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MODELING OF TRAFFIC ACCIDENTS CAUSES AT RURAL HIGHWAYS IN EGYPT

BY

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ABSTRACT

The goal of this study is to investigate traffic accidents causes and to develop statistical predictive models for traffic accidents on the agriculture highways in Egypt; Kafr-el-sheikh Governorate as a case study. Accidents models help decision makers to develop the road network to be safer and minimize the accidents rate. Models were calibrated using accidents records data collected from 5 agriculture highways. These highways were divided in two different types of roads sections, namely; agriculture roads with undivided section and agriculture roads with divided section. Simple and multiple regression analysis have been used to find the effect of each parameter on the accidents rate. The results indicated that both the pavement width for one direction and the running speed have highest effects on traffic accidents rate.

الملخص العربي

الهدف من هذا البحث هو نمذجه وتحليل أسباب الحوادث المرورية علي الطرق الزراعية في مصر (حالة الدراسة محافظة كفر الشيخ) ومحاولة الوصول إلي نموذج عام ليربط بين الحوادث وأسبابها وكذلك الوقوف علي المسببات الرئيسية للحوادث. أعتمد هذا البحث علي بيانات تم تجميعها من خمس طرق رئيسية وتم تقسيم هذه الطرق إلي قسمين: " طرق زراعية بقطاعات غير مقسمه وطرق زراعية بقطاعات مقسمه". تم دراسة وربط معدل الحوادث مع أسباب الحوادث وتم دراسة كل مسبب علي حده ثم مع العوامل مجمعة واستنتج العلاقات التبادلية ومدي الارتباط باستخدام البسيط والتحليل المتعدد. وقد أوضحت النتائج أن عرض الرصف للاتجاه الواحد وكذلك سرعة السير لهما التأثير الأكبر علي معدلات الحوادث.

KEYWORDS: Accidents Rate, Agriculture Highways, Regression Analysis, Running Speed.

1. INTRODUCTION

Traffic accident is an expression used to describe a certain failure in performance of one or more of traffic system. These include the driver, the vehicle and the roadway geometry. Accidents may cause death, injury and/or property damage. The property damage accidents are resulting destructive effect on vehicles involved in the accident and/or the road elements. Traffic safety is a function of quality of traffic management, geometric design, roadway illumination, roadside features, maintenance, enforcement, traffic control devices and traffic operation [1]. There are about 20 to 50 million victims as a result of accidents per year and that more than 90 % of road traffic deaths occur in low-income and middle-income countries and in these countries the most vulnerable are pedestrians, cyclists, users of motorized two-and three-wheelers and passengers on unsafe public transport [2]. The following subsection describes the factors influencing traffic accidents frequency and severity as reviewed in the literature.

In Egypt, human factors represent driver ability to control the vehicle, determines the probability of accident occurrence and crossing error for pedestrian. These factors are responsible for about 74% of accident occurrence. Vehicles are responsible of 17% of accident occurrence. Also, road characteristics such as road design elements, maintenance conditions, land use and weather contribute 9% in accidents occurrence [3].
The driver ability is affected by age, sex, attitudes, roadway characteristics and vehicle's condition. Males are involved in accident occurrence more than females. Age also has high effect on accidents. The age less than 30 years old is the most serious age group on accident occurrence. Also, that effective traffic control devices must be visible, recognizable, understandable and necessary. Side markings of pavement' edges, and between lanes and directions give required limitations to the drivers using the road space especially at night. For the surface conditions, the presence of distresses in highway surface may cause interruption to the driver and consequently affects safety level. These distresses may include alligator cracks, rutting, pothole, bleeding. Other pavement and surface condition factors that include road skid resistance and wet road surface are also important [1].

The effect of geometric elements of the roadway were studied by Zegeer[4]. Statistical testing as well as accident prediction model was employed. The effect of various geometric improvements, such as, lane widening, shoulder widening and shoulder surfacing on reducing accident rate was evaluated. This study concluded that the accident type found to be most related to cross-section features, were; run-off-road, head-on and sideswipe (same direction and opposite direction) accidents. The traffic and roadway variables, found to be associated with a reduced rate of single-vehicle accidents, were wider lanes, wider shoulder, greater recovery distance and lower roadside hazard rating.

Pavement width affects accidents rate. A reduction in accidents rate of about 50% is attained when pavement width is increased from 7.0 to 10.0 meters for agriculture roads with undivided sections. Also the average daily traffic volume (veh./day) affects the accidents rate [5]. Shoulder width affects accidents rate. A reduction in accidents rate of about 37% is reached due to widening shoulder by 1-3 meters in agriculture roads with undivided sections. And also percentage of trucks and buses reduces the level of service on the road as a result of the probability of accident occurrence increases. Decreasing percentage of trucks by 10% reduce accidents rate about 18% for agriculture road with undivided sections [6].

Median width is the least significant characteristics correlated to traffic hazarded, but the general trend obtained from simple regression analysis indicated that median width is inversely proportional to property damage-only accident per million vehicle kilometer [7]. Horizontal curves are the place where 10-12% of all accidents are concentrated and the number of accidents on curves increases with a decrease in their radii. Existence of entrances to the road increases the number of conflict points. This increases the possibility of accident occurrence [8].

Kay Fitzpatrick [9], applied the geometric structure variables such as the width of lane, existence of median barrier, curve radius and deflection angle. It was found from this study that, in road section of unlike width of lane has been shown an important variable through the model. In the study of Bonneson and Mccoy [10] developed accident prediction model according to each condition by distinguishing separation and non-separation of left-turn lane separating roads away from median separation facilities. As a result, they proposed that accidents were affected by AADT, length of roads, density, and land use and so on. Zegeer [11] studied the effect of side-slope and other road-side features on two-lane roads on accidents rate. Results indicated that tress and lighting poles, as fixed obstacles, were often struck by the moving vehicles. On roads which had traffic volume of 4000 veh./day or less, most accidents happened due to struck with tress as obstacles. However, lighting poles were the obstacles most frequently struck on roadways with higher volumes.

