time of reaction of the driver; bandwidth; site of the road network;
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RESEARCH OF INFLUENCE OF TIME OF REACTION OF THE DRIVER ON THE CALCULATION OF THE CAPACITY OF THE HIGHWAY

Summary. In the work we performed a review of studies of foreign scholars on changing the reaction time of the driver depending on various road conditions, namely the change in the response time when using the traffic light regulation. Earlier by the authors of this article have already been carried out research in the field of throughput of a site of a highway with traffic regulation, which showed that this value depends on the time of reaction of the driver. In this article the estimation of how much bandwidth the highway using different result obtained in the course of analysis, time value of reaction of the driver and is a direct correlation bandwidth from the time of reaction of the driver. The values obtained allow to conclude that taking into account the psycho-physiological characteristics of drivers (response time) will have a significant impact on the throughput and the various methods of organization and reorganization of sections of the road network, implementation of which is used investigated the amount of bandwidth.

ИССЛЕДОВАНИЕ ВЛИЯНИЯ ВРЕМЕНИ РЕАКЦИИ ВОДИТЕЛЯ НА РАСЧЕТ ПРОПУСКНОЙ СПОСОБНОСТИ АВТОТРАССЫ

Аннотация. В работе выполнен обзор исследований зарубежных ученых по изменению времени реакции водителя в зависимости от различных дорожных условий, а именно изменение времени реакции при использовании светофорного регулирования. Ранее авторами данной статьи уже были проведены исследования в области пропускной способности участка автотрассы при светофорном регулировании, которые показали, что данная величина зависит от времени реакции водителя. В данной статье проведен расчет величины пропускной способности автотрассы при использовании различных, полученных в ходе анализа, значений времени реакции водителя и установлена прямая зависимость пропускной способности от времени реакции водителя. Полученные значения, позволяют сделать вывод о том, что учет психофизиологических характеристик водителей (время реакции) будет оказывать значительное влияние на пропускную способность и различные методы организации и реорганизации участков улично-дорожной сети, при реализации которых используется исследуемая величина пропускной способности.

1. INTRODUCTION

Effective traffic management, the provision of security of road traffic is a prerequisite of prosperity of any country, comfort and safety of their lives. Without roads and transport will not be able to exist in most sectors of the economy, their weak development limits the activity of citizens, leads to significant economic losses and growth of discontent of people.

Accidents on the road causes huge material and moral damage in society as a whole, and individual citizens. Road traffic injuries leads to the exclusion from the sphere of production of working-age people. Die and become disabled children.

Annually in the Russian Federation as a result of road accidents more than 20 thousand people are killed and more than 200 thousand persons are injured (over 9 months, from January to September 2013, in road traffic accidents (RTA) killed 18 955 people were wounded 187 457) [1]. Demographic damage from road accidents and their consequences for 2004-2010 more than in 2 times exceeded the size of the Russian population employed in agriculture.

The goal of increasing the level of security of the transport system, reduction of growth rates in the number of traffic accidents and reducing the severity of their consequences, the number of injured and dead indicated in the Transport strategy of the Russian Federation for the period up to 2030 approved by the government of the Russian Federation of 22 November 2008 N 1734-r. Objectives of this Strategy offers strategic guidelines in addressing the security of the whole transport system of Russia.

The problem of road safety should be considered comprehensively, and it is necessary to have an overview of each component of the system «DCRE» (driver-car-road-environment). In most developed countries, relevant organizations and institutions the analysis of the accident and determine the reason or reasons that caused them. Naturally, in different countries and in different regions of the same country road, climatic and other conditions of functioning of the system DCRE vary considerably, but there are certain common patterns. The least reliable part of the system DCRE is the man. According to some, because of human error - driver and pedestrian - is more than 80% of traffic accidents. The majority of road accidents occur due to incorrect assessment by the driver of traffic and underestimation of its time responding to changes. It should be noted that the time of reaction of the driver will also have an impact on various measures on improvement of the scheme of traffic organization and evaluation of their effectiveness.

