CETRA 2012

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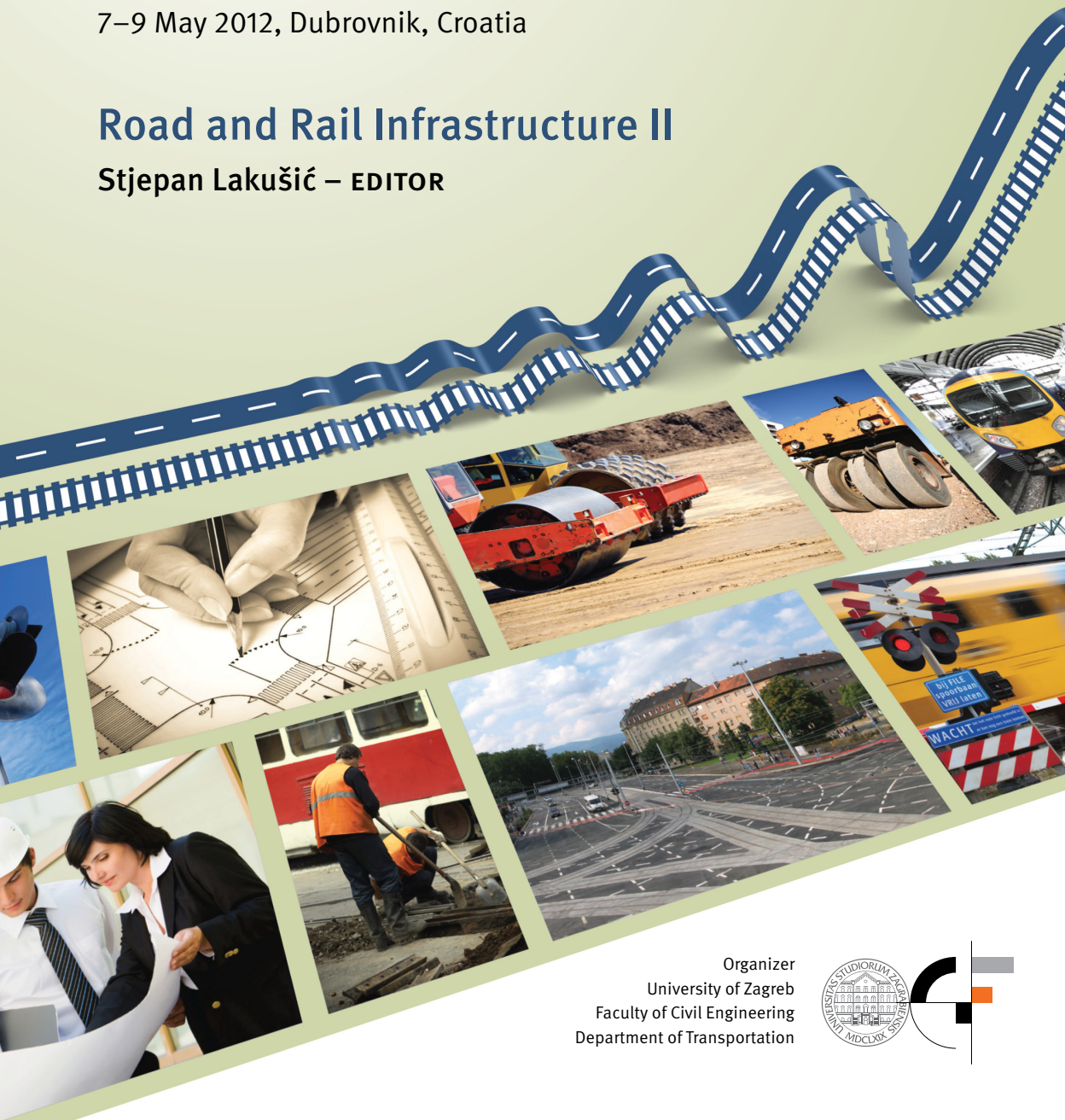
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR



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MINI–ROUNDABOUTS IN URBAN AREAS

