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Calibrating and Modelling of Statistical Delay for Signalized Intersections at Al-Nasiriyah City in Iraq

(Permodelan dan Kalibrasi Kelewatan Statistik untuk Persimpangan Berlampu Isyarat di Bandar Al-Nasiriyah Iraq)

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ABSTRACT

In this paper develops an empirical delay model for delay prediction by taking lane group parameters to make delay model in the field where delay have considered very important measure that effects at signalized intersection because of relation of delay with performance of signalized intersection, lost travel time, fuel consumption, feasible of movement, discomfortable of drivers also, it is considered the primary measure to determine the level of service at signalized intersection. The main aim of this study is to make a field delay model at signalized intersection by using microsimulation software to calibrate data and using statistical software (SPSS) to create model. The methodology of the study is made by using video recording and manual collected data by taken three biggest signalized intersections where the collection data was very challenged specifically speed forward and uncontrollable drivers and others factors. Sidra Intersection 6.0 is described as an advanced micro-analytical model with a lane-by-lane method and a vehicle drive-cycle model that is used to estimate capacity and performance measures through an iterative method. Calibration of the software is very necessary to find accurate model that can be described the field delay. Multiple Linear Regression analysis (MuLRa) has been generally statistical method to create a model. It has been taken into consideration in the modelling of delay at signalized intersection and adjusted R^2 is 80% with multi factors that effect on field delay. Vehicle speed has been improved very significance level and impact factor on delay at signalized intersection by lane group experimental method and this finding very important for all simulation software should be taken that in the accounts.

Keywords: Statistical delay model; Signalized intersection; Calibration; Multiple linear regression analysis; Lane group; Speed vehicles

INTRODUCTION

Signalized intersections are an essential part of an urban road transportation system, regulate the flow of vehicles in urban areas. Traffic movements through signalized intersections are regulated by the signal system causing vehicular delays due to stops during the red time. Vehicular delay at signalized intersections increases the total travel time in an urban road network resulting in the reduction of speed and cost-effectiveness of the entire. Transportation system is increased travel time results in the degradation of the environment through increased vehicular emission in air and sound pollution. Thus, signal timing plan optimization is inevitable from many perspectives with less consumption of fuel and less environmental pollution being the topmost (Ratrout & Reza 2014).

Increasing rate of growth population and overusing car ownership is one of the main reasons that leading to traffic congestion. So, processing and identifying problems and finding the appropriate outputs for the congestions in these days in the rush hours due to the increasing number of people looking for a consequential increase in the number of transport (vehicles) of various types required the use of modern systems and software to control the congestion and to ensure the process appropriately, especially in areas or big cities, such as Al-Nasiriyah with a population density 525,000 and the designing of the city is non broaden.

The lack of public transport cause using of private vehicles and increasing number of vehicles and narrow of roads, lack of modern technologies such as, smart camera, actuated signalization etc. that can be decreasing traffic congestion. Traffic congestion exists wherever demand exceeds the capacity of the transportation systems (that is the maximum traffic flow that can be accommodated) (Banks 2002).

The development strategy of the cities is important for the analysis of highway and urban street systems to reduce the congestion on roadways, furthermore design of transportation facilities. Sidra 6.0 has been currently become commonly software for analysis and evaluation of intersections and roundabouts on the arterials roads (Akcelik 2009). Numerous researches have seek about problems of traffic congestion and attempting to find out a result that solve these problems.

Traffic congestion consider the main problem for the traffic engineering. Increasing in the number of vehicles caused traffic congestion in the Al-Nasiriyah city (Hachamee 2011) and traditional methods for assessment of transportation are inadequate to grasp the modern technologies of intelligent transportation systems, especially applications of information technology recently developed. Identifying the problems of this incident and understanding of reasons to put solution to address the problem and putting prediction model after doing comparison and calibration between the software with multi basic saturation flow rate (BSF) to know which one is environmentally feasible for the field data to choose it for prediction model.

The aims of the study are improved traffic flow and demonstrated traffic congestion in the city by using the following objectives:

1. To estimate the road and intersection capacity, performance, level of service in congestions area by using Sidra Intersection Software.
2. To great statistical field model such as environmentally and,
3. To model for the prediction of total vehicle delay at the study area.

LITERATURE REVIEW

Traffic intersections are complex locations on any highway. An intersection is an area shared by two or more roads (Mathew & Rao 2006) whose main function is to provide for the change of route direction. Intersections vary in complexity from a simple intersection, which has only two roads crossing at a right angle to each other, and more complex intersection, where three roads or more cross within the same area (Garber & Hoel 2014).

Conflicts at an intersection are different for different types of intersection (Mathew & Rao 2006). Highway capacity manual define approach such as a set of lanes at an intersection that accommodates all left-turn, through and right-turn movements from a given direction (Manual 2000).

In the previous studies, researchers followed the empirical approach for developing of delay model (Dion et al. 2004; Mousa 2002; Sofia et al. 2014) in this study it presents a new idea according to HCM (2000) where in terms of logic, the method of modelling for approach will be inaccurate due to different at basic saturation flow rate, delay for each lane group, queuing and speed of vehicles at all lanes groups and here highway capacity manual 2000 explain that at Figure 2 in Highway Capacity Manual (Manual 2000) according to that, the study depends on a group of lane for each approach to find accurate model of delay.

Webster in 1958 has been developed a model for estimating the delay incurred by motorists at under-saturated signalized intersections that become the basis for all subsequent delay models. The formula form of the model in the equation 1:

$$d = \frac{c\left(1-l\right)^2}{2\left(1-l\ X\right)} + \frac{X^2}{2v\left(1-X\right)} - 0.65\left(\frac{c}{v^2}\right)1/3\left(x^{2+51}\right) \quad (1)$$

where:

d = average overall delay per vehicle (seconds),
λ = proportion of the cycle that is effective green (g/C), C cycle length (seconds),
v = arrival rate (vehicles/hour),
c = capacity for lane group (vehicles/hour),
g = effective green time (seconds), and
X = lane group v/c ratio or degree of saturation.

