Indicators of the movement of vehicles on the way to the city of Tashkent

Andrey Terpak*, and *Qudratilla* Azizov

Tashkent State Transport University, Tashkent, Uzbekistan

Abstract. This article presents the results of research on the indicators of the movement of vehicles on the way to the city of Tashkent. Conclusions are presented on the following indicators: intensity, composition of traffic, speed and density of traffic, road capacity, and load level.

1 Introduction

The main disadvantages of the existing road infrastructure of large cities are the imperfection of the schemes of the street and road network of cities, the low specific density of main roads and the underdevelopment of the network of local streets [1]; low throughput of streets and intersections; combined movement of public passenger transport, passenger and freight traffic in the absence of specialized roads and routes for the movement of trucks [2]; application for traffic control of outdated methods and technical means focused on the movement of traffic flows of low density[3]; the practical absence of a parking system in the city [4]; lack of urban traffic information system[5]. The ongoing activities in the field of traffic management in cities are mainly implemented in separate sections and are not linked into a single system.

The transport and operational state of the road is characterized by a set of indicators on which the efficiency of both the road and road transport depends.

To study the traffic flow on the approach to Tashkent, the following indicators were chosen: intensity, composition of traffic, speed and traffic density, throughput capacity of the highway, the level of load at the entrance and exit from the city.

2 Research methods

These tasks are performed as follows.

1. The article uses a systematic approach [6], data from experimental studies and methods for processing the results of the study. The current state of the problem needs to be examined. To study the theoretical foundations of vehicle movement indicators. Scientific literature, foreign literature, dissertations, articles, Internet information and other information on the topic are studied and compared with the current situation.

2. When studying the indicators of vehicle movement, the textbook by K. Kh. Azizov describes the indicators of vehicle movement, how they are determined and what requirements are imposed on them.

*Corresponding author: andrew.terpak@gmail.com

3 Research results

The composition of the traffic flow is characterized by the ratio of vehicles of various types in it. This indicator has a significant impact on all traffic parameters.

The city of Tashkent has 48 points of entry and exit, of which 9 are main roads through which 60% of vehicles enter the city. The study of traffic flow indicators was carried out on these roads.

The study of the intensity of traffic and the composition of the traffic flow was carried out according to the registration form of a special form for each approach, which records the number of vehicles by their types at the entrance and exit from the city. Measurements were made on working days from Tuesday to Friday for the summer and autumn periods of the year, because during these periods, agricultural work, the educational process, etc. begin. In the winter and spring periods of the year, according to the preliminary results of earlier studies[7], the intensity of vehicles is less than in the summer and autumn periods. In the morning, evening rush hour, as well as at lunchtime from 8.00 to 18.00. Since in the morning and evening rush hours in the studied areas, the highest traffic intensity (rush hour, in the morning they go to work, and in the evening, they return from work).

Next, we build graphs of intensity changes at the selected registration points. The results of the study of the intensity obtained for 10 hours must be reduced to the daily intensity, for this, the hourly intensity, using the appropriate coefficients, is reduced to the daily intensity. As a result, we obtain that the highest intensity is at the entrance to the city from the M39 counting point (Fig. 1.), and the smallest from the side of the city of Chirchik (Fig. 2.).

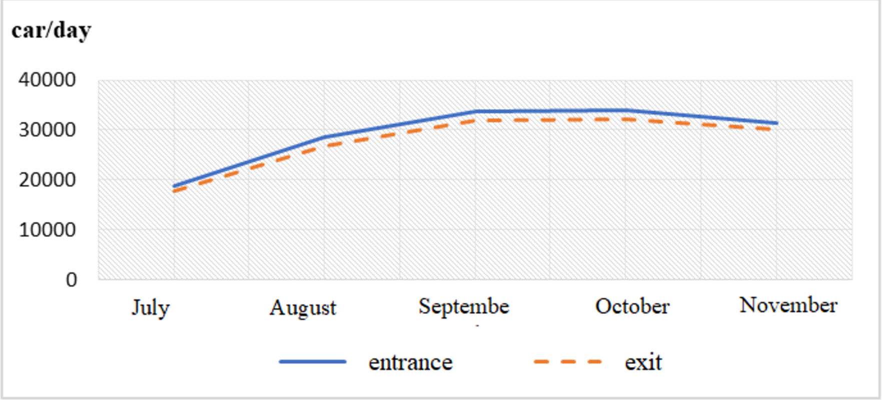

Fig 1. Diagram of traffic intensity in summer and autumn at the entrance and exit from the city in the direction of "M39"

