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Hassan Ahmed
Highway Eny., Civil Eng. Dept. Assuit Univ., youness1955@yahoo.com

Ayman Othman
Highway Eng, Civil Eng. Dept. South Valley Univ

Amr Wahaballa
Civil Eng. Dept.., South Valley Univ.

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Traffic Accident Analysis & Modelling for Upper Egypt Rural Roads

تحليل ونمذجة حوادث المرور على الطرق الخلوية فى صعيد مصر

Hassan Y.Ahmed[1], Ayman M. Othman [2] and, Amr M. Wahaballa [3]

[1]Assoc. Prof of Highway Eng., Civil Eng. Dept. Assuit Univ.
[2]Lecturer of Highway Eng , Civil Eng. Dept.., South Valley Univ.
[3]Demonestrator , Civil Eng. Dept.., South Valley Univ.

الملخص العربى

تعتبر حوادث المرور على الطرق من أخطر المشكلات التي توثر على تنمية المجتمع لما تسببه من خسائر إقتصادية وإجتماعية كبيرة مما يتطلب ضرورة تحسين أمان المرور على الطرق الى أعلى مستوى ممكن بهدف الحد من هذه المشكلة. ومن هذا المنطلق فان الهدف الرئيسى من هذا البحث هو نمذجة حوادث المرور على الطرق الخلوية بصعيد مصر لإستنتاج نماذج رياضية تربط بين معدل الحوادث و العوامل المختلفة التي تتسبب في هذه الحوادث ثم يتم دراسة هذه العوامل من أجل تقليل معدل الحوادث الى اقل مستوى ممكن.

و الطرق الخلوية بصعيد مصر التى تمت دراستها في هذا البحث لها بعض الخصائص منها الطول النسبى الامر الذى يؤثر على زمن السفر على إجهاد السائقين ، أيضا ما يعانيه سكان هذه المناطق من تدنى المستوى الإقتصادي وزيادة نسبة الأمية الأمر الذى إنعكس سلبا سلوك السائقين و على مدى صلاحية المركبات المستخدمة مما أثر على معدل الحوادث وقد تم استنتاج أن العامل البشرى و المتمثل ليس فقط فى سلوك السائقين ولكن أيضا فى سلوك المارة وكافة مستخدمى الطريق يصل إلى حوالى 81.4% ، والمركبات تتسبب فى حوالى 15% ، بينما عناصر الطريق تتسبب فى 2.2% ، والعوامل البيئية فى حوالى 1.8%.

وقد تم تصنيف موقع الحوادث على طول منطقة الدراسة حسب قيمة معدل الحوادث وتم تحديد النقاط السوداء على وصلات الطرق موضوع البحث ، وتم إستنباط نماذج رياضية تربط بين معدلات الحوادث مع كل عامل مسبب على حدة ، ثم مع العوامل مجتمعة وتم استنتاج العلاقات التبادلية ومدى الارتباط باستخدام التحليل البسيطSimple regression analysis والتحليل المتعدد الحدود Multiple regression analysis ، حيث تبين أن العلاقة الأسية تعد الأفضل لتمثيل الارتباط بين معدلات الحوادث و العوامل المؤثرة فية في حالة قطاعات الطرق المستقيمة والمنحنية المحاطة بأراضي زراعية اوسكنية. وأيضا و قطاعات الطرق المنحنية المحاطة باراضي صحراوية ، بينما تكون العلاقة الخطية الأفضل في حالة قطاعات الطرق المستقيمة المحاطة بأراضي صحراوية. كما ثبت أيضا أن معدل الحوادث يتناسب عكسيا مع عرض الطبان ، وطرديا مع نسبة الشاحنات وعدد المداخل الفرعية إلى الطريق.

ABSTRACT :-

In this research, analysis and modelling of accident records collected on Upper Egypt rural roads was performed. Accidents models are calibrated using the application of MATLAB computer program Version (6.1). The models are calibrated using accidents records collected during the study of "Safety and Protection of Public Transport on The Rural Roads in Egypt" that was provided by the "Development research and Technological Planning Center" (DRTPC). Four different types of road sections, namely: "straight road section in both residential areas and unoccupied areas", "curved road section in both or residential areas and unoccupied areas" were considered within this research. Simple, Stepwise, and multiple regression analysis have been used to find the effect of each parameter on the accident rate value. Correlation values for different mathematical formulations; linear, logarithmic, power, and exponential regression models were examined. Multiple regression analysis has shown that power model represents the highest correlation for straight and curved road sections in residential areas. While, the linear model presents the highest correlation for straight road section and curved section in unoccupied areas. In general, the results indicated that accident rate is inversely correlated to shoulder width and is proportionally correlated to number of entrances to the road, and percentage of trucks.

