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ROUNDABOUTS AS AESTHETIC ROAD SOLUTIONS FOR ORGANIZING LANDSCAPES

Summary. In the transportation systems are different types of intersections. Among them, roundabouts are considered the safest solution. The application of roundabouts is conditioned by many factors. One of them borders on area development. Roundabouts, among others, are localized in important city places, thus serve as a landmark in the city or are localized on the boundaries of areas with different communication functions, thus constituting an organizational landscape feature. Sometimes, they diversify the space of a street or close the perspective of a monotonous street. Hence, beyond the basic functions, roundabouts with the appropriate central island arrangements can also play the function of organizing the architecture of the local area. The ways and possibilities of roundabout central island arrangements are presented in this article. An interesting central island arrangement shows that roundabouts play an esthetic and organizing landscaping role.

Keywords: roundabouts, central island, esthetic, road solutions, civil engineering, transportation

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1. INTRODUCTION

Cities and urban agglomerations development contribute to transport networks thickening, which is necessary to obtain efficient connections between different points in a transport network [11]. These networks consist of linear elements - roads, as well as point elements - crossroads. Over the last nearly thirty years, intersections like roundabouts are a keen and often designed transport systems elements. Roundabouts are also the subject of multifaceted scientific research relating to their functioning, efficiency, capacity, and many other issues [1, 4, 8, 10], as well as relating to their functioning as the transport network elements or transport systems elements. Roundabouts have gained wide popularity and favor from the designers because of their high level of road traffic safety.

The most basic form of a roundabout intersection is the single-lane roundabout. Single-lane roundabouts provide a higher level of road traffic safety than other types of intersections [6]. It is mainly caused by such roundabout features as a reduced number of collision points, low crossing speeds (from the scope of 15-30 km/h), lower travel time losses compared to other types of intersections, separation of traffic flows at inlets from flows at outlets, moreover, the pedestrians have the possibility of passing the roundabout inlet and outlet separately. The main limitation of the use of single-lane roundabouts is their capacity. It is estimated that this type of roundabout is capable of serving 2,000 to 2,500 vehicles per hour. Hence, when there is a need to obtain higher capacity values, two-lane roundabouts are designed [5]. Although two-lane roundabouts have a good level of traffic handling efficiency, experience has shown, however, that they also cause some functional problems. On larger two-lane roundabouts, the distances between the inlets cause the drivers to travel on them at higher speeds in the event of a lane change maneuver from the inner lane to the outer lane (leaving the roundabout), posing a potential danger. It is due to the interweaving of traffic flows, which generates additional collision points, causing a drop in intersection safety. In 1996, Bertus Fortuijn designed a new type of multi-lane roundabout called the turbo roundabout. This roundabout has a higher capacity than the classic two-lane roundabout while maintaining a level of security similar to the one-lane roundabout. Turbo roundabout is a multi-lane roundabout with a spiral marking of the roundabout circulatory roadway and with separate lanes for some relations. It is characterized by privileging the selected direction of movement. At the inlets of turbo roundabouts, drivers are forced to the selection of the desired driving direction. It is not possible to change the direction of travel on a roundabout circulatory roadway, as the traffic flows for the outer lane and the inner lane do not intersect.

The characteristic features of a turbo roundabout include [7]:

- no more than two lanes in the roundabout circulatory roadway in the area of the inlets,
- without ring widening, it is impossible to turn in one of the traffic directions,
- no possibility of maneuvering the intersection streams of vehicle in the area of the roundabout circulatory roadway, due to the use of a horizontal marking together with the spiral shape of the roundabout circulatory roadway (it leads to a reduction of the number of collision points),
- the presence of more than one traffic lane on the roundabout circulatory roadway,
- relatively low speed through the roundabout, resulting from traffic separators and specific roundabout geometry,
- the possibility of achieving a higher value of capacity compared to a two-lane roundabout,
- the possibility of selecting a driving direction only at the entrance to the roundabout.

However, it should be noted that for technical reasons including problems of snow removal, rainwater drainage, traffic share of heavy vehicles and social problems, for example, the problem of non-acceptance of new road solutions by the public on some turbo roundabouts in Poland, no permanent traffic separators were installed raised above the road surface.

The basic geometric elements of a roundabout include the central island of the roundabout, the splitter islands at the inlets, the circulatory roadway of the roundabout, inlets and outlets.

