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PROFESSIONAL PAPER

Passive Road Safety Systems – Case Study of Road Section Prnjavor- Doboj (M16.1, R474, R474a)

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Abstract: The European Parliament and the European Council have adopted the Directive 2008/96/EC relating to the safety of traffic infrastructure. This Directive binds the EU Member States to implement the guidelines on roads comprising the parts of the Trans-European traffic network, regardless of the stage those roads are in. EU Member States have a possibility to adopt the guidelines and regulations from the Directive and build them into the national regulations on parts of the roads that are not a part of the Trans-European roads. Based on the facts stated above, there is a research problem in a form of a question "Can the Directive 2008/96/EC be applied in the traffic in Bosnia and Herzegovina?" i.e. are its guidelines implemented as a manner of approximation with the EU regulations, and what are the effects of its implementation. This is a traffic problem in its nature, closely related to road traffic safety, and we find the answer to the research problem in theoretical and empirical research in this area.

Keywords: inspection, road, traffic safety.

INTRODUCTION

In the world, 1.3 million people per year die in traffic accidents, and more than 50 million people remain permanently immobile or suffer injuries. This statistics of Bosnia and Herzegovina shows that it contributes with at least 400 dead and 11,000 injured persons per year. The traffic death rate in BiH is three times higher than in Western European countries, according to official statistics over 10 people have been killed per 100.000 inhabitants. This difference can be even bigger if you take into account accidents that have not been recorded. The actual number of people killed in traffic accidents in the Republic of Srpska is higher than the registered number in the official statistical data. In modern conditions, the country's traffic infrastructure has an extremely high significance, since it connects with other countries. However, the key problem that arises in the mentioned segment is the safety of the participants in the traffic. Bearing in mind that significant investments are made in transport innovations and the improvement of means of transport, which now have significant opportunities and acceleration, there are often traffic accidents with certain consequences for the participants in the traffic. Since the consequences are often devastating, with a fatal outcome or with serious injuries involving a degree of disability, it is necessary to draw attention and continuously work on the prevention of traffic accidents in the form of implementing measures to increase traffic safety.

On the basis of the above, the European Parliament and the European Council have adopted the Directive 2008/96 / EC concerning the safety of transport infrastructure. This Directive obliges Member States of the European Union to apply guidelines on the roads that form parts of the trans-European transport network, regardless of the stage in which the roads are located. Also, EU Member States have the possibility of adopting guidelines and regulations from the directive and as national regulations on parts of roads that are not part of the trans-European road segment, but parts of the roads are either fully funded by the European Union and its funds. In this regard, the EU Member States have an obligation to respond to the type requirements, whether the Directive 2008/96 / EC is applicable to roads in BiH, or whether its guidelines are applied or whether the regulations in this area are adapted to the regulations of the European Union, and what are the effects of its application. The problem is closely related to the traffic safety segment in road traffic, and the answer to the problem of research is found in the theoretical and empirical research in this segment.

DIRECTIVE 2008/96/ EC

Directive 2008/96 / EC is a Directive of the European Parliament and of the European Council [2] of 2008 on

the safety of transport infrastructure. The Directive applies to the roads that form part of the trans-European transport network, regardless of whether the roads are in the design stage, whether they are under construction or are already in use. The Directive does not apply to tunnels, bearing in mind that they are covered by Directive 2004/54 / EC

In accordance with Directive 2008/96 / EC, EU members are obliged to implement procedures relating to:

- Giving assessment of the impact of certain elements on traffic safety,
- Audit of traffic speed,
- Management of safety aspects on the transport network, as well
- Continuity of safety on the roads.

EU Member States have the option of applying this Directive, as part of their national regulations, or for state transport infrastructure, which does not apply to trans-European transport networks. When carrying out appropriate works, Member States of the European Union must provide appropriate traffic signs in order to respond in a timely manner to the participants in the traffic. These signs must be visible both day and night, and they must be placed at the appropriate distance prescribed by the Vienna Convention on Traffic Signs and Signaling, signed in 1968. Member States should ensure that road users are adequately informed of stocks with a high number of traffic accidents.

In the segment of traffic safety control, Member States must:

- Ensure that safety checks are carried out on existing roads in order to determine the safety features of the roads and reduce the number of traffic accidents,
- Include occasional traffic network controls and analysis of the potential impact of traffic safety on traffic safety,
- Ensure that such occasional controls are carried out by the competent institution, at such time intervals to ensure the optimal level of safety on the transport infrastructure,
- Adopt guidelines on temporary safety measures in relation to road works, which must not be at the expense of the directive's directives,
- Conduct an appropriate control program to ensure the correct application of these guidelines.