On fig. 1 shows the change in the daily intensity of the traffic flow at the registration point "M39" when entering and leaving the city. It follows from the graph that in the summer period the intensity is low and amounts to 36451 auth./day, and in the autumn period the intensity increases to 66000 auth./day. The reason for such a drastic change is: the absence of the educational process and agricultural work in the summer, and in autumn the intensity increases as the educational process begins and agricultural work is carried out.

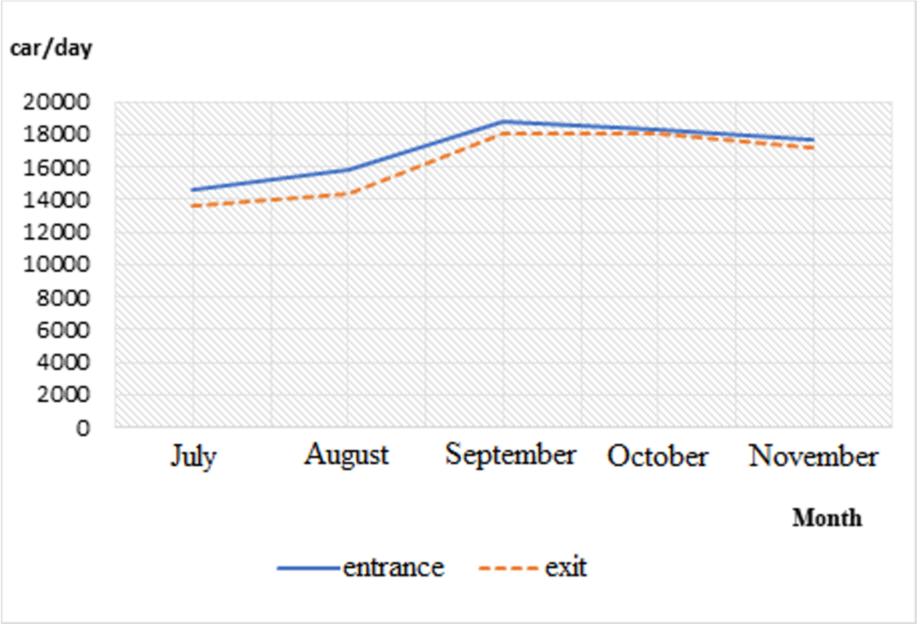

Fig. 2. Diagram of traffic intensity in summer and autumn at the entrance and exit from the city in the direction of the city of Chirchik

On fig. 2 shows the change in the daily intensity of the traffic flow at the registration point from the side of the city of Chirchik at the entrance and exit from the city. It follows from the graph that in the summer period the total intensity of both directions is low and amounts to 30117 vehicles/day, and in the autumn period it increases to 36774 vehicles/day. At this registration point, according to the results of the measurements, the lowest traffic intensity at the entrance and exit from the city is observed. This is due to the fact that there is an urban settlement outside the city, many city dwellers prefer to move outside the city, away from the bustle of the city.

