INFLUENCE OF THE TIME OF DAY ON ROAD TRAFFIC ACCIDENT RATE

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ABSTRACT

The author proceeds from the fact that human-saving efforts, technically sound and environmentally efficient measures to reduce accident rate on roads (and especially on country roads) can bring the expected results only if there is a well-established system of accident prediction. These prediction methods should take into account the impact of a complex of factors, including the time of the day, traffic intensity, features of road environment and other significant aspects of the transport process. In the present study the focus is put on dependence of traffic accidents on the period of the day, the nature of day, night and twilight hours of a calendar cycle.

Keywords: roads, time of traffic, accident rate, consequences of road accidents, human factor, forecasting, prevention.

Background. *Despite numerous efforts, the problem of accident rate on Russian roads is still acute. The increase in the number of car fleet, involvement of broad segments of population in road traffic lead to an increase in severity of the consequences of road traffic accidents, the extent of damage and the probability of death of participants in road accidents. Therefore, a set of tasks aimed at improving road safety is becoming more complex, requiring a great deal of research, attracting considerable scientific and technical resources [1, 2].*

One of the ways to improve the effectiveness of preventive measures to reduce road accident rate is prediction. And statistical methods, based on data of State Traffic Safety Inspectorate about the traffic accident with victims are the most commonly used [3]. These methods, however, have low accuracy, since the prediction is conducted using a small number of parameters, such as the season of the year, or the overall statistics plan, without any differentiation. For qualitative analysis of the situation at least a method is required that takes into account the influence of the most significant daily factors (time of day, features of a road network, traffic intensity, etc.).

In this case, we examine the influence of the time of day, that is of the factor, having a direct impact on the accident rate and requiring timely responses to it by each driver of the vehicle. In the face of declining natural light during twilight and night time there is a significant increase in visual load: in addition to reducing the range of vision, the periods of eye's adaptation and accommodation grow. In addition, the vision at the time of twilight or adaptation to darkness becomes more sensitive to light stimuli, and short-term blindness (maladaptation) occurs in case of a sharp and excessive intensity of the process.

Objective. *The objective of the author is to consider dependence of road accident rate on light intensity during various periods of the day.*

Methods. *The author uses general scientific methods, graph construction, mathematical apparatus, evaluation approach, comparative analysis, statistics analysis.*

Results. *The light level affects a functional state of a driver. By reducing the natural light and in the absence of artificial one (which is typical for country roads) a driving man experiences high tension, reflex reactions reduce, the likelihood of errors due to the fault of the «human factor» increases [4]. In addition, at night on the roads out of settlements, where a driver has often to switch to dipped beam headlights it becomes highly difficult to adequately react to danger as a result of the predominance of the length of a stopping distance over a distance of a short light beam of car headlights.*

Research of influence of time-based factors on road accidents appear in many Russian and foreign works [5–8]. There is a fairly detailed analysis of accident severity and deaths in the dark time of a day [9, 10]. And scientists in the study of this subject usually divide a day in light and dark time, either in proportional parts (periods of three or six hours), thereby excluding from the analysis such a weighty time-based unit as twilight. However, the most important thing is that there is insufficient information on the degree of influence of each of the individual parts of the day on the number of road accidents. Therefore, it is necessary to study this relationship, especially on country roads, where in contrast to the urban areas for the most part, we emphasize once again, there is no artificial lighting.

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Based on visibility conditions, a day is divided into three main parts: day, twilight, night.

During the twilight there is a significant change in light intensity, so the twilight is divided into three types: civil, navigation and astronomical. Decrease in light intensity, characteristic of the civil twilight, effects little on the ability to perform the most types of work in the open area. Borders of the period: between sunset (sunrise) until the sun dipping below the horizon on 6°. The light intensity at navigation twilight does not allow to distinguish small details, but the silhouettes of large objects are seen quite clearly. The period involves the sun dipping below the horizon from 6° to 12°, and to the end of the stage only a horizon line can be distinguished. Astronomical twilight matches sun dipping below the horizon from 12° to 18°, i.e. before approach of night. During this period, the conditions do not differ much from the night, but the sky is still visibly illuminated [11].

