TRANSPORT
2009
24(1): 42–47

THE IMPACT OF ROAD PARAMETERS AND THE SURROUNDING AREA ON TRAFFIC ACCIDENTS

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Received 22 May 2008; accepted 12 January 2009

Abstract. The article analyses the data on road traffic accidents in Lithuanian main and interurban road networks in the years 2002–2006. The road network is divided into 341 road sections. The surrounding area and road parameters of each of the sections are measured. Then, the dependence of traffic accident rate on the parameters is studied and described using linear and multiple regressions. The equations are built using 90% of the available data and tested forecasting traffic accident rate for the rest of 10% of the data comparing the obtained results with the real data.

Keywords: road, traffic accident, car, road, parameters, analysis, evaluation, regression equations, annual average daily traffic (AADT).

1. Introduction

Transport safety in Lithuania is a very important area of discussions. The country is among the leaders in Europe according to the number of people killed in car accidents (Table 1).

Table 1. The figures for the people killed in car accidents in Europe during the year 2004

Country	Number of dead per 1 000 000 citizens
Latvia	220
Lithuania	219
Poland	148
Greece	147
Hungary	131
Spain	130
Estonia	121
Austria	115
France	96
Ireland	85
Germany	80
Holland	63
UK	62
Sweden	59
Turkey	57

Traffic accidents could be analyzed from three different types of view:

a) micro view;
b) medium view;
c) macro view.

The micro view on accidents could analyze traffic reasons at the accident site, the medium view could look into car accidents in some specific roads or road sections and the macro view could investigate global reasons of road accidents at country level. This article analyzes road safety using the medium view. It is an attempt to evaluate the impact of a road section and the surrounding area parameters on the number of traffic accidents in a road section and to predict the quantity of traffic accidents considering the above mentioned parameters.

The impact of road parameters on traffic accidents is widely studied in 'before–after' road improvement analysis. More complex researches were performed by scientists Peltola (2006 and 2007). Calculation methods used for the accuracy evaluation of the results of road accident examination are analyzed by Nagurnas *et al*. (2008). Prentkovskis *et al*. (2007) investigated potential deformations developed by the elements of transport and pedestrian traffic restricting gates during motor vehicle–gate interaction. Kinderytė-Poškienė and Sokolovskij (2008) investigated the impact of traffic control elements on accidents, mobility and the environment. The research by Sokolovskij (2007) depicts the results of the investigation into automobile braking parameters and traction characteristics on different road surfaces. The evaluation of the veracity of car braking parameters used for analyzing road accidents is reviewed by Nagurnas *et al*. (2007). A

ISSN 1648-4142 print / ISSN 1648-3480 online
www.transport.vgtu.lt
DOI: 10.3846/1648-4142.2009.24.42-47

closely related topic – the impact of road parameters on annual average daily traffic – was researched by Šliupas (2006 and 2007) and by Šliupas et al. (2006). Sokolovskij *et al.* (2007) investigated the interaction between the automobile and road border.

2. Research Data

2.1. Data on Road Traffic Accidents

The article analyses data on valid road traffic accidents that occurred in the main and interurban road networks in Lithuania during the interval from the year 2002 to 2006 (LAKIS 2008). It was the latest available high quality data at the beginning of research. A valid car accident – is a car accident in which people can be injured or killed. Data on valid road traffic accidents taken place in the rural road network and streets of Lithuanian cities is not analyzed.

An overview of the researched data on traffic accidents is displayed in Tables from 2 to 5.

Table 2 shows the types of car accidents sorted by widespread acceptance in the range of the researched data (Eismo įvykių… 2003, 2004, 2005 and 2006). The list of acceptance is different from the one presented in the journal *Statistics of Road Traffic Accidents in Lithuania during 2006 year* where the accidents that occurred within the country are analyzed.

Table 2. The figures for valid car accidents on Lithuanian main and interurban road networks during the interval from the year 2002 to 2006 considering a type of an accident

Type of an accident	Year				
	2002	2003	2004	2005	2006
Collision	534	510	608	638	711
Pedestrian run down	352	352	343	366	348
Overturn (on the road or off the road)	268	240	256	304	308
Obstruction run down (on the road or off the road)	183	150	181	193	144
Collision with a bicycle	223	228	172	174	125
Other car accidents	66	61	53	65	76

Tables from 3 to 5 reveal the most dangerous road sections across the country evaluated using different parameters: Table 3 shows the highest valid traffic accident number in a section, Table 4 indicates sections with the highest valid traffic accident density and Table 5 discloses the highest number of traffic accidents per car in a section.

