CETRA[2018]

5th International Conference on Road and Rail Infrastructure

17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

Stjepan Lakušić – EDITOR

IRF GLOBAL

FEHRL

Organizer
University of Zagreb
Faculty of Civil Engineering
Department of Transportation

CETRA[2018]
5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

TITLE
Road and Rail Infrastructure V, Proceedings of the Conference CETRA 2018

EDITED BY
Stjepan Lakušić

ISSN
1848-9850

ISBN
978-953-8168-25-3

DOI
10.5592/CO/CETRA.2018

PUBLISHED BY
Department of Transportation
Faculty of Civil Engineering
University of Zagreb
Kačićeva 26, 10000 Zagreb, Croatia

DESIGN, LAYOUT & COVER PAGE
minimum d.o.o.
Marko Uremović · Matej Korlaet

PRINTED IN ZAGREB, CROATIA BY
“Tiskara Zelina”, May 2018

COPIES
500

Zagreb, May 2018.

Proceedings of the
5^{th} International Conference on Road and Rail Infrastructures – CETRA 2018
17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

EDITOR
Stjepan Lakušić
Department of Transportation
Faculty of Civil Engineering
University of Zagreb
Zagreb, Croatia

CETRA[2018]
5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

ORGANISATION

CHAIRMEN

Prof. **Stjepan Lakušić**, University of Zagreb, Faculty of Civil Engineering
Prof. emer. **Željko Korlaet**, University of Zagreb, Faculty of Civil Engineering

ORGANIZING COMMITTEE

Prof. Stjepan Lakušić
Prof. emer. Željko Korlaet
Prof. Vesna Dragčević
Prof. Tatjana Rukavina
Assist. Prof. Ivica Stančerić
Assist. Prof. Maja Ahac
Assist. Prof. Saša Ahac
Assist. Prof. Ivo Haladin
Assist. Prof. Josipa Domitrović
Tamara Džambas
Viktorija Grgić
Šime Bezina
Katarina Vranešić
Željko Stepan
Prof. Rudolf Eger
Prof. Kenneth Gavin
Prof. Janusz Madejski
Prof. Nencho Nenov
Prof. Andrei Petriaev
Prof. Otto Plašek
Assist. Prof. Andreas Schoebel
Prof. Adam Szeląg
Brendan Halleman

INTERNATIONAL ACADEMIC SCIENTIFIC COMMITTEE

Stjepan Lakušić, University of Zagreb, president
Borna Abramović, University of Zagreb
Maja Ahac, University of Zagreb
Saša Ahac, University of Zagreb
Darko Babić, University of Zagreb
Danijela Barić, University of Zagreb
Davor Brčić, University of Zagreb
Domagoj Damjanović, University of Zagreb
Sanja Dimter, J. J. Strossmayer University of Osijek
Aleksandra Deluka Tibljaš, University of Rijeka
Josipa Domitrović, University of Zagreb
Vesna Dragčević, University of Zagreb
Rudolf Eger, RheinMain Univ. of App. Sciences, Wiesbaden
Adelino Ferreira, University of Coimbra
Makoto Fujiu, Kanazawa University
Laszlo Gaspar, Széchenyi István University in Győr
Kenneth Gavin, Delft University of Technology
Nenad Gucunski, Rutgers University
Ivo Haladin, University of Zagreb
Staša Jovanović, University of Novi Sad
Lajos Kisgyörgy, Budapest Univ. of Tech. and Economics
Anastasia Konon, St. Petersburg State Transport Univ.
Željko Korlaet, University of Zagreb
Meho Saša Kovačević, University of Zagreb
Zoran Krakutovski, Ss. Cyril and Methodius Univ. in Skopje
Dirk Lauwers, Ghent University
Janusz Madejski, Silesian University of Technology
Goran Mladenović, University of Belgrade
Tomislav Josip Mlinarić, University of Zagreb
Nencho Nenov, University of Transport in Sofia
Mladen Nikšić, University of Zagreb
Andrei Petriaev, St. Petersburg State Transport University
Otto Plašek, Brno University of Technology
Mauricio Pradena, University of Concepcion
Carmen Racanel, Tech. Univ. of Civil Eng. Bucharest
Tatjana Rukavina, University of Zagreb
Andreas Schoebel, Vienna University of Technology
Ivica Stančerić, University of Zagreb
Adam Szeląg, Warsaw University of Technology
Marjan Tušar, National Institute of Chemistry, Ljubljana
Audrius Vaitkus, Vilnius Gediminas Technical University
Andrei Zaitsev, Russian University of transport, Moscow

