Wasit Journal of Engineering Sciences

Journal homepage: https://ejuow.uowasit.edu.iq

The Effects of Speed and Flow Characteristics on Crash Rates for Wasit Multi-lane Highways in Iraq

Amjad H. Albayati [1], Zahraa A. Ramadan [1]

Affiliations
1Department of Civil Engineering, University of Baghdad, Baghdad, Iraq

Correspondence
Zahraa A.Ramadan, Department of Civil Engineering, University of Baghdad, Baghdad, Iraq
Email: alkenanyz@yahoo.com

Received
31-January-2021
Revised
21-February-2021
Accepted
02-March-2021

Doi: 10.31185/ejuow.Vol9.Iss1.224

Abstract

This study describes traffic crash rates in selected multilane rural highways in Wasit governorate in Iraq. The main objective of this research is to investigate relationships between total, fatal crash rates and their kinds and factors such as hourly traffic flow and average spot speed.
The study is based on data collected from two sources: police stations and traffic surveys. Three highways are selected to cover the locations of the accidents. The selection includes Kut – Suwera with five segments, Kut – ShekhSaad with three segments, and Kut – Hay with two segments multilane divided highways.
Multiple linear regression analysis is applied to the data by using SPSS software to attain the relationships between the dependent variables and the independent variables in order to identify elements that are strongly correlated with crashes rates and severity.
Seven regression models are developed which verify weak and strong statistical relationships between crashes types and average spot speed with hourly traffic flow respectively. As the hourly traffic flow of automobile grows, the need for safe traffic facilities also grown.

Keywords: Traffic safety, crash rates, multilane highways, average spot speed, hourly traffic volume, multiple regression.

الخلاصة: تصف هذه الدراسة معدلات الحوادث المرورية للطرق الخارجية لمحافظة واسط في العراق .ان الهدف الرئيسي من هذا البحث هو ايجاد العلاقة بين معدلات الحوادث الكلية والقاتلة وانواعهما مع الاحجام المرورية بالساعة ومعدلات سرعة المركبات الموقعية .اعتمدت الدراسة على جمع البيانات من مصدرين رئيسيين هما مراكز الشرطة والمسوحات الموقعية. تم اختيار ثلاثة طرق خارجية لتغطية مواقع الحوادث المرورية وهي كالاتي : طريق كوت صويرة بخمسة مقاطع وطريق كوت شيخ سعد بثلاثة مقاطع وطريق كوت حي بمقطعين اثنين. لأغراض تحليل البيانات تم استخدام طريقة الانحدار الخطي المتعدد باستخدام برنامج spss للحصول على العلاقات بين المتغيرات التابعة والمتغيرات المستقلة ولمعرفة وتشخيص العناصر التي ترتبط بقوة مع معدلات الحوادث وقساوتها. تم استحداث سبعة موديلات اوضحت ان العلاقة بين الحوادث والسرعة كانت ضعيفة بينما العلاقة بين الحوادث والاحجام المرورية كانت قوية. كلما الاحجام المرورية للمركبات تكون بازدياد فان الحاجة للطرق المرورية الامينة تكون اكثر.

1. INTRODUCTION

Road traffic crashes represent a severe problem threatening the world societies, their well-beings, and economies. In Iraq, like other countries, traffic crashes are one of the leading causes of death [1]. The answer to the question "Who is to blame"? is usually more than complex since more than one component must be considered when determining the cause of accidents. It may be the combination of two or sometimes all the three components: the driver, the roadway parameters and environment, and the vehicle.

In order to enable engineers of implementing and identifying operative countermeasures to reduce crash incidents, a well considerate of the crashes associated factors must be recognized. Many researches and studies have showed to conclude the relations between factors connected with crashes and crash characteristics [2 and 3]. The results of these researches have not been consistent, but a strong suggestions from their data that severity and crash occurrences are affected by flow - speed features, such as average spot speed and average annual daily traffic (AADT). For example, worthy evidences are presented to suggest that occurrence of crashes in a traffic stream is greatly correlated and increased with a higher variation in vehicle speeds.

A number of researches have been implemented to relate hourly traffic volumes and average speed with crash rates and severities [4 and 5].

Nevertheless, these researches have not recognized scientific relations that can be used to predict changes in accidents characteristics because of the combined effects of changes in traffic flow and speed. The establishing of such mathematical models would considerably improve the efforts of traffic engineers to evaluate and determine suitable remedies and countermeasures to reduce the severity and occurrence of accidents crashes.

2. OBJECTVE AND PURPOSE

The main purpose of this study is to recognize and identify the hourly traffic flow and average spot speed that significantly affect different types of crash and severity rates on multilane highways of Wasit governorate in Iraq and to find mathematical relationships which define and describe how these characteristics affect crash rates.

The precise aims of the study are as follows:

1. To investigate and determine mathematical relationships between total and fatal crashes rates and their severities that occurred in Wasit governorate roads and traffic stream characteristics.
2. To show the effect of hourly traffic flow and average spot speed on the traffic stream.

3. METHODOLOGY AND PROCEDURE

The methodology surveyed and followed in this study involved of the following tasks:

1. Review of literature was accompanied in order to determine the major factors related with different types of crashes and crashes characteristics;
2. Collection of data was done to obtain crash rates and types and their location, hourly traffic flow, and average spot speed and to define roadway segments of crash locations;
3. Multiple linear regression models was established to select the best model;

4. VARIATION OF CRASHES WITH SPEED CHARACTERISTICS

Speed is generally considered a traffic element. However, the fact that the driver has full control on their vehicle and that they can choose the speed they desires, introduces speeding as a human factor as well.

When an crash takes place between two moving vehicles, all this kinetic energy must be dissipated mainly in the form of damage to both the vehicles and their occupants. The analysis of a traffic conflict between two vehicles as an inelastic impact reveals that the dissipated energy is proportional to the square of the relative speed vector. Accordingly, the severity of the conflict is significantly affected by the magnitude of the speed of each vehicle as well as by their angle of intersection [6].

Researches had shown that the greater the average vehicle speed deviation, the higher probability of that vehicle being involved in a crash. This relationship is often referred to as being "U-shaped" and has been verified in research [7].

Furthermore, the most vulnerable road users— pedestrians, cyclists, and motorcyclists—have a high risk of severe or fatal injury when motor vehicles collide with them. The probability that a pedestrian will be killed if hit by a motor vehicle increases dramatically with speed. Figure 1 illustrates the probability of fatal injury for a pedestrian hit by a vehicle. The research indicates that while most pedestrians survive if hit by a car travelling 30 km/h, the majority are killed if hit by a car travelling at 50 km/h or more [8].

