Effect of Photo- and Video-Fixation Systems of the Automobile Speed Rate in Orel Region

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Abstract. The article analyses the reasons for decreased traffic accidents in the Orel Region during 2017-2019 observed during the annual growth of traffic flow intensity. Dependence of the traffic discipline and culture of road users on existence of photo- and video-fixation systems for identification of speed infringements is checked. The methods for analyzing automobile traffic intensity and speed on areas of the motorway with and without video-fixation are used. The measures for further introduction and improvement of photo- and video-surveillance in the Orel Region and other Russian regions are suggested.

1. Introduction

The number of vehicles on Russian roads annually increases on 3-4% that results in the increased traffic intensity on motorways. In the next ten years, the motor park is expected to grow by 1.5 times.

The practical evidence shows that, despite of increased automobile traffic intensity, the road accident rate may be decreased due to preventive measures. One of such measures is photo- and video-fixation of traffic violations.

The discipline of drivers and the driving culture increase on the areas of the road where video-surveillance cameras are installed to control the speed rate. Thus, the number of accidents decreases.

All of this shows relevance of the subject of this study.

2. Study essentials

The number of automobiles increases in the Orel Region every year that results into growth of traffic intensity on motorways.

In 2019, each 1,000 inhabitants had on average 329.8 cars in the Orel Region, that is 1.5 times more than the same value from 2019 and 2.9 times more than in 2000. Nationwide, this value is 315.5, i.e. the average Russia value is less than the Orel Region's value.

The Orel Region has taken the twenty first position among all RF subjects for the number of traffic accidents during the last years. Despite of the fact that the number of accidents was reduced in 3.3% in 2019 compared with similar values for 2018, at average eighty eight persons of one thousand victims died that is more than the average national value.
Table 1. Values of traffic accidents in the Orel Region for 2017-2019.

| Years | Number of traffic accidents | Number of victims | Number of the dead |
|-------|-----------------------------|-------------------|--------------------|
| 2017  | 894                         | 1082              | 112                |
| 2018  | 798                         | 1029              | 111                |
| 2019  | 772                         | 976               | 94                 |

It must be noted that the dynamics of traffic accidents improves in the Orel Region and has the tendency to reduction. And this reduction happens regardless of the constant motor park growth in the Orel Region.

It is supposed that the reduced number of traffic accidents has been achieved due to prevention of the illegal behaviour among drivers by using the automatic photo-and video-fixation complexes used to impact the discipline of drivers, to prevent possible infringements, including the ones related to overspeed.

In order to check this hypothesis, the traffic flow value on two areas of M2 “Crimea” motorway on the territory of the Orel Region, near the Pervyi Voin settlement was studied: the first area of traffic intensity calculation had the video-fixation camera and the second area had no camera.

The studies were conducted during 2020. Both observed areas were located next to each other, that's why the behaviour of both drivers was analysed on both areas.

First, automobiles passed the area where the speed rate was not controlled. Then automobiles were caught in the camera viewing area.

The traffic speed on the federal motorway M2 “Crimea” was determined within the range from 40 km/hour to 109 km/hour as this range is the permitted automobile traffic speed.

From the viewpoint of safety, the area of M2 “Crimea” motorway near the Pervyi Voin settlement has the monotonous roadside landscape, profile and plan than results into quick tiredness and sleepiness of drivers [6].

In order to obtain accurate results of the study, surveillance was done with the fixed time for passing of 100 vehicles.

The study was done during weekdays, weekends, in different times of day (at mornings, afternoons and evenings). Then the average data were produced.

As various vehicles are passed on the motorway, once the obtained information is processed, each vehicle was corrected to the one value according to Yu.A. Vrubel's car rate [10]:

\[ f(k) = k_1 x_1 + k_2 x_2 + \ldots + k_n x_n; \]  

where: \( k_n \) is the number of n-type vehicles,  
\( x_n \) is the rate for correction to a car.

Table 2. Values of the rate for correction to a car.

| Rate of correction | Motorcycles | Trucks | Long haul trucks | Buses |
|--------------------|-------------|--------|-------------------|-------|

Intensity of traffic flow is calculated using the formula:

\[ N = \frac{n}{t}; \]  

(2)
where: \( n \) — is the number of vehicles passing the area under the study for a unit of time \( t \).

Once the number of vehicles is calculated using the rate of correction, intensity of traffic flow on the studied area for 1 hour was on average 2020 N = \( \frac{455}{1} \) = 455 vehicles.

Obtaining the average traffic flow speed is affected by various factors including illumination, existence of road signs, intensity, density, treatment of motorway and others.

The speed of vehicles was determined by the quantity of time for passing of the experimental distance.

To calculate the average speed of traffic flow the following formula was used:

\[
V = \frac{\sum (V_i \cdot n_i)}{\sum n_i},
\]

where: \( V_i \) is the average speed of one of eight vehicle ranges, \( n_i \) is the number of vehicles passing through the studied area.

### Table 3. Distribution of vehicle speeds on areas of the motorway selected for the experiment.

| Speed range, km/h | Number of vehicles on the area with a camera | Number of vehicles on the area without a camera | Average speed, \( V_c \), km/h |
|------------------|---------------------------------------------|-----------------------------------------------|-------------------------------|
| 40-50            | 6                                           | 4                                             | 45                            |
| 50-60            | 10                                          | 6                                             | 55                            |
| 60-70            | 13                                          | 8                                             | 65                            |
| 70-80            | 14                                          | 8                                             | 75                            |
| 80-90            | 24                                          | 13                                            | 85                            |
| 90-100           | 20                                          | 23                                            | 95                            |
| 100-110          | 13                                          | 21                                            | 105                           |
| >110             | 0                                           | 17                                            | 115                           |

To calculate the average speed of traffic flow, the average speed and the number of vehicles at each of eight ranges were taken into account.

Based upon the obtained results, the average speed of traffic flow on studied motorway areas was calculated using the formula (3):

For the area with a camera

\[
V = \frac{\sum (6 \cdot 45 + 10 \cdot 55 + 13 \cdot 65 + 14 \cdot 75 + 24 \cdot 85 + 20 \cdot 95 + 13 \cdot 105)}{100} = 80.2 \text{ km/hour.}
\]

For the area without a camera

\[
V = \frac{\sum (4 \cdot 45 + 6 \cdot 55 + 8 \cdot 65 + 8 \cdot 75 + 13 \cdot 85 + 23 \cdot 95 + 21 \cdot 105 + 17 \cdot 115)}{100} = 90.8 \text{ km/hour.}
\]
As seen from the obtained diagram, drivers slowed down on the area with a camera. It also should be noted, that, together with slowing down, the increase in the driving culture was observed. Drivers were going while observing all traffic rules, there wasn't aggressive driving with multiple lane changes and near collisions with other road users.

3. Conclusions and suggestions
The conclusion may be drawn that the use of photo- and video-fixation on the road really results in the growth of the driving discipline and, therefore, into the reduced number of traffic accidents on these areas.

As a practical suggestion, the further introduction of photo- and video-surveillance systems may be recommended on especially accident-prone areas where the greatest number of traffic accidents statistically happens.

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