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Optimization of Traffic Situation Using Roundabouts

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Abstract

Transport is one of the essential elements of critical infrastructure. It is necessary to solve the traffic jam problem and threaten life, health, and property. However, there are several places where these problems are. There is required to solve this problem. One of them is in the selected village in the Zlín Region, Czech Republic. There are two problem places where are frequently the accident. This paper aims to introduce this intersection and prepare the optimized. The paper is divided into few parts. Firstly, there will be a literature review in traffic and the implementation into the critical infrastructure. Secondly, there will be introduced the methods which will be used for this research. Next, there will be the central part of the paper – results. The results are suitable for supplementation with the figures. These figures will represent the current state of the traffic in the village and others with the problem places. The second part of the results will describe the optimized traffic situation by using roundabouts.

Keywords: Traffic; Simulation; Roundabouts; Optimization

1. Introduction

Critical infrastructure determines the functioning of the economy and public administration and ensures the population's basic living needs and the security of the state as a whole. Rehak et al. (2019) state that critical infrastructure plays an important role in modern societies. However, he adds that understanding what critical infrastructure is may vary from country to country (Rehak et al., 2018). One of the most concise and narrowly defined

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definitions states that infrastructure is a network of services that support industry or industrial society, such as roads, communications, or services (water, gas, electricity, etc.) (Lamming et al., 1995).

In most cases, the definition of critical infrastructure refers to infrastructure essential for preserving the basic functions of states. The failure of which would have adverse and adverse effects on the health and lives of the population, property, or the environment. The authors consider the proper identification of critical infrastructure assets to be a crucial part of the risk management process—one of the main essential infrastructure elements in the Czech Republic island transport.

Elements of transport infrastructure, such as roads and railways, are being used by more people every day. According to Patrman, land transport provides the service necessary for the functioning of society. These elements' importance depends on the level of performance they provide, i.e., their traffic-carrying capacity and traffic intensity (Patrman et al., 2019). The growing number of means of transport has been a phenomenon of the last few years. It leads to a sharp increase in oil consumption and, consequently, the amount of exhaust gases, a source of adverse effects on human health and the environment. Babak (2017) defines the synergistic consequences of transport activities. They consider the varied impacts of direct and indirect impact on an ecosystem, which are often unpredicted. Climate change, with complex causes and consequences, is the cumulative impact of several natural and anthropogenic factors, in which transportation plays a role 15% of global CO2 emissions are attributed to the transport sector. There is an effort to find possibilities that will keep society moving forward. Still, at the same time, they will try to minimize or eliminate risks and damage to the community and the ecosystem (Lacinak et al., 2017). The safety of transport and critical infrastructure in road transport leads to the gradual implementation of the different methods. The counterpart of transport safety is the hazard or threat of maintenance processes. Risk is the potential possibility of violation of the transport system safety, which can be calculated by multiplying the likelihood of an incident and the amount of its negative impact. Hazards, threats, and risks in transport are mutually conditional. (Dvorak et al., 2014).

One of the main tasks for development on the road sector is increasing the capacity of roads, primarily along the main lines, and creating city roundabouts (Volkova et al., 2019). Pilko et al. (2019) state the popularity of roundabouts worldwide has driven substantial efforts to optimize their planning and design procedures. Implementing roundabouts is a highly demanding task and requires optimizing traffic safety and traffic efficiency. Roundabouts have been considered worldwide to replace stop-controlled junctions as a means of improving operational and safety performance. Roundabouts can be used as a strategy for access road traffic management near urban areas (Fernandesa et al., 2020). Compared with traditional signalized intersections, roundabouts have been proven to help reduce the severity of accidents and play an essential role in improving transportation sustainability by reducing emissions of air pollutants (Guerrieri, 2015). The aim of the paper is to present the problematic intersection in the selected village. This intersection has a problem with safety in this area due to poor visibility. Based on this, we prepared the optimized intersection.

2. Methodology

In this paper was used four scientific methods. Firstly, there was used the method of analysis. This paper was analyzed by the current state of the selected intersection. Secondly, there was used the induction method. Based on this method, we served to examine the fact of creating a hypothesis from the points obtained. Thirdly, there was used the method of comparison. The comparison was used in the part of the results. There was compared to the current state and the optimized state of the intersection. And finally, there was used the method of simulation. For this purpose, was used the simulation software PTV Vissim. Based on this software, we provide a simulation of the current state and optimized state at the intersection.

