

## Traffic Safety

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### INTRODUCTION

High level of accident risk and injury rate during the operation process of road-traffic infrastructure objects and structures in last decade connects with the discrepancy between the demands of society and the state in a safe, comfortable traffic, low effectiveness of the traffic safety system and the lack of discipline of the road users.

Statistic indications attest that the number of the road –traffic accident victims on railway, aviation and sea transports corresponds to the one of the main cause of able-bodied population mortality.

### ARRANGEMENT ACTIONS OF SAFETY TRAFFIC

The safety of traffic and passengers movement on the roads reflects the level of road users security from the road-traffic accidents and their consequences.

Guarantee of traffic safety and demanded operation road qualities is the priority duty of all road organizations.

The concepts of traffic safety guaranty are the following [1]:

1. The road users life and health is the priority over the economic activity results
2. State responsibility for ensuring the road traffic safety is the priority over the road users responsibility
3. Safeguard of citizens, society and state interests at road safeguarding
4. System approach to the road safety insuring activity

The effectiveness of the activity on road repair and maintenance and the improvement of road safety are based on the analysis of traffic movement regularities, accident risks cause results and the conditions in which drivers work

At new construction the project documentation provides the safeguarding during movement with designed speed in dependence on road category. In real road operation conditions the number of interconnected factors influencing the traffic safety is considerably higher (fig.1) The environmental factors are not enough considered, route elements are substantiated for the favorable state of carriage way and good weather.

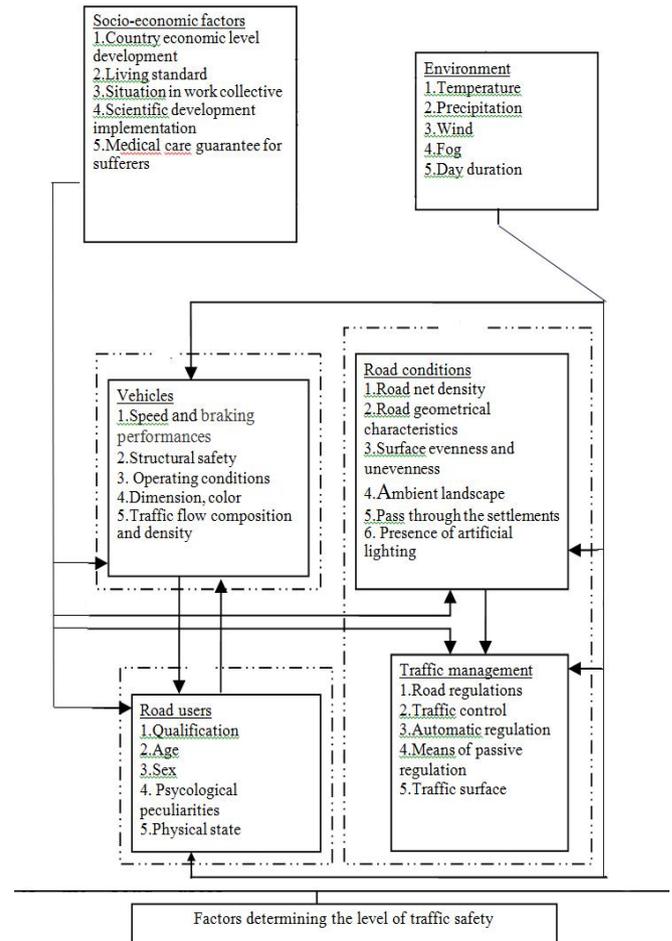


Figure.1: Main factors influencing the traffic safety

Traffic safety dependence on road has two parts – constant determined by geometric parameters and variable depending on the natural factors dynamics, climatic conditions, season and time of day. A road affects on movement by route elements, surface state and driver’s conception about the reasonable brake-release mode.

