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CHARACTERISTICS OF ROUNDABOUTS

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ХАРАКТЕРИСТИКИ КРУГОВИХ ПЕРЕХРЕСТЬ

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CHARAKTERYSTYKA OBIEKTÓW DROGOWYCH TYPU RONDO

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INTRODUCTION

The beginning of the existence of roundabouts gave the circular intersections, which were consecutively established in 1768 in Bath in England, 1899 in Brautwiesenplatz in Görlitz in Germany, 1907 in Charles de Gaulle in Paris and in 1904 in Columbus Circle in New York [37]. The first roundabout was created in 1907 in San Jose, California, it was designed by John McLaren. In Europe, the first roundabout was built in 1909 at Letchworth Garden City in England [2,13].

The extensive use of modern roundabouts began in Great Britain in the 1960s, thanks to engineers from the Transport Research Laboratory. Currently, there are approx. 5,000 roundabouts in the United States, in France about 62,000, in England about 20,000, in Australia about 15,000, while in Poland about 14,000 [14].

The aim of the work is to present the basic characteristics of roundabouts and a description of selected examples.

CHARACTERISTICS OF SELECTED ROUNDABOUTS PARAMETERS

By definition, the roundabout is an intersection with the central island and unidirectional road around the island, where vehicles drive the central island counter-clockwise in countries with right-hand traffic or in the direction of traffic in countries with left-hand traffic [33]. An exception to these rules are mini roundabouts, where long vehicles can pass through the passing island [14,33].

The basic features of modern road roundabouts include [25]:

- priority check on all inlets,
- forcing the movement of all vehicles around the central island,
- reduction of vehicle speed through appropriate geometric parameters.

Selected features and elements of the roundabout construction are shown in Fig. 1, while Fig. 2 describes the basic geometrical dimensions.

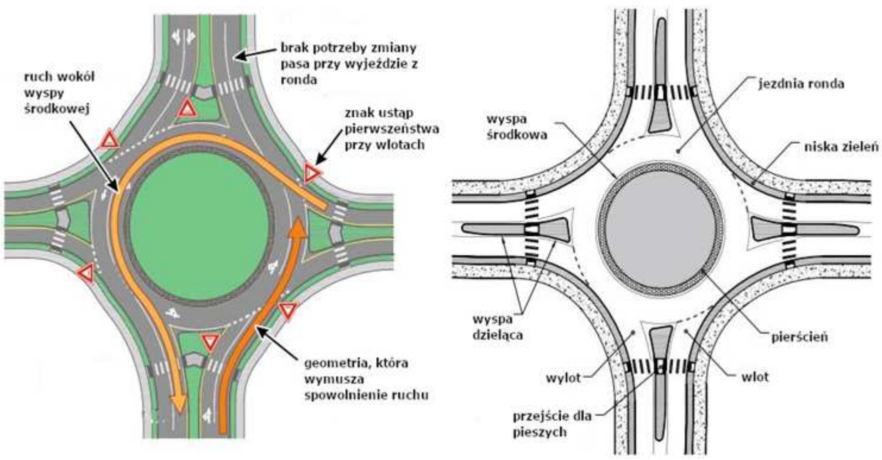

Figure 1 – Selected features and elements of the roundabout construction. Based on [25,33]

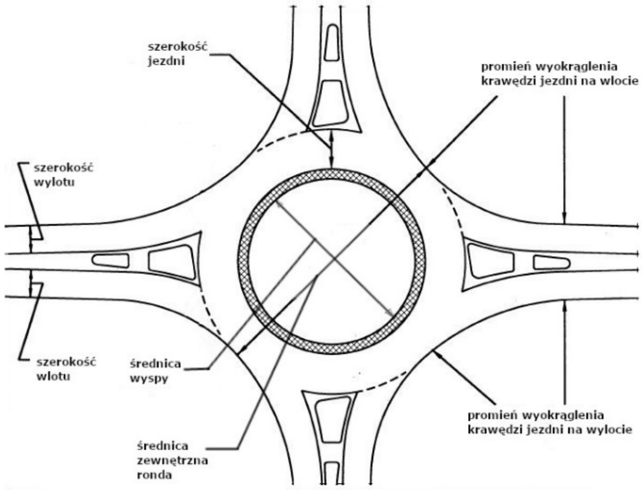

Figure 2 – Selected technical parameters of the roundabout construction. Based on [26,33]

There are four types of roundabouts depending on the diameter of the center island and the outside diameter of the roundabout. The characteristics of particular types of roundabouts with the scope of their applicability in urban areas are presented in Table 1.

