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LONGITUDINAL RESEARCH ON INFLUENCE OF TRAFFIC AND URBAN ROAD ELEMENTS ON OPERATIONAL SPEED

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Abstract

Excessive and inadequate speeds represent one of the most important causes of traffic accidents, and significantly determine the resulting consequences. The research in this paper refers to the analysis of speeds in one of the important corridors of the main city streets in the city of Rijeka, Croatia. Both streets are approx. 1.5 km long, mostly one-way and two-lane, located in a mixed mostly residential area where important recreational and tourist facilities are located also. Both streets have experienced significant changes in the recent years - the construction of an additional road network in a wider area caused a reduction in the importance of the streets in ensuring transit traffic and in traffic loads. The main intersection of the mentioned streets with the third access road was reconstructed - from a non-signalized intersection to a roundabout, certain traffic calming measures were introduced, and the reduction in traffic volume caused the appearance of long stretches of illegal street parking. Traffic counting and speed measurements were carried out at several cross-sections on this corridor in 2016 and 2019, when the construction of the roundabout had not yet begun. The aim of this research is to determine how much the construction of the roundabout and other described planned measures and unplanned changes in both streets affected the flow of traffic - primarily speed and traffic volumes. Traffic counts and speed measurements were repeated in 2023 at the same locations and in the same way as done before. A comparison of the results of operational (V85) speeds shows that traffic in the zone did not calm down due to the effect of the traffic and construction measures taken.

Keywords: operational speed, traffic calming measures, urban street

1 Introduction

The total number of traffic accidents that occur in urban areas in Croatia, according to traffic safety statistics published regularly by the Ministry of Interior, has been growing by about 10% for the past 5 years, and the average for recent years is about 80%. [1]
A positive fact is that the share of deaths in cities, in relation to the total number, is lower than the share of accidents, and for the last two years, it has been around 50% of the total number of victims. Yearly statistics also show that speed (irregular or unadjusted) is the reason for approximately 20% of traffic accidents. The data collected at the EU level for the period 2016-2018 also show that the average pedestrian injury per million inhabitants in Croatia is 50% higher than the EU average and amounts to 16 pedestrians/million inhabitants. The proportion of pedestrians injured on urban roads in Croatia was, in that period, the highest in the EU and amounts to over 80% [2].

Speed control in urban traffic in conditions of heterogeneous traffic where traffic areas are shared by pedestrians, cyclists and motorized road users is therefore of particular importance. A number of European cities are introducing and expanding zones where a speed of 30 km/h is allowed, as this speed reduces the likelihood of fatal accidents involving pedestrians [3]. This measure is systematically monitored in Graz, where it was introduced 30 years ago, and the data show that the effect of the measure is very positive, as the number of traffic accidents with injuries has decreased by 24%, and the number of accidents involving pedestrians by 17%. At the same time, statistics show that there has been no decrease in service levels and longer waits in traffic. [4].

The formation of traffic calming zones is one of the possible ways to improve pedestrian traffic safety, but it cannot be considered a unique solution because it cannot be applied on streets that have the function of ensuring mobility within the city area. Numerous studies are focused on the analysis of parameters that affect speed on city roads in order to determine those that can be influenced with the aim of speed control. The research conducted in Montreal included an analysis of the parameters that affect the operational speeds of arterial and local urban roads. Based on the analysis of 120 road sections, influential parameters from the group: geometric elements, roadway attributes, traffic characteristics and environmental factors were detected [5]. The influence of the number of traffic lanes and the number of sidewalks and pavement conditions on operating speed was determined. On arterial roads the most influencing parameter was time of the day, the speeds were higher during night.

An interesting study was conducted in New Zealand using a simulator to determine the driver's perception of city streets that affects the speed at which they drive [6]. This is particularly interesting because after 2020 and the lock down, which made cities aware of the need to create a safe space for pedestrians and cyclists, cities focused on different traffic calming measures, and it shows that the perception of drivers and also their behavior might not be changed accordingly.

The paper [7] presents the results of the study about relationship of operating speeds to roadway geometric design speed, the influence of several groups of parameters on the operational speed was analyzed. Road alignment, cross section, roadside, land use and driver/vehicle characteristics were used to define operational speed models. The value of the curve is shown in all studies as a significant parameter of influence on the operational speed, when there is no such influence on roads with a lower permitted speed, the elements of cross sections and roadside models proved to be significant [7].

