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28–30 April 2014, Split, Croatia

Road and Rail Infrastructure III

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OFFTRACKING CONTROL REQUIREMENTS FOR QUALITY ROUNDABOUT DESIGN

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Abstract

In the last 10 years in Croatia numerous roundabouts have been built in urban and interurban areas. As a rule, these roundabouts replaced the existing three-leg and four-leg intersection in order to increase intersection safety and capacity. Replacement of four and three-leg intersections with roundabouts was often carried out without taking into account the ranking of intersecting roads and spatial requirements. Because of that the capacity and safety levels on these roundabouts were often lower than those on previous four or three-leg intersections. In some cases, poor roundabout design resulted in insufficient lane width on entrance and exit (offtracking control problem). These problems are particularly pronounced when the road axis do not intersect at right angle. Unfortunately, lessons learned from these bad examples weren't adopted, and designers are continuing with poorly designed roundabouts. The main reason for this stems from the fact that there are no official guidelines or regulations for the roundabout design in Croatia. Designers are trying to cope with this situation in different ways; often they are partially studying foreign guidelines and seeking for the solution that fits their problem. In this paper key elements for successful roundabout design will be shown, based on the example of recently constructed roundabout in Croatia, findings from other researchers and international guidelines. Proposed instructions could be used for the development of quality national guidelines for roundabout design.

Keywords: design, roundabout, guidelines, offtracking control, design vehicle

1 Introduction

Professional rules dictate that the designers should take into account certain criteria when designing roundabouts, which include: position in traffic network (urban, rural), spatial limits, traffic flow, intersection capacity and safety. Unfortunately, Croatian designers frequently disregard some of these criteria. It is mainly due to the inexistence of official Croatian guidelines for roundabout design. The other reason is that tenders are frequently won by designers lacking sufficient experience in roundabout design. This paper points to the most frequent mistakes in roundabout design on the example of a constructed intersection.

2 Roundabouts design – Croatian practice

Roundabout design in Croatia is, due to the lack of official guidelines, usually carried out according to the guidelines of the Institute of Transport and Communications [1], then according to German guidelines [2], Austrian guidelines [3] and Swiss norms [4]. When analyzing the mentioned documents it can be concluded that they give similar approach in designing roundabouts which comes down to five steps:

1 designing the intersection elements (islands, lane curbs on entrance and exit, ...) and assembling them into an intersection project;
2 offtracking control of the designed intersection;
3 correction of design elements (in case previously designed intersection does not meet offtracking control requirements);
4 sight distance check;
5 fastest path check.

This approach represents the biggest defect of the mentioned guidelines and norms because it is based on a highly iterative procedure which can significantly prolong the designing procedure. What worries is the fact that in the national designing practice intersection design is usually reduced to shaping individual elements. Offtracking control and the correction of design elements is frequently disregarded in spite of many software products on the market which [5, 6] allow very simple offtracking control.

2.1 An example of a poorly designed roundabout

The previous chapter outlined the main reasons for inadequately designed roundabouts in Croatia. The roundabout in the town of Vrbovec constructed in 2013 is an example of this. The construction of this roundabout was an attempt to improve the channelization of traffic flows at the intersection of four streets (Zagrebačka (D41), Bjelovarska (D28), Križevačka (D41), M. Gupca Street) and the entrance to the petrol station (Figure 1). Because of five intersection legs and spatial restrictions the designers had an exceptionally demanding task in front of them. Axes of the existing roads were reconstructed to intersect in the middle of the elevated circular island with the 11.5 m radii. The reconstructed axes intersect at the angles from 37 to 150°. The roundabout has 1.0 m wide truck apron and the 5.5 m wide circular lane. Lane width at intersection legs ranges between 3.1 to 3.9 m, depending on the rank of the road: M. Gupca Street is in the category of street roads, while other streets are categorized as state roads (D28 and D41). Elevated dividing islands are 15.0 to 19.0 m long and were constructed on four legs. In the roundabout zone pedestrian and cyclist traffic is organized with level crossings on all legs.

