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EVALUATION OF THE IMPACT OF THE ROAD CHARACTERISTICS ON TRAFFIC SAFETY[1]

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Abstract

In order to manage safety on the roads, road authorities must have good insight in to the level of traffic safety, in to the variables that explain traffic safety, as well as in to the anticipated effects of the planned improvement measures on the traffic safety. Also, analysis of the effects of design solutions on road safety is crucial in preparation of road designs. Having this in mind, the aim of this paper is to determine the impact of road and traffic characteristics on the level of traffic safety. A method of regression analysis is used to determine the relationship between the number of accidents and the road and traffic characteristics. Field research are carried out to collect road geometry and traffic data. The results of this paper could be used by road designers, planners, decision makers and other experts involved in traffic safety.

Keywords-Traffic accidents;traffic safety;road characteristics

INTRODUCTION

Road safety modelling has attracted considerable research interest in the past four decades because of its wide variety of applications and important practical implications. Public agencies, such as State Departments of Transportation, may be interested in identifying accident-prone areas to promote safety treatments. Transportation engineers may be interested in identifying those factors that influence accident frequency and severity to improve roadway design and provide a safer driving environment. The very high cost of highway accidents paid by societies around the world makes

[1] Professional paper

highway safety improvement an important objective of transportation engineering. An overwhelming majority of previous studies have indicated that improvements to highway design could produce significant reductions in the number of crashes[1]. Therefore, in the development of feasibility studies it is necessary to properly determine the impact of road and traffic characteristics on traffic safety of a specific design solution.

Kalakota&Senevirathe[2]developed accident prediction models for two-lane roads in northern Utah. In this paper the following variables were selected as independent variables: section length, the degree of curvature, shoulder width on the right side of the road, gradient and some combinations of these variables.Vogt & Bared [3]investigated the dependence of the number of traffic accidents on various geometric and functional characteristics of two-lane rural roads. This paper examined the influence of the following variables: AADT[2], section length, lane width, shoulder width, bendiness of horizontal curvature, curvature of the vertical convex curve, gradient, roadside hazard rating, driveway density, speed limit and the share of commercial vehicles in total traffic flow.Fitzpatrick et al. [4]developed accident prediction models for two-lane rural roads in Texas. In this paper the influence of the following variables was examined: lane width, shoulder width, section length and AADT. Cafiso et al. [5]conducted a survey on two-lane rural roads, which are located in Italy. This paper examined the influence of the following variables: bendiness, tangent length, cross-section elements, access density and roadside hazard rating. Turner et al. [6]developed accident prediction models for two-lane rural roads in New Zealand. The developed models represented the quantified mathematical relationship between traffic accidents and traffic volumes, road geometry, cross-section, road surfacing, roadside hazards and driveway density.

The aim of this paper was to determine the individual impact of independent variables (horizontal curve radius, carriageway width, longitudinal grade, roadside hazard rating, the share of no passing zones, the density of access points and speed) on the dependent variable (the number of accidents per kilometer per year).

METHODOLOGY

In order to examine the impact of road characteristics on traffic accidents it was necessary to collect the data on traffic accidents and road geometry. The data on traffic accidents were obtained from the database formed by Road Traffic Safety Agency and the data on road geometry were taken from

[2]AADT – Annual average daily traffic

the database of the Public Enterprise “Roads of Serbia”. The sample consisted of the sections of two lane rural roads in Serbia.

A statistical modeling approach is used here to investigate the relationship between traffic accident and various possible influencing factors. The following steps were followed in the development of regresion models, including:

- Data integration: data from the different sources were obtained and integrated sections as the common reference.
- Exploratory data analysis and development of Regression models.

In order to determine the individual impact of independent variables (horizontal curve radius, carriageway width and longitudinal grade on the dependent variables (the number of accidents per kilometer per year and the number of injury traffic accidents per kilometer per year) a univariate regression analysis was conducted using Table Curve 2D software v5.01. The models of various forms were defined by this analysis, and then those models that were statistically best fitted were selected.

RESULTS AND DISCUSION

The impact of the horizontal curve radius on the number of traffic accidents

Results of regression analysis showed that the increase of the horizontal curve radius (R) reduces the number of traffic accidents per kilometer per year (Fig. 1). For radius up to 100 (200 m) is recorded sharp decline in the number of traffic accidents. For engineering application the following model is proposed:

$$N = 1.608 + 937.281 ln\, R/R^2$$

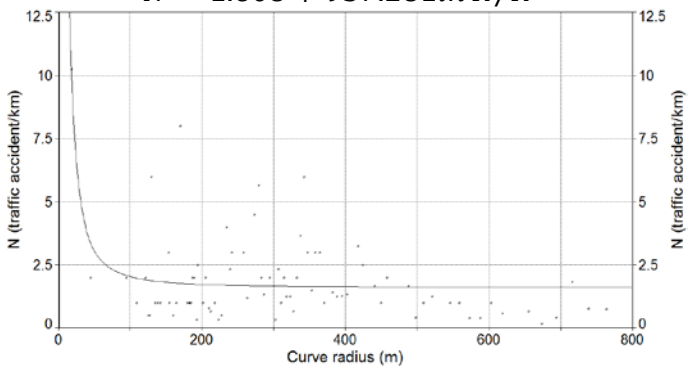

Fig. 1.The model of the dependence of the total number of accidents on the horizontal curve radius

