Identification of factors affecting accidents on the intercity road network

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Abstract. This article examines the influence of various factors that affect the accident rate on the intercity road network. Ten road sections that differ in the level of accidents, traffic characteristics and geometric parameters were selected for the research. The experiment conducted with the help of specialized equipment showed that these road sections with similar parameters of the roadbed being in compliance with all standards have a strikingly different accident rate. The lack of correlation between the measured standardized indicators of road sections and the accident rate on them indicates the influence of unaccounted factors on the latter indicator, which are not considered by approved methods.

1. Introduction

The President of the Russian Federation Vladimir Putin has appointed the government up to the 1st of December to develop and approve the third state program of the Russian Federation on road safety for the period up to 2030 aimed to reduce the amount of deaths and injuries caused by road accidents, as well as to improve the effectiveness of the management system in the field of road safety. At the moment the 2nd Federal target program for improving road safety aimed to reduce the number of road accidents (hereinafter referred to as road vehicle accidents) by 30% by 2020 compared to 2010 is being completed [1,2]. This confirms the relevance of issues related to reducing the risk of road vehicle accidents.

2. Methods and equipment

In the research carried out earlier, various methods of road safety assessment were analyzed [3]. A comparative analysis of existing road safety assessment methods has shown that with help of the accident rate method [4], which is used in practice, it is possible to assess road safety more accurately because the assessment takes the influence of several elements of the VADS system into account.

Taking into account the inevitable changes in traffic streams and local conditions it is necessary to clarify and enhance the accident rates based on the generalization of regional accident statistics. Thus, the given list of partial accident rates cannot be considered exhaustive and final. Therefore, we have conducted an investigation on the territory of the Krasnoyarsk region on ten sections of federal roads R255 and R257 (711 km, 714 km, 763 km, 770 km, 796 km, 799 km, 875 km, 879 km, 27 km, 30 km) which differ in the level of road vehicle accidents, traffic characteristics and geometric parameters.

The full-scale experiment was performed on Toyota Caldina passenger car. The selected sections were passed at a low speed (10-20 km / h) therefore the condition of the roadway was examined (figure 1) by driving. A video camera was installed at the driver's eye level in the car in order to capture the roadway, roadsides, slopes and surrounding environment on video.
To conduct this experiment we used a universal rail, a KP-203 type curvimeter (road wheel), a steel band, a rangefinder, a portable PPK-f and a Nikon D3100 camera (figure 2). To process and analyze the collected data on a computer, Windows Movie Maker, ASKON "COMPASS 3D" and Windows Microsoft Excel were required.

The measuring instruments were verified and prepared in accordance with their operating instructions. Linear dimensions were measured in accordance with GOST (National State Standard) 26433.0 - GOST (National State Standard) 26433.2 and in accordance with the instructions. The measurement sites were fenced with portable barriers and warning signs to ensure safety.

The parameters affecting road safety such as vehicle density, lane width, shoulder width, longitudinal gradient, radius of curve in the plan, visibility in the plan, visibility in the profile, the number of main lanes on the roadway to direct traffic, the width of the separation strip, the distance from the edge of the roadway to the cliff deeper than 5 m, the coefficient of friction, width of the separation strip, the composition of the stream and speed difference have been studied [5-8].

When determining the speed and intensity of traffic a 50-100 m section was selected depending on the direct visibility on the roadway. Then the passage time of this section by single cars was measured.
followed by the calculation of the speed of movement and measurement data processing [5].

The speed of a single car was determined by the formula:

\[ V_n = \frac{l}{t_n} \]  

(1)

\( l \) – the length of the section;
\( t_n \) – the time of passing the section by a car \( n \).

The average time interval was determined by the formula:

\[ \bar{t} = \frac{(t_1 + t_2 + \cdots + t_n)}{n} \]  

(2)

The average speed on the section was calculated by the formula:

\[ V = \frac{l}{\bar{t}} \]  

(3)

Based on the video recording and the obtained speed data, the speed difference was determined by the formula:

\[ V_p = V_2 - V_1 \]  

(4)

\( V_2 \) – the speed of the overtaking car;
\( V_1 \) – speed of the car being overtaken

Based on the video recording, the entire traffic stream was divided into two groups according to the exterior: passenger vehicles and multifunctional vehicles (cargo vehicles, buses, tractors and other self-propelled vehicles).

3. **Research results**

With help of the universal rail the height of the fences and the slope were determined. The range finder determined visibility according to the National State Standard GOST 32963. The width of the roadway and the length of straight sections were determined by the curvimeter KP-203 (road wheel). The width of the dividing strip, the width of the shoulder, and the distance from the edge of the roadway to the cliff with a depth more than 5 m were determined by means of a steel tape. The coefficient of adhesion was determined by the portable PPK-f.