3. Analysis of the Current State

This part of the paper is to present the current state of the solving intersection. Firstly, there will be presented the traffic routing and the shoulders of the intersection.

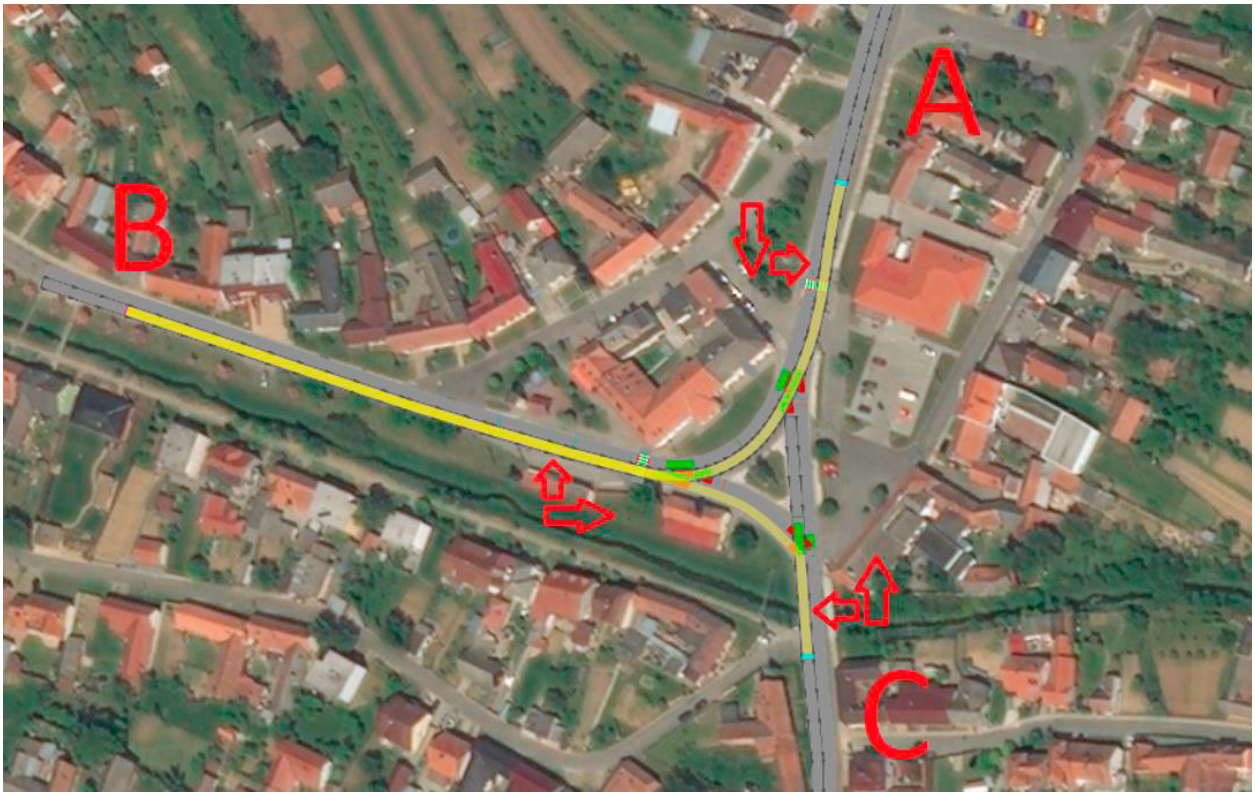

Fig. 1 Traffic routing

Figure 1 shows the current state of the intersection with the traffic routing. As can be seen, it is an intersection with the three shoulders. For the simulation of the current state, we must obtain the data about the intensity. Based on the analysis, we entered intensity–vehicle inputs (Fig. 2).

Vehicle Inputs / Vehicle Volumes By Time Interval (2)

Count: 3	No	Name	Link	Volume(0)	VehComp(0)
1	1		2	300,0	1: Default
2	2		1	180,0	1: Default
3	3		3	100,0	1: Default

Vehicle Inputs / Vehicle Vol... Vehicle Inputs / Vehicle Vol...

Fig. 2 Vehicle inputs

Figure 2 shows the vehicle inputs at the intersection. As a part of the simulation at the intersection, we solve the pedestrians too. The data of the pedestrians are presented in the following figure 3.