Key words: traffic accidents, accidents rate, human factors, road factors, environmental factors.

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1- INTRODUCTION

Traffic accidents are among the major and most dangerous problems all over the world, which cause loss of life, health damage of properties, and psychological effect on victims and their families. Rural road accidents cost the Egyptian economy about 700 million L.E as estimated for the financial year 2001 [1]. Decision makers and highway officials need accurate information about the relationships between accidents and its causes. Therefore, researches all over the world study traffic accidents to demonstrate their causes and reduce their harmful effects.

Developing accident models can help in predicting accidents effectively and allow decision makers to provide road safety measures. Most statistical technique used in accident modeling is the multiple linear regression models that give simple models which present the correlation between accident rates and the factors affecting it. Yousry [2] studied the effect of geometric design and traffic characteristics on highway safety on Cairo-Alexandria agricultural road. Yousry developed linear regression model using simple regression analysis to determine the correlation between the selected factors and the equivalent property damage-only rate. It was concluded that as the traffic volume per lane increases, the equivalent property damage-only rate increases. It was also concluded that the rate of accidents increases when the surrounding land use changes from cultivated area to built-up area land use.

Lee et al, [3] developed a model to describe the nature of the relationship between selected precursors and frequency of crashes adjusted by the appropriate level of exposure. They use three precursors. These precursors were used namely: the average variation of speed on each lane, the traffic density in (veh./ km) and the average speed difference between upstream and downstream ends of road section measured in (km/hr). A direct comparison of different roads with respect to the absolute number of accidents must give wrong results because of the wide verity of roads sections which having different lengths, horizontal and vertical alignments and differing in the traffic volume and its composition as number of trucks and buses[4]. Therefore, to compare between different roads sections accident rate measure is used. The main factors that are mainly responsible for traffic accidents are human factors, vehicular factors, roadway factors, and environmental factors. Babkov, [5] stated that an analysis of data for a number of countries showed that a width of a two-lane road way of 7.5 meter and with provision of surfaced shoulders is substantiated from the view point of traffic safety. Babkov concluded that the accident rate increases as the width of the roadway decreases. Zegeer c., R. Stewart, F. Council [6] concluded that for roadways having volumes less than 2000 vehicles per day (VPD), a lane width of 3.1 meters (10 ft.) and shoulder width of at least 1.5 meters (5 ft) provide significant reduction in crashes. The insufficient width of shoulders causes an increase in the number of accidents [7, 8].

Proper design of horizontal curves is a very important factor in enhancing traffic safety. Statistics have consistently shown that both the risk of collision and collision rates are much higher on curved section than on straight segment [9]. Abou El-Naga [10] stated that in rural areas, accidents tend to cluster on bends and accidents have generally been shown to increase in frequency with degree of horizontal curvature. Zegeer, et al [11] stated that fixed objects (trees, lighting poles, guard-rails, signs, and structures) obstructing road visibility increase the probability of accidents occurrence. Trees and lighting poles are considered road side fixed obstacles. But, lighting poles are the obstacles most frequently struck on road ways with higher volumes. Yousry [2] stated that the existence of entrances on the road increases the number of conflict points. This increases the possibility of accident occurrence. He also concluded that the increase of the percentage of trucks and buses the probability of accident occurrence increases. The environmental factors have no significant impact on the accident rate, its not surprised that about 94% of fatal accident occurred during dry weather and dry surface conditions [8]. In this research, an effort was made to model highway traffic accidents for Upper Egypt rural roads. The studied roads were divided into four different types based on their geometric design characteristics and properties of surrounding areas. The four studied road types include: straight and curved sections in both residential and unoccupied areas.

