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Analysis of conflict points, conflict situations and calculation of traffic density on a given section of the road network

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Introduction. The paper considers traffic in Kombaynostroiteley square in Rostov-on-Don. The necessity and possibility of organizational improvement of the situation on this road network section is noted. Taking into account the active development of the city in particular and the Rostov agglomeration in general, the results of the study will be relevant in the development of the control system and the street network.
Problem Statement. It is necessary to record and evaluate the main parameters of road and pedestrian traffic on the considered section of the road network in order to further improve the organization of traffic.
Theoretical Part. Conflict points and conflict situations on a given section of the road network are analyzed. For three days, traffic and pedestrians density during rush hours was recorded. The corresponding average-per-day indicator is calculated. Traffic flow composition from the point of view of types of transport is described. The data is visualized as charts and cartograms.
Conclusion. Traffic density and composition determines its speed, so they are taken into account in the design of traffic control systems, the development of the street network and the development of the general plan of the city. For the section under consideration, the rush hours are 10 a.m. and 5 p.m. The intensity increases up to 10 a.m., changes slightly from 11 a.m. to 7 p.m., and then decreases.

Keywords: traffic, conflict points, average-per-day traffic density, road network.

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Introduction. The study of car traffic on Kombaynostroiteley square near the Rostselmash cultural centre in Rostov-on-Don has showed that the traffic flow at this interchange can be optimized. For this purpose, it is necessary to assess the intensity of traffic, determine the conflict points of the site and, based on the data obtained, offer options for improving the situation, reducing accidents. The results of the study will be relevant in the design of the development of the regulatory system, the street network and the general plan of the city.

Problem statement. As part of this work, it is planned to record and evaluate the main parameters of car and pedestrian traffic on the considered section of the road network in order to further improve the organization of traffic.

Theoretical part. Analysis of conflict points and conflict situations on a given section of the road network. The paper considers the roundabout on Kombaynostroiteley square in Rostov-on-Don. The turning circle is located at the intersection of Selmash Ave., 1stKonnoyArmii St. and Selivanov St.

According to the five-point system, the conflict points available here are evaluated as follows (Fig. 1):

— the intersection (5 points),
— the merging (3 points),
— thedivision (1 point).

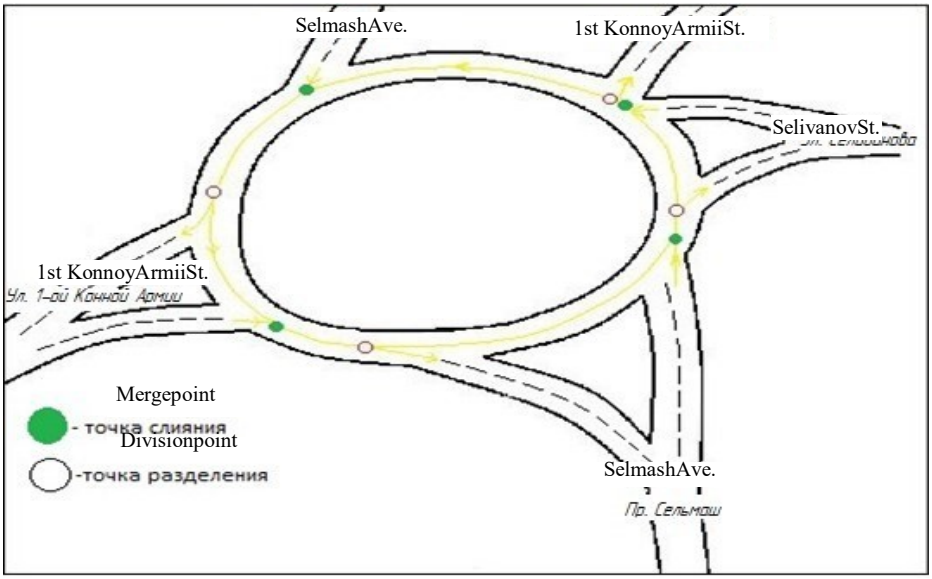

Fig. 1. Conflict points at a roundabout
(Kombaynostroiteley square, Rostov-on-Don)

We use the intersection complexity formula [1]

$$m = n_p + 3n_c + 5n_n,$$

where n_p — the number of division points, n_c — the number of merge points, n_n — the number of intersection points.

