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
5th 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

DRAFT OF TURBO ROUNDABOUTS DESIGN CONSIDERING CLIMATIC FEATURES OF RUSSIAN FEDERATION

Dmitri Nemchinov, Aleksey Kostsov, Alexandr Mikhailov, Dmitri Martiyahin
TransIngProekt,. Moscow, Russia, Irkutsk Technical University, Russia
Moscow Automobile and Road Construction State University (MADI), Russia

Abstract

The paper presents the basic design rules of turbo roundabouts proposed in Russian Federation. Before development of the national manual draft the project group analyzed manuals and working document of several countries (Croatian, Dutch, German, Poland and Slovenia). As result of comparative analysis the draft of turbo roundabouts design manual considering spiral geometry as a basis. Defining a relevant design vehicle and following roundabout templates were the first basic problem. Circular lane width and distances between edge lines of spiral roundabout, entry and exit path radii were chosen for the design vehicle which is appointed as typical Russian semitrailer. The design vehicle swept path analysis and turning trajectories are executed basing on CAD software simulation. In case of Russia especially specific turbo roundabout design problem is a set geometric and construction parapets of lane dividers. The main feature of the Russian conditions is long severe winter and high probability of heavy snowfalls. Thus, winter operation contents becomes the main factor of the choice of the divider solution. In accordance with winter conditions as design period the consideration was the flat divider which cross section width is 1,2 m and edges as a road marking. The developed decisions have to provide a possibility of snow removal and also visual perception of the lanes on turbo roundabouts in winter conditions.

Keywords: turboroundabouts, winter conditions, lane dividers, geometry design

1 Introduction

To improve turboroundabout safety and capacity different countries apply various spiral traffic management schemes – using spiral markings [6] or turboroundabouts, which have been originally developed in Holland [1, 2]. By order of the Federal Road Agency, a draft national standard has been developed, which sets requirements for the turboroundabout design including turboroundabouts.

2 Objective

The main problem of turboroundabouts adaptation to Russian conditions includes climatic features associated with the heavy snowfalls and constant snow cover within a significant period of time during the year. On the one hand, the falling snow covers the dividers on the turboroundabouts traffic way. On the other hand, the wide turboroundabouts traffic way determines the amount of snow that will move off the lane and can be stored between the lanes until it is removed fully within 1-2 days. In this way, the turboroundabouts lane dividers should be visible for the drivers during the snowfall and should function as a temporary storage of the snow displaced from the lane in addition to dividing the traffic flows. When designing

DOI: https://doi.org/10.5592/CO/CETRA.2018.725

the roundabout with spiral lanes (turboturboroundabouts), the Netherlands and Croatia use a 16.5 m road train with different axle number as a design vehicle [1, 3, 4]. Considering the traffic flow composition, it makes sense to choose a similar vehicle for plotting the geometric elements of turboroundabouts taking into account the Russian conditions.

3 Methodology

During the work, the volume of falling snow and the possibility of its storage on the dividers between the lanes on the ring roadway was estimated. Also, the experience of countries, which are subject to snowfall and currently operating the turboroundabouts, Estonia (based on field observations) and Canada, were taken into account [5]. Some areas of Russia have more than 20 snowfalls in the winter season with the snowfall intensity reaching up to 30 mm/h. As a rule, one millimeter of the snow that has fallen is equated to 1 – 1.5 centimeters of snow-cover height depending on the snow structure. Thus, up to 30 cm of snow may fall during one snowfall. However, the Russian average snowfall makes 10 mm in water equivalent. With an average lane width of 5 m 0.5 m^3 0.5 m^3 of snow should be removed from each meter and placed before removal out of the turboroundabout. The snow is compacted when it is moved by the snow clearing vehicles. If the snow clearing vehicles have a standard configuration, the snow is moved towards the external side, so the divider width should be sufficient to place the snow falling on one traffic lane. If the snow bank height is limited to 0. -0.5 m, the divider with a width of at least 1 m is required to place such a volume.

4 Lane dividers

The turboroundabouts require lane divider arrangement. Which meet the requirements set above, between the traffic lanes on the ring roadway. This allows excluding all conflict points except for the conflict at the entrance to the turboroundabout and reducing the speed if necessary. It is essential to place and select a constructive solution for the lane divider on the ring roadway because this element, on the one hand, should ensure the separation of flows and prevent changing the lanes on the ring roadway, and, on the other hand, should allow performing the roadway maintenance operations in winter period and removing water from the road surface.

Figure 1 Example of the beginning of the divider for the spiral turboroundabout in Canada [1]

Among areas with a stable snow cover, Canada [5], the United States [6], Estonia, Finland, and Great Britain [7] have the spiral turboroundabouts constructed. The road marking (Estonia, Finland) and constructive divider (Canada, Estonia) is used as a divider. Dividing the lanes with markings (Estonia, Finland) showed that in winter time the spiral marking is unworkable and the turboroundabout is used as a usual roundabout. In this regard, options for physical dividing have been proposed (Canada, Estonia) (Fig. 1, 2). The divider width is 1.2 m at the outer edges of the white line, a textured coating is placed between the white lines. Slovenia also used wide dividers with paving to divide the spiral lanes.

