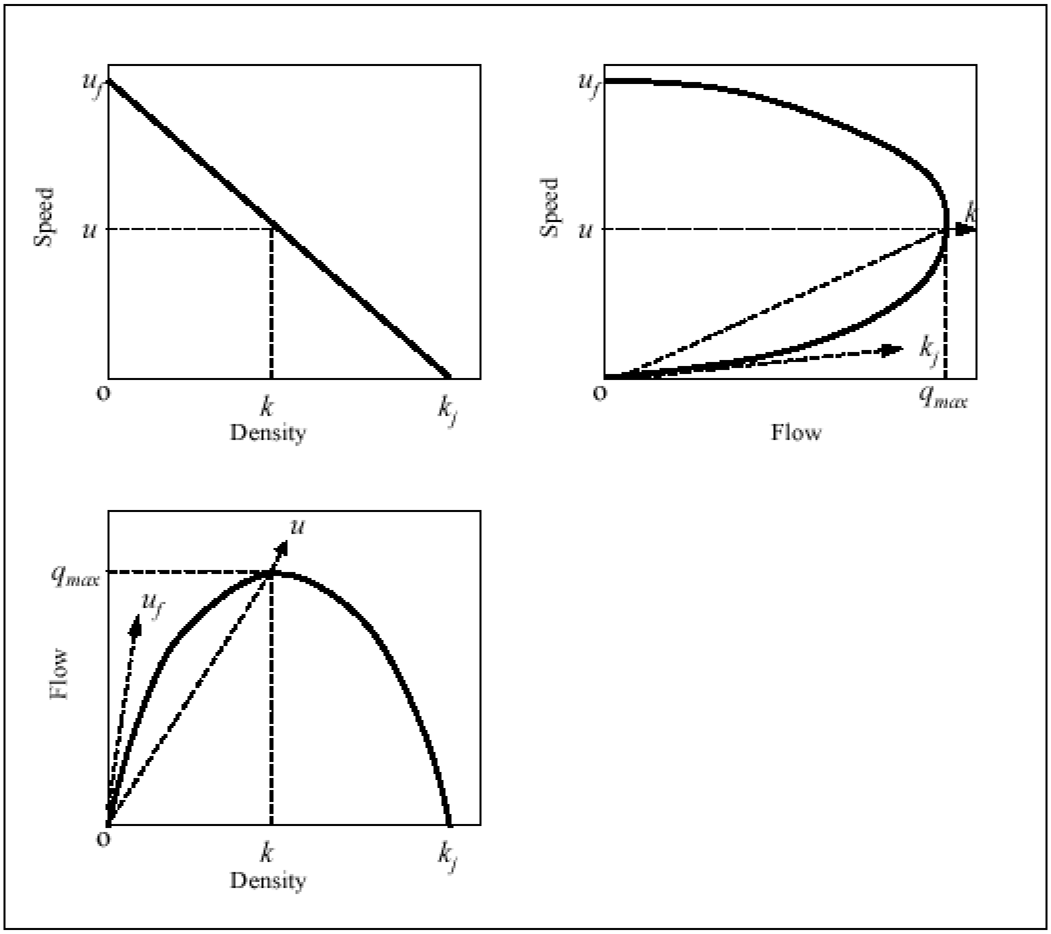


Figure (٢.١): Flow-Density, Speed-Flow, and Speed-Density Relationships [Gerlough & Huber, ١٩٧٥].

٢.٤: Simulation Programs

A simulation model is a numerical technique for conducting experiments on a digital computer. Mathematical models that describe the behavior of traffic on a given transportation system over extended periods of real time are used.

Computer simulation is one of the most important analytical tools of traffic engineering. If traffic system is simulated on a computer by means of a simulation model, it is possible to predict the effect of traffic control as expressed in terms of measures of effectiveness (MOEs), which include average vehicle speed, vehicle stops, delays, vehicle-hours of travel, vehicle-miles of travel, fuel consumptions, and pollutant emissions. The MOEs provide insight into the effects of the applied strategy on the traffic stream.

Computer simulation is more practical than a field experiments for the following reasons:

- Results are obtained quickly.
-The data generated by simulation include several measures of effectiveness that cannot be easily obtained from field studies.
- The disruption of traffic operations, which often accompanies a field experiments, is completely avoided.
- Many schemes require significant physical changes to the facility, which are not acceptable for experimental purposes.
- Evaluation of the operational impact of future traffic demand must be conducted by using simulation or an equivalent analytical tool.
- Many variables can be held constant.

The simulation programs which are used in the evaluating the measures of effectiveness of the selected arterial and other adopted programs are presented as follow:

٢.٤.١: Highway Capacity Software (HCS-٢٠٠٠)

This package is a public domain package that automates the procedures in the ٢٠٠٠ edition of the Highway Capacity Manual (HCM). It is one of the most widely used software packages that include Basic Freeway Segments, Ramps and Ramp Junctions, Signalized Intersections, Unsignalized Intersections, and Urban and Suburban Arterials **[Shafahi et. al., ١٩٩٨]**.

٢.٤.٢: Traffic Network Study Tool (TRANSYT-٧F-٢٠٠٢)

TRANSYT-٧F is a traffic simulation and signal timing optimization program. It is a macroscopic, deterministic, traffic flow model that computes the value of a specified performance index for a given signal network and a given set of signal timings. Several measures of effectiveness generated by TRANSYT-٧F were used as the basis for evaluation, which included travel time in the system, delay, fuel consumption, and a performance index which is a function of delay encountered in the system and the number of stops **[Said & Raymond, ١٩٨٧]**.

٢.٤.٣: T٧FACT

The T٧FACT program module is available from the TRANSYT-٧F Processor interface. It provides a mechanism to calculate the best phase time for evaluation and improvement runs under prevailing condition depend on the traffic volume and saturation flow for each link in node.

٢.٤.٤: CYCOPT

The CYCOPT program module is also available from the TRANSYT-٧F Processor interface. It provides a mechanism for thorough cycle length optimization. The cycle length range (minimum and maximum) and the cycle length search increment are specified on recorded type ١ of the standard TRANSYT-٧F (*.TIN) input file.

٢.٤.٥: Event Program

This program was developed by AL-Neami **[AL-Neami, ١٩٩٩]**. It was written by using C computer language. The program provides the user with digital representation of the observed traffic events. The program starts displaying a message that presses ENTER key to start and press ECS key to finish. It is counting time for successive event, the controlling of this event by press keys of the ten function keys, which are (F١, F٢, F٣, F٤, F٥, F٦, F٧, F٨, F٩ and F١٠); each one of these keys is given an alphabetic character. It would simplify the process of vehicles classification, turning movements, headway, and delay calculation. It produces time accuracy values of the recorded data.

٢.٤.٦: Excel Program

Data files obtained from EVENT program are open with Excel program, which adopted abstracting these data. Excel program facilities are simplifying headway calculation.

٢.٤.٧: SPSS Program

SPSS (Statistical Package for the Social Sciences) is a data management and analysis product. It can perform a variety of data analysis and presentation functions, including statistical analyses and graphical presentation of data. Among its features are modules for statistical data analysis, including descriptive statistics such as plots, frequencies, charts and lists, as well as sophisticated inferential and multivariate statistical procedure like analysis of variance (ANOVA), factor analysis, cluster analysis and categorical data analysis **[SPSS, ٢٠٠٢]** .

٢.٥: Summary

The brief literature review mentioned in the previous section indicates that the delay models for the arterials are directed towards the computation of the delay time at signalized intersection only. Traffic flow characteristics have been addressed in this chapter. Description of some software and other adopted programs which were used in this study have been presented in this chapter.

Site selection and data collection are the subjects of the next chapter.

CHAPTER THREE
DATA COLLECTION

٣.١: Introduction

This chapter provides a description of the data collection and methods used in conducting traffic volume and speed surveys. During periods of holiday and weekends, the traffic flow characteristics on any highway change dramatically compared with typical weekday traffic conditions. Therefore, to eliminate any variance in the data attributable to this effect, data were collected only on weekday.

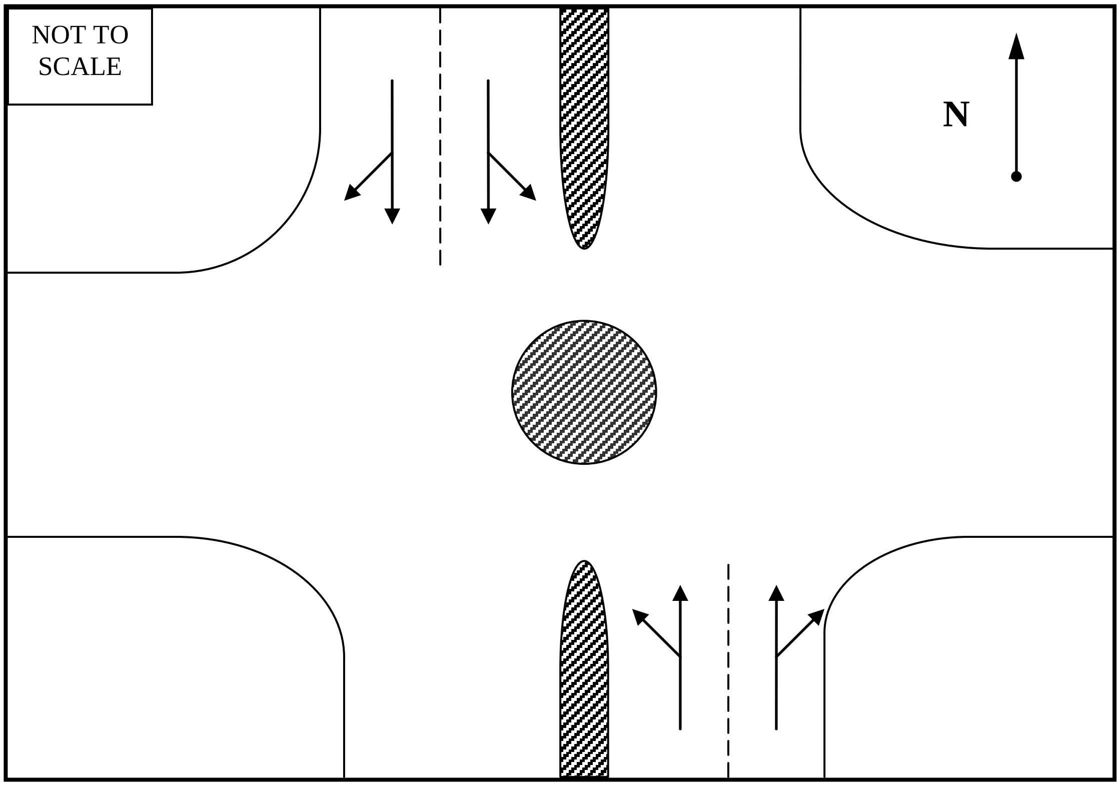
٣.٢: Site Selection

Kufa-Najaf arterial at Najaf Governorate was selected for this study. The studied area is located within the urban area which is characterized by a large number of commercial shops, and private and governmental offices. According to Table (٢.٢) **[HCM,٢٠٠٠]**, this arterial is classified as minor and urban road, and its length is (٨.٦٢٢ Km). Table (٣.١) lists arterial geometric conditions. According to the preliminary survey, the peak period is between (٧:٣٠-٩:٣٠) A.M. at the summer season. There are seven pretimed signalized intersections along the arterial; they are AL-Shehristany, Muslim Ibn-Aqeel, AL-Sahla, AL-Jinsia, AL-Sadrane, AL-Escan, and ٢٠th Revolution, respectively toward the southbound direction. Figure (٣.١) illustrates the layout of the arterial, Figures (٣.٢), (٣.٣), (٣.٤), (٣.٥), (٣.٦), (٣.٧), and (٣.٨) illustrate the layout of the intersections, and Table (٣.٢) lists the signal timing and phasing sequence for all intersections which were measured from field survey. It should be noted that when the electrical current is cutting off, the intersection will be operated by the policeman who manage the traffic movements according to signal timing approximately similar to that designed. There is no successive signal system along the arterial, so each signalized intersection operates as an isolated one.

Table (٣.١): Geometric Conditions of the Arterial Selected in this Study.

Properties	Kufa-Najaf
Type	Divided multilane with sidewalk
Total length (km)	٨.٦٢٢
Number of lanes (in one direction)	٣*
Lane width (m)	٣.٢٥
Number of signalized Intersections	٧
Approach Grade	_

* Some segments have four lanes .



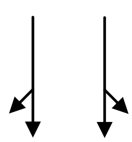
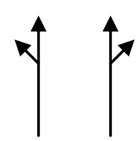
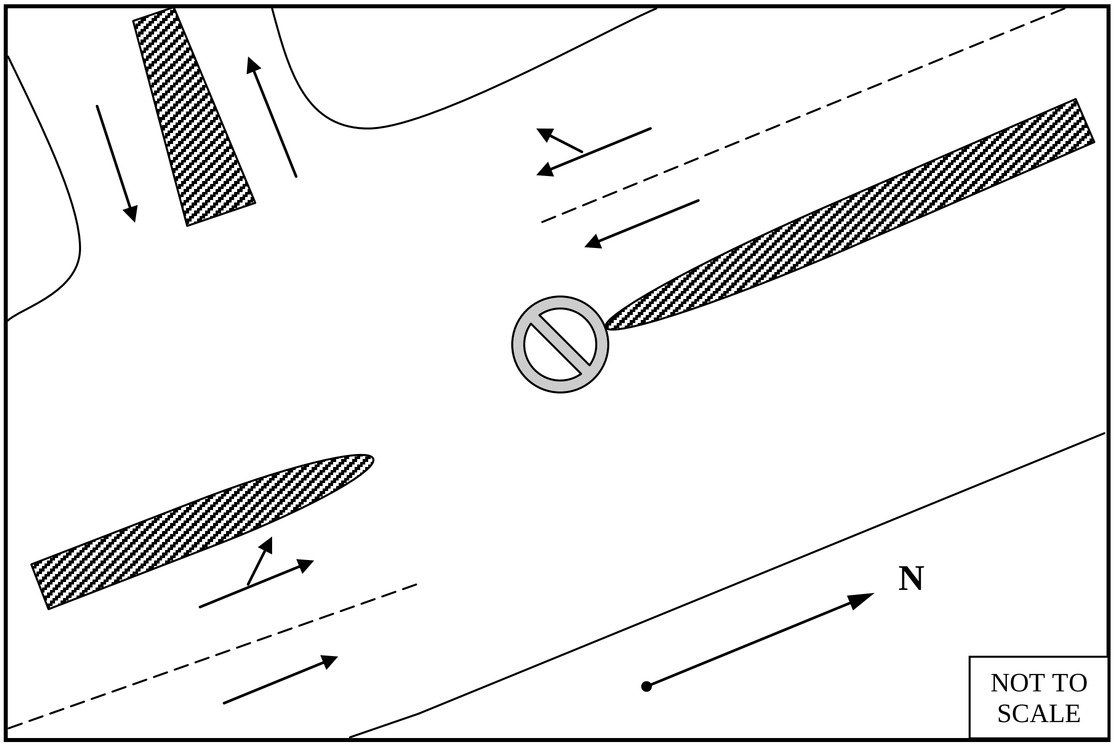
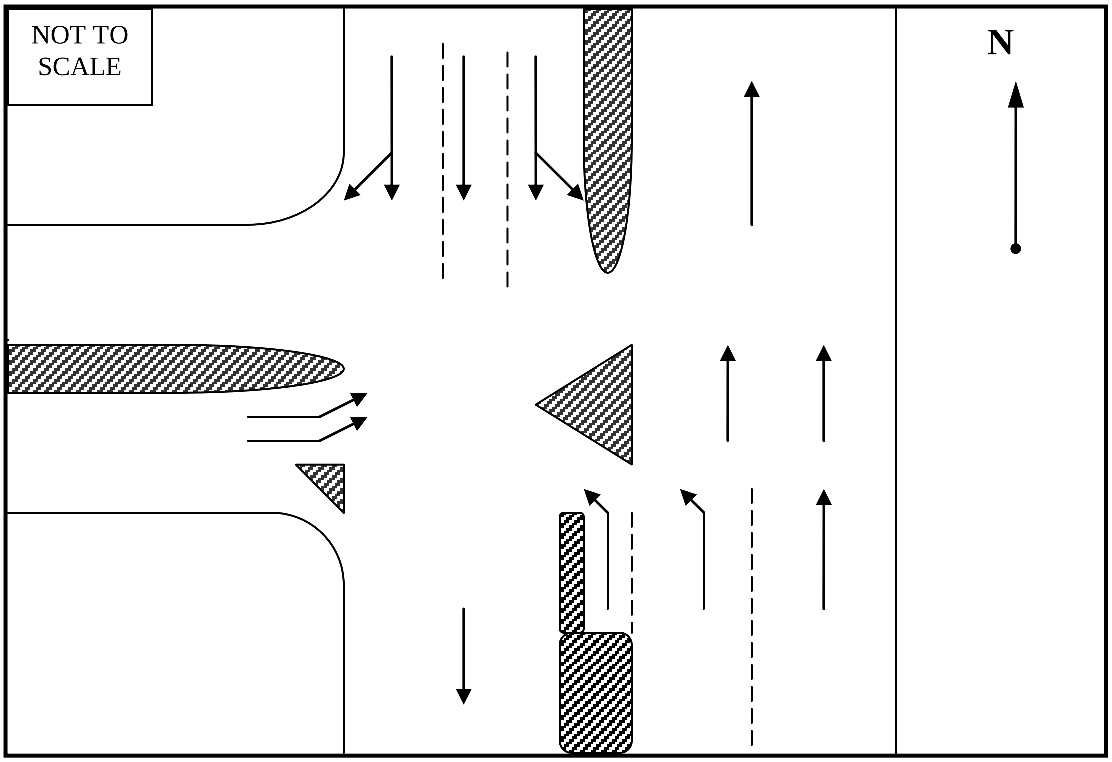
Phasing	١	٢
Diagram	 G = ٥٠ Sec	 G = ٥٠Sec
Timing	Y + ALL Red = ٥ Sec/ Phase Cycle Time = ١١٠ Sec .	

Figure (٣.٢) : Layout and Phasing of AL-Shehristany Intersection .



Phasing	١	٢
N Diagram	G = ٦٥ Sec	G = ٣٥ Sec
Timing	Y + ALL Red = ٣ Sec/Phase Cycle Time = ١٠٦ Sec .	

Figure (٣.٣) : Layout and Phasing of Muslim Intersection .



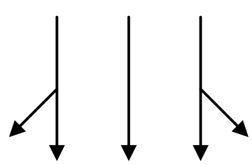
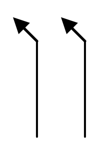
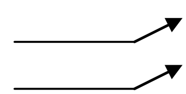
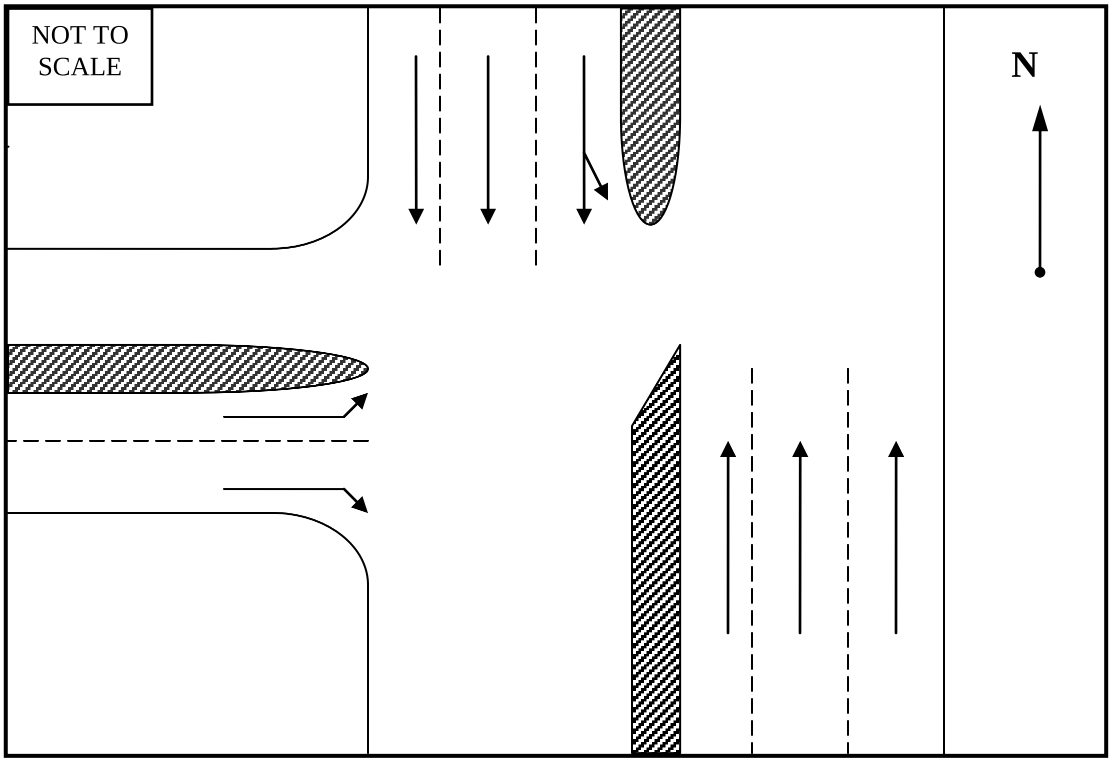
Phasing	١	٢	٣
Diagram	 G =٤٥ Sec	 G = ٢٥ Sec	 G = ٢٥ Sec
Timing	Y + ALL Red = ٤ Sec/Phase Cycle Time = ١٠٧ Sec .		

Figure (٣.٤) : Layout and Phasing of AL-Sahla Intersection .