The first term of equation 1, represents the delay when the traffic is assumed to be arriving uniformly. The second term of the equation 1 makes some allowance for the random nature of the arrivals. It is an expression for the delay experienced by vehicles arriving random lying time at a "bottleneck", queueing up, and leaving at constant headways. The third term of the equation 1 is an empirical correction term to give a closer fit for all values of flow. Normally, the last term is relatively small comparing to the total delay and frequently is omitted by reducing ten percent of the first and two terms (Charlesworth & Webster 1958).

The model of HCM 2000 has been defined as the average control delay per vehicle for a given lane group in the HCM 2000 is calculated by using the following equation 2-6.

$$d = d1 * pf + d2 + d3 \quad (2)$$

$$d = 0.5C\ \frac{\left(1-\frac{g}{c}\right)^2}{\left(1-\min\left(1,x\right)\frac{g}{c}\right)} \quad (3)$$

$$d2 = 900T\ [(x-1) + \sqrt{\left(x-1\right)^2 + \frac{8k1x}{cT}} \quad (4)$$

$$PF = \frac{\left(1-P\right)fp}{1-g} \quad (5)$$

$$d3 = \frac{1800Qb\left(1+u\right)t}{cT} \quad (6)$$

where:

d = average overall delay per vehicle (seconds/vehicles),
$d1$ = uniform delay (seconds/vehicles),
$d2$ = incremental, or random, delay (seconds/vehicles),
$d3$ = residual demand delay to account for over-saturation queues that may have existed before the analysis period (seconds/vehicles),
PF = adjustment factor for the effect of the quality of progression in coordinated systems,
C = traffic signal cycle time (seconds),
g = effective green time for lane group (seconds),
X = volume to capacity ratio of lane group,
c = capacity of lane group (vehicles/hour),
k = incremental delay factor dependent on signal controller setting (0.50 for pretimed signals; vary between 0.04 to 0.50 for actuated controllers),

I = upstream filtering/metering adjustment factor (1.0 for an isolated intersection),
T = evaluation time (hours),
P = proportion of vehicles arriving during the green interval,
fp = progression adjustment factor,
Qb = initial queue at the start of period T (veh),
c = adjusted lane group capacity (veh/h),
T = duration of analysis period (h),
t = duration of unmet demand in T (h), and
u = delay parameter.

There are significant differences between the second term of Webster's delay equation and HCM 2000's second term of delay calculation. When the degree of saturation is close to one, the delay based on the Webster's equation will approach infinity, which is unrealistic. However, the HCM 2000 delay will be somewhat along the solid line of Figure 1 for saturated and oversaturated conditions.

METHODOLOGY

Figure 3 shows the methodological analysis and the processes followed to achieve the goals of this research and show the concept used for the data collection and interpretation. Sidra Intersection 6.0 is processed simulation to simulate the existing traffic conditions such as effective green time, cycle time, speed, degree of saturation and others variables that effect on delay at signalized intersection. The Statistical Package for the Social Science (SPSS v23) model as well as Multiple linear regression analysis model is used to analyze the data of existing traffic condition. The framework for developing the models on delay model for signalized intersection is illustrated in Figure 3.

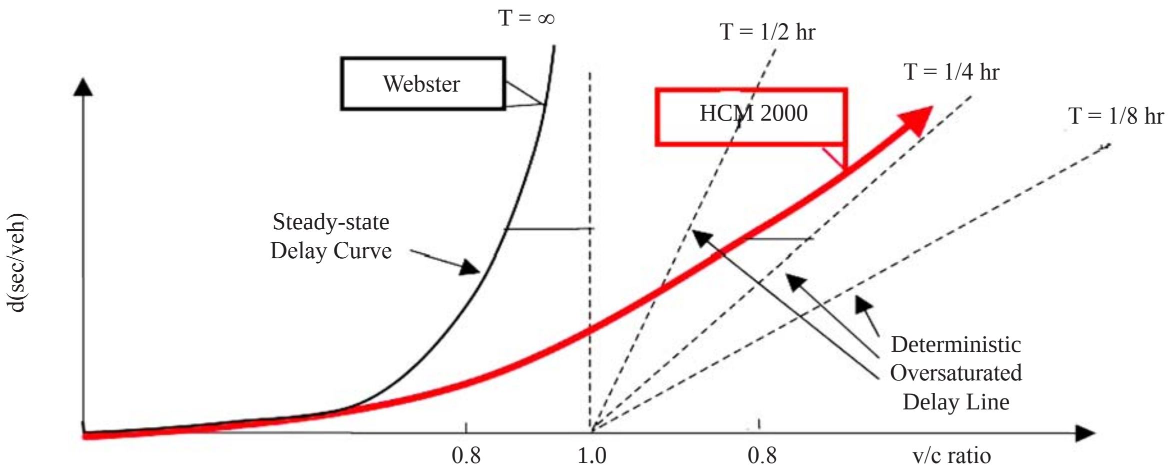

FIGURE 1. The difference between Webster method and HCM
Source: Cheng et al. 2003

STUDY AREA DESCRIPTION

Al-Nasiriyah is a capital city of the Thi Qar province in Iraq country. It is situated along the banks of the Euphrates River, about 225 miles (370 km) southeast of Baghdad, near the ruins of the ancient city of Ur. The population of the city in 2011 was about 525,000 making it the fourth largest city in Iraq. Thi Qar province's population increased to (1,925,000) in 2011. Around 36% of them are living in Nasiriyah city. The car ownership also increased from (23,000 to 102,344 veh) since 2003 to 2015 (Traffic directorate 2016). The study is concentrated in the central district area of Al-Nasiriyah city in Iraq where, those signalized intersections suffer from traffic congestion and always be bottlenecks. However, the study will be taken three signalized intersections that have been suffered from congestions and considered the biggest signalized intersections at the city and each intersection is comprised from four approach lane and each approach is comprised from three lane group (left, right, through). Figure 4 is illustrated that and explain each intersection with its coordinates.