The object is not an intersection, but a ring, so there are no intersection points here. Therefore, $5n_n$ is equal to zero:

$$m = n_p + 3n_c = 6 + 24 = 30.$$

In our case $m < 40$.This means that the node is simple.

The number of conflict points is measured by the number of lanes and permitted vehicle directions [2].

After calculating the conditional index m of intersection complexity, you need to find out which category this intersection belongs to[1]. This is the basis for measures to improve the organization of road traffic in the area under consideration [3].

Conflict points are conditionally assigned hazard points on a ten-point system (table. 1).

Table 1

Hazard points for conflict points at a transport interchange

Conflict point	Assessment, score
Segregating	1
Merging	2
Intersection at an angle, deg:	
30	3
60	4
90	6
120	7
150	8
180 (oncoming traffic)	10

[1]Recommendations for ensuring safety on the roads. Road industrial methodical document 218.1.052-2002 [Rekomendatsii po obespecheniyu bezopasnosti dvizheniya na avtomobil'nykh dorogakh. ODM 218.1.052-2002]. Moscow Automobile And Road Construction State Technical University (MADI), FSUE "Rosdornii", ITS VolgGASA; Department of operation and safety of highways of the Federal Rroad Agency. Techexpert: Available from: http://docs.cntd.ru/document/1200084056 (Accessed 22nd February2020).

Calculation of traffic intensity. The calculation was carried out in two traffic directions, separately for transport and pedestrians. First direction: Selmash Avenue — 1st KonnoyArmii street. Second: Selmash Avenue (towards the suburban bus station). The section includes the number of vehicles and pedestrians per 1 hour. The calculation was performed during the peak hours of 21.09.2019 from 8.00 to 9.00, 22.09.2019 from 12.00 to 13.00 and 23.09.2019 from 17.00 to 18.00.

The measurement results are shown in tables 2-7.

Table 2

Types of vehicles participating in the traffic flow 21.09.2019 8.00–9.00

Types of vehicles	Traffic intensity, units/h								Total
Passenger car	374	72	61	289	190	111	214	482	1793
Truck	—	11	12	—	10	4	—	—	37
Bus	32		—	32	36			36	136
Minibus	18		—	18	16			16	68
Motorcycle	2	2	—	—	—			—	4
Tram	—	—	—	—	4	4	—	—	8
Total	426	85	73	339	256	119	214	534	2046

Table 3

Types of vehicles participating in the traffic flow 22.09.2019 12.00-13.00

Types of vehicles	Traffic intensity, units/h								Total
Passenger car	285	102	85	314	196	95	252	403	1732
Truck	—	17	11	—	17	12	—	—	57
Bus	28		—	28	32			32	120
Minibus	18		—	18	16			16	68
Motorcycle	2	2	—	—	—			—	4
Tram	—	—	—	—	4	4	—	—	8
Total	333	121	96	360	265	111	252	451	1989

Table 4

Types of vehicles participating in the traffic flow 23.09.2019 17.00-18.00

Types of vehicles	Traffic intensity, units/h								Total
Passenger car	411	80	72	304	200	135	201	342	1745
Truck	—	5	2	—	7	8	—	—	22
Bus	30		—	30	34			34	128
Minibus	21		—	21	18			18	78
Motorcycle	4	4	—	—	—			—	8
Tram	—	—	—	—	3	3	—	—	6
Total	466	89	74	355	262	146	201	394	1987

Table 5

The average daily intensity of traffic flow

Types of vehicles	Traffic intensity, units/h								Total
Passenger car	357	85	73	303	196	114	223	409	1760
Truck	—	11	9	—	10	8	—	—	38
Bus	30		—	30	34			34	128
Minibus	17		—	17	17			17	68
Motorcycle	3	3	—	—	—			—	6
Tram	—	—	—	—	4	4	—	—	8
Total	407	99	82	350	261	126	223	460	2008

The calculation of traffic intensity in the given cars/hour is calculated using the general formula [4]:

$$N = \sum_{i=1}^{n} N_i K_{\text{пр}i},$$

where N_i — the traffic intensity of the given type of car, cars/h; $K_{\text{пр}i}$ — the reduction coefficient for this group of cars; n — the number of car types.