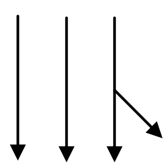
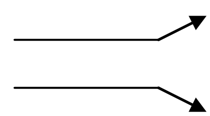
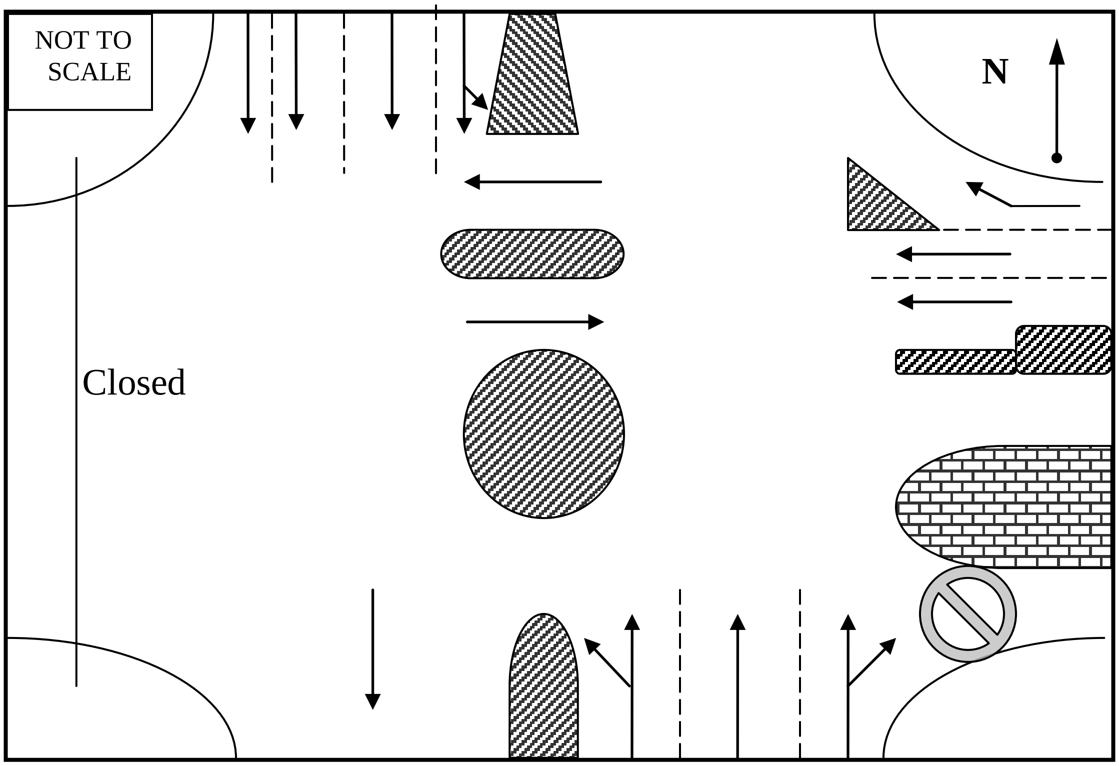
Phasing	١	٢
Diagram		
	G = ٦٠ Sec	G = ٤٠ Sec
Timing	Y + ALL Red = ٣ Sec/Phase Cycle Time = ١٠٦ Sec .	

Figure (٣.٥) : Layout and Phasing of AL-Jinsia Intersection .



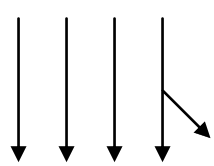
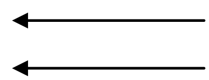
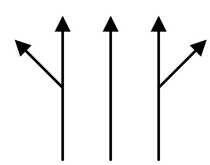
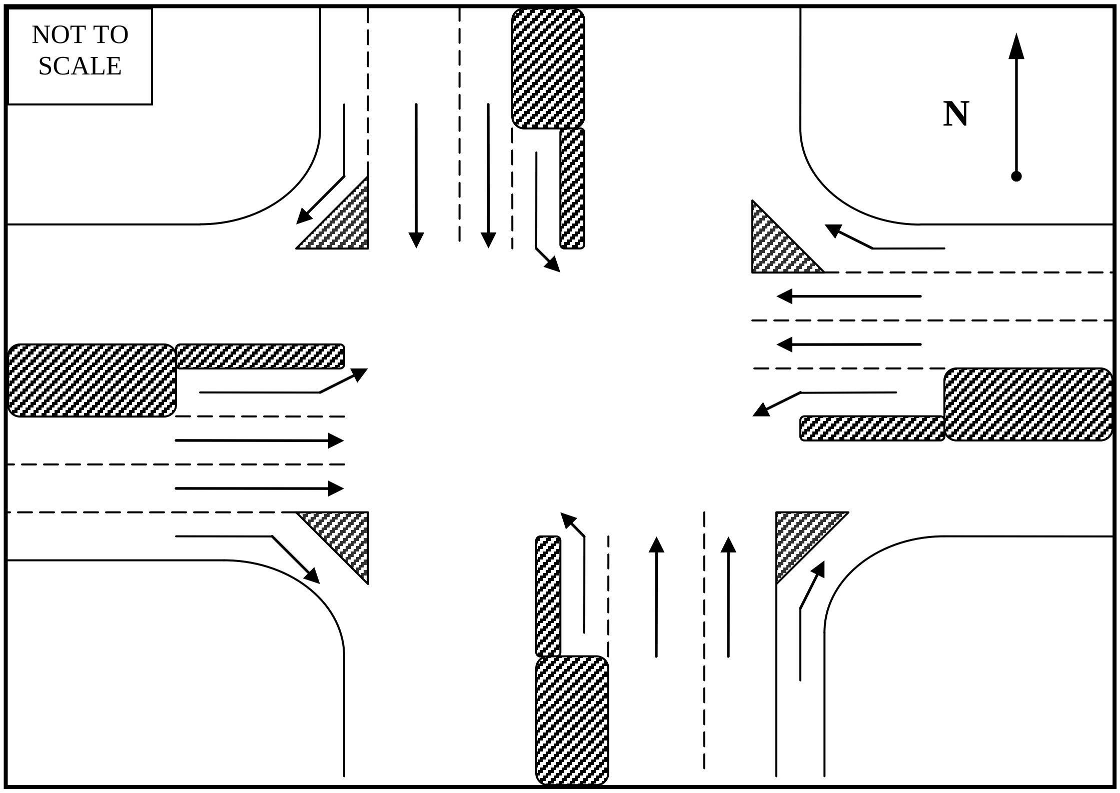
Phasing	١	٢	٣
Diagram	 G = ٤٠ Sec	 G = ٢٠Sec	 G = ٤٠ Sec
Timing	Y + ALL Red = ٤ Sec/Phase Cycle Time = ١١٢ Sec .		

Figure (٣.٦) : Layout and Phasing of AL-Sadrane Intersection .



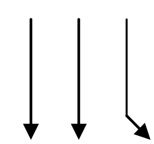
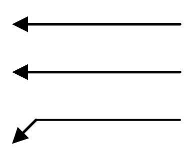
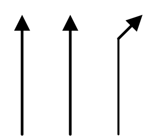
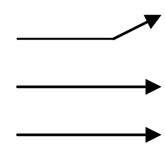
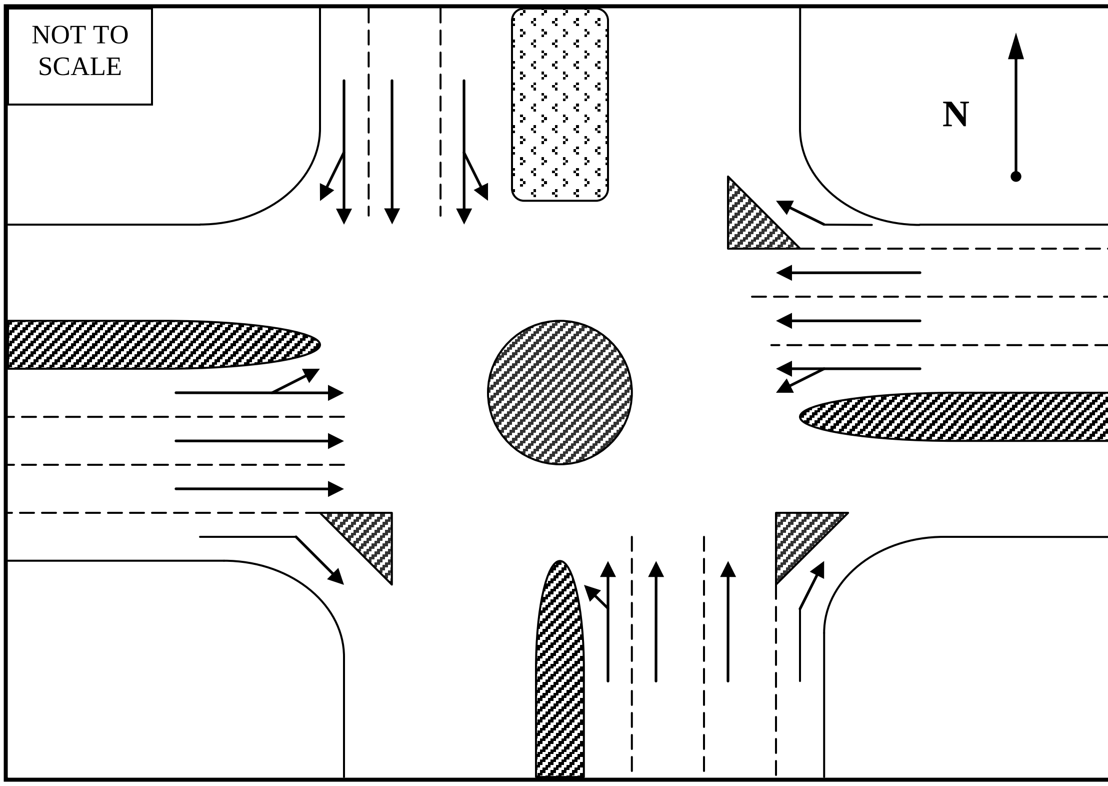
Phasing	١	٢	٣	٤
Diagram				
	G = ٢٤ Sec	G = ٢٤ Sec	G = ٢٤ Sec	G = ٢٤ Sec
Timing	Y + ALL Red = ٥ Sec/Phase Cycle Time = ١١٦ Sec .			

Figure (٣.٧) : Layout and Phasing of AL-Escan Intersection .



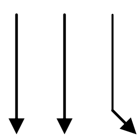
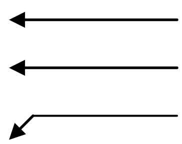
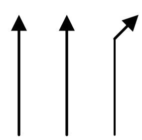
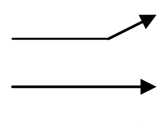
Phasing	١	٢	٣	٤
Diagram	 G = ٢٤ Sec	 G = ٢٤ Sec	 G = ٢٤ Sec	 G = ٢٤ Sec
Timing	Y + ALL Red = ٥ Sec/Phase Cycle Time = ١١٦ Sec .			

Figure (٣.٨) : Layout and Phasing of ٢٠th Revolution Intersection .

٣.٣: Dividing the Arterial

To control the data collection the arterial under study was divided into segments. Each segment was taken as one directional distance from one signalized intersection to the next **[HCM, ٢٠٠٠]**. Illustrative Figure (٣.٩) shows the concept of segment. Dividing the arterial into segments was found effective in collecting the field data.

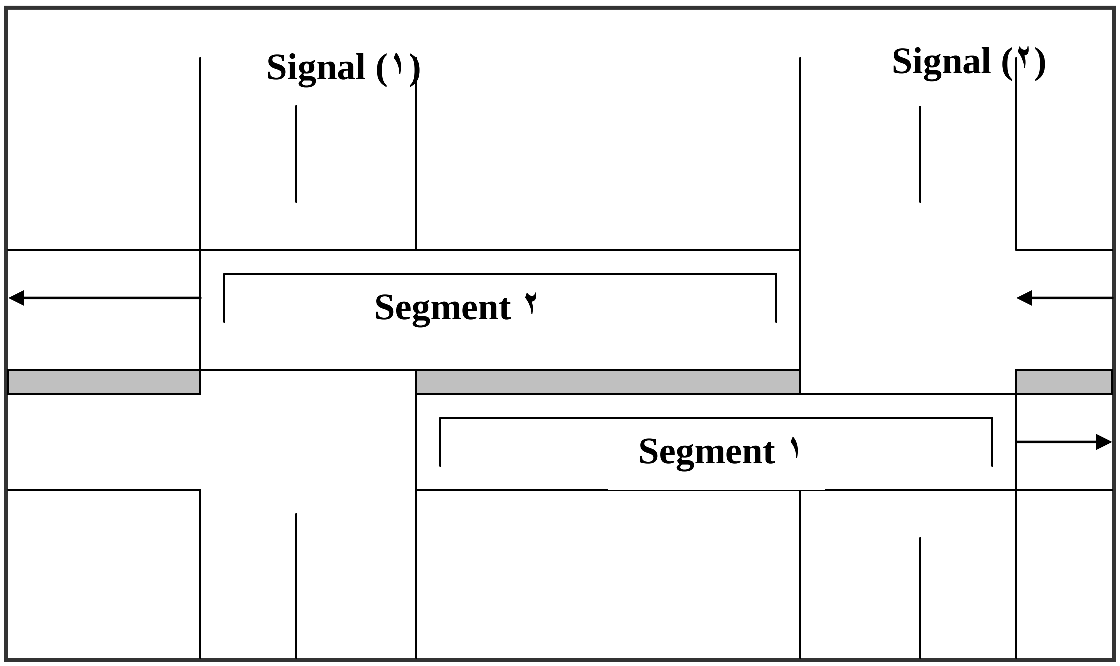


Figure (٣.٩): Segment Conception.

٣.٣. ١: Arterial Segments

Kufa-Najaf arterial was divided into ١٤ segments. Table (٣.٣) lists the arterial segments and Figure (٣.١٠) illustrates the layout of them. It should be noted that the direction of the road is an assumed direction .

Segment ١

It is southbound one-directional segment from Kufa Bridge to AL-Shehristany intersection. The number of lanes, length, and total approach width for the segment are: (٣,) (٠.٦) km and (٩.٧٥) m, respectively.

Segment ٢

It is southbound one-directional segment from AL-Shehristany intersection to Muslim Ibn-Aqeel intersection. The number of lanes, length, and total approach width for the segment are: (٢), (٠.٦) km, and (٦.٥) m, respectively.

Segment ٣

It is southbound one-directional segment from Muslim Ibn-Aqeel intersection to AL-Sahla intersection. The number of lanes, length, and total approach width for the segment are: (٣), (٢.١) km, and (٩.٧٥) m, respectively.

Segment ٤

It is southbound one-directional segment from AL-Sahla intersection to AL-Jinsia intersection. The number of lanes, length, and total approach width for the segment are: (٣), (٢.٣) km, and (٩.٧٥) m, respectively.

Segment ٥

It is southbound one-directional segment from AL-Jinsia intersection to AL-Sadrane intersection. The number of lanes, length, and total approach width for the segment are: (٣), (٠.٧) km, and (٩.٧٥) m, respectively.

Segment ٦

It is southbound one-directional segment from AL-Sadrane intersection to AL-Escan intersection. The number of lanes, length, and total approach width for the segment are: (٤), (٠.٦) km, and (١٣) m, respectively.

Segment ٧

It is southbound one-directional segment from AL-Escan intersection to ٢٠th Revolution intersection. The number of lanes, length, and total approach width are: (٣), (١.٧٢٢) km, and (٩.٧٥) m, respectively.

Segment ٨

It is northbound one-directional segment from ٢٠th Revolution intersection to AL-Escan intersection. The number of lanes, length, and total approach width for the segment are: (٤), (١.٧٢٢) km, and (١٣) m, respectively.

Segment ٩

It northbound one-directional segment from AL-Escan intersection to AL-Sadrane intersection. The number of lanes, length, and total approach width for the segment: (٣), (٠.٦) km, and (٩.٧٥), respectively.

Segment ١٠

It is northbound one-directional segment from AL-Sadrane intersection to AL-Jinsia intersection. The number of lanes, length, and total approach width for the segment are: (٣), (٠.٧) km, and (٩.٧٥) m, respectively.

Segment ١١

It is northbound one-directional segment from AL-Jinsia intersection to AL-Sahla intersection. The number of lanes, length, and total approach width for the segment are: (٣), (٢.٣) km, and (٩.٧٥) m, respectively.

Segment ١٢

It northbound one-directional segment from AL-Sahla intersection to Muslim Ibn-Aqeel intersection. The number of lanes, length, and total approach width for the segment are: (٣), (٢.١) km, and (٩.٧٥) m, respectively.

Segment ١٣

It is northbound one-directional segment from Muslim Ibn-Aqeel intersection to AL-Shehristany intersection. The number of lanes, length, and total approach width are: (٢), (٠.٦) km, and (٦.٥) m, respectively.

Segment ١٤

It is northbound one-directional segment from AL-Shehristany intersection to AL-Kufa Bridge. The number of lanes, length, and total approach width for the segment are: (٢), (٠.٦) km, and (٦.٥) m, respectively.

It should be noted that all segments of the selected arterial having lengths less than (٣ km) which achieved the limitations recorded in Highway Capacity Manual (٢٠٠٠), **[HCM, ٢٠٠٠]**.

Table (٣.٣): Kufa–Najaf Arterial Segments.

Seg.	From	To	No. of lanes	Length (km)	Approach width (m)
١	Kufa bridge	AL-Shehristany	٣	٠.٦	٩.٧٥
٢	AL-Shehristany	Muslim Int.	٢	٠.٦	٦.٥
٣	Muslim Int.	AL-Sahla Int.	٣	٢.١	٩.٧٥
٤	AL-Sahla Int.	AL-Jinsia Int.	٣	٢.٣	٩.٧٥
٥	AL-Jinsia Int.	AL-Sadrane	٣	٠.٧	٩.٧٥
٦	AL-Sadrane Int.	AL-Escan	٤	٠.٦	١٣
٧	AL-Escan Int.	٢٠th Revolution	٣	١.٧٢٢	٩.٧٥
٨	٢٠thRevolution Int.	AL-Escan	٤	١.٧٢٢	١٣
٩	AL-Escan Int.	AL-Sadrane	٣	٠.٦	٩.٧٥
١٠	AL-Sadrane Int.	AL-Jinsia Int.	٣	٠.٧	٩.٧٥
١١	AL-Jinsia Int.	AL-Sahla Int.	٣	٢.٣	٩.٧٥
١٢	AL-Sahla Int.	Muslim Int.	٣	٢.١	٩.٧٥
١٣	Muslim Int.	AL-Shehristany	٢	٠.٦	٦.٥
١٤	AL-Shehristany	Kufa bridge	٢	٠.٦	٦.٥

٣.٤: Sampling Interval

Many attempts were carried out in different periods for the arterial under study to investigate the best time for collection of the required data and determine peak period. The peak period for the arterial was at the morning, because of the characteristics of the area along the arterial. At the beginning of the work, the peak hour for each segment of the arterial was identified, so each signalized intersection was scanned using video camera between (٧:٠٠-١٠:٠٠ A.M.) during three weekdays to collect the traffic volumes at the upstream and the downstream of the segment. Information from these surveys revealed that the peak hour was between (٨:٠٠-٩:٠٠ A.M.). The data were obtained during two hours (٧:٣٠-٩:٣٠ A.M.) to ensure that the peak hour falls within them. The observations were grouped into ٥-mintues intervals to reflect the effect of traffic conditions with time on average travel speed. For each ٥-minute, the segment was controlled perfectly during the data collection.

٣.٥: Method of Data Collection

Data observations and recordings were made during the summer season in May of the year ٢٠٠٥. Total of (١٦٨) hours of data were collected. About (٨٤) hours of traffic flow observations were collected by video recordings and about (٨٤) hours of average travel speed observations were collected by manual recordings.

Video camera was used for scanning the arterial under observations. The best site for each camera was selected on a high place to ensure the optimum possible coverage of longest portion of the segment. In certain places, the data were collected manually if video camera could not be used. The signal phasing was obtained using a stop- watch at the site. Lane and approach widths were measured manually using tape measurement.

٣.٥. ١: Volume Data Conducting

Traffic volumes entering and leaving approaches at intersections were observed by a video camera which made it easy for calculation of turning flows and classified by (EVENTS) program. Because of the wide area of some intersections, two video cameras were used in photo process such as in AL-Sadrane, AL-Escan, and ٢٠th Revolution intersections.

The traffic volume is classified into two classes, passenger car and heavy vehicles in order to obtain accurate volume variations by vehicle type. Heavy vehicle is defined as “any vehicle having more than four tires touching the pavement”, which is generally grouped into three categories: truck, bus, and recreational vehicle **[HCM, ٢٠٠٠]**. The percentage of heavy vehicles (minibus & truck) ranged between (١.٠-٢٣.٠) percent, while the recreational vehicles were null. The percentage of heavy vehicles data are shown in Tables (A-١) to (A-١٤) in Appendix (A) during peak hour. Traffic volume data were taken as the average of two consecutive hours between (٧:٣٠-٩:٣٠ A.M.) for ٥-minutes intervals during three weekdays. Event program was used for abstracting the video recorded traffic data from the video films. The abstracted data were stored in the form of digital files and processed by Excel program. Use of ٥-minutes rates of flow provides enough points to obtain the traffic flow patterns. Tables (A-١) to (A-١٤) in Appendix (A) show the classified traffic volume data conducted for each segment of the selected arterial.

٣.٥.٢: Speed Data Conducting

Average through-vehicle travel speed (space mean speed) for the segment is the adopted speed in Highway Capacity Manual (HCM). In this study, spot speed (time mean speed) was depended because in one hour survey, spot speed provides more data points than the travel speed.

The method of collecting spot speed data is the measurement of the time required for a vehicle to pass a measured course. This time can be measured by manual method. This method requires a stop watch, a tape measurement, and pavement marking material.