2. THE STUDY OF VALUES OF TIME OF REACTION OF THE DRIVER IN VARIOUS ROAD CONDITIONS

Let's examine the change in the value of the bandwidth of the road at the traffic lights regulation when different values of time of reaction of the driver. In the previously written works Shevtsova and Borovskoy [2, 3] in detail described the change in bandwidth when taking into account the extended classification of passenger vehicles. It was also revealed that the considered value is directly related to the distance of security, which in turn depends on the braking time:

$$D = T \cdot \vartheta + \left(\vartheta^2 / 2 \cdot j_з \right) \quad (1)$$

where: T - braking time, s; ϑ- the vehicle speed, m/s; $j_з$- the value of the steady slowing, m/s^2.

Braking time is determined according to the formula:

$$T = T_1 + T_2 + 0{,}5 \cdot T_3 \quad (2)$$

where: T_1 – time of reaction of the driver, sec.; T_2 - the response time brake, sec.; T_3 – the rise time of a slowdown, sec.

The analysis of the literature Sivak, Post, Olson and Donohue; Olson, Sivak, Henson; Lings; Schweitzer, Apter, Ben-David, Liebermann and Parush; Brackstone and McDonald; Triggs; Broen and Chiang; Dingus, Klauer, Neale, Peterson, Lee, Sudweeks, Perez, Hankey, Ramsey, Gupta, Bucher, Doerzaph, Jarmeland, Knipling; Dabbour, Easa; Jost, Allsop, Steriu, Popolizio; Makishita and Matsunaga; Liang, Yuan, Sun and Lin [4 - 15], aimed at studying the duration time of response to different road conditions allowed to systematize the data on the hazard («Signal») and the action of the driver on its emergence («Response») that best describes the movement for traffic regulation. Due to the fact that the aim of this work is the analysis of changes in throughput of the road with this type of traffic organization and identification of changes in the value of interest at different duration of response drivers.

Review time of reaction of the driver in various road conditions, according to tab. 1 made for young drivers, biological aged up to 45 years. Studies of foreign scientists, discussed in this article are made for the period from 1981 to 1996 Sivak, Post, Olson and Donohue; Olson, Sivak, Henson; Lings; Schweitzer, Apter, Ben-David, Liebermann and Parush; Brackstone and McDonald; Triggs; Broen and Chiang [4 - 10], because in these studies was described in more detail hazard «Signal», describing traffic regulation. The value of time of reaction of the driver on the same type of factors differently when exposed to such factors, such as changing light (tab. 1).

Table 1

The response time of drivers according to the USA, Canada and Australia

Researchers	Variables	Total time (psychophysical response)	The factor of danger («Signal»)	Action (-s) of the driver to the danger («Response»)
Sivak, Post, Olson, and Donohue [4]	The location of the light sources (stop signals); Speed; Distance	0.73	Light brake lights of the car in front	Press brakes
Triggs [9]	Age; Road conditions	0.62	Light brake lights of the car in front	Press brakes
Olson and Sivak [5]	Age; Attention (presence of distractions)	0.59	Red light	BB: removal legs with «gas» MB: press brakes
Lings [6]	Experience; Disability; Age; Floor	0.588	Red lights	BB: removing the feet with «gas»
Schweitzer, Apter, Ben-David, Lieberman, and Parush [7]	The distance; Speed; Attention (presence of distractions)	0.535	Light brake lights of the car in front	The application of brakes
Scott, Chandler, and Li [10]	Landing of the driver; The growth driver	0.465	Switching green to red signal	Removing the feet with «gas», pressing on the brake
Lieberman et al. [8]	The distance; Speed	0.638	Light brake lights of the car in front	Press brakes

The values shown in tab. 1 have quite a significant difference, considering in more detail how will change the amount of bandwidth of the highway.

3. CALCULATION OF THE CAPACITY OF THE HIGHWAY AT DIFFERENT VALUES OF TIME OF REACTION OF THE DRIVER

In heavy traffic when traffic regulations by the driver leaves for themselves a safe distance, evaluating necessary for braking time. Based on the previously conducted researches in the field of bandwidth, consider changing this value when different values of time of reaction of the driver. When traffic regulation, the maximum throughput is referred to as a stream of saturation – M_n, the meaning of this value depends on the time necessary for a vehicle that would react in a cross-section of roadway – $t_{traffic}$:

$$M_n = \frac{3600}{t_{traffic}} \quad (3)$$

Earlier studies in the field of traffic regulation showed that the magnitude of the flow of saturation will be significantly affected by the composition of the transport stream, namely accounting extended classification of passenger vehicles. Overview of incoming traffic flows in the city of Belgorod, showed that the differences passenger vehicles quite substantial (Fig. 1). The study found that total traffic flow at week (working) days average of 15000 auth./h., number of cargo vehicles does not exceed 7.2%, buses of 3.2%. Revealed the relationship suggests that the main stream are passenger cars, the average number of which from the General traffic flow is approximately 90%.