TRAFFIC VOLUME AND DATA COLLECTION

Traffic volumes of the intersections must be specified for each movement on each Lane group. Data are collected during times when there were no holidays or occasions and clear weather for the intersections. The selected intersections were recorded three days in a week (Monday, Tuesday, Wednesday) during peak and off-peak periods at four hours' durations (two hours at A.M, two hours at P.M) for each intersection in a day. The period of the volume counting was divided into 15-minute intervals distributed over the best time of data counting. Video recording technique was adopted to collect traffic volume from vantage point nearby intersection. The recorded video films were played back many times to abstract the recorded data. Manually

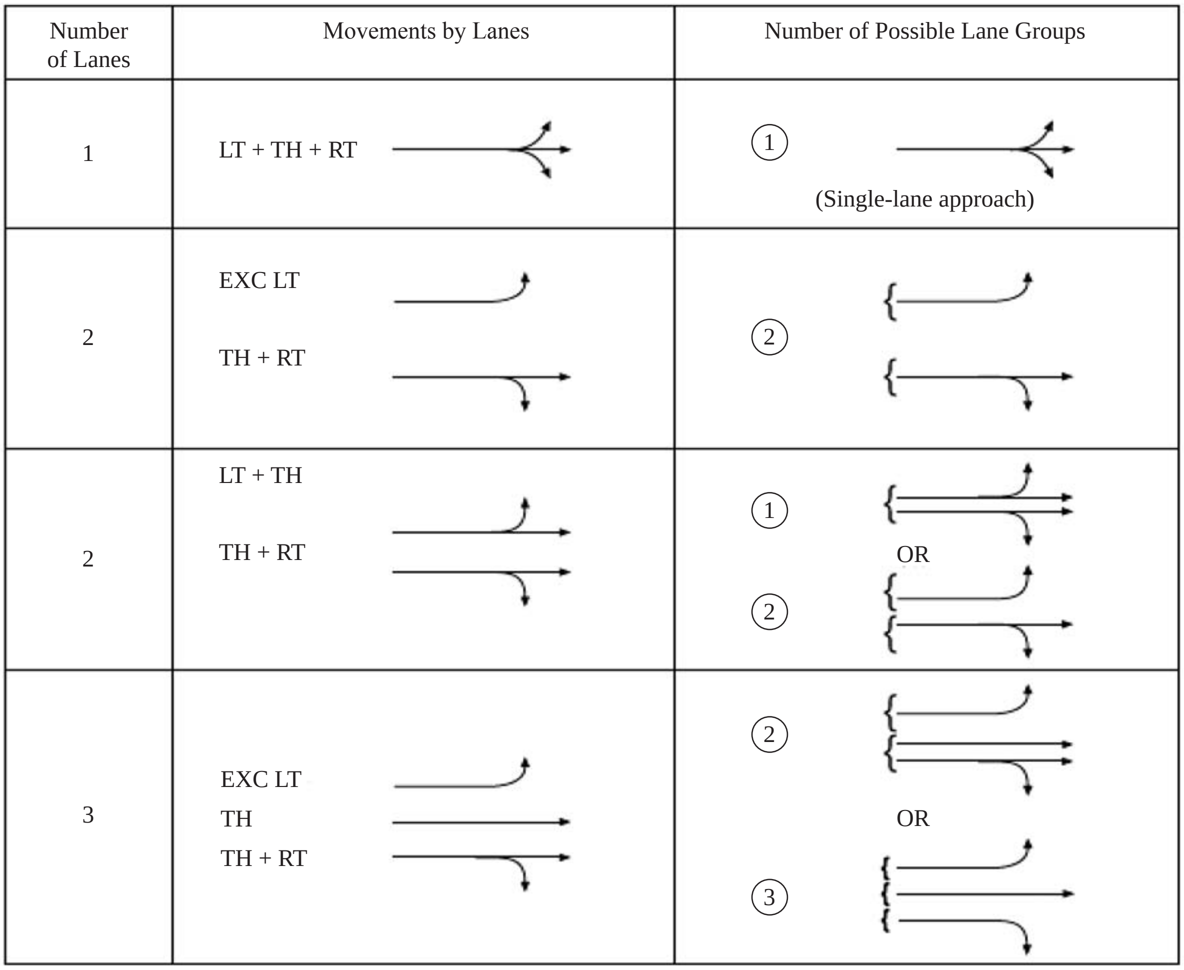

FIGURE 2. Typical lane group for analysis
Source: Manual 2000

collected data has been collected for traffic characteristics such as cycle length, effective green time, lost time, red time, queueing length, spot speeds as illustrated at the Table and geometric data such as number of lanes, Lane widths are for the selected intersections, islands width and engineering features is illustrated at the Table 1.

