

Management of High Risk Road Sections of Sarajevo - Romanija Region (Case Study)

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Abstract: Road traffic, as a part of the entire transport system, is an important factor of social growth and development, which is necessary to create conditions for its safe operation, bearing in mind that all the benefits of this phenomenon are still paying a high price of unnecessary human suffering. In a contemporary society, there is a large number of institutions that play a role in the functioning of the transport system, but they stand out as the holders of activities and measures to improve traffic safety. Given that the number of accidents in recent years has reached a worrying level, in the interest of society is to reduce the number of accidents, or to increase traffic safety, because the consequences that the society is submitting in the form of human casualties and material damage are large. The model for the absolute traffic safety does not exist, but a permanent analytical monitoring of the status of road safety, control and regulation of traffic and taking measures to eliminate the risk factors can greatly increase the level of traffic safety.

Keywords: traffic safety, road accident, high-risk road sections.

INTRODUCTION

Considering that the traffic safety system consists of a series of elements which are mutually interdependent and connected in their activities, the main task of the competent authorities is to make decisions about when and to which elements is necessary to direct activities, and therefore limited financial resources, in order to improve traffic safety and reduce the risk of accidents occurrence. Keeping in mind that the road, as one of these elements has a very important role in secure traffic, and requires a significant financial investment, it is necessary to identify high-risk road sections and establish the priorities for eliminating dangerous spots by detailed expert analysis of the road network. In the Republic of Srpska bylaws define procedures for determination of priorities for taking adequate measures to eliminate the defects on the road. The basis for the identification of high-risk road sections is an adequate database of road traffic accidents that would enable determination of real causes of accidents and their connection with deficiencies on the road. Related to previously stated, through this paper it will be given an example of application of the bylaw, as well as guidelines for identification of defects on the roads of the Sarajevo-Romanija region, by the analysis of traffic accident data.

ROAD IN THE FUNCTION OF TRAFFIC SAFETY

The basis of the problem of traffic safety consists of four essential elements, namely: human, vehicle, road and environment. On the occurrence of accidents in traffic, in addition to these four elements, is affected by inadequately defined and harmonized regulations on traffic, insufficient funds for traffic regulation and ineffective control and supervision of traffic flow. However, it is important to find risk factors to which it is possible to affect in order to improve traffic safety. Therefore, it is necessary, inter alia, to take into account the road and all of its elements that can be direct or indirect cause of traffic accidents or which may in any way affect the outcome and consequences of accidents. Expert analysis of the parts of the road network on which action is needed in terms of improving traffic safety, as well as expert formulation of measures to control trading with increased risk of traffic accidents, it is necessary to, among other things, optimize the application of financial resources and to channel funds to those defects that really are risk factors on the roads.

Traffic accidents rarely occur as a consequence of exposure to a single element or cause. They are usually intertwined combination of different elements. Traffic accidents can occur due to the effect of subjective (human) and objective (vehicle, road and environment) ele-

ments. These elements do not act separately, but represent a structural unity, within which the strength of their influence is differed, so it is difficult to measure how each element works in this interaction. In order to take appropriate actions, it is necessary to consider the characteristics of these elements in the field of traffic safety.

The Road as an objective Element of Traffic Safety

The fact that the road affects the driver and vehicle and determines conditions under which the traffic is running and traffic accidents occur, cannot be ignored. Although there is an opinion that the mistakes or bad behavior of drivers, in almost all cases, are the only cause of road accidents, it should be borne in mind that the road is equally important segment in the system of traffic safety, and that the defects on the road can be a direct cause of traffic accidents. Road elements create the conditions in which, the danger caused by some other elements, turns into a traffic accident or affect the severity (result) of it.

The road may not be the main cause of traffic accident, but it can contribute to it in a way that: [1]

- road affects on the driver and the vehicle and determines the traffic conditions and the occurrence of traffic accidents,
- defects on the road may be the immediate cause of traffic accidents,
- road elements create the conditions that the danger caused by other elements, turns into a traffic accident and
- some elements of the road do not affect the occurrence of accidents, but may affect the severity of traffic accident when it occurs.