The cyclogram shows the ratio of cars by category, divided into city and regional, moving in the traffic flow when going to the city of Tashkent:

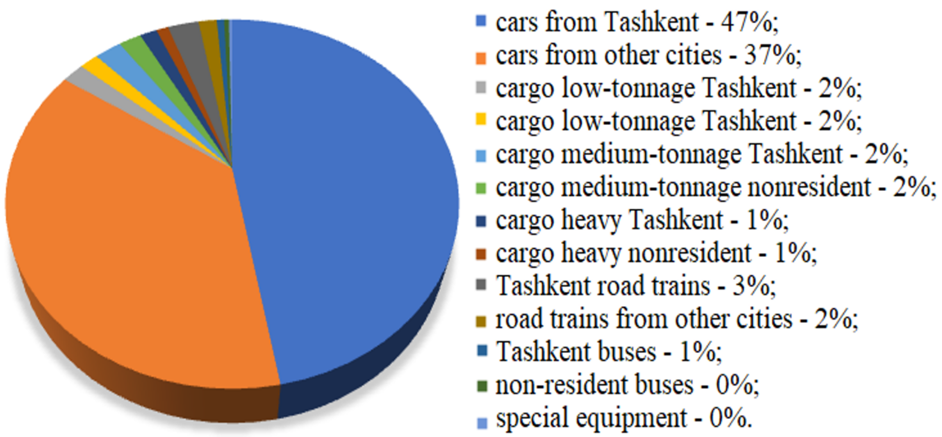

Fig. 3. Cyclogram of the composition of the traffic flow at the entrance to the city

From the obtained data on the composition of traffic, we conclude that the main flow of cars entering the city are cars, and cars with regional numbers make up 44% of the total number of cars.

When moving vehiclesat all major entrances and exits from the city temporary delays are possible, including vehicle stops[8]; in this connection, in practice, to determine the speed of movement, it is advisable to use the instantaneous speed[9].

Based on the results of measuring the instantaneous speed of the traffic flow, we build graphs of the distribution curve and the cumulative curve. The distribution curve determines the speed at which most cars move. This speed is often called modal - it corresponds to the highest value of the frequency[10]. With the help of the cumulative curve, the speeds corresponding to 15,50,85, 95% security are determined[eleven]. Speeds of 15% security mean the speed of cars that are overtaken by the remaining 85% of cars. These 15% of cars are usually the source of traffic accidents. Therefore, with artificial regulation of traffic, it is advisable to take this speed as the minimum allowable. The speeds of 50% security mean the average speed of all cars in the stream. The speed values of 85% security are taken as the maximum allowable on the considered section of the road. Usually, taking into account this speed of movement, road signs and roadway markings are made. The speed of 95% security means the maximum speed of movement of individual vehicles, equal to the calculated speed of movement.

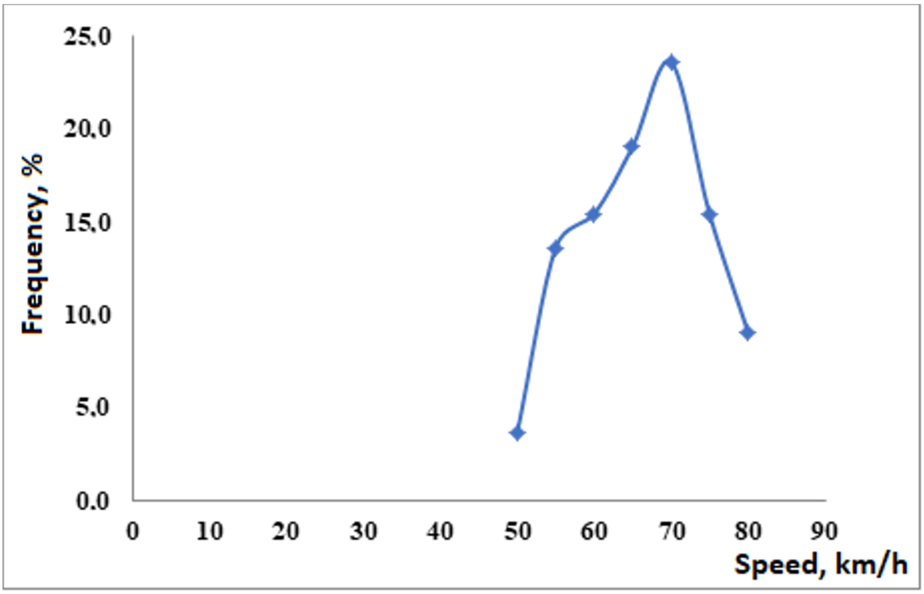

Fig. 4. Distribution curve for the object "M39" at the input

On fig. 4, using the distribution curve at the entrance to the city along the M39 road, we determined the value of the modal speed equal to 70 km / h, this is the speed at which most cars move.