A road in the complex “vehicle-road – driver” plays passive role. At traffic intensity growth and appearance of more loads – lifting and high speed vehicles there is begun to show the brake between road operational capabilities and the characteristics demanded by the traffic. The exactly the

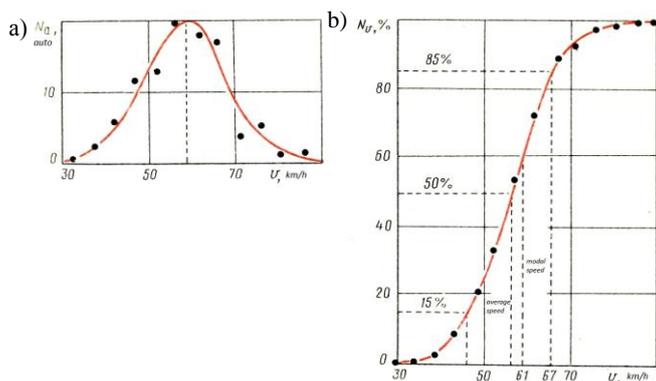
normative requirements for designing correlate with the vehicle development tendencies the longer the life cycle of the structure without the reconstruction[2].

A vehicle affect on traffic safety depends on the perfection of its tractive and braking characteristics, the possibility of quick braking without a sideslip and also on very important for modern buses and truck and tractor-lorry-trailer combinations ability to follow the small radiuses curves and move along their own traffic lane. Insufficient readability and supernormal breakaway can raise the traffic accident risk.

A driver plays the most important role in the complex “vehicle – road – driver”. Timely assessment of road conditions and traffic conditions change he can moderate inconsistent design solutions. It connects with the characteristics of adopted by driver decisions are very average. The traffic condition parameters are given in the standard regulations. They are determined according to the results of observations by the methods of math statistics.

While giving assessment to the typical traffic speeds along any road section with by cumulative curves showing what percent of vehicles move with the speeds less than designed ones proceeding from 85—90% probability (fig.2).

The most typical speed of the maximal number of vehicles corresponds to the point of inflection of curve. A right curve of cumulative curve separates the fastest vehicles breaking safety regulations. Taking into consideration the brake-release mode of such vehicles can increase the requirements for highway which leads to construction cost increase. So it is the reason why the drivers must drive slower than they want. 10-15% of the vehicles move along the curve left section.



**Figure. 2:** processing of traffic speeds control:  
 a) curve of distribution frequency; b) cumulative curve;  
 $N_a$  – vehicle number moving with given speed;  
 $N_v$  – total vehicle number moving with the speed less than designed

That is why roads are designed for normal operation conditions for the main number of the drivers giving them the necessary comfort and safety.

### Analysis o road net influence on traffic safety

The development of road net characterized by road correspondence with its general length, density, road distribution according to the value and category, society social –economic requirements in traffic and passengers travel and plays a great role in accidente forming. Disproportion in road net development leads to irregularity of road occupation with traffic and courses the risks of accidents especially on the sections where the road capacity does not correspond with observed traffic volume.

Now federal road net length is about 52000km with more than 40% of traffic volume among which 100% is international ones.

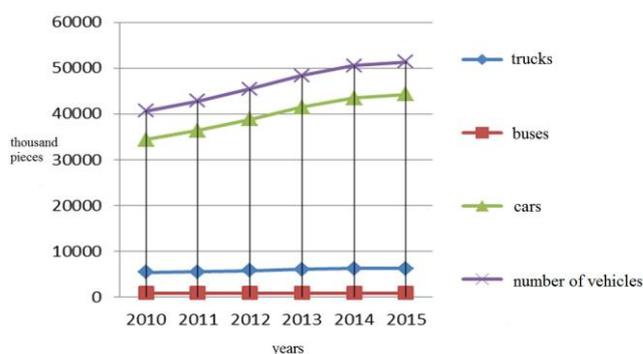
Inter-regional and inter-district road connections, approaches to urban and village settlements are realized with the help of regional roads. Now the regional roads length is 512000km.

Road economy is one of the biggest segments of Russian public wealth. Guaranteed rights of the citizens to freedom of movement travel of goods and service, unity of economic space cannot be realized without road –traffic infrastructure.

But total length of Russian road net does not meet the requirements of socio-economic development of the country, continuous acceleration of the population auto mobilization.