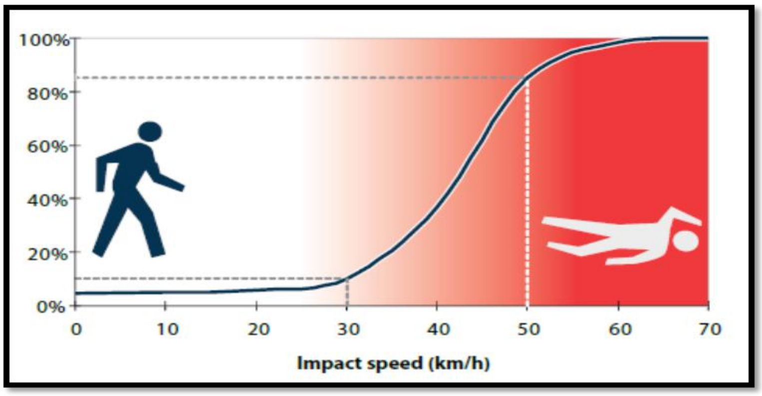

Figure 1 Probability of Fatal Injury for a Pedestrian Hit by a Vehicle.

5. VARIATION OF CRASHES WITH TRAFFIC VOLUME

A strong understanding of the relationship between traffic crashes and volume is necessary to improve traffic management and reduce crash frequency. Research stems from the 1930s, with relationships between crash occurrence and traffic volume/congestion falling into one of two broad categories: linear and non-linear [9] [10].

Generally, the relationship of speed with crashes cannot be defined without taking into account the simultaneous effect of other traffic characteristics such as traffic flow [7].

A crash prediction model can be represented by a graph as shown in Figure 2. On the x-axis, the annual traffic volume (AADT) is plotted, and on the y-axis, the number of road crashes per kilometer. On the x-axis (AADT) of different intersections is displayed, which means that it does not represent an increasing traffic volume of a single intersection [11].

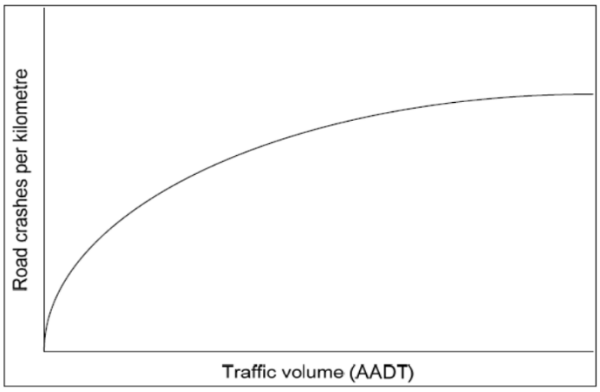

Figure 2 Graph of Crash Prediction Model.

6. DATA COLLECTION AND DESCRIPTION

The data collection stage involved of the next sub-tasks:

- Obtaining crash types and severity data;
- Describing roadway segments of crashes locations;
- Attaining hourly traffic flow and average spot speed data;

6.1.SELECTION OF THE HIGHWAYS

Based on the scope of the study, the selection of the highways may be depend on the available crash data and must be within the borders of Wasit governorate in Iraq. The points considered during highways choice are:

1. Asphalt surfaced multi-lane paved rural highways, which connect with Al Kut city that represent the central official town of the governorate.

2. The length of the studied roads ranges between 40 and 100 km. This is mainly to get true and specific locations for traffic accidents, which will be determined from the police and traffic stations along these highways.

3. Dense vehicles movement and frequent crash locations.

Therefore, to conduct the present study, three multilane rural highways are selected for the purpose of this study, which are:

1. Kut – Suwera highway, 105 km length.

2. Kut – Shekh Saad highway, 52 km length.

3. Kut – Hay highway, 43 km length.

In Iraq, highway (7) is a highway, which extends from Al Kut to Nasiriyah city. Kut – Hay highway is a part of this road. Kut – Suwera and Kut-Shekh Saad highways had number (6) in the coding system of the roads network in Iraq in which they are a part from Baghdad – Emara - Basrah highway. It radiates from Baghdad and provides access to Wasit in the southeast and Misan - Basrah in the south with Kut city being the crossroads junction to Badra, Shekh Saad, and Hay cities. This highway is the most heavily used highway facility in Wasit.

Figure 3 shows a detailed map that illustrates the administrative boundaries of Wasit governorate and the studied highways.

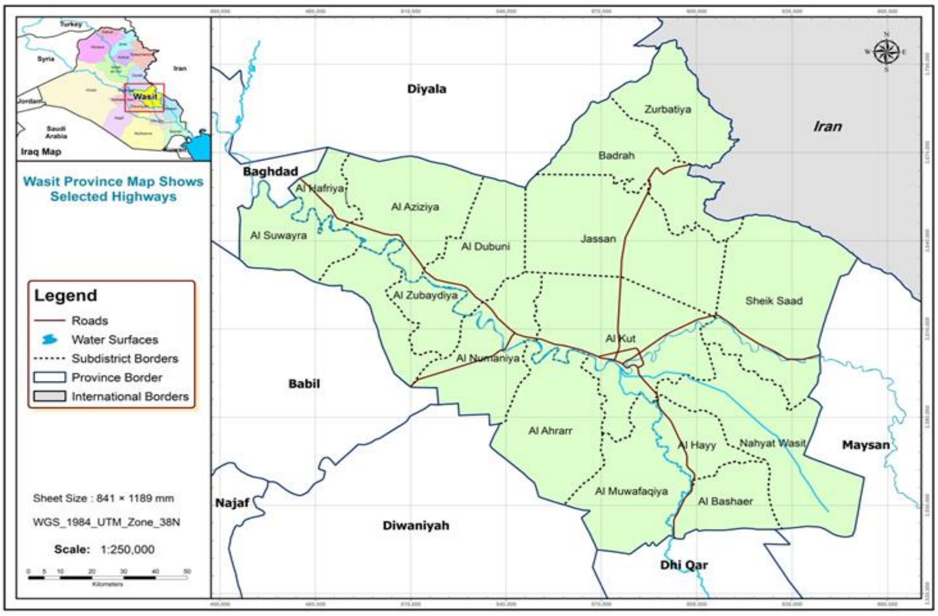

Figure 3 The Administrative Boundaries of Wasit Governorate Map Describes Studied Highways.

In order to give adequate confidence in the study results, the information's pertaining to traffic crashes in Wasit Governorate that presented herein was taken from the following authorities:

1. The annual abstracts published by the Statistics Division in the Directorate General of Police.

2. Central Statistics Organization (CSO).

3. General Traffic Directorate.

4. Crash files and reports in Police and traffic stations.

The police stations involved in this study were distributed from Wasit Police Directorate as follows:

1. For Kut – Suwera highway, four police stations were visited which are: Al Balda, Al Salam, Al Debony, and Al Azezeya stations.