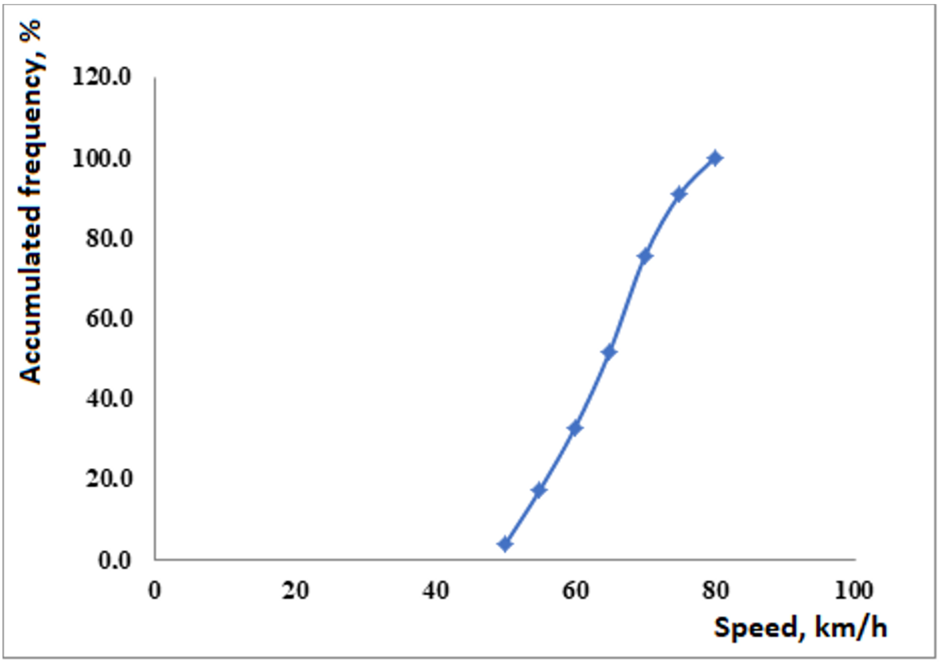

Fig. 5. Cumulative curve for object "M39" at the input

On fig. 5, using the cumulative curve, we determined the speeds at the entrance to the city along the M39 road, corresponding to 15, 50, 85, 95% security. The speed of 15% security according to the graph of the curve is 55 km/h. The speed of 50% security is 73 km/h. For further study of the density, throughput and traffic congestion level of main roads, we take the speed values of 85% availability, which is equal to 73 km/h. The speed of 95% security is 79 km/h.