When conducting our research the day was divided into five parts (x_i). Let the indices 1–5 relate, respectively, to the night (N), astronomical (AT), navigation (NT), civil (CT) twilight and the day (D). The duration of each part is denoted as T_i. The time of day in which the accident occurred, was determined taking into account geographical coordinates of the scene. In this twilight time was not divided into morning and evening, as the light intensity level of the road surface remained the same.

As the object of study a highway of federal significance A 322 Barnaul–Rubtsovsk– border with the Republic of Kazakhstan was chosen.

To determine the number of accidents that have occurred in the relevant parts of the day, the analysis of data of 2012–2014 years was conducted, the incidence of accidents was calculated:

$$p^* = \frac{n_i}{N}, \tag{1}$$
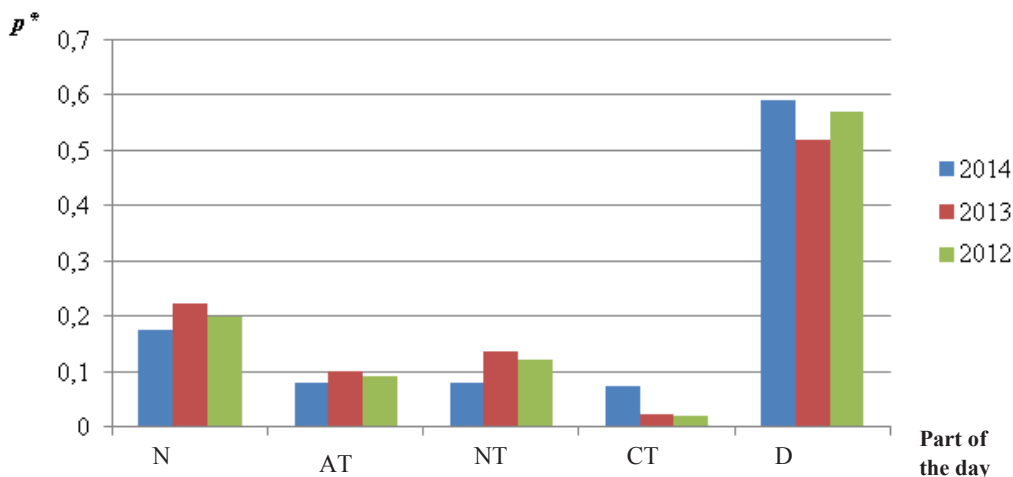
Pic. 1. Distribution of relative frequency of accidents depending on the part of the day.
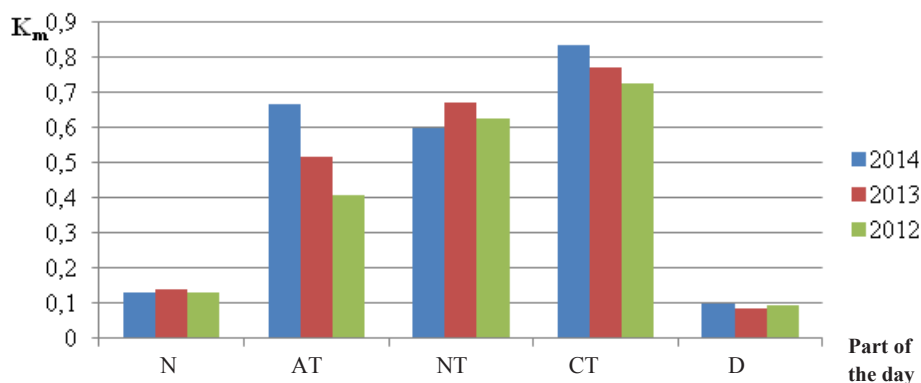
Pic. 2. The specific indicator of accident rate for the part of the day over years.

where n_i is a number of accidents in a particular part of the day; N is a total number of accidents.