Table 1 – Types of roundabouts in the building area. Based on [33]

Type of roundabout	Diameter of the central island [m]	The outer diameter of the roundabout [m]	Application - road class, roundabout position
Mini	4-10	14-22	Estate – street Z, L, D
Small	- one-lane: 10 (5) -28 -two-lane: 17-25	- one-lane: 26 (22) – 40 - two-lane: 37,5-45	Roads class G, Z, L on city inlets, in suburban zones in urban estates and on their outskirts, in the city center zone with moderate pedestrian traffic
Medium	- one-lane: 29-33 - two-lane: 25-37	- one-lane: 41-45 - two-lane: 45-55	Class G roads, Z-class multilane roads, in suburban areas, at the inlets to the city, on the outskirts of housing estates
Large	>37	>55	Not recommended in built-up areas. It is allowed on the border of the building area

Roundabouts are becoming more and more popular due to improving safety and increase traffic efficiency. The main benefits of using roundabouts are [1,7,11,16,21,23,24,34,35]:

- environmental factors – often reduce vehicle time delays when approaching an intersection and the number and duration of a stopover compared to some intersections with traffic lights. In the circumstance that the traffic at the roundabout is high, the vehicles slowly move in queues towards the intersection, rather than stop completely. This reduces noise as well as improves air quality and reduces fuel consumption by reducing the number of accelerations/brakes and idle time of vehicles,
- traffic calming - low driving speeds forced by the geometry of the roundabout construction, which has a positive effect on safety,
- pedestrian safety - the safety of pedestrians and cyclists traveling around the intersection is increased due to the reduced speed of motor vehicles during travel and driving around the roundabout. In addition, the use of the pedestrian island gives you the opportunity to focus on the traffic flow when passing/crossing the road,
- aesthetics - the central island gives the opportunity to develop them with the help of, for example, monuments, greenery, which has a positive effect on the image of the cities,
- operational and maintenance costs - roundabouts have lower operating and maintenance costs compared to intersections with traffic lights, due to the lack of technical equipment, signal

controllers, etc. Roundabouts also reduces maintenance costs due to the reduction of collisions and accidents,

- road safety - numerous studies have shown a significant increase in safety at conventional intersections modified to a roundabout intersection. The shape of the roundabout eliminates the number of conflict points, thus reducing the number of accidents. The total number of breaks decreased by 35%, while accidents with the number of victims by 76%,
- efficiency - in the case of throughput, roundabouts are characterized by lower time delays of vehicles than intersections with traffic lights. The reduction of time losses is the highest during off-peak hours. Such benefits are common in that the requirements for the number of lanes between intersections are reduced. It also contributes to reducing the cost of constructing new roads. However, compared to intersections with traffic lights, roundabouts do not give priority to the passage for a specific group of users, i.e. emergency vehicles, transit vehicles, trams,
- width of entry roads - roundabouts can reduce the width of access roads to the intersection compared to alternative crossings. Intersections with traffic lights often need additional left-handed or right-handed traffic, however roundabouts need more space for the central island.

The main limitation of using small one-lane roundabouts, despite the fact that they are one of the safest types of roundabouts (the smallest number of collision points), is their throughput, which ranges from 2000-2500 V/h [7,17-19]. For this reason, at intersections, with high traffic volume, two-lane roundabouts were built. However, on large two-lane roundabouts there are large distances between the inlets, as a result of which the drivers drive through them at higher speeds than at one-lane roundabouts [16, 17].

TWO-LANE ROUNDABOUTS

As mentioned, two-lane roundabouts are designed for higher traffic volumes. According to the requirements of the design guidelines, the diameter of such roundabouts in the inner city should be between 37.5 and 55m, while outside the urban area 40 to 65m [33]. The geometric layout of the two-lane roundabout allows drivers to change lanes across the entire roundabout.