2 . METHODOLOGY

2.1 Vehicle Exposure and Accident Rate (AR)

Vehicle exposure as shown in Equation (1), is defined as the number of times vehicles are exposed or open to the paths of others [7].

$$Exposure = \frac{AADT \times 365 \times N \times L}{1000{,}000} \qquad (1)$$

Where:

AADT = Annual average daily traffic
N = Number of years considered
L = Section length in kilometers.

Accident rates are defined as given in Equation (2) as the accident number divided by the vehicle exposure. The accident rate is expressed as accident per million vehicles kilometers for road section [12].

$$\text{Accident (AR)} = \frac{\text{Number of accidents}}{\text{Exposure}} \qquad (2)$$

Using Equations (1) and (2) , Accident rate would be defined as;

$$\text{Accident rate (AR)} = \frac{\text{Number of accidents} \times 10^6}{\text{AADT} \times 365 \times N \times L} \quad \ldots (3)$$

2.2 Simple Regression Analysis

The correlation between average accident rates at all accident locations and each of the studied parameters is investigated using different mathematical forms; linear, logarithmic, power, and exponential regression models, to find the most significant relationship correlating the average accident rate and the considered parameter. Models (4, 5, 6, and 7) are suggested as a linear, logarithmic, power, and exponential simple regression models respectively.

$$Y = B_0 + B_1 * X \quad (4)$$

$$Y = B_0 + B_1 * Ln\,X \quad (5)$$

$$Y = B_0\, X^{B_1} \quad (6)$$

$$Y = B_0 * e^{B_1 * X} \quad (7)$$

Where:

Y is the average accident rate

X is the studied parameter (pavement width, earth shoulder width, number of entrances…etc)

Bis are the coefficients to be estimated by the model.

2.3 Stepwise Regression Analysis

Stepwise regression analysis consider a few important parameters out of a large set of parameters to construct a multiple regression function [13].

2.4 Multiple Regression Models

Many of parameters contribute together to cause accidents, therefore simple regression analysis may give improper results. The combined effect of these parameters on accident rates must be taken into consideration.

Equations (8, 9, 10 and, 11) show the formulas of linear, logarithmic, power, and exponential multiple regression models respectively.

$$Y = B_0 + B_1 * X_1 + B_2 * X_2 + \cdots\cdots + B_i * X_i \quad (8)$$

$$Y = B_0 + B_1 * Ln X_1 + B_2 * Ln X_2 + \cdots\cdots + B_i * Ln X_i \quad (9)$$

$$Y = B_0 + X_1^{B_1} + X_2^{B_2} + \cdots\cdots + X_i^{B_i} \quad (10)$$

$$Y = e^{B_0 + B_1 * X_1 + B_2 * X_2 + \ldots\ldots + B_i * X_i} \quad (11)$$

Where:

Y is the average accident rate

X_{is} are the studied parameters (pavement width, earth shoulder width, number of entrances…etc)

Bis are the coefficients to be estimated by the model.

The previous steps are carried out using the computer program (Matlab 6.1) for linear, logarithmic, power, and exponential multiple regression models

3 . DATA COLLECTION AND SPLITTING

3.1 Characteristics of Study Area

Recently a considerable effort is placed towards improving and developing upper Egypt. Based on that, this research focus on modeling traffic accident in upper Egypt rural roads. The selected roads for accident modeling are Aswan-Koum Ombo (AKO) with length about 45 km. and Koum Ombo - Edfu (KOE) road with length 50 km. both have pavement width about 10 meters. The studied area has selected for its unique characteristics which includes

- Geographic location: Due to its unique geographic location, upper Egypt rural roads are relatively long which increase vehicles trip length and this in turn can have a remarkable effect on accidents occurrence.
- Environmental Conditions: The extremely hot weather in upper Egypt can increase the probability of tire burst which can have a great effect on the accidents occurrence. The hot weather also can have an affect on the driver habits and concentration.
- Cultural Characteristics: The percent of education is relatively low in upper Egypt areas. It is believed that this can have a considerable effect on the driver behavior and obeying the traffic low.
- Economical Conditions: The standard of living is relatively low in upper Egypt which is reflected on the physical condition of the driver as well as the general condition of the vehicles.