2. For Kut – Shekh Saad highway, two police stations were involved which are: Al- Khelod, Shekh Saad stations.
3. For Kut – Hay highway, two police stations were involved which are: Al- Falaheya, Al - Hay stations.

The data were obtained by checking out all the available files individually in all these stations. These files are just meant to keep the papers, which are supposed to take their way to court. Various meetings with the police personals and interviews with divers were prepared in order to assure some information about crashes location and severity. After analyzing all crashes reports, tens places are identified as crashes locations in which five, three, and two segments were recognized for Kut – Suwera, Kut – Shekh Saad, and Kut – Hay highways respectively. Table 1 illustrates crashes segments names and locations.

Table 1 Crashes locations for the studied highways.

Highway Name	Segment Number	Location
Kut – Suwera highway	Seg.1	Al – Batar village
	Seg.2	Al Salam police station
	Seg.3	Al Debony district
	Seg.4	Al Zubaidiya intersection
	Seg.5	Al Azezeya city
Kut – Shekh Saad	Seg.6	White village
	Seg.7	Shekh Saad entrance
	Seg.8	River port district
Kut – Hay highway	Seg.9	Said Abdulatheem village
	Seg.10	Old brick kilns

Reaching the targets of this study, it is preferred that, a selected five years interval is used in this study for identifying and predicting crashes models starting from 2015 and ending in 2019.

6.2.CRASHES DATA SURVEY

According to the collected Iraqi crash form reports, the crashes are classified as per type of crash into four major categories, namely: collision accident, turnover accident, run over accident, and others with fatal or non-fatal classification. Only weekday crashes were matched to weekday surveys to certify that comparable traffic and speed characteristics happened during the crashes. Reviewing and analyzing of the collected registered crash reports are presented in the next articles. Figure 4 presents the distribution of crashes by type for each year in the studied segments during the period (2015 to 2019). As it can be seen form the figure, collision crashes comprise most crashes for the five studied years (except 2015) compared to the other crashes types. This may be attributed to the high interactive between speed and traffic volume, potential conflicts between turning vehicles, and road deficiencies characteristics on rural roadway sections.

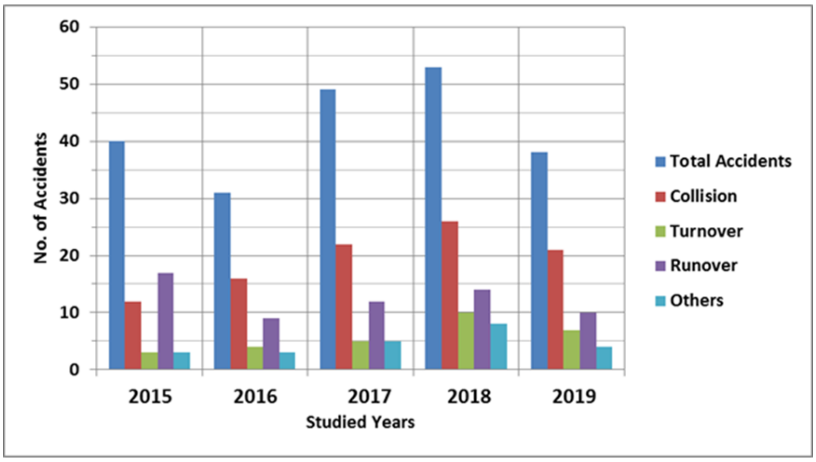

Figure 4 Crashes Distribution by Type and Year of Study.

Figure 5 shows the total number of fatal and injury crashes in the studied highways for the period (2015-2019). Fatal crashes were determined by adding deadly crashes with deadly and injury ones that collected from the police reports.

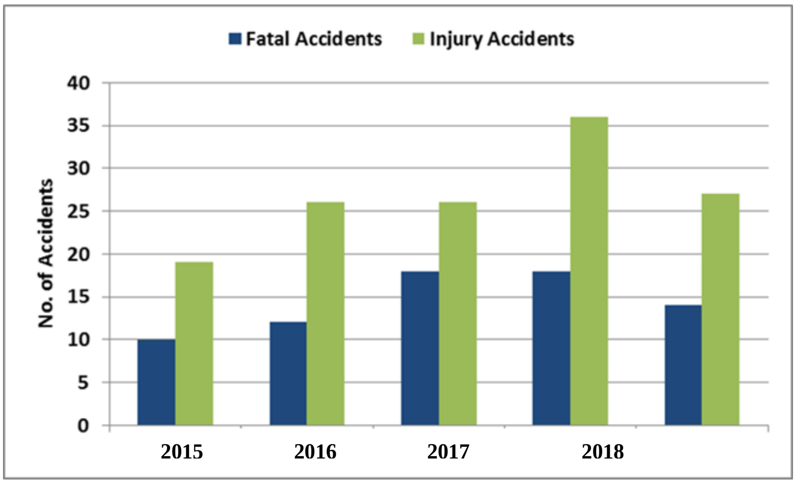

Figure 5 Total Number of Fatal and Injury Crashes (2015-2019).

6.3.SPOT SPEED SURVEY

There are different ways of measuring spot speeds depending on the equipment available and the purpose of the study. Radar speed gun tool is used in this research as shown in Figure 6.

Figure 6 Speed Gun Photo.

Speed distribution is usually based on measuring the speeds of an adequate sample of vehicles passing the spot. Normally, the sample covers 50, preferably 100, vehicles.

The hand held speed radar gun with moving mode was used in this speed study. A radar speed gun (also called radar gun and speed gun) is a Doppler radar unit that may be hand-held, vehicle-mounted or static. It measures the speed of the objects at which it is pointed by detecting a change in frequency of the returned radar signal caused by the Doppler effect, whereby the frequency of the returned signal is increased in proportion to the object's speed of approach if the object is approaching, and lowered if the object is receding. Such devices are frequently used for speed limit enforcement.

The device was handled by observer who sitting in a car parked at the edge of the roadway and was directed at an angle of approximately 15 degrees with the centerline. Readings were taken for traffic in one direction only that considered the place of crashes from the crashes report list.

Generally, for the speed study, peak hours will be included in all samples. The measurements were carried out on a fixed time interval basis (30 minutes), covering all vehicles passing the spots. Speeds were recorded for trucks, pick-ups, mini buses, big buses, and saloon cars. Data collection was done during daylight hours of work weekdays.

