Doc. dr.sc. Irena Ištoka Otković, dipl.ing.građ.
Josip Juraj Strossmayer University of Osijek, Faculty of Civil Engineering
Postal Address: Drinska 16a, 31000 Osijek, Croatia
Phone: +385 31 274 377 Fax: +385 31 274 444
E-mail address: iirena@gfos.hr

Martina Zagvozda, mag.ing.građ.
Josip Juraj Strossmayer University of Osijek, Faculty of Civil Engineering
Postal Address: Drinska 16a, 31000 Osijek, Croatia
Phone: +385 31 274 377 Fax: +385 31 274 444
E-mail address: mzagvozda@gfos.hr

ASPECTS OF TRAFFIC SAFETY OF TWO-LANE ROUNDABOUT

ASPEKTI PROMETNE SIGURNOSTI DVOTRAČNOG KRUŽNOG RASKRIŽJA

ABSTRACT

Significant improvement of functional characteristics of roundabout in relation to the classicintersections is unquestionable, but thegoalofthisresearchis to analyse thesafetyfeaturesof thetwo-lane roundabout. Traffic safety is a significant issue for the economy of a region, so application of traffic solutions that deliver greater safety of transportation is the objective. Analysis of traffic safety includes absolute indicators, but safety comparison of different solutions or different locations is only possible by analyzing the relative indicators of traffic safety. Two-lane roundabout is a complex traffic solution, because interweaving of traffic flows within the intersection has a direct impact on frequency of traffic accidents. Both direct and indirect costs of accidents are positively correlated with the severity of traffic accidents which are influenced by the traffic flow speed and the angle of conflict. A significant impact on traffic safety has users subjective perception of safety of certain solutions. Subjective perceptions of safety have been studied by surveying more than 330 drivers. Roundabout that was the subject of analysis is a two lane roundabout "Đakovština" in the urban transport network of the city of Osijek.

***Key words**: traffic safety indicators, two lane roundabout, subjective perception of safety*

SAŽETAK

Neupitno je značajno poboljšanje funkcionalnih karakteristika kružnog u odnosu na klasično raskrižje, ali cilj ovog istraživanja je analizirati sigurnosne karakterstike dvotračnog kružnog raskrižja. Sigurnost prometa je pitanje značajno za gospodarstvo regije, pa je cilj primjenjivati prometna rješenja koja donose veću sigurnosti prometnim korisnicima. Analiza sigurnosti prometa obuhvaća apsolutne pokazatelje, ali usporedbu sigurnosti različitih rješenja ili različitih lokacija moguće je samo analizom relativnih pokazatelja sigurnosti prometa. Dvotračno kružno raskrižje je kompleksno prometno rješenje, jer preplitanje prometnih tokova unutar raskrižja ima direktan utjecaj na učestalost prometnih nezgoda. Direktni i indirektni troškovi nezgoda u pozitivnoj su korelaciji sa težinom prometnih nezgoda na koju utječu brzina prometnog toka i kut pod kojim vozila dolaze u konflikt. Značajan utjecaj na sigurnost prometa ima i subjektivna percepcija sigurnosti određenog rješenja samih prometnih korisnika, koja je ispitana anketiranjem više od 330 vozača. Kružno

raskrižje koje je bilo predmet analize je dvotračno kružno raskrižje „Đakovština“ u urbanoj prometnoj mreži grada Osijeka.