The driver's obligation is to adjust the speed of his vehicle and his behavior to the road conditions. However, one can not always adapt to road conditions, so it is sometimes necessary to adapt the roads to people. The road should be equipped with signs and communication system, in order to provide high quality and reliable information. Condition and quality of the roads are of extreme importance for the traffic safety, because it affects the behavior of the driver and the vehicle. The road should, first of all, provide safety, comfort and economy and then a high level of service. [2]

The Road Elements in the Function of Traffic Safety

Traffic accidents and critical situations usually occur in places where the situation on the road unexpectedly changes, where traffic flows intersect, merge and divide, where the pedestrians, cyclists or animals unexpectedly appear, at pedestrian crossings etc. The road route significantly affects traffic safety, particularly the changes in road curve radius and road grade. Accidents concentrate on sections with much sharper corners relative to the previous direction or a slight curve, as well as on sections with the rise after a long straight section. Inadequate radiuses and gradients make drivers additionally tired, tensed, impatient and aggressive.

Number of traffic accidents increases with the number of intersections per kilometer of road. This is logical, because each intersection produces larger number conflicts and dangerous situations that can turn on into an accident. The risk of accidents is higher in intersections with more entrances with intense traffic (especially with more vehicles from side roads) and speeding at the intersection entrance. On the other hand, the intersections make drivers more tired, create the conditions for aggressiveness and other negative occurrences that increase the risk of traffic accidents between intersections. [3]

Wet and dirty roadways make steering and braking weaker. The changes in road condition is particularly dangerous. Most traffic accidents happen during the first rainfalls coming after a long dry period. After a long period of driving on a poor condition road, drivers adjust their behavior, thus the risk of traffic accidents decreases. Therefore, in winter conditions occurs lower number of accidents. On the other hand, the drivers drive slower, so the severity of accidents is lower. [1]

Alongside the road are often different obstacles (trees, concrete pillars, different objects, vegetation, etc.) that affect active and passive road safety. If these barriers obstruct visibility, it may contribute to the occurrence of traffic accidents. Common obstacles make drivers tied and occupy their attention and increase the risk of traffic accidents. On the other hand, obstacles affect the passive traffic safety. In the case of a collision with solid obstacles the severity of traffic accidents is being increased. However, the barriers may have a positive effect on accident severity. Nowadays, as a measure for speed reduction at intersections and other dangerous places are being set obstacles that reduce visibility and force drivers to reduce speed in dangerous areas. While this may increase the number of minor accidents, thus reducing the number of accidents with the greatest consequences. Therefore, these obstacles can adversely affect the active traffic safety (increasing the total number of accidents), but can be positive for passive safety (reducing the consequences of accidents).

According to some statistical data, 15-25% of road accidents occur due to bad road conditions. When analyzing the state of pavement on roads in the Republic of Srpska and its role in traffic safety, it can be said that our roads are "old" and that the surface is worn, and that investments in order to improve them are unsatisfactory, precisely because of limited financial funds. Poor condition of road surface results in deterioration of security elements during the occurrence of dangerous situation, that can be reflected in the extension of stop time of the vehicle.

It is possible to identify risk factors or elements that may negatively affect the number, flow and consequences of traffic accidents, either alone or in interaction with other elements, such as:

- damage and potholes on the road,
- substrate with a low adhesion coefficient,
- insufficient horizontal and vertical visibility,

- inadequate road gradients,
- inadequate ruts or
- narrow roadway along road curves.

HIGH-RISK ROAD SECTIONS MANAGEMENT

Considering that the elimination of road defects requires an investment of substantial financial resources, there is a need for detailed analysis to identify a real risk factors and determine priorities for taking action. For subjects that manage the roads it is a difficult task to assess the safety infrastructure of some road sections independently of other components, in order to set priorities to improve the infrastructure. Because of that, a different methodologies defined by Directive 2008/96 [5] describe a method of analysis of the road network in terms of traffic safety and provide assistance to the relevant entities to identify high-risk sections and rank these according to priority treatment. In accordance with this, road safety inspection and expert analysis on a national level is being adjusted.

The Legislative Framework for Road Safety Inspection and Management of Dangerous Spots on Public Roads

Modern approach of increasing road safety involves the combined use of active and preventive methods, because the preventive methods can not eliminate all the defects on the road. However, prevention methods are much better, because the problem is being solved before the occurrence of accidents and casualties.

In the White Paper of 12 September 2001 "European transport policy for 2010", the European Commission has expressed the need for evaluating the impact on traffic safety and the implementation of road safety inspection, with the aim of defining and fixing conditions on high-risk sections within the EU. With its Directive of the European Parliament and of the Council of Europe no. 2006/0182 on safety management of road infrastructure, published in October 2008, the European Union made a clear decision about the measures and methodologies to increase road safety, where, among other things, road safety inspection (RSI) will be required for the European road network in the years that follow. [1]

According to this, through different legal documents is defined legislative framework for the road safety inspection in Republic of Srpska. The Law on Road Traffic Safety of the Republic of Srpska (Article 28 and 30) prescribes that, in order to improve the conditions for safe traffic, a system of mandatory independent inspection of existing public roads in terms of traffic safety (RSI) is being established. [6]

When it comes to managing dangerous spots on public roads in the Republic of Srpska, as one of the management segments of traffic safety, was adopted the document on Regulations which prescribes definitions,

conditions and obligations on the identification of dangerous spots, the process of identification, determination of priorities and ways of elimination and evaluation of the proposed measures to eliminate dangerous spots.