Table 2 presents the results of the statistical analysis of spot speed data for the selected segments of the study. For each study site, the following statistical terms were computed:

- Mean and Median.
- Standard deviation.
- Standard error of the sample mean.
- Coefficient of variation.

Table 2 Spot Speed Characteristics for the Studied Segments.

Study Sites	Mean (kph)	Median (kph)	15th% (kph)	85th% (kph)	Standard Deviation (kph)	Standard Error of Mean (kph)	Coefficient of Variation (%)
Seg1	101	105	54	125	41.25	10.65	40.73
Seg2	105	113	57	125	47.98	11.99	45.4
Seg3	100	96	55	134	45.09	11.27	45
Seg4	104	104	53	135	47.99	11.99	46
Seg5	99	100	53	130	39.59	10.22	39.85
Seg6	97	92	55	120	44.11	11.02	45.18
Seg7	102	100	57	97	43.17	11.14	42
Seg8	97	97	60	117	41.65	10.41	42.8
Seg9	96	102	49	112	40.25	10.13	42
Seg10	99	100	60	150	45.15	11.28	45.55

The Median is that speed where there are just as many vehicles going faster as are going slower. This value is obtained from the cumulative speed distribution curve by reading the speed, which corresponds to the 50% value. It is apparent from the table that a significant fluctuation in the Median result can be occurred. In addition, a higher value of variation indicates a wider scatter about the mean and vice versa. It can thus be said that for example, the speed data at segment10 where coefficient of variation is equal to 45.55 % is more dispersed than at the other sites.

Figures 7, 8, and 9 showed the spot speed frequency distribution polygon cumulative curve for Kut – Suwera, Kut – Shekh Saad, and Kut – Hay) respectively. The cumulative speed distribution curves provide two major elements to be tackled for discussion, namely; 15% and 85% values.

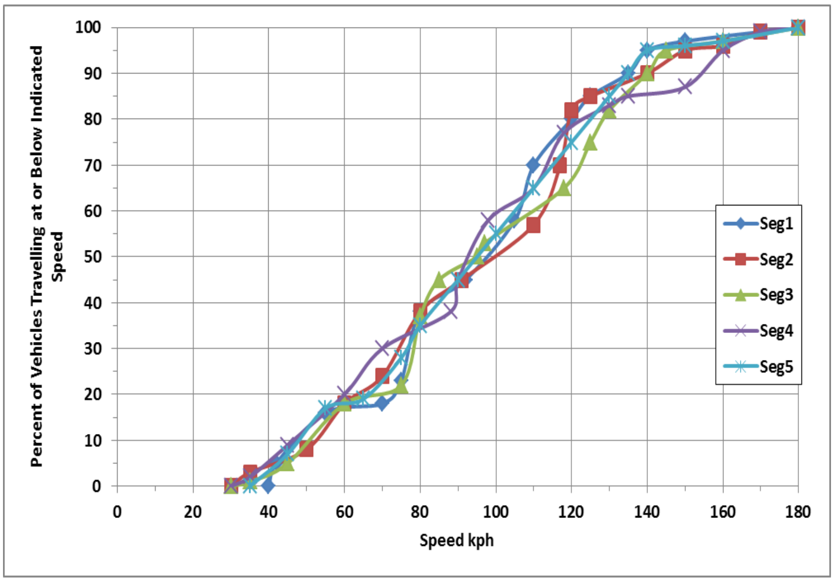

Figure 7 Cumulative Frequency Polygon Curve for (Kut – Suwera) Highway of Studied Segments.

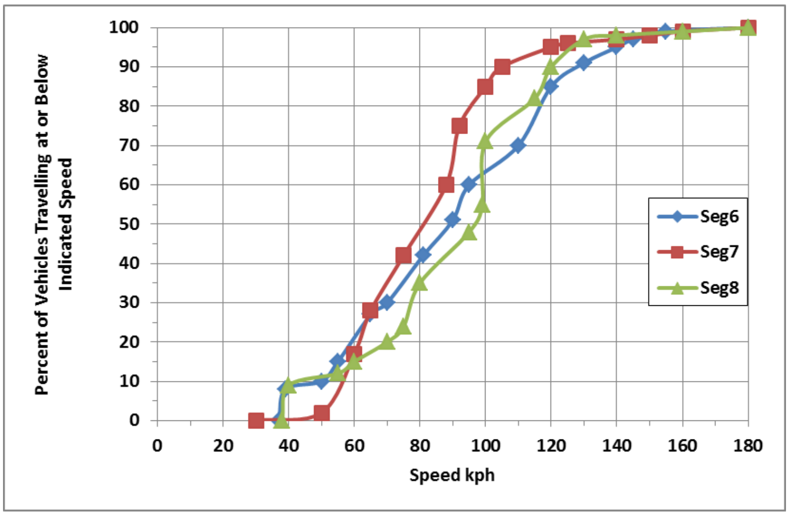

Figure 8 Cumulative Frequency Polygon Curve for (Kut – Shekh Saad) Highway of Studied Segments.

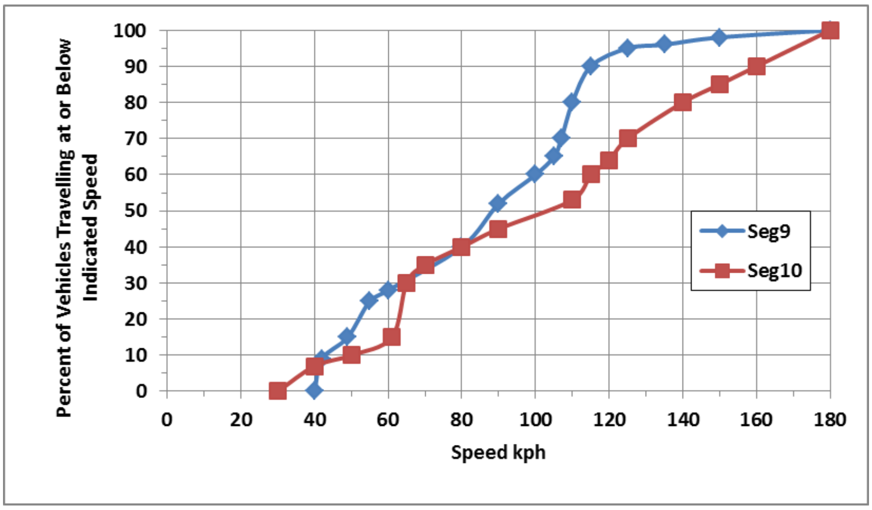

Figure 9 Cumulative Frequency Polygon Curve for (Kut – Hay) Highway of Studied Segments.