Therefore, vehicles moving at high speed on the inner lane cross the flow of vehicles from the neighboring lane. Accident situations in this case are rare, but if they do, they significantly reduce the overall efficiency of such roundabout solutions [30]. A two-lane roundabout with an outside diameter reduced to 50m is characterized by a drop in throughput, as cars rarely use the internal lane, because the small outer diameter does not allow controlling the space behind the vehicle using mirrors. Drivers are also afraid that they will not leave the roundabout with a desirable departure, due to the high traffic volume of vehicles moving along the outer lane [16]. On the basis of a literature study on the use of lanes at the inlets to the two-lane roundabout, the following features can be observed [15,18,19,20,28,32]:

- drivers are more likely to choose the right lane at the inlet than the left lane; experimental studies in Poland show that 62-87% of drivers choose the right lane, depending on the intensity of traffic, high traffic volumes at inlets, cause an increase in the choice of the left lane to 34-45%,
- based on the results of experimental studies, it can be seen that older drivers are more likely to choose the right lane at the inlet,
- the correlation between vehicle type and the choice of a lane on the roundabout is that lorry drivers are much more likely to choose an outer lane on the two-lane roundabout.

TURBO ROUNDABOUTS

As a modification of the two-lane roundabout in 1996 in the Netherlands L.G.H. Fortuijn designed a turbo roundabout [16, 27]. It has a number of advantages over the classic two-lane roundabout. Such a solution by installing barriers separating traffic lanes on the roundabout forces drivers to select a lane on the inlet, depending on where they want to go (horizontal signs). Turbo roundabouts are characterized by higher throughput than classic two-lane roundabouts, while maintaining the level of security as on single-band roundabouts [16]. The number of collision points on the turbine roundabout is significantly lower than on the two-lane roundabout. For a two-lane roundabout, this number is 24, while for a turbine roundabout only 14, which significantly reduces the number of collisions and accidents [30].

The concept of a turbo roundabout has been adopted in many European countries, including in Germany, Slovenia, the Netherlands, Denmark and Poland [31]. Experimental research shows that the use of a turbo roundabout results in a 40-50% reduction in accident rate and 20-30% in the number of injured compared to a two-band roundabout [34-37].

The characteristic features of the turbo roundabout include [12, 16, 29]:

- the occurrence of no more than two lanes on the roundabout in the area at the inlets,
- if the ring is not widened, it is impossible to turn back in one of the directions of movement,
- no possibility of maneuvering of vehicle streams in the area of the roundabout, thanks to the use of spiral horizontal markings together with the spiral shape of the roundabout (reduction of the number of collision points),

- presence of more than one lane on the roundabout,
- relatively low speed of passage through the roundabout, resulting from traffic separators and the specific roundabout geometry,
- the ability to achieve higher bandwidth compared to a two-lane roundabout,
- possibility to choose the direction of travel only at the entrance to the roundabout.
- Turbo roundabouts have the following advantages [5,8,10,38]:
- giving way to priority by drivers from inlets to a maximum of two streams of traffic moving across demarcated lanes,
- minimizing the number of collision points,
- the ability to achieve better throughput compared to a two-lane roundabout.

CONCLUSIONS

Roundabouts has been operating continuously for over 100 years, but there are still debates over which type of roundabout is best in terms of throughput, safety, environmental and geometric factors. These intersections continue to evolve from a one-lane, two-lane roundabout to new solutions, eg turbo type [21].

The popularity of turbo roundabouts in Poland is steadily growing, despite the fact that no guidelines and regulations regarding the design of this type of solutions have been developed so far. Most of the current solutions are built based on the Dutch guidelines [4,6]. The geometry shaping process is carried out in 5 stages, ranging from the diameter of the roundabout and the width of the lanes. The spiral shape of the roundabout is usually obtained on the basis of shaping lanes based on an ellipse or Archimedes' spiral [36, 39].

However, it should be noted that due to technical problems (including the problem of snow removal, rainwater drainage, heavy vehicle traffic) and social problems (including the problem of the lack of acceptance of new road solutions by the public), for parts of roundabouts operating in the country there were no fixed road separators lifted above the road surface [16].

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ABSTRACT

MĄDZIEL Maksymilian. Characteristics of roundabouts. Visnyk of National Transport University. Series «Technical sciences». Scientific and Technical Collection. Kyiv. National Transport University. 2019. Vol. 3 (45).

