

Considerations on the role of modernizing the road infrastructure in the prevention of road accidents

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Abstract. The realizing and improvement of road infrastructure, of modern road networks provides normal, safe and pleasant road traffic conditions and also help prevent road accidents. The road network, with its constructive characteristics, has to offer optimal conditions for the movement of vehicles, pedestrians and other categories of participants in the road traffic. Starting from the case study of a road sector with heavy road traffic, the current paper analyzes the increase in road safety in Romanian localities along European and national roads through the implementation of specific measures such as setting up sidewalks, installing New Jersey median barriers, expanding the road sectors with 2+1 lanes, replacing normal pedestrian crossings with elevated crossings or with pedestrian crossing with mid-road waiting areas etc.

1 Introduction

Modern society has come to rely more and more on road transportation. Therefore, road safety continues to be a major social problem and accident prevention is an international priority. Given the fact that it affects also many people on the way to their jobs or even doing their jobs, it needs to be treated like any other occupational risk, such as stress, explosion risk [1] etc.

In 2018 alone, more than 25000 persons have died in road accidents recorded in the states of the European Union, while 1.45 million people have sustained severe or light injuries.

The European Union cooperates closely with the member states in the area of road safety, seeking to address all factors and agencies involved in the prevention of accidents or in reducing the seriousness of the accidents' seriousness, such as the cars, the road infrastructure, the drivers' behavior, the intervention in emergency situations etc. At European level, the thinking is objective-oriented, such as in the case of "Vision Zero", seeking the elimination of fatalities and of serious injuries in accidents on European roads by the year 2050 [2].

While the other elements the cars are a major target of researches targeting both the increase in safety and the identification of new, more efficient and non-polluting fuel sources [3, 4], a special attention needs to be granted to the road infrastructure.

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The road infrastructure is the central element in a modern and efficient road transportation system. It can be defined as consisting of all basic facilities, services and installations required for a satisfactory functioning of road transportation, including terrain usage, network planning, (re)building and design of road sections and of intersections, signaling, systematizing of roads and road markings, maintenance of the roads system but also quality assurance measures such as audits, impact analyses and safety inspections [5].

Generally, the road infrastructure should be designed and used in such manner that the system's users can know what to expect and what is expected of them, taking into account the limited human capability to process information and consequently the errors that people may generate.

According to data from the "Eurostat Regional Yearbook 2018" [6], the occurrence of road accidents could be related to or even determined by a large array of factors, including: the quality and extent of the road infrastructure, the tendency to own a vehicle, the vehicle type, its characteristics, the distance already driven, the average speed, the population density, the climatic and geographic conditions, the legal norms applicable to vehicles and to drivers, the drivers' behavior etc.

In the current paper, the authors have analyzed the number and type of road accidents in two road sectors on the Romanian national road DN 1 and the influence of changes to the road infrastructure on the seriousness of accidents in one of those sectors.

2 Road Safety Management and its Impact on the Road Infrastructure

Road safety management is a relatively new concept in Romania, even though at world and European level the specific measures have already shown important advantages.

The concept of road safety management integrates measures and practices for all aspects of road traffic: road infrastructure, vehicles, drivers, traffic control, emergency services etc.

In the area of road infrastructure, some of the good practices proposals and measures are as follows [7, 8]:

- reclassification of roads function of their role: transit, local or access roads and adequate modification of standards, technical norms and good practices for roadbuilding and road traffic organization;
- intensification of the periodic safety inspections of the road network;
- application of the procedures for impact assessment and audit operations in the area of road safety;
- identification and classification of the road sections with a high concentration of accidents;
- intensification of the building of motorways and of expressways;
- increase of the road safety in the linear settlements along European and national roads by implementing specific measures such as building sidewalks, installing direction separators (New Jersey barriers), replacing simple pedestrian crossings with raised or lowered crossings or with pedestrian crossings with refuges on the road axis;
- continuous rehabilitation of roads, improving the horizontal and vertical signaling;
- discouragement of the theft of road signaling elements by introducing elements made of materials without commercial value;
- introduction of new road safety elements;
- transformation of the simple railroad crossings in raised or lowered crossings;
- creation or transformation of parking areas in agreement with road safety requirements;
- separation of the slow road traffic from the transit traffic, by building roads dedicated to slow vehicles such as agricultural vehicles, bicycles, non-motorized vehicles etc.