6.4.HOURLY TRAFFIC FLOW SURVEY

Traffic volumes have increased considerably over the years for the studied highways since 2000 possibly due to two factors. First is the overall increase in car ownership and consequently increase in travel and secondly, is that these highways provides access to religious cities like Baghdad, Karbala, and Najaf where the holy shrines are located. Every Thursday and Friday as well at certain periods in the year, pilgrimage exerts huge traffic on the highways especially along the section extending to Nummaneya city, which is a part of Kut – Suwera highway containing Seg1 and Seg2.

In addition to these impacts, the presence of the industrial establishments along Kut – Baghdad highway, brick kilns beside Kut – Hay highway and large agricultural areas nearby Kut – Shakh Saad highway impose a heavy commercial and agricultural nature to the traffic stream, emphasized by the relatively high percentage of trucks in daily traffic.

Manual counting involves one or more persons recording observed vehicles using a counter. Traffic flow counts held continuously for a week covering all classes of vehicles in the traffic stream, which include passenger cars, buses, and trucks. Two Sony video cameras have been used to capture the field data. The selection of a vantage point was one of the most challenging things in line with getting security permission that was faced during the data collection stage. Footbridges have been selected as the best vantage point to monitor the traffic stream.

Figures 10, 11, and 12 present the daily variation in hourly traffic flow for the studied segments in Kut – Suwara, Kut – Shaikh Sadd, Kut – Hay highways respectively as revealed by the full week counting.

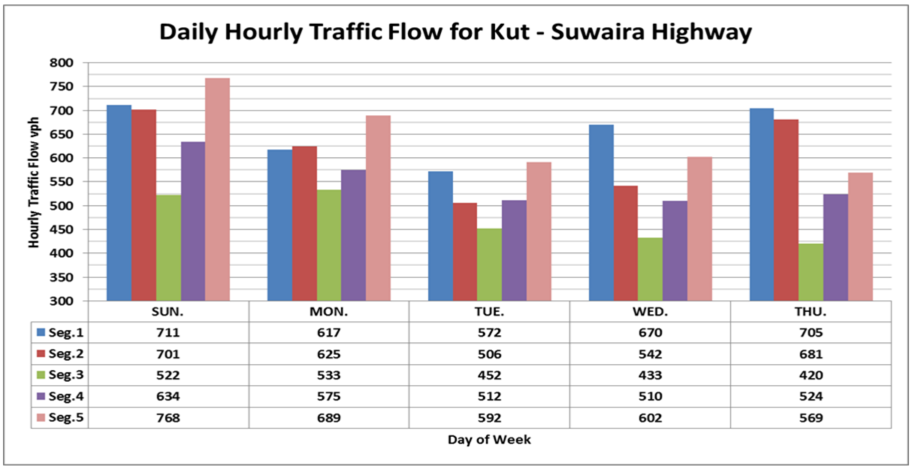

Figure 10 Daily Hourly Traffic Flow for Kut – Suwera Highway Segments.

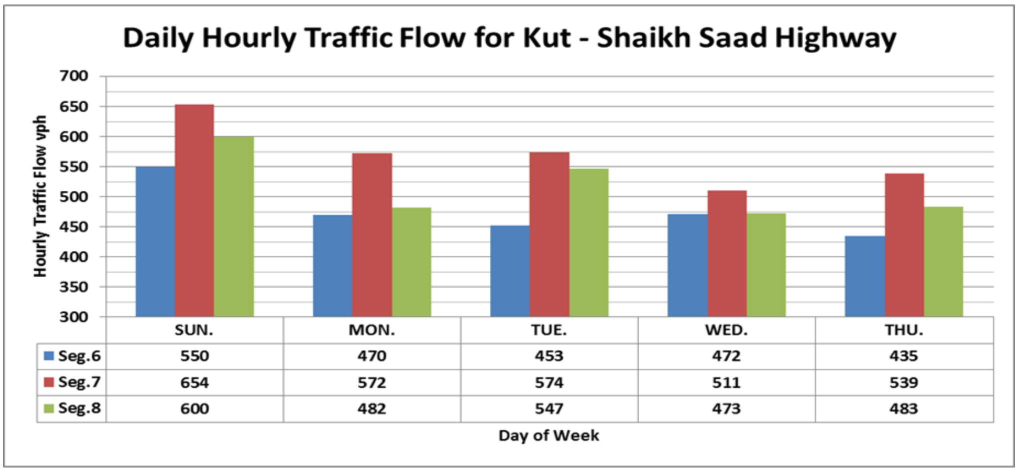

Figure 11 Daily Hourly Traffic Flow for Kut – Shekh Saad Highway Segments.

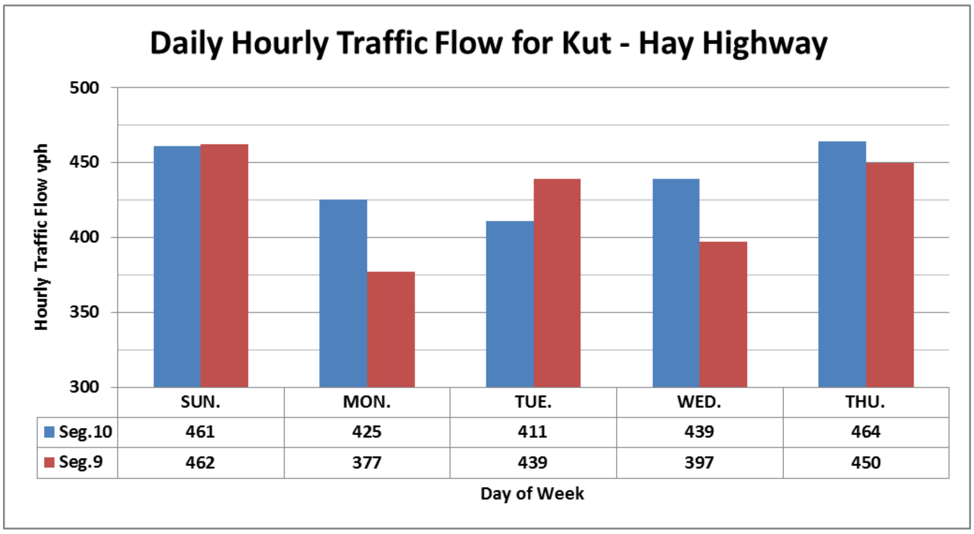

Figure 12 Daily Hourly Traffic Flow for Kut – Hay Highway Segments.

Figures 10 and 12 trends indicate two distinguishable peaks for the studied segments on Sunday and Thursday. Two factors may play a major role in this interesting case in the traffic pattern. The first factor is the religious nature of Thursday day in which a religious occasion for some Muslims was held in this day every week from the southern governorate s. That occasion caused a premature rise in traffic flow. The second factor is the beginning of the works at Sunday that contributed to the increase in traffic flow entering Baghdad, which is related to the people who live in the southern cities and from remote places are employed in Baghdad to join their work.