Stakeholders in the Process of Road Safety Inspection and Management of Dangerous Spots

In the system of traffic safety there is a great number of entities directly or indirectly involved in traffic safety management system, and each of these entities has its own function, and bears a special responsibility in terms of increasing the level of safety and creating better conditions for safe traffic. The most important entities in analysis and verification of public roads safety and dangerous spots management are the Government, the Ministry of Transport and Communications, Traffic Inspectorate and Road management company, which in accordance with the above mentioned document on Regulations, has special responsibilities and obligations in road safety inspection and dangerous spots management on public roads.

Road management company implies a public company, concessionaire, other legal entity or competent authority of local community responsible for managing the roads in accordance with the law. Road management company, as one of the parties directly involved in the traffic safety system has a specific and particularly important role when it comes to traffic safety management and is required to annually perform the identification of dangerous spots on public roads by using data on road accidents and the average annual daily traffic. When drawing up a plan of repair of dangerous spots, the company is obliged to firstly repair dangerous spots with the highest priority and to perform an expert analysis of at least 20% of dangerous spots with the highest priority annually. [4]

Road management company is obliged to, in accordance with the annual plan, perform expert analysis of dangerous spots and high-risk road sections, prepare projects for the repairing of dangerous spots and dangerous sections, and take other measures to improve traffic safety [4]. At least once a year road management company is required to report to the Ministry of Interior and the Ministry of Transport and Communications, delivering the information on identified dangerous spots, priority list for reparation, about performed expert analyzes and applied measures for reparation of dangerous spots. All subjects, including the road management company are obliged to continuously work on improvement of quality and availability of database on road accidents, which are the basis of monitoring traffic safety and road safety inspection.

The Procedures for Dangerous Spots Management on Public Roads

Dangerous spots management on a public road is the procedure of determining spots with distinctly increased risk in traffic, defining, implementing and monitoring the effects of measures aimed to reducing the risk of traffic ac-

cidents in these areas and procedures for management of dangerous spots regulated by Regulations document. Prior to presenting the dangerous spots management algorithm, it is necessary to clarify the terms “dangerous spot”, “dangerous part of section” and “dangerous section.”

Dangerous spot is a spot on the suburban public road up to 300 meters length where at least six traffic accidents with affection on human health and life happen during three year period, or an urban public road up to 100 meters length where at least four traffic accidents with affection on human health and life happen during the same period. Dangerous part of section is a part of suburban road up to 1500 meters length, which includes at least two dangerous spots, measured from the first dangerous spot. Dangerous section is a part of suburban road more than 1500 meters length with includes at least one dangerous spot per kilometer of road. [4]

During the dangerous spots management on a public road it is necessary to conduct the procedure through the following stages (Figure 1):

- Identification and ranking of dangerous spots;
- Analysis of dangerous spots and proposing measures;
- Implementation and monitoring of measures to eliminate the dangerous spots.

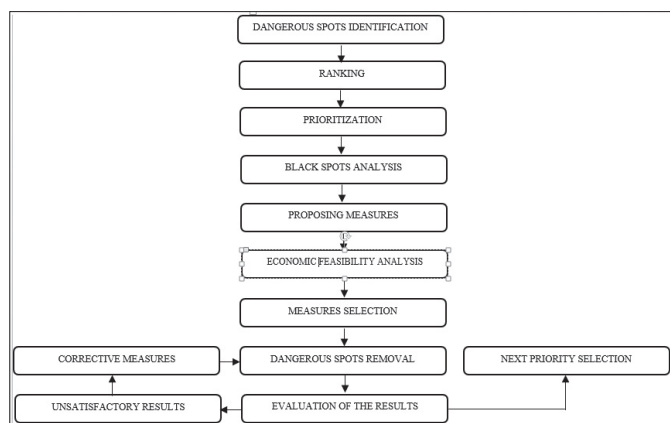


Figure 1. Simplified algorithm processes of dangerous spots management [4]

After identification, mapping of dangerous spots is being performed, as well as mapping the density of traffic accidents based on the data of location of traffic accidents. In those maps it is possible to include all available data such as flow, geographic characteristics of the terrain, objects, as well as other data describing the location of dangerous spots which may be of importance in determining risk factors. From the above definitions we can conclude what is the importance of having an adequate database on road accidents with precise data about exact spot of traffic accidents and their consequences.