CETRA2018 17–19 May 2018, Zadar, Croatia
5th International Conference on Road and Rail Infrastructure

DETERMINING THE CRITICAL HEADWAYS BY OBSERVATION THE ROUNDABOUT'S TRAFFIC FLOWS IN RUSSIAN FEDERATION

Dmitri Nemchinov[1], Alexandr Mickhailov[2], Aleksey Kostsov[3], Dmitri Martiyahin[3]
[1] *TransIngProekt, Russia*
[2] *Irkutsk National Research Technical University, Russia*
[3] *Moscow Auto & Road University, Russia*

Abstract

This paper describes the results of the critical headways surveys at roundabouts in the Russian Federation. The project is finished in 2017 and its main target is to improve the capacity and delays estimation technique. In the period of the USSR the manual of traffic circles and roundabouts design was prepared in the middle of the 80th of last century. The former manual contained the capacity estimation technique considering conflict points and weaving zones. In 40 years have changed a lot of things: daily volumes, structure of traffic flows, cars and tracks dynamic, as well as drivers behavior. The results of current project allowing to consider the actual traffic conditions at roundabouts in Russia and feature of driver's behavior. During processing of the obtained data there was a problem of the choice of the critical headways estimation technique. During the observation we got a lack of saturated conditions which are continuous queuing on the minor road entering the roundabout. So Siegloch's method which requires saturated conditions has been rejected and Ruff's method was chosen. Raff's method is based on simple technique of the accepted and rejected intervals consideration and no iterative procedures are required. Received results confirm that the general equations of roundabout's capacity estimation (HCM 2000 and HCM 2010) are applicable in Russia.

Keywords: roundabouts, gaps assumption, critical gaps estimation

1 Introduction

Over the last years, the Federal Road Agency of the Russian Federation has been working on updating the design manuals including the preparation of a draft preliminary national standard "Public roads. Rules of roundabouts design". This paper will deal with the compact turnarounds, which basic parameters for calculating the capacity are critical gaps and follow-up times. At the same time, the roundabout capacity calculation method, which was used previously, was based on the estimation of the traffic flow in weave zones, which was the result of the common practice for a long time of designing the large-diameter circles with 3 and, sometimes 4, lanes on the circulatory roadway.

2 Objective

The research work objectives were to establish the characteristics (parameters?) of traffic flows on the roundabouts including which are classified as compact ones. In accordance with this, the critical gaps became one of the most important characteristics of the interaction of traffic flows in the zone of their confluence at the entries to the circulatory roadway.

3 Methodology

Nine roundabouts were selected in the Moscow region and the city of Moscow for the research, and the main principle of site selection was the complete absence of the pedestrian impedance. The aerial video recording with quadcopter (Figure 1) was used for the field survey. The range of values of the characteristics of the investigated roundabouts is shown in Table 1.

Figure 1 One of the investigated intersections, Uspenskoye – 1st highway, (Moscow region) and the traffic flow interaction area considered on it

Table 1 Characteristics of the roundabouts survey

Characteristics of the roundabouts	Range of values
Number of lanes on the circulatory roadway	1 – 4
Number of lanes on the entries	1 – 3
Circulatory roadway traffic volume, vehicles/hour	234 – 1146
Circulatory roadway traffic volume per lane, vehicles/hour per lane	117 – 573
Traffic volume on the entries, vehicles/hour	288 – 870
Traffic volume per entry lane, vehicles/hour per lane	96 – 732

The peculiarity of the sample of the investigated intersections was that it included only very contrast situations. The highest values of the circulatory roadway traffic volumes were combined with the low values on approaches to them, and vice versa, the case of maximum traffic load on the approach of 732 vehicles/hour corresponded to the insignificant circulatory roadway traffic volume of 776 vehicles/hour (388 vehicles per lane). The obtained values of the circulatory roadway traffic volumes made it possible to conclude that in the cases under consideration the headways distributions can be described by an exponential distribution and there is no need to use a shifted exponential distribution and Cowan 3M distribution [1-3]. While processing the video records the gaps in the main flow and the follow-up times in the secondary flow were defined in accordance with the schemes shown in Figure 2.