It is obvious from Figure 11 that traffic volumes on Monday, Tuesday, Wednesday, and Thursday are approximately similar, but a peak is observed on Sunday.

7. CRASHES RATES BY HIGHWAYS AND SEGMENTS

It is conducted to use crash rates as the dependent variable in the statistical models in which crash frequencies are divided by vehicle exposure (i.e. traffic volumes), to provide rates such as crashes per million entering vehicles for spot locations (that will be used in this study) and crashes per million vehicle kilometers for highway sections [12]. The following equation will be applied to obtain crash rates for spot locations:

$$R_{sp} = A\,(10)^6 \,/\, 365\,(T * V) \quad (1)$$

Where:

R_{sp} = crash rate at a spot (crashes/ million vehicles),

A= number of crashes for the section investigated and studied period,

T = period of study in years, and

V= Hourly traffic flow (vph).

The main advantages of the crash rate method are:

1. Both exposure factor and frequency factor are taken into account.
2. It represents a relatively simple and direct method.

The value of crashes rate, when computed as an average over 5 years, should reduce the amount of chance variation in the data (or the experimental error that may tend to be significant when dealing with rural car accidents) and was used as the dependent variable of the suggested models.

Table 3 shows the general crash rates, which describe total crashes occurrence and their types in the studied sites.

Table 3 Crashes Rates by type and Studied Segments.

Seg No.	Avg. Hourly Volume (vph)	Total Accidents		Collision Accidents		Turnover Accidents		Runover Accidents	
		No.	Rate	No.	Rate	No.	Rate	No.	Rate
1	655	45	37.64	19	15.99	8	6.69	11	9.2
2	611	30	26.9	14	12.55	5	4.48	8	7.17
3	472	10	11.61	5	5.8	1	1.16	3	3.48
4	551	18	17.9	9	8.95	3	2.98	4	3.97
5	644	38	32.33	16	13.61	5	4.25	15	12.76
6	476	13	14.96	6	6.9	1	1.15	5	5.75
7	570	25	24.03	10	9.61	3	2.88	7	6.72
8	517	8	8.47	3	3.17	2	2.11	3	3.17
9	425	15	19.34	7	9.02	1	1.28	5	6.44
10	440	9	11.2	8	9.96	0	0	1	1.24

By the same meaning, Figure (13) summarizes and shows total, collision, turnover, and runover crash rates. As crashes number, still segments (1, 2, and 5) on Kut – Suwera highway are the most hazardous locations according to their total crashes rates.

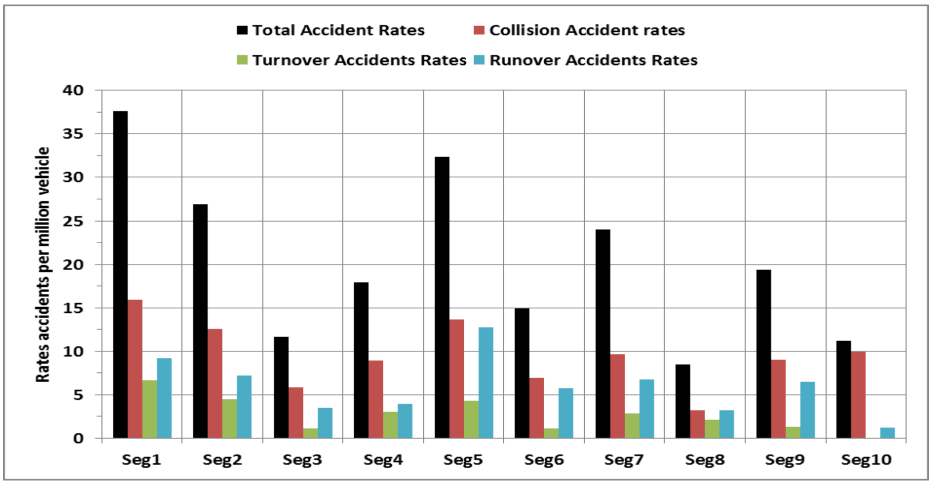

Figure 13 Crashes Rates by type and Studied Segments.

The same procedure is used for computing fatal crash rates that describe crashes severity and to identify most factors affecting the severity of crashes and how factors contributing in severity of crashes. Table 4 and Figure 14 presents these rates.

Table 4 Crashes Severity Rates by type and Studied Segments.

Seg. No.	Avg. Hourly Volume (vph)	Fatal Accidents		Injury Accidents		PDO Accidents	
		No.	Rate	No.	Rate	No.	Rate
1	655	30	25.09	8	6.69	15	12.54
2	611	20	17.93	7	6.27	10	8.09
3	472	5	5.8	5	5.8	5	5.8
4	551	10	9.94	6	5.96	9	8.95
5	644	25	21.27	12	10.21	13	11.06
6	476	9	10.36	9	10.36	4	4.6
7	570	17	16.34	6	5.76	7	6.72
8	517	5	5.29	3	3.17	3	3.17
9	425	9	11.6	3	3.86	6	7.73
10	440	5	6.22	4	4.98	4	4.98

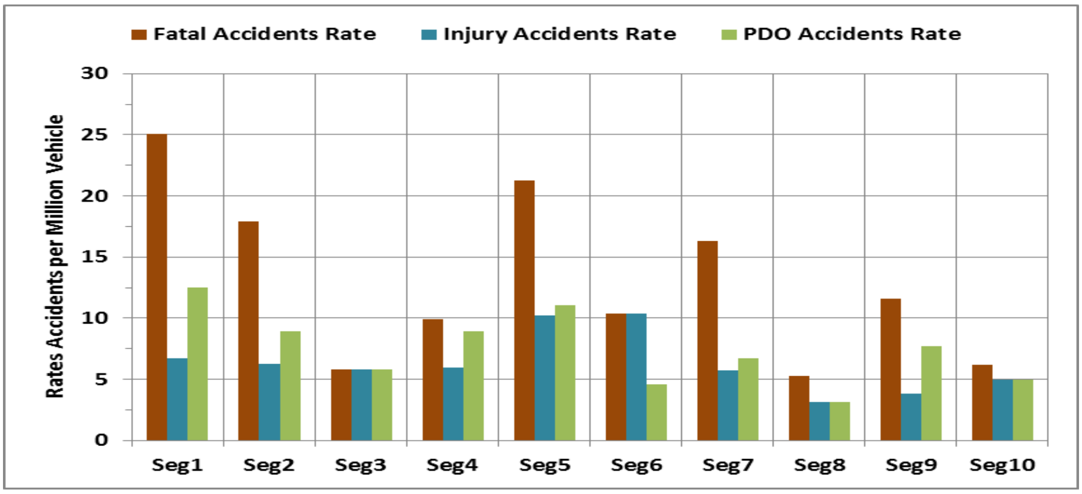

Figure 14 Crashes Severity Rates by type and Studied Segments.