- illumination of the roads during the night, especially at intersections and in areas with pedestrian activity, as well as at the pedestrian crossings;
- design of the road transportation infrastructure to be able to adapt to extreme weather phenomena;
- elimination of potential hazards from the areas around the road, such as high-strength elements that can pose a danger on impact, or deep ditches;
- marking of the road sections, especially those on motorways, for a better orientation of drivers and to help the adopt and maintain a minimal safe distance towards the vehicle in the front;
- increase of the efficiency of evacuating the road surface after road accidents;
- expansion of road sections with 2+1 lanes, one of the lanes being a pendular lane with direction separator, as implemented for example on DN 7 in the Olt river gorge etc.

3 The Analyzed Road Sections: Infrastructure Changes and Road Accident Dynamics

The authors have analyzed the relationship between the dynamics of road accidents and of their consequences and the implementation of different types of road modernization measures in the case of three road sections located on the DN1 national road (fig. 1, [9]):

- a 38-km stretch (from km 259 to km 297) between the border of Sibiu and Braşov counties and the intersection of DN 1 with DN7 near Veştem;
- a relatively short (8 km) stretch from the intersection of DN 1 with DN7 near Veştem to the entrance of DN1 into the city of Sibiu;
- the road section of DN1 from the city of Sibiu to the border between Sibiu and Alba counties;

The analysis encompassed a period of 9 years, from 2010 to 2018.

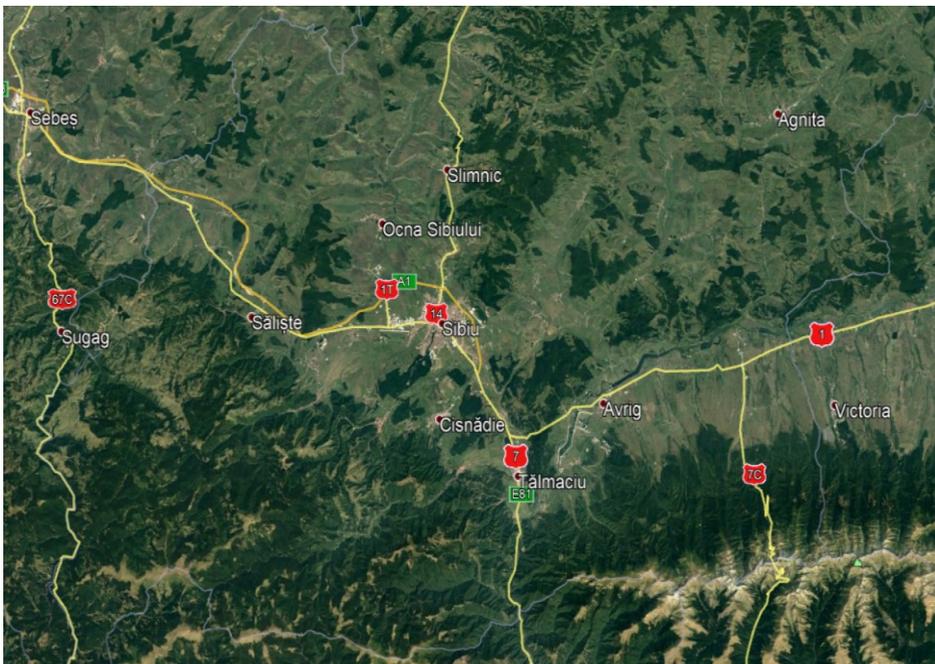


Fig. 1. The analyzed road sections [9]

During this period, on the first two road sections, there have been recorded 260 road accidents, with 50 fatalities, 146 severely injured persons and 340 lightly injured persons [10, 11]. The distribution of these road accidents by year is presented in figure 2.

