Evaluation of the efficiency of roundabouts in modern cities

A S Gavaev

Tyumen Industrial University, 625000, Tyumen, Volodarskogo Street, 38
E-mail: gavaev@list.ru

Abstract. The article presents the results of studies that allow to reduce time delays by determining the optimal parameters of roundabouts based on the established dependencies of road characteristics on the geometric parameters of road intersections and traffic flows. In analytical studies, we identify the most effective types of configurations of the road intersection at the same level and establish the dependence of the average vehicle speed on the total traffic intensity for these configurations. Moreover, the paper establishes the dependence of the average speed on the intensity of traffic flow at different radii of the central guide island of the roundabout and the dependence of the average speed on the radius of the central guide island with different bandwidth of the carriageway on the approach to the roundabout.

1. Introduction
The high rate of motorization in major cities around the world is steadily leading to an increase in the number of road congestion. The problem is especially acute in the intersection zone, in the areas of merging and interweaving of traffic flows, where the direction of movement changes. At these points, the parameters of traffic flows deteriorate - the connection speed decreases and travel time increases due to traffic delays and traffic imperfections [15]. This leads not only to a decrease in the comfort of travel and quality of transport services [1], but also to an increase in ambient air pollution by products of incomplete combustion of fuel due to an unstable driving regime, frequent forced stops and congestion of cars at intersections [10]. The population of the city is constantly exposed to noise and exhaust gases [2]. An increase in the intensity of traffic and pedestrian flows directly affects road safety [6]. Ensuring fast and safe movement of vehicles in modern cities requires the use of a range of architectural, planning and organizational measures [3].

Existing guidelines are aimed at increasing the efficiency of using roundabouts, namely, reducing the number of conflict situations in traffic [4], preventing accidents and reducing the severity of their consequences at roundabouts [8].

Roundabouts belong to intersections at which the movement of vehicles takes place in a circle, which unloads the transport hub. However, the number of accidents at such intersections is higher than at a standard four-way intersection. Traffic accidents at such intersections rarely lead to serious consequences, injuries and deaths [7, 14, 16]. But at the same time, the number of small incidents here is quite large, which obviously reduces the throughput of city streets.
2. The main part

To evaluate the efficiency of roundabouts we used micromodelling as the main research method [9]. To forecast traffic flows, we should assess the main parameters of the traffic conditions - speed of movement, level of loading, time spent [5].

Modeling of intersections [11] was carried out with different variants of traffic organization: a four-way intersection (X-intersection) and a roundabout.

When changing the configuration of the intersection from a four-way two-lane intersection to a roundabout, the traffic parameters for traffic flows change in a positive direction [13]. So the average delay time is reduced by 43%, and the average speed increases by 28%.

![Figure 1. Dependence of the change in average vehicle speed on the total traffic intensity for various intersection configurations.](image)

With an increase in the total intensity of traffic, the average speed of traffic decreases both at the four-way intersection and at roundabouts. However, the average speed at the roundabouts is higher than at the four-way intersection. Therefore, roundabouts are more efficient.

Research aimed at improving the organization of traffic was implemented using the computer simulation program PTV Vissim 11, based on the laboratory of transport modeling of the Tyumen Industrial University [8]. The software allows to build an intersection, simulate the movement of traffic and pedestrian flows along them and evaluate measures to improve traffic and the appropriateness of their implementation.

The intensity of traffic flows in both the main and secondary directions was used as input parameters [12].

The dependences of changes in traffic parameters, namely, the average speed of movement, on the radius of the central guiding island of a roundabout for different traffic intensities and lanes at the approach to the roundabouts are shown in Figures 1-4.

The radii of the central guiding island - 40, 60, 80, 100 meters, were considered based on the classification of the guiding central island and its types.
Figure 2. The dependence of the change in average speed on the radius of the central guide island with a bandwidth of 2/2 and traffic intensity of 1000, 1500, 2000, 2500 vehicles per hour.

Figure 3. The dependence of the change in average speed on the radius of the central guiding island with a bandwidth of 4/2 and traffic intensity of 1000, 1500, 2000, 2500 vehicles per hour.
3. Conclusion

At an intensity of less than 2000 vehicles per hour and an increase in the radius of the central guide island of the roundabout from 40 m to 100 m, the average speed does not change significantly.

With increased intensity and an increase in the radius of the central guide island of the roundabout, the average speed increases significantly, logarithmically.

The revealed patterns allow us to conclude that the potential for using roundabouts in cities with high traffic intensity exceeds the capabilities of the most common four-way intersections.

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