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Abstract

Today's urban space offers little possible traffic solutions of the intersections, especially when it comes to city centres. Possible solutions, which do not require great area, are mini–roundabouts. They are characterized by a transit central island, around which passenger vehicles (and other small sizes vehicles) operate as in other roundabouts, while long vehicles (buses, trucks, etc.) operate as in classic intersections at level, crossing fully or partly over the central island. This type of roundabouts is usually carried out in populated areas, as a measure traffic calming or as a solution to increase the capacity of existing classic intersection or intersection with traffic lights. Many studies have shown that the application of this type of intersection has significantly increased the capacity of the intersection and reduced the number of traffic accidents. Traffic calming and relatively low construction costs are considered to be a significant positive feature of these intersections. However, in case of application of mini–roundabouts as traffic calming measures it is necessary to be careful because a roundabout without a raised central island may be poorly visible for drivers of passenger cars and thus may increase the risk of accidents. In such cases, special attention should be given to street lighting and other elements to calm traffic at the approach to the intersection. In the case of a large number of pedestrians and cyclists, mini–roundabouts are poorer solutions compared to classic intersections because at classic intersections their crossing is usually protected by traffic lights.
This paper will compare the guidelines for the performance of mini–roundabouts of other states, because the Croatian guidelines do not deal with this type of intersection, even though there are many mini–roundabouts already exist in Croatia.

Keywords: mini–roundabout, guidelines, urban area, design, costs

1 Introduction

Mini–roundabouts are subtypes of roundabouts, but deserve to be viewed as a chapter for itself because of the special features associated with the design, implementation and capacity of these intersections. For this reason, in the guidelines of many countries, these intersections have a separate chapter.
Although one might expect that from these types of roundabouts other roundabouts were developed, the fact is that these intersections developed more recently and still are quite unexplored. The first mini–roundabout appeared in USA, in early 20th century. Vehicles were circling in one direction around the central pillar which was called 'dummy cop'. Sometime later, those mini–roundabouts (primarily those with a minimum diameter of 10m) were made with a small central island, in the form of a dome or fungi. Connecticut State first started with the performance of mini–roundabouts. At the beginning, those intersections were made without a raised central island. Those islands were drawn in white colour. The first such intersection, made by the engineer Eno, had a 'target' in the middle, which consisted of a white circle with a diameter of 60cm and 2 concentric circles 30cm width on the mutual distance of 30cm, so the diameter

in whole was 3m. This was the beginning of mini–roundabouts, which are used all over England even today [1].

I the United Kingdom mini roundabouts were developed in the 1960s and 1970s. The yield–on–entry rule was widely tested and proven over the period from 1962 to 1966. Roundabouts could become smaller because they were no longer locked up. Tests in 1971 showed that large roundabout layouts didn´t work well even with the yield rule. Further tests on smaller three–arm roundabouts proved that the mini–roundabout with its nominal central island would work at appropriate sites and would yield much higher capacity than equivalent traffic signals [2].

The period between the 1966 and 1974 in England, was the time of extensive research on the roundabouts with small and very small diameter of central islands and on roundabouts without a raised central island. Small expenses enabled verification of many ideas and requirements for their performance and use. It is interesting to mention that in England all studies during that time, were performed at the 'real' roundabouts, not at polygons, or using computer simulation, in a real environment! During this period of extensive analysis another, less known form of roundabouts appeared (double mini–roundabouts, 'split minis', 'multiple minis', 'hollow minis ', 'ring systems'). Only recently they started to gain their meaning and application [3].

Since the beginning of the introduction of mini–roundabouts in England, three extensive and comprehensive analysis of traffic safety were performed on those roundabouts (in1974, 1980. and 1993.), which included almost all previously built mini–roundabouts. The last one (1993) covered the 85% of all mini–roundabouts, of which 95% were three–arms. The main conclusions of this analysis were as follows [3]:

- mini (and 'normal') roundabouts had a lower level of accidents than other types of roundabouts,
- multiarm mini–roundabouts had the largest number accidents, in which one participant was a pedestrian,
- number of car accidents (vehicle–vehicle) was increased with decreasing the radius of the mini roundabout,
- no accident has occurred at a U–turn ('U' manoeuvre),
- at the traffic load of 15.000–25.000 veh/day, the level of traffic accidents in a mini–roundabout amounted to 2.5 accident/year, and at the 'normal' roundabout 1.5 accident/year.