Roundabouts are perceived as a possible measure to calm traffic on the city's road network, because due to the way of movement, necessarily lead drivers to reduce their speed, and as a result, the number of traffic accidents also decreases [8, 9]

The analysis of operational speeds conducted by the authors on the road network in Rijeka in 2016 and 2019 [10] indicated worrying data on operational speeds. Several important city corridors were analyzed and an extremely large proportion of vehicles driving at speeds above the permitted speed limit was determined. The analysis of the influence of the various analyzed geometrical elements, elements of traffic flow and traffic regulation showed that the operating speed is dominantly affected by the speed limit. In the meantime, certain infrastructural and traffic conditions in the mentioned area have been changed - the biggest change in the zone is the roundabout that was implemented at the place of the non-signalised intersection.

In this paper, analyzes of recently measured speeds at the same locations are presented. The aim of the paper is to compare the speeds measured in 2016 and 2019 under the same conditions and at identical locations with those measured in 2023 in order to determine the impact of implemented infrastructure interventions and changes in traffic flows on operational speed. Analyses of traffic accidents that happened on analysed streets is presented too.

2 Methodology

2.1 Analyzed streets and positions of field measurement

The Pećine neighborhood is predominantly a residential area, which, in addition to residential buildings and family houses, also has facilities such as schools, kindergarten, park, but also many city beaches, as the area itself is located by the sea. The observed corridor includes Janka Polić Kamova Street and Šetalište 13.divizije Street, both streets part of the primary road network (main city roads) but at the same time also state roads (D8), on which heterogeneous traffic is present. In addition to local traffic, these streets also take over part of the transit traffic towards the eastern part of the city area (Kostrena municipality) and further south in the direction of Dalmatia, as well as in the opposite, western direction towards the city center.

Janka Polić Kamova Street is a residential-business and partially transit street, traffic from the east, from the state road D8, is directed towards the city center. The street is one-way and two-lane, and on the southern side of the road there is one additional lane intended for longitudinal parking. Along the road, there is also a sidewalk on each side, with tall greenery (row of trees). Šetalište XIII. Divizije Street has the same function as J.P.Kamova Street, residential-business and partly transit. Transit traffic takes is from the direction of the city center towards the Municipality of Kostrena and further along the state road D8 in the direction of Dalmatia. Street is a one-way, mostly two-lane road, with no parking on the street, although vehicles on most of the street use the right traffic lane and the northern sidewalk of the street for parking. The northern pedestrian sidewalk of the street is not continuous along the entire street.

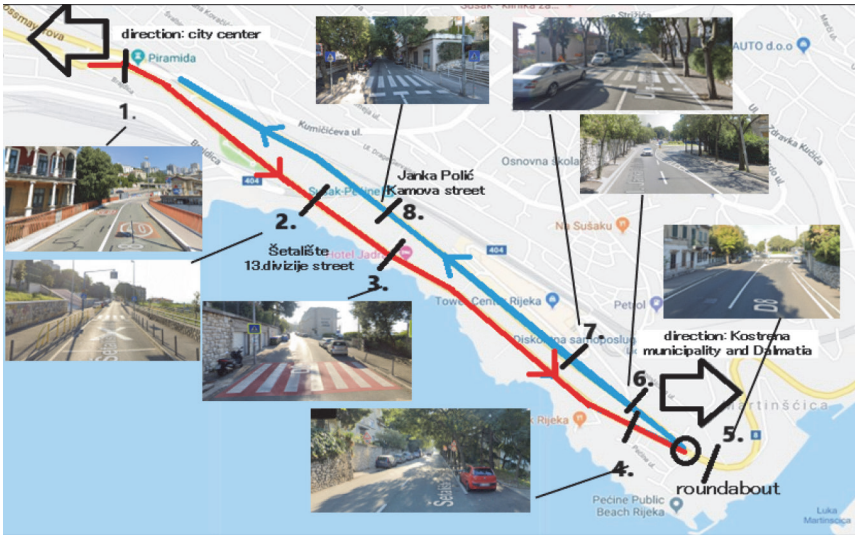

Figure 1 Analyzed streets and locations of field measurements

Most of the street has a sidewalk on both sides of different dimensions, the northern sidewalk is 1.85 m wide, and the southern sidewalk is 2.25 m wide. In the second part of the street, there is additionally a high green area between the roadway and the southern sidewalk, and it differs the width of the southern sidewalk, which in this part is reduced from 2.25 m to 1.85 m due to the high greenery.

