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IS ROUNDABOUT BETTER SOLUTION THAN A SIGNALIZED INTERSECTION?

Key Words

Traffic simulation

Signalized intersection

Roundabout intersection

Simulation software

Abstract

Roundabouts have become a common model of traffic control in urban areas in Serbia. This type of intersection is increasingly used as an alternative solution to signalized intersections. But is that always a good solution, regarding traffic capacity and level of service? This paper gives insight into the comparative analysis of capacity and level of service on 3 signalized intersections and 3 roundabouts in the City of Novi Sad, Serbia. The main goal is to compare the traffic conditions in the existing state and proposed state (roundabouts to signalized intersections and vice versa). All analyses were performed in a simulated environment.

1. INTRODUCTION

The most common way of traffic control at intersections with high traffic volume is the use of signalized intersections or roundabouts.

At the signalized intersections, the priority is defined by traffic signals. Advantages of this way of control are flexible control, possibility to adapt green time to traffic volume which can enlarge approach capacity and improve the level of service. Traffic lights are a common way of control at the intersections where traffic flow exceeds unsignalized intersection capacity. Disadvantages of traffic lights are higher vehicle speeds in the center of the intersections, more conflict points than a roundabout, as well as pedestrians passing crosswalks during right or left turns.

In recent days, roundabouts became very common on street and road networks. The advantages of roundabouts are lower vehicle speeds and fewer points of conflict compared to signalized intersections, which makes them generally safer than signalized intersections. Average vehicle delay during peak periods can be lower at roundabouts than at signalized or two-way stop-controlled intersections. Disadvantages of roundabouts are high construction costs, unsignalized pedestrian crosswalks and inability to face a potential increase in traffic demands.

In this paper, an analysis of traffic control change was made. Three signalized intersections and three roundabouts were selected as a subject of potential traffic control change. The proposed solution changed control at the roundabout to a signalized intersection and vice versa. Analyses of capacity and level of service were made for all six intersections.

2. PREVIOUS RESEARCH

Traffic conditions are analyzed by many researchers. According to HCM, traffic conditions are observed through delays [1].

There are various papers regarding both types of analyzed intersections (roundabouts and signalized intersections). Many of those papers focused on the idea of changing traffic control at the intersection, either roundabout into a signalized intersection or vice versa. Rune Elvik [2] analyzed the safety effects caused by changing a signalized intersection into a roundabout. He defined advantages of such solutions.

Evaluation of benefits of changing roundabouts into signalized intersections, to get better capacity and level of service, has been analyzed by Mahmoud Owais, Omar Abulwafa, and Youssef Ali Abbas [3]. In their paper, two roundabouts from the cities of Jeddah and Al-Madinah were analyzed using Sidra and Synchro software. The results of this research showed the benefits of reconstruction of the roundabout into a signalized intersection.

Ibrahim Khliefat, Mohammad Naser, Fadi Alhomaidat, and Shadi Hanandeh [4] analyzed the existing traffic condition at the roundabout by using VISSIM and C++ software. They concluded that signalized intersections offer a higher level of service, as well as a significant decrease in delays.

Jithender Jatoth, Nawal Kishor Singh, and Arpan Mehar [5] analyzed two signalized intersections. Their paper showed that the usage of the countdown timer showed a better level of service and higher capacity values.

According to Aleksandr Novikov, Ivan Novikov, and Anastasia Shevtsova, the capacity on signalized intersections has been decreased in the wintertime and when the road is wet, and the changes in signal schedule resulted in a capacity increase [6].

In their paper A. Polus, S. Shumeli [7], H. R. Al-Masaeid, and M. Z. Faddah [8] had focused on the influence of the roundabout's geometry on its capacity and level of service both in Germany and Jordan. They had used various models to analyze

several roundabouts with different dimensions and concluded that the size of the central island influenced capacity increase.

Roundabout's advantages have been analyzed by Marc T. Johnson and William A. Hange [9]. They conducted 4 independent studies and analyzed several intersections. Their paper showed that the roundabouts provide better results in both level of service and higher capacity.