Road lighting is normally installed at the locations where the road goes through towns and large villages to alert drivers to the presence of residential activities in order to reduce speed of moving vehicles. Street lights brighten the road surface so that objects are seen in silhouette i.e; as dark objects against a light background. Increasing the brightness of the road surface decreases the risk of accidents. Since objects are seen in the light of headlights as bright against a dark background; the result may be worse for the driver than if side lights are used instead of headlights. Several studies have concluded that continuous highway lighting reduces night-time accidents rate [1, 12]; other studies doubted this conclusion.

Malyshkina and Mannering [13] studied the impact of design exceptions allowed in the highway construction on the traffic accident rate (design exception: safety deviation in roadway design factors). They found exceptions don't necessarily increase accidents in their dataset. In another analysis of the data of 10 Canadian cities, Andrey [14] related weather and accident rates and found that accident rates drop under severe weather conditions.

Adbul Aziz et. al. [15] developed an accident prediction model for Federal Route 50 by using multiple linear regression analysis. The result of the analyses provide sufficient evidence to support the hypothesis that the existence of a larger major junction density, an increase in traffic volume and vehicle speed in Federal Route 50 are the contributors to traffic accidents. Reduction of vehicle speed, access point, traffic volume and gap are likely to have an influential effect on the road traffic accidents.

Sharad K Maheshwari and Kelwyn A. D'Souza [16] developed statistical predictive models for vehicular traffic accidents at the city intersections. The information derived from the accident analysis could assist in improving road structures, road conditions and/or modify the administrative policies to reduce accidents and congestion at intersections.

In recent years, several studies have applied data mining techniques along with statistical modeling to determine the impact of major factors like traffic volume and road design characteristics along with minor factors such as potholes and surface roughness. Graves, et al., [17] reported about the impact of potholes and surface roughness on the accident rate. However, due to paucity of data a clear link could not be established between these surface factors (pot holes, roughness, etc.). Washington, et al., [18] performed an extensive study to validate previously reported accident prediction models and methods. Validation was performed using recalculation of original model coefficients, recalculation using of additional year data, and recalculation using data from a different state. The study reported that beside traffic volume other factors should be considered on a case-by-case basis for a given site.

2. DATA COLLECTION

The occurrence of a traffic accident reflects a shortcoming in one more components of the driver-vehicle-roadway system. The correction of problems associated with these components is sufficient to keep an accident from occurrence. Thus, although many individual factors may contribute to an accident, improvements to highway can have a significant effect in reducing crash experience. So, data required for this study consisted of two sets of data which had taken into account:

i. Accident reporting data.

ii. Roadway and traffic characteristics data (field survey).

2.1 Traffic Accidents Reporting Data

Data of traffic accidents collected from the central traffic police department of Kafr-el-sheikh Governorate. Data were collected for the accidents which occurred during year 2011. A simple form type was used in the accident reporting for this research. The form is usually filled out after the police have carefully investigated the accident including questioning participants and witnesses, making physical measurements and giving diagrammatic sketching for the accident locations. Data were collected in the simple form included information concerning the following:

1. Location and severity of accident.
2. Type of collision and vehicles involved in the collision.
3. Probable causes of the accident.
4. Number of persons killed and injured in the accident.
5. Weather conditions.

2.2 Roadway and Traffic Characteristics Data [field Survey]

Five roads are branched from Kafr-el-sheikh city were selected to study the effect of the roadway and traffic characteristics on the accidents rate. These selected roads form a part of the major highway system of the road network of Kafr-el-sheikh Governorate and have a very high volume of traffic and considerable number of accidents. The selected five roads include some divided and undivided roads. The roads with undivided sections are:

1. Kafr-el-sheikh – El-Mahalla road (KFM)
2. Kafr-el-sheikh – Biyala road (KFB)

3. Kafr-el-sheikh – Desouk road (KFD)
The roads with divided sections are:
1. Kafr-el-sheikh – Tant road (KFT)
2. Kafr-el-sheikh – Baltem road (KFl)
Data collected from field survey including all environmental characteristics for each road that affect the risk and rate of accidents. Traffic volume and their compositions were obtained by manual field traffic count survey for each road. Running speed was determined by using moving car method. For each of the selected roadway sections, the following traffic and roadway variables are identified below were collected.

1. Cross-Section Characteristics
   i. Pavement width in meter [P]
   ii. Shoulder width in meter [S]
   iii. Median width im meter [M]
2. Traffic Volume
   i. Annual Average Daily Traffic [ADT] (veh./day)
   ii. Heavy Vehicles Daily Traffic [HDT] (veh./day)
3. Surrounding Areas Land Use
   i. Cultivated areas land use [CUL]
   ii Built-up areas land use [BUL]
   iii. Mixture of cultivated and built-up areas land use [BOTH]
4. Running Speed [SR] (Km/hr)
5. Conflict Point per Km [CP]
6. Lighting Status [LG]
   i. Good (two sides)
   ii. Bad (one side)
   iii. Not exist

3. RESEARCH METHODOLOGY

To develop a general model for accidents, the data available has been divided into two groups according to its location as:
1) Agriculture roads with undivided sections
2) Agriculture roads with divided sections
Analysis was carried out by SPSS (V17) program to calibrate models for each type of road sections. Dependent variable considered was accidents rate (AR) as model (1). Independent variables were 8 variables as pavement width, shoulder width, annual average daily traffic, heavy vehicles daily traffic, running speed, land use area, conflict point and lighting status. Accidents rate (AR) is the accidents number divided by the vehicle exposure. It is expressed as accident per million vehicles-kilometers for road section per year [5]. Exposure is defined as the count of the number of times vehicles are exposed or open to the paths of others.

$$AR = \frac{N \times 10^6}{ADT \times 365 \times NY \times L} \text{.....................(1)}$$

Where:
N= number of accidents, NY= number of years and L= section length.