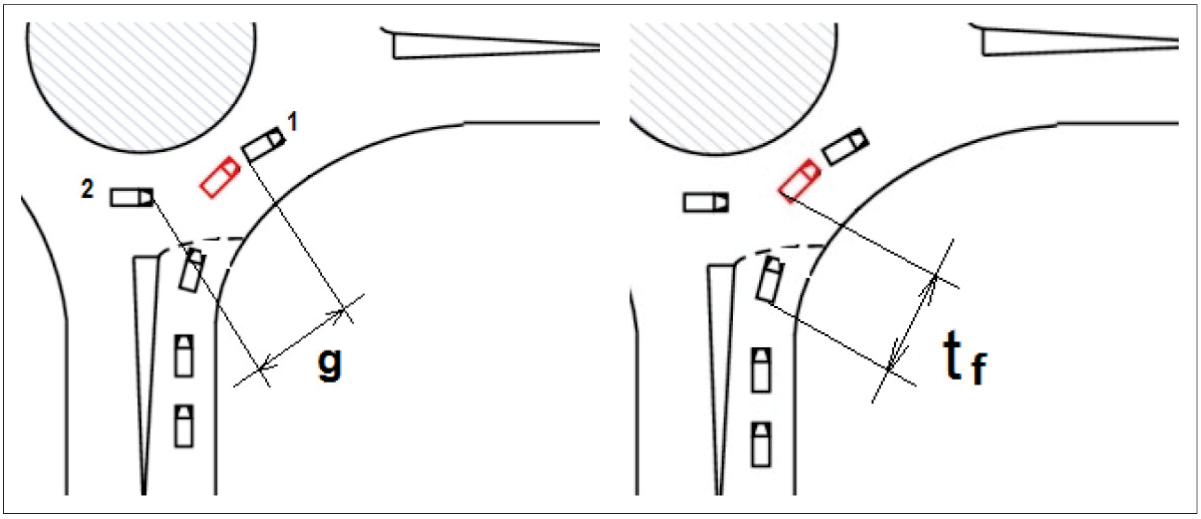

Figure 2 Accepted schemes to define the gaps and follow-up times

Critical gaps cannot be determined directly by field surveys. There are several methods to calculate the critical gaps based on essentially different statistical estimates: Siegloch's Method; Ashworth's Method; Raff's Method et al [2-5]. From the practical point of view, Siegloch's Method is most attractive as it allows constructing the regression model, which allows determining two parameters at once: critical gap and follow-up time. According to Siegloch's Method the t_c critical gap is determined as:

$$t_c = g_0 + 0.5t_f \tag{1}$$

Where g_0 is minimum accepted gap (s); t_f is follow-up time in minor stream (s).

To apply the method under consideration the condition that there is a vehicle queue on the approach to the turnaround at the secondary direction throughout the measurement period should be met. The survey data analysis showed that in most examined cases the vehicle queue included 2-3 vehicles and the set values of follow-up time vary greatly from 2.36 to 6.01 (s). The obtained values vary significantly from the results of earlier studies that examined the case of saturated approaches [6]. In this regard, Siegloch's Method had to be abandoned. It should also be noted that absence of queues on the entries to the rounabouts did not allow obtaining the regression models of capacity estimation as it was done in HCM 2010.
Raff's Method seems to be more effective under the conditions of unsaturated flows at the secondary directions (e.g. roundabout entries). Determination of the critical gap using the Raff's Method is based on the proposition that there is a sum of two probabilities [4, 5]:

$$F_a(g) + F_r(g) = 1 \tag{2}$$

Where g is gap of major stream; $F_a(g)$ is cumulative probability of accepted gap; $F_r(g)$ is cumulative probability of rejected gap.