The results of calculation of relative frequency of accidents are shown in Pic. 1. The distribution of road accidents depending on the part of the day does not change significantly in the period of three years, which proves their sustainable impact on the accident rate.

The greatest number of accidents (55%) takes place during the day, during daylight. However, the numerical predominance of accidents in this period can be attributed to its longer duration during the year, compared with other parts of the day (average daytime occupies 51%) and a greater traffic intensity in the hour period natural for population's activity.

Daily intensity distribution depends on working hours (morning rise), the period of visit of suburban areas (rise in the evening and at weekends during the summer season) and on other factors. The duration of daylight does not have at the same time a decisive impact on the value of the automobile flow, during the year the bursts of intensity occur for different reasons, so we evaluated only a direct correlation of parts of the day and accident rate, excluding traffic intensity.

Distribution of traffic accidents during the year is uneven, and therefore to correlate their number with the mean value of the day duration is incorrect, an additional parameter is necessary that allows to assess the potential accident rate on the timeline. It must take into account the duration of a particular part of the day, taking into account the geographical coordinates of the area and physical features of the landscape of time zones evolving during a year.

For further analysis the specific indicator Y_{ij} was calculated, which is a ratio of the number of accidents that have occurred during the day in one of the selected periods to the duration of the period:

$$Y_{ij} = \frac{x_i^\Sigma}{T_i}, \qquad (2)$$

where x_i^Σ is a total number of accidents, that have occurred during the considered period.

For a quantitative assessment of the risk of an accident a mean indicator K_m was calculated for each of the selected parts of the day:

$$K_m = \frac{\sum Y_{ij}}{n}, \qquad (3)$$

where n is a number of parts of the day, when the accidents occurred during the year.

The distribution of a calculated specific indicator of the accident rate over years (Pic. 2) is quite even, which indicates the stable influence of parts of the day on the level of accidents within the considered period of time.

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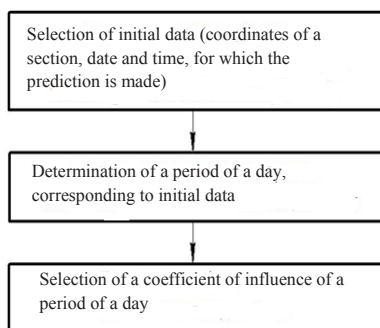
Pic. 3. Block diagram to determine the coefficient of accident rate depending on time of the day.

Averaging the indicator for three years and bringing it to unity, we obtain the accident rate for the part of the day K_{day}^{Σ}, which allows to take into account their impact and represents a piecewise-linear function depending on time:

$$K_{day}^{\Sigma} = \begin{cases} 1,45, & t \in T_1 \\ 5,82 & t \in T_2 \\ 6,93 & t \in T_3, \\ 8,54 & t \in T_4 \\ 1 & t \in T_5 \end{cases} \qquad (4)$$

where t is time, for which the prediction is made, T_i is period of time, corresponding to a particular part of the day.

The obtained function can be used to build a prediction of potential accidents based in the block diagram, shown in Pic.3.

Conclusions. With the help of the analysis and the resulting functional dependency quantitative influence of effect of the time of the day on road traffic accident rate was established. The calculation of the average specific indicator showed an increased risk of accidents at twilight time. The most dangerous in this case are civil twilight preceding onset of daylight in the morning and coming after sunset in the evening.

Establishing the dependence of influence of the time of day on the accident rate helps to improve the accuracy of prediction of accidents on roads outside settlements, where the problem of light intensity on the road is the most acute. The prediction, in turn, allows for effective preventive measures aimed at preventing accidents and reducing severity of their consequences. Among the priority measures it is necessary to note the installation of artificial lighting in emergency areas, as well as increased traffic police control in the dark over the observance of traffic rules by the drivers on the roads outside settlements.

The results obtained in the current study results underscore the importance of an integrated approach to the forecasting of road accidents, system and multivariate analysis system of human-saving means and methods used in the transport medium.

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