The main and interurban road network in Lithuania is divisioned into the above mentioned road sections revealing alike Annual Average Daily Traffic (AADT) value intervals. Due to changes in the road network, the road sections are annually changing. All researched data is grouped according to the established road sections.

2.2. Road Section Classification

Considering certain parameters, the road sections of Lithuanian road network can be divided into the following road classes used nationwide: AM (highway), I, II, III, IV, V. The roads from class AM usually have the highest quality and the biggest traffic volume, whereas the situation is different class in V (STR 2.06.03:2001).

Table 3. Top 10 road sections with the highest number of valid car accidents that occurred on Lithuanian main and interurban road networks during the years 2002–2006

Running number	Road number	Section start, km	Section end, km	Number of valid car accidents
1	A6	30.84	72.59	113
2	141	208.31	228.92	94
3	130	10.53	34.37	90
4	141	181.49	208.31	89
5	A12	129.49	155.46	78
6	141	141.31	172.84	77
7	A1	17.4	36.32	76
8	A6	14.04	30.84	75
9	A9	53.04	70.61	69
10	A14	21.17	62.6	67

Table 4. Top 10 road sections with the highest density of car accidents that occurred on Lithuanian main and interurban road networks during the years 2002–2006

Running number	Road number	Section start, km	Section end, km	Density of car accidents
1	130	5.21	10.53	9.40
2	A6	5.95	14.04	8.16
3	A5	52.66	58.49	7.20
4	A13	2.27	10.96	6.90
5	A13	0.00	2.27	6.61
6	A9	70.61	75.63	6.37
7	229	0.00	10.23	6.35
8	A1	10.00	17.40	5.68
9	A1	95.52	102.90	5.15
10	A6	130.66	142.71	4.90

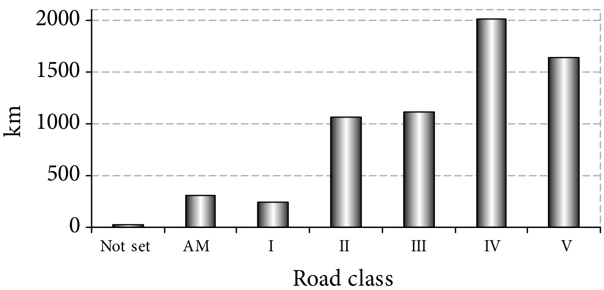

Fig. 1. Lithuanian main and interurban road network considering road class

There is a small number of road sections the class of which is not indicated. Fig. 1 displays road classes considering their demand in the analyzed road network.

A road section class variable (C) used in research evaluating road section class in a way that allows comparing different road sections made of multiple road class sections. It is calculated in the following way:

$$C = \left(100 \cdot \frac{L_{AM}}{L} + 83 \cdot \frac{L_I}{L} + 67 \cdot \frac{L_{II}}{L} + 50 \cdot \frac{L_{III}}{L} + \right.$$

Table 5. Top 10 road sections with the highest risk of a valid car accident per car on Lithuanian main and interurban road networks in the years 2002–2006

Running number	Road number	Section start, km	Section end, km	Number of valid car accidents	Average AADT 2002–2006 years	Valid accidents division by average AADT 2002–2006 years
1	181	0.00	21.11	13	189	0.069
2	147	0.00	31.70	66	1033	0.064
3	173	0.00	42.34	27	471	0.057
4	221	0.00	32.62	16	281	0.057
5	196	0.00	39.06	67	1288	0.052
6	141	96.17	141.31	50	988	0.051
7	143	3.60	45.82	37	740	0.050
8	144	0.00	23.48	59	1210	0.049
9	127	16.42	46.78	28	579	0.048
10	194	0.00	25.76	13	304	0.043

$$33 \cdot \frac{L_{IV}}{L} + 17 \cdot \frac{L_V}{L} \Bigg) / 100,$$

where: C – road section class variable; L – the length of a section, km; L_{AM} – AM class road length in a section; L_I – I class road length in a section etc.

The coefficients of the equation are used to balancing 'the weight' of road classes.