The critical gap estimation procedure using the Raff's Method has simple geometric interpretation according to which the critical gap t_c is a point of intersection of cumulative probabilities $F_a(g)$ and $F_r(g)$. This method was used to determine critical gaps on all investigated intersections (Figure 3).

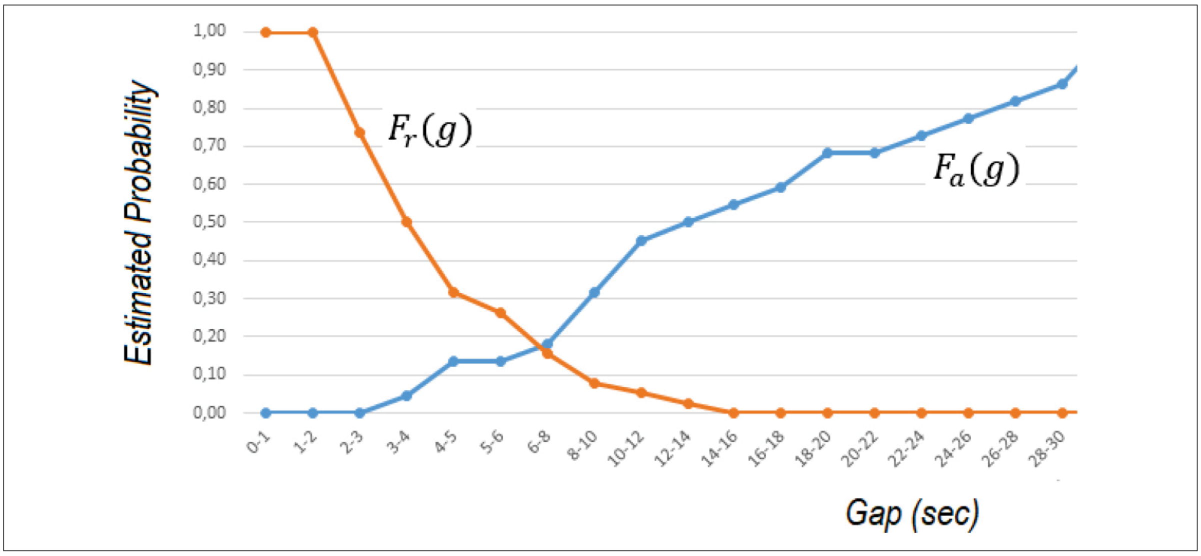

Figure 3 Critical gap estimation (Golovinskoye Highway)

4 Results

The estimation results using Raff's Method are presented in Table 2. The obtained values varied greatly, which required analysis and explanation. A part of results shown in Table 2 (t_c = 16.56 s and t_c = 11.68 s) is explained by insignificant values of the circulatory roadway traffic volume, when, correspondingly, the critical lags acceptance should be considered instead of critical gaps acceptance. In case of approach with two lanes, the value t_c = 2.8 s is obtained on the entry to the 4 lane circulatory roadway and explained by the fact that the secondary flow entering at high speed and at an acute angle into the main flow on the circulatory roadway of large diameter. The latter case has nothing to do with the roundabouts traffic mode and is not considered. After the case with low values of the circulatory roadway traffic volume have been excluded from consideration the final result of the study is as follows (Table 3).

Table 2 Critical gaps according to exam. results

Critical gap, ts	Number of lanes	
	On the roundabout entry	On the circulatory roadway
16.56	1	1
11.68	1	2
5.13	1	2
10.2	2	2
6.22	2	2
8.21	2	2
3.89	2	2
6.12	2	2
6.50	2	2
4.18	2	3
8.32	2	3
3.25	3	2
4.16	3	3
4.16	3	3
2.80	2	4

Table 3 Critical gaps depending on the no. of lanes

Critical gap, ts	Number of lanes	
	On the roundabout entry	On the circulatory roadway
9	1	1-2
8.6	2	2
6.2	2	3
4.2	3	3

It was interesting to analyze the traffic volume effect on the value of the critical gap accepted by drivers. The traffic load effect on the ring carriageway was discovered.

$$t_c = 10{,}48 - 0{,}0069 v_r ; R = -0{,}47 \tag{3}$$

Where v_r is traffic volume on the circulatory roadway, vehicles/hour.