Prof.Werner Brilon research group (from Ruhr Universitat Bochum, Germany), conducted a study on 18 intersections in the centres of major cities or in their suburbs (residential areas), which were reconstructed in four years in the mini–roundabouts. Traffic volumes on these intersections were from 2.000 to 17.000 veh/day. Those intersections were selected for the mini roundabouts reconstruction because of the low level of traffic safety, high speeds of vehicles, high conflict area, long waiting time from the minor directions [4].

The results of the German study show that traffic volume of 15,000 vehicles/day for a mini–roundabout does not represent any problem. In especially good conditions (the traffic load is evenly distributed on all approaches, and the percentage of left–turning vehicles is very small), those intersections can handle the traffic load of up to 20,000 vehicles/day [4].

The study results confirmed that the mini–roundabouts in the German residential areas are not only a better solution than classic intersections, but also better than common (small and medium) roundabouts. It was also concluded that for the German conditions mini–roundabout is a much cheaper solution than reconstruction in a new classic intersection [4].

The first mini–roundabout in Croatia was built in Zagreb in 2002. After that, a double mini–roundabout was built on the island of Rab in 2003 and that was the beginning of small and mini–roundabouts in Zagreb and Istria, especially in Poreč. The first prefabricated mini–roundabout was built in 2006 near Opatija, which has already, in the first summer season after the performance (with a very low–cost performance), confirmed the expected increase in capacity and reduced speeds at the intersection [5].

The goal of this paper is to present basic strategies for design of mini–roundabouts applied in UK, USA, Switzerland and Germany.

2 Brief summary of guidelines of different countries

2.1 UK guidelines

UK guidelines define design elements for mini–roundabouts, give instructions about the safety, about road users specific requirements, about the assessment, and about the conspicuity.
Mini–roundabouts must only be used on roads with a speed limit of 50km/h or less and where the 85th percentile dry weather speed of traffic is less than 60km/h within a distance of 70 metres from the proposed give way line on all approaches, unless installed in combination with speed reduction measures.
Mini–roundabouts must not be used:

- at new junctions;
- at direct accesses;
- on dual carriageways;
- at a junction where the forecast traffic flow on any arm is below 500 vehicles per day (2–way AADT).
- at or near junctions where turns into or out from side roads are prohibited, because drivers do not expect to see vehicles U–turning on mini–roundabouts;
- if there is five or more arms.

Careful consideration is required where significant numbers of pedestrian crossing movements are likely to take place across any of the arms of a mini–roundabout. The safety of cyclists and motorcyclists must be considered when choosing, sitting and designing a mini–roundabout. They should not be used at sites where inexperienced riders are likely to use them (on routes to schools for example) except in conjunction with adequate speed reduction measures [6].

Figure 1 Mini–roundabout with a transit central island [7]

The maximum inscribed circle diameter (ICD) of a mini–roundabout is 28m. Above this dimension, a normal roundabout can accommodate the largest design vehicle and must be used. The white circle (in the centre of a mini–roundabout) must be as large as practicable (diameter 1m–4m), positioned using the inside of the swept path of cars. Vehicle proceeding through the junction must keep to the left of the white circle, unless the size of the vehicle or the layout of the junction makes it impracticable to do so (Fig. 1.). Therefore, the white circle must be sized and located so that drivers of light vehicles are not encouraged to drive on it or pass on the wrong side of it when negotiating the junction. The white circle should be formed and in white reflectorised materials. It may be domed to a recommended maximum height at the cen-

tre of 100mm (125mm, but not recommended) for a four–metre diameter marking. No other road markings then the prescribed mini–roundabout markings are permitted. A concentric overrun area (maximum diameter is 7.5m) may be used if required to increase the deflection and conspicuity. Overrun areas may be sloped up to the white circle at an angle of up to 150. Traffic islands may be provided to separate opposing streams of traffic and to assist provision of adequate deflection of the path of vehicles approaching the mini–roundabout. They can increase conspicuity to drivers approaching the mini–roundabout and also provide location for pedestrian crossing. A kerbed splitter island must be provided where, without it, vehicles would encounter an easier path if they were to pass on the wrong side of the white circle.
The entry lane width is 3–4m, except at a two lane approach where the minimum lane widths can be reduced to 2.5m. [6]
Local authority consultation suggests the range £10,000–£30,000 for 3–arm or £15,000–£50,000 for 4–arm single mini–roundabouts (at 2003 outturn prices) [8].