***Ključne riječi**: pokazatelji sigurnosti prometa, dvotračnokružno raskrižje, subjektivna percepcija sigurnosti*

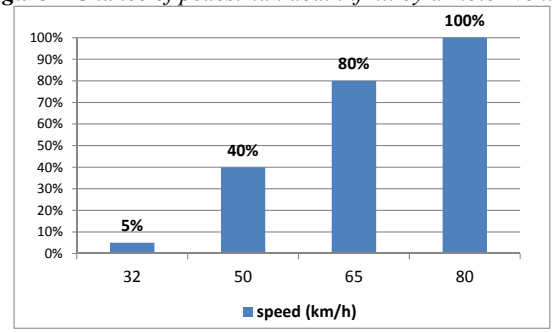
1. Introduction

According to a report of the World Health Organization, road traffic injuries account for almost 1.2 million deathsa yeararoundtheworldand for 20–50 millioninjuriesordisabilities (WHO, 2013).Developing countries accounted for more than 85% of all deaths due to road traffic crashes globally and for 96% of all children killed (Nantulya, Reich 2002).In addition to the human aspect, theeconomicconsequencesofroadtrafficaccidentsare alsoveryimportant, interms of both lost productivity andall healthcare resources needed.Assessments of the costsof road accidents included estimations of direct (property damagecosts, insurance administration costs, hospital costs) and indirect (lost productivity due to hospitalization and mortality) costs. According to research conducted in 12 different countries (Elvik, 2000), on the average the total costsof road accidents, including an economic valuation of lostquality of life, were estimated to about 2.5% of the gross nationalproduct.
More than 50% of road traffic crashesoccur in the urban space and the importanceof the problem imposes task for planners and transport analysts to find solutionsto reduce them.From the above it is clear that any traffic solution must be analyzed according to the functional characteristics as well as the characteristics of the traffic safety.Single-lane roundabouts show, according to a large number of studies, the improvement of functional characteristics (Ištoka Otković, 2008) and increase traffic safety.According to the subjective evaluation of transport users a two - lane roundaboutisperceived as lesssafethansingle-lane roundabout.

2. Indicators of safety of observed two-line roundabout

Traffic safety can be analyzed through a series of direct and indirect mutually comparable indicators (Archer, 2004). Indirect indicators of traffic safety such as the number of conflict points show a significant increase in safety at the roundabout in comparison with the classic intersection (Tollazzi, 2007). The principle of preventing high speeds at an intersection by the geometry of the intersection (roundabout) showed better results than the principle of sanctioning (classic intersection with the main and the side direction). Lower speed and angle of conflict between vehicles from opposing traffic streams have a significant influence on the severity of traffic accidents (Archer, 2004). For pedestrians, speed plays a significant role inthe severity of the consequences of an accident in vehicle-pedestrian interaction. Figure 1 shows that a pedestrian is about 8 times more likely to die when struck at 50 km/h than 32 km/h (TRB, 2010). Therefore, the difference in design speed is critical issue for pedestrians and cyclists and an important parameter for all transport users.The minor additional delay or inconvenience to drivers of lower-speed roundabout designs is a trade-off for the substantial safety benefit to pedestrians and bicyclists. Drivers may benefit from the additional time to perceive, think, react, and correct their errors which is particularly important for older drivers and beginners.

Figure 1 *Chance of pedestrian death if hit by a motor vehicle*



Source: authors

Roundabout that was the subject of analysis is a two lane roundabout "Đakovština" in the urban transport network of the city of Osijek (Figure 2).Roundabout has five access roads, two with two-lane entrance and three with one-lane.

Figure 2 *Two-lane roundabout „Đakovština“*

Source: CopyrightGoogle Maps

Analysis of the functional characteristics of the intersection shows that at intersections of the same operational level and of nearly the same traffic volume, roundabouts offer delay savings, if compared with any other alternative. Time saving depends on the traffic volume and percentage of left turns at an intersection. Higher percentages of left turns reduce the operability of any classic type of intersection, with relatively insignificant effect on a roundabout. The measurements taken for the travelling time between the parallel reference points at the observed roundabout (“Đakovština”) and the signal-controlled intersection (Gundulićeva-Županijska) in the city of Osijek have revealed the following:

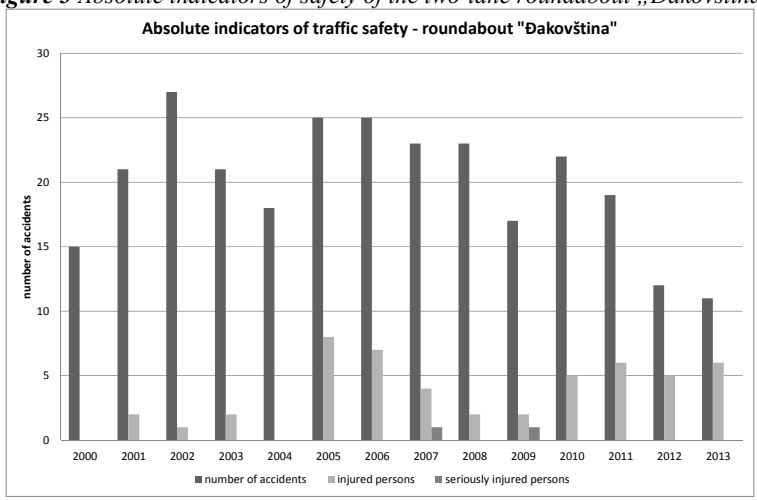
– delay savings of roundabout versus signal-controlled intersection are notable;

– according to the statistical parameters, the dispersion of data from the mean value of the travelling time between the reference points is smaller at roundabout (Ištoka Otković, Dadić, 2009).