Pedestrian Inputs / Pedestrian Volumes By Time Interval

Pedestrian volumes by

Count: 17	No	Name	Area	Volume(0)	PedComp(0)
1	1		22	30,0	1: Pedestrians
2	2		23	30,0	1: Pedestrians
3	3		40	30,0	1: Pedestrians
4	4		24	30,0	1: Pedestrians
5	5		21	30,0	1: Pedestrians
6	6		25	30,0	1: Pedestrians
7	7		26	30,0	1: Pedestrians
8	8		20	30,0	1: Pedestrians
9	9		27	30,0	1: Pedestrians
10	10		31	30,0	1: Pedestrians
11	11		30	30,0	1: Pedestrians
12	12		49	30,0	1: Pedestrians
13	13		44	30,0	1: Pedestrians
14	14		39	30,0	1: Pedestrians
15	15		28	30,0	1: Pedestrians
16	17		41	30,0	1: Pedestrians
17	18		29	30,0	1: Pedestrians

Fig. 3 Pedestrian inputs

Figure 3 shows the pedestrian inputs in the area of the intersection. Based on these inputs, we prepared the simulation of the current state and the optimized intersection.

3. Results and discussion

This part of the paper is focused on higher safety at the selected intersection. The following figure presents the current state of the chosen intersection.

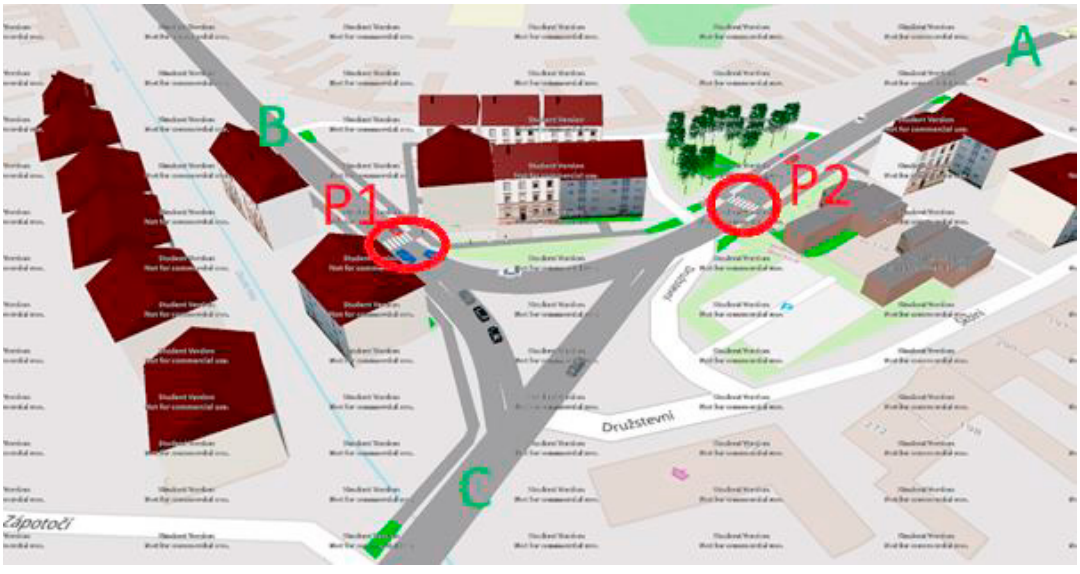

Fig. 4 Current state of the intersection with the problem places

Figure 4 presents the current state of the selected intersection. As can be seen, there are highlighted two crosswalks. These crosswalks present a problematic place for the safety of pedestrians. As can be seen, both crosswalks are placed near the crossing.

Firstly, we will solve the problem no. 1 (P1). As can be seen, the P1 is placed near the crossing and behind the building. This pedestrian crosswalk is lighted at night. If a driver familiar with local roads passes through this intersection, then a pedestrian crossing is not waiting near the intersection and especially behind the building. Pedestrians also have reduced visibility due to the built passage to the adjacent building. A pedestrian can easily overlook an oncoming vehicle and enter the road (see Fig. 5).

