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Audit of Road Safety Elements in National Road N25.2 "Prishtinë – Gjilan"

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Abstract. With the increase of the number of vehicles and the number of kilometers of the road as well as the time of their construction, the number of accidents has also increased, therefore it is very important to audit the road elements (level of roughness, macro and micro deformations, turns, longitudinal and transverse slope, shoulders, erosion and filling in roads, drainage, etc.) which directly affect the safety of road traffic. The audit of road elements will give us a clear picture on the identification of road factor elements in certain road segments of the road N -25.2 Prishtina - Gjilan, which will then be processed to take preventive measures in the relevant institutions.

1 Introduction

One of the most serious problems of our society is the increase in the number of accidents, especially those with fatalities.

The best possibility of accident prevention comes from the Audit of road safety elements, respectively the Inspection of road safety elements.

Road safety auditing is an accident prevention process and is based on the method that "prevention is better than cure". This method is more effective. A qualified audit team can identify and eliminate an element of uncertainty in a road project, the repair of which can cost much more once the road is built. In other words, a road safety check can eliminate a safety problem while it is still a pencil line on a piece of paper instead of waiting for project construction and the occurrence of accidents as well as the installation of costly safeguards [1].

With the directive of the European Parliament, no. 2008/96 "On road infrastructure safety management", published in November 2008, the European Union issued a clear road safety audit decision, which will be mandatory for the trans-European road network in the coming years:

- Road Safety Audit-RSA;
- Road Safety Inspection-RSI.

Road Safety Inspection: An audit can also be performed on an existing road - in this case it is called a Road Safety Inspection (RSI).

A road safety inspection allows the identification of hazards on existing roads before they lead to accidents.

Road safety inspections are especially useful in places where reliable and accurate accident data are not available [2].

The main goal of RSA is to provide roads maximally safe for traffic and traffic participants. This implies that traffic safety must be considered during the whole design process as well as implementation of any design and project [3].

2 Data used

Study Area

Gjilan is located in the south-east of Kosovo in Anamorava with coordinates (42.4605,21.4699) and Prishtina is located in the northeastern part of Kosovo with coordinates (42.6727,21.1669).Air distance from Gjilan to Prishtina is 34 km. If we measure it by car, the driving distance between Gjilan and Prishtina is 46 km.

2.1 Data collection of the most dangerous places for accidents

During the research we first started with the field investigation, where we started the investigation in two locations out of four that are presented as the most dangerous, where we are based on statistics provided by the Ministry of Infrastructure, then with the use of equations, literature and Prishtina-Gjilan road signaling project. We have presented the locations in the table below [4]:

Table 1. Data of accidents for two of most dangerous locations of national road Pishtina-Gjilan.

Road	Location	Coordinate	No. of fatal accidents	No. of accidents with injuries	No. of damaging accidents
N 25.2	'Restaurant Natyra' (Mramor)	42.500-21.108	1/0	12/11	7/5
N 25.2	Slivovë	42.620-21.318	0/0	15/16	14/12

3 Analysis and presentation of results

For the realization of the Audit of road elements, we went through these stages during the research process:

- Investigation and measurement of road elements,
- Use of equations to arrive at finding the influencing factor in causing accidents as well as possible solutions to reduce the number of accidents, presented below:

Determining the width of road safety, to identify dangerous places:

$$Gja = 0.4 + 0.005(V_1 + V_2); \quad Gj_1 = Gj_2 = 0.2 + 0.005 * V_1$$
$$\mathbf{B^*_{rr} = B_{v1} + Gj_1 + Gja + Gj_2 + B_{v2}} \tag{1}$$

Determining the limiting speed of the vehicle without taking into account the transverse slope:

$$V_{gz} \leq \sqrt{R * g * \mu_b} \tag{2}$$

Determining the limiting speed of the vehicle taking into account the transverse slope:

$$V_{gz} \leq \sqrt{R * g * \frac{tg_\beta * \mu_b}{1 + \mu_b * tg_\beta}} \tag{3}$$

Determination of vehicle stability against rotation:

$$V = \sqrt{\frac{R * g * b}{2 * h}} \tag{4}$$

Determining the impact of the turning radius on accidents:
The ratio between two consecutive turns is determined by the ratio:

$$\frac{R1}{R2} = \mathbf{1.2\ up\ 1.5} \tag{5}$$

3.1 Technical elements of the road

Width of road safety: Traffic lane values

Table 2. The values of the circulation strips.

Location (km) Mramor Village	The actual width of the strips	Width of road safety
+ 544.85 km	6m (3+3m)	7.4m
+958.66 km	6m (3+3m)	7.0m
+230.34 km	6m (3+3m)	7.0m
+412.57 km	6m (3+3m)	7.0m

Location (km) Slivovo Village	
The actual width of the strips	5.6m (2.8+2.8m)
Width of traffic lanes according to the project:	6m (3+3m)
Width of road safety	6.8m

Note: The values that do not match the security values are shaded in red, while the values that match the security values are highlighted in green.

The locations in question are presented as dangerous on the grounds that the width of road safety has turned out to be smaller than it currently is.