The following Equation is used to determine the speed for any chosen length of study course **[Kadiyali, ١٩٩١]:**

$$Spot\ Speed = \frac{Course\ Length\ (km)}{Elapsed\ Time\ (hr)} \quad \text{............ (٣.١)}$$

A typical spot speed study plan is illustrated in Figure (٣.١١). The measured course begins at a point designated by a transverse crack in the pavement, or by a transverse mark made on the pavement. Each one of the observers stands at the end of the measured course. As the front wheels (or other part) of the vehicle cross the mark or crack at the beginning the measured course, the observer starts the stop watch. The watch is stopped at the instant that vehicle passes the observer **[Box & Oppenlander, ١٩٧٦]**. A course length for this research was selected as (١٠٠ m) for all segments of the arterial according to Table (٣.٤) which is depending on the average speed of traffic stream, **[Box & Oppenlander, ١٩٧٦]**.

Table (٣.٤): Recommended Course Lengths for Spot Speed Studies [Box & Oppenlander, ١٩٧٦].

Average Speed of Traffic Stream (kph)	Course Length (m)
Below ٤٠	٢٥
٤٠ - ٦٥	٥٠
Above ٦٥	٧٥ - ١٠٠

The measured course should not be close to the signalized intersection to avoid the effect the signal timing on the average travel speed **[HCM, ٢٠٠٠].** Tables (B-١) to (B-١٤) in Appendix (B) show the results of average spot speed for each ٥-minutes intervals of all selected segments in Kufa-Najaf arterial, and Table (٣.٥) lists the characteristics of the average travel speed data for each segment of the arterial .

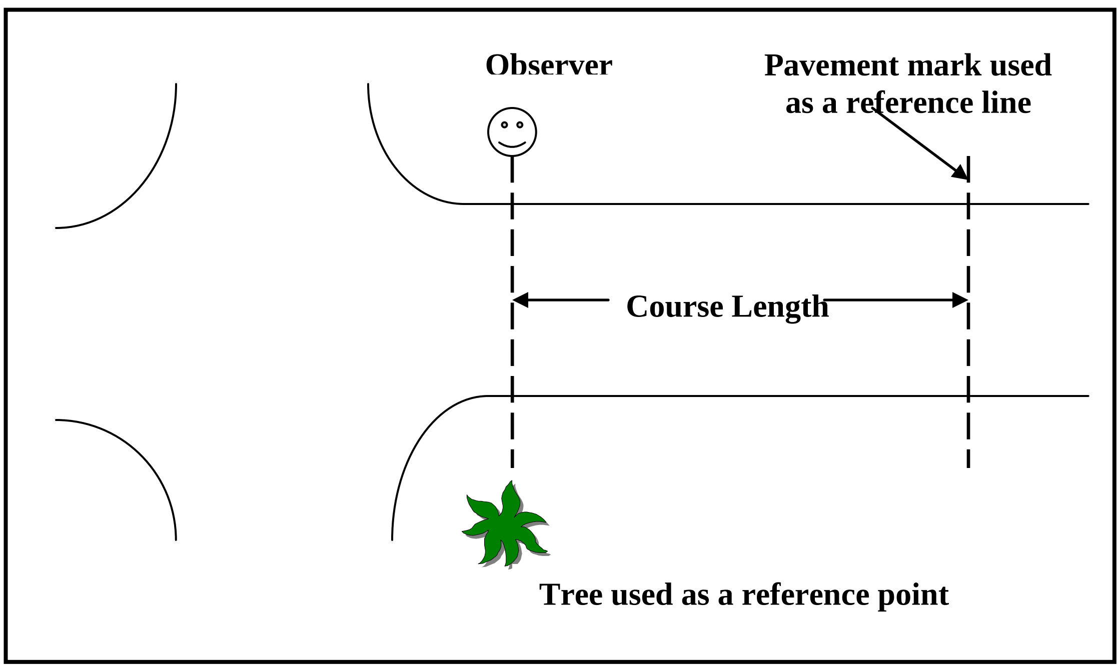


Figure (٣.١١): Typical Spot Speed Study Plan.

[Box & Oppenlander, ١٩٧٦]

Table (٣.٥): The Characteristics of the Average Travel Speed (Km/hr) Data for each Segment of the Arterial.

Seg.	Number of intervals	Minimum	Maximum	Mean	Standard Deviation
١	٢٤	١٨.٧٢	٢٩.٨٨	٢٣.٣٢٥٠	٣.٠١٧٥٤
٢	٢٤	٢٢.٦٨	٤٥.٠٠	٣١.٩٥٠٠	٦.٥٨٨٨٧
٣	٢٤	٢٧.٠٠	٦٠.٨٤	٤١.٠٧٠٠	٩.١٥٢٣٦
٤	٢٤	١٩.٨٠	٥٩.٧٦	٣٥.٤٧٥٠	١٠.٣١٤٨٣
٥	٢٤	١٩.٠٨	٤١.٠٤	٢٥.٨٢٠٠	٦.٣١٧٠٥
٦	٢٤	١٩.٠٨	٢٦.٦٤	٢٢.٧٨٥٠	٢.٢٦٥٦٢
٧	٢٤	١٩.٠٨	٣٤.٥٦	٢٣.٦٥٥٠	٣.٩٩٥٣٩
٨	٢٤	٢٢.٦٨	٥٢.٢٠	٣٣.٥١٠٠	٧.٣١٧٩٣
٩	٢٤	١٦.٥٦	٣٢.٤٠	٢٢.٣١٠٠	٤٥٦٣٤٢
١٠	٢٤	٢٣.٧٦	٤٧.٨٨	٣٠.٧٨٠٠	٧.٢٧٣٩٧
١١	٢٤	٢٦.٦٤	٥٦.٨٨	٣٨.٤٤٥٠	٨.٤١٩٣٤
١٢	٢٤	٢٧.٧٢	٥٩.٧٦	٤٦.٠٢٠٠	٩.٤٨٩٥٤
١٣	٢٤	٢٢.٣٢	٤٠.٣٢	٢٩.٨٦٥٠	٥.٠٤٦١٢
١٤	٢٤	١٨.٣٦	٢٥.٢٠	٢٠.٦٧٠٠	١.٦٤٠٨٨

* Interval equals to ٥-minutes for two hours.

٣.٦: Summary

The constituent of this chapter is the procedure which was followed in the field measurements. Two types of data were collected. Traffic volume data were collected by video recordings and average travel speed were collected by manual recordings during the peak period. Traffic flow data were abstracted and classified using Event program. Preliminary survey information revealed that the peak hour was between (٨:٠٠-٩:٠٠ A.M.).

Data reduction, arterial evaluation and improvements are the subjects of the next chapter.

CHAPTER FOUR

DATA REDUCTION AND ANAYLSIS

٤.١: Introduction

The main goal of any paved road is to minimize the delay time or to decrease the travel time over the road. The travel time is defined as the total duration for a vehicle to travel over a section of the road .Decreasing the travel time leads to increase the travel speed which is computed by dividing the distance by the total travel time **[HCM, ٢٠٠٠]**.

Data reduction is a multiphase effort that depends heavily upon the mode of data collection used. Essentially, data reduction takes the information in the form recorded in the field and manipulates it into a form in which it can be readily understood and interpreted. This may involve taking data recorded on one medium and transferring it to another. It may also involve changing the format in which the data is presented **[Mcshane & Roess, ١٩٩٠].**

Analysis is the functional interpretation of field data in order to understand the observed situation and to plan and design improvements. Depending upon the type of situation being studied, analysis can range from the simple and straight forward to the complex **[Mcshane &Roess, ١٩٩٠]**.

Highway Capacity Software HCS (٢٠٠٠) and TRANSYT-٧F (٢٠٠٢) are the packages that were used for the arterial analysis for the purposes of this study.

٤.٢ Data Reduction

The traffic volume data obtained from the field survey as explained in the pervious chapter at ٥-minutes intervals during two peak consecutive hours should be reduced for the effect of the heavy vehicles in order to obtain accurate volume variations by vehicle type. Vehicles of different types required different amount of road space because of variations in size and performance. To allow for this in capacity measurements for roads and junctions, traffic volumes are expressed in passenger car units (PCU’s) **[SORB, ١٩٨٢]**.

As explained in the pervious chapter the observed traffic volumes consist of three classes of vehicles namely the: Passenger car, Minibus, and truck. To convert the traffic volume to passenger car equivalents (PCU's) values were taken as (١.٢٥) for minibus, and (٢) for truck for condition of level terrain. These values were selected based on available document **[SORB, ١٩٨٢]**. Tables (B.١) to (B.١٤) in Appendix (B) show the traffic flow after conversion to passenger car unit for ٥-minutes intervals survey, and Table (٤.١) lists the characteristics of the flow rate data for each segment of the arterial. Observations of (٨٤) hours revealed that the maximum flow rate was (٢٤٦٠) veh/hr, while the minimum volume was (٦٤٨) veh/hr.

Table (٤.١): The Characteristics of Flow Rate (pc/hr) Data for each Segment of the Arterial.

Seg.	Number of intervals	Minimum	Maximum	Mean	Standard Deviation
١	٢٤	٨٧٦.٠٠	١٧٤٠.٠٠	١٢٩٩.٥٠	٢٦٠.٩٣٤٢٧
٢	٢٤	٨٥٢.٠٠	١٥٩٦.٠٠	١٢٠٨.٠٠	٢١١.٩٢٢٨٧
٣	٢٤	٩٧٢.٠٠	٢٠٠٤.٠٠	١٤٣٥.٠٠	٣٣٦.٠٩١٦٠
٤	٢٤	١١٢٨.٠٠	٢١٧٢.٠٠	١٦٤٧.٠٠	٣٩٦.٤٣٨٤٩
٥	٢٤	١١١٦.٠٠	٢٢٨٠.٠٠	١٦٢٠.٠٠	٤١٢.٢٧٤٢٩
٦	٢٤	١١١٦.٠٠	١٩٠٨.٠٠	١٤٥٩.٠٠	٢١٣.٦٠٧٥٢
٧	٢٤	٨٦٤.٠٠	٢١٨٤.٠٠	١٤٨٧.٥٠	٣٢٩.٨٥٩٦٥
٨	٢٤	٦٤٨.٠٠	١٥٦٠.٠٠	١٠٦٢.٠٠	٢٥٩.٧٩٢٥٦
٩	٢٤	١١١٦.٠٠	٢٢٥٦.٠٠	١٤٦٩.٦٢٥	٣١٤.١٨٢٥٦
١٠	٢٤	١٠٣٢.٠٠	١٦٤٤.٠٠	١٢٩٩.٥٠	١٨٢.١٧٧٤١
١١	٢٤	١٠٩٢.٠٠	٢٤٦٠.٠٠	١٦٤٠.٠٠	٤١٣.٠١٢٦٩
١٢	٢٤	١١٧٦.٠٠	١٨٦٠.٠٠	١٤١٠.٠٠	٢٠٣.٢١٥٨٨
١٣	٢٤	٨٢٨.٠٠	١٥٩٦.٠٠	١٢٧٦.٠٠	٢١٦.٥١١٤٧
١٤	٢٤	٨٠٤.٠٠	١٣٨٠.٠٠	١٠٩٨.٥٠	١٨٨.٤٤٤٦٦

*Each interval equals to ٥-minutes for two hours.

٤.٣: Arterial Evaluation

HCS (٢٠٠٠) and TRANSYT-٧F (٢٠٠٢) are used for the purpose of analysis and evaluating the selected arterial.

٤.٣.١: HCS-٢٠٠٠ Software

HCS-٢٠٠٠ Software is one of the packages available for evaluating urban arterial operations improvements. It follows the same procedure described in (HCM-٢٠٠٠) which is Copyright by the Transportation Research Board (TRB) for evaluating the urban arterials which is reported in chapter two.

(HCS) needs the following input data to analyze the arterial and determine the level of service:

* Street name,
* Length, mile,
* Arterial Class,
* Free Flow Speed;
* File name of the intersection at the end of the segment.

Arterial level of service is defined in terms of average travel speed of all through vehicles on the arterial. It is strongly influenced by the number of signals per mile and the average intersection delay **[HCM, ٢٠٠٠].** The procedure to determine arterial level of service involves seven steps, as shown in Figure (٤.١٥).

٤.٣.١.١: *Level of Service (LOS)*

LOS is a qualitative measure describing operational conditions within a traffic stream, and their perception by motorists and / or passengers **[HCM, ٢٠٠٠]**. Using Table (٢.٢), the chosen arterial is minor arterial according to its functional category, and urban arterial according to its design category **[HCM, ٢٠٠٠]**. So, the arterial classification is (III) using Table (٢.٣).

The HCM (٢٠٠٠) determine six levels of service, as shown in Table (٢.٥). The arterial level of service is based on average travel speed for all through vehicles on the arterial. The average travel speed for each LOS is determined according to the free flow speed, as follows, **[HCM, ٢٠٠٠]**:

LOS A = average travel speed ≥ ٩٠٪ free flow speed

LOS B = average travel speed ≥ ٧٠٪ free flow speed

LOS C = average travel speed ≥ ٥٠٪ free flow speed

LOS D = average travel speed ≥ ٤٠٪ free flow speed

LOS E = average travel speed ≥ ١/٣ of free flow speed

LOS F = average travel speed < ١/٣ of free flow speed.

To determine the level of service of the segments and arterial, the average travel speed was computed for each segment during the peak hour which was between (٨.٠٠-٩.٠٠ A.M.) according to Equation (٢.١٥) which is illustrated in chapter two.

The level of service of the signalized intersections is defined in terms of delay. The intersection approach delay time per vehicle is computed according to Equation (٢.١). It depends on:

١- Flow rate (v) for through lane group during the peak ١٥ minutes of peak hour time in vph;

٢- Capacity (c) for through lane group in vph;

٣- Cycle length (C), sec; and

٤- Effective green time for through lane group (g), sec.

The (v) values were computed for the chosen arterial according to the peak ١٥-mintues of the peak hour (٨:٠٠-٩:٠٠ A.M.). The HCS-٢٠٠٠ Software outputs for AL-Sadrane intersection is presented in Appendix (C). Figure (٤.١) shows speed profile of the selected arterial .

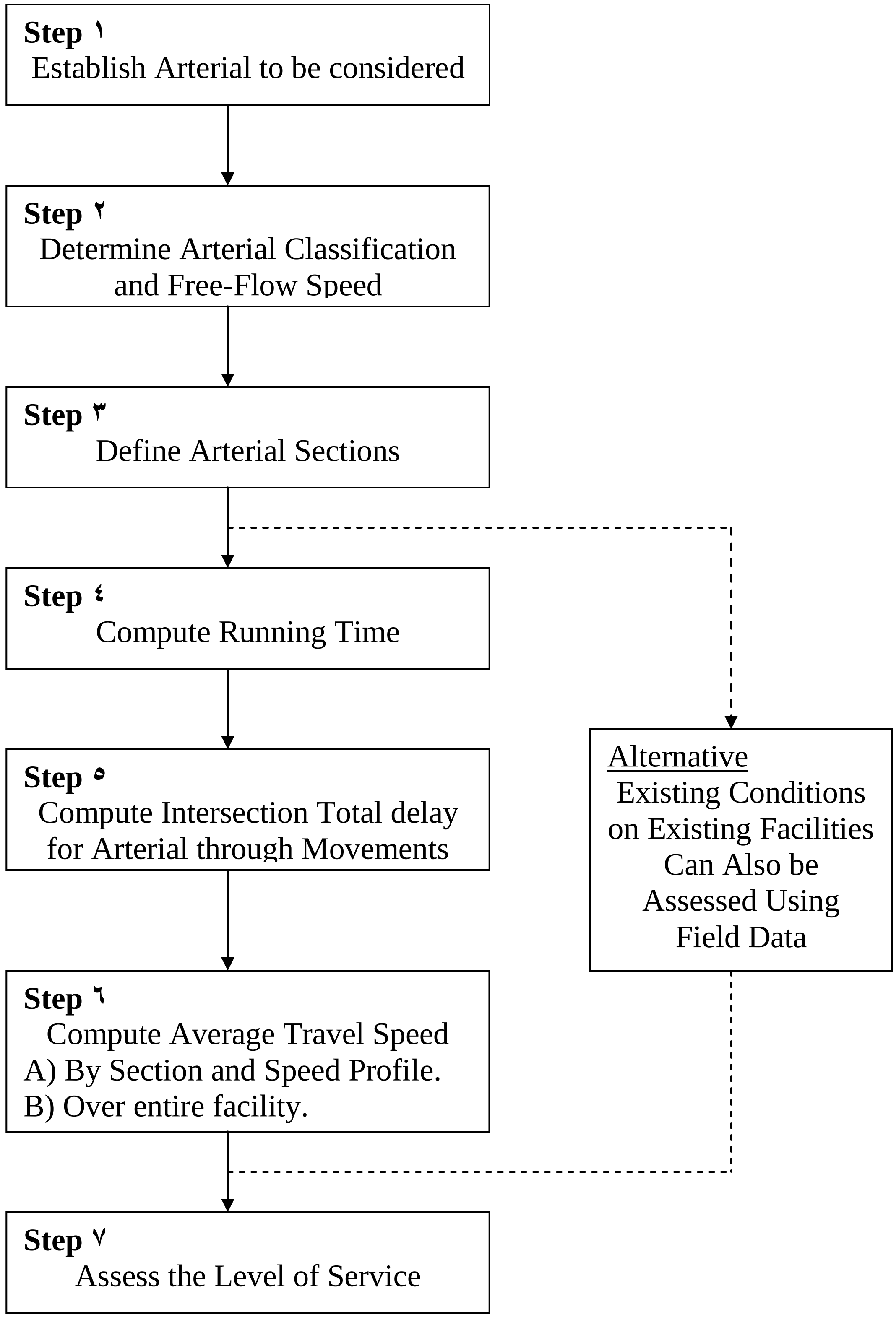


Chart (٤.١): Arterial Level of Service Methodology[HCM, ٢٠٠٠].

Table (٤.٢): Level of Service Evaluation.

Dir.	Seg.	Arterial Class	Length (km)	Running Time (sec)	Intersection Total Delay (sec)	Sum of Time (sec)	Arterial Speed (kph)	LOS
SB	١	III	٠.٦	٣٩.٣	٣٠٠.٣	٣٣٩.٦	٦.٤	F
SB	٢	III	٠.٦	٣٩.٣	٢١.٠	٦٠.٣	٣٥.٨	C
SB	٣	III	٢.١	١٣٧.٥	٤٤.٢	١٨١.٧	٤١.٦	B
SB	٤	III	٢.٣	١٥٠.٥	١٧.٣	١٦٧.٨	٤٩.٣	B
SB	٥	III	٠.٧	٤٥.٨	٣٨٤.٢	٤٣٠	٥.٩	F
SB	٦	III	٠.٦	٣٩.٣	٢١٣.١	٢٥٢.٤	٨.٦	F
SB	٧	III	١.٧٢٢	١١٢.٦	٥٥٤.٧	٦٦٧.٣	٩.٣	F
NB	٨	III	١.٧٢٢	١١٢.٦	٦٨.٣	١٨٠.٩	٣٤.٢	C
NB	٩	III	٠.٦	٣٩.٣	١٨٠.٤	٢١٩.٦	٩.٨	F
NB	١٠	III	٠.٧	Free Phase for through flow				
NB	١١	III	٢.٣	Free Phase for through flow				
NB	١٢	III	٢.١	Free Phase for through flow				
NB	١٣	III	٠.٦	٣٩.٣	٣٢٣.١	٣٦٢.٤	٦.٠	F
NB	١٤	III	٠.٦	No signalized intersection at downstream.				

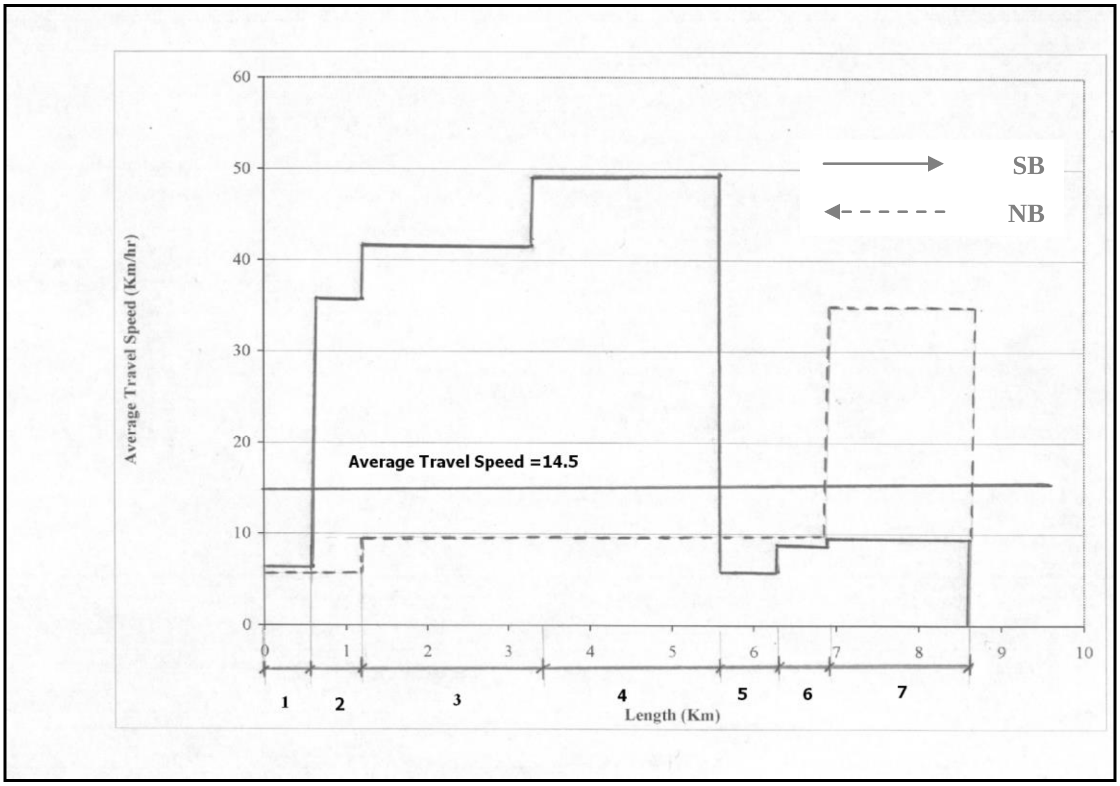


Figure (٤.١): Speed profile for Kufa-Najaf Street at (٨.٠٠ -٩.٠٠) A.M. According to Field Data.

