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TURBO ROUNDABOUT – AN ALTERNATIVE TO CLASSIC TWO - LANE ROUNDABOUT AT THE INTERSECTION OF "JOSIPA BROZA STREET" AND "V PROLETERSKE BRIGADE STREET" IN PODGORICA

Keywords
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Environment
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Abstract

The progressive increase of individual motorization, inadequately developed system of public transport, together with immense lack of interest in alternative types of transport that do not endanger the environment, make human life unpleasant. Moreover, it has already been sufficiently disrupted by the development of technology and negative impact of the modern way of life. Needless to say, Podgorica, as the capital of Montenegro, is not immune to the pressing problems of unsustainable mobility, either. Initiatives that can participate in resolving this global issue in cities can be defined through the appropriate choice of organization of interrupted traffic flows in urban areas. By implementing alternative, modern types of intersections that can face current challenges, it is possible to direct the present situation towards a new dimension of mobility. Namely, in addition to increased capacity, such solutions are distinguished by improved safety for all traffic participants. Safety at intersections is one of the valued factors for choosing a humane form of traffic, whether it is use of a bicycle or walking. Therefore, the subject of this article is the reconstruction of the existing two–lane roundabout with two entrances and exits, in Podgorica, at the intersection of "Josipa Broza Tita Street" and "V Proleterske brigade Street", into a turbo roundabout.

1. INTRODUCTION

The main reason for the construction of two-lane roundabouts was the expected doubling of the capacity of single-lane roundabouts. After some time, the reality showed a contradiction in the calculation and design theories that supported the introduction and use of an additional lane in the roundabout [3]. Namely, the main advantage of single-lane roundabouts compared to standard intersections is the elimination of conflict points. In relation to the four-way intersection, 4 conflicting points of merging, diverging, as well as all crossing points were eliminated, reducing the total number of conflict points from 32 to 8.

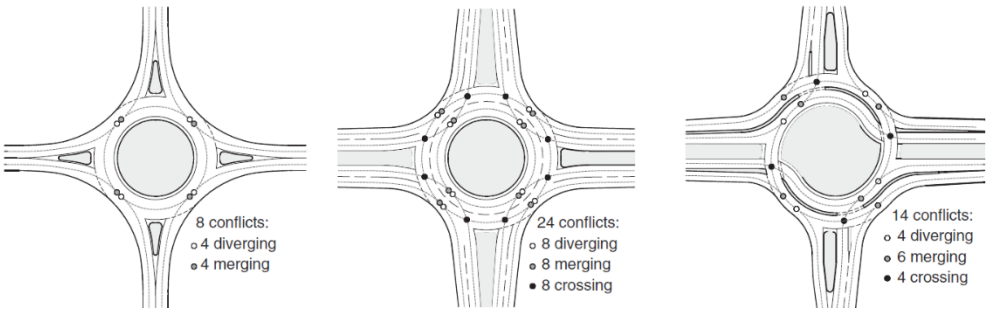

Figure 1. Number of conflicts on classic one-lane, two-lane and turbo roundabout [1]

In the case of a two-lane roundabout, the number of conflict points increases by 8 intersection points. The specific number of conflict points depends on the number of lanes at the entrances and exits. However, in practice it is not only possible to talk about these collision points, but potential sequences of conflict points which are also problematic because there are no specific positions and measures by which drivers are forced to stay or change lanes in the roundabout [3]. Two-lane roundabouts with two entrances and exits (24 conflict points) are particularly unsafe.

In this regard, it was proven that the additional lane in the roundabout increased the capacity by only about 30% [3]. These data show an insufficient improvement of capacity considering the significantly lower safety compared to single-lane roundabouts.

In addition, the impact on the environment is another aspect, which in urban areas such as Podgorica, should be on the list of priorities when selecting and designing appropriate intersections. This problem becomes much more important if we take into account the increase in the number of inhabitants and the disproportionate increase of individual motorization.

2. TURBO ROUNDABOUTS – AN ALTERNATIVE TO TWO-LANE ROUNDABOUTS

The negative effects of two-lane roundabouts can be compensated by an alternative intersection, known as a turbo roundabout, intersection with spiral driving flow. Physical barriers before entering, but also in the roundabout itself, clearly determine which lane the vehicle moves in from the moment it enters the roundabout, until it leaves it.

Professor L.G.H. Fortuijn first introduced turbo roundabouts in the late 90s. This alternative type of a roundabout has become popular throughout Europe and America in the last two decades. The first turbo roundabout was built in the Netherlands, where it was developed. In this country, the construction of classic two-lane roundabouts is prohibited.