Table 6

Traffic intensity coefficient in the cars shown/hour [5]

Types of vehicles	Coefficient
Passenger cars	1
Motorcycles	0,5
Trucks	2
Buses	2,5
Minibuses	1,5
Tractors	3

Traffic intensity in the cars/hour for the intervals 8.00–9.00, 12.00–13.00, 17.00–18.00 is calculated using the above formula [6]:

$$N = 1793 \times 1 + 37 \times 2 + 140 \times 2,5 + 68 \times 1,5 + 4 \times 0,5 = 2321 \text{ (cars/hour)},$$

$$N = 1732 \times 1 + 57 \times 2 + 128 \times 2,5 + 68 \times 1,5 + 4 \times 0,5 = 2270 \text{ (cars/hour)},$$

$$N = 1745 \times 1 + 22 \times 2 + 134 \times 2,5 + 78 \times 1,5 + 8 \times 0,5 = 2245 \text{ (cars/hour)}.$$

The average daily traffic intensity in the cars/hour is calculated using the formula [7]:

$$N = 1760 \times 1 + 38 \times 2 + 136 \times 2,5 + 68 \times 1,5 + 6 \times 0,5 = 2281 \text{ (cars/hour)}.$$

The coefficients of distribution of traffic intensity depending on the time of observation are shown in table 7.

Table 7

The distribution coefficients of traffic density[2]

Hours	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8
Coefficient	0,083	0,025	0,009	0,023	0,059	0,144	0,270	0,32
Hours	8–9	9–10	10–11	11–12	12–13	13–14	14–15	15–16
Coefficient	0,52	0,68	1,0	0,84	0,74	0,75	0,83	0,97
Hours	16–17	17–18	18–19	19–20	20–21	21–22	22–23	23–0
Coefficient	1,05	0,95	0,9	0,47	0,26	0,24	0,19	0,12

Figures 2-5 provide visualized data on traffic intensity [8].

2Gosavtoinspektsiya [Road Safety Unit]. Available from:https://xn--90adear.xn--p1ai/r/61 (Accessed 24th September2019).