3. METHODOLOGY

For this paper, a 24-hrs traffic recording was conducted. Video recordings were used for acquiring data of the traffic flow and traffic distribution by directions on the intersections. The obtained values of peak hour flow are given in Table 1.

Table 1. Peak hour flow (veh/h)

	Approach 1	Approach 2	Approach 3	Approach 4	Total
Bul. Oslobođenja - Futoška St. - Jevrejska St. (I1)	1451	928	1472	779	**4630**
Futoški put - Bul. patrijarha Pavla - Bul. kneza Miloša (I2)	907	1345	785	934	**3971**
Bul. Oslobođenja - Bul. Cara Lazara (I3)	1404	1333	980	1285	**5002**
Rumenački put - Bul.Evrope - Rumenačka St. (R1)	954	589	954	1185	**3682**
K. Stankovića St. - Bul.Evrope - Bul. vojvode Stepe (R2)	905	916	733	924	**3478**
Bul. Evrope - Bul. Cara Lazara - Bul. patrijarha Pavla (R3)	828	1615	112	883	**3438**

The obtained data were used to determine the capacity and level of service in the existing state. In the proposed state, it was presumed that traffic control is changed at the intersections (roundabout to signalized intersection, and vice versa). In that case, the capacity and level of service had been determined. Models used in this research were HCM [10, 11, 12].

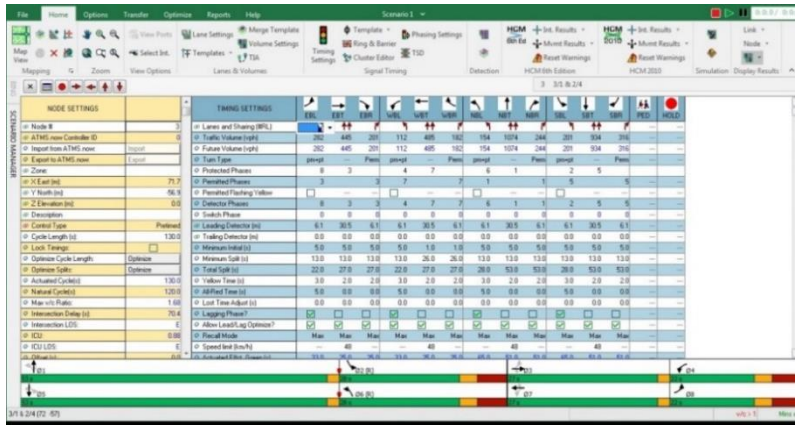
All analyses were made using Synchro software. Every analyzed intersection was modeled in the existing state and proposed state. The intersection model in the existing state and its traffic volume is shown in Figure 1, while the proposed state is shown in Figure 2.

Figure 1. Model of the signalized intersection in Synchro software

Figure 2. Model of the roundabout in Synchro software

An example of input data is given in Table 2.

Table 2. Example of input parameters for software analysis



The results are presented in the next Chapter.

4. RESULTS

Six intersections were chosen for the study, three of them are signalized while three are roundabouts. Every intersection has a different traffic volume. All intersections are chosen by traffic flow parameters to get different traffic conditions for all analyzed cases. Positions of the intersections at the street network of Novi Sad are shown in Figure 3.

Figure 3. Position of intersections at the street network of Novi Sad

For this paper, the following steps are made:

Step 1: The level of service at the intersections in the existing state was analyzed.

Step 2: Traffic control was proposed to be changed. Roundabouts became signalized intersections and vice versa.

Step 3: The level of service in the proposed conditions was analyzed.

Step 4: The comparative analysis in the level of service at existing and proposed conditions was determined. Results of all previous steps are shown in Table 3.