FIELD DELAY MEASUREMENT

The method suggested by Manual (2000) is adopted in this study to collect existing field delay which based on direct observed of vehicles-in-queue counts at the intersection. This method has not directly measured delay during deceleration and during part of acceleration, which are very difficult to

TABLE 1. Geometric and traffic data of nominated signalized intersections

Intersection	Approach	Entry Width (m)	No. of Entry lanes	Effective green time (sec)	Exit Width (m)	Island Width (m)
Al-Bho	S/N	15	4/4	99/99	12	1.3/1
	E/W	9.6	3/3	56/58	6.6	3/0.5
Al-Raiyah	S/N	15	4/5	77/77	12	8/8
	E/W	12	3/3	70/35	12	2.5/6
Al-Azdhar	S/N	12	3/3	23/34	12	3.5/3.5
	E/W	12	3/3	59/29	12	1.5/1.5

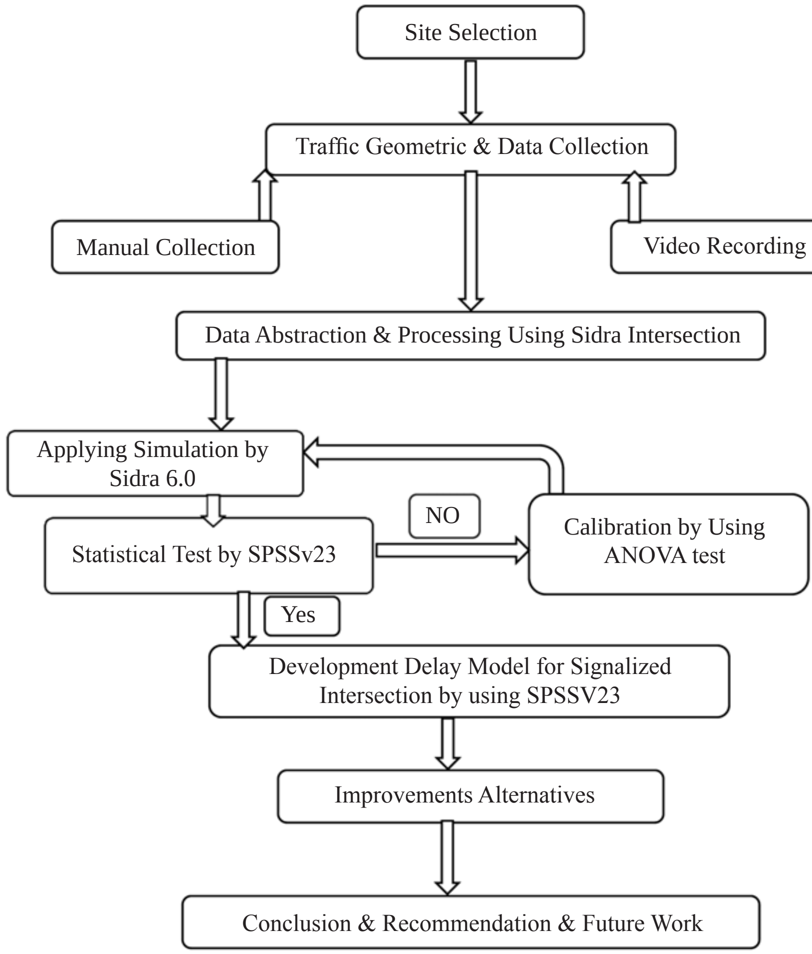

FIGURE 3. Research methodology flow chart

FIGURE 4. Study area description

measure without sophisticated tracking instrument. The method of estimation average time-in-queue per vehicle arriving in the survey period by Manual (2000):

$$\text{Delay time-in-queue “per vehicle,”}\ dvq = \left(I * \frac{\Sigma Viq}{Vtot} \right) * 0.9 \qquad (7)$$

where:

- I = interval time between vehicle-in-queue counts, (s)
- Viq = sum of vehicle-in-queue counts, (veh)
- $Vtot$ = total number of vehicles arriving during the survey period, (veh)
- 0.9 = an empirical adjustment factor accounts for the errors that may occur when

The fraction of vehicles stopping and the average number of vehicles stopping in a queue in each cycle are computed.

$$\text{FVS} = \text{Fraction of vehicles stopping} = \frac{V_{stop}}{V_{total}} \quad (8)$$

$$dad = FVS*CF \quad (9)$$

$$\text{Control Delay/vehicle, } d = dVq + dad \quad (10)$$

Also the way that following by using sheet Manual (2000) in the Figure 5 Control delay includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.

SIDRA MODEL CALIBRATION

The Roads and Maritime Services (RMS) Modelling Guidelines define Calibration as the process of adjusting the model parameters, network and demand to reflect observed site data or conditions. The calibration process aims to

Highway Capacity Manual 2000

INTERSECTION CONTROL DELAY WORKSHEET

General Information

Analyst: Abdullah Hajal
Agency or Company: (-)
Date Performed: 15/08/2016
Analysis Time Period: 6:00 to 6:30 pm

Site Information

Intersection: AL-BHO
Area Type: ☑ CBD ☐ Other
Jurisdiction:
Analysis Year: 2016

Input Initial Parameters

Number of lanes, N: 2
Free-flow speed, FFS (mi/h): 38 Km/hr
Survey count interval, I_s (s): 10 sec
Total vehicles arriving, V_{tot}: 56
Stopped-vehicle count, V_{stop}: 20
Cycle length, C (s): 324 sec

Input Field Data

Clock Time	Cycle Number	Number of Vehicles in Queue – Count Interval 1	2	3	4	5	6	7	8	9	10
5:45	1	0	4	7	7	8	10	11	3	0	0
	2	3	2	6	8	7	7	11	7	0	0
	3	4	6	7	12	17	12	13	16	17	0
	4	0	3	3	8	15	16	18	11	13	8
6:06											
Total		7	15	23	35	47	35	46	37	30	8

