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INFLUENCE OF THE SHARED RIGHT/THROUGH LANE ON SIGNALIZED INTERSECTION CAPACITY

Key Words

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Shared
right/through
lane
Capacity

Abstract

At the signalized intersections, lanes are designed for use by the vehicles doing a different movement. Shared lanes increase the flexibility to fulfill different traffic volumes. However, a shared lane is not always beneficial. This paper compares two types of lane design at signalized intersections and their influence on the intersection capacity. An approach with a shared through/right lane with permitted Right Turn on Red (RTOR) is compared with an approach with the same lane layout but without permitted RTOR. This analysis showed whether the permitted RTOR is necessary at the intersection and how it affects intersection capacity.

1. INTRODUCTION

In some cases, more than one approach lane serves one directional flow due to large traffic demands. The exact number of lanes for through traffic is easy to calculate according to the volume.

The adjustment factors of the saturation flow rates at signalized intersections can also help determine the intersection's layout, including the exact number of lanes in each direction [1].

Turning movements have a determining effect on the safety and operations at the signalized intersections. Therefore, various treatments of turning movements have been the focus of attention of those involved in the design and operations of the intersection signal control. Right-turn movements at the signalized intersections are

subjected to multiple treatments. Lower volume intersections typically involve a shared lane for the through and right-turning traffic. As traffic level increases, including the right-turning traffic, the need for providing an exclusive right also increases [2]. A traffic light is a common way of regulating traffic in places where flows collide because of the lack of capacity for some or all traffic flows appear unjustifiably large congestion or more serious deterioration of traffic safety. Traffic regulation is performed by applying appropriate light signaling systems. Unwarranted signals might cause some problems [3].

When right turn on red (RTOR) is permitted, the right-turn volume for analysis may be reduced by the volume of right-turning vehicles moving on the red phase. This reduction is generally made based on hourly volumes before the conversion to flow rates. The number of vehicles able to turn right on a red phase is a function of several factors, including

- Approach lane allocation (shared or exclusive right-turn lane),
- Demand for right-turn movements,
- Sight distance at the intersection approach,
- Degree of saturation of the conflicting through movement,
- Arrival patterns over the signal cycle,
- Left-turn signal phasing on the conflicting street, and
- Conflicts with pedestrians.

For an existing intersection, it is appropriate to consider the RTORs that occur. For both the shared lane and the exclusive right-turn lane conditions, the number of RTORs may be subtracted from the right-turn volume before analysis of lane group capacity or LOS. At the existing intersection, the number of RTORs should be determined by field observation. [4]

In this paper, an analysis of two signalized intersections was performed. At the first intersection, shared through/right lane that has permitted RTOR. At the second intersection, shared through/right lane that does not have permitted RTOR. According to conducted analyses, the influence of permitted RTOR on capacity was established.

2. METHODOLOGY

Traffic counting was performed on August 13, 2021, at two locations at Novi Sad. At the intersection Futoska ulica – Brace Ribnikara (Figure 1), the counting was performed in peak period from 08:00-09:00h, on approach that has an exclusive left lane, a through lane, and shared right / through lane on which there is a permitted RTOR. The cycle length on this intersection is 130s. Traffic lanes are separated by a median that is 1.30 m wide. The width of traffic lanes at all approaches is 3.0 m.

At the intersection Bulevar kralja Petra I - Rumenacka, traffic counting was performed on August 13, 2021, in a peak period from 15:00h-16:00h. The observed approach (Figure 2) consists of six traffic lanes. Traffic lanes are separated by a median that is 1.50 m wide. The cycle length on this intersection is 110s.

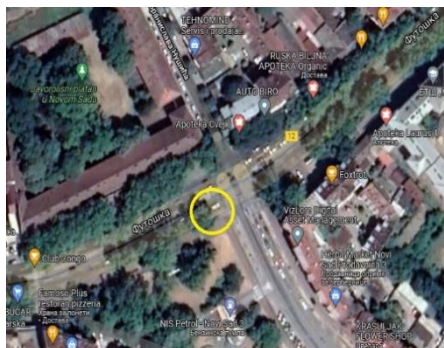


Figure 1. Analyzed approach at the intersection Futoska ulica - Brace Ribnikara

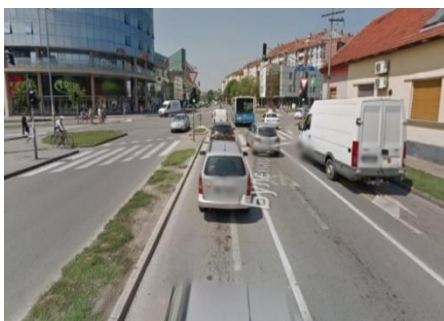


Figure 2. Analyzed approach at the intersection Bulevar kralja Petra I-Rumenacka

3. RESULTS

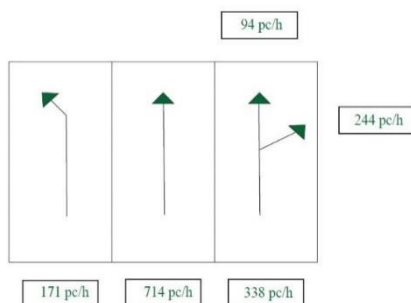
A capacitive analysis was performed based on the traffic counting, and the level of services for each lane on the observed approach was determined.