Identification of Dangerous Spots on the Public Road

Identification of dangerous spots on public roads

is one of the segments of traffic safety management and road safety inspection, aimed to identify high risk road parts, as well as taking measures to eliminate these risk factors. Considering that the major problem for the entities involved and responsible for traffic safety is reasonable and justified investment of funds to improve traffic safety, the identification and ranking of priorities on high-risk sections and dangerous spots provides proper aiming of these funds precisely where needed.

Given the fact that investment in roads as an element of traffic safety require significant financial resources, it is especially important to perform detailed expert analysis in order to identify the main defects on road infrastructure, which removal would increase the level of traffic safety [7].

Risk Assessment of the Traffic Accident Occurrence per Municipalities of Sarajevo – Romanija Region

Considering that solving the problem of traffic safety is not only the responsibility of entities on the national level, it is necessary to emphasize the role of the local authorities (municipalities) in undertaking activities aimed at creating safer traffic conditions. According to this, it is essential for the authorities in the local government to realize and recognize the risk of traffic accidents, actually that on the basis of reliable analysis results have a clear idea of where and how they can affect to reduce the risk of traffic accidents. For this purpose may be useful a risk assessment of traffic accidents occurrence per municipalities, which are based on exposure of traffic participants to a risk of traffic accidents occurrence. Related to this, as the most reliable and the most commonly used indicators for risk assessment in road traffic exist:

- The number of fatalities per 100,000 population (public risk);
- The number of fatalities per 10,000 registered vehicles (traffic risk);
- The number of fatalities per 100 million kilometers (dynamic traffic risk).

Public risk represents mortality rate (the annual number of fatalities) per 100,000 population and measure the risk of of each inhabitant to die in a traffic accident. Different areas can be compared according to this criterion only if their population is equally exposed to traffic. If there are a significant differences in the level of motorization (number of registered vehicles per 1,000 population) and the mobility of the population (number of trips and the mileage), then isn't correct to compare areas (municipalities) only based on indicators of the public risk. So there are some other relative indicators of traffic safety that can be used, especially traffic risk.

Traffic risk represents mortality rate (the annual number of fatalities) per 10,000 registered vehicles and it takes into account the level of motorization. It is possible that two areas may have a similar level of motorization, but the degree of use of vehicles is significantly

different. Therefore it is necessary to take into account the mobility of the population during the assessing level of traffic safety. If mobility is significantly different, then the level of traffic safety can be evaluated using dynamic traffic risk.

Dynamic traffic risk represents the number of fatalities per 100 million kilometers. This indicator is the best measure of the risk of fatalities during the trips by car and the best indicator of traffic safety. However, there are a lot of problems related to the determination and application of dynamic traffic risk. The main problem is determination of the mileage in a certain period. Mileage can be measured directly (correctly determined kilometers of each vehicle during the regular technical inspection), calculated indirectly (the quantity of sold fuel, as well as average fuel efficiency), or evaluated through a pilot studies (determining the mileage of the representative samples of vehicles) and so on. Considering that there isn't developed methodology of determining the mileage in the Republic of Srpska, the risk assessment based on this parameter does not apply.

Below are presented the maps of public risk (Figure 2) and the traffic risk (Figure 3) for the individual municipalities of the Sarajevo-Romanija region, which are based on the number of fatalities, as well as registered vehicles in 2015, and the data of population per municipalities in recent years.