Computations

Total vehicles in queue, ΣV_{iq} = 293
Time-in-queue per vehicle, $d_{vq} = (I_s * \frac{\Sigma V_{iq}}{V_{tot}}) * 0.9$ = 52.3 s
No. of vehicles stopping per lane each cycle = $\frac{V_{stop}}{(N_c \times N)}$ = 2.5
Accel/Decel correction factor, CF (Ex. A16-2) = -1
Number of cycles surveyed, N_c = 4
Fraction of vehicles stopping, $FVS = \frac{V_{stop}}{V_{tot}}$ = 0.36
Accel/Decel correction delay, $d_{ad} = FVS * CF$ = -0.36 s
Control delay/vehicle, $d = d_{vq} + d_{ad}$ = 51.94 s

Chapter 16 - Signalized Intersections

FIGURE 5. Sheet highway capacity manual for collected existing delay at signalized intersection at Al-Bho Intersection

produce a model that is sufficiently refined to provide reliable forecasts that will be able to satisfy the study objectives. In another words, Model calibration is a crucial step to obtaining any results from analysis (Gagnon et al. 2008) so, Microscopic simulation models contain several independent parameters to describe traffic control operation, traffic flow characteristics, and the driver behaviour.

These models contain default values for each parameter, but the user also is allowed to input a range of values for each parameter. Changing the values of these parameters during calibration should be based on field measurements or conditions.

There are several methods of assessing data are normal or not distributed or not, by using Q-Q histogram or P-P plot also Shapiro-Wilk (S-W) test are designed to test normality by comparing the data to a normal distribution with the same mean and standard deviation of the sample. If the test is not significant, then the data are normal, so any value above 0.05 indicates normality (Razali & Wah 2011). If the test is significant (less than 0.05), then the data are non-normal. Thus, results of tests in Table 2 show that all results above 0.05 follow normal distribution.

Analysis of variance (ANOVA), a more accurate statistical method, is applied to identify key parameters. ANOVA tests the null hypothesis that the means for several groups in the population are equal by comparing the sample variance estimated from the group means with that estimated within the groups during value of significance and must be more than 0.05 to be no significance difference (Dion et al. 2004; Murat et al. 2014; Park & Qi 2005; Park & Won 2006). The default value of the basic saturation flow rate used by Sidra Intersection software model is 1950 through passenger car unit per hour green per lane group (pcuphgpl), while it is 1900 (pcphgpl) for HCM model in another words, Using the default saturation flow rate, the relationship between the measured and predicted delays is shown in Figure 6.

It can be concluded that, for low to medium delay ranges SIDRA slightly over-estimates the delay. For higher delay ranges, SIDRA has a mix of underestimations and over-estimations with some points that are severely overestimated.

In the previous study Bester and Meyers (2007) have been created formula by using regression analysis as explained in the equation 11:

$$S = 990 + 288TL + 8,5SL - 26,8G \qquad (11)$$

where:

S = Saturation flow rate (veh/h/lane),
TL = Number of through lanes (1or 2),
SL = Speed limit (60 or 80 km/h) and, G = Gradient (%)

While, in previous Iraqi study, Al-Eigaidy (2004) has been created formula for saturation flow rate such a function of effective green time and heavy vehicles as explained in the equation 12,

$$S = 2112.5 - 84.5Hv - 8.56gi \qquad (12)$$

where,

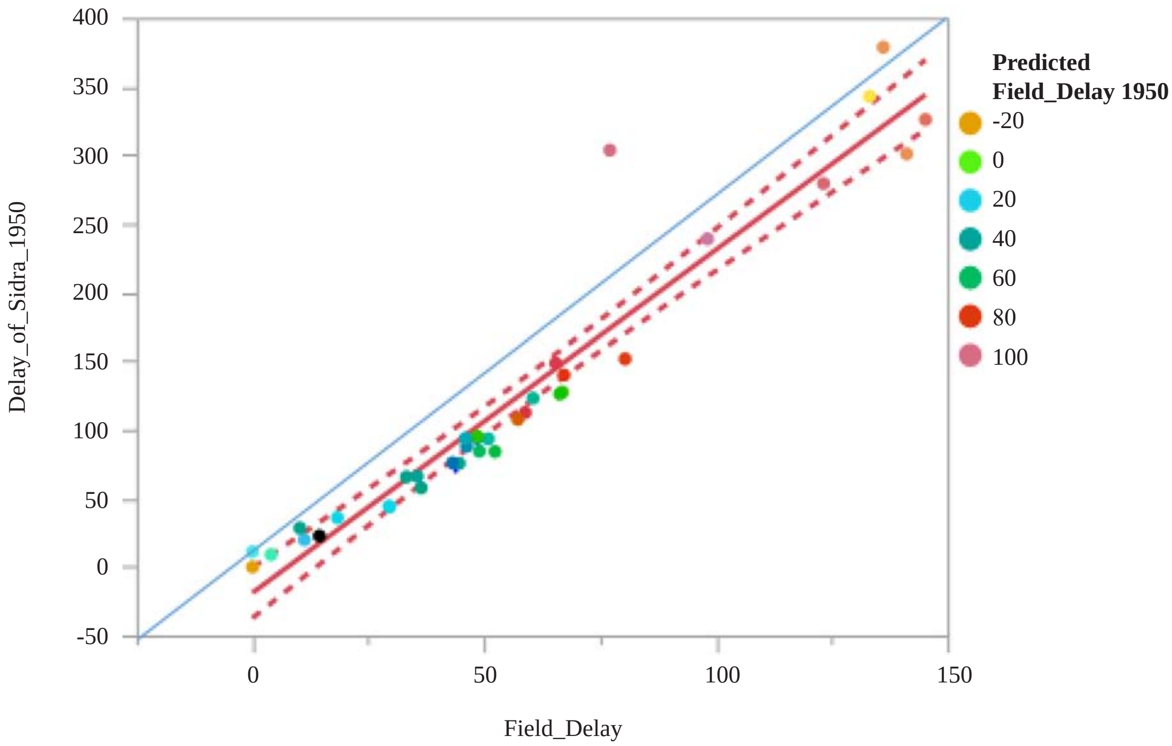

FIGURE 6. Field delay versus sidra prediction delay with default basic saturation flow rate of Sidra 6.0

S: Saturation Flow (pcuphg, *Hv*: Heavy vehicles (%), and *gi*: effective green (sec).