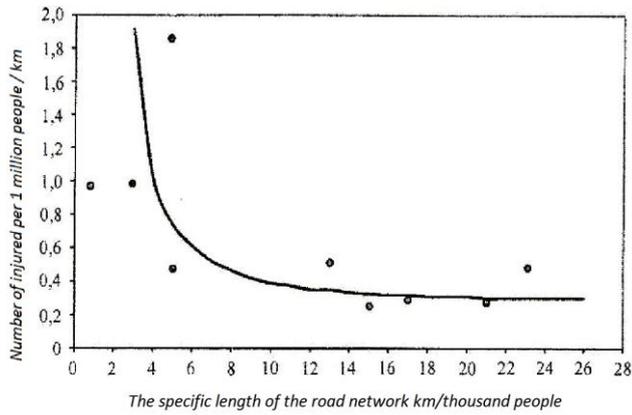
The distribution of the roads with hard surface across regions of Russian Federation is very uneven because of their difference in socio-economic development, population density caused by objective peculiarities of natural- climatic conditions.

The solution of the problem of road net length deficit becomes more actual because of the growth of the vehicle number (fig.3).



**Figure. 3:** Dynamic of the vehicle number change

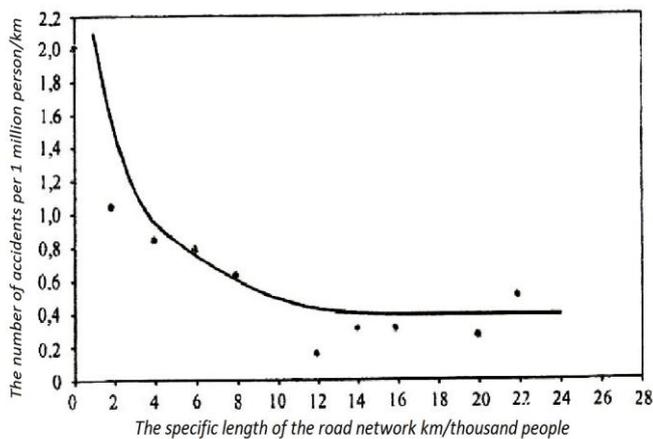
So the length of the public roads deficit negatively affects on the average factor injury risks of road users and total risk of road accident. The information presented in fig. 4 shows that the injury risk grows at the specific road net length less than 6km at 1000 citizens.



**Figure. 4:** Road users' injury risk dependence on specific road net length towards the number of citizens.

Stable increase of specific accident risk for people is observed during the specific length change from 6 up to 12km per 1000 citizens. The further growth of the index more than 12 per 1000 citizens does not influence the decrease of injury risk.

The average accident risk is stabilized and has the lowest value at road net length for 1000 of people more than 14km (fig. 1.3.1.6). With further decrease of specific road length from 14 up to 4 km at 1000 of people the accident risk gradually increases and sharply grows at specific length of less than 4km.

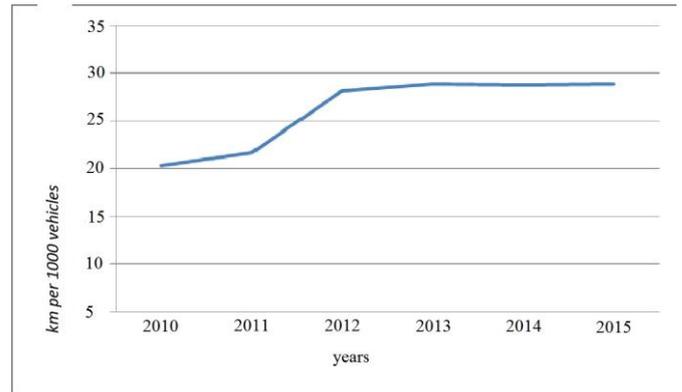


**Figure.5:** Dependence of accident participations on specific road net length

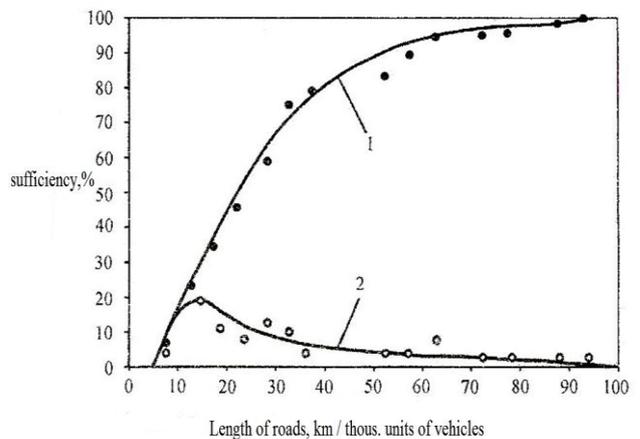
The adduced situation is not accidental as at comparable level of population auto mobilization with specific road length reduction the traffic flow density and participants of traffic accident grows.