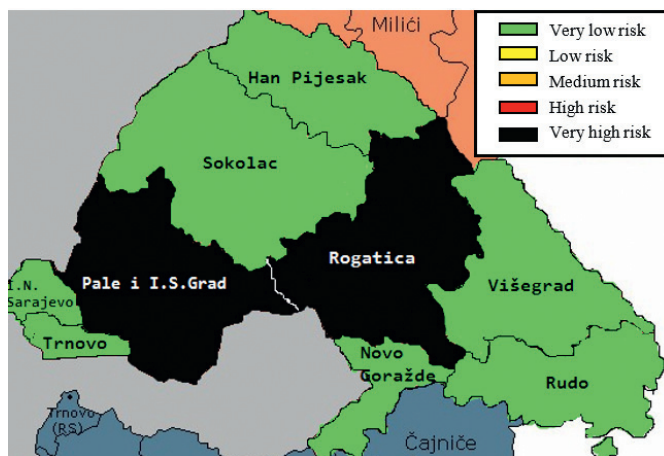


Figure 2. Public risk per municipalities of the Sarajevo-Romanija region

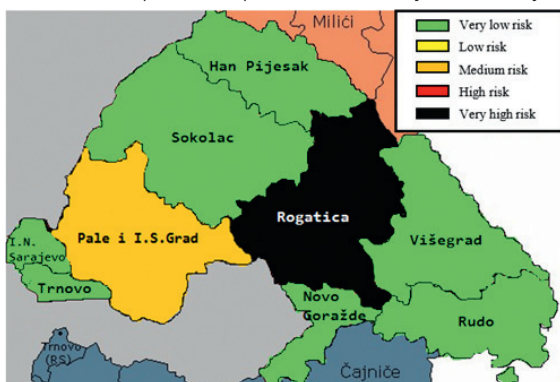


Figure 3. Traffic risk per municipalities of the Sarajevo-Romanija region

In the traffic safety assessment process of some specific location on the road (vertical or horizontal curve, bridge and others endangered places) it should be used parameters that take into account the intensity of traffic, such as number of accidents per 100,000 vehicles that pass through these sections, as well as the number of victims (fatalities and injured persons) to 100,000 vehicles that pass through these road section.

If we consider the traffic safety assessment on the crossroads, it is important to observe the geometry of crossroads and traffic regime at driveways (the crossroads similar in geometry and regime of traffic can be compared).

Prioritization of removing Dangerous Spots on Road Network of Sarajevo – Romanija Region

The implementation of certain measures aimed to improve traffic safety requires an investment of significant financial resources, so it is necessary to optimize their use and direct them where their application is justified. This ensures that the ratio of invested funds on one side, and savings caused by reducing the number traffic accidents and their consequences on the other side, would be as big as possible. Therefore, it is particularly important professional identification of parts of the road network on which action is needed in terms of traffic safety, what can be done based on the risk assessment on roads and detailed analysis of high risk sections and finding valid solutions for improvement.

Regulations define the procedures for prioritization of dangerous spots on public roads in the Republic of Srpska, and this requires data on the number, structure and consequences of traffic accidents, with emphasis on incidents which have resulted in dead and injured persons, as well as data on average annual daily traffic (AADT).

Prioritization of dangerous spots on a public road shall be based on the following indicators: [4]

1) The coefficient of severity of accidents (C_s), which is determined by:

$$C_s = 1 \cdot MI + 13 \cdot SI + 99 \cdot DI$$

where:

MI - the number of persons who have suffered minor injuries in reported road accidents,

SI - the number of persons who have suffered serious injuries in reported road accidents,

DI - the number of persons who have suffered injuries that caused death within 30 days,

2) The coefficient of potential dangers (C_{PD}), which is determined by:

$$C_{PD} = \frac{MSDI}{365 \cdot AADT \cdot 10^{-6}}$$

where:

MSDI - number of accidents with minor and serious injuries and dead persons,

AADT - average annual daily traffic.

The ranking list of priorities is based on the value of the coefficient of priorities, which is calculated by the formula:

$$C = 0,8 \cdot C_s + 0,2 \cdot C_{PD}$$

Considering that the data on traffic accidents in the Republic of Srpska show that a large number of them happens on roadways and taking into account the functional and economic importance of roadways, this part of paper will give an example of determining the order of priority in the management of high-risk sections and dangerous spots on roadways M-5, M-18, M-19, M-19.3 and M-20, according to the division into sections by which a database is being made (calculation based on data of traffic accidents that have occurred in 2014, and the value of AADT for 2011) [8].

Table 1. Ranking road sections based on calculation of the coefficient of priorities