The purpose of the article is to present the main characteristics of the ring intersections and a description of the selected examples. The article presents a brief history of the origins of road traffic interchanges and their stages of development. The article also deals with issues related to roundabouts in terms of their geometric parameters and structural elements, as well as the main difference between roundabouts in terms of shell size. This analysis also takes into account measures to improve the level of safety on the roads and measures to introduce elements of road structures to ensure the movement of vehicles around the circle.

The characteristics and purpose of two types of ring intersections - two-lane and turbine - are considered in more detail. The purpose of such intersections is to reduce delays in traffic, improve the safety of cars and pedestrians, more efficient use of the intersection area, as well as reducing the total cost of maintaining them. The effectiveness of the use of two-lane and turbine ring intersections, as well as the stages of construction of such intersections.

Despite the significant advantages of roundabouts, they have drawbacks that can be applied to technical and social ones. The former are characterized by the duration of construction and the possibility of integrating such structures already into the road network, while the latter are not by the desire or lack of strong thought about the benefits of circular intersections.

KEYWORDS: RING ROAD, GEOMETRY OF THE RING ROAD, CONSTRUCTION OF THE RING ROAD, TWO-WAY RING CROSS, TURBINE RING CROSS.

РЕФЕРАТ

МАДЗИЕЛ Максиміліан. Характеристики дорожних рондо / МАДЗЫЕЛ Максиміліан // Вісник Національного транспортного університету. Серія «Технічні науки». Науково-технічний збірник – К.: НТУ, 2019. – Вип. 3 (45).

Метою статті є представлення основних характеристик кільцевих перехресть і опис вибраних прикладів. Стаття представляє коротку історію витоків існування автодорожніх кільцевих розвязок та їх етапи розвитку. У статті також розглядаються питання, пов'язані з кільцевими розв'язками з точки зору їх геометричних параметрів та елементів конструкції, а також основна відмінність кільцевих розвязок з точки зору розміру оболонки. При даному аналізі, також враховуються заходи по підвищенню рівня безпеки на автошляхах і заходи по впровадженню елементів дорожніх споруд по забезпеченню руху транспортних засобів по колу.

Більш детально розглядається характеристика і призначення двох типів кільцевих перехресть – двох-смугового і турбінного. Призначення подібних перехресть полягає в зменшенні затримок в дорожньому русі, підвищенню безпеки автомобілів і пішоходів, більш ефективному використанню площі перехрестя, а також зменшення загальних витрат на їх утримання. Проаналізовано ефективність використання двох-смугових і турбінних кільцевих перехресть, а також етапи будівництва таких перехресть.

Незважаючи на значні переваги кільцевих розвязок вони мають недоліки, які можна поділти на технічні та соціальні. Перші характеризуються тривалістю будівництва і можливістю інтеграції подібних споруд вже існуюсу дорожню мережу, а другі – не бажанням або відсутністю сусільної думки відносно користі кільцевих перехресть.

КЛЮЧОВІ СЛОВА: КІЛЬЦЕВА РОЗВЯЗКА, ГЕОМЕТРІЯ КІЛЬЦЕВОЇ РОЗВЯЗКИ, КОНСТРУКЦІЯ КІЛЬЦЕВОЇ РОЗВЯЗКИ, ДВОХСМУГОВЕ КІЛЬЦЕВЕ ПЕРЕХРЕСТЯ, ТУРБІННЕ КІЛЬЦЕВЕ ПЕРЕХРЕСТЯ.

STRESZCZENIE

MĄDZIEL Maksymilian. Charakterystyka obiektów drogowych typu rondo / MĄDZIEL Maksymilian // Wisnyk Narodowego Uniwersytetu Transportu. – K. : NTU, 2019. – № 3 (45).

W pracy przedstawiono tematykę obiektów drogowych typu rondo. Wstęp pracy prezentuje krótką historię początków istnienia rond oraz ich stopniowy rozwój. Artykuł porusza również kwestie związane z charakterystyką rond w zakresie ich parametrów geometrycznych oraz elementów budowy, jak również opisuje podstawowe rozróżnienie rond pod względem wielkości obwiedni. Ostatnia część pracy dotyczy charakterystyki wybranych dwóch rodzajów rond – dwupasmowego oraz turbinowego. W tej części pracy opisana jest ogólna istota stosowania tego rodzaju rozwiązań, jak również korzyści oraz ograniczenia stosowania tych rozwiązań.

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