Within the competent institutions, it is necessary to establish a regular compilation of reports on traffic accidents with fatal outcomes. Each country for its territory should calculate the average social cost of a fatal accident and the average social cost of an accident with severe consequences. There is also the possibility of further elaboration of these costs according to country initiatives independently, and they must be updated at least every five years. As of 19 December 2011, Member States were obliged [2] to adopt a training program for auditors for road safety, if such program has not already been adopted. States that use the services of auditors for traffic safety must provide initial auditor training, which includes issuing an adequate certificate of competence, and occasionally organize additional training courses for these auditors. Traffic safety auditors must also have a certificate of competence. Only acknowledgments received prior to the entry into force of this Directive shall be recognized.

Setting up an auditor [7,8] must take place according to the following conditions:

- The auditors should have the appropriate experience or qualification in designing roads, in the area of traffic safety, and in carrying out analyzes of traffic accidents,
- For the purpose of efficiency of the audit of the infrastructure project, the auditor should not be involved in the design or management of the infrastructure project during the audit period.

In order to provide additional security on roads within the European Union that are not included in the trans-European transport network, an adequate system for the exchange of positive experiences between member states should be developed, including, inter alia, existing projects to improve safety on infrastructure projects and proven technologies for improving traffic safety. Member States were required to adopt laws, administrative acts and regulations necessary to comply with this Directive by 19 December 2010. They were also required to provide the Commission with the text of those acts. Member States of the European Union are obliged to provide the text of the basic legal provisions to the Commission which they adopt in the field covered by this Directive.

The Republic of Srpska is the only institution in Bosnia and Herzegovina that fully implemented the Directive 2008/96 / EC with regard to the adoption of regulations and the implementation thereof.

CASE STUDY (PRNJAVOR- DOBOJ)

The analysis of passive road safety is presented in this case study according to the impact of roadside objects on road safety along the road section Prnjavor-Doboj. In February 2017, the entire research-relevant stock was recorded with a camera placed in a cockpit of a passenger car. Analyzing the snapshots, additional field research was not necessary, given that the output information from the camera, or video recording, was of very good quality and could fully represent the real state of the road. Considering that the observed section contains two categories of road in its route, main and regional roads, passing through inhabited and uninhabited places, the number of observed roadside objects was generally quite large. Such result, looking at the state of the road and the environment, was not surprising.

The roadside object impact factor for the consequences of a traffic accident was somehow always viewed as a secondary and not so important thing. But the fact is that an adequately set front rebound fence or an adequately protected concrete pole can significantly reduce the consequences for the persons and the vehicle involved in an accident, changes significantly the thinking about this topic. One of the aims of this case study is to precisely prove this claim and that the vision of the competent authorities for the safety of traffic in the Republic of Srpska have to be enlightened to the extent that investing in the safety of transport is not a cost but a profit.

Why profit?

Well, if we look at the annual cost of traffic accidents [9], we will come to a simple conclusion that investments in adequate equipment for the protection of roadside disturbances are far less than the total cost of traffic accidents. Adequately protected side disturbances reduce the consequences of traffic accidents and reduce costs in an analogous way, thus releasing budget funds for investments in other projects. The cost of a traffic accident only with pecuniary damage, based on the "readiness to pay" calculation process, which represents the minimum economic loss, is 3.258 convertible marks (hereinafter KM). If we compare this amount with the cost of a traffic accident with severely injured or dead persons we will have 66.683KM or 620.618KM. We can conclude that the difference between economic losses is enormous depending on the severity of the traffic accident. Therefore, if the consequences of traffic accidents are reduced to a greater extent, the costs of this will decrease.

So if the consequences of traffic accidents are reduced to a greater extent, the costs will also be reduced in analogy.

In Table 1. The categories of observed road shares are displayed.

Table 1. View of the observed section from the aspect category of the road

Banja Luka – Klašnice	Road reserved for traffic of motor vehicles (M16)
Klašnice – Prnjavor	Main road (M16.1)
Gornja Vijaka – Razboj	Regional road (R474)
Razboj – Rudanka	Regional road (R474a)

Identification of Sides

The identification of roadside disturbances was done by a detailed overview of the video material [1]. For the position of each significant point, that is, the lateral disturbance, the marking [6] of its place was used by hour, minute, and second on the record. Each category of road was predominantly dominated by one category of roadside disturbances with a smaller share of others.