2.3. Population within a Road Section Area

Territory areas are drawn around each analyzed road section of the main and interurban road network in Lithuania. Population getting into each of these areas is counted using data taken from Lithuanian Department of Statistics and displayed in a vectorial way in the database GDB200 (version 2.6) of the *State Enterprise National Center of Remote Sensing and Geoinformatics* (population census of the year 2001). Fig. 2 displays the way of how the area is drawn around the road section.

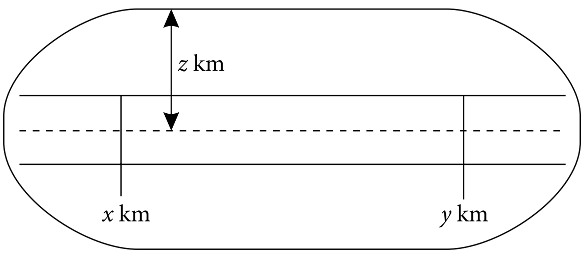

Fig. 2. Road section area where population is counted

x km is the beginning of an analysed road section, y km is the end of the analysed road section and z km is population area radius around the road section. The following population area radius values (z) including the distances of 3 km, 5 km, 7 km, 9 km, 11 km, 13 km, 15 km, 17 km, 19 km and 21 km were given.

Lithuanian highway and state road network was divided into 341 sections in total. The calculations were performed with each of these sections. Correlation between the number of valid traffic accidents and population was calculated (Fig. 3).

As indicated in Fig. 3, traffic accidents on a road section are not strictly dependant on the population around it.

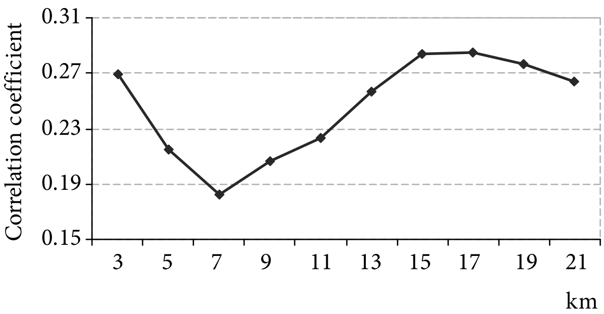

Fig. 3. Correlation between traffic accidents and population in an area

At a later stage, the population within 17 km radius will be used in calculations because it has the highest correlation with traffic accidents.

2.4. Road Grounds

There are 4 different types of road grounds behind Lithuanian main and interurban roads (LAKIS 2008):

a) bus stop grounds;
b) rest grounds (lay-by);
c) long time rest grounds;
d) gasoline stations.

A total of 5 782 types of ground are researched. Fig. 4 displays the repartition of ground considering the type behind the main and interurban road network in Lithuania.

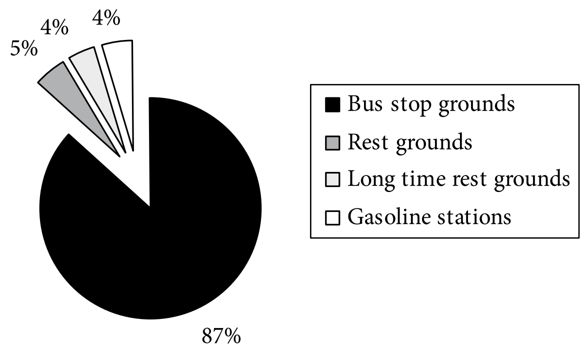

Fig. 4. The repartition of ground considering the main and interurban road networks in Lithuania

It has been calculated the number of different types of grounds in the researched road sections. Next, the impact of the type of ground on traffic accidents will be studied.

2.5. The Remaining Data

Also the impact of the illuminated road sections on traffic accidents is analysed (LAKIS 2008). The length of the illuminated interval of a section is calculated and its impact on the number of traffic accidents is measured. The same procedure is followed dealing with tracks for cyclists/pedestrians and road barriers.

Then, the number of 3-way and 4-way crossroads is calculated in each road section studied and their impact on traffic accidents is analysed (LAKIS 2008). The same level crossroads (6 226 units) have been analysed due to the fact that they have been found the least save. Grade separated crossroads are not analysed. Fig. 5 displays the repartition of crossroads in Lithuanian main and interurban road network.