٤.٣.٢: TRANSYT-٧F (٢٠٠٢)

Traffic Network Study Tool release ٩.٤ (٢٠٠٢) was one of the selected programs to evaluate the arterial under study. The original TRANSYT model was developed by the Transport Research Laboratory formerly (Transport and Road Research Laboratory) in the United Kingdom. TRANSYT, version ٧ was "Americanized" for the Federal Highway Administration (FHWA); thus the "٧F". The TRANSYT-٧F program and the original TRANSYT-٧F manual were developed for the Federal Highway Administration (FHWA) under the National Signal Timing Optimization (NSTOP) Project by the University of Florida Transportation Research Center (TRC).

The two major functions of TRANSYT-٧F are simulation of traffic flow and optimization of traffic signal timing plans. The TRANSYT-٧F model assumes that delayed vehicles are only the stopped vehicles.

٤. ٣. ٢. ١: *Network Description*

The first step in defining a data set for TRANSYT-٧F is describing the geometry of the network. The network of streets and intersections is represented in TRANSYT-٧F by a node / link identification scheme. Figure (٤.٢) shows the suggested scheme.

Nodes: A node is an intersection of two or more conflicting streets. Each node is assigned unique identifying number from ١ to ٩٩٩. TRANSYT-٧F is dimensioned to have a maximum of ٥٠ nodes in the network.

***Links*:** A link is a unidirectional section of roadway connecting two nodes. The actual roadway between two nodes may constitute a single link or a number of links. Each link is also assigned an identifying number from ١ to ٩٩٩٩. A link may carry through traffic, and turning traffic. A link can be visualized as starting at the stop-line of the upstream
Intersection and ending at the downstream intersection stop-line. External links have no physical “starting points " and are generally assumed to have zero length .TRANSYT-٧F is dimensioned to allow a maximum of ٢٥٠ links in the network.

Figure (٤.٣) shows the link-node diagram for the arterial street under study.

***Link Distance*:** The distance between nodes (the link length) is used in the traffic flow model. The distance should be measured from stop-line to stop-line of intersections.

Table (٤.٣) lists the link length for each node of the selected arterial.

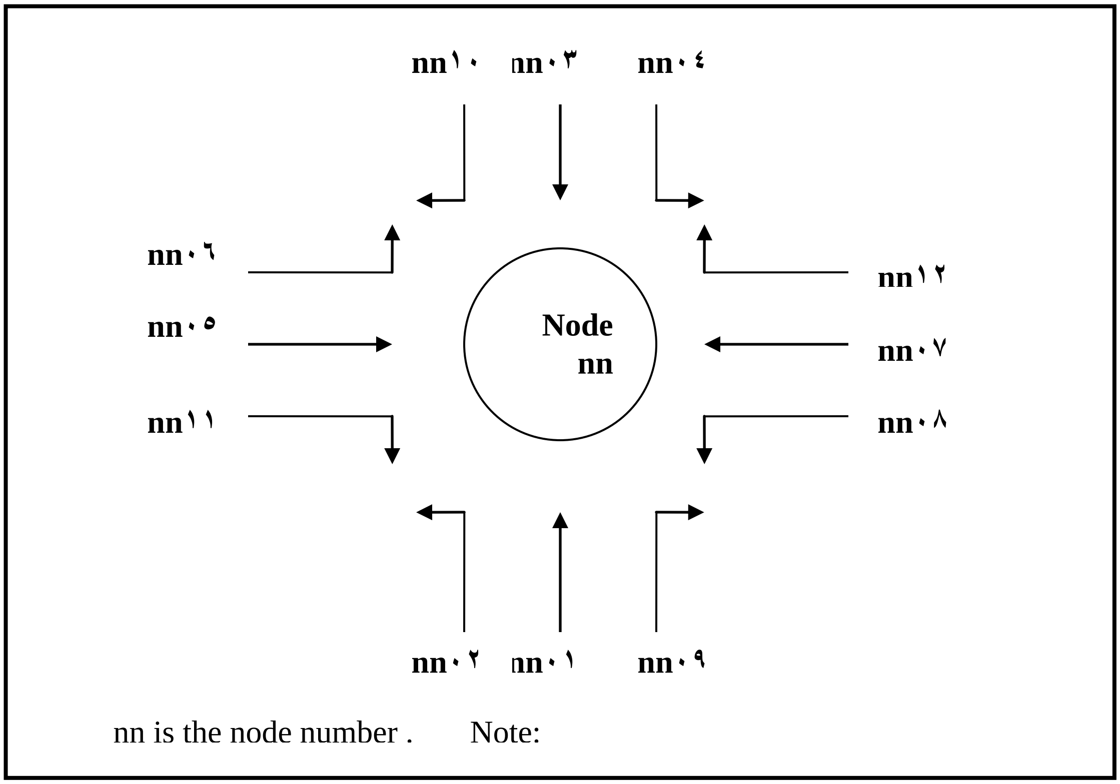
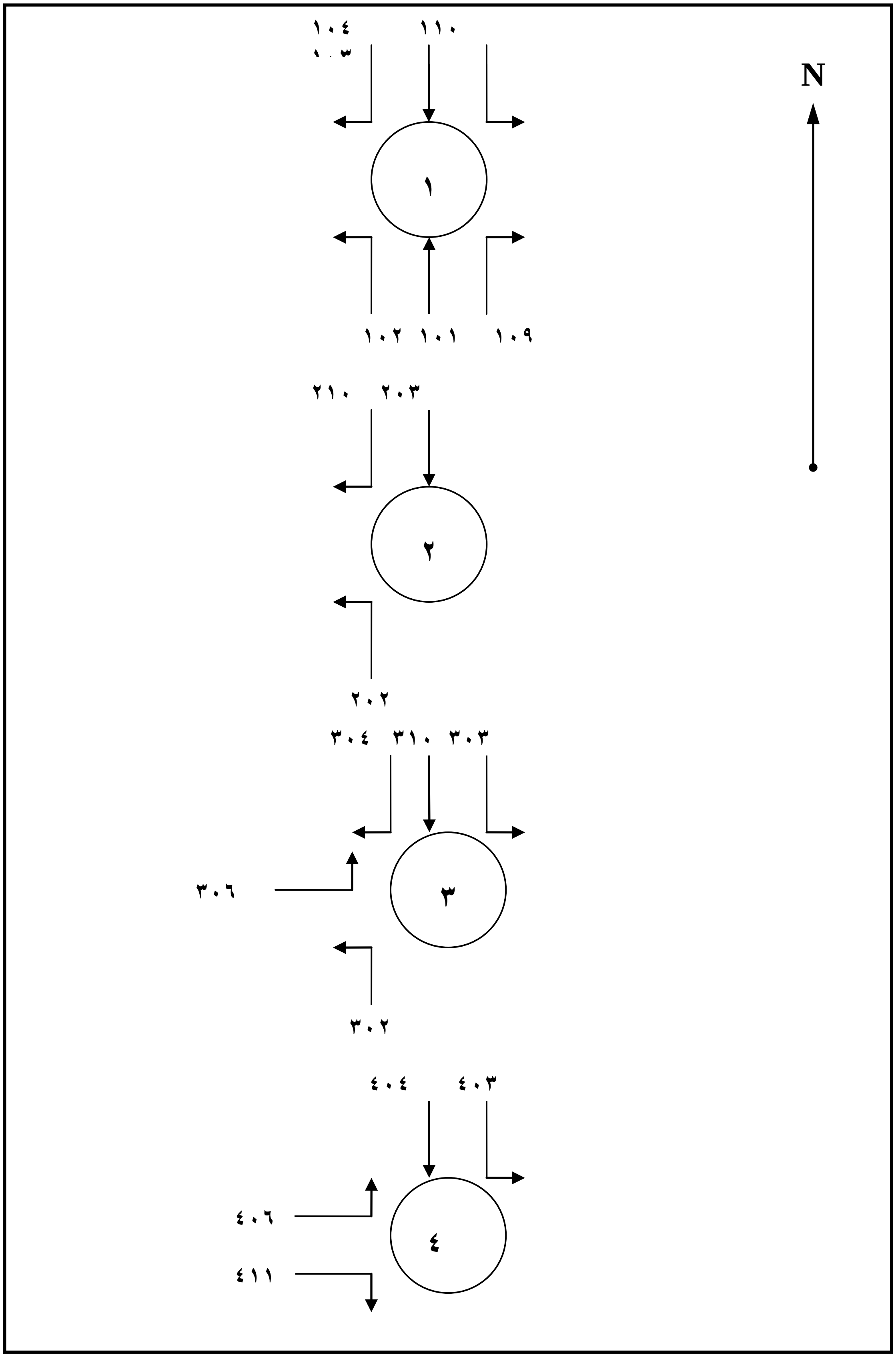


Figure (٤.٢): Node/link Number Scheme for TRANSYT-٧F.



١٠٤
١١٠
١٠٣
N
١
١٠٢ ١٠١ ١٠٩
٢١٠ ٢٠٣
٢
٢٠٢
٣٠٤ ٣١٠ ٣٠٣
٣٠٦
٣
٣٠٢
٤٠٤ ٤٠٣
٤٠٦
٤
٤١١

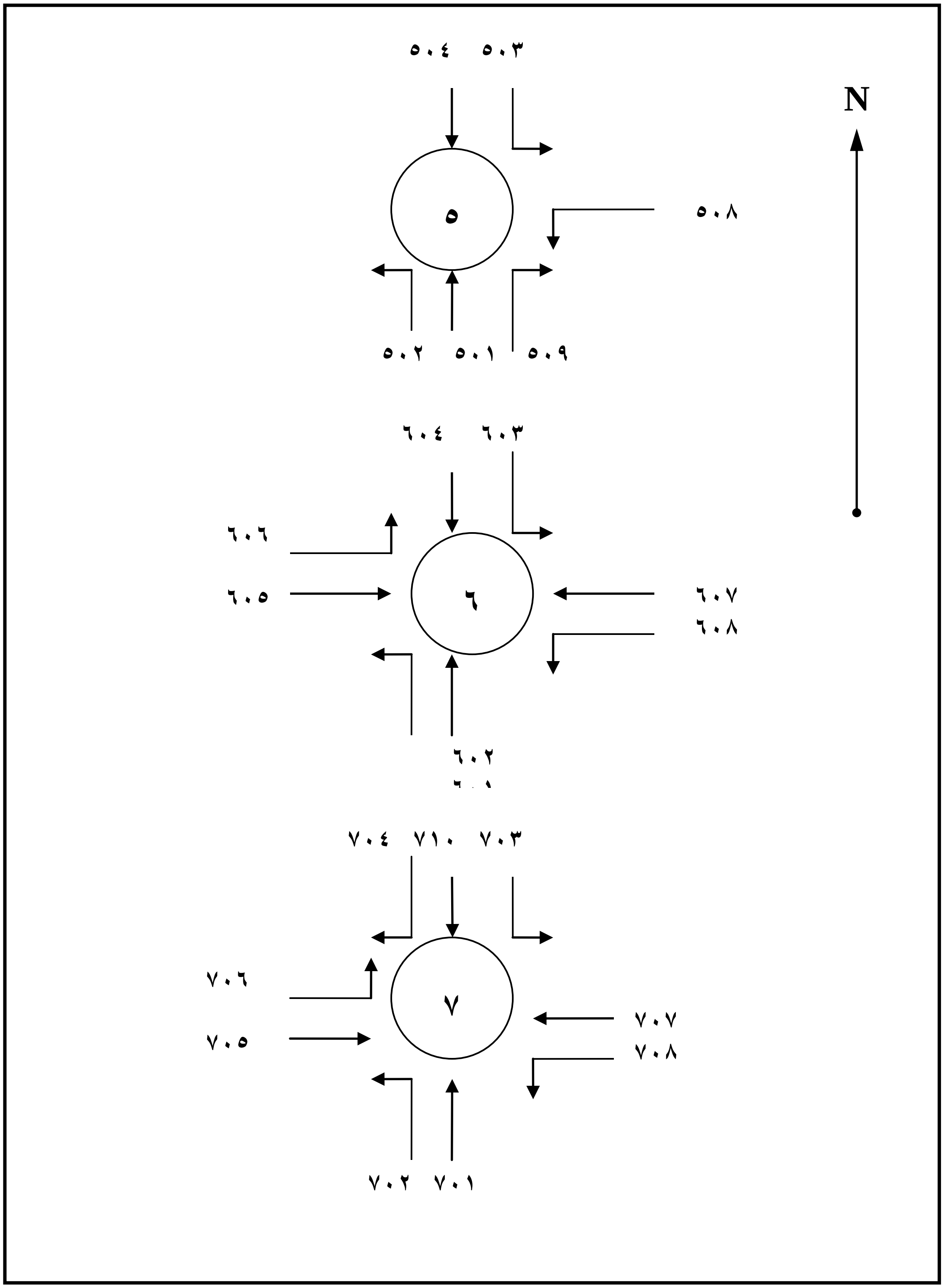


Figure (٤.٣) : Node / Link Diagram for the Chosen Arterial .

Table (٤.٣): Link Length.

Node No.	Name of Intersection	Link No.	Link Length
١	AL-Shehristany	١٠١	٦٠٠
		١٠٢	٦٠٠
		١٠٣	٦٠٠
		١٠٤	٦٠٠
		١٠٩	٦٠٠
		١١٠	٦٠٠
٢	Muslim	٢٠٢	٢١٠٠
		٢٠٣	٦٠٠
		٢١٠	٦٠٠
٣	AL-Sahla	٣٠٢	٢٣٠٠
		٣٠٣	٢١٠٠
		٣٠٤	٢١٠٠
		٣٠٦	٠
		٣١٠	٢١٠٠
٤	Al-Jinsia	٤٠٣	٢٣٠٠
		٤٠٤	٢٣٠٠
		٤٠٦	٠
		٤١١	٠
٥	AL-Sadrane	٥٠١	٦٠٠
		٥٠٢	٦٠٠
		٥٠٣	٧٠٠
٥	AL-Sadrane	٥٠٤	٧٠٠
		٥٠٨	٠
		٥٠٩	٦٠٠
٦	AL-Escan	٦٠١	١٧٢٢
		٦٠٢	١٧٢٢
		٦٠٣	٦٠٠
		٦٠٤	٦٠٠
		٦٠٥	٠
		٦٠٦	٠
		٦٠٧	٠
		٦٠٨	٠
٧	٢٠th Revolution	٧٠١	٠
		٧٠٢	٠
		٧٠٣	١٧٢٢
		٧٠٤	١٧٢٢
		٧٠٥	٠
		٧٠٦	٠
		٧٠٧	٠
		٧٠٨	٠
		٧١٠	١٧٢٢

٤. ٣. ٢. ٢: *Data Preparation*

The data required byTRANSYT-٧F are:

٤.٣.٢.٢.١: Signal Timing Parameters

The timing data required are:

١) Cycle length, phase sequences, and the Green, Yellow and All red intervals are specified for each node which is presented in the Figures of intersections layout from (٣.٢) to (٣.٨) in chapter three.

٢) Both the start-up lost time which is the time from the actual start of green until the front of the first vehicle crosses the stop-line and green extension time which is the time from the actual end of green until the front wheels of the last vehicle cross the stop-line or other reference point are calculated from video films by using Event program and presented in Table (٤.٤) .

Table (٤.٤): Start-up Lost Time & Extension of Effective Green Time by Link.

Link No.	Average Start-up Lost Time (sec.)	Average Extension of Effective Green Time (sec.)
١٠١	١.٩٦	١.٩٢
١٠٢	١.٨٩	١.٨١
١٠٣	١.٥٦	١.٤٩
١٠٤	١.٧٧	١.٨٠
١٠٩	٢.١٣	١.٩٥
١١٠	١.٦٨	١.٦٢
٢٠٢	٢.٣١	١.٩٥
٢٠٣	٢.٢٢	١.٧٤
٢١٠	١.٨٨	٢.٠٠
٣٠٢	١.٣٩	١.٥٠
٣٠٣	٢.٠٠	١.٩٨
٣٠٤	١.٩٩	١.٦٧
٣٠٦	١.٥٤	١.٦٩
٣١٠	١.٨٣	١.٥٧
٤٠٣	١.٨٩	١.١٢
٤٠٤	١.٧٦	١.٤٩
٤٠٦	٢.٥٤	١.٨٢
٤١١	١.٩٣	١.١٦
٥٠١	٢.٠٠	١.٥٦
٥٠٢	٢.١٥	١.٣٥
٥٠٣	١.٨٠	١.٦٧
٥٠٤	١.٧٤	١.٧٠
٥٠٨	١.٣٤	١.٥٢
٥٠٩	١.٦٩	٢.٠٠
٦٠١	١.٧٨	١.١٠
٦٠٢	١.٨٠	١.٨٤
٦٠٣	١.٩٣	١.٨٨
٦٠٤	١.٥٩	١.٩٢
٦٠٥	٢.٢٠	١.٦٩
٦٠٦	٢.٠٠	١.٣٦
٦٠٧	١.٨١	١.٢٠
٦٠٨	١.٩١	١.٣٢
٧٠١	٢.٠١	١.٩٨
٧٠٢	٢.٣٥	٢.٢٠
٧٠٣	٢.٠٣	١.٧٦
٧٠٤	١.٩٩	١.٨٤
٧٠٥	١.٨٦	١.٣١
٧٠٦	١.٧٧	١.٤٩
٧٠٧	١.٨٥	١.٢٨
٧٠٨	١.٩٨	١.١٥
٧١٠	١.٩٣	١.٤٧

٤.٣.٢.٢.٢: Traffic Volume Data

The design hourly volume (DHV) for each intersection turning movement is as follows **[FHWA, ١٩٨٤]** :

$$DHV = V - (V \times \frac{\%\ Truck}{100}) + (V \times 2.25 \times \frac{\%\ Truck}{100}) \quad \text{..... (٤.١)}$$

Where:

DHV = Design hourly volume, in (pcu);

V =the one-half peak hourly volume multiplied by two, in (vph); and

%Truck = Percentage of trucks.

Traffic volume data are recorded every ١٥-mintue interval for one peak hour for each intersection. Traffic volumes for each link under study are illustrated in Table (٤.٥).

٤.٣.٢.٢.٣: Saturation Flow Data

Saturation flow rate is the term used to describe the capacity of a traffic movement through a signalized intersection and it is expressed in vehicle per hour of green time (vphg). It can be calculated as follows **[FHWA, ١٩٨٤]**:

$$S = \left(\frac{3600}{h}\right) \times l \quad \text{............ (٤.٢)}$$

Where

S = Saturation flow rate, in (vphg);

l = Number of lanes; and

h = Average discharge headway, of all queued vehicles beginning with third vehicle, in (sec).

According to the (HCM-٢٠٠٠), the calculation of the headway is as follows**:**

$$h = \frac{\sum tr / R - 3}{N} \quad \text{............(٤.٣)}$$

Where

tr = The time required to discharge the queued vehicles starting with fourth vehicle, (sec);

R = Total number of vehicles in the queue, and

N = Number of observations.

Table (٤.٥) summarizes the number of lanes in the links, and the saturation flow rates for link movements in the present study intersection.

Table (٤.٥) : Traffic Volume, Saturation Flow, and Number of Lanes by Link in Studied Intersections .

Node No.	Link No.	Traffic Volume (vph)	Saturation Flow (vphg)	No. of Lanes
١	١٠١	١٣٧٠	٢٩٥٠	٢
	١٠٢	٤٩٨	٩٩٥	١
	١٠٣	١١٣٣	٢٦٧٦	٢
	١٠٤	٤١٩	١٥٠١	١
	١٠٩	٣٢	٢٣٨٣	١
	١١٠	١٨٩	١٧١٢	١
٢	٢٠٢	٤٧٠	١٠١٤	١
	٢٠٣	١٤٤٤	٢٣٦٠	٢
	٢١٠	٨٢	١٧٥٥	١
٣	٣٠٢	٦٥٣	١٩٧٤	٢
	٣٠٣	١٣٢١	٣٧٧١	٣
	٣٠٤	٩٣	١٣١٠	١
	٣٠٦	٣١٤	٢٧٢٩	٢
	٣١٠	١٣٠	١٦٣٧	١
٤	٤٠٣	١٦٤٢	٣٦٨٥	٣
	٤٠٤	٣٨	١٤٠٠	١
	٤٠٦	٦٠٩	٢٥٧٢	٢
	٤١١	٦١٤	١٨١٤	١

Table (٤.٥): Continue.

Node No.	Link No.	Traffic Volume (vph)	Saturation Flow (vphg)	No. of Lanes
٥	٥٠١	١٣٢٥	٣٨٢٣	٣
	٥٠٢	١٦٦	١٢٢٨	١
	٥٠٣	١٤٣٦	٣٨٨٥	٣
	٥٠٤	٩١١	١٧٥٥	١
	٥٠٨	٢٥٢	٢٢١١	٢
	٥٠٩	٢٤٩	١٠٧٨	١
٦	٦٠١	٨٤٩	٤٦٦١	٣
	٦٠٢	٢٤٩	٩٧٤	١
	٦٠٣	١١٩٨	٣١٥٢	٣
	٦٠٤	١٦٢	١٠٤٥	١
	٦٠٥	٧٦٧	٣٨٠٥	٣
	٦٠٦	٦٢٣	١٠٥٩	١
	٦٠٧	٥١٧	٣٣٧١	٣
	٦٠٨	٤٦٦	١١٨٤	١
٧	٧٠١	٩٢٦	٢١٨٥	٣
	٧٠٢	١١٢	١١١١	١
	٧٠٣	١١١٧	٣٠٧٧	٣
	٧٠٤	٨٠	١٢٣٢	١
	٧٠٥	٨٠٦	٣٩١٣	٣
	٧٠٦	١٥١	١٦٥٧	١
	٧٠٧	٩١٦	٤٣٥٣	٣
	٧٠٨	١٧١	١١٢٠	١
	٧١٠	٤٨٤	١٢٣٢	١

٤.٣.٢.٣ *Interpretation of Measures of Effectiveness (MOEs)*

TRANSYT-٧F produces a comprehensive set of MOEs that the engineer can use for evaluating signal timing plans. The following important MOEs are printed in the Performance Table for each link:

٤.٣.٢.٣.١: Degree of Saturation

The degree of saturation is an indicator of the degree of congestion that can be expected on a link. The degree of saturation should be interpreted as follows:

١. If the degree of saturation is less than ٩٥٪, the traffic performance on a link will probably be acceptable and the other MOE values produced by the program will be accurate.