Simple Regression Analysis gives the correlation between average accidents rate at all accident locations and each of the studied parameters using different mathematical form; linear, logarithmic, power, polynomial and exponential simple regression models. To find the most significant relationship correlating the average accident rate and the considered parameter, models are suggested as linear, logarithmic, power, polynomial and exponential simple regression models, respectively.

Many of parameters contribute together to cause accidents, therefore simple regression analysis may give improper results. Multiple Regression Models would be the proper one and the combined effect of these parameters on accidents rate must be taken into consideration.
Stepwise Regression Analysis is the method used in multiple regression analysis. It considers a few important parameters out of a large set of parameters to construct a multiple regression function by select the variables have high effects in accidents rate.

4. ANALYSIS OF ACCIDENTS DATA

The purpose of this part of study is to find the possible causes of accidents. In order to investigate the highly affected factors which lead to the occurrence of the traffic accidents, all probable factors should be considered and analyzed. Human factors, vehicle factors, roadway characteristics in addition to environmental factors must be considered. The occurrence of accident results forms complex integration among a driver, vehicle, roadway and environment. Accident data analysis shows that the most affected factor in accident occurrence is human factors, which involved in about 88% of all accidents occurred on main roads network of Kafr-el-sheikh Governorate, vehicle and roadway involved in about 10% and finally, environment was responsible of accident occurrence by 2%. Figure 1 and Figure 2 show the percentage of involving these factors in accidents occurrence to the total number of accidents occurred on main roads network of Kafr-el-sheikh Governorate.

4.1 Human Factors:

Human factors include drivers and pedestrians behavior. Accident data analysis indicates that about 36.4% of all accidents occurred was due to inattention of drivers. Also, it is found that about 26% of all accidents were to wrong overtaking by drivers which need an additional paved width and shoulder with space for overtaking. In the other side, it is appeared that about 18.8% of all accidents occurred were due to over speeding. So, the behavior of the drivers in controlling speed and overtaking has high influence on reducing accident rate.

4.2 Vehicle Factors:

Vehicle factors are second highly affected factor in accident occurrence after human factors. Vehicle tires condition have the considerable factors in accident occurrence. It is found that, about 9.7% of all accidents were due to tire dust and about 73.3% of which were fatal accidents.

4.3 Environmental Factors:

Environmental and weather conditions share about 2% of all accidents occurred on main roads network of Kafr-el-sheikh Governorate and about 67.7% of which were fatal accidents.

5. REGRESSION MODELS DEVELOPMENT AND DISCUSSION

To identify traffic safety measures, accidents models must be done to evaluate accident probability causes. Accident models help planners to develop roads network to be more safe and reduce accidents rate. To develop a general model of traffic accidents causes for main roads network of Kafr-el-sheikh Governorate, the data collected in Kafr-el-sheikh Governorate has been divided into groups according to its location as:

1) Agriculture roads with undivided sections
2) Agriculture roads with divided sections

5.1. Simple Regression Analysis

The correlation between accident rates (AR) with each attribute variable was reached by simple regression analysis using linear, exponential and polynomial regression models in order to find the best correlation. The best regression models are shown below for both the agriculture roads with undivided sections and the agriculture roads with divided sections.

5.1.1 Models for Agriculture Roads with Undivided Sections

The best regression models for the agriculture roads with undivided sections are shown as follows:

$$AR = -2.824\,P + 12.153 \quad (2) \qquad [R^2=0.912]$$

$$AR = -1.201\,S + 3.169 \quad (3) \qquad [R^2=0.811]$$

$$AR = 1.36 * 10\text{-}7\,ADT^2 - 0.001\,ADT + 4.472 \quad (4) \qquad [R^2=0.329]$$

$$AR = -5.3 * 10\text{-}5\,HDT^2 + 0.049\,HDT - 10.241 \quad (5) \qquad [R^2=0.324]$$

$$AR = -3.869\,SR + 157.926 \quad (6) \qquad [R^2=0.824]$$

$$AR = -0.333\,CUL + 0.1\,BUL + 0.948 \quad (7) \qquad [R^2=0.221]$$

$$AR = 0.217\,CP^2 - 0.79\,CP + 1.406 \quad (8) \qquad [R^2=0.551]$$

$$AR = 0.245\,LG^2 - 0.879\,LG + 1.383 \quad (9) \qquad [R^2=0.562]$$

5.1.2 Models for Agriculture Roads with Divided Sections

The best regression models for the agriculture roads with divided sections are shown as follows:

$$AR = 3.621\,P^2 - 49.8\,P + 171.886 \quad (10) \qquad [R^2=0.790]$$

$$AR = 10.352\,S^2 - 29.441\,S + 21.551 \quad (11) \qquad [R^2=0.738]$$

$$AR = 0.091\, e^{0.001ADT} \quad (12) \qquad [R^2=0.472]$$

$$AR = -1.6 * 10^{-7}\,HDT^3 + 0.135\,HDT - 46.637 \quad (13) \qquad [R^2=0.271]$$

$$AR = 0.022\,SR^2 - 3.581\,SR + 4.589 \quad (14) \qquad [R^2=0.751]$$

$$AR = 0.168\,CUL + 0.118\,BUL + 0.565 \quad (15) \qquad [R^2=0.351]$$

$$AR = 0.168\,CP^2 - 0.542\,CP + 1.085 \quad (16) \qquad [R^2=0.485]$$

$$AR = 0.178\,LG^2 - 0.228\,LG + 0.71 \quad (17) \qquad [R^2=0.498]$$

Where:
AR = Accidents Rate (accident / million veh-km)
P = Pavement Width for one direction in meter
S = Shoulder Width for one side in meter
ADT= Annual Average Daily Traffic (veh./day)
HDT= Heavy Vehicles Daily Traffic (veh./day) $*10^{-3}$
SR= Running Speed (km/hr)