As shown in the literature, according to the technical standards for roads, on national roads, at speeds up to 80 km / h, the width of the lanes must be at least 3.25 m (one lane). On this road, except that there is no minimum width, in some segments of the road after measurements we have noticed that the traffic lanes have been reduced to 2.80 m, as seen in the following figure:

Fig. 1. The actual width of the road.

From these results we have obtained, we note that the small width of the road poses a potential risk of road accidents, noting that the road is constantly used by large trucks. Determining the limiting speed of transport and rotation of the vehicle:

Table 3. Limiting speeds of transport and rotation of the vehicle.

Mramor Village	Current vehicle speed (km/h)	Limit speed of vehicle transport without transverse slope (km / h)		Limiting speed of vehicle transport with transverse slop (km / h)		Vehicle speed limit to rotation
		$\mu b = 0.8$	$\mu b = 0.6$	$\mu b = 0.8$	$\mu b = 0.6$	
+544.85	80	50	45	50	45	70
		$\mu b = 1.0$	$\mu b = 0.6$	$\mu b = 1.0$	$\mu b = 0.6$	
+958.66 km	60	40	30	40	35	50
+230.34 km	60	50	40	45	40	60
+412.57 km	60	35	30	35	30	45

Slivovo Village	Current vehicle speed (km/h)	Limit speed of vehicle transport without transverse slope (km / h)		Limiting speed of vehicle transport with transverse slop (km / h)		Vehicle speed limit to rotation
		$\mu b = 0.8$	$\mu b = 0.6$	$\mu b = 0.8$	$\mu b = 0.6$	
+544.85	80	35	30	35	30	45
+958.66 km	60	45	35	40	40	55

Note: The values that do not match the security values are shaded in red, while the values that match the security values are highlighted in green.

Driving speed at the same time is an indicator of the level of service in the given traffic conditions. From the obtained results, we confirm that the driving speed should be maximum up to 80 km / h along the entire road Prishtina-Gjilan, if we aim to at least reduce the number of accidents. In some segments we have examined, the speed should be less than the actual speed according to the results obtained, taking into account some of the factors such as:
road characteristics, characteristics and condition of vehicles, turning radius, intersections, width of lanes, visibility, roughness of the road, etc.

Impact of turning radius on accidents: For turns with a radius of less than 150 m there is an immediate increase in accidents and is expressed through the diagram:
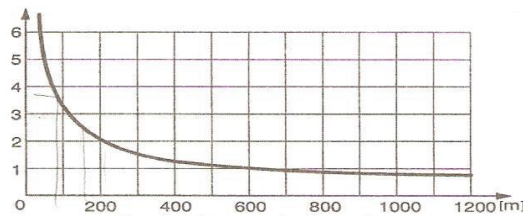

Fig. 2. Turn Radius -Accident Relationship.

The ratio of two consecutive turns is expressed:
Location: Mramor Village

$$\text{Where } \frac{R_1}{R_2} = 1.2 \text{ deri } 1.5 \qquad\qquad (6)$$

1. $\frac{R_1}{R_2} = \frac{1200}{300} = 4.0 \neq 1.2 \text{ deri } 1.5$

2. $\frac{R_1}{R_2} = \frac{200}{160} = 1.25 = 1.2 \text{ deri } 1.5$

3. $\frac{R_1}{R_2} = \frac{160}{250} = 0.64 \neq 1.2 \text{ deri } 1.5$

4. $\frac{R_1}{R_2} = \frac{250}{130} = 1.92 \neq 1.2 \text{ deri } 1.5$

Location: Slivovo Village

$\frac{R_1}{R_2} = \frac{130}{200} = 0.65 \neq 1.2 \text{ deri } 1.5$

The length of straight lines and turns must be harmonized with each other because their dis-harmonization represents insecurity in traffic and the turns between them

must not have a large difference in radius because the direction of the vehicle becomes unstable.

From the curves that have been examined, we see that the ratio between them is not within certain norms, so we have potential risk in these segments.

4 Discussions and Conclusions

From the results we have obtained in certain segments, we have noticed that some of the most important and at the same time most dangerous factors causing accidents are:
  • Small and non-harmonized radius between successive turns;
  • Small width of vehicle lanes;
  • Inadequate driving speed in some segments, especially in turns;
  • Unsatisfactory road maintenance.

One of the possible solutions is to build two lanes for one direction of movement. With this solution the movement will become safer and more comfortable for the users.

Driving speed after the results has been proven that the maximum speed should be 80 km / h, but in some segments and especially in turns the speed should be defined lower than it is now, but not to have instability of vehicles that send up to get off the road.

One of the most influential factors of any road category, regardless of whether the road is worn / old or not, is road maintenance. Road control and inspection should be performed by companies contracted by the Ministry of Infrastructure headed by the relevant professional staff, periodically without hindering or endangering the free movement of traffic.

As the construction of the road is quite worn out, the formation of shock holes has started to appear to a greater extent, where the departure of vehicles from them causes a direct accident of vehicles between them, given the small width of the traffic lanes.

Immediately after the rain, the road becomes almost unusable by falling rocks or soil on the road surface.

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