3.2 Source of Data

Accident data used in this studying were obtained from recorded data in the "Egyptian General Authority for Roads, Bridges, and Land Transport. (GARBLT)" the study of "Safety and Protection of Public Transport on The Rural Roads in Egypt" that was provided by the "Development research and Technological Planning Center" (DRTPC) [14]. Accidents were classified and ranked according to its types (Fatal , injures, and probably damage), location, traffic characteristics (% of trucks), roadway geometric, shoulder condition, and the condition of surrounding land use.

Second type of data were collected within field surveying [15]. To classify the recorded accident data , its location must be characterized. So, effort has been done in field surveying to collect the effective road characteristics, traffic operational conditions and, environmental conditions at the locations of the accident. The special field survey form is designed as shown in Table (1).

Table (1)

Field Survey Collecting Data Form

Road name ..... From Km ..... To Km .....

	Factor	Value or description	
1	Pavement width		
2	Earth shoulder width	R	
		L	
3	Number of entrances to the road	R	
		L	
4	Road curvature	Straight	
		Curved	
5	Surrounding land	Residential	
		Agricultural	
		Unoccupied	
6	Pedestrian or animal at-grade crossing	Existing	
		Not existing	
7	Lighting	Good	
		Bad	
		Not existing	
8	Percentage of trucks and buses		

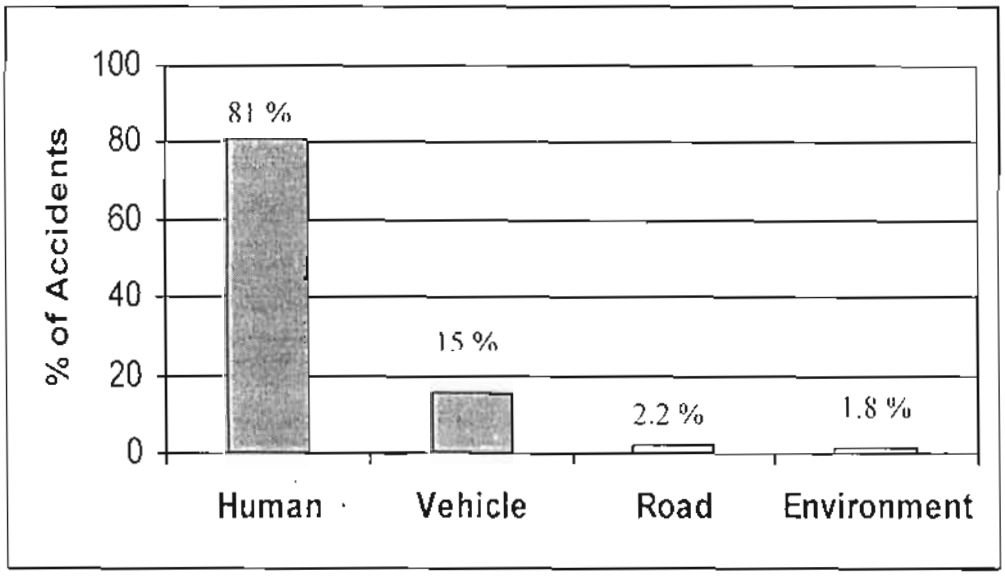

Fig. (1): Percentages of Accidents Causing Factors on the Upper Egypt Rural Roads

4. ANALYSIS OF ACCIDENTS DATA

To find the highly affected factors lead to the occurrence of traffic accidents, all probable factors should be considered and analyzed. Roadway characteristics traffic compositions, environmental conditions in addition to human factors must be considered.

4.1 Analysis According to Accident Causes

The occurrence of accident results from complex integration among a driver , vehicle roadway, and environment. Accident data analysis shows that the most affected factor in accident occurrence is human factor, which involved in about 81% of all accidents occurred on the selected roads. In Upper Egypt rural roads; vehicle , roadway, and environment were responsible of accident occurrence by the percentages of 15 %, 2.2 %, and 1.8 % respectively. Fig. (1) shows the percentages of involving these factors in accidents occurrence to the total number of accidents occurred on upper Egypt rural roads.