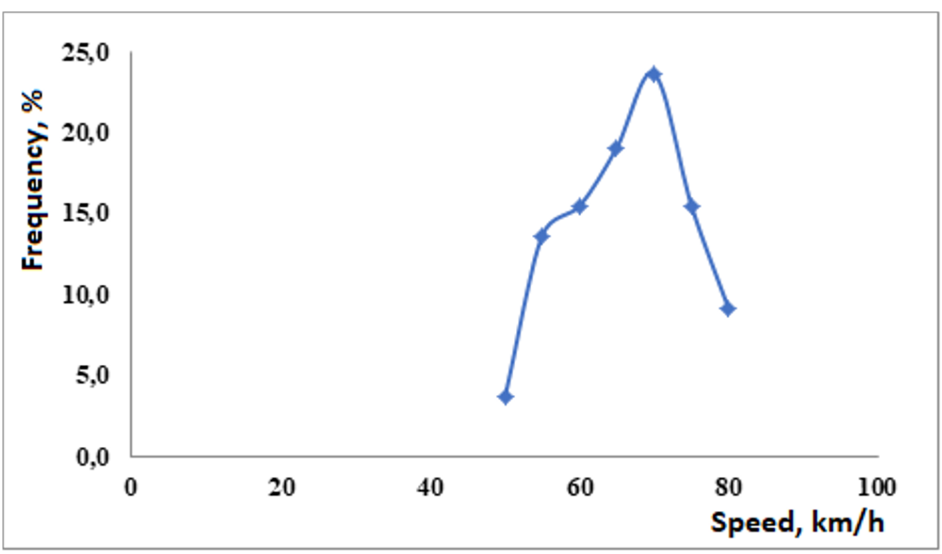

Fig. 6. Distribution curve for the object "M39" at the output

 https://doi.org/10.1051/e3sconf/202340102058

On fig. 6. using the distribution curve at the exit from the city along the road “M39”, we determined the value of the modal speed equal to 70 km / h, this is the speed at which most cars move.

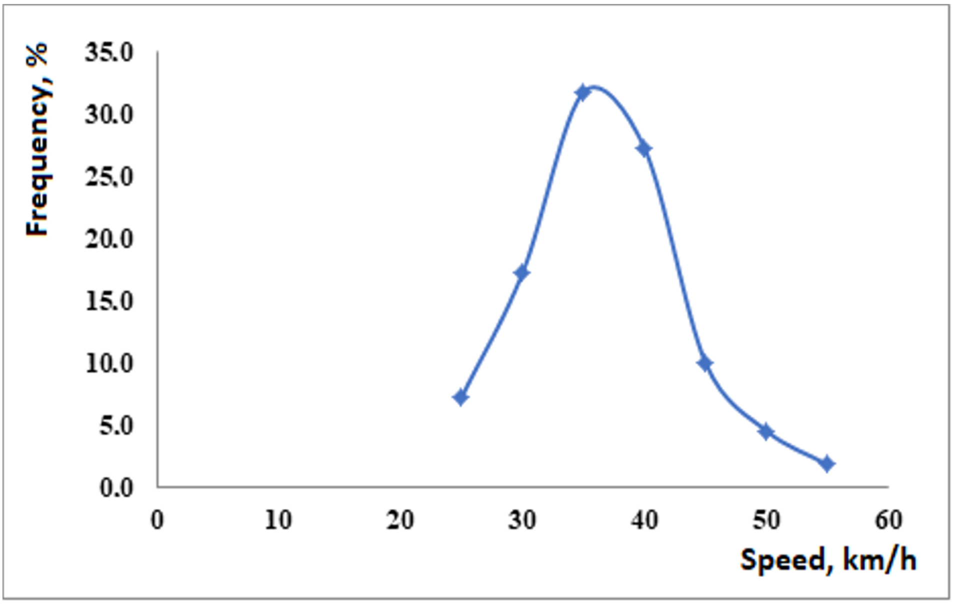

Fig . 7. Distribution curve for object “Min. water” at the inlet

On fig. 7 using the distribution curve at the entrance to the city in the direction of “Min. water” determined the value of the modal speed equal to 37 km / h, this is the speed at which most cars move.