Today, there are around 700 completed turbo roundabouts in the world, of which 414 are in the Netherlands. In the Balkans, Croatia leads the way, having built 9 and Bosnia and Herzegovina one intersection with a spiral road. Also, its construction has been completed in Serbia (Novi Sad, at the intersection of Car Lazar Boulevard and Fruškogorska Street). As for neighboring countries, Slovenia leads the way in their construction (17 turbo roundabouts).

The main role and reason for the creation of turbo roundabouts is the resolution of conflicts at the entrance and exit of the two-lane roundabout, as well as interweaving within the roundabout itself by physically separating the lanes. With this, the curb (delineator) is set as its most important element, which is why drivers must choose the appropriate lane before entering the intersection.

2.1. Bicycle traffic at turbo roundabouts

From the aspect of positive changes in Podgorica in order to approach a humane city, great attention should be paid to motivating the population to choose an alternative, bicycle traffic. The mentality of the Balkan people, including the Montenegrin people, is not inclined to accept changes, especially when it comes to the reduced use of the overwhelmingly predominant choice for overcoming distances in cities - the car. The topography in Podgorica favors the ability to quickly go from one end of the city to the other.

A bicycle would be a sufficient means of transport for the inhabitants of Podgorica. However, the benefits of using a bicycle must be communicated to future users. One of the effective measures can be the construction of efficient bicycle paths within the city traffic network. Problems occur in areas where traffic routes cross, at intersections. The most effective solution has already been implemented in developed European countries, such as highways exclusively for bicycle traffic, in which Denmark is leading the way. Of course, Podgorica, for several reasons, will probably not be up to that challenge in the near future. However, there are other, realistic measures, such as the construction of suitable intersections, the solution which would implement the safe possibility of using bicycles.

The issue of traffic safety is one of the important reasons for using bicycles as a means of transportation. A positive answer to this question can be given by the already mentioned turbo roundabout. In addition to the obvious benefits in terms of capacity, this type of intersection also provides safety, primarily for motor traffic. Safe and efficient cycling can be enabled by choosing the right design solution. The positive effects that can be achieved in this way promise an eventual decision to minimize the use of the biggest polluter of the environment in cities - cars.

Therefore, the two main advantages of turbo roundabouts are increased capacity and greater safety of motor vehicles, which is why it is suitable for implementation in urban areas. Precisely for this reason, in addition to the safety of motorized vehicles, the safety of other road users should also be taken into account.

In order to solve the problem of their safety, it is necessary to provide:

- speed control during dimensioning of the geometric shape of the intersection (the speed during the process must not exceed the value of 30-35 km/h (37-40 km/h);

- central island in the zone of pedestrian and bicycle crossings (preferable width of 2m (not less than 1.5m));

- detoured bicycle crossings (eventually) in order to reduce the speed of movement of cyclists in the intersection zone, provided that cyclists and drivers are constantly in visual contact;

- raised pedestrian crossings to calm traffic before entering the turbo roundabout, (reduction of traffic speed);

- pedestrian and bicycle traffic at different levels in relation to motor traffic if there is enough space for such a solution (overpass or underpass).

Campisi et al. [1] considered cycling mobility and safety at turbo roundabouts in two cases:

- segregation of motor and bicycle traffic (special paths for cyclists);

- integration of motor and bicycle traffic.

They concluded that in the case of higher flows, separated bicycle paths favor the safety of road users. However, if the traffic demand is lower, which can be the case in urban areas, even the integration of cyclists and drivers provides sufficient safety for all traffic participants.

3. COMPARISON OF THE CLASSIC TWO-LANE ROUNDABOUT AND THE NEWLY DESIGNED TURBO ROUNDABOUT AT THE INTERSECTION OF BOULEVARD V PROLETERSKA BRIGADA AND JOSIPA BROZA TITA STREET

Figure 2 shows the situational plan of the reconstruction project of the classical two-lane roundabout in question. The comparison of the safety of two types of roundabouts was performed based on defining the speed of passage and the number of conflict points, both between motorized vehicles and between motorized and non-motorized road users.