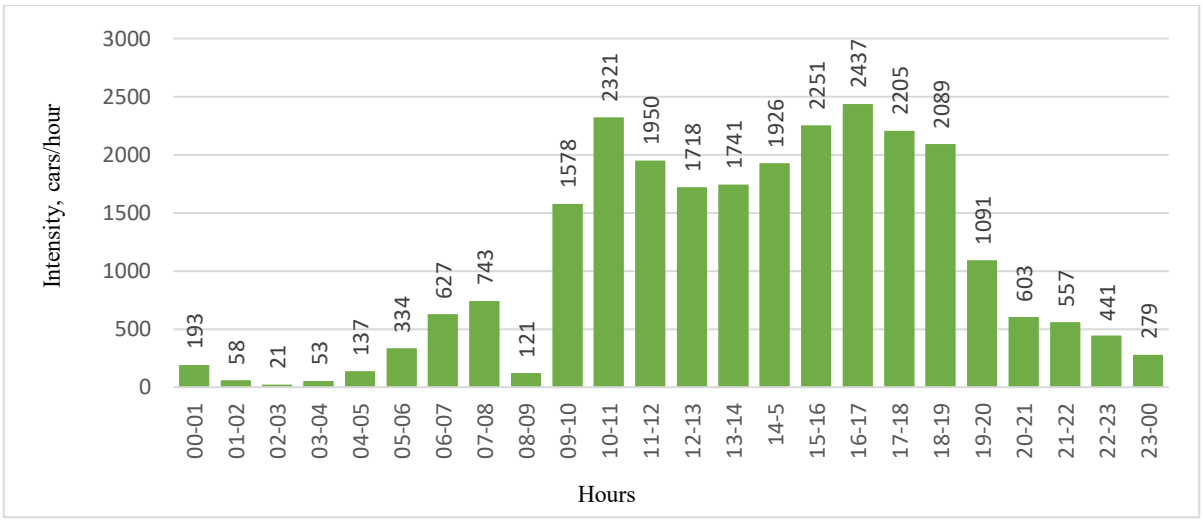

Fig. 2. Traffic intensity 21.09.19

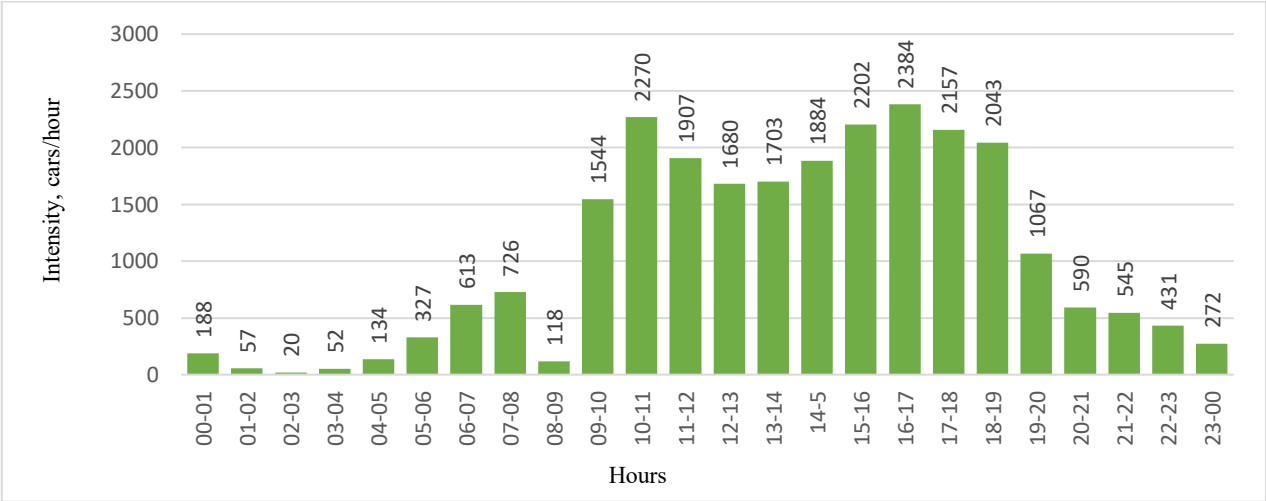

Fig. 3. Traffic intensity 22.09.19

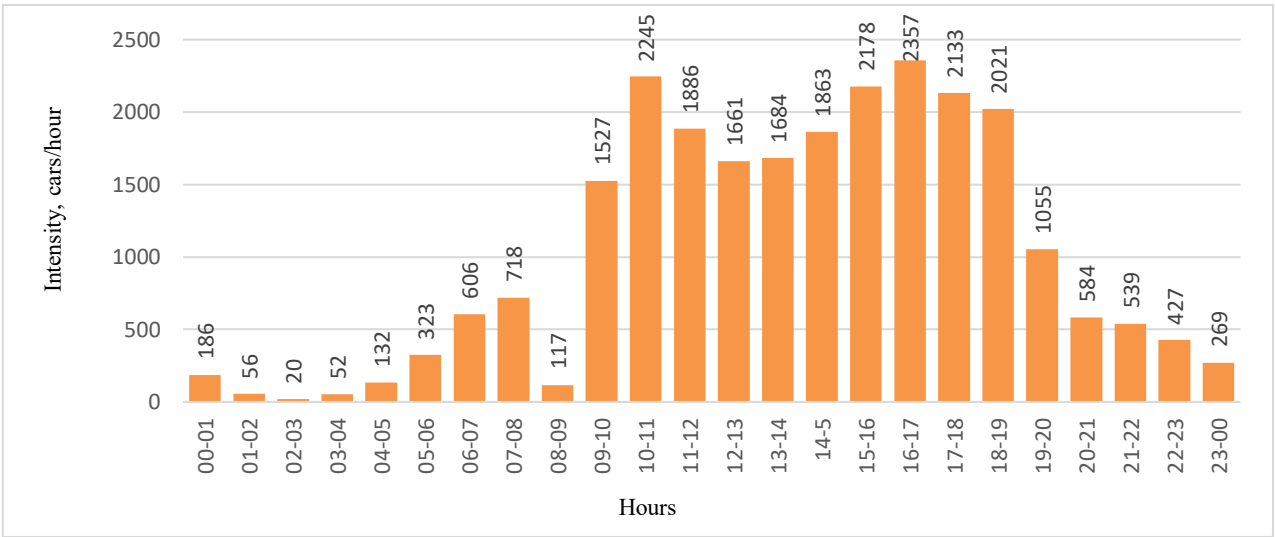

Fig. 4. Traffic intensity 23.09.19