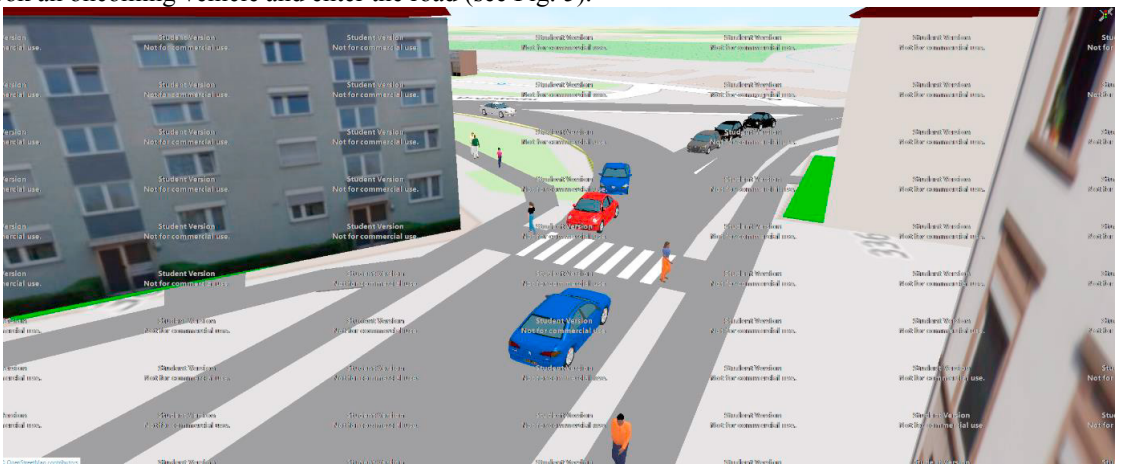

Fig. 5 Problem place (P1)

Secondly, we will solve the problem no. 2 (P2). As can be seen, the P2 is placed near the crossing. This issue will not affect a pedestrian crossing. It is a problem that is a turn of vehicles coming from road A. Vehicles can continue to road B and a pedestrian crossing (P1), but they can also turn to road C. Accidents often occur here. This site presents two problems. At first, it can be a problem where road A is downhill, and drivers are often off to see the turning vehicle and then hit it. There can often be a mass accident of several cars. Secondly, there may be a situation where vehicles want to turn from road C towards road A, and vehicles coming from road B appear quickly behind buildings that obscure the driver's view. It causes a collision of vehicles at this intersection.

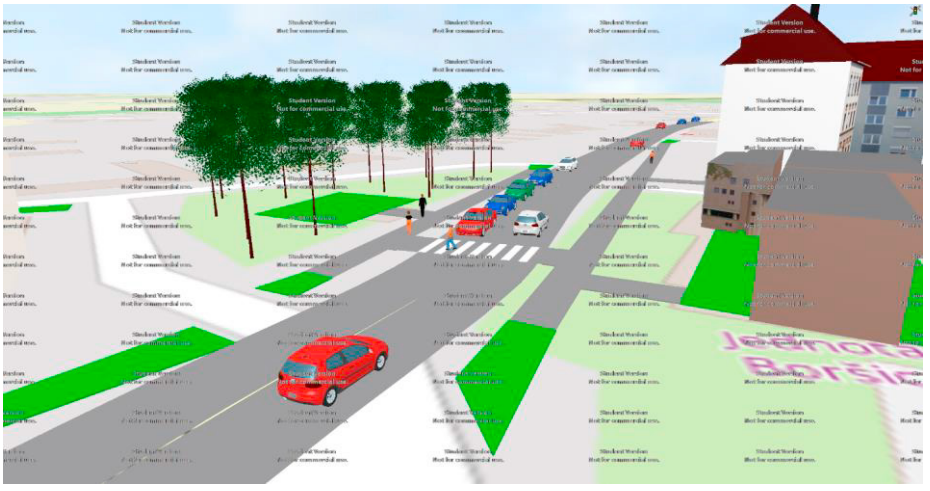

Fig. 6 Problem place (P2)

To ensure more excellent safety, we have proposed the introduction of a roundabout at this intersection. As already mentioned in the introduction, roundabouts provide higher protection and passability. We, therefore, assume that the introduction of the roundabout will eliminate the problem of accidents at the intersection of roads A and C.