Analogical situation is observed if compare the road length for vehicle number in Russia (fig. 6) and abroad which is considerably smaller the average value characterized for the

countries of developed auto mobilization.



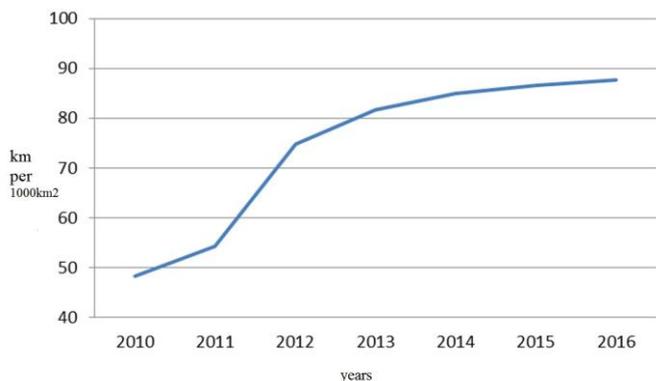
**Figure. 6:** Dynamic of road length changes towards the total traffic number



**Figure 7:** The results of assessment of road length towards the number of vehicles in the countries with developed auto mobilization:

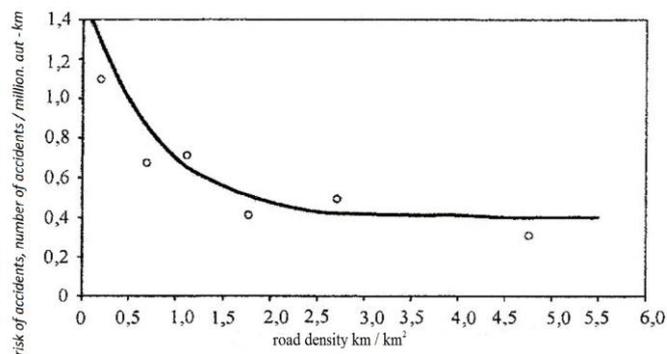
To reduce accidental risk when the road net expansion does not influence traffic safety the total road length should be doubled but the length of the road with rigid surface should be about 1600km. Such road development must be the subject of a long-term program and base both on the calculations according to the criteria of traffic safety and on the detailed substations of investments into road net development with account of budgetary possibilities and economic effectiveness. The social economic effectiveness of such investments because of the increase of traffic safety is a significant component of the calculations if taking into consideration the loss of the one dead person in the traffic accident for Russia is about 300\$ USA.

The similar results can be received if use the results of assessment of road net affect on the level of traffic safety.



**Figure. 8:** Dynamic of the indicator of road net density change

Bringing road net density in correspondence with the requirements of automobile traffic is the principal compound for increasing traffic safety, which approved by the dependence of accident risk on the road net density presented in fig. 9.



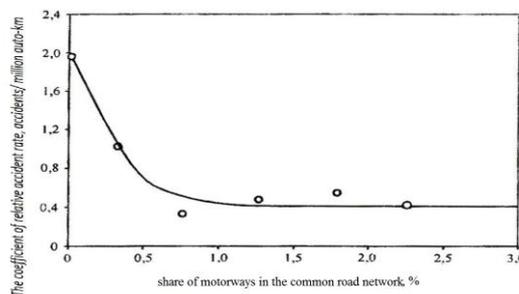
**Figure. 9:** Affect of road net density on accident risk.