Field measurements have shown improvement of functional characteristics of observed roundabout in relation to thesignal-controlled intersections, but the goal of this research is to analyze the safety features of the observed roundabout. Objective insight into the safety of the

intersection is provided by absolute indicators such as statistics on the number and severity of traffic accidents, but the real picture takes longer period of monitoring. The Figure3.shows the total number of accidents, number of severe traffic accidents and the number of minor traffic accidents causing only material damage at the observed two-lane roundabout during the 13 years period of monitoring. During that monitoring time, there were no traffic accidents with fatalities.

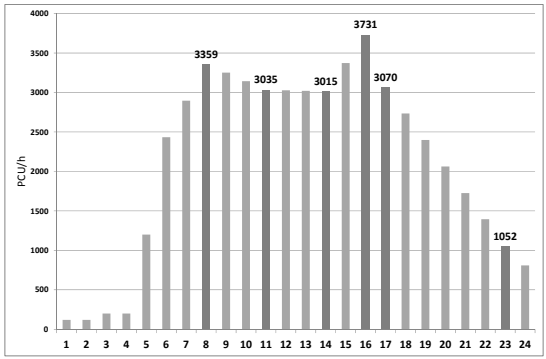
Figure 3 *Absolute indicators of safety of the two-lane roundabout „Đakovština"*



Source: authors

In order to be able to compare several intersections, and, for example, an intersection before and after a reconstruction, it is necessary to observe the number of accidents per year in relation to the traffic load. Measured total traffic load (November 2013) of the observed two-lane roundabout and the approximation of the daily load are given in the Figure4.

Figure 4 *Daily load curve approximation for the observed roundabout and the data on the total number of vehicles stated in PCU1/h*



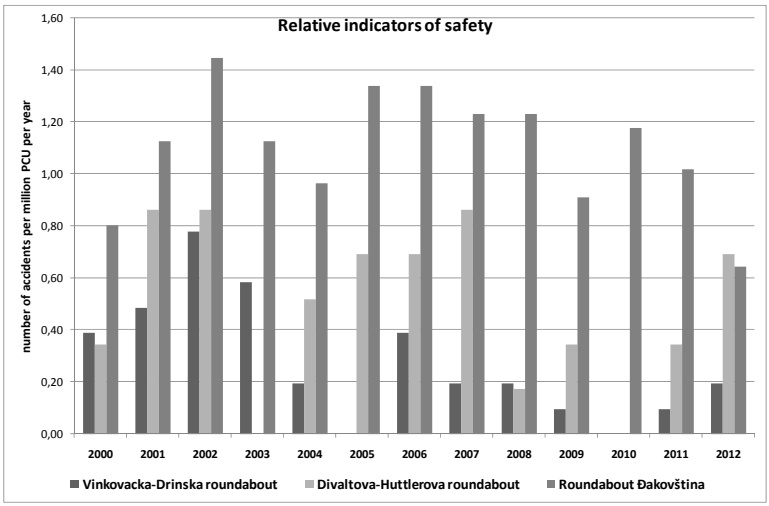
Source: authors

The Figure 4 shows the total number of accidents per million vehicles annually for two one-lane roundabouts, Divaltova-Huttlerova St. and Vinkovačka-Drinska St. roundabouts (Ištoka

[1]Passenger Car Unit (PCU) used for homogenizationmixed traffic flow

Otković et al.,2013)and observed two-lane roundabout "Đakovština".Comparison of the number of traffic accident shows that the single-lane roundabouts are safer than two-lane roundabout.

