CETRA 2012

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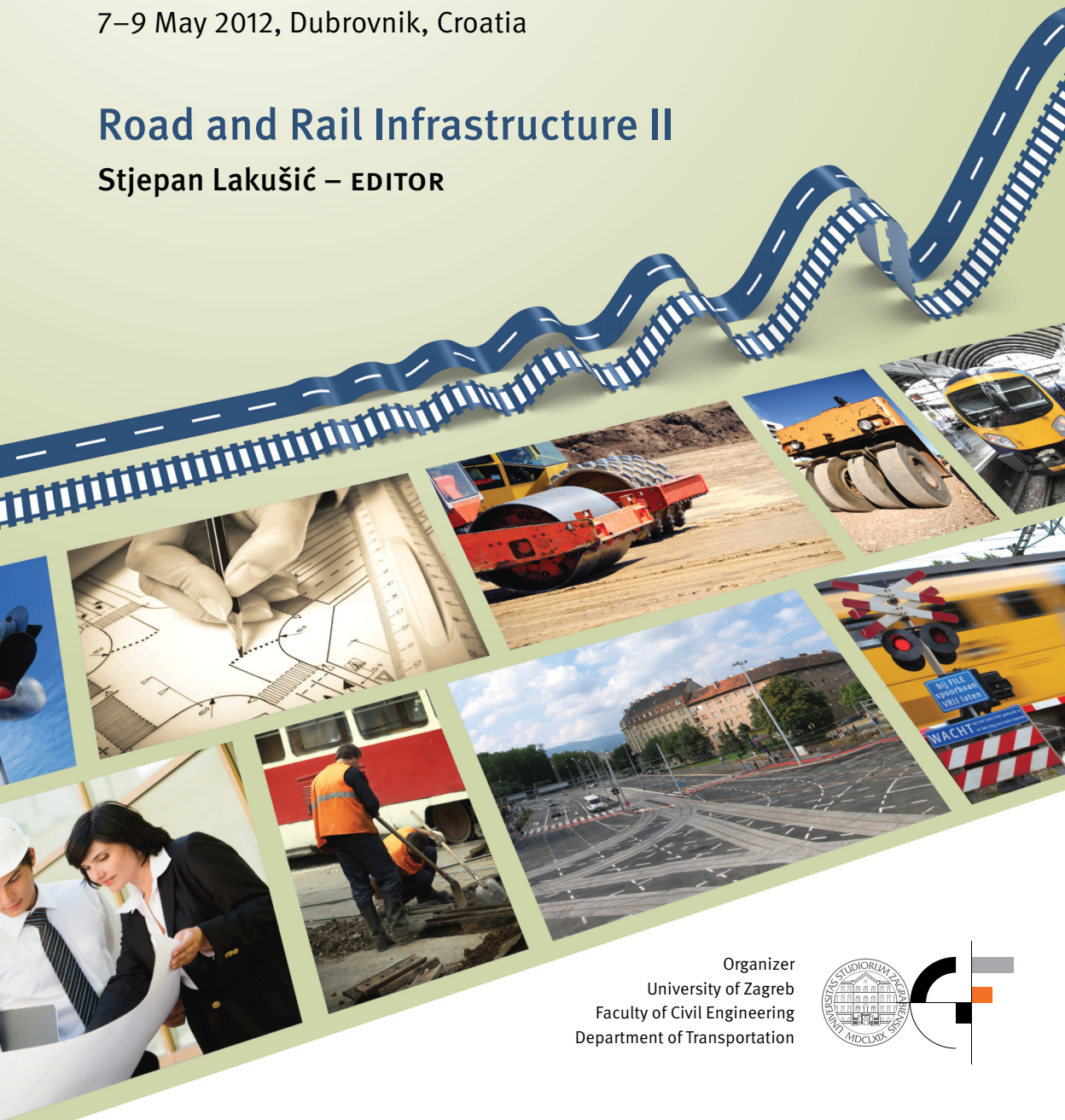
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR



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ANALYSIS OF ROAD TRAFFIC SAFETY AFTER THE CONSTRUCTION OF THE FULL PROFILE OF THE RIJEKA–ZAGREB MOTORWAY

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Abstract

Upgrade of the Rijeka–Zagreb motorway to full profile was completed in October 2008, and its basic aim is raising the level of traffic and safety–related services primarily through reducing the number of road traffic accidents. This paper presents the current situation, possible causes of road traffic accidents with a special commentary of the main factors of traffic safety. A detailed analysis of the accidents was carried out, and the methods, procedures and solutions with the objective of increasing traffic safety were suggested in the stated methodology.