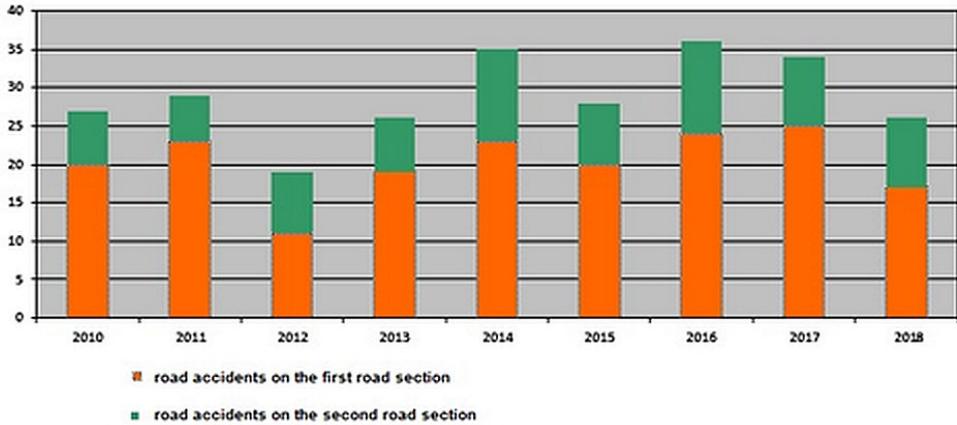


Fig. 2. Distribution of the number of road accidents on the first two road sections, by year.

Table 1 details the data corresponding to the first road section in terms of the number of serious accidents and of consequences (fatalities, severe injuries and light injuries, while table 2 shows the same details corresponding to the second road section (data in both cases from [10, 11]).

Table 1. The number of accidents and of the various types of casualties on the DN1 section between km 259 and 297 between 2010 and 2018.

Year	Total no. of accidents	Serious accidents	Fatalities	Severe injuries	Light injuries
2010	20	14	6	12	20
2011	23	13	6	13	21
2012	11	6	1	8	16
2013	19	11	3	11	17
2014	23	12	7	10	31
2015	20	6	5	13	22
2016	24	10	2	14	27
2017	25	10	4	9	29
2018	17	5	2	5	23
TOTAL	182	87	36	95	206

The main causes for the road accidents on these two road sections were identified as follows:

- excessive speed or speed not adapted to road or meteorological conditions - 82 road accidents (31.53%),
- failure to grant right of way to vehicles - 30 road accidents (11.53%),
- illegal road crossing by pedestrians - 26 road accidents (10%),
- failure to maintain a safe distance between vehicles - 24 accidents (9.23%)
- illegal overtaking maneuvers - 18 road accidents (6.92%).

Table 2. The number of accidents and of the various types of casualties on the DN1 section between km 297 and 305 between 2010 and 2018.

Year	Total no. of accidents	Serious accidents	Fatalities	Severe injuries	Light injuries
2010	7	5	3	6	7
2011	6	4	5	10	19
2012	8	4	1	3	8
2013	7	4	1	7	7
2014	12	6	2	9	27
2015	8	4	2	3	11
2016	12	5	0	5	25
2017	9	3	0	3	16
2018	9	5	0	5	14
TOTAL	78	40	14	51	134

While the first section has remained largely unchanged over the mentioned period, the second section underwent in 2016 fundamental changes in the area of road safety. The main changes consisted in:

- creating central “islands” at the entrance in rural settlements or at the intersections of the national road with county roads or local roads;
- installing metallic barriers on the roadsides.
- installing noisemaking strips/resonators;
- installing traffic calming devices on the roads.
- applying longitudinal and transversal markings of different colors to improve visibility;
- applying two-component road markings for improving the road traffic conditions during the night and in low visibility conditions;
- installing mechanical direction separators (New Jersey barriers)
- supplementing the vertical and horizontal road signaling in blackspot areas.

While the data in table 1 show no obvious trends over the years, in table 2 there can be noticed that starting with the year 2016 there have been recorded no fatalities there, while the severe injuries resulting from road accidents in that road section also show a descending trend. This can only be ascribed to the changes that were made to the road infrastructure in the year 2016 and especially to the installation of New Jersey barriers. Moreover, these measures led to the virtual disappearance of road accidents caused by the driving on the wrong side of the road, by the illegal road crossing by pedestrians and also by illegal overtaking maneuvers.

The third analyzed road section of DN1, from the city of Sibiu to the border between Sibiu and Alba counties, has been doubled in 2014 by a motorway section. However, in the year 2015, the motorway section had to be closed in order to allow some repairs to be carried out and reopened only in the year 2016.

Table 3 shows the dynamics of the number of accidents and of the various types of casualties both on DN1 between km 314 and km 350 and on the corresponding motorway section (data from [10, 11]).

As can be seen from table 3, the number of accidents and the number of fatalities and of severe injuries resulting from these accidents on DN1 has decreased significantly once the motorway section had been opened and even the sum of accidents and of fatalities and severe injuries, respectively, on the DN1 section and on the motorway section, is lower than most numbers in previous years.