Figure 5 *Relative indicators of the safety of the observed two-lane roundabout Đakovština and two one-lane roundabouts*



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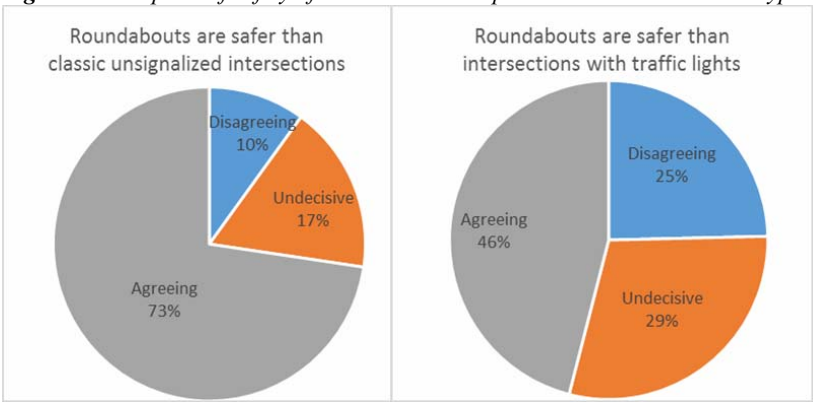
3. The subjective perception of safety

Subjective perception of safety in a given traffic situation is considered as possible indicator of traffic safety. Subjective perception of risk could give faster feedback to safety evaluation of certain traffic solution. Whether subjective perception follows the same trend as objective indicators and how is traffic safety of two-lane roundabout "Đakovština" evaluated by users has been examined by means of questionnaire survey. Survey was comprised of questions regarding subjective perception of risk in the urban network of Osijek with emphasis on roundabouts. Perception of risk was graded as emotionally based risk (feeling of insecurity), concern about personal safety and safety of others (worry) and cognitive assessment of possibility of traffic accident.

Subjective risk perception was tested on more than 330 participants involved in local transportation network. 53 % of respondents were males and 47% were females, with 10% of all respondents being professional drivers. More than half of all respondents (56%) has participated in at least one traffic accident.

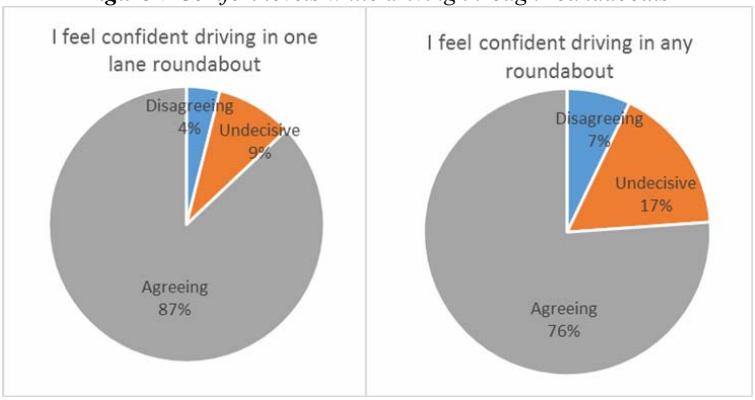
Figure 6 *Perception of safety of roundabouts compared to other intersection types*



Source: authors

Figure 6. shows subjective risk perception of roundabouts in urban network of Osijek. It is shown that in the most part participants of survey find roundabouts as safer than classic unsignalized intersection, unlike safety of roundabouts compared to intersections with traffic lights where opinions are divided. Fact that one-lane roundabouts are safer traffic solutions can be seen in responses to the survey in which majority of participants (87%) stated that they feel confident while driving through one-lane roundabouts. When all types of roundabouts are concerned, 76% of respondents will claim the same (fig. 7).

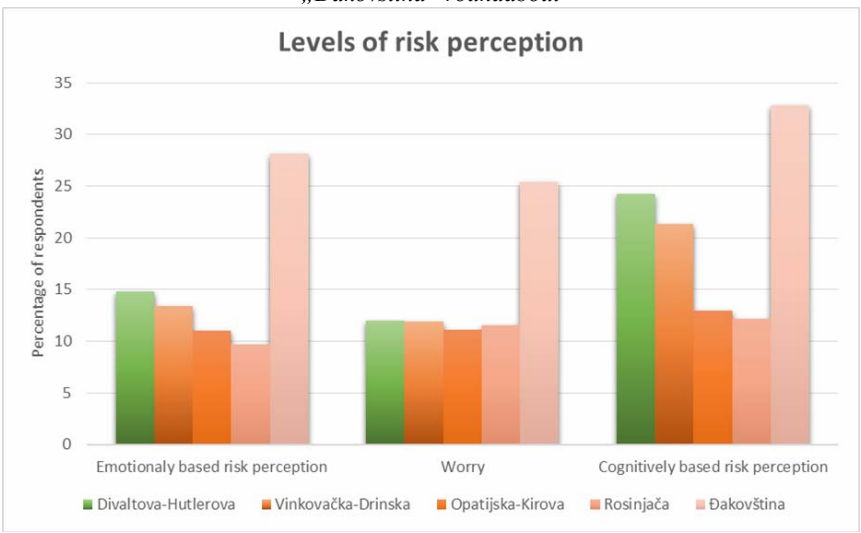
Figure 7 *Comfort levels while driving through roundabouts*