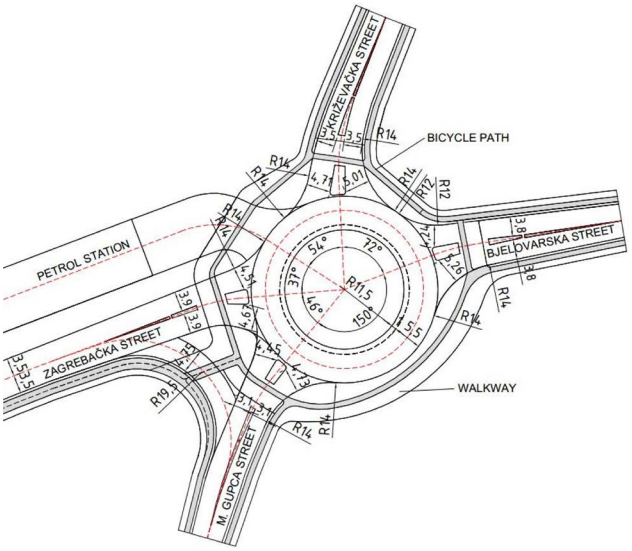

Figure 1 Plan of the roundabout in Vrbovec

After the roundabout construction and its opening to traffic it was found that, when turning from Zagrebačka and Bjelovarska into Križevačka Street, trailers and semi-trailers of heavy trucks tread with their wheels on the elevated curbs. The basic reasons for that are the following:

- exit lane width was insufficient because offtracking control with design vehicles was not taken into consideration;
- the applied rounding radii of carriageway edges, recommended by design guidelines [1] are applicable at intersections with approach road intersection axes of 90°, but not in the case of the mentioned intersection;
- recommendations of guidelines [8] and norms [3] which refer to the smallest lengths of the arc between the neighbouring legs axes were disregarded (Figure 2).

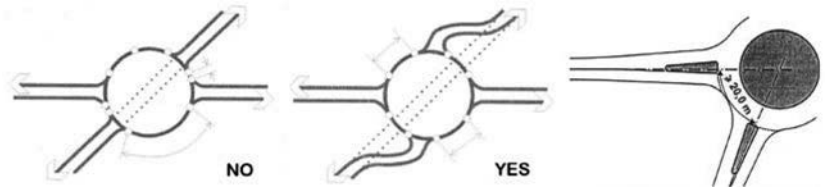

Figure 2 Reconstruction of road axes [8] and the minimum length of the arc between neighbouring leg axes [3]

2.2 Reconstruction solution

After offtracking control, by means of a specialized software [7] for the design vehicle 16.5 m long truck with semitrailer, it was found that the mentioned lane on Križevačka street should be widened by roughly 1.3 m (Figure 3). Although additional offtracking control showed that there is a need for widening the remaining lanes (for the value ranging between 0.1 to 0.5 m) only that critical lane was reconstructed (Figures 3, 4). Additional costs and the waste of time could have been avoided if offtracking control had been conducted already in the design phase.

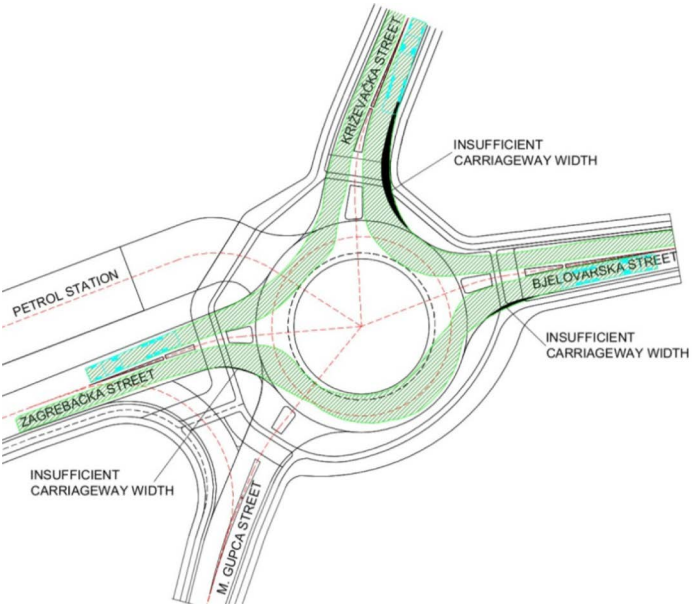

Figure 3 Offtracking control of the roundabout in Vrbovec

Figure 4 Lane widening on Križevačka Street

3 Proposal of offtracking control at roundabouts

At all intersections including roundabouts safe and unobstructed traffic flow should be secured. That is the reason why in the designing phase it is essential to check the design vehicle's possibility of passing through the roundabout.