Even more, once the motorway had to be closed for repairs, the numbers of accidents, fatalities and severe injuries have returned to pre-2014 levels. Once the motorway had reopened, all values decreased again. This points once again to the huge effect of introducing motorways as another means to modernize the road infrastructure on the increase in road safety levels.

This is also supported by the fact that the main causes for the producing of road accidents on the third road section (national road) were as follows:

- excessive speed or speed not adapted to road or meteorological conditions - 95 road accidents (40.33%)
- failure to maintain a safe distance between vehicles – 27 road accidents (11.34%)
- pedestrian indiscipline – 21 road accidents (8.86%)

while the main causes on the motorway section were:

- failure to maintain a safe distance between vehicles – 12 road accidents (36.36%)
- other preoccupation of drivers – 7 accidents (21.21%)
- excessive speed or speed not adapted to road or meteorological conditions - 95 road accidents (40.33%).

Table 3. The dynamics of the number of accidents and of the various types of casualties on DN1 between km 314 and km 350 and on the corresponding A1 motorway section

Period	DN 1 (km 331 – km 350)					A 1 (km 270 – km 292)				
	No. of acc.	Serious acc.	Fatalities	Severe injuries	Light injuries	No. of acc.	Serious acc.	Fatalities	Severe injuries	Light injuries
08.09.2010 - 07.09.2011	24	18	1	18	14					
08.09.2011 - 07.09.2012	24	12	6	13	27					
08.09.2012 - 07.09.2013	17	10	7	13	21					
08.09.2013 - 07.09.2014	24	16	3	20	26					
08.09.2014 - 07.09.2015	8	4	2	5	6	9	4	1	6	4
08.09.2015 - 07.09.2016	26	13	10	21	32	Motorway closed				
08.09.2016 - 07.09.2017	4	2	0	5	14	7	4	1	6	10
08.09.2017 - 07.09.2018	4	2	0	3	3	6	5	1	7	4
TOTAL	131	77	29	98	143	22	13	3	19	18

It should be mentioned also that both the modernizing measures introduced on the second analyzed road section and the opening of the motorway on the third road section

have managed to eliminate three of the main causes of accidents in previous years: wrong-way driving, illegal crossing of the road by pedestrians and illegal overtaking of vehicles.

4 Discussion and conclusions

The data presented in the current paper have shown that by implementing adequate measures for the modernization of the road infrastructure, it was possible to significantly reduce the number of accidents and of their most serious consequences.

It can be stated that during the period targeted by this analysis, from 2010 to 2018, the number of accidents has fluctuated, but during the last three years of the study there could be noticed a descending trend, both concerning the number of accidents and concerning the number of more serious consequences of these accidents (fatalities and severe injuries).

While in the case of the second road section, this is visible only in terms of fatalities, for the third section the reduction in the number of all categories of accidents and of their consequences is obvious, emphasizing once more the important role of motorways not only in the reduction of the travel time between cities, but also in the increase of road safety.

Furthermore, the implementation of modernizing measures such as those described in this paper has led to the elimination, on the analyzed road sections, of some of the most important causes for accidents - wrong-way driving, illegal crossing of the road by pedestrians and illegal overtaking of vehicles.

Since road safety management is a new concept in Romania, it would be beneficial to elaborate a dedicated handbook to assist the authorities with attributions in the area of road infrastructure. This handbook should comprise the best practices from Romania and other member states of the European Union and be a source of inspiration for the design of safety elements, including elements that require attention on and along the roads in residential or industrial areas.

The existing roadbuilding standards should be revised in order to identify road safety issues that require updating and to include the state of the art in the area of road safety.

The list of blackspot areas should also be updated regularly, as well as the management system for such areas the the relevant information should be communicated to all interested parties. The analysis of the situation in each blackspot area could lead to valuable lessons and to measures that could be applied in other blackspot areas, such as physical improvements that would supplement and eventually even replace the installation of blackspot area signs.

As indicated also in the General Transportation Masterplan of Romania [7], the elimination of blackspots should be done in agreement with the best practices from the states of the European Union.

In future, the authors intend to continue their researches in order to obtain more data and refine their results in terms of the correlation between various types of road infrastructure improvements and the increase of road safety aspects.

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