Al-Eigaidy model gives approximately similar results such as obtained by the field while Besters and Meyers give higher saturation flow rates. The field delays were regressed against the predicted ones producing the results shown in Table 2.

The interpretation of the Table 2 is the R^2 value indicates that SIDRA explains about only 72% of the variability in total delay. The ANOVA One-Way test results show that the mean of difference in delay is 65.7 second, with a P-value of 0.011, so the hypothesis that the deviations are equal to zero is rejected at 95% confidence level at default saturation flow rate of Sidra 6.0 and have accepted at 2200 (pcuphgpl).

The calibration process is to adjust the basic saturation flow rate to be 2200 (pcuphgpl) in lane groups with high values of saturation flow rate (v/c), as recommended by HCM. The results show 63% variability in delay times, Figure 7. ANOVA test shows that, the mean of delay differences of 38.6 seconds is lower than the difference obtained by using the default value of saturation flow, with a P-value of 0.073 So, the hypothesis is that there is no significant difference and accepted at 95% confidence level.

RESULTS AND DISCUSSION

Multiple Linear Regression analysis (MuLRa) has been generally statistical method to create a model of such science such as delay, queueing, speed limit, cycle time, and various models. It has been taken into consideration in modeling of delay at signalized intersection. It is used the relationships between two or more variable quantities to create or generate a model that may predict one variable from the others. The term multiple linear regression (MuLRa) is applied when a model is a function of more than one independent variable. The objective behind (MuLRa) is to obtain accuracy model, at a selected confidence level, using the variable data, while at the same time satisfying the basic assumptions of regression analysis.

The objective is accomplished by selecting the model, which provides the highest adjusted coefficient of determination (R^2) and the lowest mean square error (MSE) (Keller et al. 1994; Murat et al. 2014). Stepwise Multi Regression analysis is becomes very common major to examine independent variables with dependent variable If two independent variables are highly correlated, only one of them will enter the equation. Once the first variable is included, the added explanatory power of the second variable will be minimal and its f-statistic (SPSS software uses the f- statistics and the standard is usually set at $F = 3.84$ which is chosen because the significant level is about 5%) also, the parameters that have significance level must be less than 0.05 (Pallant 2013).

The variables that have been used to simulate traffic characteristics where Independent variables such as effective green time (EGT/ sec), capacity of lane group (c /veh/hr), cycle time (C/sec), vehicle flow rate (v/veh/hr), average speed of the vehicle while green time on (u-1.2 (m/sec) and (1.2 m/sec) is 1995 Canadian Capacity Guide for Signalized Intersections (Ite & Teply 1995) they demonstrate the delay will incurred

TABLE 2. Comparison of actual delay and SIDRA prediction delay for signalized intersection

	Default Values of Saturation Flow rate (1950veh/hr)	Default Values of Saturation Flow rate (2200veh/hr)
	Fit Y by X	
Field Delay	0.4*Sidra Delay+7.548	0.667Sidra Delay+6.5
R^2	0.92	0.79
Adj R^2	0.91	0.78
	Testing of Normality	
	Shapiro-Wilk W test	
	Statistics	Sig
Field Delay	0.967346	0.3746
	Ho = The data is the Normal distribution. Small p-values reject Ho	
	One-Way ANOVA	
Difference mean in Delay(sec)	65.7	38.6
t	5.968	8.723
P value	0.011	0.073
R^2	0.72	0.63
	If P value more than 0.05, there is no statistically significance difference	