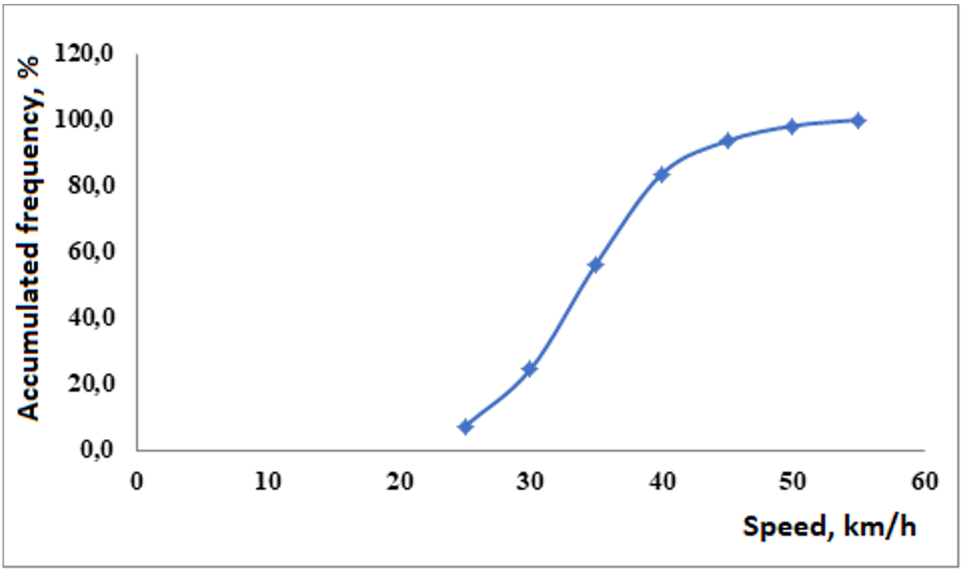

Fig. 8. Cumulative curve “Min. water” at the inlet

On fig. 8, using the cumulative curve, we determined the speeds at the entrance to the city in the direction “Min. water”, corresponding to 15, 50, 85, 95% security. The speed of 15% security according to the graph of the curve is 28 km/h. The speed of 50% security is 33 km/h. For further study of the density, throughput and traffic congestion level of main roads, we take the speed values of 85% availability, which is equal to 40 km/h. The speed of 95% security is 46 km/h.

In difficult road conditions, the intensity indicator does not give a sufficiently clear idea of the nature of the movement, therefore it is supplemented with such an indicator as traffic density - q. Traffic density is determined by the number of vehicles per**1 km traffic lanes.** Unit of measurement - avt./km.[12]Density quantitatively characterizes the relative occupancy of a road section and is related to the average distance between consecutive cars moving one after another. With an increase in the density of the traffic flow, the distance between cars is reduced, the speed of movement decreases, the driver's stress increases, and traffic conditions worsen. The maximum traffic flow density is observed in congestion situations.

Traffic density it is convenient to measure using aerial photography or shooting from the side of the road. Along the road, traffic density is constantly changing, which indicates the presence of instantaneous density.

The traffic flow density can be determined by the formula

$$q = \frac{N}{V} \text{ auto./km} \qquad (1)$$

Where N is the traffic intensity per one lane, avt./km; V is the speed of the traffic flow, km/h.

We calculate the traffic flow density for 8 registration points:

- for the first registration point "M39" the density of the traffic flow is:

$$\text{q} = \frac{2540}{73} = 35 \text{ auto./km.}$$

- for the second registration point "Tuytepa" the density of the traffic flow is:

$$\text{q} = \frac{1523}{33} = 46 \text{ auto./km.}$$

- for the third registration point "Almalyk" the density of the traffic flow is:

$$\text{q} = \frac{1453}{37} = 39 \text{ auto./km.}$$

- for the fourth registration point "Chirchik", the density of the traffic flow is:

$$\text{q} = \frac{1512}{36} = 42 \text{ auto./km.}$$

- for the fifth registration point "Gishkuprik" the density of the traffic flow is:

$$\text{q} = \frac{1540}{51} = 30 \text{ auto./km.}$$

- for the sixth registration point "Keles" the density of the traffic flow is:

$$\text{q} = \frac{1459}{45} = 32 \text{ auto./km.}$$

- for the seventh registration point "Min. water" the density of the traffic flow is:

$$q = \frac{1149}{40} = 29 \text{ auto./km.}$$

- for the eighth registration point "Nazarbek" the density of the traffic flow is:

$$q = \frac{1394}{37} = 38 \text{ auto./km.}$$

- for the ninth registration point, road 4P1v, the traffic flow density is:

$$q = \frac{1706}{47} = 36 \text{ auto./km.}$$

We calculate the capacity of one lane for 9 roads on the approaches to the city using the formula[13]:

- The capacity of one lane for the M39 highway is:

$$P = \frac{1000*73}{\left(\frac{73}{3,6}+\left(\frac{73}{3,6}+\frac{1,2*73^2}{254(0,5+0,01)}+4\right)+5\right)} = \frac{73000}{93,4} = 781 \text{auth./hour}$$

- The capacity of one lane for the main road in the direction of "Tuytepa" is: auto./hour;

$$P = \frac{1000 \cdot 33}{\left(\frac{33}{3.6}+\left(\frac{33}{3.6}+\frac{1.2 \cdot 33^2}{254(0.5+0.01)}+4\right)+5\right)} = \frac{33000}{33.1} = 996$$

- throughput capacity of one lane for the main road in the direction "Mr. Almalyk" is: auto./hour;

$$P = \frac{1000 \cdot 37}{\left(\frac{37}{3.6}+\left(\frac{37}{3.6}+\frac{1.2 \cdot 37^2}{254(0.5+0.01)}+4\right)+5\right)} = \frac{37000}{37.9} = 977$$

- throughput capacity of one lane for the main road in the direction "Mr. Chirchik" is: auto./hour;

$$P = \frac{1000 \cdot 36}{\left(\frac{36}{3.6}+\left(\frac{36}{3.6}+\frac{1.2 * 36^2}{254(0.5+0.01)}+4\right)+5\right)} = \frac{36000}{36.6} = 982$$

- The capacity of one lane for the main road in the direction of "Gishkuprik" is: auto./hour;

$$P = \frac{1000 \cdot 51}{\left(\frac{51}{3.6}+\left(\frac{51}{3.6}+\frac{1.2 * 51^2}{254(0.5+0.01)}+4\right)+5\right)} = \frac{51000}{56.7} = 899$$

- The capacity of one lane for the main road in the direction of Keles is: auto./hour;

$$P = \frac{1000 \cdot 45}{\left(\frac{45}{3.6}+\left(\frac{45}{3.6}+\frac{1.2 \cdot 45^2}{254(0.5+0.01)}+4\right)+5\right)} = \frac{45000}{48.2} = 934$$

- capacity of one lane for the main road in the direction "Min. water" is:

auto./hour;

$$P = \frac{1000 \cdot 40}{\left(\frac{40}{3.6} + \left(\frac{40}{3.6} + \frac{1{,}2 \cdot 40^2}{254(0.5 + 0.01)} + 4\right) + 5\right)} = \frac{40000}{41.6} = 962$$

- The capacity of one lane for the main road in the direction of “Nazarbek” is:

auto./hour

$$P = \frac{1000 \cdot 37}{\left(\frac{37}{3.6} + \left(\frac{37}{3.6} + \frac{1.2 \cdot 37^2}{254(0.5 + 0.01)} + 4\right) + 5\right)} = \frac{37000}{37.9} = 977$$

- The capacity of one lane for the main road 4P1v is:

auto./hour

$$P = \frac{1000 \cdot 47}{\left(\frac{47}{3.6} + \left(\frac{47}{3.6} + \frac{1.2 \cdot 47^2}{254(0.5 + 0.01)} + 4\right) + 5\right)} = \frac{47000}{55.7} = 844$$

To calculate the road load level (z), it is necessary to bring the traffic intensity to a passenger car[14]:

- for the first accounting point “M39”:

Npr \u003d 2331 + (81 · 1.5) + (28 · 3) + (17 · 3.5) + (22 · 5) + (61 · 2.6) \u003d 2865 auto / hour;

- for the second registration point “Tuytepa”:

Npr \u003d 1458 + (19 · 1.5) + (19 · 3) + (17 · 3.5) + (3 · 5) + (7 · 2.6) \u003d 1636 cars / hour;

- for the third accounting point “Mr. Almalyk":

Npr \u003d 1291 + (53 · 1.5) + (28 · 3) + (41 · 3.5) + (20 · 5) + (20 · 2.6) \u003d 1750 auto / hour;

- for the fourth registration point “Mr. Chirchik":