Source: authors

Greatest issue for drivers in two-lane roundabouts are interweaving operations that should be done in circulatory roadway. For some drives problem is presented in their own insecurities while performing such operations, while for others problematic are drivers that do not know or do not follow traffic rules for two lane roundabouts. Respondents also highlighted greater speed of vehicles as a reason for discomfort in "Đakovština" roundabout as well as the way surfaces for other traffic participants are designed (pedestrian and cyclist paths and crossings, tram going through roundabout).

Figure 8 *Subjective risk perception of 4 one-lane roundabouts compared to two-lane „Đakovština" roundabout*



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All this elements have contributed to greater subjective risk perception of two-lane roundabouts compared to one-lane roundabouts. Figure 8 shows that both emotionally based risk perception and feeling of worry are perceived in double as many respondents as when single lane roundabout are concerned. Only cognitively based risk perception differs less when compared to Divaltova-Hutlerova and Vinkovačka-Drinska roundabouts because those are as well complicated traffic solutions with tram going through them.

4. Discussion an dconclusion

Many studies have found (TRB, 2010) that one of the benefits of the installation of a roundaboutis the improvement in overall safety performance. Single-lane roundabouts achieved greater improvement of traffic safety thanmultilane.Comparison of the number of traffic accident in local traffic network clearly shows that the one-lane roundabouts are safer than observed two-lane roundabout (fig. 5).

Three basic types ofconflicts occur at multilane roundabouts that do not happen at single-lane roundabouts: fail to maintain lane position, enter next to an existing vehicle and turn out from the innerlane. While these conflicts may also be present at conventional multilane intersections, they can be more prevalent with drivers who are unfamiliar with roundabout operation. Proper roundabout geometry, traffic control devices and driver education and experience may also help to reduce these types of crashes.

According to the monitoring of traffic accidents for a period of 13 years at roundabouts in Osijek, there has been no traffic accident with fatalities on single-lane roundaboutsas well as on observed two-lane roundabout. The use of roundabouts is a proven safety strategy for improving intersection safety by reducing accident severity, and causing drivers to reduce speeds as they proceed into and through intersections.Decreased vehicle speeds will also contribute to the homogenization of the speed of traffic flow, which means decreaseof the vehicle speed differentials with other road users.

Numerous studies around the world also show the connection between perception of risk and insecurity (Loewenstein, Mather 1990, Sjöberg 1999 and Kobbeltvedt et al 2005). Subjective emotionally and cognitively based estimation of safety at the roundabout in Osijek was

examined by means of a survey.Surveyed driversexperience two-lane roundabout less safe than single-laneaccording to both emotionally-based and cognitive-based criteria of insecurity.
The survey tested emotionally and cognitively based perceptions of risk and the results (fig. 8) show very good agreement with the statistical indicators of intersection safety (fig. 5), especially in case of cognitive-based risk perception.
Survey results for the roundabouts in Osijek show that a significant number of respondents (81%) believe that roundabouts are safer than classic intersections, the type of intersection examined roundabout was before intersection. Respondents also evaluate roundabouts as positive according to other traffic safety indicators, such as indicators showing that 70% do not experience roundabouts less safe than other solutions for pedestrians, 54% for cyclists and 62% for children as traffic participants.
The surveyed population of drivers in Osijek expresses generally positive attitude towards reconstruction of classic intersections into roundabouts according to traffic safety criteria. Respondents perceive them as safer for all traffic participants, not just drivers.
Observed two-lane roundabout is less safe than single-lane roundabouts in local traffic network because of problem of interweaving traffic flows within the circular lanes at a relatively small length.Reduced speed of traffic flow in a circular intersection, reduces the severity of accidents, which is a significant advantage compared to other types of intersections.
Although most drivers learned the rules of driving in a two-lane roundabout, alternative solutions should be taken into consideration, such as turbo roundabout and the "flower" type of the roundabout (Tollazzi, Renčelj, Turnšek, 2011). It is possible to make a realistic analysis and comparison of alternative solutions in the planning stage by using traffic microsimulation tools.

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