The mini-ring intersections efficiency estimation at Volgograd street road network

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Abstract. The studies to evaluate the effectiveness of mini-circular intersections at the Volgograd street road network to improve traffic safety, which is achieved by eliminating the traffic flows intersection conflict points and reducing speed have been conducted.

Introduction
In the Russian normative documents developed to date [1,2], a certain attention is paid to mini ring intersections. The problems of their boundary parameters were in particular solved.

Main Part
However, to date, practical experience and assessment of the mini ring intersections use effectiveness on the Russian cities’ SRN are still insignificant [3,4].

Figure 1. The mini-ring intersections elements and basic geometric parameters
In this regard, the department SCTC VolSTU conducted such studies. As objects of observation, a number of mini ring intersections characteristics are performed and a general view of their location is presented in Table 1 and in Figure 2.

### Table 1.

| Location of the object of observation | Number of ring entries | Outer radius of the ring \(R_m\), m | Roadway width \(B_{rw}\), m | Intensity of movement veh/hour | Composition of passenger transport flow, % | Ring intersection type |
|---------------------------------------|------------------------|--------------------------------------|-----------------------------|----------------------------------|---------------------------------------------|----------------------|
| Pisemskogo str. – Tupoleva str.       | 3                      | 8                                    | 6                           | 990                              | 97%                                         | MINI                 |
| Academicheskaya str. – Kozlovskaya str. | 4                      | 8                                    | 5,5                         | 2300                             | 98%                                         | MINI                 |
| 62nd Army Embankment – 0 Prodolnaya Highway | 3                      | 14                                   | 7                           | 4000                             | 96%                                         | MINI                 |
| 62nd Army Embankment – Komsomolskaya str. | 3                      | 12                                   | 8                           | 3500                             | 96%                                         | MINI                 |
| Kachintsev str. – Novosokolnicheskaya str. | 3                      | 10                                   | 6                           | 1400                             | 98%                                         | MINI                 |

![Figure 2. Mini ring intersections observation objects](image)

To assess the effectiveness of mini ring intersections, we selected the following parameters:
- speed;
- intensity;
- delays.
For the study of speeds movement, a method of frame-by-frame comparison of the location of vehicles obtained using a CANON LEGRIA R806 digital video camera, which was recorded for a certain time, was used. Then, the resulting video was processed using a computer. In this case, the speed was calculated taking into account the video camera location according to Figure 3.

Since video recording gives a distorted picture when recording from the side, and not from a height, that is, the distance the vehicle travels is greater than the distance of the installed landmarks in front of the carriageway, it is necessary to make a calculation to determine the error in calculating the distance DE. As can be seen in the diagram, there is a video camera at point A at a distance AF from the edge of the roadway. At points B and C, the marking posts are installed. The distances of the aircraft and AF are clearly fixed and known. The distance FG (from the carriageway edge to the passing car) is taken 0.7-1.0 m from the safety clearance condition. Thus, to determine the real distance traveled by a car (DE), we use the formula:

\[ DE = AG \cdot \left( \frac{BC}{AF} \right) \]

To determine the actual vehicle speed, we substitute the known values in the formula:

\[ V = \frac{DE}{\Delta t} \]

where \( \Delta t \) is the period of time for which the car traveled from point B to point C on the monitor screen:

![Figure 3. The camcorder layout to monitor the modes of movement of vehicles](image-url)
\[ \Delta t = t_1 - t_2 \]

In turn, at the mini-ring intersection there is a significant decrease in speed directly in the ring zone.

Moreover, it was found that here the external radius of the mini-ring intersection (\( R_{in} \)) has a significant effect.

As a result of data collection and processing, as well as previously measured using the well-known methods of mathematical statistics, the traffic flow speed in the area of Mini-ring intersections has been obtained.

These results suggest that the mini ring intersections use is possible as a means of forcibly reducing the traffic speed. Also, observations showed that the movement speed on the Mini ring intersections itself depends not only on the outer radius of the ring, but also on the safety separation islands shape. So, the speeds measurements on the mini ring intersections with the outer radius \( R_{in} = 12 \text{ m} \) in Russia showed the speed values of 29 - 34 km/h.

The vehicle delays field observations were carried out before and after the mini ring intersection.
Figure 6. Traffic intensity at the intersection (vehicle/hour) before (a) and after (b) the mini ring intersection device.

Since the intensity of movement on the directions is not constant, it was considered to be the total intensity at the whole intersection as the base. So, before the Mini ring intersections device, the total intensity at the intersection was 1359 vehicle/h, and after 3528 vehicle/h (Fig. 7).

Each individual car delays measurements processing and analysis showed that the average delay of the entire intersection to the Mini ring intersections device was 5 sec/veh. Moreover, the greatest losses of time were in 3 directions ($t'_3 = 20.03$ seconds/vehicle, see Fig. 3.3.4 a), and, on the contrary, cars in 1 and 2 directions moved without delays, since the directions had the advantage of moving to Mini ring intersections devices.

Figure 7. Each individual traffic flow average delays of (sec/vehicle) before (a) and after (b) the mini ring crossing device

In turn, at the mini ring intersection, the average delays were distributed evenly in directions 1 and 2 ($1 \div 3$ sec/vehicle, (see Figure 7b) and for the whole intersection the average delay was 3.67 sec/vehicle.
Summary
The studies were conducted throughout the year, from April 2018 to April 2019. Thus, as a result of the observations, it was possible to establish that the speed, the junction angle, the radius, the entry angle, weather and climatic conditions, as well as the coating condition directly affect the movement of cars at the mini-ring intersections of the city of Volgograd.

References
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[3] Lipnitsky A S 2008 *Evaluating the area of effective use of compact ring intersections.*
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