



UNIVERSITY OF MONTENEGRO
FACULTY OF CIVIL ENGINEERING



THE NINTH INTERNATIONAL CONFERENCE
CIVIL ENGINEERING - SCIENCE & PRACTICE

GNP 2024 PROCEEDINGS



Kolašin, March 2024



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ROAD SAFETY INSPECTION IN THE FUNCTION OF DETERMINING UNSAFE ROAD LOCATIONS

Abstract

A road safety inspection (RSI) is a systematic and independent assessment of the parameters of road safety projects with the aim of preventing traffic accidents and creating safer roads for all road users. It covers all road users, not only car drivers, but also pedestrians, cyclists, motorcyclists, trucks, buses and public transport vehicles, and considers all road safety stakeholders (road users, road maintenance, vehicle, weather conditions, etc.).

Using the RSI procedure and analyzing the current state of traffic safety on the section of the regional road R1106 (from the intersection with Boris Trajkovski Blvd. to the intersection for the local road to the Church of St. Dimitrija), as well as the AADT data, conducted traffic accidents, and the previously performed inspection with a implemented project to increase traffic safety, it can be seen that the situation is not at a satisfactory level.

It is necessary to take measures that will contribute to the improvement and increase of safety, taking into account all the influential risks included in the two subcategories: objective - which are related to the objective factors (environment) and subjective - which are conditioned by the individual ability, properties, characteristics, motivation, understandings, attitudes and prejudices of the person. The obtained results are compared with the initially carried out inspection of the road to increase safety and the effects of the already carried out reconstruction to improve traffic safety, which was carried out in 2014. Based on this analysis and comparison, dangerous locations will be detected, i.e. reasons why they are unsafe, and conclusions and recommendations will be made that can serve as a direction for improving the safety of other road sections.

Keywords

Audit, safety, roads, transport, maintenance, traffic.

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1. INTRODUCTION

Traffic safety is the primary social responsibility of all entities. Every traffic accident, every injury or loss of human life as a result of a traffic accident, represents irreparable damage primarily to the family, but also to society, the population and the economy. Awareness of road safety can significantly reduce the chances of an accident, making the road a safe place for all users [1].

The purpose of this paper is to show the importance and advantage of using the RSI procedure on the road to identify the risks that lead to an accident, with a vision of improving road safety and its more frequent implementation.

Through the analysis of traffic accidents that have occurred and the reasons for which they occurred, dangerous places and factors affecting road safety will be detected. The obtained results will be compared with the initially performed safety inspection and with the effects of the already performed reconstruction of the road in 2014. Based on this analysis and comparison, conclusions and recommendations will be made that can serve as a direction for improving the safety of other road sections.

The preparation of this paper defines an approach that can be used in the future on every other road section in our country for RSI in traffic, data analysis and proposed measures that can be taken to increase traffic safety, with the possibility of further expansion and improvement.

2. EXISTING CONDITION

The selected section is located in the southern part of the Skopje Valley and is on the regional road R1106, Ilinden - Kalugjerec, which has a total length of 106 km. The section under consideration is from km 13+200 to km 23+200, i.e. from the intersection with Boris Trajkovski Blvd. to the crossroads with the church of Saint Dimitrija, in a length of 10.0 km. This road passes through the settlements of Batinci, Varvara and Markova Sushica.

The geometric cross-section of the road is 6.0 m wide, and allows two-way movement of vehicles. From the starting station to the crossroads at the Drisla dump, a 1.50 m wide pedestrian path has been constructed, with street lighting on one side.

There is also a bus service on part of the regional road, that is, to the crossroad for Markov Monastery [2]. The pavement was reconstructed in 2008, while in 2014 a traffic project was carried out to improve traffic safety in two phases. In the first phase, traffic signals and road equipment were installed on the entire section, while sidewalks with lighting were installed only in the Batinci settlement.

At the request of local residents, for the sake of increased safety for pedestrians, in the second phase the path with street lighting was extended to the intersection with Boris Trajkovski Blvd.

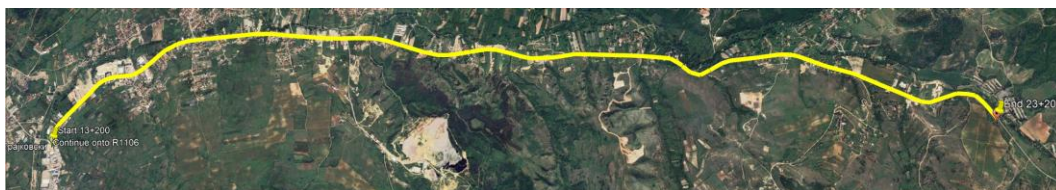


Figure 1. Preview map of the section R1106 from km 13+200 to km 23+200



Figure 2. Longitudinal profile of the section R1106 from km 13+200 to km 23+200

3. PREVIOUSLY IMPLEMENTED PROJECT ACCORDING TO RSI FOR R1106

Through the program of the government, PESR, World Bank and European Bank in the period between 2008-2012, a project was implemented to improve traffic safety on local and regional roads. An inspection of the safety of the regional road P1106 with a length of 10 km was carried out and on the basis of it a project was prepared for the reconstruction and design of measures to improve the safety of traffic on the section.