CUL= Existing Cultivated Area Land Use (1 if present, 0 if not)

LG= Lighting Status (0 for two sides, 1 for one side and 2 for not exist)

Since many of road and traffic characteristics contribute together to cause accidents, their combined effect on road safety must be taken into account. Multiple regression analysis is an appropriate method in which the accident rate (AR) can be expressed as a function of several independent variables simultaneously. In pervious sections, simple regression was employed to find the correlation between accidents rate and each of selected factors. In this section a step-wise regression technique is conducted. First variable is selected according to the highest correlation coefficient found previously. Independent variables are added in turn starting from the highest correlation coefficient until the regression model with the best multiple coefficient is selected. However, the highest correlation coefficient is reached when using multiple linear regression analysis. Many of trails were carried out to conclude the best models for the agriculture roads (both with undivided sections and with divided sections) with the highest correlation coefficients.

BUL= Existing Built-up Area Land Use (1 if present, 0 if not)
CP= Conflict Point per Km

5.2 Multiple Regression Analysis

5.2.1 Models for Agriculture Roads with Undivided Sections

5.2.1.1 Multiple Linear Regression Analysis

Firstly, multiple linear regression analysis has been used in order to develop the relationship between accidents rate as dependent variable and the road and traffic characteristics as independent variables. A summary of stepwise analysis procedure are given in Table (1).

In this technique P is taken as the main parameter that affects the accidents rate and the other parameters are taken in step way manners. As shown in Table (1), R^2 increases significantly as important variable are added to the stepwise regression model to step number 8. The results of the multiple linear regression analysis are summarized in the following model:

$$\mathbf{AR = 6.021 - 1.341\,P - 0.611\,S + 0.0001\,ADT + 0.005\,HDT + 0.007\,SR + 0.034\,CUL + 0.022\,BUL + 0.37\,CP - 0.02L \quad \ldots\ldots(18)}$$

$$\mathbf{[R^2 = 0.973]}$$

The above relationship shows that the accidents rate decreases as the pavement width for one direction, shoulder width per one side and lighting increase. However, the accidents rate increases as the traffic volume, heavy vehicles traffic volume, running speed and conflict points increase. Also, the accidents rate increases as the area land use change from built-up area to cultivated area. It is expected that drivers speeds their vehicles at cultivated areas which results in higher number of accidents.

Figure (3) illustrates the relationship between accidents rate and pavement width for different types of land use for the undivided highways. Generally, as the pavement width of one direction increases, the accidents rate decreases by a constant rate. A reduction in accidents rate of about 45% is attained when pavement width is increased from 4.0 to 4.5 meters for one direction. This decease is found out at constant value of shoulder width per one side equal to 2.0 meters and constant value of running speed equal 65 Km/hr. It is apparent that the pavement width is a significant factor in reducing the accidents rate. Also, the mixture of both cultivated and built-up areas land use has the highest accidents rate. The built-up area land use has the lowest accidents rate. This is expected, since in built-up area drivers have to slow down their speed.

Figure (4) introduces the relationship between accidents rate and shoulder width for different types of land use for the undivided highways. It shows that the accidents rate decreases as the shoulder width per one side increases. A reduction in accidents rate of about 21% is reached when shoulder width is increased from 2.0 to 2.5 meter for one direction. This decease is found out at constant value of pavement width for one direction equal to 4.0 meters and constant value of running speed equal 65 Km/hr.

Figure (5) illustrates the relationship between accidents rate and running speed for different types of land use for the undivided highways. Generally, as the running speed increases, the accidents rate increases by a constant rate. Accidents rate increases about 30% is attained when running speed is increased from 60 Km/hr to 90 Km/hr. This increase is found out at constant value of pavement width of one direction equal to 4.0 meters and constant value of shoulder width per one side equal to 2.0 meters. From this figure, it is found that, the built-up area land use has the lowest accidents rate. This is expected, since in built-up area drivers have to slow down their speed.

5.2.1.2 Multiple Nonlinear Regression Analysis

Consequently, a multiple nonlinear regression analysis has been performed. A series of models was produced that beat fit between accidents rate as dependent variable and road and traffic characteristics as independent variables. A summary of the results of this analysis are shown in the following model:

$$\mathbf{AR = 13.122 - 3.314\,P^{0.9} - 0.002\,S^{5.5} + 1.77*10^{-18}\,ADT^{4.5} + 1.16 * 10^{-21}\,HDT^{7.5} + 0.017SR + 0.037\,CUL + 0.032\,BUL + 0.061\,CP - 0.064\,LG} \quad \mathbf{(20)}$$

$$[R^2 = 0.95]$$

5.2.1 Models for Agriculture Roads with Divided Sections

5.2.2.1 Multiple Linear Regression Analysis

Firstly, multiple linear regression analysis has been used in order to develop the relationship between accidents rate as dependent variable and the road and traffic characteristics as independent variables. A summary of stepwise analysis procedure are given in Table (2).

In this technique P is taken as the main parameter that affects the accidents rate and the other parameters are taken in step way manners. As shown in Table (2), R^2 increases significantly as important variable are added to the stepwise regression model to step number 8. The results of this analysis are summarized in the following model:

$$\mathbf{AR = 4.447 - 0.793\,P - 0.571\,S + 8.97*10^{-5}\,ADT + 0.001\,HDT + 0.016\,SR + 0.013\,CUL + 0.003\,BUL + 0.056\,CP + 0.107} \quad \mathbf{(21)}$$

$$[R^2 = 0.904]$$

The above relationship shows that the accidents rate decreases as the pavement width for one direction, shoulder width per one side and lighting increase. However, the accidents rate increases as the traffic volume, heavy vehicles traffic volume, running speed and conflict points increase. Also, the accidents rate increases as the area land use change from built-up area to cultivated area. It is expected that drivers speeds their vehicles at cultivated areas which results in higher number of accidents.