Correlation of relationship “critical gap — traffic volume on the circulatory roadway and the roundabout entry” is slightly higher:

$$t_c = 13{,}14 - 0{,}48 v_r - 0{,}23 v_a \; ; R = 0{,}53 \tag{4}$$

Where v_r is traffic volume on the circulatory roadway, vehicles/hour, v_a is the roundabout entry, vehicles/hour.

The results obtained are similar to the research data of other countries [2, 3, 7, 8]. At the same time, the high value of the critical gap t_c = 9 s obtained for the combination “one lane on the approach – 1 or 2 lanes on the ring” draws attention. More such roundabouts should be included in the further examinations when planning the experiment.

5 Conclusion

As a result of the research, critical gap values were obtained for different combinations of the number of lanes at the roundabouts and entries to them. Further researches should be aimed at studying the cases of saturated flows in the secondary directions, which will allow obtaining the required statistical material to evaluate the follow-up time. This will require expanding the surveys geography, i.e. the roundabouts should be considered in as many regions of the country as possible.

References

[1] Capacity and Level of Service at Finnish Unsignalized Intersections// Finnra Reports, 2004, 214 p.

[2] Cowan, R.C.: “Useful headway models,” Transportation Research, vol. 9, no. 6, pp. 371–375, 1975.

[3] Troutbeck, R.J.: A review on the process to estimate the Cowan M3 headway distribution parameters. //Traffic Engineering and Control, 1997, vol. 38, no. 11, pp. 600–603.

[4] Brilon, W., Koenig, R., Troutbeck, R.J.: “Useful estimation procedures for critical gaps,” Transportation Research Part A: Policy and Practice, vol. 33, no. 3-4, pp. 161–186, 1999.

[5] Vasconcelos, A.L.P., Seco, A.J.M., Silva, A.M.C.B.: Comparison of procedures to estimate critical headways at roundabouts Traffic&Transportation, Vol. 25, 2013, No. 1, pp. 43-53

[6] Липницкий, А.С., Михайлов, А.Ю.: Компактные кольцевые пересечения // Мир Дорог. – Санкт-Петербург: Издательский дом Мир, 2010. – Февраль. С. 58 – 60. (A.S. Lipnitsky, A.Yu. Mikhailov Compact turnarounds // Mir Dorog. – St. Petersburg: Mir Publishing House, 2010. – February. pp. 58–60

[7] Ashworth, R.: “The analysis and interpretation of gap acceptance data,” Transportation Science, vol. 4, no. 3, pp. 270–280, 1970.

[8] Kimber, R.: Gap-acceptance and empiricism in capacity prediction. Transportation Science, 23 (2), 1989, pp. 100-111.

[9] Vasconcelos, A.L.P., Seco, A.J.M., Silva, A.M.C.B.: Comparison of procedures to estimate critical headways at roundabouts Traffic&Transportation, Vol. 25, 2013, No. 1, pp. 43-53

[10] Липницкий, А.С., Михайлов, А.Ю.: Компактные кольцевые пересечения // Мир Дорог. – Санкт-Петербург: Издательский дом Мир, 2010. – Февраль. С. 58 – 60. (A.S. Lipnitsky, A.Yu. Mikhailov Compact turnarounds // Mir Dorog. – St. Petersburg: Mir Publishing House, 2010. – February. pp. 58 – 60)

[11] Ashworth, R.: "The analysis and interpretation of gap acceptance data," Transportation Science, vol. 4, no. 3, pp. 270–280, 1970.

[12] Kimber, R.: Gap-acceptance and empiricism in capacity prediction. Transportation Science, 23 (2), 1989, pp. 100-111.