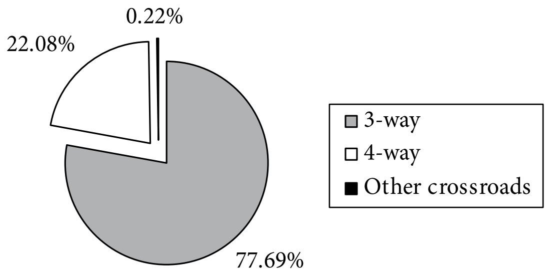

Fig. 5. The repartition of the same level crossroads in Lithuanian main and interurban road networks

At a later stage, the weight average of road section width is calculated and its impact on traffic accidents in the section is analysed.

3. Analysis

Table 6 describes the correlation between traffic accidents and the described road and surrounding area parameters (LAKIS 2008; Automobilių eismo… 2002; Eismo intensyvumo… 2003; Valstybinės reikšmės… 2003 and 2006; Lietuvos… 2005).

The correlation coefficient can gain values from –1 to 1. When a value is close to 0, it means that the studied variables are either poorly related or have no relation at all. A value close to –1 means that relation is reverse: the lesser value has an independent variable *X* and the higher value has a dependant variable *Y*.

The table does not show a high impact of any road parameter on accident rate but all parameters combined might have a major impact on accident rate. The majority of the above discussed parameters must have negative correlation, however it is not observed. The data most likely is distorted by 2 other important traffic accident reasons – human factor and vehicle breakdowns.

An exceptional factor is illuminations in dual carriageway. Low correlation with traffic accidents could be explained by presuming that this parameter evaluates not only illumination but also indicates that the road section has dual carriageway protecting from front collision.

Table 6. The correlation coefficient between traffic accidents in a road section in Lithuanian main and interurban road networks and the described road section parameters in the years 2002–2006

A road section surrounding area parameter	Correlation coefficient
Average AADT 2002–2006 years (P_{AADT})	0.34
Population within 17 km area around a road section (P_P)	0.29
Class of a road section (P_{Cl})	0.29
Length of a road section (P_L)	0.37
Weight average of a road section width (P_W)	0.24
All one level crossroads ($P_{Cr.All}$)	0.20
Tripartite one level crossroads (P_{Cr3})	0.18
Quadruple one level crossroads (P_{Cr4})	0.18
All road grounds ($P_{G.All}$)	0.41
Bus stop grounds (P_{GB})	0.32
Rest or lay-by grounds (P_{GR})	0.32
Long time rest grounds (P_{GL})	0.22
Gasoline stations (P_{GG})	0.53
Tracks for bicyclists/pedestrians (P_T)	0.24
All road barriers ($P_{B.All}$)	0.36
Barriers in dual carriageway ($P_{B.Dual}$)	0.27
Barriers on sides of a road ($P_{B.Sides}$)	0.35
All type illumination ($P_{I.All}$)	0.21
Illumination in dual carriageway ($P_{I.Dual}$)	0.08
Illumination on sides of a road ($P_{I.Sides}$)	0.20

Let's build regression equations using 90% percent of the researched data and forecast accident rate using the introduced parameters to the rest of 10% of the data. Results are displayed in Table 7: AR_C – calculated accident rate. The rest of variable notation is explained in Table 6.

Linear regression equations 2 and 3 are built using all available data on parameters. The same may be noticed referring to multiple regression equations 4 and 5 but the importance of more significant parameters is increased by square. Equations 6 and 7 are built using the most important parameters only and eliminating the rest.

Using the equations placed in Table 7, forecast accident rate for the rest of 10% of the data and compare them with real data. Table 8 displays the obtained results.

It can be noted that error level is very high because of poor parameter correlation and probably the equations do not adequately represent the data.