Figure (6) shows the relationship between accidents rate and pavement width of one direction for different types of land use for the divided highways. It is apparent from this figure that, as the pavement width of one direction increases, the accidents rate decreases by a constant rate. A reduction in accidents rate of about 74% is attained when pavement width of one direction is increased from 7.0 to 7.5 meters for one direction. This decease is found out at constant value of shoulder width equal to 1.5 meter for one side and constant value of running speed equal 85 Km/hr. It is apparent that the pavement width is a significant factor in reducing the accidents rate. Also, the mixture of both cultivated and built-up areas land use has the highest accidents rate. The built-up area land use has the lowest accidents rate. This is expected, since in built-up area drivers have to slow down their speed.

Figure (7) introduces the relationship between accidents rate and shoulder width for different types of land use for the divided highways. It shows that the accidents rate decreases as the shoulder width per one side increases. A reduction in accidents rate of about 4% is reached when shoulder width per one side is increased from 1.5 to 2.0 meters. This decease is found out at constant value of pavement width for one direction equal to 7.0 meters and constant value of running speed equal 85 Km/hr.

Figure (8) illustrates the relationship between accidents rate and running speed for different types of land use for the divided highways. Generally, as the running speed increases, the accidents rate increases by a constant rate. Accidents rate increases about 47% is attained when running speed is increased from 80 Km/hr to 100 Km/hr. This increase is found out at constant value of pavement width of one direction equal to 7.0 meters and constant value of shoulder width per one side equal to 1.5 meter. From this figure, it is found that, the built-up area land use has the lowest accidents rate. This is expected, since in built-up area drivers have to slow down their speed.

5.2.2.2 Multiple Nonlinear Regression Analysis

Consequently, a multiple nonlinear regression analysis has been performed. A series of models was produced that beat fit between accidents rate as dependent variable and road and traffic characteristics as independent variables. A summary of the results of this analysis are shown in the following model:

$$\mathbf{AR = 7.455 - 2.108\,P^{0.7} - 0.069\,S^{3.5} + 3.8*10^{-18}\,ADT^{4.5} + 1.41 * 10^{-16}\,HDT^{5.5} + 0.016\,SR + 0.019\,CUL + 0.007\,BUL + 0.055\,CP - 0.106LG} \quad \mathbf{(22)}$$

[R^2 = 0.901]

6. CONCLUSIONS

1. Human factors are responsible of nearly 88% of all accidents occurred on main roads network of Kafr-el-sheikh Governorate while, vehicle and roadway characteristics involved about 10% and finally, environment was responsible of accident occurrence by 2%.
2. Inattention of drivers represents about 36.4% of all accidents, 26% of all accidents were due to wrong overtaking by drivers and about 18.8% of all accidents occurred were due to over speeding (Human Factors). It is found that, about 9.7% of all accidents were due to tire dust (Vehicle Factors).
3. Results from regression analysis show that pavement width for one direction has high effect on traffic accidents rate. A reduction in accidents rate of about 45% is attained when pavement width is increased from 4.0 to 4.5 meters for one direction for undivided highways and a reduction in accidents rate of about 74% is reached when pavement width of one direction is increased from 7.0 to 7.5 meters for divided highways.
4. Analysis indicated that, as the running speed increases, the traffic accidents rate increases by a constant rate. Accidents rate increases about 30% is attained when running speed is increased from 60 Km/hr to 90 Km/hr for undivided highways. In the other side, accidents rate increases about 47% is reached when running speed is increased from 80 Km/hr to 100 Km/hr for divided highways.
5. The built-up area land use has the lowest accidents rate. This is expected, since in built-up area drivers have to slow down their speed.

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Table (1): Stepwise Regression Analysis for Agriculture Roads with Undivided Sections

Step No.	**Variable**	**R^2**
1	P	0.912
2	P+SR	0.915
3	P+SR+S	0.923
4	P+SR+S+CUL+BUL	0.929
5	P+SR+S+CUL+BUL+CP	0.944
6	P+SR+S+CUL+BUL+CP+LG	0.947
7	P+SR+S+CUL+BUL+CP+LG+ADT	0.950
8	P+SR+S+CUL+BUL+CP+LG+ADT+HDT	0.973

Table (2): Stepwise Regression Analysis for Agriculture Roads with Divided Sections

Step No.	Variable	R^2
1	P	0.569
2	P+SR	0.615
3	P+SR+S	0.647
4	P+SR+S+CUL+BUL	0.830
5	P+SR+S+CUL+BUL+CP	0.841
6	P+SR+S+CUL+BUL+CP+LG	0.859
7	P+SR+S+CUL+BUL+CP+LG+ADT	0.872
8	P+SR+S+CUL+BUL+CP+LG+ADT+HDT	0.904