2.2 U.S. guidelines

The U.S.guidelines define a mini–roundabout as a type of intersection that can be used at physically–constrained locations in place of stop–controlled or signalized intersections to help improve safety problems and reduce excessive delays at minor approaches.
A mini–roundabout can often be developed to fit within the existing right–of–way constraints, and generally it is not recommended for intersections with more than four arms. In some cases there may be adequate spacing between arms to allow for two closely–spaced mini–roundabouts. Mini–roundabouts do not provide explicit priority to specific users such as trains, transit, or emergency vehicles. They are less suited for roadways with speeds exceeding 30 to 35 mph (50 to 55 km/h).
A number of these factors may preclude the installation of a mini–roundabout:
· high volumes of trucks;
· locations in which U–turn truck traffic is expected;
· locations with light volumes of minor street traffic.

Mini–roundabouts are generally recommended for intersections in which the total entering daily traffic volume is no more than approximately 15,000 vehicles. Multilane mini–roundabouts have been used in the U.K. but are rare elsewhere.
A mini–roundabout inscribed circle diameter generally should not exceed 90 ft (30 m). Above 90 ft (30 m), the inscribed circle diameter is typically large enough to accommodate the design vehicles navigating around a raised central island.
The central island is typically fully traversable and may either be domed or raised with a mountable curb and flat top for larger islands. The central island should be domed using 5 to 6% cross slope, with a maximum height of 5in (12 cm).
Raised islands are preferred over flush islands. A non–traversable island is used if all design vehicles can navigate the roundabout without tracking over the splitter island area, if there is sufficient space available to provide an island with a minimum area of 50 ft2 (4.6 m2) and if there are pedestrians present at the intersection with regular frequency (Fig. 2.). A traversable island is used if some design vehicles must travel over the splitter island area and truck volumes are minor, and if there is sufficient space available to provide an island with a minimum area of 50 ft2 (4.6 m2). A flush island is used if vehicles are expected to travel over the splitter island area with relative frequency to navigate the intersection, an island with a minimum area of 50 ft2 (4.6 m2) cannot be achieved and the approach has low vehicle speeds (preferably no more than 25 mph [40 km/h]) [9].
Costs range from about $50,000 for an installation consisting entirely of pavement markings and signage to $250,000 or more for mini–roundabouts that include raised islands and pedestrian improvements [9].

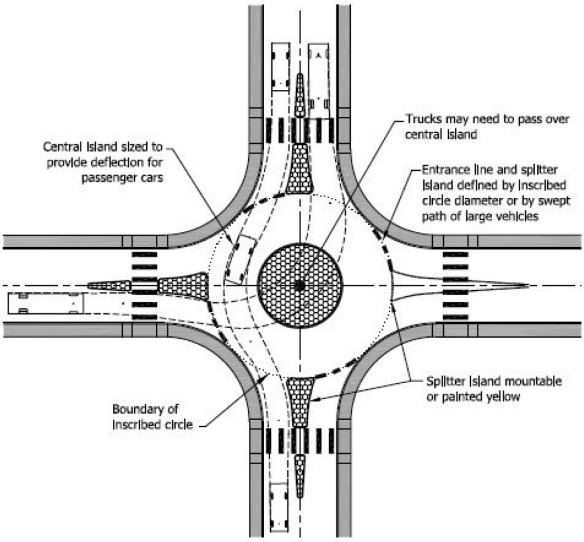

Figure 2 Design features of a mini–roundabout [9]