4.1.1 Human Factors

Accident data analysis shows that the main factor of accident occurrence is human factor which is responsible of 81% of accidents. This finding agrees to a great extent with previous study made by Hassan [16]. Human factors include drivers and pedestrians behavior. Accidents data analysis indicates that at grade crossing of pedestrians and animals increase accidents probability. About 62.5% to 65 % of all accidents occurred in sections have 'pedestrian' and animal crossing. Where analyzed data shows that about 57% to 62% of all accidents occurred were due to over speeding. Also accidents data analysis shows that about 8 % to 24 % of all accidents occurred in study area were wrong overtaking that may be

because driver needs an additional width for overtaking. Wider lanes, and shoulder width provide space for overtaking. So, the behavior of the drivers in controlling his speed and overtaking the front vehicle carefully have good impact in reducing (AR).

4.1.2 Vehicle Factor

The second highly affected factor in accident occurrence after human factor is vehicular factors, which represent about 15 % of all accidents occurred on the selected roads. Vehicle types and tires condition have the main considerable factors in accidence occurrences. In this study analysis shows that trucks present about 36 % of all vehicles involved in accidents occurred on the selected roads, 48 % of which are fatal accidents. This due to the relatively large size and heavy loads of these vehicles which reduces the level of service on the road and restricts the freedom of drivers for maneuvering. Also tire burst has considerable factors in accidents .In the studied areas, about 9% to 18 % of all accidents occurred were due to worn-out tire.

4.1.3 Roadway Factors

In spite of roadway factors have only about 2.2% in responsibility of accidents within this study, one would reveal most of human factors to road conditions. Narrow roads, poor alignment, poor maintenance of pavement, objects beside road, non-functional signals and signs, patches, insufficient sight distance, and poor lighting were the most important deficiency of road characteristics causes accidents. The analysis indicated that the increasing in pavement width, and earth shoulder width decreases accident rate. Wide pavement, and shoulder provides; a space for overtaking, allow moving vehicles to pass vehicles in the traffic lane and stopped vehicles, and recovery distance, which decrease roadside hazard. On the other hand, as number of entrances to the road increase accident rate (AR) increases. This due to the increase of conflict points between the main road and feeder roads which increase accident probability.

4.1.4 Environmental Factors.

Environmental conditions shared about 1.8 % of all accidents occurred in the selected roads. Land Surrounding the road may be residential, agricultural, industrial areas, desert, etc. Surrounding land affecting accident rates where it describing the existence of any entrances to the road and pedestrian or animal crossing it.

5- DEVELOPING OF ACCIDENTS MODELS.

Accidents models developed and calibrated using the application of Excel and Matlab (Version 6.1) computer programs. The models are used for four different road sections, 1- straight road section in agricultural or residential areas, 2- straight road section in unoccupied areas, 3- curved road section in agricultural or residential areas, and 4- curved road section in unoccupied areas.

The selected roads for accident modeling are Aswan-Kom Ombo (AKO) with length about 45 km. and Kom Ombo - Edfu (KOE) road with length 50 km. both have pavement width about 10 meters Simple regression analysis of linear, logarithmic, power, and exponential regression models for the four road sections are examined. Table (2) through Table (5) shows the results of simple regression analysis where, linear, logarithmic, power, and exponential regression models for each group of accident data is analyzed using Excel computer program.

Stepwise regression analysis was also, carried out to develop multiple regression models. The resulted multiple regression models are given in Table (6).

6. ANALYSIS AND DISCUTION

Multiple regression analysis represents the best fit for the correlation between accident rate and affecting factors on straight road section in "agricultural or residential" areas. The model given in equation (12)

shows the best correlation, where the square of the correlation factor ($R^2 = 0.874$).

$$AR = 0.12 + SW^{-2.42} + e^{0.24NE} + TR^{2.061} \quad \ldots(12)$$

In case of straight road section in unoccupied areas. The model given in equation (13) shows that correlation where the square of the correlation factor ($R^2 = 0.873$).

$$AR = 0.84 - 0.08SW + 0.003NE + 2.12TR \quad \ldots(13)$$

For curved road section in "agricultural or residential" areas, power model gives the best correlation.. The model given in equation (14) shows that correlation where the square of the correlation factors $R^2 = 0.873$

$$AR = 1.16 + SW^{-10.23} + e^{0.04\,NE} + TR^{1.01} \quad \ldots(14)$$

The model given in equation shows that correlation between AR and affecting factors for curved road section in "unoccupied areas" exponential model was considered where the square of correlation factor $R^2 = 0.824$.

$$AR = 0.14 + SW^{-5.95} + e^{0.09NE} \quad \ldots(15)$$

The finding models show that accident rate is inversely correlated to earth shoulder width. As the width of earth shoulder increases the accident rate (AR) decreases. This because earth shoulder width provides an area for errant vehicles and allows a certain amount of flexibility. Accident rate is proportionally correlated to number of entrances to the road, and percentage of trucks. Its found that as number of entrances to the road increases the accident rate increase. That is because of increasing of conflict points between the main and secondary traffic flow. Also, the accident rate increases as the percentage of trucks increase .This is attributed to the relatively large size, and heavy loads of these vehicles which reduces the level of service on the road.