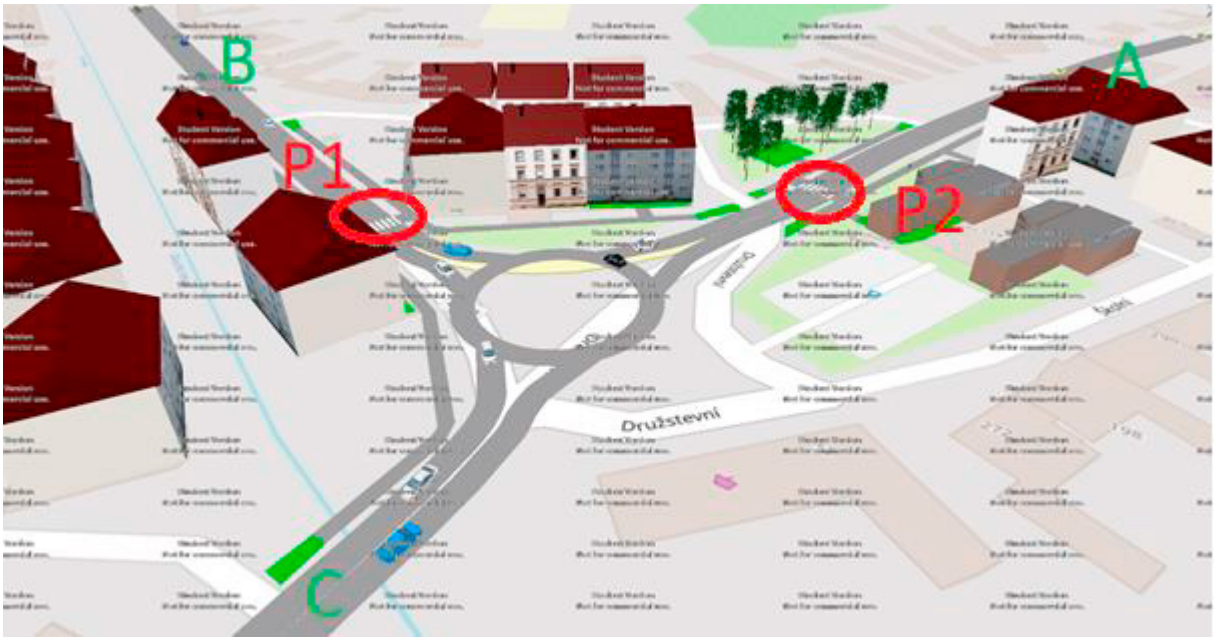

Fig. 7 Optimized intersection

Figure 7 shows the optimized selected intersection. This optimized intersection leads to higher safety and clarity of the intersection. The authors also considered the possibility of moving the pedestrian crossing. However, this option is not permitted due to the location of bus stops. It is not possible to relocate the stops due to the construction of family houses.

The aim of the paper was to present the problematic intersection in the selected village. The limitation of this research is to narrow the focus of research on only one selected intersection. An intersection is an essential element of a road network connecting two or more road elements. This intersection has a problem with safety in this area due to poor visibility. Based on this, we prepared the optimized intersection. There was proposed the small roundabout. This type of roundabouts is typically used on roads of low traffic importance within cities and villages. Piotr et al. (2019) specify that the roundabout is one of the most common intersection types. Roundabouts have a smaller number of conflict points, lower crash frequencies, and there could not be used traffic lights (Ambros et al., 2016), (Persaud et al., 2000; Mocioszek et al., 2015). Future research is focused on the analysis of multiple traffic intersections. After performing several intersections and optimization simulations, the research will focus on traffic in the environment. Not only are roundabouts safer, but higher throughput is also ensured. It reduces the number of exhaust fumes in cars that spend time at intersections. Therefore, the impact of traffic at intersections will be compared if their throughput increases.

5. Conclusion

The paper Optimization of traffic intersection was focused on analyzing the selected intersection in the Czech Republic, Zlín region. This intersection was chosen based on the frequent problem with safety. Not only vehicle drivers were endangered, but also pedestrians at adjacent pedestrian crossings. Firstly, a prepared literature review focused on the critical part of the traffic and the popularity of roundabouts in the whole world. Secondly, there the methodology was introduced, for the simulation was selected the simulation software PTV Vissim. The central part

of the paper was focused on the results. This part was simulated the current state of the selected intersection. The problem parts were described and designed the optimized version of the intersection. In the discussion, these outputs of the article were commented on.

Acknowledgements

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