2.3 Swiss guidelines

Swiss guidelines recommend the use of mini–roundabouts on the roads in urban areas, while only exceptionally on roads outside populated areas, if it is not possible to apply other types of roundabouts or other intersections. Mini roundabouts should not be built:
· if it is not possible to apply the minimum design elements;
· when in a certain area a small roundabout (not mini!) can be build;
· when the daily traffic load exceeds 15.000 veh/day, or when the sum of the traffic load at the entrance and in the circle is more than 1200 veh/hour;
· where pedestrian traffic is especially dense.
The minimum outside diameter of these roundabouts is 14 to 26m. Mini–roundabouts with transit central island have a minimum diameter of 14m, while the mini–roundabouts with partially transit central island, must have a minimum diameter of 18m. The centre of the roundabout should be located at the intersection of all arm axis. Arrangement of arms should prevent passing without turning. Entrance angle should be selected so as to prevent tangent entry into the roundabout. The minimum angle between the two arms must be at least 30 degrees.[10]

2.4 German guidelines

German guidelines recommend a diameter between 13m and 24m for mini–roundabouts. Larger vehicles can override the central island as far as their swept pat. As a result of the investigations the following rules are recommended for application [11,12]:
· application only in urban areas (maximum allowed speed = 50 km/h);
· inscribed circle diameter between 13 and 24 m;
· circular roadway width between 4,5 and 6 m;
· cross slope 2,5 % inclined to the outside;
· central island with a maximum height of 12 cm (in the centre) above the circular lane.
· capacity up to a maximum of 20.000 veh/day;
· no flaring of the entries;
· only single lane entries and exits.

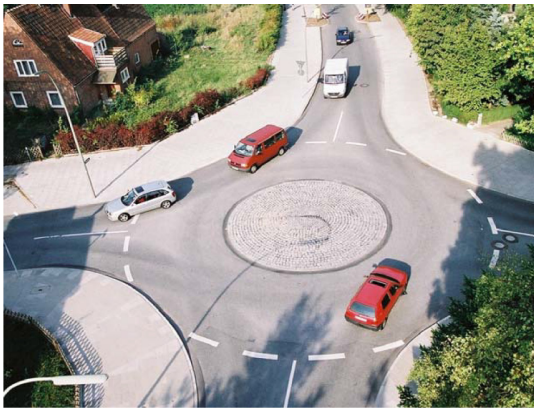

Figure 3 Mini–Roundabout in Hamburg [13]

Experiments with rural mini–roundabouts have also been performed. As a result, mini–roundabouts are not further recommended outside built up areas due to safety concerns [13].

3 Conclusion

Mini–roundabouts in some countries are present for decades, which enabled their detailed research. The results of these studies have greatly contributed to the development of guidelines for the design of this type of roundabouts. UK guidelines stand out as a particularly detailed one. Apart from suggesting sites where the use of mini–roundabouts is favorable, they provide detailed guidelines on the safety, about road users specific requirements, about the assessment, about the geometric design features, and about the conspicuity. U.S. guidelines have taken over a large part of U.K. guidelines, although in some parts they are applying their own experiences (e.g. avoiding only flashed central islands because they believe that traversable raised central islands are more visible).

Regarding the main design elements, nearly all guidelines are similar: maximum inscribed diameter is recommended by the U.S. guidelines (up to 30m), while the German guidelines recommend up to 24m. Regarding the speed on these intersections, all the guidelines point out 50–55 km/h as a maximum speed. Marking a mini–roundabout (horizontal and vertical) is different from country to country, but all have in common timely identification and notification such as intersections for all road users.

The capacity of these intersections is poorly covered in all guidelines: UK guidelines suggest the use of software to calculate the capacity, the U.S. provide information on maximum daily load of the intersection in which this type of intersection is applicable, while this area is slightly more elaborated in the paper of Werner Brilon [13] .

Recently, mini–roundabouts began to appear in Croatia, but in the absence of experience and guidelines, designers often reach for the guidelines of countries, where the tradition of mini–roundabouts is present for several decades. Such a great experience, which of course included a number of mistakes in the beginning of design of these intersections, is a precondition for the development of quality guidelines. However, 'copying' of guidelines of other countries does not ensure a quality design of mini–roundabouts in Croatia. Driving culture in some countries and the presence of a large number of other types of roundabouts are a precondition for the proper functioning of mini–roundabouts. Given the above, it is necessary to ask yourself whether such requirements exist in our county and at which level.

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