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Influence of COVID-19 crisis on the traffic flow characteristics on roundabout

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ABSTRACT

COVID-19 pandemic caused many restrictive measures. Most of these measures were in the relationship with the restrictions of mobility which caused some differences in traffic flow demands. In this paper the comparative analysis of traffic flow characteristics at roundabouts in the City of Banja Luka was conducted. The analysis included two different states of traffic condition: the first one, normal condition before COVID-19 crisis, and the second one, during the state of emergency caused by the pandemic. The analysis shows the difference between some of motorized vehicle and pedestrian traffic flow parameters.

1. Introduction

After the proclamation of the pandemic caused by the virus COVID-19 almost all countries started with the implementation of different restrictive measures with the aim of preventing the virus spreading. The restrictive measures mostly meant social distance, which significantly affected the reduction of needs and possibilities for travel conducting, thus mobility and the number of trips. On the other hand, a part of population whose need for travel continued significantly affected the change in the mode of transport. (Vitello, et al., 2021) (Junghwan & Mei-Po, 2021) (Medimorec, Enriquez, Hosek, Peet, & Cortez, 2020) (Siemens Mobility, 2020)

During previous two years, the phenomenon of COVID-19 virus impact on different social and economic segments was the subject of many research studies. The case studies usually showed a significant decrease in the number of journeys. The impact of COVID-19 on the mobility differs by the travel purpose. According to the source (Medimorec, Enriquez, Hosek, Peet, & Cortez, 2020) in European countries the number of trips for the purposes of retail and recreation decreased by 40-65%.

The impact of COVID-19-related restrictions on mobility to parks is relatively low (between -30 and -40%) by the end of March 2020, and increases again quickly in early April 2020 to a level close to and even above the January baseline. Also, the data analysis shows that the percentage of trips to workplaces decreased by at least 40% by mid-April. Trips with the aim of reaching the public transport station also have a significant decrease, and by the end of the April of 2020 the number of these trips was around 50% lower than in the period before the pandemic. The deviation was noticed with the travel purpose related to the mobility within narrow residence where the number of these trips increased by 12-25%.

According to the survey conducted among the respondents older than 18, it has been established that the occurrence of COVID-19 pandemic affected the way of transport means use. (Siemens Mobility, 2020) The respondents declared how much they use a certain means of transport, given in percentages. The survey results showed that 19% of the respondents mostly use the passenger car. On the other hand, more than 60% of the respondents declared that they use mass transit and train less than before the pandemic. In this way, the change of modal split occurs, which, on the other hand, can reflect traffic flows in the street network.

Within this paper the analysis of traffic flows at the roundabout in the city of Banja Luka, The Republic of Srpska, Bosnia and Herzegovina, was conducted. The case study analysis included motorist, pedestrian and cycling flows, that is, their characteristics determined on the sample before and during the COVID-19 pandemic. The aim of the analysis was to show the influence of the current repressive measures on the characteristics of traffic flow.

2. Methodology

The recording before COVID-19 crisis was conducted in August 2019, and the recording during COVID-19 crisis was conducted in April 2020. Both recordings were conducted on the same day of a week (Thursday), at relatively the same period of day and out of the peak hour. During the recordings, it was sunny with the temperature of 25-35 ºC, without fog, rain, gales or any other unfavourable climate conditions, the roadway was dry and without any damages, and the traffic without the situations which would influence unhindered and safe traffic.
During the recording in the April of 2020, in the city of Banja Luka, the following restrictive measures were in force:

- For persons over 65 years of age it was forbidden to leave their homes;
- Urban public transport and suburban public transport were suspended;
- All educational institutions were closed all day;
- Shopping malls, restaurants, fitness centres, hotels, restaurants, footwear and clothing stores, bookmakers, cinemas, theatres, beauty salons were closed all day;
- Any industry where it is not possible to realize recommendations on the distance between workers were all day closed.

2.1. Description of the research location

The analyzed intersection is in Banja Luka (Bosnia and Herzegovina), a town with around 180,000 inhabitants. The intersection of Boulevard Desanke Maksimović/Boulevard vojvode Petra Bojovica – Boulevard vojvode Stepe Stepanovića was used for data collecting. The position of the intersection in WGS-84 coordinate system is on coordinate 44.766366, 17.209049. The intersection is placed in the urban area of the town, and its type belongs to large town roundabouts.

Table 1. Geometrical characteristics of the roundabout

Geometrical parameter	Dimension
Inscribed circle diameter (m)	57.2
Central island circle diameter (m)	34.8
The roundabout width (m)	9.4
Number of lanes at the roundabout	2
Width of lanes at the roundabout (m)	4.7

Figure 1. Orthophoto image of the analyzed intersection

Table 2. Geometrical characteristics of the approaches

Geometrical parameter	Approach			
	1	2	3	4
Number of lanes on the approach	2	1	2	2
Entry width (m)	8	4.2	8.4	9.2
Width of the lane on appr. (m)	4[1]	4.2	4.2[1]	4.6[1]
Entry radius (m)	23	17.9	20	23.7
Exit width (m)	9.4	4.7	9.4	5.8
Number of lanes on departure	2	1	2	1
Width of lanes on departure (m)	3.6[1]	4	3.7[1]	3.8
Exit radius (m)	26.9	20.2	26.2	20.2

[1]Note: both lanes have the same width.