Roadway	Roadway sections	Length of the section (km)	AADT	C
M-19.3	Podromanija - Rogatica	28,598	2502	344,456
M-19	Sumbulovac - Ljubogošta	5,030	5224	241,744
M-5	Ljubogošta - Pale 1	4,460	5112	182,829
M-19	Han Pijesak 2 - Sokolac	27,483	1724	133,578
M-5	Sastavci - Ustiprača	11,195	2091	126,386
M-19	Sokolac - Podromanija	3,598	7047	113,111
M-5	Ustiprača - Međeđa	12,890	1892	83,269
M-20	granica RS/FBH (Kopači) - Ustiprača	8,127	3731	82,187
M-5	granica RS/FBH (Lapišnica) - Ljubogošta	6,884	7197	59,085
M-19	Podromanija - Sumbulovac	21,559	3769	46,399
M-18	Kula - Krupac	5,165	7746	38,895
M-18	Krupac - granica RS/FBH (Bogatići)	11,265	3360	35,689
M-5	Dobrun - granica BH/SR (Vardište)	6,226	872	35,314
M-5	Brodar - Višegrad 1	10,950	2680	22,809
M-5	Višegrad 1 - Višegrad 2	0,660	3240	22,107
M-5	Pale 1 - Podgrab	15,660	1860	12,589
M-19.3	Rogatica - Sastavci	6,422	2410	12,455
M-5	Podgrab - granica RS/FBH (Prača)	6,155	1728	1,917

Table 1 shows the results of the coefficient of priorities calculation, based on which sections are ranked according to priority of interventions or shares on which it is necessary to carry out detailed expert analysis, to identify all the defects on them that are potential causes of accidents. In order to implement more qualitative analysis it is necessary to have reliable information on exact location of accidents, aimed to precise identification of dangerous spots, taking into account the period of 3 consecutive years, as defined in the Regulations [4].

The Procedures of Road Safety Inspection Based on Traffic Accidents Data

In order to perform detailed and expert road safety inspection on identified high-risk sections and dangerous spots, it is necessary to dispose with adequate data on traffic accidents that have occurred, especially in terms of number, structure, consequences and characteristics and timing of the traffic accidents, participants in the accident, the condition of external factors and weather conditions at the time of occurrence of accidents and trip data (state of the road surface, infrastructure and equipment, damage on the road, obstacles, etc).

These data provide conditions to road management company to carry out field inspection of dangerous spots, which contains the following procedures: [4]

- Examination of the site and inspection of maps of dangerous spots;
- Inspection of a traffic accident location and obtaining detailed data on traffic accidents through access to the investigating documentation in accordance with special regulations;
- Inspection of condition of the road and road surface, traffic planning and regulation;
- Other known methods.

Considering the previous chapter provided the identification of high-risk sections on roadways M-5, M-18, M-19, M-19.3 and M-20, and that the priorities are identified for intervention, it is partially created a precondition for detailed expert analyses of sections. For the purpose of providing guidelines for the analysis of crash data and connecting their elements with the road damages, in this paper is given a brief analysis of certain elements of traffic accidents that occurred in 2015 on the roads in the area covered by the PSC East Sarajevo. As there were not available detailed data exclusively for the roadways, the analysis applies to all categories of roads that are located in this area, but statistics show that the largest number of registered traffic accidents (1068) happened just on roadways (483). Considering that fact, it is obvious that this category of roads have priority in taking measures and elimination of defects.

Also, if it is considered the location of traffic accidents on the road in 2015, it is noticeable that the largest number of them occurs in a urban area (604 accidents of 1068 totally registered) characteristic by frequent traffic flows intercession, merging and dividing, which creates a greater number of conflicts and dangerous situations that can turn into an accident. Also, the traffic is more intense, and there is frequent appearance of large numbers of pedestrians and bicyclists. Because of that it is necessary to consider the needs of all participants in traffic (additional lanes, pedestrian and bicycle paths, etc) and traffic signs (horizontal, vertical, traffic lights) to clearly regulate movement and the right of passage.

Statistical data show that traffic accidents usually occur on straight roads, horizontal curves and intersections, which can be seen from the chart 1.

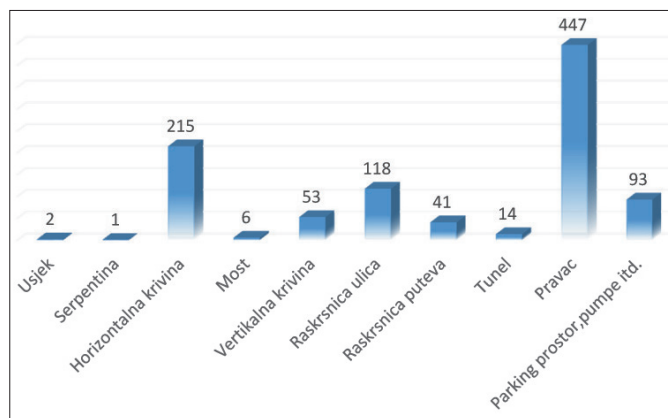


Chart 1. Traffic accidents with regard to location of occurrence

Of the total number of traffic accidents (1068) that occurred in 2015 on the roads in the area covered by the PSC East Sarajevo, there were only 10 traffic accidents occurred as a result of sediment and rock falls on road, 8 accidents caused by defects or deficiencies or traffic signals road equipment, and 1 accident caused by road surface damage. For the remaining 1049 traffic accidents, during the investigation were not recorded obvious disadvantages on the road surface and/or its equipment, which does not necessarily mean that the individual elements (road surface condition, insufficient lighting, narrow road in horizontal curves, lack of pedestrian lanes) were not cause of road accidents or influenced the outcome and their consequences.