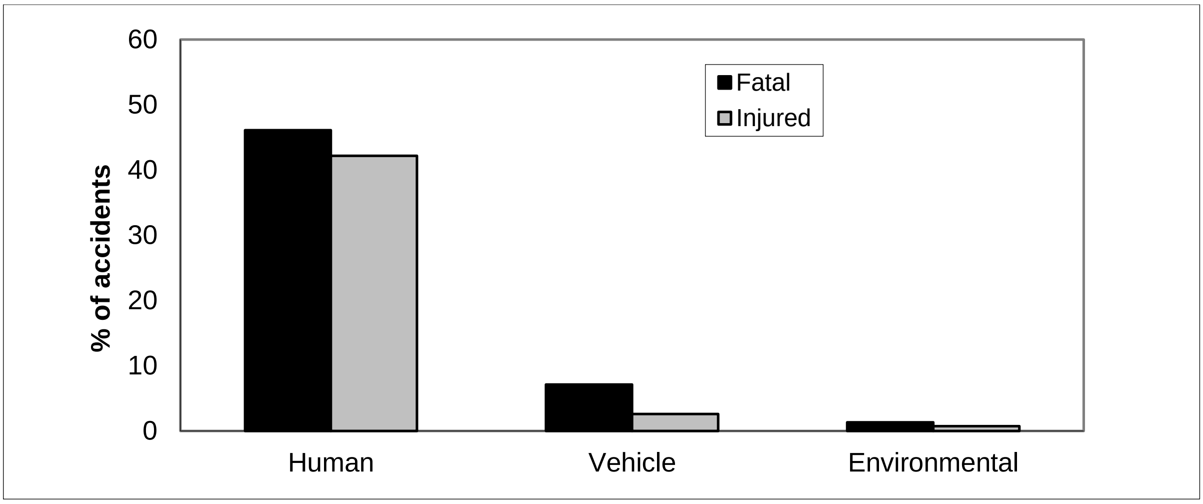

Figure (1): Percentage of Traffic Accident Causes Factors

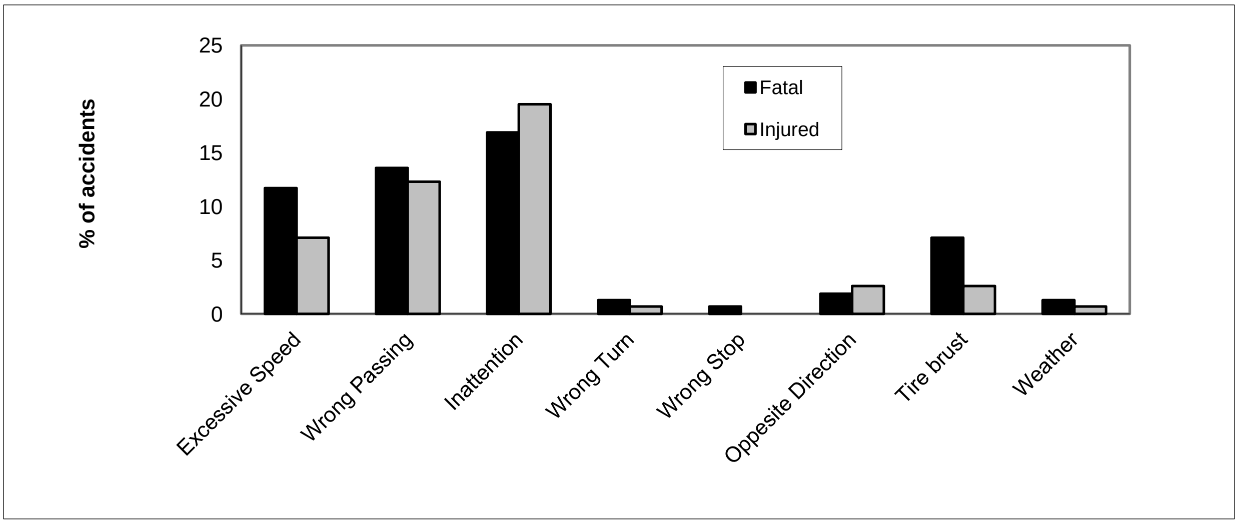

Figure (2): Traffic Accident Causes According to Traffic Accident Report Data

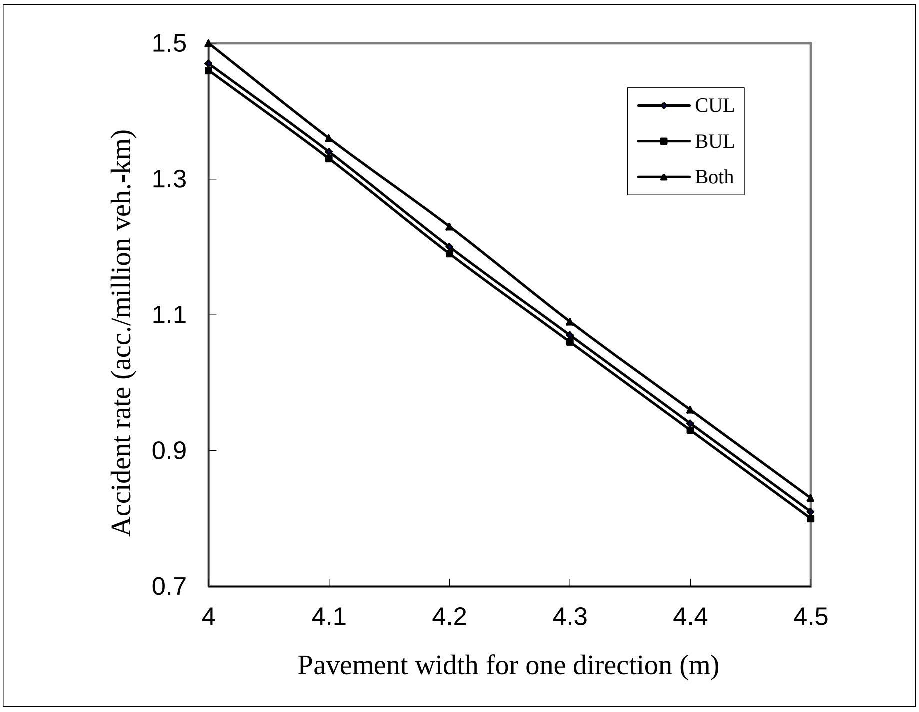

Figure (3): Relationship between Pavement Width and Accidents Rate for Undivided Highways