The dependence given in this diagram is determined according to the results of mutual accident risk analysis and the road net density in 30 countries of Europe and North America that is why it is necessary to observe it as the tendency of general character. If we use this dependence for assessment of possible accident risk decrease at increase of average road net density in our country then the predicting accident risk decrease on the public roads is approximately from 5 up to 20% with account of the growth rates of vehicle number.

The information about the accident rate improves the deficit of the length of federal high category roads providing the traffic flows with high intensity and very irregular loading of public road net by traffic in general.

The investigation shows that the highway construction promotes the essential increase of the risk along the whole road net,

The results in fig.1 indicate that the high level of safety is reached at highway portion in general road net not less than 1%.



**Figure.10:** Dependence of average traffic accident risk on highways.

The analysis of interaction of separate parameters characterizing road net development on the level of safety shows that specified values of quantities indicators of road net development satisfy every of them.

**Table 1.**

Traffic safety level	Road net length, mln.km	Road net density, km/km <sup>2</sup>	Highways length, Thousand km	Lowning og accidental risk rate
High	12,0-14,0	<More than 1,5	More than 18,5	0,35-0,45
Average	8,0-12,0	1,0-1,5	7,5-15,0	0,45-0,70
Transitional	4,0-8,0	0,5-1,0	Not less than 1,0	0,7-1,0

Values of road net development necessary for traffic safety in Russia

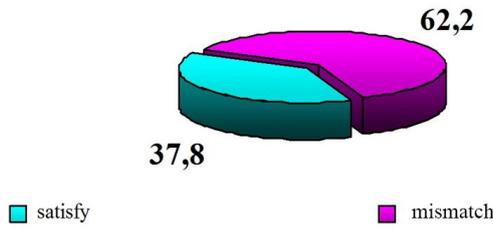
The length extension of public road with rigid pavement up to 46,2 thousand km and federal roads –up to 52 thousand km. is a strategic task for Russia. Accounting the misbalance in traffic means growing and significantly low growth of road net length it is possible to conclude that the achievements of such indexes of road net growth allows stabilizing the accidents number on existing rate.

The total length of road net should be in 1,5-2 times more. The solution of the problem of stable lowning of accident rate is to become the main element of federal national program of the road - traffic infrastructure development and modernization based on the results of accident rate monitoring on the roads.

#### Road conditions affect on the traffic accident rate

Road conditions affect on the traffic accident rate can be assessed according to the results of road net diagnosis which gives the roads condition indexes having the

departure from the norm requirements according to the traffic safety conditions.



**Figure. 11:** Federal roads correspondence with traffic-operational factors normal requirements

The proportion of accidents because of the unfavorable road conditions has been stable during the years and did not exceed 12% from their total number, but since 2000 there has been their growth. It is because the accepted indexes do not correspondent to the road parameters design standards.

The results of traffic accidents risk on the standard sections with average characteristics of road net operation condition indicate of the importance of road net and traffic safety interaction. Straight horizontal sections of double line roads with carriageways of 7,5m, roadsides of 3,75m with rough and even surface located far from the settlements without crossings and junctions can be taken as the standard sections. While analyzing the day time, seasons and surface moisture state at traffic accidents is considered.

It is so happened that average annual relative accident rate on pilot sections are about 25% lower that on double line roads which indicates of road component in the total volume of accident rate. Thus the role of such factors both during the day time, season and surface moisture state is very high. During the traffic on the pilot sections with dry surface in summer day time the risk of traffic accidents is in 5 times less than on pilot sections with wet surface and in 8 times more in comparison with the average rate on double line roads.

The conducted research helped to solve the problem connected with traffic safety by improvement the road maintenance during winter, traffic conditions at nights, enhancement of road surface roughness.