7 - Model Validity

The developed models give estimation for average accident rate. These values are compared with the actual values of the same segments at the same time intervals. Figs. (2,3,4, and 5) present the actual average accident rates which drawn versus the theoretical average accident rates developed on the same chart for "straight road section in agricultural or residential areas", "straight road section in unoccupied areas", "curved road section in agricultural or residential areas", and "curved road section in unoccupied areas".

Table (2) : Simple Regression Analysis Models for "straight road section in agricultural or residential areas"

Model type	Model	R^2	Model type	Model	R^2
Linear	$AR = 3.55 - 1.02 * SW$	0.26	Exponential	$AR = 4.08 * e^{-0.52\,SW}$	0.31
	$AR = 1.66 + 0.4 * NE$	0.45		$AR = 1.6 * e^{0.17\,NE}$	0.36
	$AR = 9.65 * TR$	0.37		$AR = 0.45 * e^{4.87\,TR}$	0.43
Logarithmic	$AR = 2.52 - 1.4 * Ln\ SW$	0.27	Power	$AR = 2.41 * SW^{-0.71}$	0.32
	$AR = 5.32 + 2.63 * Ln\ TR$	0.37		$AR = 10.06 * TR^{1.34}$	0.44

Table (3): Simple Regression Analysis Models for "straight road section in unoccupied areas"

Model type	Model	R^2	Model type	Model	R^2
Linear	$AR = 1.83 - 0.29 * SW$	0.3	Exponential	$AR = 1.92 * e^{-0.22\,SW}$	0.3
	$AR = 1.34 + 0.04 * NE$	0.31		$AR = 1.33 * e^{0.03\,NE}$	0.31
	$AR = 0.66 + 2.38 * TR$	0.86		$AR = 0.8 * e^{1.77\,TR}$	0.86
Logarithmic	$AR = 1.55 - 0.38 * Ln\ SW$	0.28	Power	$AR = 1.55 * PW^{-0.28}$	0.84
	$AR = 2.19 + 0.67 * Ln\ TR$	0.84		$AR = 2.51 * TR^{0.5}$	0.28

Table (4): Simple Regression Analysis Models for "curved road section in agricultural or residential areas"

Model type	Model	R^2	Model type	Model	R^2
Linear	$AR = 2.76 - 0.66 * SW$	0.36	Exponential	$AR = 2.83 * e^{-0.34\,SW}$	0.37
	$AR = 1.46 + 0.12 * NE$	0.22		$AR = 1.38 * e^{0.11\,NE}$	0.43
	$AR = 1.02 + 2.8 * TR$	0.11		$AR = 1.2 * e^{1.31\,TR}$	0.09
Logarithmic	$AR = 2.17 - 1.12 * Ln\ SW$	0.43	Power	$AR = 2.08 * SW^{-0.58}$	0.43
	$AR = 2.74 + 0.71 * Ln\ TR$	0.09		$AR = 2.67 * TR^{0.34}$	0.08

Table (5): Simple Regression Analysis Models for "curved road section in unoccupied areas"

Model type	Model	R^2	Model type	Model	R^2
Linear	$AR = 2.59 - 0.79 * SW$	0.41	Exponential	$AR = 2.9 * e^{-0.5\,SW}$	0.45
	$AR = 1.26 + 0.19 * NE$	0.61		$AR = 1.27 * e^{0.11\,NE}$	0.53
	$AR = 1.23 + 0.89 * TR$	0.007		$AR = 1.11 * e^{0.99\,TR}$	0.03
Logarithmic	$AR = 1.9 - 1.29 * Ln\ SW$	0.47	Power	$AR = 1.87 * SW^{-0.81}$	0.51
	$AR = 1.77 + 0.23 * Ln\ TR$	0.007		$AR = 2.03 * TR^{-0.25}$	0.03

Table (6 : The developed models and the best selected model for different road sections.