Next figure shows all geometrical characteristics mentioned in Table 1 and Table 2.

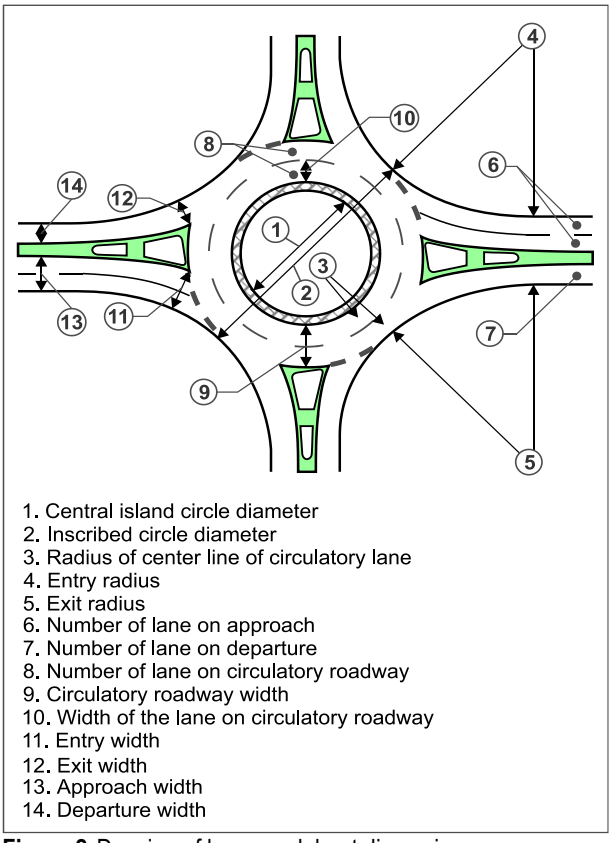

Figure 2. Drawing of key roundabout dimensions

2.2. Data collection and data analyzing methods

Data collecting was conducted by recording real traffic flows at four urban roundabouts. The recording was carried out by means of a drone "DJI Mavic 2 Pro", which was set at a certain height above the analyzed roundabouts and it recorded traffic. For determining traffic flows characteristics, the method of video recording processing and analysis was used. This method proved to be extremely efficient for traffic flow parameters measuring, because its use minimizes the influence of the research on the drivers. The applied methodology enabled the analysis in the real traffic flow, where the speed of the traffic flow depends exclusively on the degree of the interaction between the vehicle and the geometric characteristics of the roundabout.

For traffic analysis of the video data, the authors used “Data From Sky – Traffic Survey” platform. “Traffic Survey” is a video-analytics platform for fully automated extraction of accurate traffic data using artificial intelligence and machine learning methods. (Data From Sky, 2021) The use of this platform indicated an extreme convenience in other similar research studies. (Apeltauer, Babinec, Herman, & Apeltauer, 2015) (Agerholm, et al., 2017)
The collected data were primarily processed within the purpose software package “Data From Sky VIEWER“, where from the original reports were formed. The final data processing was conducted in MS Excel.

3. Research results and discussion

3.1. Motorized traffic flows

In the analysis of vehicles flow by approaches it was determined that there is a difference in the total number of vehicles at the intersection before and during the pandemic of COVID-19. Namely, the case study analysis showed that the total traffic of motor vehicles at the intersection was increased by 35%, from 1,543 veh/h to 2,084 veh/h. The following table shows the values of the flows by the direction of movement depending on the analysis period.

Table 3. Volumes at the analysed intersection before COVID-19

approach	direction	Volume (veh/h)	% from total by direction	% from total by approach
1	left	290	19%	**38%**
	through	189	12%	
	right	105	7%	
2	left	93	6%	**18%**
	through	170	11%	
	right	16	1%	
3	left	12	1%	**17%**
	through	162	10%	
	right	81	5%	
4	left	58	4%	**28%**
	through	151	10%	
	right	216	14%	

Table 4. Volumes at the analysed intersection during COVID-19

approach	direction	Volume (veh/h)	% from total by direction	% from total by approach
1	left	355	17%	**36%**
	through	251	12%	
	right	143	7%	
2	left	162	8%	**17%**
	through	186	9%	
	right	8	0%	
3	left	20	1%	**17%**
	through	232	11%	
	right	105	5%	
4	left	93	4%	**30%**
	through	174	8%	
	right	355	17%	

The comparative analysis of the percentage distribution of the flow by approaches in relation to the total achieved vehicles flow at the intersection before and during the pandemic indicates that there are no significant deviations. Based on this, it can be concluded that the flow demand increase was evenly distributed.

On the other hand, significant deviations have been noticed in the structure of the traffic flow. The analysis has shown that during the pandemic the percentage of vehicles decreased, while the percentage of medium and heavy vehicles increased from 4% to 11% of the presence in the flow.