Subsequently, there are three types of islands designed at roundabouts. There are central island, islands dividing traffic flows at the entries (splitter islands), and - if necessary, given a traffic lane conducting traffic flow outside the roundabout in a right turn relation – lateral islands. According to Polish Guidelines [3], a roundabout central island should be located in the middle of an intersection and be circular in shape (in exceptional cases, a shape that is close to a circle). Small, medium and large roundabout's central island may be impassable because the central island arrangement and border curb around the island prevents vehicle entry. In the case of mini-roundabouts, the central island is designed to allow passing long vehicles across the island by the design and pavement surface. In turn, according to the same Polish Guidelines, islands dividing traffic flows at entries are defined as islands, which separate the entry from the exit and traffic flow entering into the roundabout main roadway from traffic flow exiting from the roundabout main roadway. In roundabouts, the lateral island may also be designed. This type of island has separate traffic lanes dedicated to turning right vehicle drivers from the roundabout main roadway. Among these three types of islands, the central island is the most important functional element of the roundabout. The central island determines the size of the occupied area by the roundabout, dictates the road traffic safety in the area of the roundabout, as well as the aesthetics of the whole intersection. Both central island dimensions and height have significant effects on a roundabout's recognizability and legibility. Apart from the central island operational functions and functions resulting from the roundabout geometry, it also allows for an interesting arrangement.

The central island arrangement of roundabouts localized in urban areas may be interesting and refer to the surrounding and other elements of city zoning. Whereas central island arrangement of roundabouts localized outside urban areas may refer to the specifics of the surrounding landscape. The ways and possibilities of central island arrangements of roundabouts localized in Poland and other countries in the world are presented in this article.

2. WAYS OF DEVELOPING CENTRAL ISLANDS IN ROUNDABOUTS

Nowadays, the main purpose of roundabouts design and construction is primarily to ensure a high level of road traffic safety and meet the desired capacity in transport system networks. Roundabouts are attractive alternatives for canalized intersections and intersections with traffic lights. The advantages of roundabouts predispose them to their use, both in urban and outside urban areas. Today's roundabouts are characterized by a very diverse form of functional and organizational solutions, location in the urban space and elements of the arrangement of the central island. Roundabouts are important elements of the urban landscape. From the perspective of spatial composition, they are the elements that crystallize the city plan, the dominants of the spatial arrangement, outstanding elements of the landscape, as well as nodal points and special elements in the transport networks. In large cities, roundabouts are built at the junction of major roads: roadways and tram tracks. They are an important element of the communication network and, as such, must provide drivers with the possibility of efficient and safe travel. However, the large area normally occupied by a roundabout can be used in other

ways. Planted with plants and well lit, and therefore visible at dusk and night, it will become a decorative element in the urban space, breaking the ugliness of big streets full of noise and exhaust fumes. The attractiveness of roundabouts is evidenced not only by the area or location but also by the development idea.

The central island, the external diameter of the central island, height formation and arrangement are some of the basic geometrical elements of small, medium and large roundabouts. From the viewpoint of road traffic safety, it should be borne in mind that the larger the size of the central island, the greater will be the vehicles' speed on the roundabout. The guidelines [3] recommend that the central island be circular circularly shaped, ensuring constant curvature for internal arcing of the main roadway of the roundabout. The oval central island shape in the same guidelines is not recommended for designing.

The center part of the central island should be clearly visible from all the roundabout entries and create an optical obstacle for vehicle drivers approaching the roundabout. Designing a high central island creates an optical obstacle for vehicle drivers approaching the roundabout so that vehicle drivers can focus their attention on vehicles approaching from the left side without any unnecessary deconcentration by the observation of traffic flow on the opposite side of the roundabout.

The most common solution is the central island arrangement with greenery (low, medium, high, very high or a mix of them - Figure 1).

a). b).

c). d).