٢. If the degree of saturation is above ٩٥٪, the link may be congested. The user should be aware that cycle failures (failing to clear the queue on a link during the green period) are probable.

٤.٣.٢.٣.٢: Delay

Total delay is the sum of the uniform and random plus saturation delay components. The average delay per vehicle is the total delay on the link divided by the total flow on the link. The delay MOE values are the delay due to signal timing only. The amount of delay affects fuel consumption.

٤.٣.٢.٣.٣: Stops

Vehicle stops play a significant role in determining fuel consumption. Stops are reported in units of vehicles per hour and also percentage of vehicles stopped.

٤.٣.٢.٣.٤: Fuel Consumption

The estimate of fuel consumption is based on a linear combination of total travel, delay, and stops. The fuel consumption value includes fuel consumed at cruise, idle, and acceleration / deceleration. It is measured by units of gallons (liters) per hour.

٤.٣.٢.٣.٥: Performance Index

The performance index (PI) is the value of the optimization objective function. Simply stated, TRANSYT-٧F develops a single timing plan that produces a minimum value of the PI. Table (٤.٦) summarized the results for all intersections for existing flows in A.M. peak period. The TRANSYT-٧F Software output for Node No. ٥ as an illustrative example is presented in Appendix (E).

٤.٤: Improvement of Traffic Flow

An evaluation study for intersections network under prevailing conditions revealed that most intersections were operating with a degree of saturation greater than ٩٥٪, level of service F, and very high delay, therefore we should make alternative to improve movement at these intersections.

٤.٤.١: Optimization of Phase Sequence

This alternative includes the determination of the best phase’s time by using T٧FACT program on existing cycle length as shown in Table (٤.٧), which causes minimizing delay and improving performance index but there was no changes in measures of effectiveness for most intersections.

٤.٤.٢: Best Cycle Length

This alternative involves choosing the best cycle length by using CYCOPT program which gives a range of cycle length, then using T٧FACT program to determine the best phases time for the selected cycle length. We noticed that there was an improvement in the average delay but it was still great for most intersections, as shown in Table (٤.٨).

٤.٤.٣: Preventing Trucks

Although there was a little percentage of trucks entered the intersections, preventing them from entering at peak periods was led to decrease the average delay and performance index for these intersections, and to improve level of service for node ١ from E to D, as shown in Table (٤.٩).

٤.٤.٤: Increasing No. of Lanes

This alternative is containing the change in number of lanes for some links which leads to increase the saturation flow rate for these links. These changes include node No. ١, ٢, ٥, ٦, and ٧. From field measurements, we can observe that the number of lanes can be increased by reducing the width of divisional and refuge islands, such as in node No. ١, node No. ٢, and node No. ٧. On the other hand, the rights of way for node ٥ and node ٦ are very large, so a number of lanes can be increased by widening the roadway at these intersections. Table (٤.١٠) lists links before and after changing number of lanes. We noticed that the level of service for node No. ١ was improved from D to C; node No. ٢ was improved from F to C, and node No. ٥ from F to E, as shown in Table (٤.١١).

Saving is calculated by using the following equation **[FHWA, ١٩٨٤]**:

$$\% Saving\ in\ M.O.Es = \frac{M.O.Es(Existing) - M.O.Es(\text{Im}\,proving)}{M.O.Es(Existing)} \times 100 \quad .... (٤.٤)$$

Table (٤.١٤) shows the percentage of saving in measures of effectiveness for all intersections, and Figures (٤.١٨) to (٤.٢٤) show the percentage of saving in M.O.Es for all nodes.

Table (٤.١٤): Percentage of Saving in M.O.Es for the Operation Isolated Intersections.

Node Number	Average Delay (sec/veh)			Total Stops (veh/hr)			Total Fuel Consumption (lit./hr)			Performance Index (P.I)		
	Existing	Improving	% Saving	Existing	Improving	% Saving	Existing	Improving	% Saving	Existing	Improving	% Saving
١	٦٦	٣٥	٤٧	٤٤٠٤	٢٩٣٧	٣٣	٤٦٥	٣٥٠	٢٥	٩٧.٣٧	٥٤	٤٥
٢	٢٩١.٢	٢٣.٩	٩٢	٣٩٥٣	١٣٦٦	٦٥	٦٧٣	٢٣٥	٦٥	١٨٨.٩	٢١.٧	٨٩
٣	٤٦.٨	٤٣.١	٨	٢٥٦٩	٢٢٥١	١٢	٥٩٧	٥٥٩	٦	٥٠.٤٦	٤٤.٠٦	١٣
٤	٢٧.٣	٢٨.٥	٠	٢٤١٣	٢٢٠٩	٨	٤٨٣	٤٦٧	٣	٣٨.٧٣	٣٦.٤٣	٦
٥	١٦٤.٦	٣٥.٤	٧٨	٦٤٦٠	٣٥٨٢	٤٥	٨٩٣	٤٣٨	٥١	٢٤٣.٢	٦٦.٣	٧٣
٦	١٠٢٣.٨	٧٣٨.٥	٢٨	٩٧٧٦	٥٩٧٦	٣٩	٤١٦٨	١٦٨٨	٦٠	١٤٤٢	٦١٢.٦	٥٨
٧	٧٧٢.٥	٢٨٧.	٦٣	٩٩٧٤	٧١٧٥	٢٨	٣٢١٢	١٢١٤	٦٢	١٠٩١	٣٨٥.	٦٥

		٣									٧	

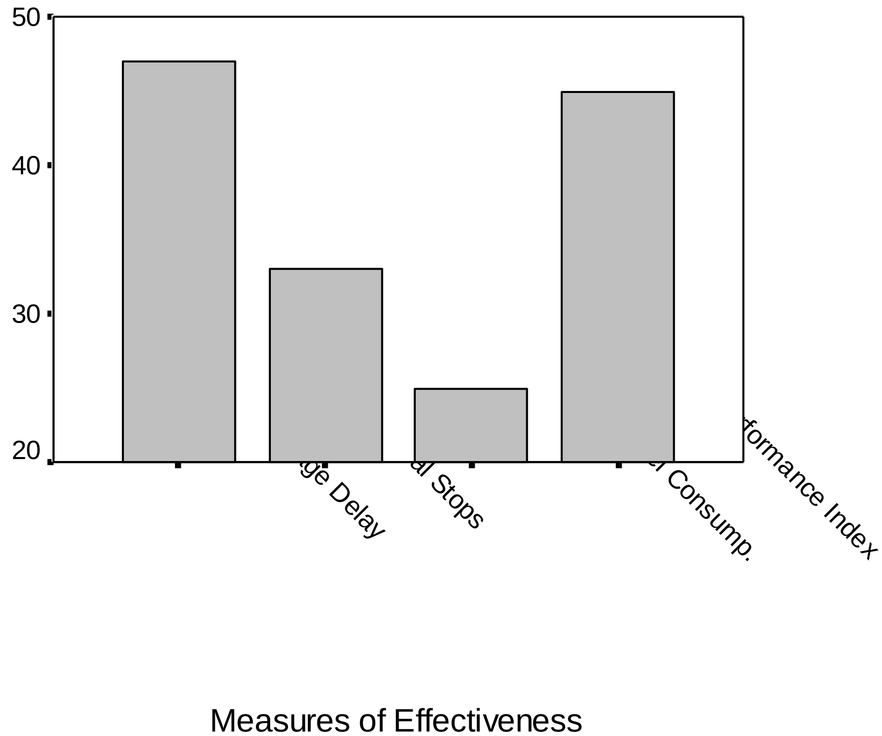
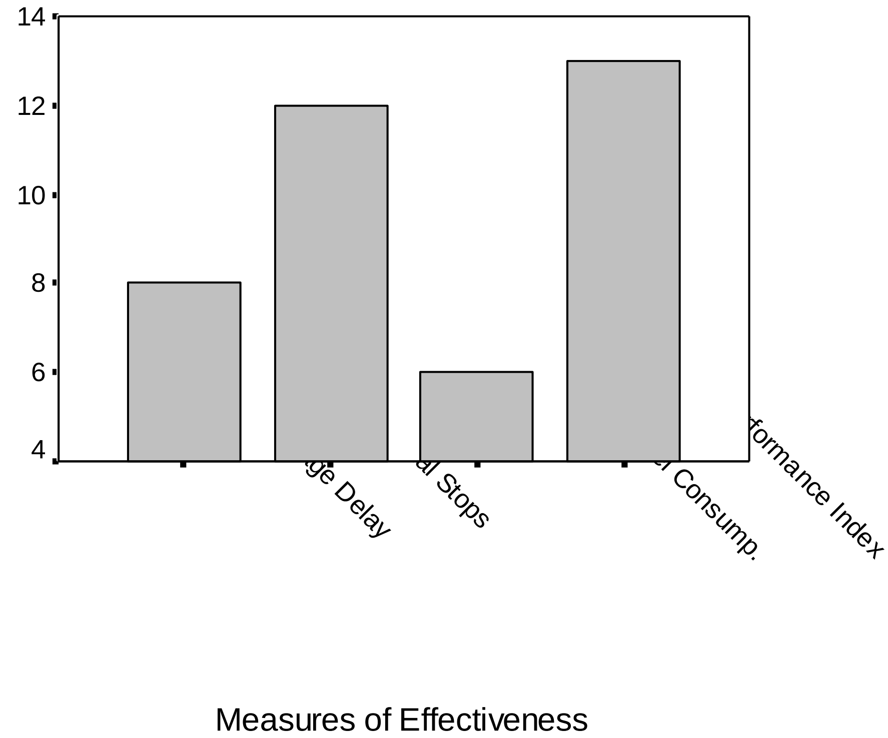


Figure (٤.٣) : % Saving in M.O.Es at Node No. ١ .



Figure(٤.٤) : % Saving in M.O.Es at Node No. ٢ .

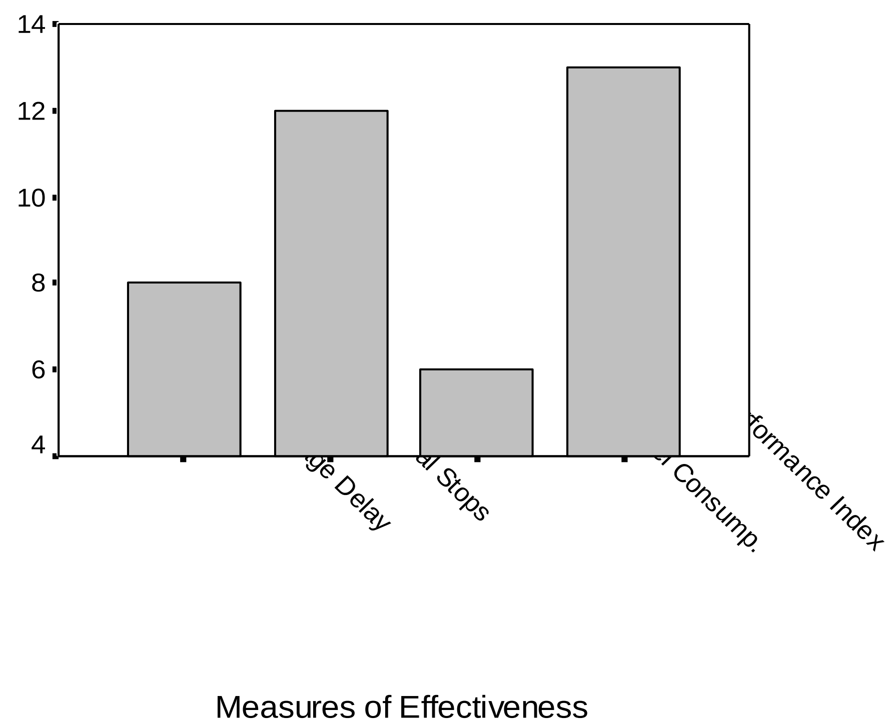


Figure (٤.٥): % Saving in M.O.Es at Node No. ٣.

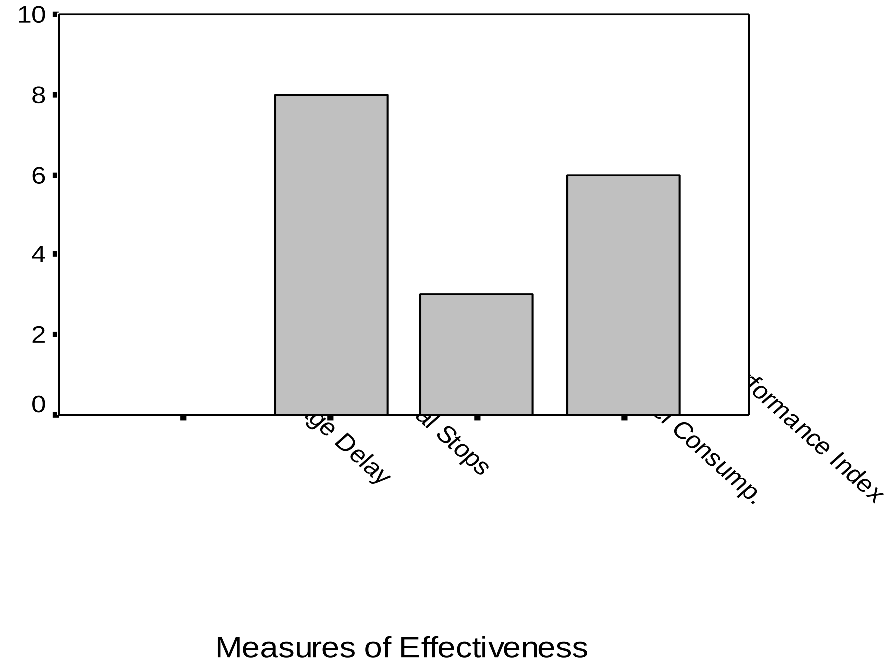


Figure (٤.٦): % Saving in M.O.Es at Node No. ٤.

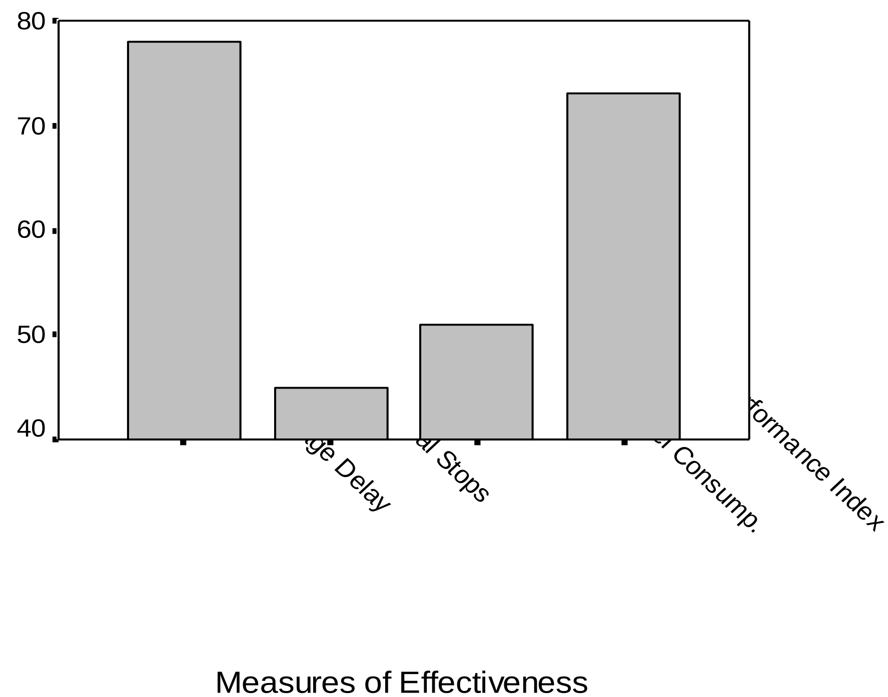


Figure (٤.٧): % Saving in M.O.Es at Node No. ٥.

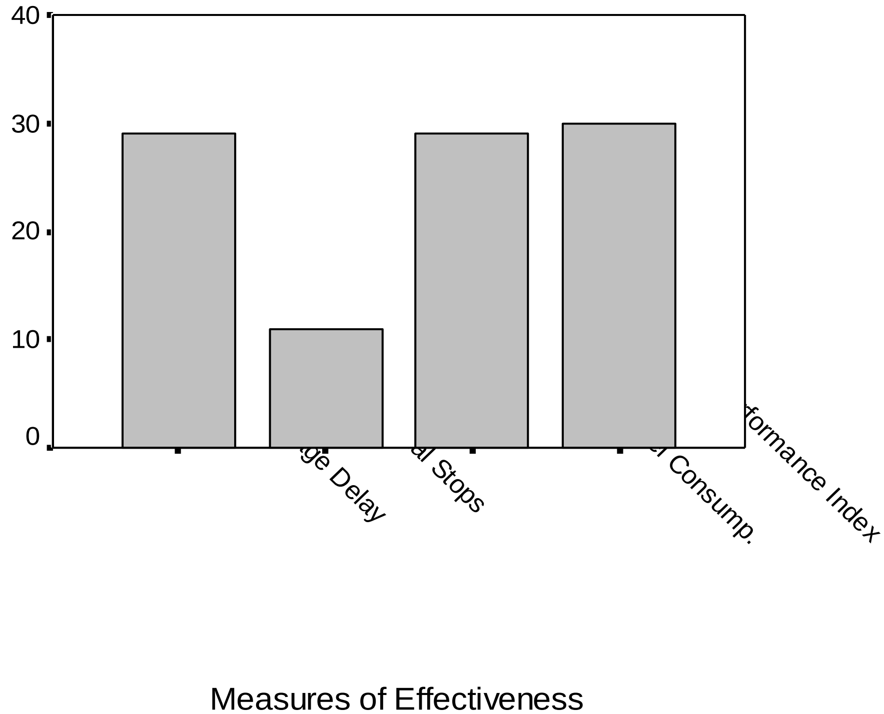


Figure (٤.٨): % Saving in M.O.Es at Node No. ٦.

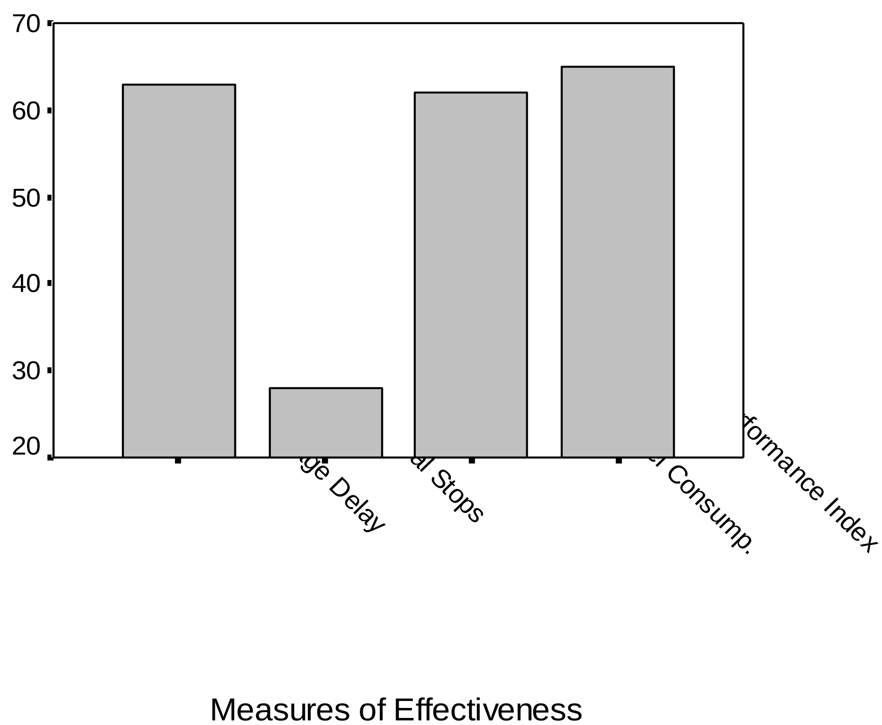


Figure (٤.٩): % Saving in M.O.Es at Node No. ٧.

٤.٥: Comparison between Results of HCS (٢٠٠٠) & TRANSYT-٧F (٢٠٠٢)

Measures of effectiveness resulted by TRANSYT-٧F(٢٠٠٢) and HCS(٢٠٠٠) are presented in Table (٤.١٥).The delay time and degree of saturation results for both HCS (٢٠٠٠) and TRANSYT-٧F (٢٠٠٢) computer programs for all nodes were compared statistically by t-test method **[Kennedy & Neville, ١٩٨٦]** using SPSS program **[SPSS, ٢٠٠٢]**, as shown in Table (٤.١٦). It can be noticed that the test results indicated no significant difference between the two software programs. Figures (٤.١١) and (٤.١٢) shows the relationship between average delay and degree of saturation for both TRANSYT-٧F (٢٠٠٢) and HCS (٢٠٠٠) software programs.

Table (٤.١٥): MOEs by TRANSYT-٧F & HCS for all Intersections .