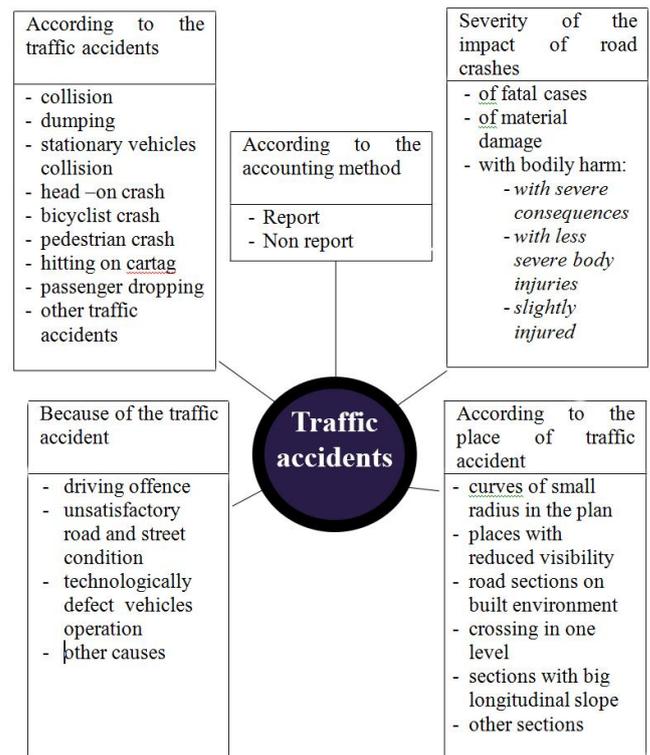
The main problem for the road maintenance is the public roads safety at the expense of minimal necessary operations implementation. Standard level of traffic safety in these conditions was supported mainly by the regulation operation on road maintenance, arrangement of surface treatments of carriageway, placing of safeguards and introduction of local speed limit, prohibition of overtaking on the complicated road sections etc.

To solve the problem there was adopted the new classification of maintenance and repair works and the long – term program

on bringing the federal roads into standard condition base on redistribution of the road budget was realized.

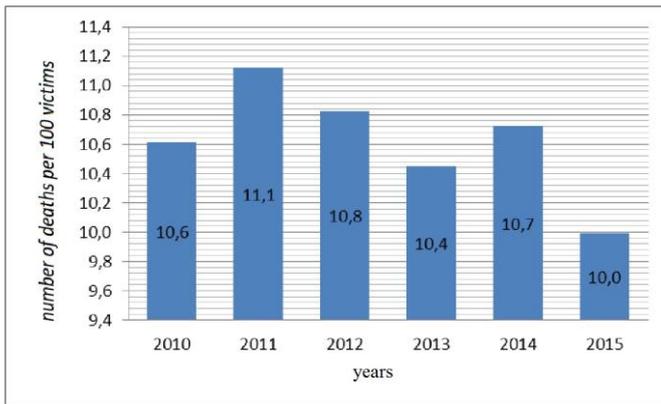
The improvement of public road traffic-operation condition will positively affect on the reduction of accident rate. This can be achieved at the deficit of finances by:

- address planning of actions on increase of accident rate on the road sections where accident rate closely connects with operation defects.
- Introduction of measures on traffic safety increase into the operation volume including annual and medium-term road repair
- perfection of road economy reference base in the sphere of correction of requirements to the road condition from the point of traffic safety.
- Development of the theoretical basis of prediction of accidents connecting with road conditions to prevent the possible formation of dangerous sections because of the road net low operation state.

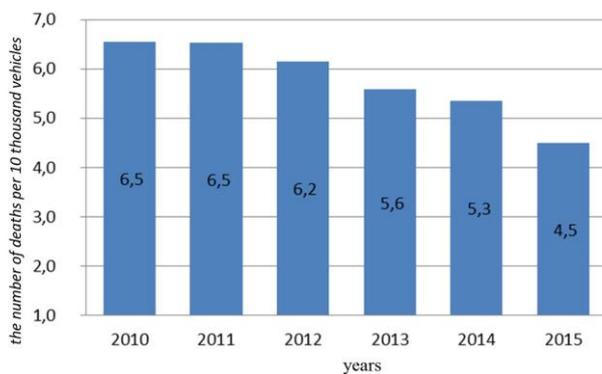


**Figure.12:** Traffic accidents classification

In the period from 2010-2015 there was a gradual decrease in the values of the indicators (Fig. 13, 14) [3].