A similar form of research was also performed by the Finnish National Road Administration (TARVA model) in Finland. Different kinds of road improvement affecting a decrease in the number of traffic accidents were estimated. However, the data used in the article had not been employed before such research the extent of which involved all main and interurban road networks. The research also analyses all road factors that could be evaluated. The idea of associating the density of population around the road and the quantity of traffic accidents is new. Also there is no information that the statistical method to predict the level of traffic accidents used in

Table 7. Linear and multiple regression equations built using 90% of the analyzed data

No.	*R* value	Equation
2	0.706	$AR_C = -2.93587 + 0.00207 \cdot P_{AADT} + 0.00001 \cdot P_P + 36.75039 \cdot P_{Cl} + 0.32817 \cdot P_L - 1.92862 \cdot P_W + 0.1332 \cdot P_{Cr.All} + 0.68809 \cdot P_{G.All} + 0.46008 \cdot P_T + 0.71472 \cdot P_{B.All} - 0.94336 \cdot P_{I.All}$
3	0.751	$AR_C = -0.87109 + 0.00173 \cdot P_{AADT} + 0.0001 \cdot P_P + 30.23776 \cdot P_{Cl} + 0.35688 \cdot P_L - 1.75714 \cdot P_W + 0.16471 \cdot P_{Cr3} + 0.00840 \cdot P_{Cr4} + 0.30971 \cdot P_{GB} + 1.32079 \cdot P_{GR} + 0.48352 \cdot P_{GL} + 6.10691 \cdot P_{GG} + 0.11695 \cdot P_T + 0.07339 \cdot P_{B.Dual} + 0.73456 \cdot P_{B.Sides} + 1.01002 \cdot P_{I.Dual} - 0.840207 \cdot P_{I.Sides}$
4	–	$AR_C = -4.98474 + 0.000003 \cdot P_{AADT}^2 + 0.00440 \cdot P_P + 1.05250 \cdot P_{Cl} - 1.09652 \cdot P_L^2 - 0.83766 \cdot P_W - 1.10848 \cdot P_{Cr.All} - 2.02538 \cdot P_{G.All}^2 - 1.68089 \cdot P_T - 2.22175 \cdot P_{B.All}^2 - 1.66117 \cdot P_{I.All}$
5	–	$AR_C = -5.91410 + 0.00001 \cdot P_{AADT}^2 - 0.01259 \cdot P_P + 1.18969 \cdot P_{Cl} + 0.39715 \cdot P_L^2 - 0.13325 \cdot P_W + 0.12821 \cdot P_{Cr3} + 0.07106 \cdot P_{Cr4} + 0.00591 \cdot P_{GB} - 1.67756 \cdot P_{GR} - 1.75914 \cdot P_{GL} + 1.84341 \cdot P_{GG}^2 - 2.05638 \cdot P_T - 2.15767 \cdot P_{B.Dual} - 2.18483 \cdot P_{B.Sides} - 2.32082 \cdot P_{I.Dual} - 2.00772 \cdot P_{I.Sides}$
6	0.723	$AR_C = -5.14648 + 0.00083 \cdot P_{AADT} + 0.00001 \cdot P_P + 1.18969 \cdot P_{Cl} + 0.28715 \cdot P_L - 0.10148 \cdot P_{Cr.All} + 0.43460 \cdot P_{GB} + 6.67414 \cdot P_{GG} + 0.71732 \cdot P_{B.Slides} - 0.81745 \cdot P_{I.Slides}$
7	0.718	$AR_C = 0.02657 + 0.00140 \cdot P_{AADT} + 0.27472 \cdot P_L + 0.55741 \cdot P_{GB} + 1.64014 \cdot P_{GR} + 6.68811 \cdot P_{GG} + 0.20539 \cdot P_{B.All} - 0.68160 \cdot P_{I.All}$

Table 8. The average error of equations listed in Table 7 computed testing the rest of 10% of the analyzed data

Equation number	Error
2	54.63%
3	53.34%
4	6 528.77%
5	6 470.77%
6	49.83%
7	53.67%

the article was applied by other researchers. The results of similar studies are used to the economical evaluation of the road transport project because it describes a possible impact of traffic accidents on the future projects.

4. Conclusions

1. Finding out the most dangerous road sections (Tables from 3 to 5) nationwide using various evaluation criteria, different results are received. However, some of the road sections appear in a few top ten lists.
2. As we can notice from Table 6, there is no strong relation between single road parameters and traffic accidents. The data most likely is distorted by the underestimated accident reasons such as human factor and vehicle breakdowns.
3. The length of a road section, average Annual Average Daily Traffic (AADT), road grounds and road barriers have the strongest relation with the number of accidents in the section in common case.
4. It would be a good idea to perform equivalent researches in the neighbouring countries and to indicate the similarities and differences of the obtained results. Then, it will be possible to make decisions about the practical use of the proposed method.

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