Several studies concluded that the rate of traffic accidents fell with the rise of the radius of horizontal curve until the size of the radius became approximately 400m to 500m. The decrease of traffic accident rate was not recorded for the radii larger than 500m[7][8]. So, the results of this research are in accordance with the former research.

The impact of the longitudinal gradient on the number of traffic accidents

Regression analysis showed that the increase of longitudinal gradient reduces the number of accidents per kilometer per year (Fig. 2). However, the resulting model explains only 7% of the variability of the dependent variable. The equation of the model is of the form:

$$N = -4.4333 + 18.052 \times ln\, G/G$$

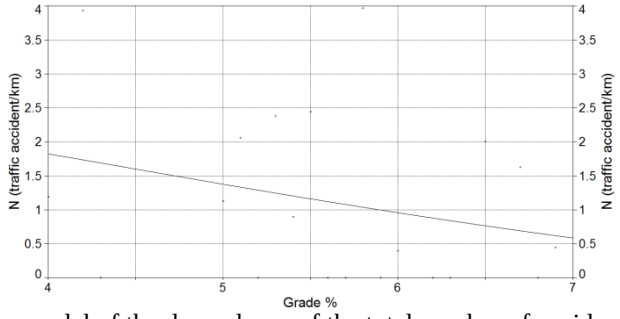

Fig. 2.The model of the dependence of the total number of accidents on the gradient

The number of traffic accidents rises with the increase of gradient, at the rate of 1.6% at each percentage of gradient increase[9]. However, Mayora et al. [10]found out that the rate of injury traffic accidents decreased with the increase of gradient and this result is in accordance with result of our research.

The impact of the carriageway width on the number of traffic accidents

Regression analysis showed that the increase of the roadway width reduces the number of accidents per kilometer per year (Fig. 3). The resulting (obtained) model, which had the best fit, explaining 97.2% of the variability of the dependent variable. The equation of the model is of the form:

$$N = 3.002 - 0.0007 \times e^{CW}$$

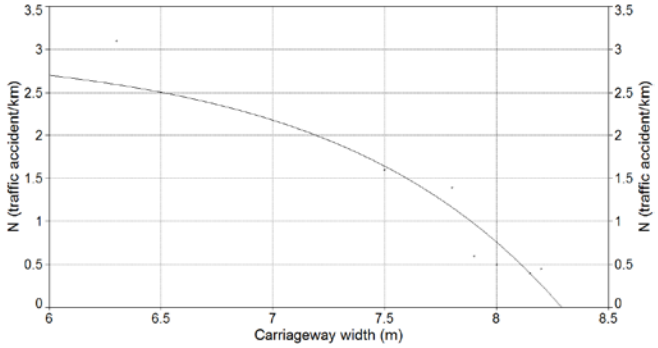

Fig. 3. The model of the dependence of the number of accidents on the carriageway width

Increasing the width of a traffic lane on two-lane rural roads decreases the number of traffic accidents [4][7]. Keeping this in mind it can be concluded that the results of this research are in accordance with the foreign researches.

The impact of the roadside hazard rating on the number of traffic accidents

The roadside hazardis ranked on the scale from 1 to 7, where 1 represents the best rating and 7 the worst rating. The results of this research have shown that the number of traffic accidents is bigger when the rating of roadside hazard is higher, i.e. the larger number of traffic accidents occurs at the sections with poorer roadside characteristics (Fig. 4). The following model was the best:

$$N = 3.829 + (-16.394) lnRHR/RHR^2$$

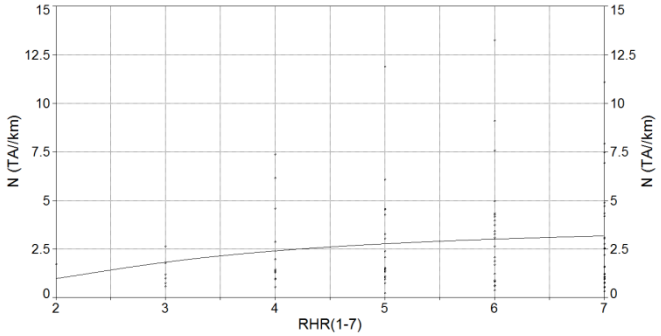

Fig. 4. The model of the dependence of the number of accidents on the roadside hazard rating