Side disturbances are categorized [3] on the basis of common features:

- Concrete and iron poles of electricity distribution and public lighting;
- Open beginnings of the frontal rebound barriers;
- Approaches and fences on the bridges;
- Unprotected approaches to the petrol stations;

Concrete and iron poles of power distribution and public lighting pose a problem to the greatest extent on the main road M16.1 and the regional roads R474 and R474a. The present poles, in most cases, are located in the immediate vicinity of road, where they pose a serious threat [7,6] to road users if a wandering vehicle hits one of them.

Figure 1 shows the percentage of impact in the lateral disturbance, depending on its distance from the edge of the driveway.

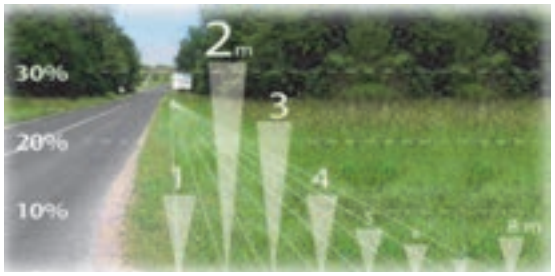

Figure 1. Percentage of impact rate in lateral disturbance

Observing the our case, especially on the main road M16.1 Klašnice – Prnjavor and road R474 Gornja Vijaka-Razboj, the distance of roadside disturbances is roughly 2m from the edge of the driveway. In some segments of this road, the poles are located at a great distance, somewhere even on a smaller one. The point is that these poles are not adequately protected in any way and pose a direct danger to traffic participants in case a wandering vehicle hits some of them.

Figure 2 shows an example of inadequately shielded poles of power distribution and public lighting from a real life situation.

Figure 2. Inadequately protected pillars of electricity distribution and public lighting

For such segments of the road, it is necessary to protect the lateral disturbance, that is, the columns, the setting of the reflecting fences, so that the columns are not in the working width of the same fence or completely replace the existing poles with passive safety poles where possible.

The frontal open beginnings of rebound fences pose a major problem in the entire observed section. The beginnings and endings of the rebound fences are in most cases open, which poses a great danger for the passengers in case the vehicle impacts the fence.

The example from Figure 3. shows the open start of the rebound fence on the road section Gornja Vijaka-Razboj (R474).

Figure 3. The open end of the front reflecting fence

The open start of the front reflecting fence acts as a kind of blade during the vehicle's encounter, so the opposite effect of the reflecting fence is obtained here. Instead of turning the wandering vehicle that encounters at the beginning of a frontal reflecting fence from it and returning it on a cart track or, in the other case, safely stopping the fence length, it will in this case leak directly on a metal structure that at that speed encounters becomes "cutting edge" that breaks through the chassis vehicles. Apart from the bad condition of the reflecting fences in some places, they are not placed at the appropriate height and are not connected in an adequate way with the attachments of other fences. Insufficient maintenance of the infrastructure and poor remediation after traffic accidents has led to the loss offunctional aspect over time and now have almost no impact on reducing the consequences of a traffic accident, on the contrary they can act the opposite and increase the consequences for the passengers in the vehicle and for the vehicle itself.

Approaches and fences on bridges are critical points on the observed section. There are openings between the guardrails of the fences on the bridges themselves and the frontal reflecting fences.

Figure 4 shows the openings between the protective fence and the open end of the front reflecting fence.

Figure 4. The open end of the front reflecting fence

The gap that exists between the protective fence and the open end of the front fence is a problem of traffic safety [3] in the event of a vehicle in the area just in that zone. Additionally, the fence on the bridge is set up to protect pedestrians and vehicles from possible drops, but the question arises as to how it will behave when a vehicle is on the move on it, as it has not been tested in any way prior to its implementation.

Figure 5 shows a bridge on which a reflective fence is missing before it is often the case on the observed section of the road.

Figure 5. The lack of a protective fence on the bridge

Unprotected petrol stations on the observed section of the road are located in areas where the speed limit is 50km / h. The curbs placed at the access road do not represent any kind of protection against collision and can not prevent the vehicle from passing. An advertisement with fuel prices is placed very close to the edge of the carriageway, with its foundation of concrete structure, which in most cases expands so it poses additional danger. Also, the iron pillars of lighting are also in the immediate vicinity of advertising structures.

Figure 6 shows the unprotected construction of the gas station.

Figure 6. Unprotected steel structure of the gas station

Analysis of Safety Risks

The observed sections of the main road M16.1 and the regional roads R474 and R474a contain a mixed function of local and remote traffic, which indicates different speeds of allowed movement. Pedestrians and bikers also use the route, but are present mostly in liner settlements and villages than in rural areas. Tractors and other transport vehicles used by farmers are most often present in rural areas. The presence of connecting roads, without traffic signalization and without asphalt cover, from various private estates is quite large. Mixed road users with varying speed and safety requirements make these three high-risk road sections at risk from an accident.