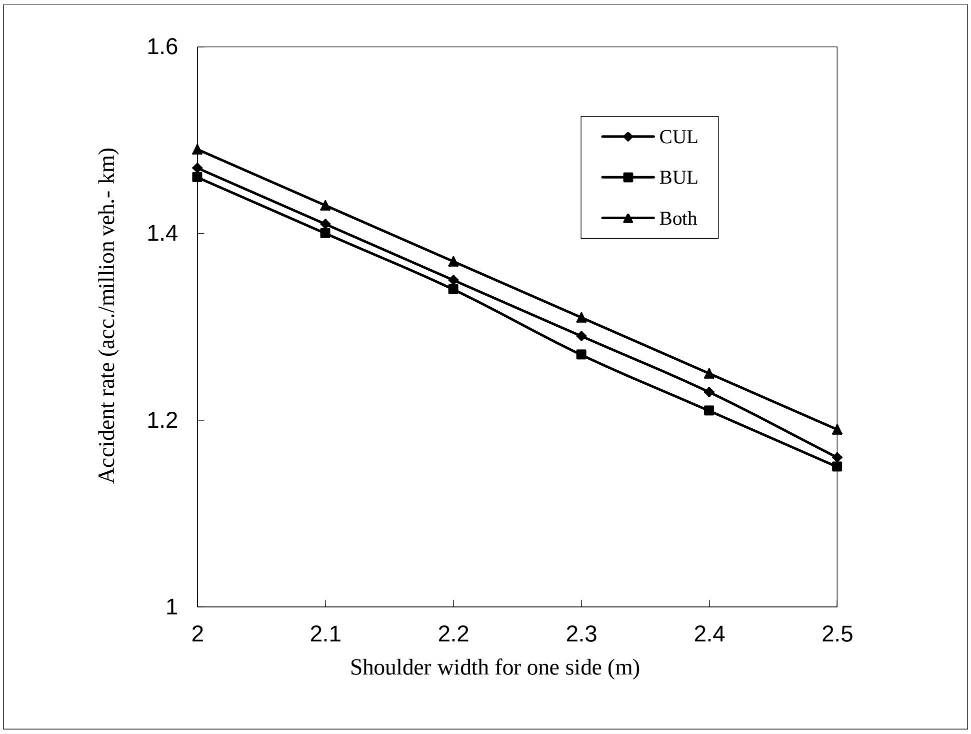

Figure (4): Relationship between Shoulder Width and Accidents Rate for Undivided Highways

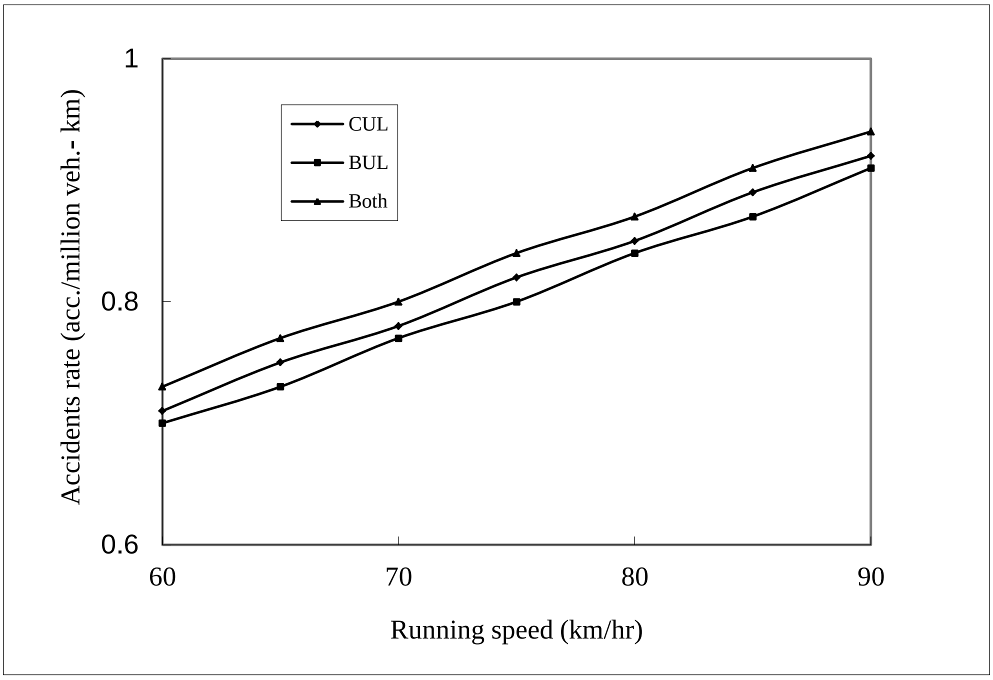

Figure (5): Relationship between Running Speed and Accidents Rate for Undivided Highways

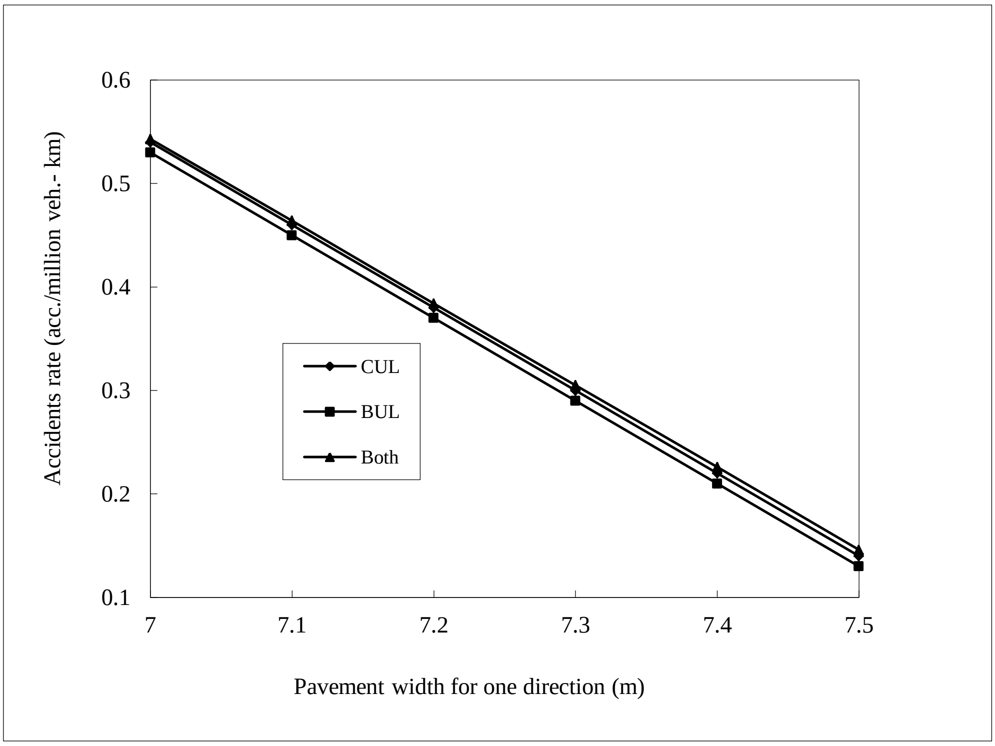

Figure (6): Relationship between Pavement Width and Accidents Rate for Divided Highways