The values obtained flows saturation for different classes of cars is proposed to reduce to one - real. In the use of introducing a new definition of a real flow of saturation (M_{real}) - the maximum traffic intensity with which a set of cars of different classes would go in a section under normal conditions 100% combustion light signal. To determine the real flow of saturation is offered by the following formula:

$$M_{real} = M_{n\max A} \cdot k_A + M_{n\max B} \cdot k_B + ...M_{n\max n} \cdot k_n \quad (4)$$

where: $M_{n\ maxA}...M_{n\ maxn}$ – the maximum value of the stream of saturation, depending on the type of movement (straight, right, left) and class passenger car units/hour; $k_A...k_n$ – the factor that determines the percentage of each class of the car in traffic; n – one of the eight common classes of cars.

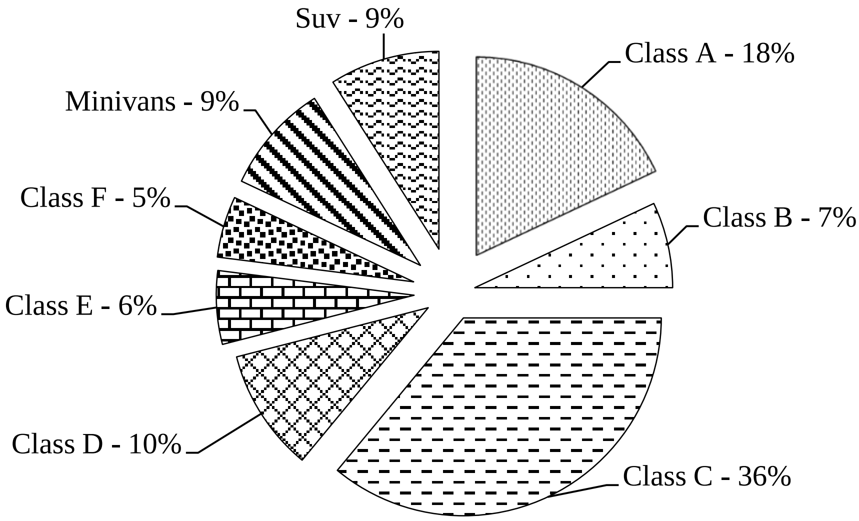

Fig. 1. The average percentage distribution of classes of vehicles for all the entrance areas of the city of Belgorod
Рис. 1. Среднее процентное распределение классов автомобилей по всем въездным направлениям города Белгорода

Using the obtained values of the distribution of main classes of cars, determine the flux of saturation for each of the considered time of the reaction (tab. 1). By calculating the real flow of saturation, using the coefficients of the distribution of the main classes of cars depending on the dimensions adopted according to the Russian-European classification on the basis of the analysis of incoming traffic flows, in Belgorod (fig. 1), the values refer to fig. 2. The calculation made by the formula 4, showed that depending on the changes of time of reaction of the driver will change and the flow of saturation throughput for traffic regulation. So, the real value of the stream of saturation is inversely proportional dependence on the response time, the less response time is assumed in the calculations, the more bandwidth provides a considered site of the road network and vice versa.