Case	Model	R^2
Straight section in agricultural or residential areas	$AR = 2.8 - 1.06SW + 0.38NE + 1.72\ TR$	0.766
	$AR = 2 - 1.54\ Ln\ SW + e^{0.23NE} + 0.57\ Ln\ TR$	0.851
	$AR = 0.12 + SW^{-2.42} + e^{0.24\ NE} + TR^{20.61}$	0.874*
	$AR = e^{1.0 - 0.59\ SW + 0.17\ NE + 1.3TR}$	0.814
Straight section in unoccupied areas	$AR = 0.84 - 0.08SW + 0.003NE + 2.12\ TR$	0.873
	$AR = 1.12 - 0.11 * Ln\ SW + e^{0.005\ NE} + 0.58 * Ln\ TR$	0.859
	$AR = 0.102 + SW^{-0.2} + 0.02 * NE + TR^{0.75}$	0.809
	$AR = e^{-0.13 - 0.04\ PW + 0.002\ NE + 1.63TR}$	0.869
Curved section in agricultural or residential areas	$AR = 2.16 - 0.47SW + 0.17NE$	0.636
	$AR = 0.72 - 0.76 * Ln\ SW + e^{0.13\ NE}$	0.705
	$AR = 1.16 + SW^{-10.23} + e^{0.04\ NE} + TR^{1.01}$	0.863
	$AR = e^{0.83 - 0.33\ SW + 0.09\ NE}$	0.737
Curved section in unoccupied areas	$AR = 1.84 - 0.37\ SW + 0.15NE$	0.673
	$AR = 1.38 - 0.26 * Ln\ SW + e^{0.14\ NE} + 0.68 * Ln\ TR$	0.761
	$AR = 0.14 + SW^{-5.95} + e^{0.09NE}$	0.824
	$AR = e^{-0.01 - 0.14\ SW + 0.12\ NE + 1.98\ TR}$	0.758

8 . SUMMARY AND CONCLUSIONS

The main goal of this research is to analyze and model accident on Upper Egypt rural roads. Accident data is analyzed to determine the main factors affecting accidents that used for developing models for straight and curved road sections and surrounded by agricultural or residential areas or desert abutting road section. The models are developed using simple regression, stepwise regression, and multiple regression analyses using linear, logarithmic, power, and exponential models to select the best models that have the highest coefficient of determination (R^2).

The main findings from the analysis of accident data are summarized in the following items:

1- Human factors are responsible of 81 % of all accidents occurred on the selected roads for this study.

2- Random crossing of pedestrians and animal increases the accidents probability (65% of accidents occurred in pedestrians and animal crossing area).

3- Speed limit violation represents 41 % of all accidents occurred,

4- Tire burst is the main cause of accidents in about 11 % of all accidents occurred in these roads.

5- Multiple regression analysis showed that power model represents the highest correlation between accident rate and factors affecting it.

6- Percentage of trucks in the traffic volume increases accident rate. It is recommended that percentage of trucks should be reduced this can be provided by using alternative roads to accommodate heavy traffic vehicle

7- Accident rate is proportionally related to number of entrances to the road, and percentage of trucks. Accident rate increases as number of entrances to the road increase due to the increase of conflict points between the main and secondary flow.

8- The result of regression analysis show that accident rate is inversely related to earth shoulder width. This is increase earth shoulder width provides an area for errant vehicles and allows certain amount of flexibility.

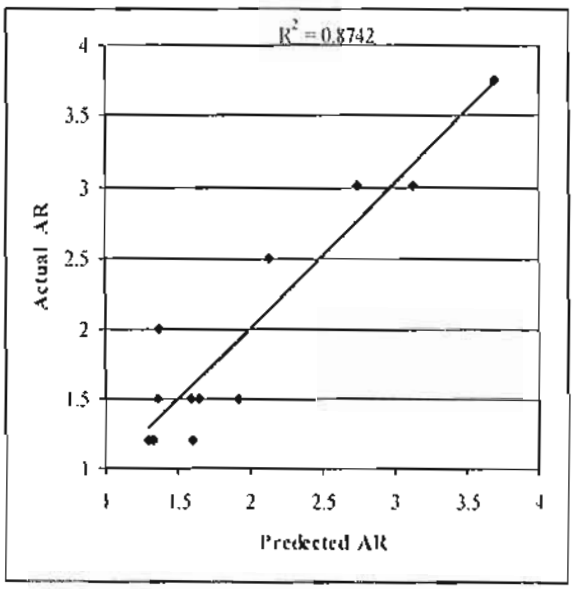

Fig. (2) Actual Accident Rates versus Predicted Accident Rates in "Straight Road Section in Agricultural or Residential Areas"