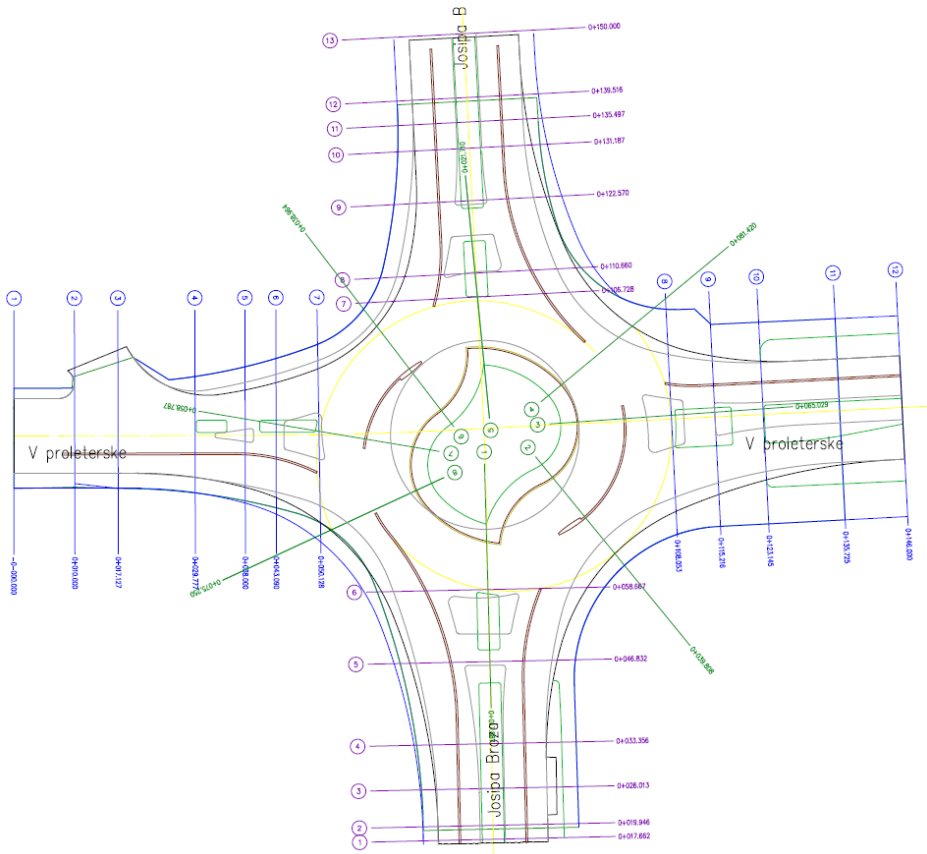

Figure 2. Situational plan of reconstruction of classic two-lane roundabout (grey lines) into turbo roundabout

3.1. Passing speed through the subject intersections

For the purposes of comparing driving speed, the method of drawing traffic lines [2] was used, whereby the speed is checked by the following equation:

$$v = 7.4 \cdot \sqrt{R} \tag{1}$$

Here, R is the radius of the traffic line, which depends on two elements: U (curvature - the length between the edge of the central island (or delineator) and the extension of the right edge of the roadway and L (the length between the beginning of the curve at the entrance and the end of the curve at the exit) [2]. The value of the radius of the traffic line is calculated as follows:

$$R = \frac{0.25 \cdot L^2 + 0.5 \cdot (U+2)^2}{U+2} \tag{2}$$

For the existing two-lane roundabout, 4 traffic lines can be drawn, and for the newly designed turbo roundabout, 12. The obtained values of the speed of traffic lines passing through the intersections are shown in the following tables:

Table 1. Passing speed on classic two-lane roundabout

Traffic line	v (km/h)
1	55
2	59.80
3	60
4	51.24

Table 2. Passing speed on turbo roundabout

Traffic line	v (km/h)
1	45.48
2	47.25
3	53.56
4	43.30
5	44.26
6	43.96
7	49
8	45
9	51.80
10	52
11	47.96
12	46.50

The passing speed through a classic two-lane roundabout range from 51 to 60 km/h. The speed at the turbo roundabout does not exceed the value of 54 km/h (three critical traffic lines). As the speed of passing through the turbo roundabout ranges from 43 to 54 km/h, it is a safer solution than the classic two-lane roundabout.

3.2. Number of conflict points at subject intersections

The number of conflict points between vehicles on a classic two-lane roundabout with two-lane entrances and exits is 24, and on a standard turbo roundabout, that number is 14.

The number of conflict points between vehicles and pedestrians and/or cyclists on a classic two-lane roundabout is 8. As this number depends on the number of lanes at the exits, the turbo roundabout has two fewer conflict points, because the exits on the minor road are single-lane.

Therefore, the criterion of conflict points gives an unquestionable advantage to the turbo roundabout in relation to the classic two-lane roundabout.

4. CONCLUSION

After comparing the speed of passing through the intersections, as well as the number of conflict points, the reconstruction of the classic two-lane roundabout at the location in question into a turbo roundabout is a completely justified solution. As the turbo roundabout has proven better aspects in terms of traffic safety, its construction would potentially cause traffic calming and help in making safer environment for cyclists. In this way, the use of cars could be reduced to an acceptable limit, and the capital of Montenegro would really step on the road to new, better mobility.

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