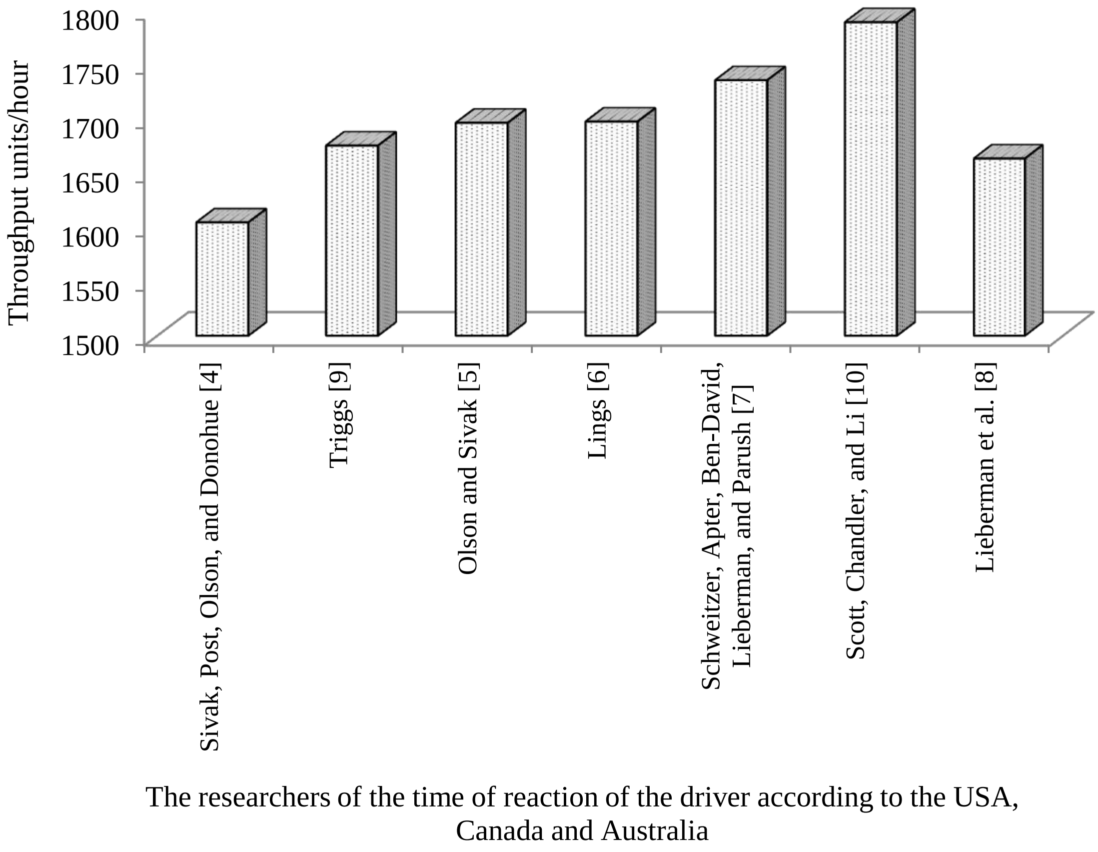

Fig. 2. Changing the bandwidth of the site of road network, depending on the values of time of reaction of the driver

Рис. 2. Изменение пропускной способности участка улично-дорожной сети в зависимости от значения времени реакции водителя

Thus, we can formulate the following conclusion that taking into account the psycho-physiological characteristics of drivers (response time) will have an impact on throughput and the various methods of organization and reorganization of sections of the road network, implementation of which is used investigated the amount of bandwidth. This paper deals with traffic regulation which is directly related to the magnitude of the flow of saturation, here you can talk about what the value will be quite different if the calculation to use the time of reaction of the driver to change the light. To date, studies of the reaction time are not carried out in full, which gives preconditions to the exact methods of traffic organization, both at traffic lights regulation and the choice of method of regulation.

4. CONCLUSION

Undertaking research in this area, possibly, will receive more precise data when carried out the calculations which in turn will help to improve the methods used and reduce the number of delays of vehicles and to prevent satarovich situations, which in turn the majority of causes of road accidents.

Of course, for all the methods of the improvement of the road traffic affected all components of the previously mentioned systems «driver-car-road-environment», and transport must be comprehensive, but, nevertheless, the main is not a reliable factor is human, and it is this factor is under-lays more detailed consideration. One of the variants of this research was to establish the amount, which is used at the stage of planning and organization during road works - bandwidth and its change to the account of one of the components of psycho-physiological characteristics of the driver reaction time. It was determined the impact of this time to the value, so in the future a more detailed review of existing methods for determining the time of reaction and experimental research in this area.

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