Identified safety risks for the observed road sections:

- Function and the road environment
  - Along the observed sections there are connecting roads without traffic signalization and without built-in asphalt cover,
  - The signs of speed limits on certain parts of the road are not placed in the appropriate places, thus provoking drivers not to comply with the limit.
- Cross section
  - Road is divided by a central line, and there are also edge lines that are in poor condition (damaged and with poor reflection);
  - The edges of the carriageway are damaged, the banks are not in the same level with the cart track an they do not have enough width,
  - Ruts made of car tires are visible, which prevents drainage from the carriageway. This factor will cause aqua planning at a time when it rains,
  - The pavement surface is smooth and slippery with a small coefficient of adhesion especially in rainy conditions,
  - There are no crosswalks of the carriageway in some segments, which prevents drainage and where they are not properly directed.
- Passive safety features
  - The raised pavements, where they are present, are present on both sides of the bridges. Raised both by road and by the banks,
  - Unprotected drains, power poles and public lighting,
  - Lack of protective fences in most of the curves,
  - Existing frontal rebound barriers are not long enough and do not have safe ends and beginnings.

After the identification of lateral disturbances and security risk analysis on the observed sections of the road, in line with the guidelines of EU Directive 2008/96 / EC it is necessary to find solutions for improving the protection of lateral disturbances.

Improvements will be divided into three groups:

- Short-term improvement measures,
- Medium-term measures of improvement,
- Long-term improvement measures.

Short-term improvement measures are a type of solution that can be implemented in a short period of time. It is especially important to have stable goals and ideas regarding short-term measures for further implementation of medium and long-term measures.

As short-term measures within this report, the following recommendations are given:

- Replacement of concrete and iron pillars with passive safety pillars,
- Where replacement of existing pillars is not possible, it is necessary to protect pillars with appropriate impact buffers especially for zones 50km / h and zones over 70km / h;
- Rehabilitation of frontal reflecting fences with a special emphasis on the proper performance of the beginnings and endings that are the biggest problem,
- Installation of reflective fences before and after the bridge and removing the existing voids between the end of the reflecting fence and the beginning of the protective fence on the bridges.

Passive safety poles must comply with EN 12767.

EN 12767 differs in terms of energy absorption [3] in vehicle impact, through three column categories:

- HE - high energy absorption,
- LE - low absorption,
- NO - without energy absorption.

Areas of use of these pillars are very wide and can easily be applied to solve the observed problems in this case study.

Pillars must be passively safe:

- On all roads outside the settlement, where the speed is higher than 50 km / h and where the pillars are not protected by a reflective fence,
- On all roads, where the speed is less than 50 km / h and the pillars are far away from the running surface of less than 4 m and are not protected by a reflective fence,
- Whenever the pillar is behind the reflecting fence, it is in the area of its working width.

Figure 7 shows an example of the behavior of a passive safety pillar.

Figure 7. An example of the behavior of a pillar when a vehicle hits

In case the replacement of the existing pillar with a passive safety pillar is not possible, there is another method of protection against impact and impact of the vehicle on the same. SMA Tree Moisture Shock [3] is the best solution for this. Originally designed to protect the trees from possible vehicle accidents, it can be applied with the same analogy for pillars as well.

Figure 8 shows a shock absorber.

Figure 8. Smash hitter

Figure 9 shows the technical characteristics of the SMA Tree [3] shock absorber.

Figure 9. Dimensions SMA Tree (mm)

The SMA Tree system is 80% re-usable after the impact of the vehicle. The absorbent cells after the impact of the vehicle can be replaced and the shock absorber can again perform its function.

Correct execution of the beginnings and endings of the frontal fence rails and the rehabilitation of swinging is a serious procedure that will eliminate the security threat if there is a ride on some of them. Many fences have not been repaired after the impact of the vehicle and can not perform their function in the right way.

A possible solution to the problem in this case is:

- Repair or replacement of reflective fences that have been damaged during the vehicle's collision,
- The beginnings and ends of the front fenders must be carried out in the right way so that they do not have a sharp start and end that can break the front of the vehicle, the beginning must not be such a form to catapult the vehicle into the air when it comes to flight.

Medium-term improvement measures involve the removal of a large number of unshielded connecting lines on sections M16.1, R474 and R474a and the creation of a pair of collection paths by segments.

Long-term improvement measures involve the permanent removal of lateral disturbances where possible.