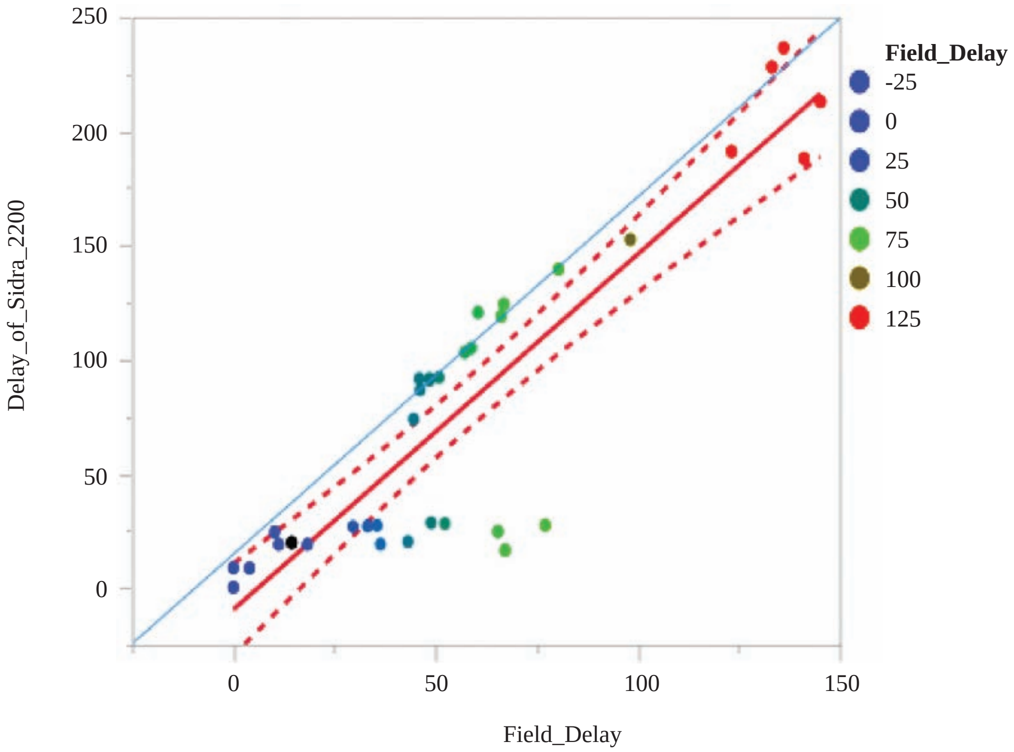

FIGURE 7. Field delay versus Sidra prediction delay after adjustment

while moving at a speed that is less than the average speed of a pedestrian (1.2 m/s) cited by (Dion et al. 2004), number of trajectory for each lane group reaction time for each lane group (RT/sec). phase split (g/c), width of each lane group (W/m), and total volume of each lane group (TV/veh/lane group). The summary of stepwise regression delay model can be seen at Table 3.

The result of MuLRa technique and developed delay model is shown in the Equation 12

$$D = 58.4 - 7.194 * (u\text{-}1.2) + 0.287\ EGT \qquad (12)$$

where:

D = Delay of each vehicle (sec)
v/c = Degree of saturation flow rate
u-1.2 = speed of the vehicle during green time (m/sec) and (1.2 m/sec) is in (1995) Canadian Capacity Guide for Signalized Intersections (Ite & Teply 1995), they have been demonstrated the delay will incurred while moving at a speed that is less than the average speed of a pedestrian (1.2 m/s) cited by (Dion et al. 2004); and
EGT = Effective green time (sec).

From the equation can be concluded as following:

1. Increasing of flow vehicle ratio will lead to increase in total delay.
2. Increasing of average flow speed for the vehicles more than 1.2 will lead to decreasing the total delay that is meaning inverse relationship, and
3. Effective green time is significance level and need to modify in the study area also has impacted in the equation.

TABLE 3. Summary of stepwise multiple regression delay model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig	R	R^2	Adj R^2
		B	Std. Error	Beta		P value			
Field	v/c	58.4	12.037	0.542	4.852	0.000			
Delay	u-1.2	-7.194	1.58	-0.49	-4.55	0.000	0.89	0.8	0.78
	EGT	0.287	0.135	0.179	2.12	0.042			
If P value less than 0.05 is significance level									

DELAY MODEL VALIDATION

The validation process compares model outputs with observed data that has not been previously used in the calibration process. Validation is therefore an independent verification to confirm that the model has been accurately calibrated (RMS 2012). The objective of validation is to assess the efficiency of the proposed prediction model, and measure the accuracy of the prediction for the validation period. There are several methods used for models validation as explained are following:

1. One of these methods is checking distribution histogram of the predicted delay and tests of Kolmogorov-Smirnova (K-S) and Shapiro-Wilk (S-W) by check the results of the formula if the P value more than 0.05 the data of equation is normal (Razali & Wah 2011) as explain in Figure 7 and Table 4.

TABLE 4. Testing of normality of the prediction of the formula by using SPSSv23

Test of Normality of the Prediction Field Delay		
Model	Kolmogorov-Smirnova P (value)	Shapiro-Wilk P (value)
Prediction Field delay	0.103	0.289
If P-value is more than significance level (0.05), the data is normal		

2. It compares model prediction with measurements or observations (Hoque & Imran 2007). Second of these methods are to compare the model with another data set that is not included in model building. The data used for this purpose is rush hour data abstracted from video recording films at different times for the different and same intersections in the network. The average field delay from rush hour is regressed with the delay time predicted by the model. The regression results are shown in Table 5 and Figure 8. It can be concluded that from the models values of R^2 that the predicted values from models can represent estimation of the actual field values of delay in another word, using of polynomial sketch to know the significance difference between linear and nonlinear according to R^2 and, according to the Table 5 there is no much difference between them.

CONCLUSION

Field surveys were conducted to collect data on traffic volume, traffic speed, intersection geometry, signal timing and control delay for 18 hours from12 approaches at 3 signalized intersections in Al-Nasiriyah city, Iraq. Traffic volume and delay data were collected through videotaping, traffic speed data were collected using radar gun and geometric data were collected by field surveys. The main conclusions that can be obtained from this study summarization are followings:

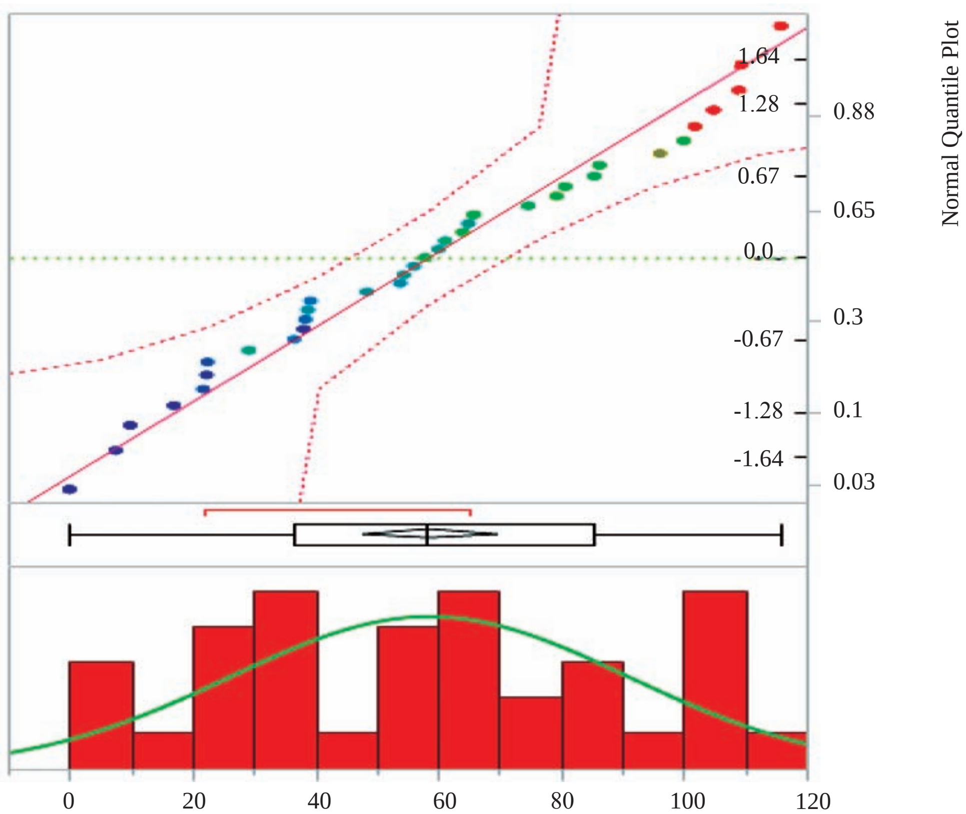

FIGURE 8. Distribution Histogram of Delay Prediction

1. The results of the analysis showed that, for low delay by using Manual (2000) and over estimated delay by using Sidra Intersection after calibration of the basic saturation flow rate Sidra Show that no significance difference and 63% (from Table 2) variability at 95% confidence level.
2. Multiple Linear Regression Analysis models, developed to estimate delay time, show good correlation with field values. Delay model can be used to estimate delay time at any intersections knowing signal timing, traffic volume and average speed of the vehicle.
3. According to Table 3 Speed of vehicles very important impact factor for delay at signalized intersection and must be taken in the accounts for delay model specifically for the software of traffic engineering.
4. From Table 3 such equation model, the delay decrease when the driver could raise up his speed during intersection and rush of the reaction time to reduce lost time.
5. After investigation for the study sites, there are a need for fixing permanent video recording camera on streets and intersections to measure traffic volume and speed of vehicle, which helps in the data collection process and analysis for future studies and for continuous monitoring of causes of delay and congestion.
6. Developing public transport in the city to be active and that leading to decrease delay at the intersection.

This study showed that traffic software, which are being used in the developed countries, should be used in Iraq or other developing countries after calibrating to the exist conditions parameters as used in such countries such as Australia, Malaysia and others.

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TABLE 5. Regression results for the models with linear and polynomial

Model	Model Fit	R^2	Adj R^2	Sig
Delay Model	15.3+0.75*Field Delay	0.85	0.84	0.0000
Polynomial Delay Model	14.29 + 0.867*Field Delay - 0.003*(Field Delay-57.56)^2	0.89	0.88	0.0013

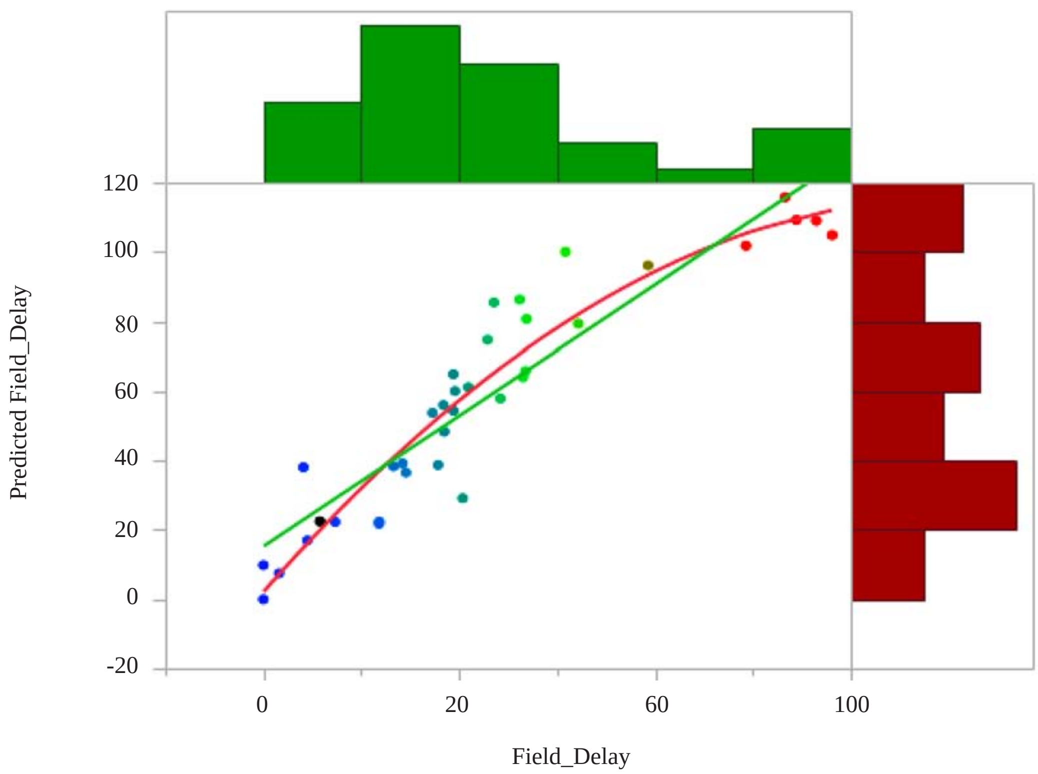

FIGURE 9. Comparison between predicted delay with observation data (Field Delay)

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