Keywords: safety, road traffic accident, causes and analysis, methods, solutions

1 Introduction

The Rijeka–Zagreb motorway is a part of the European road route E65 Budapest–Varaždin–Zagreb–Rijeka, which links the Central European countries with the port of Rijeka, and further towards the other Mediterranean and Middle East countries. In addition to its role in the European context, this road represents a key link of the continental and coastal part of the Republic of Croatia, and integrates the area of the country connecting it with the European transport corridors.

Figure 1 Rijeka–Zagreb motorway

Rijeka–Zagreb motorway (Figure 1.), 146.50 km long, was open to traffic in the second half of 2008 as a dual carriageway. The completion of a safe, reliable and fast traffic link of Croatia's capital with the largest port was a key factor of the Traffic Development Strategy of the Republic of Croatia.

2 Traffic safety conditions

By its character, a motorway is an infrastructure road object with 'a high level of servitude', and it gives users the highest standard in comfort and safety. The objective of the global campaign 'MAKE ROADS SAFE' which was conducted through 2007 was raising awareness of road users and general public on road safety worldwide, as a priority issue within sustainable development. The Rijeka–Zagreb motorway is in every respect constructed according to the highest standards, however, even though modern roads are a lot safer compared to other roads, the experience of the countries in which motorways have been used for years, shows that road accidents on modern roads occur with tragic consequences.

2.1 Official data and classification of road accidents

In order to gain a clearer insight into the number and consequences of road accidents, accidents are shown by means of various safety coefficients per 100 million of driven kilometres. The term 'driven kilometres' represents a product of the number of vehicles on a particular section together with length of that particular section. By stating the safety level through these coefficients, it is possible to compare the condition of traffic safety under various loading on roads of diverse length and construction stage (single/dual carriageway) (Figure 2.). Comparison of traffic volume on the single/dual carriageway in 2008/2011 is shown in Table 1.

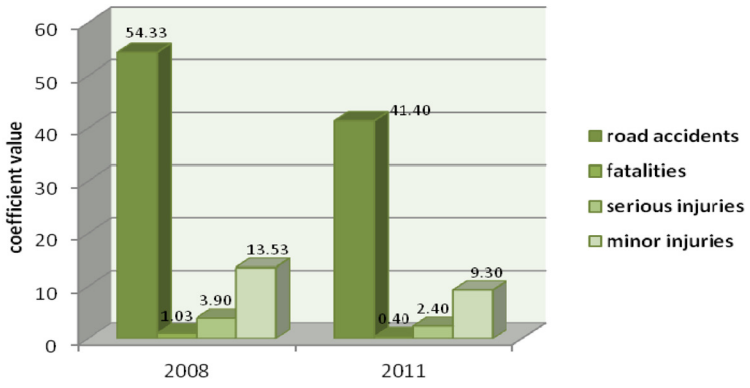

Figure 2 Comparison of coefficients per 100,000,000 driven kilometres in 2008 and 2011 on Rijeka–Zagreb single/dual carriageway according to consequences [4]

Table 1 Traffic volume on single/dual carriageway in 2008 and 2011 [4]

Year		2008	2011
Traffic volume		14,863,300	14,591,938
Driven kilometres		975,421,678	968,675,212
Total accidents		530	401
Fatalities		10	4
Serious injuries		38	23
Minor injuries		132	90
on 100 000 000 driven km	Total accidents	54.33	41.40
	Fatalities	1.03	0.40
	Serious injuries	3.90	2.40
	Minor injuries	13.53	9.30

3 Causes and analysis of road accidents

In road traffic structure we can see a mechanical system, which consists of the 'vehicle–road' relation and the biomechanical system, which consists of the 'person–vehicle' and 'person–road' relations [1]. The effect of these three systems to traffic safety can be shown by the Venn diagram (Figure 3.) [2].

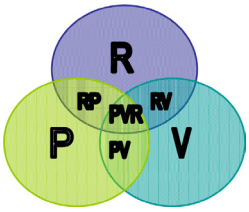

Figure 3 Venn diagram

If the cybernetic system consisting of the following factors: 'driver', 'vehicle' and 'surroundings' is considered, then the function of operation is carried out by the driver, vehicle is the object of the operation, while the surroundings refer to a source of information based on which the condition of the system is defined. In the factor called 'surroundings', the road is singled out as a carrier of information.
The factors: 'person', 'vehicle' and 'road' do not cover all the elements that can have an effect on the condition of the system, such as e.g. traffic regulations, traffic operation etc.; 'traffic on the road' should be singled out as the fourth factor. Those factors are subject to certain regularities, but they do not include other elements which occur unexpectedly or unsystematically, and they have an effect on the situation of the system. This mainly refers to the weather conditions and other elements, such as stones on the road, oil and mud on the road surface. Therefore a need to introduce another factor appears in which all the mentioned elements are contained. That factor is called 'incident factor' in order to single out its unsystematic and unexpected occurrence.