Node No.	TRANSYT-٧F			HCS		
	Average Delay (sec/veh)	Degree of Saturation	LOS	Average Delay (sec/veh)	Degree of Saturation	LOS
١	٦٦	١.٠١	E	٣٦٥.٧	١.٦٢	F
٢	٢٩١	١.١٤	F	١٤٢.٦	١.١٢	F
٣	٤٦.٨	٠.٩١	D	١٢٣.٧	٠.٩٣	F
٤	٢٧.٣	٠.٨٢	C	١١٢.٥	١.٠٦	F
٥	١٦٤.٦	١.١٢	F	١٧٠.٨	١.١٣	F
٦	١٠٢٣.٨	١.٩٥	F	٣٧٠.٤	١.٧٩	F
٧	٧٧٢.٥	١.٤٧	F	٣٩٧.٥	١.٥٣	F

Table (٤.١٦): Summary of t-test Results for both HCS & TRANSYT-٧F

	Mean	Std. Deviation	Std. Error Mean	٩٥٪ confidence interval of the difference		t	Degree of Freedom	Sig.
				Lower	Upper			
Degree of Saturation	-٠.١٠٨٦	٠.٢٥٠٧٦	٠.٠٩٤٧٨	-٠.٣٤٠٥	٠.١٢٣٣	-١.١٤٦	٦	٠.٢٩٦
Average Delay	١٠١.٢٥٧	٣٢١.٦٧٢٥١	١٢١.٥٨٠٧٨	-١٩٦.٢٤٠٣	٣٩٨.٧٥٤٦	٠.٨٣٣	٦	٠.٤٣٧

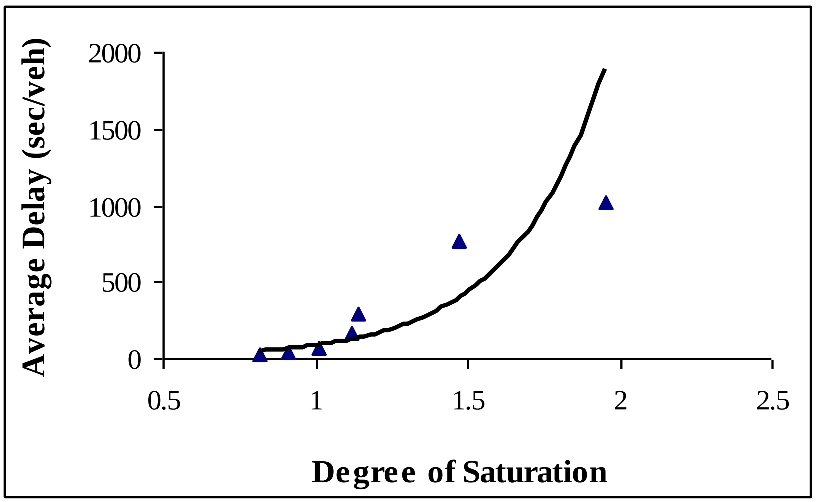


Figure (٤.١١): TRANSYT-٧F Estimate of Delay.

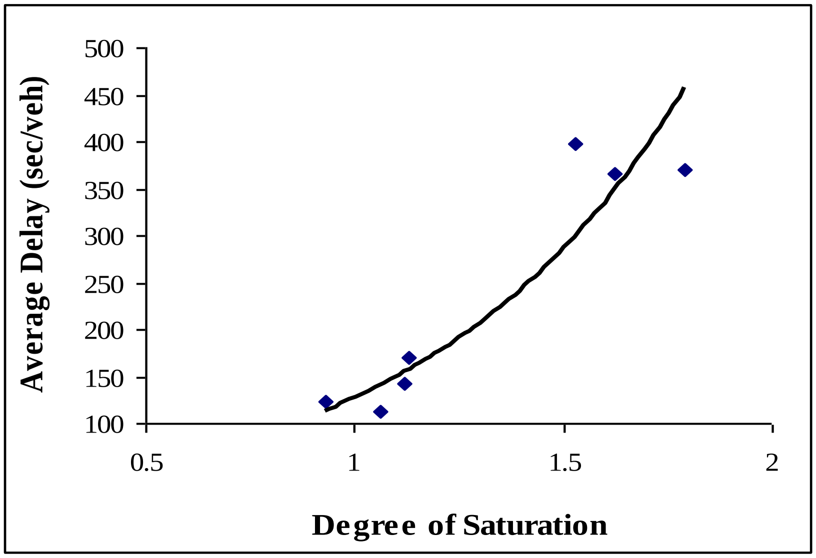


Figure (٤.١٢): HCS Estimate of Delay.

The curves in Figures (٤.١١) and (٤.١٢) showed that average delay rapidly increases when a link is saturated, and this condition will strongly influence the MOEs estimates, including that of fuel consumption. This delay model is clearly more realistic in the range near a degree of saturation ratio of ١٠٠٪ .

٤.٦: Summary

Conversion Traffic volumes from vehicles to passenger car for surveys in urban arterial are presented in this chapter. This chapter also deals with the discussion of the packages that are used for urban arterial analysis and evaluation in this research and gives a brief intuitive overview about them. All the data required to run these packages and outputs from them are presented in this chapter.

The level of service and other measures of effectiveness (MOEs)of the arterial were evaluated using HCS (٢٠٠٠) and TRANSYT-٧F (٢٠٠٢) software packages. Depending on the results of evaluation, six alternatives were made to improve the level of service and other measures of effectiveness (MOEs) using T٧FACT and CYCOPT programs which are found with TRANSYT-٧F (٢٠٠٢) program.

CHAPTER FIVE

CONCLUSIONS

٥.١: Introduction

This chapter presents the main conclusions which are evolved from the present research.

٥.٢: Conclusions

The main conclusions that can be drawn from the present study are as follows :

١) From the results of HCS-٢٠٠٠ program, the level of service for all intersections was F, the arterial's level of service was F and average travel speed was equal ١٤.٥ km/hr.

٢) From the results of TRANSYT-٧F program, the level of service for intersections ranged between (C & F).

٣) By comparison between HCS-٢٠٠٠ and TRANSYT-٧F-٢٠٠٢, there was no significant difference between the two software programs.

٤) Preventing trucks to enter intersections at peak periods (alternative number three) decreased the average delay and performance index, and improved level of service from E to D for node No. ١.

٥) From the results of alternative number four (increasing number of lanes), we noticed that the level of service for node No. ١ was improved from D to C, node No. ٢ was improved from F to C, and node No. ٥ from F to E.

٦) Changing in geometric design for node No. ٥ was led to improve its level of service from E to D.

٧) From the five alternatives it can be concluded that the optimization of phase sequence and cycle time did not introduce changes in the measures of effectiveness for the intersections like other alternatives. This means that the traffic congestion problems are so difficult to solve by only giving consideration to traffic cycle length or phasing, but it should be extended to change in geometric design for the intersections.

٨)The results obtained from simulation of isolated signalized intersections by TRANSYT-٧F release ٩.٤ (٢٠٠٢) program and five alternatives, revealed that a significant saving in the measure of effectiveness was found in the Muslim Intersection (node No.٢). It was found that the saving in average delay equals (٩٢ %), the saving in total stops equals (٦٥ %), the saving in total fuel consumption equals (٦٥٪), and the saving in Performance Index equals (٨٩٪) .

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APPENDIX A
TRAFFIC VOLUME DATA &
PERCENTAGE OF HEAVY VEHICLES
(FOR EACH ٥-MINTUTES)
INTERVAL

Table (A-١) : Traffic Volume Data for Southbound Direction-

Segment ١ .

Time Period	Passenger Cars	Minibuses	Trucks	%HV
٧:٣٠-٧:٣٥	٧٠	٤	٠	٥
٧:٣٥-٧:٤٠	٦٧	٤	١	٧
٧:٤٠-٧:٤٥	٧٠	١	١	٣
٧:٤٥-٧:٥٠	٨٥	٦	٠	٧
٧:٥٠-٧:٥٥	٨٢	٧	٠	٨
٧:٥٥-٨:٠٠	٩٣	٨	٠	٨
٨:٠٠-٨:٠٥	١٠٦	١٢	٣	١٢
٨:٠٥-٨:١٠	١٠٠	١٠	٢	١١
٨:١٠-٨:١٥	١٠٨	٧	٠	٦
٨:١٥-٨:٢٠	١١٠	١٠	٠	٨
٨:٢٠-٨:٢٥	٩٧	١١	٢	١٢
٨:٢٥-٨:٣٠	١٠٦	٨	٤	١٠
٨:٣٠-٨:٣٥	١٠٤	١٤	٢	١٣
٨:٣٥-٨:٤٠	١٢٠	٦	٢	٦
٨:٤٠-٨:٤٥	١٠٤	١٥	١	١٣
٨:٤٥-٨:٥٠	١١٨	١٠	١	٩
٨:٥٠-٨:٥٥	١١٨	١٧	٣	١٤
٨:٥٥-٩:٠٠	١٢٣	١٠	١	٨
٩:٠٠-٩:٠٥	٩٥	٨	٠	٨
٩:٠٥-٩:١٠	٩٨	٥	٠	٥
٩:١٠-٩:١٥	٨٥	٣	١	٤
٩:١٥-٩:٢٠	٩٩	٥	٠	٥
٩:٢٠-٩:٢٥	٧٣	٦	١	٩
٩:٢٥-٩:٣٠	٧٥	٤	٠	٥

Table (A-٢) : Traffic Volume Data for Southbound Direction-Segment ٢ .

Time Period	Passenger Cars	Minibuses	Trucks	%HV
٧:٣٠-٧:٣٥	٧١	٥	٢	٩
٧:٣٥-٧:٤٠	٦٧	٣	١	٦
٧:٤٠-٧:٤٥	٧٠	١	٠	١
٧:٤٥-٧:٥٠	٨١	٢	٠	٢
٧:٥٠-٧:٥٥	٧٩	٦	١	٨
٧:٥٥-٨:٠٠	٩٠	٧	١	٨
٨:٠٠-٨:٠٥	٩٩	١٤	٢	١٤
٨:٠٥-٨:١٠	٨٠	٩	٣	١٣
٨:١٠-٨:١٥	٩٦	٨	٠	٨
٨:١٥-٨:٢٠	٩٥	١٢	٠	١١
٨:٢٠-٨:٢٥	٨٧	١٢	١	١٣
٨:٢٥-٨:٣٠	٩٨	٩	٨	١٥
٨:٣٠-٨:٣٥	١٠٣	١٢	٣	١٣
٨:٣٥-٨:٤٠	٩٤	٦	١	٧
٨:٤٠-٨:٤٥	٩١	١٣	١	١٣
٨:٤٥-٨:٥٠	١١٦	١٠	٢	٩
٨:٥٠-٨:٥٥	٩٢	١٠	٣	١٢
٨:٥٥-٩:٠٠	١١٧	٨	١	٧
٩:٠٠-٩:٠٥	٩٤	٣	٠	٣
٩:٠٥-٩:١٠	٩١	٣	٠	٣
٩:١٠-٩:١٥	٨٩	٥	١	٦
٩:١٥-٩:٢٠	٨٥	٤	٢	٧
٩:٢٠-٩:٢٥	٧٧	٦	٠	٧
٩:٢٥-٩:٣٠	٧٠	٢	١	٤

Table (A-٣) : Traffic Volume Data for Southbound Direction-Segment ٣ .

Time Period	Passenger Cars	Minibuses	Trucks	%HV
٧:٣٠_٧:٣٥	٨٠	٥	٠	٦
٧:٣٥_٧:٤٠	٧٩	٥	٢	٨
٧:٤٠_٧:٤٥	٨١	٦	٢	٩
٧:٤٥_٧:٥٠	٩٢	٣	١	٤
٧:٥٠_٧:٥٥	٨٠	٩	٠	١٠
٧:٥٥_٨:٠٠	٩٥	٨	٢	١٠
٨:٠٠_٨:٠٥	١١٦	١٣	١	١١
٨:٠٥_٨:١٠	١٠٣	٨	٤	١٠
٨:١٠_٨:١٥	١٤٨	١٠	٣	٨
٨:١٥_٨:٢٠	١٠٥	١٣	٦	١٥
٨:٢٠_٨:٢٥	١٤٢	٦	٣	٦
٨:٢٥_٨:٣٠	١٤٣	١٤	٣	١١
٨:٣٠_٨:٣٥	١٠٨	١٤	٤	١٤
٨:٣٥_٨:٤٠	١١٥	١٣	٣	١٢
٨:٤٠_٨:٤٥	١٣٤	١٢	٣	١٠
٨:٤٥_٨:٥٠	١٢٥	١٤	١	١١
٨:٥٠_٨:٥٥	١٠٧	١٠	٢	١٠
٨:٥٥_٩:٠٠	١٣٥	١٢	٢	٩
٩:٠٠_٩:٠٥	٩٧	٨	٠	٨
٩:٠٥_٩:١٠	٨٨	٥	٠	٥
٩:١٠_٩:١٥	١٠١	٧	٢	٨
٩:١٥_٩:٢٠	٧٥	٦	٢	١٠
٩:٢٠_٩:٢٥	٧٥	٣	١	٥
٩:٢٥_٩:٣٠	٨٩	٤	٠	٤

Table (A-٤) : Traffic Volume Data for Southbound Direction-Segment ٤ .

Time Period	Passenger Cars	Minibuses	Trucks	%HV
٧:٣٠-٧:٣٥	٩٩	٧	٠	٧
٧:٣٥-٧:٤٠	٨٥	٦	١	٨
٧:٤٠-٧:٤٥	٨٩	٤	٢	٦
٧:٤٥-٧:٥٠	٩٨	٨	١	٨
٧:٥٠-٧:٥٥	١٠٠	٦	١	٧
٧:٥٥-٨:٠٠	٩٩	٥	٠	٥
٨:٠٠-٨:٠٥	١٣١	١١	٦	١١
٨:٠٥-٨:١٠	١٤٥	٩	٨	١٠
٨:١٠-٨:١٥	١٢٤	١٤	٤	١٣
٨:١٥-٨:٢٠	١٥٧	١٠	٢	٧
٨:٢٠-٨:٢٥	١٤٩	١٦	٣	١١
٨:٢٥-٨:٣٠	١٤٦	١٧	٤	١٣
٨:٣٠-٨:٣٥	١٥١	١٥	٣	١١
٨:٣٥-٨:٤٠	١٣٨	١٣	٤	١١
٨:٤٠-٨:٤٥	١٥٩	٨	٢	٦
٨:٤٥-٨:٥٠	١٣٢	١٠	١	٨
٨:٥٠-٨:٥٥	١٦٠	١٥	١	٩
٨:٥٥-٩:٠٠	١٥٤	١٢	٣	٩
٩:٠٠-٩:٠٥	١١٣	٨	٠	٧
٩:٠٥-٩:١٠	٩٩	١٢	٣	١٣
٩:١٠-٩:١٥	٩٦	٦	١	٧
٩:١٥-٩:٢٠	٩٧	٦	٢	٨
٩:٢٠-٩:٢٥	٨٩	٥	٢	٧
٩:٢٥-٩:٣٠	٩٠	٣	٠	٣

Table (A-٥) : Traffic Volume Data for Southbound Direction-Segment ٥ .

Time Period	Passenger Cars	Minibuses	Trucks	%HV
٧:٣٠-٧:٣٥	٩٠	٥	١	٦
٧:٣٥-٧:٤٠	٨٧	٣	٢	٥
٧:٤٠-٧:٤٥	٨٨	٤	٠	٤
٧:٤٥-٧:٥٠	٨٩	٥	٣	٨
٧:٥٠-٧:٥٥	٩١	٧	١	٨
٧:٥٥-٨:٠٠	٩٠	٩	٠	٩
٨:٠٠-٨:٠٥	١٤٠	١٠	١	٧
٨:٠٥-٨:١٠	١٥٧	١١	١	٧
٨:١٠-٨:١٥	١٣٣	١٢	٤	١١
٨:١٥-٨:٢٠	١٢٦	٩	١	٧
٨:٢٠-٨:٢٥	١٣٨	١٥	٠	١٠
٨:٢٥-٨:٣٠	١٥٠	١١	١	٧
٨:٣٠-٨:٣٥	١٥٥	٢٠	٥	١٤
٨:٣٥-٨:٤٠	١٤٩	١٤	٤	١١
٨:٤٠-٨:٤٥	١٣٨	٨	٢	٧
٨:٤٥-٨:٥٠	١٦٢	١٤	٥	١٠
٨:٥٠-٨:٥٥	١٥٠	١٦	٣	١١
٨:٥٥-٩:٠٠	١٥٢	١١	٢	٨
٩:٠٠-٩:٠٥	١٠١	١١	١	١١
٩:٠٥-٩:١٠	١٠٣	٨	١	٨
٩:١٠-٩:١٥	٩٩	٤	٠	٤
٩:١٥-٩:٢٠	٩٦	٨	٢	٩
٩:٢٠-٩:٢٥	٩٣	٧	٠	٧
٩:٢٥-٩:٣٠	٩٥	٥	١	٦

Table (A-٦) : Traffic Volume Data for Southbound Direction-Segment ٦ .

Time Period	Passenger Cars	Minibuses	Trucks	%HV
٧:٣٠-٧:٣٥	٩٥	٦	٢	٨
٧:٣٥-٧:٤٠	٩٣	٦	١	٧
٧:٤٠-٧:٤٥	٨٩	٩	٠	٩
٧:٤٥-٧:٥٠	٩٩	٨	٠	٧
٧:٥٠-٧:٥٥	١٠١	٦	٢	٧
٧:٥٥-٨:٠٠	٩٨	٨	١	٨
٨:٠٠-٨:٠٥	١٠٤	١٧	٢	١٥
٨:٠٥-٨:١٠	١٢٣	١١	٤	١١
٨:١٠-٨:١٥	١٠٦	١١	٠	٩
٨:١٥-٨:٢٠	١٠٤	١٣	١	١٢
٨:٢٠-٨:٢٥	١٠٧	١٥	٢	١٤
٨:٢٥-٨:٣٠	١٢٣	١٩	١	١٤
٨:٣٠-٨:٣٥	١١٧	١٦	١	١٣
٨:٣٥-٨:٤٠	١٠١	١٨	٢	١٧
٨:٤٠-٨:٤٥	١٠١	١٠	٤	١٢
٨:٤٥-٨:٥٠	١٣٥	١٦	٢	١٢
٨:٥٠-٨:٥٥	١٢٦	١٠	٠	٧
٨:٥٥-٩:٠٠	١٣٤	٩	٢	٨
٩:٠٠-٩:٠٥	١٠٧	٨	٠	٧
٩:٠٥-٩:١٠	٩٩	١٣	٢	١٣
٩:١٠-٩:١٥	١٠١	٧	٠	٦
٩:١٥-٩:٢٠	٨٨	١٠	١	١١
٩:٢٠-٩:٢٥	٨٥	٥	١	٧
٩:٢٥-٩:٣٠	٩٥	٥	١	٦

Table (A-٧) : Traffic Volume Data for Southbound Direction-Segment ٧ .

Time Period	Passenger Cars	Minibuses	Trucks	%HV
٧:٣٠_٧:٣٥	٦٢	٨	٠	١١
٧:٣٥_٧:٤٠	٧٢	٨	٠	٩
٧:٤٠_٧:٤٥	٩٨	١٠	٠	٩
٧:٤٥_٧:٥٠	٩٨	٧	١	٨
٧:٥٠_٧:٥٥	٨٥	٣	٠	٣
٧:٥٥_٨:٠٠	٩٩	١١	١	١١
٨:٠٠_٨:٠٥	١٠٧	٢٣	٠	١٨
٨:٠٥_٨:١٠	١٢٢	١٢	١	١٠
٨:١٠_٨:١٥	١٥٨	١٥	٠	٩
٨:١٥_٨:٢٠	١٠٨	١٥	٠	١٢
٨:٢٠_٨:٢٥	١٤١	٢	٠	١
٨:٢٥_٨:٣٠	١٥٩	١٨	٠	١٠
٨:٣٠_٨:٣٥	١١٢	١٤	٠	١١
٨:٣٥_٨:٤٠	١٢٥	١٧	٠	١٢
٨:٤٠_٨:٤٥	١٣١	٢٣	٠	١٥
٨:٤٥_٨:٥٠	١١٥	١٥	١	١٢
٨:٥٠_٨:٥٥	١٢٧	١٦	٠	١١
٨:٥٥_٩:٠٠	١١٦	١٤	٠	١١
٩:٠٠_٩:٠٥	١٠٢	٧	٠	٦
٩:٠٥_٩:١٠	٩٩	٧	١	٧
٩:١٠_٩:١٥	١٠٠	٥	٠	٥
٩:١٥_٩:٢٠	٨٥	٩	١	١١
٩:٢٠_٩:٢٥	٨٧	١٠	١	١١
٩:٢٥_٩:٣٠	٩٧	٦	٠	٦

Table (A-٨) : Traffic Volume Data for Northbound Direction-Segment ٨.

Time Period	Passenger Cars	Minibuses	Trucks	%HV
٧:٣٠-٧:٣٥	٥١	١	١	٤
٧:٣٥-٧:٤٠	٥٥	٣	١	٧
٧:٤٠-٧:٤٥	٦٨	٤	١	٧
٧:٤٥-٧:٥٠	٥٢	٩	٠	١٥
٧:٥٠-٧:٥٥	٦٠	٣	٠	٥
٧:٥٥-٨:٠٠	٦٩	٤	٢	٨
٨:٠٠-٨:٠٥	٧٣	٨	١	١١
٨:٠٥-٨:١٠	٧٨	١٤	٢	١٧
٨:١٠-٨:١٥	٨٩	٦	٠	٦
٨:١٥-٨:٢٠	٩١	١٠	٠	١٠
٨:٢٠-٨:٢٥	٩٧	٢٤	١	٢٠
٨:٢٥-٨:٣٠	٧٢	١٩	٢	٢٣
٨:٣٠-٨:٣٥	٨٢	١٣	٢	١٥
٨:٣٥-٨:٤٠	٦٨	٧	٠	٩
٨:٤٠-٨:٤٥	١٠٠	١٣	١	١٢
٨:٤٥-٨:٥٠	٩٢	٩	٠	٩
٨:٥٠-٨:٥٥	١١٤	١١	١	١٠
٨:٥٥-٩:٠٠	٩٦	١٧	٠	١٥
٩:٠٠-٩:٠٥	٨٣	٦	١	٨
٩:٠٥-٩:١٠	٦١	١٠	٠	١٤
٩:١٠-٩:١٥	٧٠	٣	٠	٤
٩:١٥-٩:٢٠	٨٠	٥	٠	٦
٩:٢٠-٩:٢٥	٥٧	٩	١	١٥
٩:٢٥-٩:٣٠	٥٧	٩	١	١٥

Table (A-٩) : Traffic Volume Data for Northbound Direction-Segment ٩.