Fig. 1. Central island arrangement with the use of a) low greenery in the roundabout localized in Radzionków, b) high greenery in the Wileńskie Roundabout localized in Rybnik, c) very high greenery in the large four-lane roundabout localized in China, d) very high greenery in the large two-lane roundabout in Budapest
Source: authors' documentation

The choice of species of trees and shrubs for planting depends on climatic conditions, particularly the temperature in winter. In addition, applied trees and shrubs should be resistant to air pollution and soil (mainly salinity), which in urban conditions and along roads with heavy traffic is very important. The shrubs (for example, meadowsweets, cotoneasters, berberis, cinquefoils), coniferous plants (for example, arborvitaes, junipers), ground cover plants which do not require frequent treatments (for example, roses), annual plants selected based on the time of year (for example, pansies, bechases, marigolds, geraniums, ageratums, salvias), grasses and perennials (for example, berges, crinoids), are readily planted on the central island. Most of these plants are resistant to drought and do not require frequent watering.

Besides the greenery, on the roundabout central islands, small architectural objects are used. These are small building structures constructed within the framework of land use. In the case of the central island of roundabouts, such elements as sculptures, figures, statues, fountains, small rock gardens, shrines or elements referring to the surroundings are used (Figure 2a). Sometimes, lighting is placed on a roundabout's central island. Lighting provides a good roundabout roadway visibility at dusk and night, even from a distance.

According to [9], during the central island arrangements designing process, the following should be considered:

- ensure the visibility of the intersection area for drivers both approaching the roundabout as well as driving on the main road of the roundabout,
- the fact that the design on a central island should be solid objects and not sliding obstacles such as trees, walls, columns, sculptures, or large boulders that may pose threats to both drivers and passengers after falling out of the roadway (Figure 2b),
- the fact that the central island can serve as a gateway between city areas with various communication functions. Thus, drivers will be in a different communication zone after crossing the roundabout,
- the need to plan the maintenance schedule and care of the central island during the roundabout operation,
- the additional costs associated with the project, arrangement and maintenance of the central island.

a). b).

Fig. 2. Central island arrangement in roundabouts localized in Rybnik
a) by elements appeal to surroundings in Boguszowickie Roundabout,
b) by concrete elements localized circumferentially in Mikołowskie Roundabout
Source: authors' documentation

3. CENTRAL ISLAND ARRANGEMENTS AT ROUNDABOUTS IN POLAND

In Poland, roundabouts are a popular intersection solution. The first modern roundabouts in Poland were built in the early nineties of the twentieth century. Presently, there are nearly 1500 different types of roundabouts. There are small, medium, large, one-lane, two-lane, semi-two-lane, spiral- and turbo-roundabouts. The most popular roundabouts in Poland (above 40) is in Rybnik city (in 2016, the population was 139 540 people [2]). Figure 3 presents the various possibilities of central island arrangements at roundabouts in Rybnik.

a). b).

Fig. 3. Central island arrangements in roundabouts localized in Rybnik
a) by components touches on the nature of the surrounding,
b) by components of small architecture
Source: authors' documentation

Whereas the biggest roundabout in Poland, at the same time one of the largest in Europe, is the roundabout named "Constitution 3rd of May" in the center of Głogów city. Its central island has an area of approximately 5 hectares. It is also the largest Polish circular traffic intersection with circular motion. In Poland, a fairly common practice in roundabout central island arrangements is grassing. Often at the center of the central island is set a lighting pole. Sometimes, roundabouts are designed in places of transportation networks, through which oversize vehicles pass through and for which passing through the roundabout was not guaranteed. For the passage of these types of vehicles on the central island, a special traffic lane needs to be designed, which in appropriate cases, after proper preparation, is used for oversized vehicles. Figure 4 presents a central island with a special traffic lane for oversize vehicles.

a). b).

Fig. 4. Central island with special traffic lanes for oversize vehicles
Source: authors' documentation

At roundabouts, sight distance decides the size and type of materials to be used for its central island arrangements. Another important element of the design of the central island arrangement (type, selecting plant materials, and other landscape features) is the speed of the roadway, because, at low speeds at roundabout entries, the potential risk of traffic incidents is small, while at higher speeds, the potential risk of traffic incidents increases. Furthermore, the type of central island arrangements should discourage pedestrians from going through the central island. During the design of roundabouts central island, elements that attract pedestrians, for example, benches, stairs, and pavement tiles, should be avoided.

4. CENTRAL ISLAND ARRANGEMENTS AT ROUNDABOUTS AROUND THE WORLD

Despite existing restrictions on the development of central islands, diverse and often interesting examples of central island arrangements can be found in different countries around the world. An example is Parisian roundabouts with their unique representational architecture. One of them is "La Place de l'Etolie". There is the first roundabout built in Europe. On the central island is localized the Arc de Triomphe (Figure 5). Another example of an interesting arrangement of a central island in Paris is the central island roundabout localized near the Louvre Museum, which is an important element of the city's image (Figure 6).

a). b).