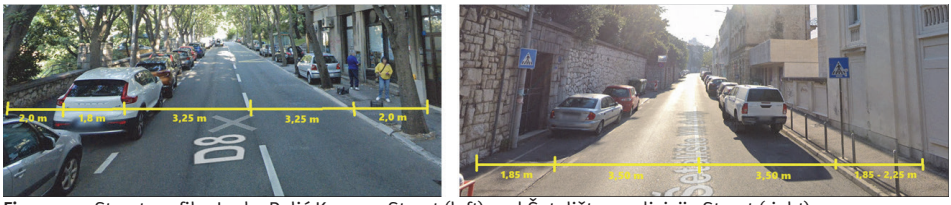

Figure 2 Street profile: Janka Polić Kamova Street (left) and Šetalište 13. divizije Street (right)

2.2 Field measurements in 2016, 2019 and 2023 at selected locations

Field measurements in 2023. were done on 8 locations (Figure 1), with traffic counters Data-collect SDR Traffic without interruption of traffic-free flow conditions in order to assure the quality of database for analyses. At all locations, traffic load and operational speeds were recorded in stable weather conditions. Location 1-4 are on Šetalište 13.divizije Street while locations 5-8 are on J.P Kamova Street. Similar field measurements were made in 2016 (on positions 1, 2, 3,7 and 8) and 2019 (on positions 4, 5, 6 and 8).

Location 1 represents the entrance to Šetalište 13.divizije Street. The street at that location is two-lane and one-way street, with a sidewalk on one side only, and with speed limit signs (40km/h) on the roadway, marked before 2016. Since there were no new traffic calming measures at this position, it is treated as control location.

Location 2 is in front of the elementary school. After measurements in 2016, the street profile was narrowed at this location, from 2 traffic lanes to 1, as a traffic calming measure. The speed limit is 30 km/h.

Location 3 is after the pedestrian crossing, a two-lane and one-way street, with vehicles parked in the right lane so only the left lane is used for driving. The sidewalk is only on the right side of the street, speed limit 40 km/h. After measurements in 2016, the pedestrian crossing was highlighted/painted red in 2023.

Locations 4 (Šetalište 13.divizije Street) and 5 and 6 (J.P. Kamova Street) represent the entrances to the roundabout, reconstructed in 2021. The speed limit in the roundabout zone is 40 km/h.

Location 7 was chosen as a control location, without traffic calming measures, located in front of the pedestrian crossing near the shopping center and the bus station. The street at that position is two-lane and one-way, with parking along the left traffic lane, and with a sidewalk on both sides. The speed limit is 50 km/h.

Location 8 is also in front of the pedestrian crossing, near the elementary school. The street at that position is two-lane and one-way, with parking along the left traffic lane, and with a sidewalk on both sides, whereby the sidewalk on the right side is continuously occupied with parked vehicles. The speed limit is 50 km/h. At that location, after the measurements in 2016, led lights were installed at the pedestrian crossing.

3 Results

In addition to field measurements, data on traffic accidents in the last 5 years for both streets were also collected. Table 1 shows that in the period of 5 years, many accidents were recorded in both streets, especially in J.P. Kamova Street.

Table 1 Accidents in the analyzed streets for the period 2019 - 2023.

Street	2019.	2020.	2021.	2022.	2023.	total in 5 years
Šetalište 13. divizije	8/1	12/1	6/2	10/1	9/0	45/5
J.P. Kamova	40/4	15/2	30/1	23/1	34/3	142/11

total accidents / accidents due to excessive speed

Both streets are one-way, with no connections or intersections , where there is usually a greater possibility of accidents but still lots of accident were recorded. Even formally very small number of accidents is connected to speed problem in both streets there is large amount of accidents for which explicit reason is not defined so, the assumption is that part of that accident are also result of inappropriate driving speed. As field measurements in 2016. were not carried out as daily (24 h) in Table 2 are presented data from 2019. and 2023.