The impact of the share of no passing zones on the number of traffic accidents

This paper has determined that the rate of traffic accidents rises per kilometer annually with the increase of the share of no passing zones (PNP) (Fig. 5). The following model was the best fitted:

$$N = 0.563 + 0.004 * PNP * lnPNP$$

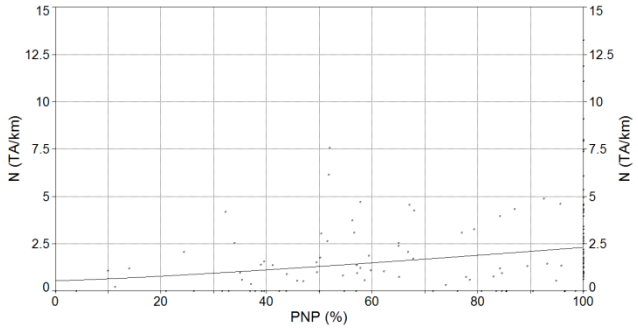

Fig. 5.The model of the dependence of the number of accidents on the PNP

Mayora et al. [10]determined that the variable signifying the share of no passing zones in the total section length statistically significantly correlates with the rate of traffic accidents. The results have shown that the rate of traffic accidents rises with the increase of the share of no passing zones, until the share of no passing zones reaches 20% of the section's length.

The impact of the density of access points on the number of traffic accidents

This research has shown that the increase of the density of access points leads to the rise of traffic accidents per kilometer annually. The obtained dependability is represented in Fig. 6. The following model was the best fitted:

$$N = 1.605 * e^{(-AP/-18.389)}$$

Mayora et al. [10]in their research have shown that the rates of traffic accidents are constant for the values of access points' density lower than 0.5 access points per kilometer and then they start increasing. The rise becomes abrupt for the densities of access points bigger than 1.5 access points/km.

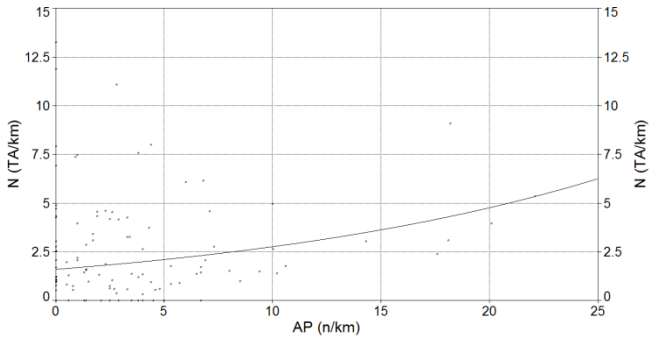

Fig. 9.The model of the dependence of the number of accidents on the access points

The impact of the operational speed on the number of traffic accidents

This research has shown that the increase of operational speed leads to the rise of traffic accidents per kilometer annually (Fig. 9). The following model was best fitted:

$$N = 4.253 + (-6758.932)/S^2$$

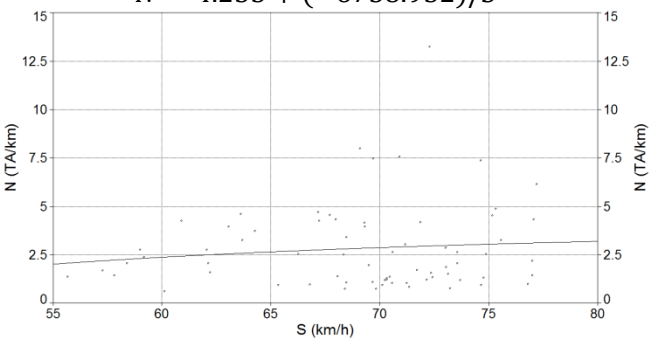

Fig. 9.The model of the dependence of the number of accidents on the speed

One of the most frequently used and well-regarded sources is Nilsson's 'Power Model', which illustrates that a 5% increase in average speed leads to approximately a 10% increase in all injury accidents and a 20% increase in fatal accidents.

CONCLUSION

Traffic accident prediction models, also known as the functions of traffic safety indicators, represent a direct method of analyzing the relationship between the traffic safety indicators and different characteristics of a road segment. Traffic planners and engineers can use a traffic accident prediction model as a tool for improving the safety of the existing roads and designing new safer roads. In order to manage traffic safety on roads, practitioners such as policy creators and the authorities competent for traffic jobs should have comprehensive insight into the level of their roads' safety, about the variables which define this level and about the expected effects of their plans about road safety, which is facilitated by the accident prediction models.

Therefore, there are numerous applications of traffic accident prediction models. The traffic accident prediction models developed in this paper can be used in road and traffic engineering in Serbia and in the region, primarily in cost benefit analyses, traffic analyses, traffic safety analyses, ecological analyses, multi-criteria analyses, etc.

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