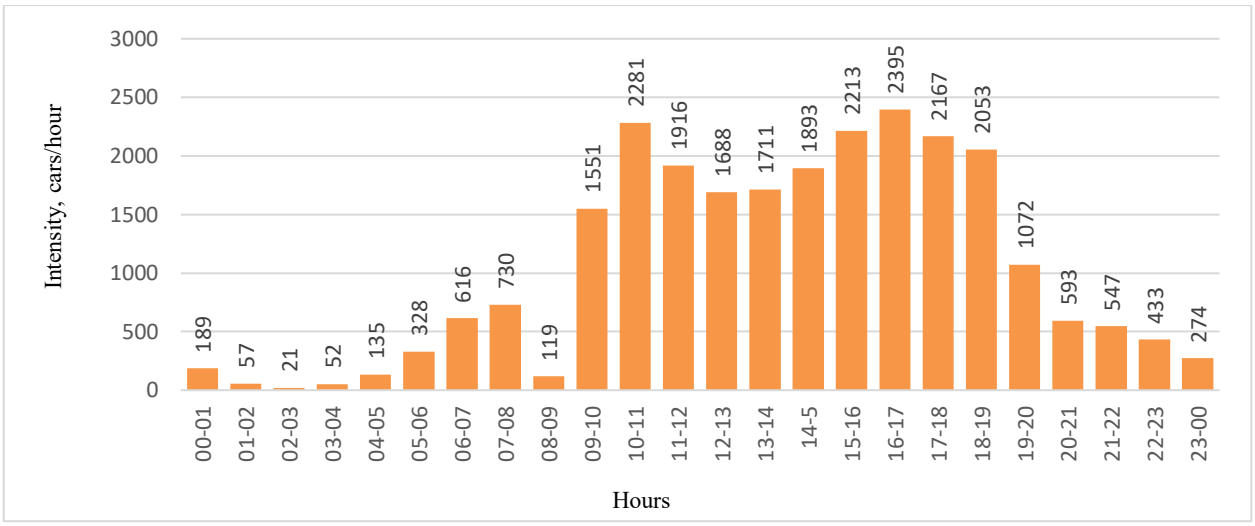

Fig. 5. Average daily traffic intensity dynamics

Observations have shown that the traffic flow in the study area consists of almost 90% of passenger cars (Fig. 6).