3.1 Road as a factor

Technical road deficiencies are often a cause of road accidents, and they can occur during road design and construction (Table 2.). Road as a factor of road safety is characterized by: alignment, technical road elements, pavement condition, road furniture, road lighting, intersections, side barrier influence and road maintenance [3]. Particularly important is the characteristic of the road alignment which should be homogeneous, i.e. that it enables uniform speed of vehicles.

Table 2 Overview of road accidents according to road characteristics for the period from January–December 2008 and 2011 [4]

Road accidents according to road characteristics	No. of accidents	F	SI	MI	MD
	Jan–Dec 2008				
	Jan–Dec 2011				
Curve	112	2	16	32	85
	94	1	8	22	76
Straight road	313	5	20	84	247
	236	2	12	60	193
Tunnel	14	-	-	4	11
	13	1	3	4	8
Viaduct/Bridge	19	3	2	5	14
	-	-	-	-	-
Interchange	30	-	-	5	27
	22	-	-	1	21
Toll plaza	25	-	-	1	24
	23	-	-	-	23
Other	17	-	-	1	16
	13	-	-	3	11
Total	530	10	38	132	424
	401	4	23	90	332

3.2 Vehicle and driver in traffic

Vehicle elements which have an effect on traffic safety can be divided into active and passive elements [5]. Active elements include those technical solutions of vehicles that have a duty to minimise the number of road accidents e.g. brakes, tyres, lighting and signalling devices, i.e. to reduce the possibility of road accident occurrence. Passive elements include those technical solutions that have a duty to alleviate the consequences of road accidents (e.g. safety belts, headrests, air bags).
The most important of all factors which influence the safety in traffic is the driver/person. When in traffic, the driver receives information on the conditions on the road, takes into account the vehicle and traffic regulations, and then determines the vehicle's course [6]. The 'person' factor is the most important one, but at the same time the weakest link in the safety chain. According to the analysis, a large number of road accidents occur due to unadjusted speed and not maintaining a safe following distance in conditions of clear visibility and good pavement conditions (Table 3.). Improper speed and speed unadjusted to road conditions are the most frequent drivers' mistakes which lead to road accidents.

Table 3 Overview of the number of road accidents according to road users' mistakes for the period from January–December 2008 and 2011 [4]

Road accidents According to road users' mistakes	Jan – Dec 2008	Jan – Dec 2011
Speed unsuitable for road conditions	159	140
Unexpected danger on road	56	27
Improper backing	10	10
Improper changing of lanes	30	28
Improper passing	13	2
Improper turning	12	3
Joining traffic improperly	14	3
Driving at inadequate distance	91	56
Other driver's mistakes	145	132
Total	530	401

3.3 Weather conditions and influence of other factors

Weather condition factors that most frequently influence road traffic safety are: rain, snow, glaze ice, fog and wind (Table 4.). It is also necessary to mention the wind as an explicit cause or circumstance of road accident occurrence. Due to wind, speed limits should be implemented on those specific areas where it occurs. There are in general fewer accidents in conditions with snow on the pavement, since there are fewer vehicles on the road, and those who are driving are more careful and drive slowly. Hence there are more road accidents with minor material damage than accidents with injuries. Typical winter road accidents are vehicle impacts, which occur due to the speed unadjusted to road conditions. It is indisputable that correct and timely meteorological information is very useful and essential for road users in the sense of increasing the level of safety in traffic. Such information on Rijeka–Zagreb motorway can be found on the Company's web page www.arz.hr (Autocesta Rijeka–Zagreb d.d.).

Table 4 Condition of road surface on occurrence of road accidents for the period from January–December 2008 and 2011 [4]

Condition of road surface on occurrence of road accidents	No. of accidents	F	SI	MI	MD
	Jan–Dec 2008				
	Jan–Dec 2011				
Dry	380 296	7 4	29 20	108 70	301 245
Wet	139 88	3 -	5 3	23 16	114 74
Snow–ploughed	7 10	- -	2 -	1 3	6 7
Snow–unploughed	2 6	- -	- -	- 1	2 5
Ice	1 1	- -	2 -	- -	- 1
Oil and other	1 -	- -	- -	- -	1 -
Total	530 401	10 4	38 23	132 90	424 332

Presence of animal species along the motorway route is one of the more important factors, which need to be mentioned, and which has an effect on the road traffic safety (Figure 4.).