Table 2 Traffic load - comparison of 2019 and 2023 measurements.

Street - location	year	traffic load			
		24 h	morning peak hour	afternoon peak hour	night period (00-06)
Šetalište 13.divizije 4	2019	4622	359	387	127
	2023	4896	380	430	119
J.P.Kamova	2019	7508	519	583	156
	2023	7329	501	557	130

From data in Table 2 it is possible to compare traffic load at 2 locations, Location 4 (Šetalište 13.divizije Street) and Location 8 (J.P. Kamova Street). The data show small changes in the traffic load, on the Šetalište 13.divizije Street there was a 6% increase in daily traffic (from 6-11% in the peak period), the night traffic load decreased by 9%. On J.P. Kamova Street, the daily traffic load in 2023 is 3% less (3-5% less in peak hours), and 17% at night.

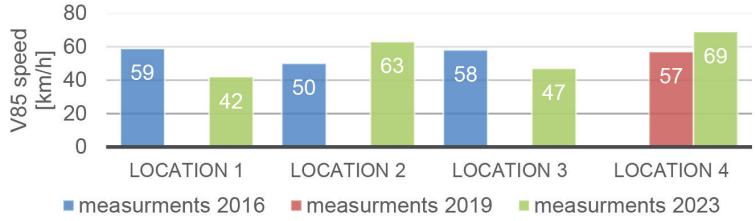

Figure 3 Šetalište 13. divizije Street: a comparison of operational speeds

In the Šetalište 13. divizije Street, V85 speed was compared at all 4 locations (Figure 3). At 3 locations, the comparison is between 2016-2023 measurements, and at the last one, Location 4, 2019-2023 measurements. At Locations 1 and 3, measurements from 2023. show a decrease in V85 speed (by 19 and 29%), while an increase in V85 speed (by 21 and 26%) occurred at Locations 2 and 4.

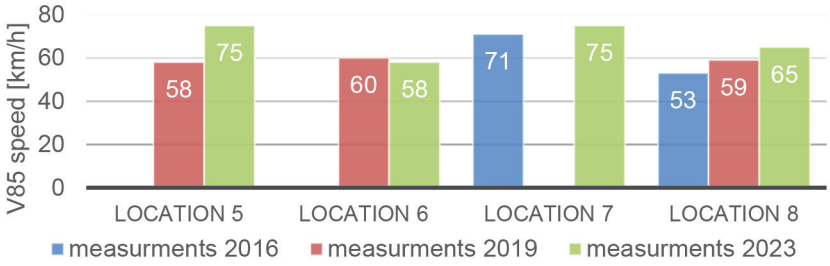

Figure 4 J.P. Kamova Street: a comparison of operational speeds

In the J.P.Kamova Street, V85 speed was compared also at all 4 locations (Location 5-8) (Figure 4). At 2 locations (Location 5 and 6), the comparison is between 2019-2023 measurements, at Location 7, between 2016-2023 measurements, and at Location 8 between 2016-2019-2023. At 3 locations there was an increase in operational speed (6-29%), while only at location 6 there was a slight decrease (3%). Posted speed limit (PSL) at Locations 2 and 3 is 30 km/h, at Locations 1, 4, 5 and 6 it is 40 km/h and at Locations 7 and 8 it is 50 km/h.
At all locations, PSL was exceeded in all measurements (2016, 2019 and 2023). The percentage of exceeding the posted speed limit (PSL) in 2023 is shown in Figure 5.