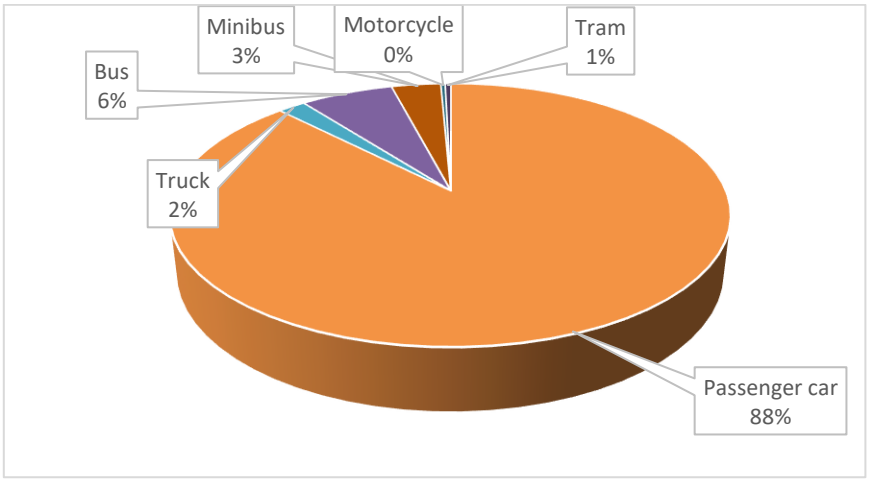

Fig. 6. Types of vehicles involved in road traffic

Table 8

Daily average intensity of movement of pedestrians

Direction	1	2	3	4	5	6	7	8
Intensity, units/hour	117	110	104	100	128	100	121	106

Data from Table 8 are visualized in Fig. 7.

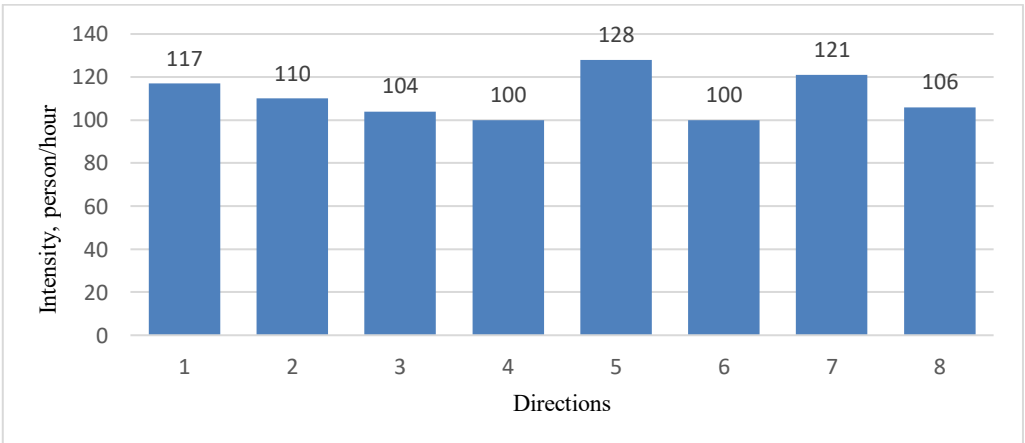

Fig. 7. The intensity of pedestrian traffic at the intersection

The results obtained are recorded on a conditional cartogram (Fig. 8).

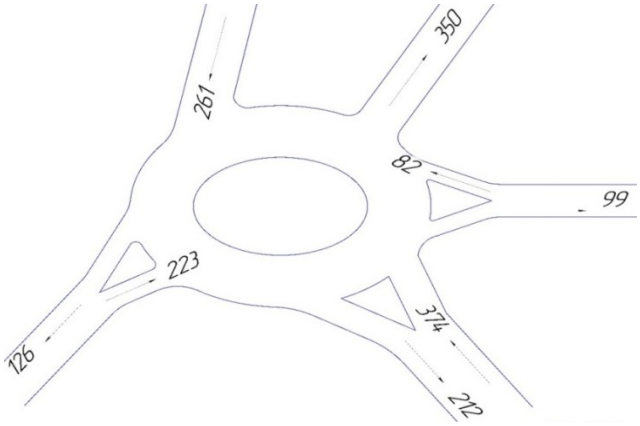

Fig. 8. Cartogram of traffic intensity at the intersection

Conclusion. The intensity and composition of traffic flow are taken into account when designing traffic control systems, developing the street network, and developing the general plan of the city. The data about the vehicles involved in the flow determines its speed. In order to approximate the calculated values of this speed to the real ones, the actual speeds of the prevailing modes of transport should be taken into account.

The results of the study of the intensity of transport and pedestrian traffic suggest that for the section under consideration, the peak hours are at 10.00 and 17.00. The intensity gradually increases up to 10 hours. From 11.00 to 19.00, the intensity changes slightly, and then decreases.

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Contribution of the authors

R.S. Durov — collection and analysis of literary data, participation in research, critical analysis, editing. E. V. Varnakova — literary and patent analysis, participation in theoretical research, text editing. K.O. Kobzev — scientific supervision, formulation of the main research concept and structure of the article. N. D. Kobzeva — methodology of the study, statement of the problem.