Figure 4 Notification for the drivers on game habitat

Taking into consideration the ground configuration, there are many tunnels, viaducts and other passages as well as one animal crossing – Dedin, which is 100 m long and enables natural migration of animal species, on the extensive portion of the motorway. In its entire length the motorway is enclosed by safety fence and its primary objective is to prevent the animals from entering the motorway and increase the safety of road users, as well as animals which live in their natural habitat. Animal hits participate with 4% in the total number of road accidents. Most road accidents occur on the section of the motorway between Zagreb and Bosiljevo, since ground configuration in that area is lowland, and there are fewer possibilities for animal migrations when compared to the section between the Bosiljevo and Orehovica Interchange (mountainous area) with the entire range of road structures which serve as animal crossings. In most of the cases animal hits occurred in the evening, with mainly material damage.

4 Methodology of finding measures to increase road safety

The main focus areas in increasing motorway safety refer to users, vehicles, road infrastructure, safe transportation of goods and passengers (heavy vehicles and buses), emergency services and care for accident victims, and collection and analysis of accident data. In Rijeka–Zagreb Motorway, data collection is done in the following way: when an accident occurs, a form is filled out to collect detailed data such as speed at the moment of the accident, use of safety equipment, detailed condition of the road surface in summer and winter conditions, signalling, etc.

4.1 Methods and pragmatic steps

Experience and scientific and research work in the world, and to some extent in the Republic of Croatia, confirms that effective decrease of road accidents and their consequences is made possible by influencing the change in the drivers' surroundings at dangerous points, i.e. the surroundings of road users, in order to communicate set up clear and unambiguous information on road layout that drivers get from their surroundings, and which are important for safe vehicle operation. The surroundings of road users, primarily drivers, include the complete image drivers see and its relationship to road layout and the drivers' actions to take appropriate measures to avoid a road accident. Suggestions to improve dangerous points (so–called black spots) can be made in the form of typical (usual) solutions, atypical (unusual) solutions and a combination of the two. Typical solutions add up to changes to the drivers' surroundings through signalling:

- putting up traffic signs (restrictions, mandatory signs and limits),
- putting up panels for traffic direction (visual barriers – red and white or in different colours) of appropriate dimensions (standard and non–standard – large),
- removing certain visual obstacles or barriers (commercial billboards) which distract the driver or block clear vision, and similar.

Atypical solutions include changes to the surroundings by placing certain elements in the field of vision of the driver, such as hedges (shrubs and trees), visual walls (panels of different sizes, colours and shapes), and changes to the colour of certain roadside elements. The combination of typical and atypical solutions includes systematic use of both solutions to achieve the best system of information on road layout as possible. Progressive increase in dimensions of certain elements is also possible, and serves to highlight certain elements of the road by way of visual illusion (sharp bends, and similar elements), so that the drivers can instinctively react by reducing their speed on time.

4.2 Modelling and implementing the measures

By constructing roads of a higher level of service, i.e. roads with superior elements, or with larger radii of horizontal and vertical bends, smaller longitudinal slopes, multi–level intersections, built parking lots, signalling and computer systems to direct and manage traffic, better road maintenance – the level of service is greatly improved and the safety is greatly increased. Improving dangerous points by changing the drivers' surroundings can decrease the number of road accidents in dangerous points by between 30 and 70% or more, if it is done on the basis of scientific and professional understanding and approach. Measures to improve dangerous points refer to changing the drivers' surroundings, i.e. introducing standard and non–standard traffic signalling, and to a lesser extent to equipment on the part of the road at the dangerous point. Micro asphalt surfacing or roughening of the road surface is sometimes understood as a complementary measure required as a result of a study or research efforts.

5 Conclusion

By analysing all factors causing a road accident, it is possible to design and optimise solutions for decreasing the number of road accidents, and the number of 'black spots' on certain parts of the motorway. Along with decreasing the number of fatalities in 2011, the number of serious injuries has decreased by 15, and the number of minor injuries by 42, compared to 2008. Companies operating motorways in the Republic of Croatia, including Rijeka–Zagreb Motorway, aim at providing quality service to their users, and enable them to use the motorway for a safe and fast journey. Regular maintenance, which is done within the available financial framework, serves as a way to raise the level of service of the road, and make the journey safer and more comfortable.

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