Figure 2 Example of the beginning of the divider for the spiral turboroundabout in Estonia

Based on the foregoing, the essential requirement should be provided, which states that the turboroundabouts lane dividers create a physical impact on a vehicle that is not dangerous according to the road safety criteria but sensible for the driver. The turboroundabouts lane dividers in the form of the dividing strip with a width of more than 1,2 m with paving or planting at a width of more than 1.5 m may be recommended as a main option for the Russian winter. All dividers should be adapted to the technologies of winter maintenance used on the road section, which turboroundabouts are designed for.

5 Geometric parameters of turboroundabouts

In terms of geometry, the turboroundabouts consists of two (in some cases – three) embedded spirals that represent the lane boundaries. Each spiral consists of three semirings (1/3 of a ring in the case of a uniform distribution of three entry points) with successively large radii -each next arc has a radius greater than the previous one. When the arc radius changes, the arc center is displaced by an appropriate value so that the curve remains continuous. The displacement size is the width of one carriageway and divider. According to the European established experience and to develop the drivers' behavioral stereotypes and habits the internal radius should be generally standardized based on four basic values [1, 2, 3, 4]:

Ri = 10.50 meters – the minimum radius in confined spaces; not recommended is free space is available;

Ri = 12.00 meters – the basic radius for standard turboroundabouts;

Ri = 15.00 meters – the radius of the average turboroundabouts with less stringent speed limit parameters;

Ri = 20.00 meters – radius for large turboroundabouts with a greater design speed.

Displacements can be calculated based on the cross-section sketch. The principle of calculating the turboroundabouts radius is shown in Table 1.

Table 1 The principles of calculating the radii of semi-ring of turboroundabouts spiral [1,2]

Element radius	Calculation formula	Example of width calculation (m)
R1		12.00
R2	R2 = R1+ Li (average)	12.00+5.15=17.15
R3	R3 = R2+Ls	17.15+1,2=18.35
R4	R4 = R3+Le	18.35+5.00=23.35

Where:
R1 – radius of internal edge of internal lane, m;
R2 – radius of external edge of internal lane, m;
R3 – radius of internal edge of external lane, m;
R4 – radius of external edge of external lane, m;
Li – width of the internal lane, m;
Ls – width of the dividing strip, m;
Le – width of the external lane, m.

Based on the above factors, the **basic dimensions of standard turboroundabouts are calculated with a divider width of 1.2 m** (**Table 2**, Fig. 3a). Circular lane width and distances between edge lines of spiral roundabout, entry and exit path radii were chosen for the design vehicle that is appointed as typical Russian semitrailer (two-axle truck tractor with a three-axle semitrailer, length: 16.5 m, width 2.55 m). The design vehicle swept path analysis and turning trajectories are executed based on CAD software simulation CadTool (Fig. 3b).

Table 2 Basic dimensions of standard turboroundabouts with a divider width of 1.2 m

Element			Size (m)			
Internal lane	Internal radius	R1	10.50	12.00	15.00	20.00
	External radius	R2	15.85	17.15	20.00	24.90
External lane	Internal radius	R3	17.05	18.35	21.20	26.10
	External radius	R4	22.05	23.35	26.10	30.80
Internal lane	Initial width	Li	5.70	5.30	5.10	5.10
	Final width	Li	5.00	5.00	4.90	4.70
	Average width	Li	5.34	5.15	5.00	4.90
External lane width		Le	5.00	5.00	4.90	4.70
Lane divider width		Ls	1.2			
The distance between the external center points (internal lanes)		Δv	6.90	6.50	6.30	6.30
The distance between the internal center points (external lanes)		Δu	6.20	6.20	6.10	5.90

The initial section of the turboroundabouts internal lanes may have plane curves to lead the incoming traffic away from the entry lane in accordance with the vehicle movement pattern or the internal lane can begin sharply (Fig. 4).
However, to arrange the winter maintenance there are good reasons to stick to the option with the internal lanes beginning with plane curves and this option is practical for Russia.