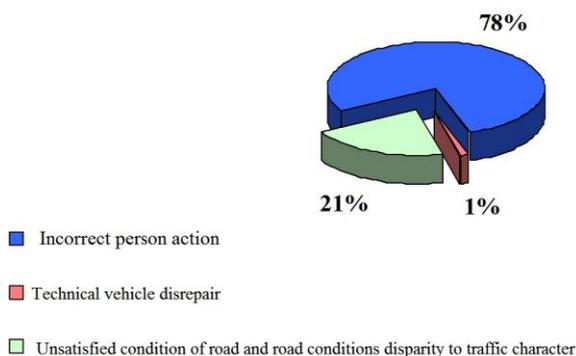


**Figure. 13:** Dynamic of the deaths number



**Figure. 14:** Dynamic of traffic accidents severity change

The statistic analysis of the traffic accidents causes (fig.15) shows that the most number of traffic accidents takes place because of the incorrect person actions (a driver, a bicyclist) and only the fifth part of all accidents caused by the road factors affect[4].

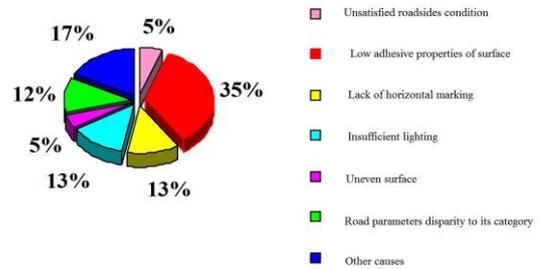


**Figure. 15:** Causes of road accidents

But the detailed analysis of the traffic accident causes indicates that the road condition complicates a car control or calls a driver's mistakes.

Low surface adhesion properties, insufficient lightning, road

parameters disparity to its category, lack of horizontal marking, unsatisfied roadsides condition and uneven surface as they are the main causes of traffic accidents because of the road conditions.



**Figure. 16:** The causes of road accidents with the attendant road conditions

Traffic accidents in the urban conditions and out – of –town public roads are accumulated on the certain sections on which the drivers face with sudden complication of road conditions invoking the necessity to change the formed traffic rhythm or abrupt speed reduction. Such sections are crossings in one level, curves in the plan of small radius, places with limited reduced visibility, road sections on residential. As a result the number of traffic accident is growing every year.

Bid amount of traffic accidents are caused by unfavorable road conditions, imperfection of the traffic scheme organization. In these situations the improvement of the road conditions on the sections of traffic accidents concentration can reduce traffic accident risk on the observed road net.

Organization measures and engineering solutions includes a perfection of road net , guarantee of traffic and pedestrians safety conditions, application of modern methods of traffic regulations, complex schemes of organization of traffic and pedestrian traffic, reduction of road net affect on traffic accidents, road net arrangement.

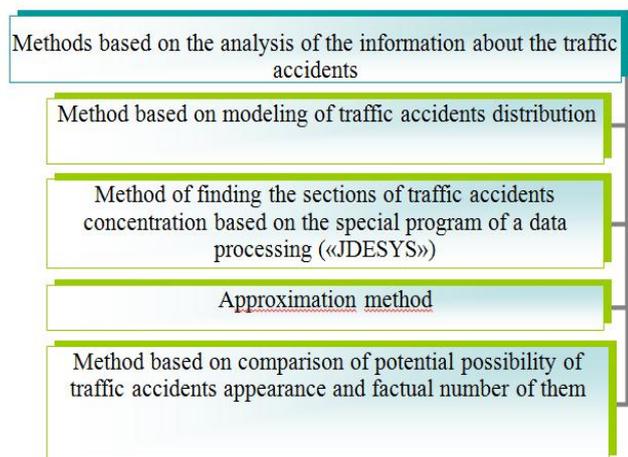
Traffic accidents have the tendency for accumulation on separate sections called the sections of traffic accident concentration characterized by the accident rate level exceeding the designed critical values.

For finding of potentially dangerous sections where it is necessary to plan the immediate measures for traffic safety guarantee can be applied:

- Method based on the analysis of traffic accidents information
- Method of traffic accidents coefficient
- Method of safety coefficients
- Method of conflict situations

The possible application of every method depends on the stage of measures development and also on the information completeness about the traffic accidents on the existed road[5].