In order to make a systematic approach to the analysis of traffic accidents, it is necessary to consider the aspect of traffic accidents by their origin, where it is necessary to dispose with accurate information where those accidents occurred. Based on data on road accidents that occurred in the area covered by the PSC East Sarajevo in 2015, it is important to mention the significant number of accidents that resulted in collision with another vehicle (624), crashing vehicle off the road (151), vehicle rollover (34) and rush into the animals (10).

Since the state of road surface (wet, dry, icy or snow-covered) together with other elements of the road, can also be a risk factor and the cause of traffic accidents, it is important to consider these factors during expert analysis, considering that the individual defects can be eliminated by better maintenance (drainage regulation, sprinkling abrasive materials and intensive snow removal during the winter, etc). Analysis of data shows that 567 accidents occurred on dry roadway, 331 on wet and 95 on icy and snowy driveway.

Considering the fact that bad weather conditions increase risk of traffic accident, it is necessary to analyze whether any elements of road during lower or normal visibility (day, night, fog) can additionally increase the risk. Therefore, it should be considered existence and visibility of horizontal and vertical road signs, protective fences and other road equipment and lighting on road junctions. Also, it is necessary to identify if there are any damages

or obstacles on road/alongside the road, which require additional temporary traffic signals, in order to alert all traffic participants on time about dangerous situations that cannot be noticed in lower visibility conditions. Previously stated is caused by the fact that large number of traffic accidents registered in 2015 occurred during the low visibility conditions (night, dusk and dawn - 281 traffic accidents, fog - 29 traffic accidents), of which 5 fatalities, 25 with seriously injured and 49 with minor injuries.

These are only some of the data on traffic accidents which may be considered during analysis and road safety inspection, but can be useful during the identification of road damages in order to establish and enforce measures to eliminate these problems or at least keep them at minimum, and thus reduce the risk of traffic accidents.

Considering the above data, it is necessary to perform analyses and road safety inspection based on following parameters:

- Function of road;
- Cross-section of road;
- State and maintenance of road;
- The road route;
- Appropriately designed and marked intersections;
- Adequately designed and marked tunnels;
- Public and private services, restroom facilities, public transport;
- The needs of endangered traffic participants;
- Adequate protection of road from wild and other animals;
- Adequate traffic signs, marking and lighting;
- Features of curbs and passive road safety.

It is important that road safety inspection procedure or technical analysis is carried out carefully and with consideration of all the road elements, by using the expertise and best practices in the assessment of the current situation. It is desirable that in the process of checking and analysis to involve experts with significant experience in design and construction of roads, road safety engineering and accident analysis and persons with knowledge related to maintenance of roads, including signaling, lighting traffic signals, vegetation and snow removal.

PROPOSING THE MEASURES TO ELIMINATE DANGEROUS SPOTS AND MONITORING

After completion of the technical analysis, summarizing the results, the identification of defects on the roads and finding ways for their removal, it is possible to suggest some of the following measures: [4]

- Removal or protection of the lateral interference;
- Speed limits, improving control of speed limits;
- Improving visibility in different conditions;
- Improving the passive protection of road and reconstruction of road safety equipment;

- Improving the logical connection, visibility, readability and location of traffic signs;
- Protection against escarpments, landslides and snow drifts,
- Improving intersections;
- Change the width of the road by adding side banks of solid surfaces;
- Installation of traffic control system;
- Reconstruction of the road in accordance with the applicable standards of design;
- Reconstruction or replacement of road surface;
- The use of intelligent transport systems (eg. variable traffic signs);
- Other known technical measures.

All proposed measures are necessary to be evaluated in order to deliver adequate and acceptable choice of those which will justify the investment in technical and security as well as economic terms. Firstly, it is necessary to make evaluation of the economic feasibility of investments, as well as a comparison of the proposed measures based on the criteria for selection of measures. It is important to note that while proposing measures aimed to removal of road defects their safety effects should be considered. Besides that, the following criteria are being considered:

- technical feasibility,
- economic justification,
- possibilities,
- convenience and
- compatibility.