8. THE REGRESSION ANALYSIS TECHNIQUES

The regression analysis technique is used to create a useful step-wise regression model that could be used to develop priority aspects for selecting the type of highway improvement. In order to save money, time, and efforts, the regression statistical technique allows a researcher to evaluate independent or predictor variables. The most important use of the technique is to find the best linear predictive model with a minimum number of independent variables.

The overall accuracy of any predictive model in multiple linear regression analysis is described by the correlation coefficient (R) and coefficient of determination (R2). The predictive accuracy in absolute units is reflected by the standard error of estimation about the regression line.

The various elements of a multiple linear regression equation can illustrated as follows:

$$Y = b_o \pm b_{1x1} \pm b_{2x2} \pm b_{3x3} \dots \dots . \pm b_o \pm b_{nxn} \quad (2)$$

Where:

Y = dependent variable,

b_o= regression coefficient (sample intercept if any, or the value of the dependent variable when the independent variable are zero.

b_n= regression coefficient of the n^{th} independent variable , and

x_n = quantified value , or coefficient of the qualitative value of the n^{th} independent variable,

The dependent and independent variables that considered in this study isolated for each crash type, which examined in the models were summarized and reported in Table 5 with their abbreviations.

Table 5 List of Variables Considered in Regression Analysis.

Variables Type		Abbreviation
Dependent Variables	**Total Crashes Rate**	**TAR**
	Collision Crashes Rate	**CAR**
	Turnover Crashes Rate	**TOAR**
	Runover Crashes Rate	**RAR**
	PDO Crashes Rate	**PDOAR**
	Fatal Crashes Rate	**FAR**
	Injury Crashes Rate	**IAR**
Independent Variables	**Hourly Traffic Flow (vph)**	**Flow**
	Average Spot Speed (kph)	**Speed**

The descriptions of the statistical and regression analysis results are briefly discussed in the following paragraphs.

9. MODELS DEVELOPMENT

The data were used and applied to the multiple linear regression model using SPSS software package that states the mean of the dependent variable as a linear relationship of two predictor variables which are hourly traffic flow and average spot speed.

By using the method of least squares, the models were fitted to the data and a t-test achieved and performed to test the resulting (regression coefficients) comparing with the null hypothesis of being equal to zero at the 5 % significance level. The adequacy of the fit was judged based on the R^2 value and the normality of the residuals.

Analysis of correlation was implemented in order to find independent variables that were correlated to each other. Variables that correlated were not used together in any suggested model. Average spot speed and hourly traffic flow data are selected and tested for correlation. The results indicate that a weak relation was detected between the two variables in which correlation factor is equal to 0.571 with no significant effect (p=0.085).

Table 6 illustrates the resulted linear models that consider hourly traffic flow and average spot speed of the studied segments as independent variables. This table reveals that some of the suggested models are highly correlated.

Table 6 Results of Regression Analysis Considering Segments hourly traffic flow and average spot speed.

Rates type	The Predicted Model	Correlation Factor (R)	Coefficient of Determination (R^2)	F - Value	P value
Total Crash Rate	**TAR=7.41+0.106flow-0.436speed**	**0.842**	**0.709**	**8.53**	**0.013**
Collision Crash Rate	**CAR=-12.7+0.03flow+0.062speed**	**0.691**	**0.477**	**3.192**	**0.103**
Turnover Crash Rate	**TOAR=-6.994+0.023flow-0.027speed**	**0.938**	**0.879**	**25.48**	**0.01**
Runover Crash Rate	**RAR= 38.52+0.041flow-0.543speed**	**0.84**	**0.705**	**8.38**	**0.014**
PDO Crash Rate	**PDOAR=-9.71+0.026flow+0.032speed**	**0.751**	**0.565**	**4.53**	**0.054**
Fatal Crash Rate	**FAR= 13.38+0.078flow-0.424speed**	**0.856**	**0.733**	**9.6**	**0.01**
Injury Crash Rate	**IAR= 19.74+0.016flow-0.219speed**	**0.452**	**0.204**	**0.89**	**0.45**

Four developed models which are (TAR, TOAR, RAR, and FAR) proved statistically for its significance at 5 % level and suggesting increasing numbers of crashes with rising levels of traffic flow.

All of the models for each crash type show similar trends. The positive relation implies that the increasing of traffic flow will increase crashes rates and their severity. This could be attributed to the fact that on multilane rural roads conflicts due to wrong over taking, improper lane changing, following too closely, merging, and diverging when traffic increased provide no clearance that may encourage the drivers to deviate from their paths and make improper maneuvers. Therefore, the occurrence of crashes becomes possible. Most of models were found to be highly significant with a coefficient of determination (R^2) greater than (0.70) except CAR, PDOAR, and IAR models. The R^2 value of 0.709 for TAR model indicates that 70.9 percent of the variation in crash rates are explained by variation in traffic flow and spot speed values with correlation factor of (R= 0.842). These outcomes obviously display that variations in accidents rates are not certainly caused by any one independent factor, but that these variations are a result of the combined effects of these independent factors and other unstudied factors. The residual analysis assured that the models with (R^2) higher than 0.70 represents the situation well as shown in Figures 15, 16, 17 and 18. Investigation of residual plots showed that the residuals were normally distributed and that the normality hypothesis inherent in the development of a linear regression model was not violated in which all data are meeting and collecting around the 45° straight line. It was therefore concluded that linear relationships can be used to describe the data obtained for Wasit governorate multilane road types.