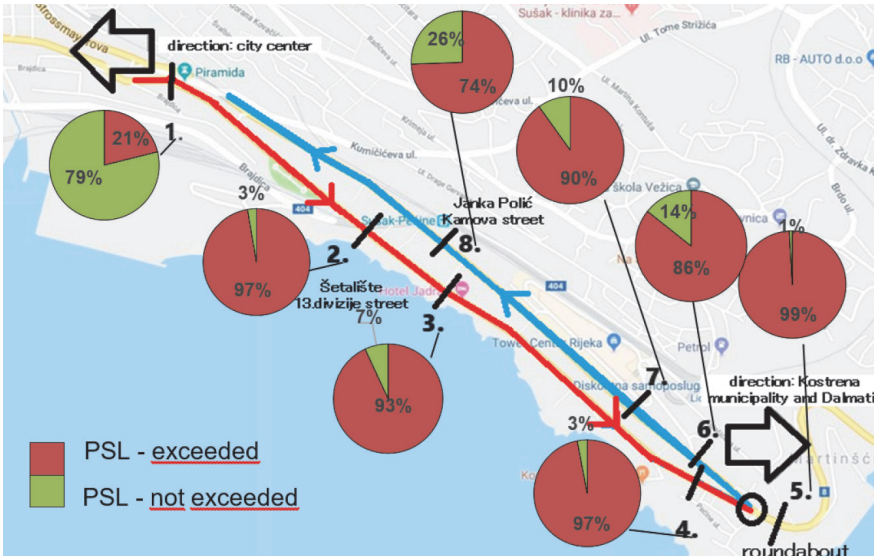

Figure 5 Exceeding posted speed limit by location

4 Conclusions

The analysis of speeds on a selected corridor of primary city roads in the city of Rijeka conducted as longitudinal research in 2016, 2019, and 2023 showed worrying results. In all analysed years, although it is a predominantly residential and, especially in the summer, recreational and touristic zone with pedestrian traffic, a significant number of drivers exceed the speed limit. Recognizing this problem, several interventions were made in the street before and during the analyzed period through infrastructural solutions (roundabout at the place of non-traffic intersection, narrowing of the cross-section) and by arranging signaling and equipment (several solutions in pedestrian crossing zones).

Measurements made under the same conditions and at the same locations after the aforementioned changes were implemented, however, did not show that they had an impact on the operational speed.
Out of the mentioned measures, the measures of marking the road with noticeable red paint (speed limit, pedestrian crossing zone) proved to be effective, while the expected effect of the roundabout on speed reduction was absent, as the speed reduction of approximately 5% occurred on only one of the approaches. The research shows that in order to effectively calm the traffic, the effects of individual measures should be analyzed in advance, for which traffic microsimulations prove to be a good tool, and for this case too, based on the available data of actual measurements, the research will continue in that direction.

Acknowledgments

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References

[1] Ministarstvo unutarnjih poslova RH, https://mup.gov.hr/pristup-informacijama-16/statistika-228/statistika-mup-a-i-bilteni-o-sigurnosti-cestovnog-prometa/bilteni-o-sigurnosti-cestovnog-prometa/287330, 15.01.2024.

[2] How safe is walking and cycling in Europe, PIN Flash Report 38, European Transport Safety Council, January, 2020.

[3] Rosén, E., Sander, U.: Pedestrian fatality risk as a function of car impact speed, Accident Analysis & Prevention, 41 (2009) 3, pp. 536-542

[4] Global Alliance of NGOs for Road Safety https://www.roadsafetyngos.org/toolkit/priority-interventions/30-km-h-zones/,15.01.2024.

[5] Eluru, N., Chakour, V., Chamberlain, M., Miranda-Moreno, L.F.: Modeling vehicle operating speed on urban roads in Montreal: A panel mixed ordered probit fractional split model, Accident Analysis & Prevention, 59 (2013), pp. 125-134

[6] Charlton, S.G., Starkey, N.J.: Driving on urban roads: How we come to expect the 'correct'speed, Accident Analysis & Prevention, 108 (2017), pp. 251-260

[7] Poe, C., Tarric, J., Jacquelyn M.: Operating speed approach to geometric design of low-speed urban streets, Transportation research circular E-C003, 1998.

[8] De Brabander, B., Nuyts, E., Vereeck, L.: Road safety effects of roundabouts in Flanders, Journal of Safety Research, 36 (2005) 3, pp. 289-296

[9] Antov, D., Abel, K., Sürje, P., Rõuk, H., Rõivas, T. Speed reduction effects of urban roundabouts, The Baltic Journal of Road and Bridge Engineering, 4 (2009) 1, pp. 22-26

[10] Deluka-Tibljaš, A., Šurdonja, S., Malatestinić, D., Strineka, L.: Operating Speed On Urban Road Network, 5th International Conference on Road and Rail Infrastructure - CETRA 2018, Zadar, 17-19 May 2018.