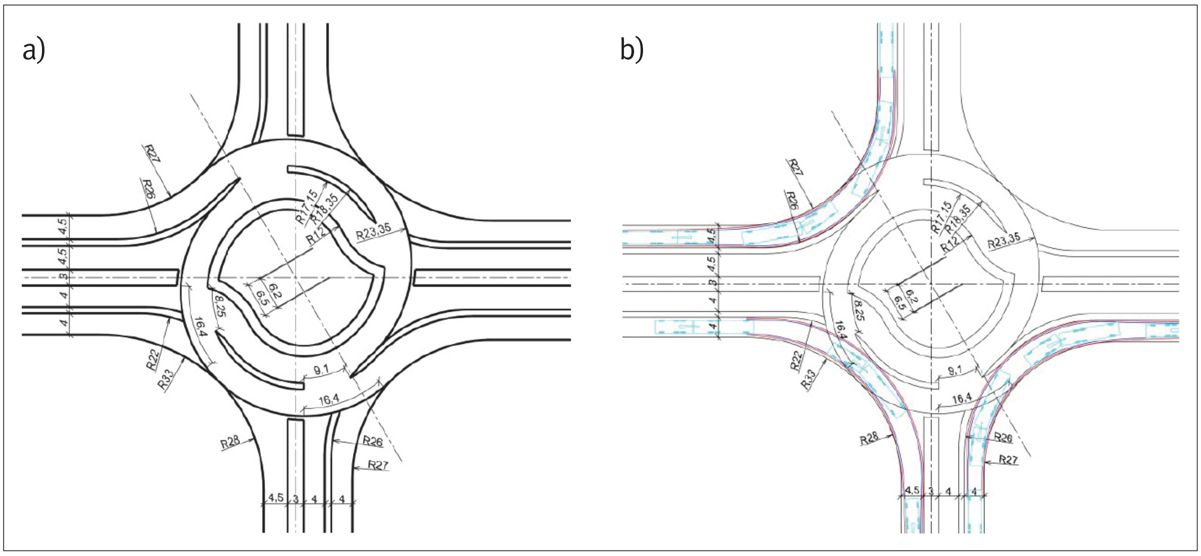

Figure 3 Variants of turboroundabout with internal radius 12 m and lane divider width 1.2 m. a) geometric parameters, b) example of the design car trajectory model

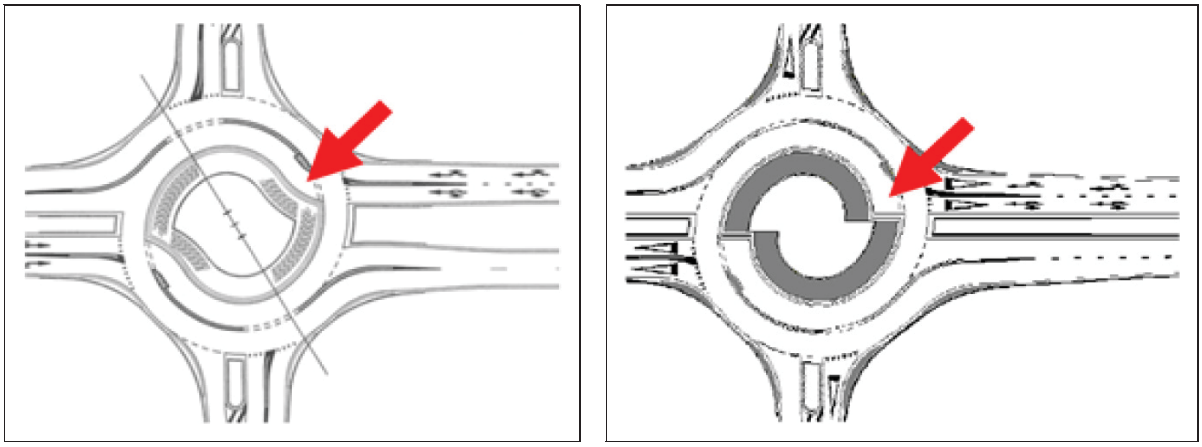

Figure 4 Variants of project solutions for entry to the internal lane [1]

6 Conclusion

This work allowed the planning solutions for turboroundabouts to be adapted to the Russian conditions. The winter operation contents become the main factor of the choice of the divider solution. In accordance with winter conditions as design period, the consideration was the flat divider, which cross-section width is 1,2 m and edges as a road marking. The developed decisions have to provide a possibility of snow removal and also visual perception of the lanes on turbo roundabouts in winter conditions.

7 References

[1] Roundabouts – Application and design. A practical manual. Ministry of Transport, Public Works and Water management. Partners for Roads. Holland. June 2009

[2] Provincie Zuid Holland. 2008. Werkgroep Evaluatie Geregelde Turbopleinen: Toepassing Geregelde Turbopleinen

[3] Dzambas, T., Ahac, S., Dragcevic, V.: Geometric design of turbo roundabouts, Tehnički vjesnik, 24 (2017) 1, pp. 309-318.

[4] http://www.yubs.rs/Simpozijumi/RAP_2014_Prezentacije/042_Tollazzi_Turbo_roundabouts_in_Slovenia_RAP_2014_Prezentacija.pdf

[5] Murphy, T.: The Turbo Roundabout a First in North America Paper prepared for consideration of the TAC 2015 Road Safety Engineering Award of the 2015 Conference of the Transportation Association of Canada, Charlottetown, PEI

[6] Roundabouts: An Informational Guide. Second Edition// Federal Highway Administration. NCHRP report 672. 2010, 407 p.

[7] TA 78/97 Design of Road Markings at Roundabouts. Design Manual for Roads and bridges. Road geometry. Volume 6, Section 2, Junctions, 1997. 23 p.

[8] Фролов, Д.М.: Пространственное распределение снегопадов и их интенсивности на территории России. //Интеллектуальная Система Тематического Исследования Наукометрических данных https://istina.msu.ru/media/publications/article/9ee/f00/1067623/frolov.pdf (D.M. Frolov. Spatial distribution of snowfalls and their intensity in Russia.// Intellectual system of the thematic research of scientometric data)