Time Period	Passenger Cars	Minibuses	Trucks	%HV
٧:٣٠_٧:٣٥	٨٧	٥	٢	٧
٧:٣٥_٧:٤٠	٨٨	٤	٠	٤
٧:٤٠_٧:٤٥	٩٣	٢	٠	٢
٧:٤٥_٧:٥٠	٨٩	٦	١	٧
٧:٥٠_٧:٥٥	٩٥	٨	١	٩
٧:٥٥_٨:٠٠	٩٨	٥	٠	٥
٨:٠٠_٨:٠٥	١٣٢	٣	٠	٢
٨:٠٥_٨:١٠	١١١	٢٢	٣	١٨
٨:١٠_٨:١٥	١٢٦	١١	٢	٩
٨:١٥_٨:٢٠	٩٢	٧	١	٨
٨:٢٠_٨:٢٥	١٤٠	٢٧	١	١٧
٨:٢٥_٨:٣٠	١٢٩	٢١	٣	١٦
٨:٣٠_٨:٣٥	١١٤	١٤	١	١٢
٨:٣٥_٨:٤٠	١٠٦	١٣	٢	١٢
٨:٤٠_٨:٤٥	١١٦	٨	٢	٨
٨:٤٥_٨:٥٠	١١١	١٣	١	١١
٨:٥٠_٨:٥٥	١٢٣	٦	١	٥
٨:٥٥_٩:٠٠	١٦٣	١٧	٢	١٠
٩:٠٠_٩:٠٥	١١٥	٣	٠	٣
٩:٠٥_٩:١٠	١٠٠	٣	٠	٣
٩:١٠_٩:١٥	٩٩	٩	١	٩
٩:١٥_٩:٢٠	٩٩	٥	٢	٧
٩:٢٠_٩:٢٥	٨٩	٧	١	٨
٩:٢٥_٩:٣٠	٨٥	٨	٠	٩

Table (A-١٠) : Traffic Volume Data for Northbound Direction-Segment ١٠ .

Time Period	Passenger Cars	Minibuses	Trucks	%HV
٧:٣٠_٧:٣٥	٨١	٢	١	٤
٧:٣٥_٧:٤٠	٨١	٣	٢	٦
٧:٤٠_٧:٤٥	٨٦	٩	٠	٩
٧:٤٥_٧:٥٠	٩٠	٨	١	٩
٧:٥٠_٧:٥٥	٩٢	١٠	١	١١
٧:٥٥_٨:٠٠	٨٤	٧	٠	٨
٨:٠٠_٨:٠٥	٨٨	٣	٠	٣
٨:٠٥_٨:١٠	٨٦	١٥	٢	١٧
٨:١٠_٨:١٥	١١٣	١٠	٢	١٠
٨:١٥_٨:٢٠	٩٤	١٢	١	١٢
٨:٢٠_٨:٢٥	١١٧	١٣	٠	١٠
٨:٢٥_٨:٣٠	١١٦	١٥	١	١٢
٨:٣٠_٨:٣٥	٩٣	١٣	٢	١٤
٨:٣٥_٨:٤٠	١٠٢	١٢	٠	١١
٨:٤٠_٨:٤٥	١١٥	٤	٤	٧
٨:٤٥_٨:٥٠	٩٤	١٣	٠	١٢
٨:٥٠_٨:٥٥	١٢٢	١	١	٢
٨:٥٥_٩:٠٠	١١٦	٧	٠	٦
٩:٠٠_٩:٠٥	٩٩	٦	٠	٦
٩:٠٥_٩:١٠	٩٥	٦	٠	٦
٩:١٠_٩:١٥	٩٢	٨	١	٩
٩:١٥_٩:٢٠	٩٠	٤	٣	٧
٩:٢٠_٩:٢٥	٨٩	٢	١	٣
٩:٢٥_٩:٣٠	٨١	٤	٠	٥

Table (A-١١) : Traffic Volume Data for Northbound Direction-Segment ١١ .

Time Period	Passenger Cars	Minibuses	Trucks	%HV
٧:٣٠_٧:٣٥	٨٥	٣	١	٤
٧:٣٥_٧:٤٠	٨٥	٧	١	٩
٧:٤٠_٧:٤٥	٨٩	٥	٠	٥
٧:٤٥_٧:٥٠	٩٩	٥	٣	٧
٧:٥٠_٧:٥٥	١٠٠	٦	٠	٦
٧:٥٥_٨:٠٠	٩٣	٩	١	١٠
٨:٠٠_٨:٠٥	١٥٥	١٨	١	١١
٨:٠٥_٨:١٠	١٢٦	١٢	٩	١٦
٨:١٠_٨:١٥	١٤٦	١٠	٣	٨
٨:١٥_٨:٢٠	١٣٣	١٧	١	١٢
٨:٢٠_٨:٢٥	١٤٠	١٧	٧	١٥
٨:٢٥_٨:٣٠	١٦١	١٧	٣	١١
٨:٣٠_٨:٣٥	١٦٦	١٣	٠	٧
٨:٣٥_٨:٤٠	١٦٩	٢٢	٤	١٣
٨:٤٠_٨:٤٥	١٣٠	١٠	٤	١٠
٨:٤٥_٨:٥٠	١٣٢	١٨	٢	١٣
٨:٥٠_٨:٥٥	١٢٧	١٢	١	٩
٨:٥٥_٩:٠٠	١٢٨	٩	٣	٩
٩:٠٠_٩:٠٥	١٠٠	١١	١	١١
٩:٠٥_٩:١٠	٩٩	٧	٠	٧
٩:١٠_٩:١٥	٩٨	٨	٠	٨
٩:١٥_٩:٢٠	٩٨	١٠	٢	١١
٩:٢٠_٩:٢٥	٩٧	٤	٢	٦
٩:٢٥_٩:٣٠	٩٥	١١	١	١١

Table (A-١٢) : Traffic Volume Data for Northbound Direction-Segment ١٢ .

Time Period	Passenger Cars	Minibuses	Trucks	%HV
٧:٣٠_٧:٣٥	٩١	٥	١	٦
٧:٣٥_٧:٤٠	٩٠	٣	٢	٥
٧:٤٠_٧:٤٥	٩١	٨	٢	١٠
٧:٤٥_٧:٥٠	٩٢	٦	٠	٦
٧:٥٠_٧:٥٥	٩٥	١٤	٠	١٣
٧:٥٥_٨:٠٠	٩٨	٧	١	٨
٨:٠٠_٨:٠٥	١٠٠	٧	٢	٨
٨:٠٥_٨:١٠	٩٩	١٩	٥	٢٠
٨:١٠_٨:١٥	١٢٠	٥	٤	٧
٨:١٥_٨:٢٠	١٠٧	١٨	٣	١٦
٨:٢٠_٨:٢٥	١٠٢	١	٢	٣
٨:٢٥_٨:٣٠	١٠٨	١٦	٠	١٣
٨:٣٠_٨:٣٥	١٣١	٨	٦	٩
٨:٣٥_٨:٤٠	١١٧	٩	٣	٩
٨:٤٠_٨:٤٥	١٠٠	٧	٩	١٤
٨:٤٥_٨:٥٠	٧٦	١٣	٤	١٨
٨:٥٠_٨:٥٥	١١٧	١١	٠	٩
٨:٥٥_٩:٠٠	١٣٦	١٢	٢	٩
٩:٠٠_٩:٠٥	١٠٤	٩	٠	٨
٩:٠٥_٩:١٠	٩٩	٦	٠	٦
٩:١٠_٩:١٥	١٠٠	٤	١	٥
٩:١٥_٩:٢٠	٩٧	٧	٢	٨
٩:٢٠_٩:٢٥	٨٩	٩	١	١٠
٩:٢٥_٩:٣٠	٩٣	٧	١	٨

Table (A-١٣) : Traffic Volume Data for Northbound Direction-Segment ١٣ .

Time Period	Passenger Cars	Minibuses	Trucks	%HV
٧:٣٠_٧:٣٥	٥٩	٨	٠	١٢
٧:٣٥_٧:٤٠	٦٨	٦	٠	٨
٧:٤٠_٧:٤٥	٦٦	٦	١	١٠
٧:٤٥_٧:٥٠	٨٥	٩	١	١١
٧:٥٠_٧:٥٥	٩٠	١٠	٢	١٢
٧:٥٥_٨:٠٠	٨٨	٨	٣	١١
٨:٠٠_٨:٠٥	٩٠	١٦	٦	٢٠
٨:٠٥_٨:١٠	٩٨	١٠	٢	١١
٨:١٠_٨:١٥	٩٥	١٦	٤	١٧
٨:١٥_٨:٢٠	١١٢	١٢	٣	١٢
٨:٢٠_٨:٢٥	١٠٠	١٨	٢	١٧
٨:٢٥_٨:٣٠	١٠٤	١٨	٠	١٥
٨:٣٠_٨:٣٥	١٠٠	١٠	١	١٠
٨:٣٥_٨:٤٠	١٠٠	١٧	٠	١٥
٨:٤٠_٨:٤٥	١٠٣	١٤	٥	١٦
٨:٤٥_٨:٥٠	٨٨	١٠	٣	١٣
٨:٥٠_٨:٥٥	٩٩	١١	٣	١٢
٨:٥٥_٩:٠٠	٨١	١٦	٢	١٨
٩:٠٠_٩:٠٥	٧٩	٩	١	١١
٩:٠٥_٩:١٠	٨٠	٨	٢	١١
٩:١٠_٩:١٥	٩١	٩	٣	١٢
٩:١٥_٩:٢٠	٩١	١١	٣	١٣
٩:٢٠_٩:٢٥	٧٨	٥	٢	٨
٩:٢٥_٩:٣٠	٧٧	٦	١	٨

Table (A-١٤) : Traffic Volume Data for Northbound Direction-Segment ١٤ .

Time Period	Passenger Cars	Minibuses	Trucks	%HV
٧:٣٠-٧:٣٥	٦٥	٦	١	١٠
٧:٣٥-٧:٤٠	٦٠	٥	١	٩
٧:٤٠-٧:٤٥	٧١	٨	٠	١٠
٧:٤٥-٧:٥٠	٦٢	٤	٢	٩
٧:٥٠-٧:٥٥	٧٥	٥	١	٧
٧:٥٥-٨:٠٠	٧٩	٣	٠	٤
٨:٠٠-٨:٠٥	٨٠	٨	١	١٠
٨:٠٥-٨:١٠	٧٧	٩	٠	١٠
٨:١٠-٨:١٥	٧٧	١٧	٢	٢٠
٨:١٥-٨:٢٠	٨٤	١٣	١	١٤
٨:٢٠-٨:٢٥	٨٢	١٧	٣	٢٠
٨:٢٥-٨:٣٠	٩١	١٥	٢	١٦
٨:٣٠-٨:٣٥	٩٥	١١	٣	١٣
٨:٣٥-٨:٤٠	٩٦	١١	٢	١٢
٨:٤٠-٨:٤٥	٨٥	١٥	٢	١٧
٨:٤٥-٨:٥٠	٨٧	١١	٦	١٦
٨:٥٠-٨:٥٥	٩١	١٤	٠	١٣
٨:٥٥-٩:٠٠	٧٣	١٣	١	١٦
٩:٠٠-٩:٠٥	٦٦	٨	٢	١٣
٩:٠٥-٩:١٠	٧٠	٨	٢	١٣
٩:١٠-٩:١٥	٦٨	١٠	١	١٤
٩:١٥-٩:٢٠	٥٩	٥	١	٩
٩:٢٠-٩:٢٥	٧٥	٥	٠	٦
٩:٢٥-٩:٣٠	٧١	٩	١	١٢

APPENDIX B

REDUCED FLOW, AND SPEED DATA

Table (B-١) : Flow and Speed Data for Segment ١ .

Time (min.)	Flow (pc/hr)	Speed (km/hr)
٧:٣٠_٧:٣٥	٩٠٠	٢٥.٩٢
٧:٣٥_٧:٤٠	٨٨٨	٢٥.٩٢
٧:٤٠_٧:٤٥	٨٧٩	٢٨.٤٤
٧:٤٥_٧:٥٠	١١١٠	٢٤.٨٤
٧:٥٠_٧:٥٥	١٠٨٩	٢١.٢٤
٧:٥٥_٨:٠٠	١٢٣٦	٢١.٩٦
٨:٠٠_٨:٠٥	١٥٢٤	٢٤.١٢
٨:٠٥_٨:١٠	١٣٩٨	٢٣.٠٤
٨:١٠_٨:١٥	١٤٠١	٢٣.٧٦
٨:١٥_٨:٢٠	١٤٧٠	٢٣.٧٦
٨:٢٠_٨:٢٥	١٣٧٧	٢٣.٤
٨:٢٥_٨:٣٠	١٤٨٨	٢٠.٨٨
٨:٣٠_٨:٣٥	١٥٠٦	٢٠.١٦
٨:٣٥_٨:٤٠	١٥٧٨	١٩.٤٤
٨:٤٠_٨:٤٥	١٤٩٧	٢٠.١٦
٨:٤٥_٨:٥٠	١٥٩٠	٢٠.١٦
٨:٥٠_٨:٥٥	١٧٤٣	١٩.٨
٨:٥٥_٩:٠٠	١٦٥٠	١٨.٧٢
٩:٠٠_٩:٠٥	١٢٦٠	٢٢.٣٢
٩:٠٥_٩:١٠	١٢٥١	٢٢.٦٨
٩:١٠_٩:١٥	١٠٨٩	٢٥.٥٦
٩:١٥_٩:٢٠	١٢٦٣	٢٥.٩٢
٩:٢٠_٩:٢٥	٩٩٠	٢٩.٨٨
٩:٢٥_٩:٣٠	٩٦٠	٢٧.٧٢

Table (B-٢) : Flow and Speed Data for Segment ٢ .

Time (min.)	Flow (pc/hr)	Speed (km/hr)
٧:٣٠-٧:٣٥	٩٧٥	٣٨٫٨٨
٧:٣٥-٧:٤٠	٨٧٣	٣٩٫٢٤
٧:٤٠-٧:٤٥	٨٥٥	٤١٫٠٤
٧:٤٥-٧:٥٠	١٠٠٢	٤٥
٧:٥٠-٧:٥٥	١٠٦٢	٣٧٫٨
٧:٥٥-٨:٠٠	١٢٠٩	٣٦
٨:٠٠-٨:٠٥	١٤٤٦	٣٤٫٥٦
٨:٠٥-٨:١٠	١١٦٧	٣٥٫٢٨
٨:١٠-٨:١٥	١٢٧٢	٣٠٫٩٦
٨:١٥-٨:٢٠	١٣٢٠	٢٨٫٠٨
٨:٢٠-٨:٢٥	١٢٤٨	٢٨٫٤٤
٨:٢٥-٨:٣٠	١٥٠٣	٢٧٫٣٦
٨:٣٠-٨:٣٥	١٤٨٨	٢٧٫٣٦
٨:٣٥-٨:٤٠	١٢٤٢	٢٨٫٠٨
٨:٤٠-٨:٤٥	١٣١١	٢٥٫٩٢
٨:٤٥-٨:٥٠	١٥٩٠	٢٦٫٦٤
٨:٥٠-٨:٥٥	١٣٢٦	٢٤٫٤٨
٨:٥٥-٩:٠٠	١٥٤٨	٢٤٫٨٤
٩:٠٠-٩:٠٥	١١٧٣	٢٢٫٦٨
٩:٠٥-٩:١٠	١١٣٧	٢٥٫٥٦
٩:١٠-٩:١٥	١١٦٧	٢٧
٩:١٥-٩:٢٠	١١٢٨	٢٩٫٨٨
٩:٢٠-٩:٢٥	١٠١٤	٣٩٫٢٤
٩:٢٥-٩:٣٠	٨٩٤	٤٢٫٤٨

Table (B-٣) :Flow and Speed Data for Segment ٣ .

Time (min.)	Flow (pc/hr)	Speed (km/hr)
٧:٣٠-٧:٣٥	١٠٣٥	٦٠.٨٤
٧:٣٥-٧:٤٠	١٠٧١	٥٢.٥٦
٧:٤٠-٧:٤٥	١١١٠	٥٣.٦٤
٧:٤٥-٧:٥٠	١١٧٣	٥٢.٥٦
٧:٥٠-٧:٥٥	١٠٩٥	٤٥
٧:٥٥-٨:٠٠	١٣٠٨	٤٩.٣٢
٨:٠٠-٨:٠٥	١٦١١	٣٤.٩٢
٨:٠٥-٨:١٠	١٤٥٢	٣٤.٩٢
٨:١٠-٨:١٥	١٩٩٨	٢٨.٨
٨:١٥-٨:٢٠	١٥٩٩	٢٧
٨:٢٠-٨:٢٥	١٨٦٦	٢٧.٧٢
٨:٢٥-٨:٣٠	١٩٩٨	٣٠.٦
٨:٣٠-٨:٣٥	١٦٠٢	٢٩.٨٨
٨:٣٥-٨:٤٠	١٦٤٧	٣٩.٩٦
٨:٤٠-٨:٤٥	١٨٦٠	٤٣.٢
٨:٤٥-٨:٥٠	١٧٤٣	٤٧.٥٢
٨:٥٠-٨:٥٥	١٤٨٢	٤٣.٢
٨:٥٥-٩:٠٠	١٨٤٨	٤٣.٩٢
٩:٠٠-٩:٠٥	١٢٨٤	٣٤.٩٢
٩:٠٥-٩:١٠	١١٣١	٣٤.٩٢
٩:١٠-٩:١٥	١٣٦٥	٣٧.٨
٩:١٥-٩:٢٠	١٠٣٨	٤١.٧٦
٩:٢٠-٩:٢٥	٩٦٩	٤٣.٢
٩:٢٥-٩:٣٠	١١٢٨	٤٧.٥٢

Table (B-٤) : Flow and Speed Data for Segment ٤ .

Time (min.)	Flow (pc/hr)	Speed (km/hr)
٧:٣٠_٧:٣٥	١٢٩٣	٥٩.٧٦
٧:٣٥_٧:٤٠	١١٣٤	٤٥
٧:٤٠_٧:٤٥	١١٧٦	٤٩.٣٢
٧:٤٥_٧:٥٠	١٣٢٠	٥١.٤٨
٧:٥٠_٧:٥٥	١٣١٤	٤٢.٤٨
٧:٥٥_٨:٠٠	١٢٦٣	٣٨.٨٨
٨:٠٠_٨:٠٥	١٨٨١	٣٤.٩٢
٨:٠٥_٨:١٠	٢٠٦٧	٣٥.٢٨
٨:١٠_٨:١٥	١٧٩٤	٢٩.٥٢
٨:١٥_٨:٢٠	٢٠٨٨	٢٧.٧٢
٨:٢٠_٨:٢٥	٢١٠٠	٢٣.٤
٨:٢٥_٨:٣٠	٢١٠٣	٢٤.٤٨
٨:٣٠_٨:٣٥	٢١٠٩	٢٤.٨٤
٨:٣٥_٨:٤٠	١٩٤٧	٢٦.٢٨
٨:٤٠_٨:٤٥	٢٠٧٦	١٩.٨
٨:٤٥_٨:٥٠	١٧٥٨	٢٧.٧٢
٨:٥٠_٨:٥٥	٢١٦٩	٣٠.٩٦
٨:٥٥_٩:٠٠	٢١٠٠	٢٩.٨٨
٩:٠٠_٩:٠٥	١٤٧٦	٢٨.٨
٩:٠٥_٩:١٠	١٤٤٠	٣٣.١٢
٩:١٠_٩:١٥	١٢٦٦	٣٢.٤
٩:١٥_٩:٢٠	١٣٠٢	٤٥
٩:٢٠_٩:٢٥	١١٩١	٤٦.٠٨
٩:٢٥_٩:٣٠	١١٢٥	٤٤.٢٨

Table (B-٥) : Flow and Speed Data for Segment ٥ .

Time Period	Flow (pc/hr)	Speed (km/hr)
٧:٣٠-٧:٣٥	١١٧٩	٣٧.٠٨
٧:٣٥-٧:٤٠	١١٣٧	٣٦.٧٢
٧:٤٠-٧:٤٥	١١١٦	٣٣.١٢
٧:٤٥-٧:٥٠	١٢١٥	٣٢.٠٤
٧:٥٠-٧:٥٥	١٢٢١	٣٢.٠٤
٧:٥٥-٨:٠٠	١٢١٥	٢٧.٣٦
٨:٠٠-٨:٠٥	١٨٥٤	٢٥.٩٢
٨:٠٥-٨:١٠	٢٠٧٣	٢٤.٨٤
٨:١٠-٨:١٥	١٨٧٢	٢٨.٤٤
٨:١٥-٨:٢٠	١٦٧١	٢٣.٤
٨:٢٠-٨:٢٥	١٨٨١	٢٤.٨٤
٨:٢٥-٨:٣٠	١٩٨٩	٤١.٠٤
٨:٣٠-٨:٣٥	٢٢٨٠	٢١.٩٦
٨:٣٥-٨:٤٠	٢٠٩٤	١٩.٨
٨:٤٠-٨:٤٥	١٨٢٤	٢٠.١٦
٨:٤٥-٨:٥٠	٢٢٧٤	٢٢.٠٨
٨:٥٠-٨:٥٥	٢١١٢	١٩.٨
٨:٥٥-٩:٠٠	٢٠٣٧	١٩.٤٤
٩:٠٠-٩:٠٥	١٤٠١	١٩.٠٨
٩:٠٥-٩:١٠	١٣٨٠	٢٠.٥٢
٩:١٠-٩:١٥	١٢٤٨	٢٣.٠٤
٩:١٥-٩:٢٠	١٣٢٠	٢١.٦
٩:٢٠-٩:٢٥	١٢٢١	٢٢.٦٨
٩:٢٥-٩:٣٠	١٢٣٩	٢٢.٦٨

Table (B-٦) : Flow and Speed Data for Segment ٦ .