3.1 Design vehicle selection

Just as in Croatia there are no official guidelines for roundabout design, there are, equally, no defined design vehicles for offtracking control at such intersections. The valid Croatian norm for the design and construction of intersections at grade (based on standard JUS U.C4.050 from 1990) defines the following design vehicles for offtracking testing conditions: a truck and a truck with trailer [15]. The mentioned norm does not include the rules for designing roundabouts, and the features of design vehicles defined by the norm [15] have not been harmonized with the features of the vehicles defined in the existing legislation of the Republic of Croatia [14]. Namely, the dimensions of vehicles in road traffic in the Republic of Croatia, as well as in other EU member states, have been harmonized with the Council's Directive 2002/7/EC (96/53/EC) [13] through the book of regulations [14] which prescribes the technical categories of vehicles, their dimensions and masses, axial load carrying capacity, devices and equipment that they must possess and the requirements that the devices and equipment of motor vehicles and trailers in road traffic must meet. With regard to the stated facts it can be concluded that in Croatia it is necessary to establish the range of vehicles for the selection of the design vehicle according to the position of the intersection in the road network. The range of vehicles can be established by means of three principles:

1 by statistical data analysis on the presence of a certain group of vehicles (personal vehicles, freight vehicles, truck trailers, buses) and their dimensions on the roads in Croatia, in which the criterion for the design vehicle selection would be the frequency of appearance;
2 by statistical data analysis on the presence of a certain group of vehicles (personal vehicles, freight vehicles, truck trailers, buses) and their dimensions on the roads in Croatia, in which the criterion for the design vehicle selection would be the vehicle dimensions (the selected design vehicle should have bigger dimensions and bigger smallest turning radius than the other vehicles from its group);
3 by selecting a vehicle from the existing range of design vehicles of the discussed guidelines [9, 10, 11, 12] according to the criterion of the biggest width occupied by the vehicles in driving on curves. Here it should be mentioned that German [10] and Serbian [8] guidelines offer the widest range of vehicles and that, unlike other guidelines, take into account garbage trucks and public transport vehicles (articulated bus).

3.2 Offtracking control

Offtracking control should be checked at all intersection legs and for all three directions: straight, right and left (Figure 5).

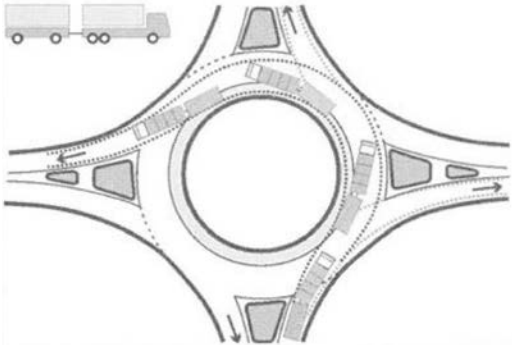

Figure 5 Offtracking control at roundabouts [8]

In order to have a drivable roundabout according to [2, 3, 4, 8] offtracking control should meet the following requirements:

- select a design vehicle which corresponds to the intersection position in the road network;
- ensure the safety lateral width of at least 0.25 m along elevated curbs in the circular lane;
- ensure the safety lateral width of at least 0.25 m along elevated curbs at entrance and exit;
- the design vehicle bus is not allowed to use the paved part of the circular pavement around the central island (truck apron);
- offtracking control should be conducted by design vehicle's templates or verified software.

4 Conclusions

One of the main problems in designing roundabouts in Croatia is the lack of quality design guidelines and frequent dereliction of important design steps such as offtracking control, which cause significant mistakes leading to unnecessary reconstruction expenses as well as the reduced traffic flow safety at intersections. Special attention should be dedicated to offtracking control during the reconstruction of the existing intersections, where larger departures of intersection angles from the right angle lead to additional designing problems. Due to this it is important to clearly establish minimum allowable intersection angles for which the diversion of the approach road axis is not necessary. Since the selection of the design vehicle plays the most important role in appropriate roundabout design, it is indispensable to define the range of the design vehicles and harmonize their characteristics with those of vehicles defined in the existing legislature of the Republic of Croatia.

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