Table 3. Level of service – existing and proposed state

Intersection	Rush hour peak (veh/h)		Existing state LOS			Proposed state LOS		
Bul. Oslobođenja - Futoška St. - Jevrejska St. (I1)	4630	**Signalized int.**	E	(70,4)	**Roundabout**	F	(227,7)
Futoški put - Bul. patrijarha Pavla - Bul. kneza Miloša (I2)	3971		E	(79,2)		F	(80,8)
Bul. Oslobođenja - Bul. Cara Lazara (I3)	5002		F	(107,9)		F	(207,7)
			Existing state LOS			**Proposed state LOS**	
Rumenački put - Bul.Evrope - Rumenačka St. (R1)	3682	**Roundabout**	F	(245,3)	**Signalized int.**	D	(35,6)
K. Stankovića St. - Bul.Evrope - Bul. vojvode Stepe (R2)	3478		F	(148,7)		D	(45,0)
Bul. Evrope - Bul. Cara Lazara - Bul. patrijarha Pavla (R3)	3438		C	(16,6)		C	(21,9)

Results of changing way of control showed:

- At the intersection **R1** (roundabout), the determined level of service is **F** (**d = 245,3 s/veh**). After changing traffic control into signalized, the level of service has been improved to **D** (**d = 35,6 s/veh**).

- At the intersection **R2** (roundabout), the determined level of service is **F** (**d = 148,7 s/veh**). After changing traffic control into signalized, the level of service has been increased at **D** (**d = 45,0 s/veh**).

- At the intersection **R3** (roundabout) level of service in the existing state is **C** (**d = 16,6 s/veh**). After changing traffic control, roundabout into the signalized intersection, level of service remains **C**, while the delays of the intersection have been increased to **21,9 s/veh**.

- For the roundabout, change of control into signalized intersection leads to the level of service improvement in case if traffic volume exceeds 3500 veh/h. On the other hand, if the traffic volume is less than 3500, the level of service remains the same or getting worse.

- Intersection **I1 (signalized)** has level of service **E** (**d = 70,4 s/veh**). After changing traffic control into the roundabout, the level of service getting worse - **F** (**d = 227,7 s/veh**).

- Intersection **I2 (signalized)** has level of service **E** (**d = 79,2 s/veh**). After changing traffic control into the roundabout, the level of service has slightly lower - **F** (**d = 80,8 s/veh**).

- The same case is for the **I3 (signalized)**. This intersection has the level of service **F** (**d = 107,9 s/veh**) in existing conditions. After changing traffic control to a roundabout, the level of service remains F, while the intersection delays have been increased to **207,7 s/veh**.

- For signalized intersections, change of traffic control to roundabout always degrade the level of service for high traffic volume (more than 3500 veh/h).

The results shown in this paper indicated that the method of turning roundabout into signalized intersection could be applicable at intersections with a traffic volume higher than 3500 veh/h. Other analyzed studies did not determine the exact volume when the roundabout should be changed to signalized intersection.

5. CONCLUSION

In many cities, it is a typical case to change a signalized intersection into a roundabout. However, that is not always a good solution. By changing traffic control to a roundabout, the level of service can become worse than at the signalized intersections. This paper shows an analysis of three signalized intersections and three roundabouts in Novi Sad, with a traffic volume of more than 3000 veh/h.

The analysis results show that the signalized intersections will have a lower level of service if they are converted into roundabouts. According to the results, in cases when traffic volume exceeds 3000 veh/h (3500 veh/h at most), changing signalized intersection into a roundabout is not a good solution.

On the other hand, the level of service at the analyzed roundabouts is improved after changing traffic control into a signalized intersection. For high traffic volume (over 3500 veh/h), changing the roundabout into a signalized intersection proved as a better solution. In two cases, the results showed a significantly better level of service (from F to D) and much smaller delays.

The limit of 3500 veh/h determined in this paper is subject to adjustment. If the number of circulating lanes reduces from two to one, the capacity of a roundabout will be lower. Increased percent of heavy vehicles and left-turn volume can lead to LOS deterioration, reducing the limit of 3500 veh/h. As a general conclusion, whenever LOS is F on all approaches, a change of roundabout to a signalized intersection should be considered.

ACKNOWLEDGMENT

This work has been partially supported by the Ministry of Education and Science of the Republic of Serbia within the Project " Development and application of modern tools and research methods in the field of traffic and transport", University of Novi Sad, Faculty of Technical Sciences.

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