The research showed that the busiest areas are those that are located in the boundaries of the Krasnoyarsk agglomeration (Figure 3).

![Figure 3. Daily intensity in the considered areas](image)

It was also found out, that the hourly traffic intensity of trucks on various sections of the Federal highway ranges from 6% to 55% of the total number of recorded vehicles. The average value on sections
not included in the territory of the Krasnoyarsk agglomeration is about 35% and this figure increases annually. Bus intensity is about 2% of the total number of vehicles (Figure 4).

The research showed that the stream rate is not uniform and 50% of the vehicles exceed the safety speed limit on the specified sections. Figure 5 shows the speed division on 799 km of the road.

The analysis of the speed difference between the overtaking vehicle and the vehicle being overtaken showed that the difference reaches up to 70 km/h. (Figure 6). In 70% of cases the speed difference in the stream occurred when there was a multifunctional vehicle (a cargo vehicle or a bus) in the stream. All the data obtained for each section were included in the table.
Figure 6. The Graph of the speed difference on the section of 799 km

Table 1. Results of the research

| Parameter | 27  | 30  | 711 | 714 | 763 | 770 | 796 | 799 | 875 | 879 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Traffic intensity, Vehicle/day | 10896 | 9809 | 15755 | 14328 | 10281 | 12382 | 22197 | 26367 | 5267 | 4445 |
| Lane width, m | 3,5 | 3,5 | 3,5 | 3,5 | 3,5 | 3,5 | 3,5 | 3,75 | 3,5 | 3,5 |
| Shoulder width, m | 3,5 | 3,5 | 3,5 | 3,5 | 3,5 | 3,5 | 3,5 | 3,75 | 3,5 | 3,5 |
| Longitudinal slope, % | 3 | 3 | 3 | 5 | 0 | 0 | 0 | 0,03 | 0 | 0 |
| The radius of the curve in the plan, m | 656 | 695 | 322 | 30000 | 2000 | 426 | 12900 | 1042 | 1850 | 1850 |
| Visibility in the plan, m | 600 | 600 | 300 | 820 | 820 | 400 | 820 | 820 | 700 | 700 |
| Visibility in the profile, m | 70 | 70 | 50 | 100 | 100 | 60 | 1000 | 80 | 100 | 100 |
| Number of main lanes on the roadway | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 2 | 2 |
| Width of the dividing strip, m | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 2,5 | 0,2 | 0,2 |
| Distance from the edge of the roadway to a cliff more than 5 m deep, m | - | - | - | - | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 |
| The coefficient of friction | 0,75 | 0,75 | 0,75 | 0,75 | 0,75 | 0,75 | 0,75 | 0,75 | 0,75 |
| The stream composition, % of cargo vehicles | 8 | 8 | 33 | 33 | 27 | 26 | 5 | 5 | 17 | 17 |
| The average speed difference, km/h | 16 | 17 | 42 | 45 | 39 | 38 | 23 | 25 | 32 | 32 |
Thus, the characteristics of 10 road sections with various configurations and different number of road vehicle accidents on federal roads P255 and P257 were determined and series of data such as traffic volume, lane width, shoulder width, longitudinal gradient, radius of curve in the plan, visibility in the plan, the number of main lanes on the roadway for direct traffic, the width of the separation strip, the distance from the edge of the roadway to the cliff deeper than 5 m, the coefficient of friction, width of the separation strip, the length of the straight sections, the composition of the stream, speed difference were systemised.

4. Findings
The research found that the analysed sections have similar parameters of the roadbed meeting all the standards, but the accident rate on them is strikingly different. The lack of correlation between the measured standardized indicators of road sections and the accident rate on them indicates the influence of unaccounted factors on the latter indicator, which are not considered by approved methods.

The analysis of the systematized data showed that there is also a big speed difference in the sections where there is a significant number of multifunctional vehicles in the traffic stream.

In areas with a high intensity (more than 20%) of multifunctional vehicles and with a significant speed difference there is a big number of accidents over the past 5 years.

It is necessary to quantify the impact of each of the identified factors on road safety.

5. Conclusion
The qualitative composition of the traffic stream is not uniform and significantly differs on different sections of federal roads. Thus, to improve road safety it is advisable to improve the methodology of accident rates, taking into account the composition of the traffic stream and the speed difference that occurs due to the nonuniformity of the traffic composition.

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