With the road safety inspection, deficiencies were found in the geometric cross-sectional profile, upper structure, intersections, public transport, traffic signaling, vulnerable group of participants and lighting.

For the defined deficiencies, improvement in several positions is foreseen. Mainly, the permitted speed has been reduced, traffic signals have been rehabilitated and pedestrian flows have been provided.

4. DATA FOR THE NEW RSI

The data used include the fixed characteristics of the road and its surroundings (construction characteristics, signaling, drainage, position of intersections, etc.), variable data at the annual level (AADT, traffic accidents, etc.) and survey data obtained by the engineers for maintenance and the local population.

4.1. DATA FOR ROAD ENVIRONMENT

Road environment data includes the entire environment of the road corridor with all the physical characteristics that affect road safety.

- **The road cross section.** In the largest part of the route, the two traffic lanes have a reduced width of less than 3 m. The gutters and shoulders are overgrown with vegetation and are non-functional. On the entire length of the section, the transverse slopes are in accordance with the road regulations [5].
- **Horizontal and vertical geometry of the route.** The sizes of the radii of the circular arcs along the entire length of the section are above the limits. The part of the route with an "S" curve at settlement Varvara is satisfied with the minimum values for the geometrical elements in accordance with the rules, but they are not mutually compatible. The vertical

elements along the entire length of the section are in accordance with the road regulations [5].

- **Visibility.** The horizontal visibility of the regional road is reduced by the roadside facilities. It is also not satisfied due to overgrown vegetation along the entire length. The vertical visibility meets the conditions given in the road regulations [5].
- **Pavement.** At the beginning of the section, in a length of 500m, the right traffic lane was damaged during cleaning of the drift from the hill which is in close proximity to the road and has a reduced width. This part of the section is in a curve and vehicles from the right traffic lane are forced to enter the left traffic lane, thus endangering traffic safety. Along the route there are potholes and drifts of earth and dust accumulated along the curbs, as well as on the traffic lanes themselves.
- **Drainage.** Along the entire length of the route, the culverts are non-functional, some of them are completely buried because they are located in private property. Along the newly built sidewalk, there are no gutters that would accept the outflow of water that previously took place through the shoulder.



Figure 3. Inadequate drainage at km 3+200

- **Traffic signaling and equipment.** The vertical signaling from the exit from Boris Trajkovski Blvd., up to the village of Varvara was destroyed. There are only parts of plates with the names of settlements left that are distorted. On the rest of the section, there is vertical signage, which is faded and mostly obscured by vegetation. Horizontal signaling from the exit of Boris Trajkovski Blvd. does not exist until after the crossroad for Drizla. On the remaining section of horizontal signaling, only longitudinal markings are made. The dividing line is not properly constructed, so the traffic lanes change their width. There are no transverse and other markings on the roadway, pedestrian crossings, arrows and inscriptions on the roadway are not marked [6]. The guardrail of the road is in poor condition. In many places, parts of the guardrail have been arbitrarily removed due to newly built buildings or damaged by vehicle impacts [9].
- **Lighting** was carried out only on the part of the road from the exit of Boris Trajkovski Blvd., in the settlement of Batintci, next to the crossroad for Drisla. Then suddenly is entering part of the road that is without lighting, and has a vertical curve and reduced visibility.
- **Access roads.** The section has a large number of access roads. At the intersections in Batintci, Varvara and Markova Sushica settlements, the crossing of the regional road is on paved roads with a width of less than 4 m.



Figure 4. Batinci intersection

Along the finish line, there are improvised dirt paths of non-standard width that connect directly to the regional road. One of the most dangerous places where there are such improvised connections is the bend after the town of Varvara towards the town of Markova Sushica, where an improvised dirt road joins the bend itself on both sides. These wild connections represent dangerous places for traffic safety because visibility is poor. When it rains, drifts on the ground and buffer from the improvised roads flow onto the regional road, posing a traffic safety hazard.

- **Public transport.** There are only two bus stops separated from the traffic lanes on one side of the road in the settlement of Batinci, and they are in bad condition. There are drifts of earth and the roadway is destroyed, so it is not even noticed that they exist. On the rest of the route, passengers enter and exit the buses at improvised locations that are not properly marked and move along the road lanes.
- **Heavy goods vehicles.** The intensity of heavy goods vehicles is high due to the proximity of several quarries, a concrete production base, Drisla dump and construction companies that are located on the route of the road and are moving at an inappropriate speed.
- **Vulnerable group of road users.** There is no traffic signal for pedestrian crossings at intersections. The pedestrian protection fence has been broken by vehicle impacts. On parts of the section where the road is in an embankment and there is no space for pedestrians, the same is marked with appropriate vertical signaling.

4.2. DATA FROM CONCERNED INSTITUTIONS

4.2.1. AVERAGE ANNUAL DAILY TRAFFIC (AADT)

From the Public Enterprise for State Roads (PESR) is received data for average annual daily traffic (AADT) for a period of 12 years, ie from 2014. until 2022, shown in table 1. From the obtained data, it can be seen that the total AADT moves on average around 2130 - 2150 vehicles per day. The data shown in the table are data obtained from counting with mobile vehicle counters.