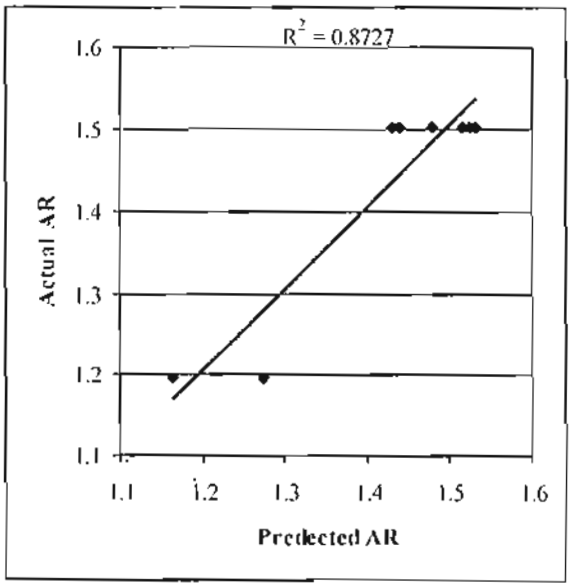

Fig. (3) Actual Accident Rates versus Predicted Accident Rates in "Straight Road Section in Unoccupied Areas"

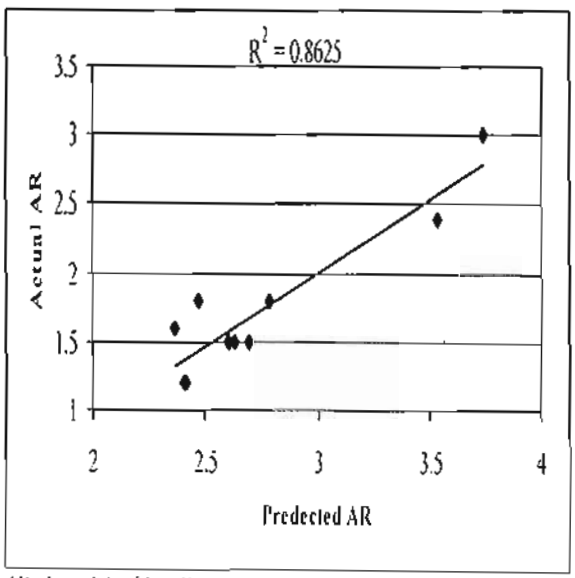

Fig. (4). Actual Accident Rates versus Predicted Accident Rates in "Curved Road Section in Agricultural or Residential Areas"

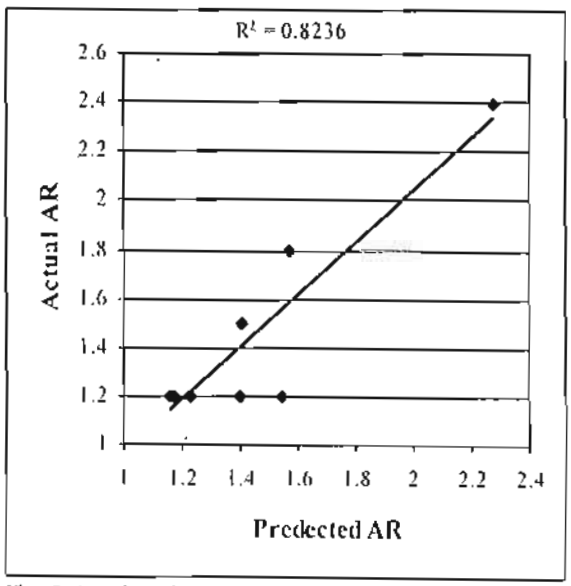

Fig. (5) Actual accident rates versus predicted accident rates in "curved road section in unoccupied areas"

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