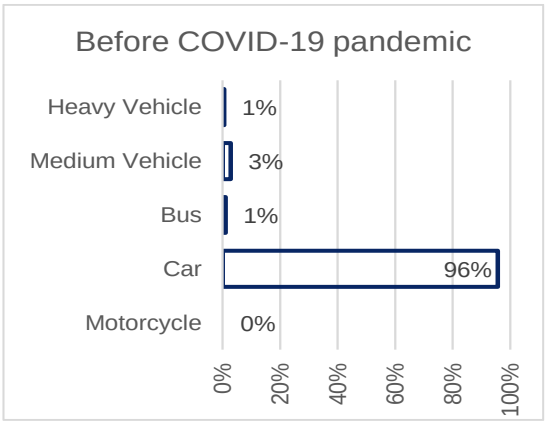

Figure 3. Distribution of traffic flow before COVID-19

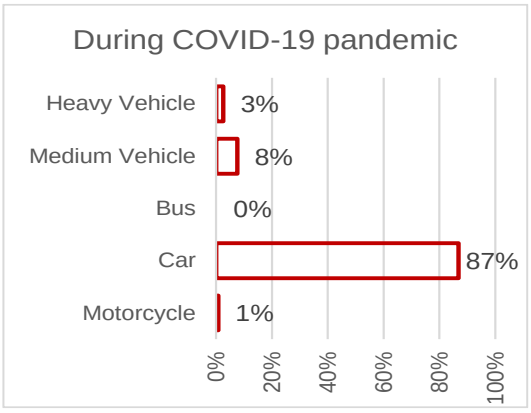

Figure 4. Distribution of traffic flow before COVID-19

Considering the increase in the demand of flow, the change in average flow speed occurred, as well. The average speed of all vehicles in the flow before the pandemic was 23.2 km/h, while during the pandemic its value was 21.4 km/h. The following figures shows heat maps of traffic flow speed.

a) before COVID-19 pandemic *b) during COVID-19 pandemic*

Figure 5. Average speed of motorized traffic flow at the roundabout

3.2. Non-motorized traffic flows

In the case study analysis pedestrians and cyclists were taken as the participants of the non-motorized flows at the observed intersection. Within the first part of the analysis of these flows the maximal concentration of non-motorized flows was observed in the area of the intersection. Figure 6 shows a graph display of the concentration of the analysed objects, in this case pedestrians and cyclists as the participants of the non-motorized flows.

a) before COVID-19 pandemic *b) during COVID-19 pandemic*

Figure 6. Object (pedestrian+bicycle) concentration at the roundabout

On the basis of the displayed figures, it can be concluded that the concentration of non-motorized flows is higher than in the period of the repressive measures. In the situation before COVID-19, the concentration is within the limits 1-3, while in the situation during the pandemic it is within the limits 2-5.
The processing of the collected material implies the increase of the number of participants of non-motorized flows in the following way:

- Pedestrian flows increased by 159%, that is, the pedestrian flow at the intersection in the observed period during the pandemic was 285 ped/h, unlike the same period before the pandemic, when the pedestrian flow was 110 ped/h;
- Cyclists flow increased by 62%, that is, the flow of cyclists at the intersection in the observed period during the pandemic was 21 cyc/h, unlike the same period before the pandemic, when the flow was 16 cyc/h.

Observing from the aspect of the speed of pedestrian and cyclist movement, the established differences are of no significance. Pedestrian flow speed before the pandemic was 1.8 m/s, and during the pandemics it was 1.9 m/s. Cyclists flow speed before pandemic was 7.3 km/h, and during the pandemic it was 8.4 km/h.

4. Conclusion

Global pandemic of COVID-19 affected different aspects of everyday life, among others the characteristics of travel. The conducted research studies have shown that mobility decreased for most travel purposes, in some cases up 50%. Also, the pandemics has apart from the stated also affected modal split, mostly trips where public transport is used. In the case study the characteristics of traffic flows at the roundabouts in Banja Luka were analysed. The analysis included one-hour traffic samples before the pandemic and during the pandemic, with restrictive measures in force. On the basis of the comparative analysis, the following differences have been identified as the key ones:

- The total flow of the motorized vehicles during the pandemics was higher by 35% than the flow volume before the pandemic.
- The percentage of passenger cars and buses in the traffic flow during the pandemic is lower in relation to the values before the pandemic.
- In the traffic flow of non-motorzed participants in traffic during the pandemic, 159% more pedestrians and 62% more cyclists were noticed in relation to the flow recorded before the pandemic.

The obtained results at first deviate from the previous research studies which imply that due to the pandemic there was a decrease in the mobility rate. The authors assumption is that the decrease of total mobility does not necessarily mean the reduction of the number of vehicles in the network, if the mobility change also means the change in the modal split. In the concrete case, during the pandemic public transport traffic was suspended, therefore, the previous users of public transport, who still have the need for mobility, were forced to make a redistribution to other transport modes. Apart from this, schools and a part of industry closing created additional free time which was possible to use for recreational trips which were not restricted.
Considering the sample size and the researched parameters, it is neither possible to make more powerful conclusions than the above mentioned, nor define the trends. The stated assumptions of the authors can serve as hypotheses for further research studies which would be conducted on a larger sample, in the sense of space and time.

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