On the indicated section, there is an increased intensity of traffic with heavy trucks due to the proximity of several quarries, a concrete production plant, several construction companies, as well

as the Drizla dump. In the summer period and on weekends, the intensity with light motor vehicles is increased due to the several surrounding picnic and tourist spots.

Table 1 AADT for R1106, section from km 13+200 to km 23+200

Year	Total AADT
2021	2131
2022	2083
2023	2101

4.2.2. DATA FOR TRAFFIC ACCIDENTS

From the Ministry of Internal Affairs is received data for the number of traffic accidents with material damage, as well as the number of people who were injured or died. Data are also given on the reasons for which the traffic accidents occurred. The data refer to the period from 2021, 2022 and until April 2023, and are given in tables 2 and 3.

Table 2. Data from the Ministry of the Interior for the reasons of the occurred traffic accidents

Year	Reasons
2021	Improper speed, illegal overtaking, illegal actions with a vehicle
2022	Inappropriate speed, illegal actions with a vehicle, failure to yield the right of way
Until 04. 2023	Inappropriate speed, failure to yield the right of way

Table 3. Data from the Ministry of the Interior on traffic accidents, with type of consequences

Year	Total number of traffic accidents	Physical injuries	Serious bodily injuries	Deadly consequences
2021	16	31	5	3
2022	15	25	1	/
Until 04.2023	6	10	1	/

4.2.3. SURVEY DATA

Through survey sheets to the maintenance engineers and the local population, a rough picture and an approximate insight of the critical locations was obtained.

The main reasons that contribute to reduced traffic safety are the degraded roadway, reduced visibility, non-functional drainage, insufficient traffic signals, etc.

Crossroads in the town of Batinci were identified as the most unsafe locations.

5. PROPOSED MEASURES TO IMPROVE SECURITY

In relation to the defined shortcomings of the section, the following measures are foreseen:

- Complete shaping of the normal cross-section with the creation of a fixed width of driving and edge lanes and rehabilitation of ditches and berms where necessary;
- Reducing the speed of movement in front of populated areas and in locations where visibility is reduced due to built objects with means of reducing speed (elevated surfaces, vibro strips, sound strips, etc.);
- Cleaning and reshaping of the culverts that are closed or collapsed. On the part where there is a sidewalk, grids for collecting and channeling the surface water should be constructed;
- Continuation of the lighting in the part of the vertical curve;
- On the approaches to the access roads, as well as on the access roads themselves, which are less than 4 m wide, appropriate vertical signage should be placed. To install advanced signaling for the announcement of intersections and signs for the right of way, side road, etc. in accordance with the traffic project. To prohibit direct access to the regional road from improvised dirt roads wherever there is an opportunity to build a collector street that will channel the vehicles to the first intersection with the regional road;
- Urbanization of the area, where the terrain allows, a gathering street can be built that will direct all vehicles from the surrounding buildings to the intersections where they can safely join the regional road, appropriate vertical and horizontal signage should be installed;
- Dislocate the objects on the road (advertising panels, poles, electrical supply cabinets, etc.) that are an obstacle to visibility;
- Installation of new horizontal and vertical signaling and equipment that includes regulation of directions and speed, marking of agricultural machinery, bicycle traffic, bus facilities, reconstruction of road equipment (guardrail according to MKS EN1317 with guideposts and catadioptrers).

6. CONCLUSION

Analyzing the performed RSI, on the basis of which the reconstruction project was implemented, it can be concluded that the introduction of a new traffic regime and installation of vertical and horizontal signaling and road equipment has largely contributed to increasing the traffic safety of the section. All road users are promptly, clearly, transparently and unequivocally informed about traffic rules and road conditions. With the construction of a pedestrian path and street lighting, installation of appropriate vertical and horizontal signaling and road equipment, the safety of the most vulnerable category of traffic participants, pedestrians, has been increased. Limiting the speed in certain places due to inappropriate elements of the road, as well as on sections that pass through populated areas and the installation of appropriate signaling contributes to the timely awareness of all road users about road conditions and increased safety in traffic.

Comparing the data on AADT and traffic accidents, it can be concluded that although traffic has been decreasing over the years, the number of accidents is the same or increasing. From here it can be concluded that reducing AADT does not affect road safety.

Analyzing the data received from the Ministry of the Interior on traffic accidents, it can be concluded that in 2021 the most traffic accidents occurred, a total of 16, with the most fatal consequences and serious bodily injuries.

By comparing the situation about ten years ago and now, you get the impression and can conclude that instead of improving and increasing awareness of the importance of traffic safety, over the years it is rapidly decreasing.

As an important factor affecting traffic safety in parts of this section, the characteristics of the road can be pointed out, i.e. the mutual non-compliance of road elements, as well as visibility in curves and at intersections. Because of this, it is necessary to limit movement speeds, to carry out regular road maintenance. The large and intensive construction of the environment on the road in settlement Batinci mentions thinking about re-categorization of that part of the road and a new planning solution in order to increase traffic safety for all participants.

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