CONCLUSION

When making this case study, passing through and analyzing the observed shares through the lens of the camcorder, things that are not satisfactory from the aspect of traffic safety or the impact of lateral disturbances on the safety of the road have too many. When we look at the amount of vehicles that are driving the observed section of the road, things look very worrying if the landing vehicle arrives. For years, the road equipment was not working, the protection of lateral disturbances almost did not exist or was minimal. The pavement blind additionally increases the risk of landing because it is in decadent state, especially at a time of rainy weather and snow. The percentage of heavy goods vehicles in the traffic flow is high, especially at the time when this case study was conducted due to the construction of the Doboj-Banja Luka highway section.

Over the years, a lot of human lives have been taken on these road segments from Banja Luka through Prnjavor to Doboj, and they have brought a lot of budget costs. Adequately protected lateral disturbances can significantly reduce the consequences of a traffic accident and, in the same way, its costs. Of course, this is only the first phase in which the main goal is to mitigate the possible consequences of road accidents such as landing. Over a long period of time, equipment that protects lateral disturbances that cannot be removed should be maintained regularly and other disturbances should be permanently removed. To this end, especially on the main and regional roads M16.1 and R474, R474a it is necessary to carry out the re-arrangement of the connecting rural roads, which should be classified into smaller collection paths that will be correctly signaled by vertical and horizontal signaling.

One of the aims of this paper is to show how much the observed sections of the road are dangerous and do not forgive even the minimal mistake of the participants in the traffic. This situation should be the opposite; it is necessary to create an ambient of the path that falsifies mistakes [2], which will not lead the participants to a dangerous or fatal situation, even in case they exceed the allowed speed of movement.

Investments in traffic safety should not be considered a cost [5], but vice versa. It is a gain in terms of saving lives and avoiding serious bodily injuries (analysis: costs / benefits). The arrangement of connecting rural roads would be beneficial, which should be classified into smaller collection paths that are correctly signaled by vertical and horizontal signaling.

One of the essences and tasks of this paper is to show how much the observed sections of the road are dangerous and do not forgive even the minimal mistake of traffic participants. This situation should be the opposite, it is necessary to create an ambient of the path that fills the mistakes, which will not bring the participants into a dangerous or fatal situation, and if they exceed the allowed speed of movement. Therefore, investments in traffic safety should not be considered a cost, but vice versa. It is a gain in terms of saving lives and avoiding serious bodily injuries.

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TRANSPORTATION RESEARCH BOARD 97th ANNUAL MEETING WAS HELD IN WASHINGTON, D.C.

The Transportation Research Board (TRB) 97th Annual Meeting was held January 7–11, 2018, at the Walter E. Washington Convention Center, in Washington, D.C. This is the largest international conference in the world in the field of traffic and transport, which has been held since 1921, every year in month of January. This year, the information-packed program, attracted more than 12,000 transportation professionals from around the world. The meeting program covered all transportation modes, with about 4,500 presentations in nearly 800 sessions and workshops, addressing topics of interest to policy makers, administrators, practitioners, researchers, and representatives of government, industry, and academic institutions. A number of sessions and workshops has focused on the spotlight theme for the 2018 meeting: ***Transportation: Moving the Economy of the Future***

More information about this conference can be found at **www.trb.org/AnnualMeeting**


Photos from the Annual TRB Conference, Washington, D.C.

ODRŽANA 97. KONFERENCIJA ODBORA ZA SAOBRAĆAJNO-TRANSPORTNA ISTRAŽIVANJA

Devedeset sedma godišnja konferencija Odbora za saobraćajno-transportna istraživanje (TRB) održana je od 7. do 11. januara 2018. godine u Walter E. Washington Convention Centru u Vašingtonu, D.C., SAD. Ovo je najveća međunarodna konferencija u svijetu u oblasti saobraćaja i transporta koja se od 1921 godine održava u mjesecu januaru svake godine. Ovogodišnji, informativno prepun program, je privukao više od 12.000 stručnjaka iz oblasti saobraćaja i transporta iz cijelog svijeta. Program konferencije obuhvatio je sve vidove transporta, sa oko 4,500 prezentacija na skoro 800 sesija i radionica, obrađujući teme od interesa za kreiranje politike, administratore, praktičare, istraživače i predstavnike vlasti, industrije i akademskih institucija. Brojne sesije i radionice su se fokusirale na glavnu temu konferencije za ovu, 2018. godinu: ***Transport: Pokretanje ekonomije budućnosti***

Više informacija o ovoj konferenciji može se naći na **www.trb.org/AnnualMeeting**

Prof. dr. sc Mirsad Kulović