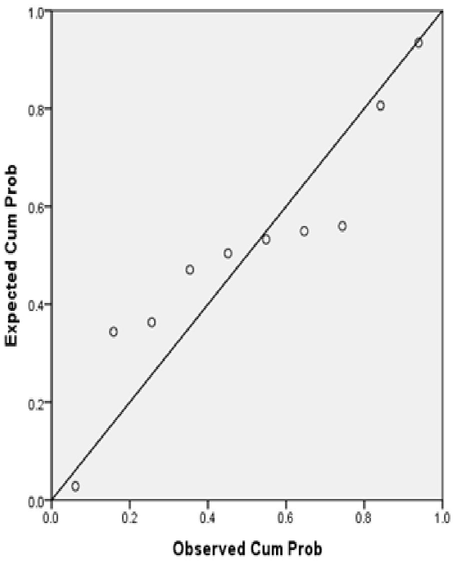

Figure 15 Normal p-p plot of regression residual for TAR model

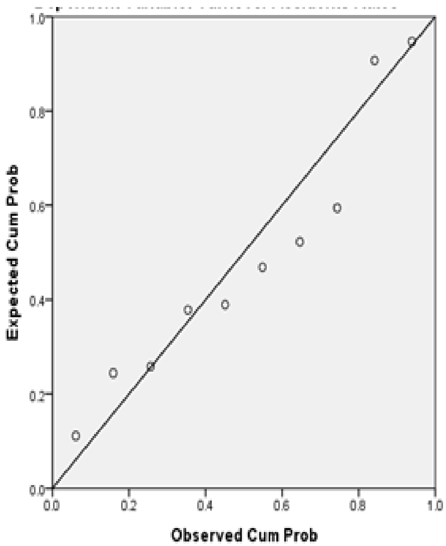

Figure 16) Normal p-p plot of regression residual for TOAR model

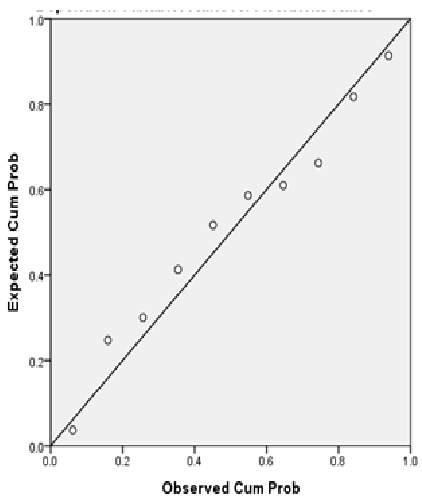

Figure 17 Normal p-p plot of regression residual for RAR model

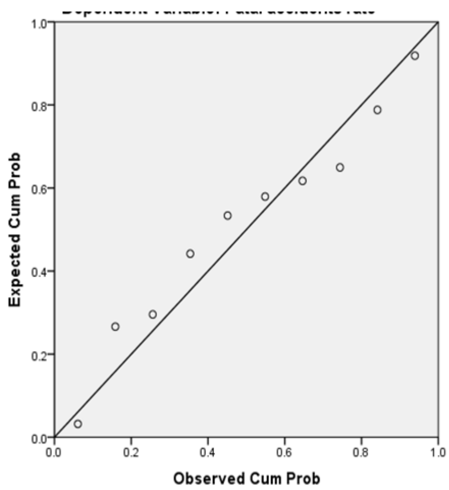

Figure 18 Normal p-p plot of regression residual for FAR model

The fatal crash rate model is significant at the 0.01 level. This implies that the apparent relationship is expected purely by chance once in 100 times, if there is no relationship between the fatal crash rate and traffic flow. The value of (F) explain the variance ratio statistic used to test the hypothesis that all of the partial regression coefficients on the independent variables in the model are zero. For the adopted four models, negative relationship was detected between crashes occurrence and average spot speed. This may be due to the fact that on rural dual carriageways, average spot speed is less effective on crashes especially congested ones that restrict the driver to limit his vehicle speed and be more careful. Other contributing factors such as driver behavior, environment conditions, and vehicle characteristics may be responsible for these accidents.

10. CONCLUSIONS

Based on the survey results and the subsequent analysis of data, the following conclusions can be summarized as follows:

1. According to the traffic crashes types, the collision type produces a higher proportion (46%) of total accidents. While the runover, turnover, and other kinds represent only (29%), (14%), and (11%) of total crashes respectively.
2. As the hourly traffic flow of automobile grows, the need for safe traffic facilities also grown.
3. No significant relation at 5 % level is found for CAR, PDOAR, and IAR models with average spot speed and hourly traffic flow, whilst a good correlation and a significant relation is established for TAR, TOAR, RAR, and FAR models and can be adopted for this study.
4. The linear regression equation, for traffic flow and spot speed representation and relation to crashes occurrence was an acceptable and adequate model to use in modeling data on number of road traffic crashes within rural roads in Wasit governorate .

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support of the Wasit Police Directorate through Wasit Traffic Directorate that played a great part in the effort to assemble the required crash data for the study.

REFERENCES

1. CSO, 2019 "Statistics Roads Traffic Crashesin Iraq in 2018", Central Statistical Organization, Ministry of Planning,.

2. Rural and Urban Crashes: A Comparative Analysis. U.S. Department of Transportation Technical Report1996. DOT HS 808 450..
3. Lassarre, S.. 1996The Introduction of the Variables Traffic Volume, Speed, and Belt-Wearing into a Predictive Model of the Severity of Accidents. CrashAnalysis and Prevention. Vol. 18. No. 2. pp. 129-134..
4. Lord, D., A. Manar, and A. Vizioli. 2005Modeling Crash–Flow–Density and Crash–Flow–V/C Ratio for Rural and Urban Freeway Segments. CrashAnalysis and Prevention, Vol. 37, No. 1,.
5. Harwood, D. W. 1995Relationships Between Operational and Safety Considerations in Geometric Design Improvements. In Transportation Research Record 1512, TRB, National Research Council, Washington, D.C.,.
6. Razouki S.S, Fady S. Yasso, Saba S. Yaso, Petra S. Yasso, Isam V. Dafdony, 2013"Medical -Engineering Pattern of Severe Iraqi Road Traffic Accidents", American Journal of Medical Sciences and Medicine, , Vol. 1, No. 5, 86-91,.
7. Aarts, L., and Schagen, I. van 2006"Driving Speed and the Risk of Road Crashes: A review". CrashAnalysis and Prevention, 38,215–224, .
8. WHO, 2018World Health Organization, "Speed and Road Crashes". PAHO/NMH/18-007, Pan American Health Organization,.
9. Wang, C.; Quddus, M.; Ison, S2013. "A Spatio-Temporal Analysis of the Impact of Congestion on Traffic Safety on Major Roads in the UK. Transp. A Transp. Sci., 9, 124–148,.
10. Retallack, A.E.; Ostendorf, B2019." Current Understanding of the Effects of Congestion on Traffic Accidents". Int. J. Environ. Res. Public Health, 16, 3400,.
11. Eenink, R., et al2008. "CrashPrediction Models and Road Safety Impact Assessment: Recommendations for Using These Tools". Final report. Deliverable D2 of the RiPCORD-iSEREST project. European Commission, Directorate-General for Transport and Energy, Brussels. .
12. Khisty C. Jotin and Lall B. Kent2003, "Transportation Engineering: An Introduction", 3rd Edition, Illinois Institute of Technology, Chicago, Portland State University,.