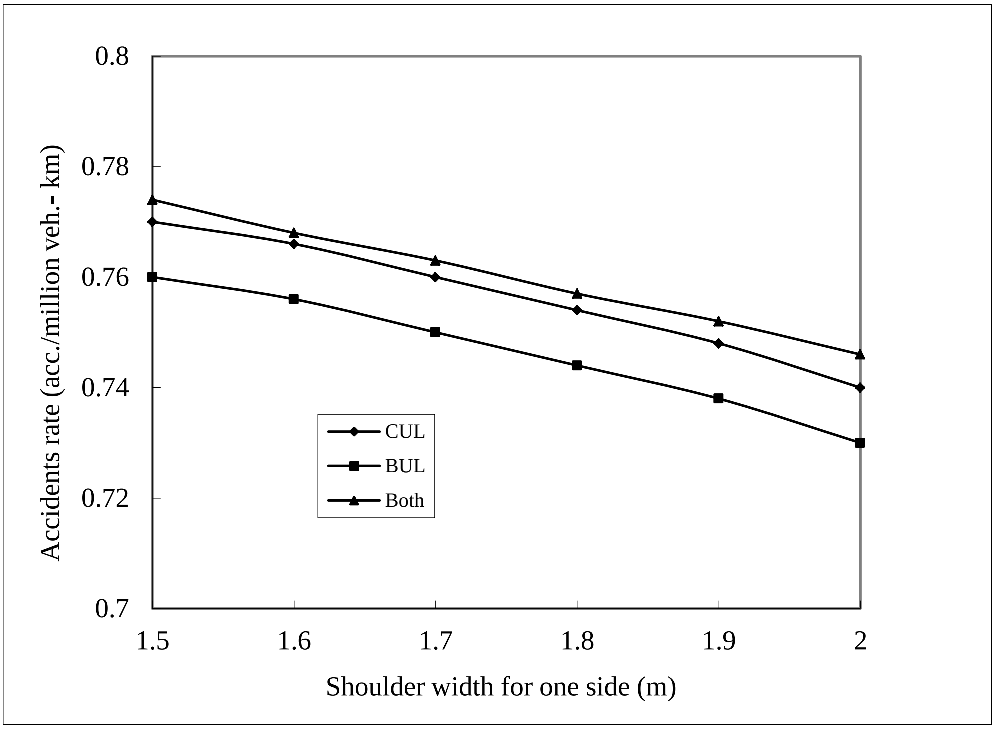

Figure (7): Relationship between Shoulder Width and Accidents Rate for Divided Highways

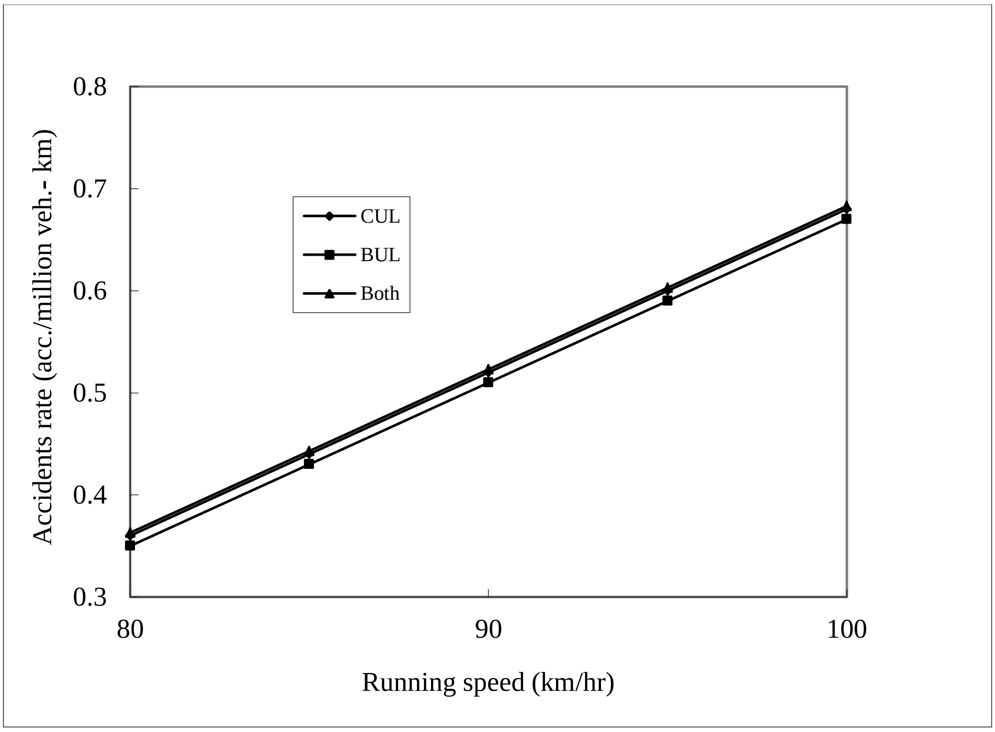

Figure (8): Relationship between Running Speed and Accidents Rate for Divided Highways