Since all the measures proposed, among other things, are being evaluated through economic justification, it is necessary that road management company provide an investment plan for implementation of these measures, in order to make decisions about necessary investments. After presented defects and proposed measures with a detailed analysis and evaluation of the same, the final decision whether the recommendations will be adopted or not is being made. It is desirable that all documentation arising from the very beginning of road safety inspection, starting from the data collected on traffic accidents remains a part of the project documentation.

After the proposed specific measures are implemented, it is necessary to conduct monitoring of the situation in order to determine the feasibility of the entire project, both in terms of efficiency and funding. Monitoring can take several years after the implementation of corrective measures.

CONCLUSION

Considering that unsatisfactory level of traffic safety requires appropriate individual and joint intervention of all subjects involved in the system and also directing of activities and financial funds, in segments of traffic safety system in which the "hidden" fundamental prob-

lems appear, it is important that mentioned subjects constantly perform monitoring and analysis of the situation, which is the basic prerequisite for traffic safety management. Considering that the road, as one of the elements of traffic safety has a key role in the smooth operation of traffic, it is necessary to maintain it in such a condition that the risks of traffic accidents would be minimal. If an accident does occur, road equipment should be adequate in order to mitigate the consequences of these accidents. However, providing the adequate road infrastructure and creating uniform conditions for safe traffic performance is a problem of entities responsible for road management to direct its activities and significant financial resources where needed.

The task to assess the impact of road on the occurrence of accidents can be difficult for the entities that manage the roads, so it is necessary to perform expert analysis and verification of safety of all road elements. Regarding to this, the objective of this study was to give an example of identifying the priorities to eliminate dangerous spots on high-risk road sections according to the Regulations document, as well as an example of data analysis on traffic accidents to determine the defects in the road which is necessary to be eliminated. Evaluating and adopting adequate measures being proposed can save a considerable amount of financial funds, and most importantly, improve roads and increase the level of traffic safety.

REFERENCES

- [1] Mandić, V. Identifikacija visokorizičnih dionica na magistralnoj putnoj mreži shodno Direktivi 2008/96. *Master thesis*, The Faculty of Traffic and Communication, Sarajevo, 2012, pp. 18-24.
- [2] Truman, W., Clarke, D., Ward, P. and C. Bartle. An In-depth Study of Workrelated Road Traffic Accidents. *Road Safety Research Report*, No. 58, University of Nottingham, United Kingdom, 2005.
- [3] Lipovac, K. *Bezbednost saobraćaja*. The Faculty of Transport and Traffic Engineering, Belgrade, 2008.
- [4] Pravilnik o identifikaciji opasnog mjesta, načinu i kriterijumima za utvrđivanje prioriteta otklanjanja opasnih mjesta i načinu otklanjanja opasnih mjesta. Službeni glasnik RS, No. 94/14, Banja Luka. 2014. pp. 23-25.
- [5] Directive 2008/96/EC on road infrastructure safety management. Official Journal of the European Union, No.319/59.EN.2008.http://www.polisnetwork.eu/uploads/Modules/PublicDocuments/191108_Directive_road_infrastructure_safety_management.pdf. Accessed Oct. 6, 2015.
- [6] Zakon o bezbjednosti saobraćaja na putevima Republike Srpske, Službeni glasnik RS, No. 63/11. Banja Luka.2011.[http://www.mup.vladars.net/zakoni/rs_cir/ZAKON%20O%20BEZBJEDNOSTI%20SAOBRAĆAJA%20NA%20PUTEVIMA%20REPUBLIKE%20SRPSKE%20\(Službeni%20glasnik%20RS,%20broj:%2063.11\).pdf](http://www.mup.vladars.net/zakoni/rs_cir/ZAKON%20O%20BEZBJEDNOSTI%20SAOBRAĆAJA%20NA%20PUTEVIMA%20REPUBLIKE%20SRPSKE%20(Službeni%20glasnik%20RS,%20broj:%2063.11).pdf). Accessed Nov. 8, 2015.
- [7] Mandić, V. and Lindov, O. Metodologija upravljanja visokorizičnim dionicama putne mreže korištenjem dubinske analize saobraćajnih nezgoda. In Proceedings of the 3rd B&H Congress on Roads, Sarajevo, 2012, pp. 2-13.
- [8] Vehicle counting on the Road network of the Republic of Srpska. P.C. „Republic of Srpska Roads“, Banja Luka, 2013.http://www.putevirs.com/korisnik/dokumenti/Brojanje_saobraćaja_2011.pdf. Accessed Dec. 15, 2015.