The methods of finding the dangerous sections based on the given information are presented in fig. 19



**Figure.17:** Methods of dangerous sections finding

Mathematical apparatus applied for the finding of the sections with traffic accidents concentration on road net with application of the methods of math statistic should promote their reliable identification. There are spatial, interim and spatial-interim models of description of accidents distribution. The most spread ones are spatial-interim models as they are able to be used on any road net.

Engineering basis of finding the sections of traffic accidents concentration with the application of data processing program («JDESYS») includes the preliminary definition of the characteristics of density and severity of the traffic accidents and also the risk of accidents appearance. In this case there is used the system of criteria for including the participants for analysis.

- Number of accidents on the sections more or equal to critical
- Number of accidents with hard followings more or equal to the design minimal number of such accidents
- Number of accidents on the section and number of accidents with hard followings less than relative to the design minimal ones of such accidents
- Number of accidents on the section more than critical number designed in dependence on traffic intensity [6].

#### Assessment of measures effectiveness on traffic safety growth

Assessment of measures effectiveness on traffic safety growth for reduction of accident rate on the sections of traffic accidents concentration is completed by the comparison of the

observed level of accident rate before fulfillment of correspondent road works with the level of accident rate after their execution. The predictable reduction of the accident rate after the realization of the planned measures is determined by calculation with application of the observed results of the accident number change after the implementation of road works for improvement of traffic conditions.

An average variability of accident number reduction on the observed section ( $P_m$ ), expressed in a decimal fraction is taken as the initial data characterizing the

While assisting the probability of accident rate reduction as a result of road works on the sections of accidents concentration it is necessary to account the sections length where the works are done. If the length of this section is less than the length of the section with accident concentration the probability of the accident rate reduction is determined by the formula

$$P = P_m \times \frac{L_i}{L} \quad (1)$$

where  $L_i$  – section length of activities realization with the influence zones, km;

$L$  – length of the section with accident concentration, km;

$P_m$  – average probability of accident number reduction [7]

Average probability of accidents number in a year  $t$  as a result of activities is determined by the formula

$$P_M = \frac{\sum_{m=1}^M \left( \frac{1}{1-P_m} - 1 \right)}{1 + \sum_{m=1}^M \left( \frac{1}{1-P_m} - 1 \right)} \quad (2)$$

where  $M$  – activity number on increase in traffic safety which in a year  $t$  influences the accident rate reduction ( $t_m^{cr} \leq t$ ).

The expected reduction of accidents number as a result of the activities on increase in traffic safety on the sections of their concentration is determined from the following dependence

$$A_t = \frac{N^{OTq} \cdot P_M * Nt * Li}{N_t^{OTq} * Li} \quad (3)$$

$Nt^{rep}$  – accident – traffic intensity in the reported year.

where  $Nrep$  accident – traffic accidents number in the reported year,

$Nt^{rep}$  – traffic intensity in the reported year.

Reduction of accidents number as a result of activities on increase in traffic safety directs to simultaneous reduction of the dead and injured people. The expected reduction of the dead and injured people on the accident concentration sections in comparison with the initial level before the road activities is found proportionally to the reduction of the total number of the accident rate.

Showings of the economic activities effectiveness on increase in traffic safety characterize the reasonability of expenditures for the mentioned activities [8].

The evaluation of the results and expenditures while determining the indexes of effectiveness is done for the whole period of the activities implementation. While comparing two or more variants of activities functions the effectiveness is evaluated for the same period. For the determination of the reference period it is to orientate for the lasting variant. The beginning of the reference period is defined by the moment of the time from which the choice of the variant affects on the future expenditures and results. The end of the reference period is a moment from which the expenditures and results according to the all compared variants practically

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## CONCLUSIONS

1. Reduction of accidents rate on the one territory based on the creation of the holistic mechanism of management of all the kinds of activities of traffic safety guarantee.
2. The leading role in the program belongs to the problem and target system while the sum of the activities, executors' and resources abilities serve only as the means of their achievements.
3. The process of traffic safety proposes the presence of inverse connections allowing accounting additionally appeared possibilities for financing the main program directions, following the changes of relative indexes of accident rate and also unrecorded circumstances.

References of the activities for traffic safety guarantee on the sections with traffic accidents concentration.

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