Time Period	Flow (pc/hr)	Speed (km/hr)
٧:٣٠_٧:٣٥	١٢٧٨	٢٣.٧٦
٧:٣٥_٧:٤٠	١٢٣٠	٢٦.٦٤
٧:٤٠_٧:٤٥	١٢٠٣	٢٣.٧٦
٧:٤٥_٧:٥٠	١٣٠٨	٢٥.٥٦
٧:٥٠_٧:٥٥	١٣٥٠	٢٤.٨٤
٧:٥٥_٨:٠٠	١٣٢٠	٢٤.١٢
٨:٠٠_٨:٠٥	١٥٥١	٢٣.٠٤
٨:٠٥_٨:١٠	١٧٣٧	٢٣.٠٤
٨:١٠_٨:١٥	١٤٣٧	٢٣.٠٤
٨:١٥_٨:٢٠	١٤٦٧	٢١.٢٤
٨:٢٠_٨:٢٥	١٥٥٧	٢١.٢٤
٨:٢٥_٨:٣٠	١٧٨٥	٢١.٢٤
٨:٣٠_٨:٣٥	١٦٦٨	٢٢.٣٢
٨:٣٥_٨:٤٠	١٥٣٠	٢٠.١٦
٨:٤٠_٨:٤٥	١٤٥٨	١٩.٠٨
٨:٤٥_٨:٥٠	١٩٠٨	٢٠.٥٢
٨:٥٠_٨:٥٥	١٦٦٢	٢٠.١٦
٨:٥٥_٩:٠٠	١٧٩١	١٩.٠٨
٩:٠٠_٩:٠٥	١٤٠٤	٢٠.١٦
٩:٠٥_٩:١٠	١٤٣١	٢٤.٨٤
٩:١٠_٩:١٥	١٣١٧	٢٥.٩٢
٩:١٥_٩:٢٠	١٢٣٠	٢٢.٦٨
٩:٢٠_٩:٢٥	١١١٩	٢٥.٩٢
٩:٢٥_٩:٣٠	١٢٣٩	٢٤.٤٨

Table (B-٧) : Flow and Speed Data for Segment ٧ .

Time Period	Flow (pc/hr)	Speed (km/hr)
٧:٣٠_٧:٣٥	٨٦٤	٣٤.٥٦
٧:٣٥_٧:٤٠	٩٨٤	٣٠.٢٤
٧:٤٠_٧:٤٥	١٣٢٦	٢٩.٨٨
٧:٤٥_٧:٥٠	١٣٠٥	٢٨.٤٤
٧:٥٠_٧:٥٥	١٠٦٥	٢٧.٧٢
٧:٥٥_٨:٠٠	١٣٧٧	٢٤.١٢
٨:٠٠_٨:٠٥	١٦٢٩	٢٥.٥٦
٨:٠٥_٨:١٠	١٦٦٨	٢٤.٨٤
٨:١٠_٨:١٥	٢١٢١	٢١.٢٤
٨:١٥_٨:٢٠	١٥٢١	٢٣.٠٤
٨:٢٠_٨:٢٥	١٧٢٢	٢٣.٠٤
٨:٢٥_٨:٣٠	٢١٧٨	٢٣.٠٤
٨:٣٠_٨:٣٥	١٥٥٤	٢٣.٧٦
٨:٣٥_٨:٤٠	١٧٥٥	٢٣.٤
٨:٤٠_٨:٤٥	١٩١٧	٢١.٦
٨:٤٥_٨:٥٠	١٦٢٩	٢١.٩٦
٨:٥٠_٨:٥٥	١٧٦٤	١٩.٤٤
٨:٥٥_٩:٠٠	١٦٠٢	١٩.٠٨
٩:٠٠_٩:٠٥	١٣٢٩	١٩.٠٨
٩:٠٥_٩:١٠	١٣١٧	٢١.٩٦
٩:١٠_٩:١٥	١٢٧٥	٢٠.١٦
٩:١٥_٩:٢٠	١١٧٩	٢١.٢٤
٩:٢٠_٩:٢٥	١٢١٨	١٩.٠٨
٩:٢٥_٩:٣٠	١٢٥٤	٢١.٢٤

Table (B-٨) : Flow and Speed data for Segment ٨ .

Time Period	Flow (pc/hr)	Speed (km/hr)
٧.٣٠-٧.٣٥	٦٥١	٥٢.٢
٧.٣٥-٧.٤٠	٧٢٩	٤٩.٦٨
٧.٤٠-٧.٤٥	٩٠٠	٤٦.٤٤
٧.٤٥-٧.٥٠	٧٥٩	٣٣.٤٨
٧.٥٠-٧.٥٥	٧٦٥	٣٨.٥٢
٧.٥٥-٨.٠٠	٩٣٦	٣٣.١٢
٨.٠٠-٨.٠٥	١٠٢٠	٣٨.١٦
٨.٠٥-٨.١٠	١١٩٤	٣٠.٩٦
٨.١٠-٨.١٥	١١٥٨	٢٩.٥٢
٨.١٥-٨.٢٠	١٢٤٢	٢٩.٨٨
٨.٢٠-٨.٢٥	١٥٤٨	٣٣.١٢
٨.٢٥-٨.٣٠	١١٩٧	٣٦.٣٦
٨.٣٠-٨.٣٥	١٢٢٧	٢٧.٣٦
٨.٣٥-٨.٤٠	٩٢١	٢٨.٠٨
٨.٤٠-٨.٤٥	١٤١٩	٣٠.٢٤
٨.٤٥-٨.٥٠	١٢٣٩	٣١.٣٢
٨.٥٠-٨.٥٥	١٥٥٧	٢٧.٧٢
٨.٥٥-٩.٠٠	١٤٠٧	٣١.٣٢
٩.٠٠-٩.٠٥	١١١٠	٢٥.٢
٩.٠٥-٩.١٠	٨٨٢	٢٢.٦٨
٩.١٠-٩.١٥	٨٨٥	٢٦.٢٨
٩.١٥-٩.٢٠	١٠٣٥	٣٣.٨٤
٩.٢٠-٩.٢٥	٨٤٣	٣٣.٤٨
٩.٢٥-٩.٣٠	٨٤٣	٣٥.٢٨

Table (B-٩) : Flow and Speed Data for Segment ٩ .

Time Period	Flow (pc/hr)	Speed (km/hr)
٧:٣٠-٧:٣٥	١١٦٧	٢٨.٤٤
٧:٣٥-٧:٤٠	١١١٦	٢٩.١٦
٧:٤٠-٧:٤٥	١١٤٦	٢٨.٠٨
٧:٤٥-٧:٥٠	١١٨٢	٢٧
٧:٥٠-٧:٥٥	١٢٨٤	٣٢.٤
٧:٥٥-٨:٠٠	١٢٥١	٢٦.٦٤
٨:٠٠-٨:٠٥	١٦٢٩	١٩.٨
٨:٠٥-٨:١٠	١٧٣٤	١٩.٤٤
٨:١٠-٨:١٥	١٧٢٥	١٩.٤٤
٨:١٥-٨:٢٠	١٢٣٣	١٧.٦٤
٨:٢٠-٨:٢٥	٢١٠٩	١٨.٧٢
٨:٢٥-٨:٣٠	١٩٣٥	١٨
٨:٣٠-٨:٣٥	١٦٠٢	١٧.٦٤
٨:٣٥-٨:٤٠	١٥٣٩	١٨.٣٦
٨:٤٠-٨:٤٥	١٥٦٠	١٦.٩٢
٨:٤٥-٨:٥٠	١٥٥١	١٧.٢٨
٨:٥٠-٨:٥٥	١٥٩٠	١٦.٥٦
٨:٥٥-٩:٠٠	٢٢٥٩	٢٤.١٢
٩:٠٠-٩:٠٥	١٤٢٥	٢٤.١٢
٩:٠٥-٩:١٠	١٢٤٥	٢١.٩٦
٩:١٠-٩:١٥	١٣٤٧	٢٢.٦٨
٩:١٥-٩:٢٠	١٣١١	٢٥.٥٦
٩:٢٠-٩:٢٥	١١٩٧	٢٢.٦٨
٩:٢٥-٩:٣٠	١١٤٠	٢٢.٨

Table (B-١٠) : Flow and Speed Data for Segment ١٠ .

Time Period	Flow (pc/hr)	Speed (km/hr)
٧:٣٠-٧:٣٥	١٠٢٦	٤٧.٨٨
٧:٣٥-٧:٤٠	١٠٦٥	٤٦.٠٨
٧:٤٠-٧:٤٥	١١٦٧	٤٦.٤٤
٧:٤٥-٧:٥٠	١٢٢٤	٣٧.٠٨
٧:٥٠-٧:٥٥	١٢٧٨	٣٧.٨
٧:٥٥-٨:٠٠	١١١٣	٣٥.٦٤
٨:٠٠-٨:٠٥	١١٠١	٢٩.١٦
٨:٠٥-٨:١٠	١٣٠٥	٣٠.٢٤
٨:١٠-٨:١٥	١٥٥٤	٣٠.٢٤
٨:١٥-٨:٢٠	١٣٣٢	٢٩.١٦
٨:٢٠-٨:٢٥	١٥٩٩	٢٨.٠٨
٨:٢٥-٨:٣٠	١٦٤١	٢٩.٨٨
٨:٣٠-٨:٣٥	١٣٥٩	٢٩.١٦
٨:٣٥-٨:٤٠	١٤٠٤	٢٦.٦٤
٨:٤٠-٨:٤٥	١٥٣٦	٢٥.٥٦
٨:٤٥-٨:٥٠	١٣٢٣	٢٤.٨٤
٨:٥٠-٨:٥٥	١٥٠٣	٢٣.٧٦
٨:٥٥-٩:٠٠	١٤٩٧	٢٤.١٢
٩:٠٠-٩:٠٥	١٢٧٨	٢٤.١٢
٩:٠٥-٩:١٠	١٢٣٠	٢٤.٤٨
٩:١٠-٩:١٥	١٢٤٨	٢٨.٤٤
٩:١٥-٩:٢٠	١٢١٢	٢٥.٥٦
٩:٢٠-٩:٢٥	١١٢٢	٢٧
٩:٢٥-٩:٣٠	١٠٣٢	٢٧.٣٦

Table (B-١١) : Flow and Speed Data for Segment ١١ .

Time Period	Flow (pc/hr)	Speed (km/hr)
٧:٣٠_٧:٣٥	١٠٨٩	٤٨.٢٤
٧:٣٥_٧:٤٠	١١٤٩	٤٩.٦٨
٧:٤٠_٧:٤٥	١١٤٣	٤٧.١٦
٧:٤٥_٧:٥٠	١٣٣٥	٤٦.٠٨
٧:٥٠_٧:٥٥	١٢٩٠	٤٢.٨٤
٧:٥٥_٨:٠٠	١٢٧٥	٤١.٤
٨:٠٠_٨:٠٥	٢١٥٤	٤٠.٣٢
٨:٠٥_٨:١٠	١٩٠٨	٣٨.٥٢
٨:١٠_٨:١٥	١٩٧٤	٢٩.١٦
٨:١٥_٨:٢٠	١٨٧٥	٣٤.٩٢
٨:٢٠_٨:٢٥	٢١٠٣	٢٩.٥٢
٨:٢٥_٨:٣٠	٢٢٥٩	٣٦.٧٢
٨:٣٠_٨:٣٥	٢١٨٧	٢٩.٨٨
٨:٣٥_٨:٤٠	٢٤٥٤	٣١.٣٢
٨:٤٠_٨:٤٥	١٨٠٦	٣١.٣٢
٨:٤٥_٨:٥٠	١٩٠٢	٢٦.٦٤
٨:٥٠_٨:٥٥	١٧٢٨	٢٩.١٦
٨:٥٥_٩:٠٠	١٧٤٣	٢٧.٣٦
٩:٠٠_٩:٠٥	١٣٨٩	٣٩.٢٤
٩:٠٥_٩:١٠	١٢٩٣	٣٤.٢
٩:١٠_٩:١٥	١٢٩٦	٤١.٤
٩:١٥_٩:٢٠	١٣٧٤	٥١.٤٨
٩:٢٠_٩:٢٥	١٢٧٢	٣٩.٢٤
٩:٢٥_٩:٣٠	١٣٢٩	٥٦.٨٨

Table (B-١٢) : Flow and Speed Data for Segment ١٢ .

Time Period	Flow (pc/hr)	Speed (km/hr)
٧:٣٠-٧:٣٥	١١٩١	٥٨.٣٢
٧:٣٥-٧:٤٠	١١٧٣	٥٩.٤
٧:٤٠-٧:٤٥	١٢٦٠	٥٦.٨٨
٧:٤٥-٧:٥٠	١١٩٤	٤٧.٨٨
٧:٥٠-٧:٥٥	١٣٥٠	٤٦.٠٨
٧:٥٥-٨:٠٠	١٣٠٥	٥٢.٢
٨:٠٠-٨:٠٥	١٣٥٣	٥٣.٦٤
٨:٠٥-٨:١٠	١٥٩٣	٥٥.٤٤
٨:١٠-٨:١٥	١٦١١	٤٧.٥٢
٨:١٥-٨:٢٠	١٦٢٦	٤٢.٤٨
٨:٢٠-٨:٢٥	١٢٨٧	٤٠.٣٢
٨:٢٥-٨:٣٠	١٥٣٦	٣٧.٨
٨:٣٠-٨:٣٥	١٨٣٦	٣٦
٨:٣٥-٨:٤٠	١٦١١	٢٨.٨
٨:٤٠-٨:٤٥	١٥٢١	٢٧.٧٢
٨:٤٥-٨:٥٠	١٢٠٣	٣٢.٤
٨:٥٠-٨:٥٥	١٥٦٩	٣٨.١٦
٨:٥٥-٩:٠٠	١٨٦٠	٤٥
٩:٠٠-٩:٠٥	١٣٨٣	٤١.٤
٩:٠٥-٩:١٠	١٢٧٨	٤٦.٠٨
٩:١٠-٩:١٥	١٢٨٤	٤٧.٨٨
٩:١٥-٩:٢٠	١٣١٧	٥٧.٢٤
٩:٢٠-٩:٢٥	١٢٢٧	٥٩.٧٦
٩:٢٥-٩:٣٠	١٢٤٥	٤٦.٠٨

Table (B-١٣) : Flow and Speed Data for Segment ١٣ .

Time Period	Flow (pc/hr)	Speed (km/hr)
٧:٣٠-٧:٣٥	٨٢٨	٣٦.٧٢
٧:٣٥-٧:٤٠	٩٠٦	٣٧.٨
٧:٤٠-٧:٤٥	٩٠٦	٤٠.٣٢
٧:٤٥-٧:٥٠	١١٧٩	٣٩.٢٤
٧:٥٠-٧:٥٥	١٢٧٨	٣٣.٤٨
٧:٥٥-٨:٠٠	١٢٤٨	٣٠.٦
٨:٠٠-٨:٠٥	١٤٦٤	٣٢.٠٤
٨:٠٥-٨:١٠	١٣٧٤	٢٧.٧٢
٨:١٠-٨:١٥	١٤٧٦	٣٠.٦
٨:١٥-٨:٢٠	١٥٩٦	٢٨.٠٨
٨:٢٠-٨:٢٥	١٥١٨	٢٤.٤٨
٨:٢٥-٨:٣٠	١٥١٨	٢٥.٩٢
٨:٣٠-٨:٣٥	١٣٧٤	٢٧.٣٦
٨:٣٥-٨:٤٠	١٤٥٥	٢٤.٤٨
٨:٤٠-٨:٤٥	١٥٦٦	٢٣.٧٦
٨:٤٥-٨:٥٠	١٢٧٨	٢٢.٣٢
٨:٥٠-٨:٥٥	١٤٢٥	٢٤.٤٨
٨:٥٥-٩:٠٠	١٢٦٠	٢٥.٥٦
٩:٠٠-٩:٠٥	١١٠٧	٢٨.٤٤
٩:٠٥-٩:١٠	١١٢٨	٢٧
٩:١٠-٩:١٥	١٢٩٩	٢٩.٥٢
٩:١٥-٩:٢٠	١٣٢٩	٣١.٣٢
٩:٢٠-٩:٢٥	١٠٥٩	٣٢.٠٤
٩:٢٥-٩:٣٠	١٠٣٨	٣٣.٤٨

Table (B-١٤) : Flow and Speed Data for Segment ١٤ .

Time Period	Flow (pc/hr)	Speed (km/hr)
٧:٣٠-٧:٣٥	٨٩٤	٢١.٩٦
٧:٣٥-٧:٤٠	٨١٩	٢٠.٨٨
٧:٤٠-٧:٤٥	٩٧٢	٢٠.٨٨
٧:٤٥-٧:٥٠	٨٥٢	٢١.٢٤
٧:٥٠-٧:٥٥	٩٩٩	٢٢.٣٢
٧:٥٥-٨:٠٠	٩٩٣	٢٣.٧٦
٨:٠٠-٨:٠٥	١١٠٤	٢١.٢٤
٨:٠٥-٨:١٠	١٠٥٩	٢٠.٨٨
٨:١٠-٨:١٥	١٢٢٧	١٩.٤٤
٨:١٥-٨:٢٠	١٢٢٧	٢١.٩٦
٨:٢٠-٨:٢٥	١٣١١	١٩.٤٤
٨:٢٥-٨:٣٠	١٣٦٥	١٩.٤٤
٨:٣٠-٨:٣٥	١٣٧٧	١٨.٧٢
٨:٣٥-٨:٤٠	١٣٦٥	٢٠.٨٨
٨:٤٠-٨:٤٥	١٢٩٣	١٩.٨
٨:٤٥-٨:٥٠	١٣٥٣	١٩.٠٨
٨:٥٠-٨:٥٥	١٣٠٢	١٨.٣٦
٨:٥٥-٩:٠٠	١٠٩٥	٢٠.٨٨
٩:٠٠-٩:٠٥	٩٦٠	١٩.٤٤
٩:٠٥-٩:١٠	١٠٠٨	١٨.٣٦
٩:١٠-٩:١٥	٩٩٠	٢٠.٨٨
٩:١٥-٩:٢٠	٨٠٧	١٩.٨
٩:٢٠-٩:٢٥	٩٧٥	٢١.٢٤
٩:٢٥-٩:٣٠	١٠١١	٢٥.٢

الخلاصة

البحث يتضمن دراسة واحد من أهم الشبكات المرورية في مدينة النجف . حيث يهدف البحث الى تقييم الحركة المرورية لطريق كوفة – نجف ووضع البدائل المناسبة لغرض تحسين محددات الكفاءة لتلك الطريق .

من اجل السيطرة على جمع المسوحات الحقلية، فقد تم تقسيم طريق كوفة-النجف الى مقاطع . المقطع هو المسافة بين التقاطع والتقاطع الذي يليه وباتجاه واحد. HCM-٢٠٠٠) بالاعتماد على (كل تقاطع تم تصويره باستخدام كاميرا فيديو لفترات مختلفة من اجل تحديد ساعة الذروة. معدل بيانات الأحجام المرورية تم جمعها باستخدام التصوير بالفيديو، بينما معدل بيانات السرعة اللحظية لغرض جمع وتهيئة **Event**)تم جمعها بالطريقة اليدوية خلال ساعة الذروة . أستخدم برنامج (بيانات الأحجام المرورية من أفلام الفيديو حيث تخزن هذه البيانات على شكل فايلات ثم معالجتها . الخصائص الهندسية للطريق تم الحصول عليها مباشرة من الحقل . **Excel**)بواسطة برنامج (أظهرت المسوحات الحقلية أنّ معدل الجريان المروري كان ما بين (١٠٠٠-٢٥٠٠) مركبة\ساعة، بينما كان معدل السرعة اللحظية يتراوح ما بين (٢٠-١٠٠) كم\ساعة .

لتقييم التقاطعات وذلك بحساب(٢٠٠٢) HCS و (٢٠٠٢) TRANSYT-٧Fتم استخدام برنامجي مستوى الخدمة وغيرها من محددات الكفاءة تحت الظروف الاعتيادية للطريق ، وعلى ضوء النتائج تم عمل ستة بدائل لتحسين مستوى الخدمة وغيرها من محددات الكفاءة للطريق باستخدام برنامجي CYCOPT و T٧FACT الموجودين ضمنا في برنامج TRANSYT-٧F.

، بينما مستوى الخدمة F تشير الى إن مستوى الخدمة لكافة التقاطعات هو (HCS-٢٠٠٠)نتائج . التحسينات التي (TRANSYT-٧F) عند استخدام برنامج (F & C)لتلك التقاطعات يتراوح بين تم إجراءها على التقاطعات أدت الى تحسين محددات الكفاءة للتقاطعات بصورة ملحوظة ، حيث تم C الى F ، وتقاطع مسلم تم تحسينه من C الى Eتحسين مستوى الخدمة لتقاطع الشهرستاني من . D الى F، أما تقاطع الصدرين فقد تم تحسين مستوى الخدمة له من

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رسالة
مقدمة الى قسم الهندسة المدنية في جامعة بابل
كجزء من متطلبات نيل شهادة الماجستير في علوم
الهندسة المدنية .

من قبل :
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