Fig. 5. La Place de l'etoile in Paris (France) with Arc de Triomphe localized on the central island
Source: authors' documentation

Roundabouts are often localized near shopping centers to ensure safe access to and from the shopping centers. On a central island, a variety of plants and compositions consisting of rock formations or colored stones can be used (Figures 7 and 8).

Some central islands have not only aesthetic but also bear hidden ideological messages. Further, in the arrangement of central islands, fountains should only be used in areas without strong winds. Otherwise, the water spray they generate may adversely affect drivers' visibility in the area of the roundabout (Figure 9).

Fig. 6. An interesting arrangement of a central island with the use of low greenery in the roundabout localized near the Louvre Museum in Paris (France)
Source: authors' documentation

a). b).

Fig. 7. The arrangement of central islands with the use of
a) sculpture and high greenery in the roundabout localized in Athens (Greece),
b) low greenery in the turbo roundabout localized in Szeged (Hungary)
Source: authors' documentation

a). b).

Fig. 8. The arrangement of mounted central islands with the use of colored stones in roundabouts a). localized in Krk island (Croatia), b). localized in Varna (Bulgaria) Source: authors' documentation

a). b).

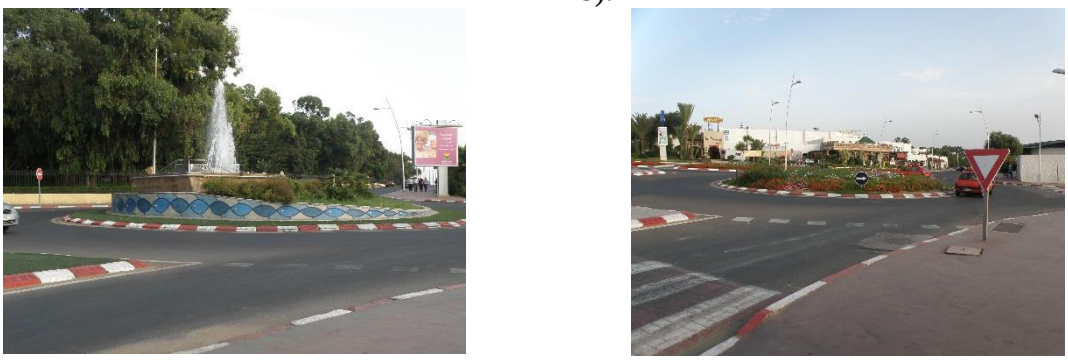

Fig. 9. The arrangement of central islands in roundabouts localized in Agadir (Morocco) with the use of a). fountain, b). average greenery
Source: authors' documentation

5. CONCLUSIONS

The traditional roundabout is a crossroad without traffic lights, where traffic moves around the central island. In comparison to other intersection solutions, the roundabout is more efficient, performing many functions simultaneously, for example, regulation and traffic calming. Single-lane roundabouts are particularly popular due to their ability to increase traffic flow and improvement of safety. However, errors in decision-making and misunderstanding of road traffic rules by drivers lead to collisions in traffic directions on circular lanes of multi-lane roundabouts. Although these incidents are not serious, they are nonetheless common and impede traffic flow.

Roundabout central island arrangements are recommended due to their roundabouts functions and positive role in noise suppressing and exhaust emissions reduction. The most common solution in the arrangement of roundabout central islands is the use of low, medium and high greenery. The potential barrier in the central island design is the non-obscuring visibility condition. Besides greenery, diverse interesting ways of designing central islands are developing in Poland and other countries of the world. The benefit of an interesting arrangement of the central island is one of the distinguishing features that give such intersections like roundabouts an aesthetic advantage over the traditional ones. Proper arrangement of the central island enhances the community and improves public safety. Sometimes, roundabout central islands are used for displaying local arts or as gateway features. On some roundabouts, the central island is illuminated at night. Various things can be found on central islands, for example, plant and plant-rock compositions, which undoubtedly, augment the aesthetic value of roundabouts. Some of these aesthetics have hidden ideological undertones.

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