By counting the vehicles at the observed approach, at the intersection Futoska-Brace Ribnikar, distribution by lanes was obtained (Figure 3). Capacity analysis in the HCS 2000 (Highway Capacity Software) was performed. The output of this program is the capacity data of the individual lanes on this approach.

The number of the counted vehicles that are turning right is 244 pc/h. A total of 189 vehicles were blocked from turning right due to 94 vehicles in the same lane going through. That means that 51% of the vehicles that would turn right are blocked, which significantly affects the lane's capacity.

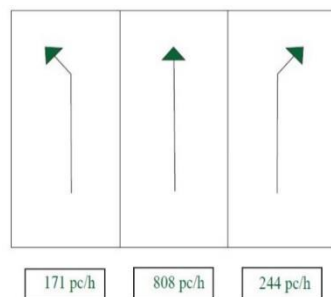
The existing level of service at the observed approach in all lanes D. If the right lane, which is shared right/through, would be converted to the exclusive right turn lane, it would have a different level of service, shown in Figure 4.

LOS is slightly lower in a through lane, downgraded from D to E using the new lane layout. On the other hand, LOS would be significantly better in the right turn lane. It would be improved from D to A.



LOS by lane D, D, and D, respectively.

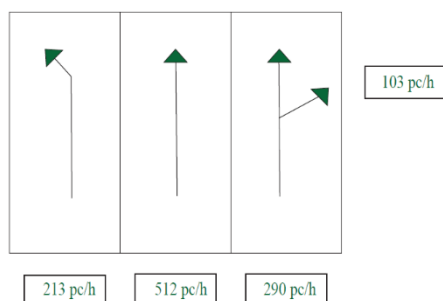
Figure 3. Traffic flow distribution by lanes and LOS at the observed approach



LOS by lane D, E, and A, respectively.

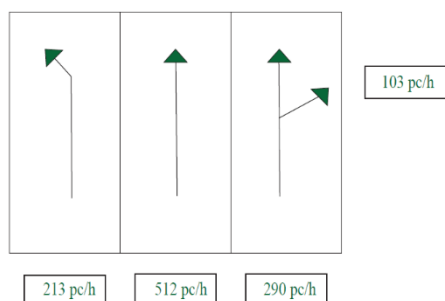
Figure 4. Traffic flow distribution by lane and LOS at the observed approach with a new lane layout

By counting the vehicles at the observed approach at the intersection of Bulevar kralja Petra I - Rumenacka, distribution by lanes was obtained. Capacity analysis results are shown in Figure 5.



LOS by lanes F, F, and C, respectively.

Figure 5. Traffic flow distribution by lanes and LOS at the observed approach



LOS by lanes F, F, and A, respectively.

Figure 6. Distribution by lanes and LOS on observed approach

At the shared right/through lane, RTOR is not permitted 290 pc/h vehicles that are going through during the cycle were blocked by 103 vehicles that are turning right. That means that 65% of vehicles that would go through are blocked.

If the shared right/through lane has permitted Right Turn on Red (RTOR), the level of service (shown in Figure 6) would be better.

4. CONCLUSION

In this paper, analysis of the intersection Futoska ulica-Brace Ribnikar and the intersection Bulevar kralja Petra I – Rumenacka, was performed. At the intersection Futoska ulica - Brace Ribnikar, an approach that has an exclusive left lane, a through

lane, and a shared right/through lane on which there is permitted Right Turn on Red (RTOR) was analyzed. Another approach was also analyzed at the signalized intersection Bulevar kralja Petra - Rumenacka with the same lane layout, except that the shared right/through lane does not have a permitted RTOR.

In order to determine the traffic conditions at the analyzed intersection, an analysis of existing conditions was performed. For that purpose, traffic counting was made.

By analyzing the capacity using the HCS 2000, it was found that all the lanes at the intersection Futoska ulica - Brace Ribnikar have a level of service D. At this approach, in the shared through/right lane with permitted RTOR, 51% of right-turning vehicles were blocked by the vehicles that are going through. Regarding the existing level of service, if the shared right/through lane would be converted to an exclusive right turn lane, the level of service would be A.

At the intersection Bulevar kralja Petra I – Rumenacka in shared through/right lane with no permitted RTOR, 65% of through vehicles were blocked by the right-turning vehicles. At this lane, the calculated LOS is C. If we introduce permitted RTOR for this lane, LOS would be A.

Traffic conditions at the signalized intersections are influenced mainly by traffic signal phasing design and the green light duration. Minor corrections, as well as very cheap measures, can significantly affect the level of service. This paper showed how the soft measures (change of lane designation or addition of green light arrow) could improve traffic conditions and level of service at the signalized intersection.

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REFERENCES

- [1] Qi, H.; Wang, D.; Chen, P.; Bie, Y. Simulation of departure flow profile at stop lines for signal approach spillover. *Transp. Res. Part C Emerg. Technol.* 2013, 33, 88–106.
- [2] Wang, Y.; Rong, J.; Zhou, C.; Chang, X.; Liu, S. An Analysis of the Interactions between Adjustment Factors of Saturation Flow Rates at Signalized Intersections. *Sustainability* 2020, 12, 665.
- [3] Lj. Kuzović: Kapacitet i nivo usluge drumskih saobraćajnica. Beograd, 2000.
- [4] Highway Capacity manual, 2016.
- [5] Highway Capacity manual, Transportation Research Board, National Research Council. Washington D.C., 2010.