Npr \u003d 1340 + (89 · 1.5) + (26 · 3) + (14 · 3.5) + (4 · 5) + (39 · 2.6) \u003d 1722 auto / hour;

- for the fifth registration point “Gishkuprik”:

Npr \u003d 1471 + (19 · 1.5) + (29 · 3) + (8 · 3.5) + (5 · 5) + (8 · 2.6) \u003d 1660 auto / hour;

- for the sixth registration point “Keles”:

Npr \u003d 1351 + (48 · 1.5) + (33 · 3) + (13 · 3.5) + (3 · 5) + (11 · 2.6) \u003d 1611 cars / hour;

- for the seventh registration point “Min. water":

Npr \u003d 1038 + (50 · 1.5) + (25 · 3) + (13 · 3.5) + (0 · 5) + (23 · 2.6) \u003d 1293 cars / hour;

- for the eighth registration point “Nazarbek”:

Npr \u003d 1235 + (55 · 1.5) + (54 · 3) + (22 · 3.5) + (13 · 5) + (15 · 2.6) \u003d 1661 auto / h.

- for the ninth accounting point 4P1в:

Npr \u003d 1669 + (17 · 1.5) + (8 · 3) + (22 · 3.5) + (5 · 5) + (7 · 2.6) \u003d 1839 auto/h.

Load levelis the ratio of traffic intensity to capacity[15][16]. Distinguish6loading levels, a / d:

- Loading level A - the maximum traffic intensity does not exceed 20% of the capacity - Free traffic.

- Load level B - maximum traffic intensity 20% -50% of the capacity - Movement in groups.
- Load level B - the maximum traffic intensity is 50% -70% of the throughput - Traffic in large groups.
- Loading level G - maximum traffic intensity 70% -90% of the throughput - Movement in a column with an interval inside it.
- Loading level G - a - maximum traffic intensity 90% -100% - Movement of a continuous column.
- Loading level G - b - the maximum traffic intensity exceeds 90% - Movement in a continuous column with stops.

Convenience of traffic is directly related to the level of traffic congestion, the less the road is loaded, the more convenience for traffic [17, 18].

The traffic load level of the road is calculated by the formula:

$$Z = N/P \cdot n \qquad (2)$$

Where **N**- average hourly traffic intensity, reduced to a passenger car for one lane, avt./h.; *R* **-** maximum traffic capacity for one traffic lane, vehicle/h; n is the number of traffic lanes on the highway.

We determine the load level for the main roads on the way to Tashkent city for one lane:

- mainroad on the way to the city "M39":

$$Z = \frac{2865}{781 \cdot 4} = 0.92;$$

- the main road on the approach to the city from the side of "Tuytepa":

$$Z = \frac{1636}{996 \cdot 2} = 0.82;$$

- the main road on the way to the city from the side of “m. Almalyk":

$$Z = \frac{1750}{977 \cdot 2} = 0.89;$$

- the main road on the way to the city from the side of “m. Chirchik":

$$Z = \frac{1722}{982 \cdot 2} = 0.88;$$

- the main road on the approach to the city from the “Gishkuprik” side:

$$Z = \frac{1660}{899 \cdot 2} = 0.92;$$

- the main road on the approach to the city from the side of “Keles”:

$$Z = \frac{1611}{934 \cdot 2} = 0.86;$$

- main road on the approach to the city from the side of “Min. water":

$$Z = \frac{1293}{962 \cdot 2} = 0.70;$$

- the main road on the approach to the city from the side of "Nazarbek":

$$Z = \frac{1661}{977 \cdot 2} = 0.85.$$

- main road on the way to the city along the road 4R1v:

$$Z = \frac{1839}{844 \cdot 3} = 0.73.$$

Load level for one lane for roads, entering the city from the side:"M39" Z = 0.92, "Gishkuprik" Z = 0.92 - can be characterized as follows, traffic flow characteristics – the flow moves with stops, congestion occurs, throughput mode, flow state is dense, the emotional load of the driver is very high, the driver's work comfort is very inconvenient and cost-effective[19] [20]road work is inefficient;

Load level for one lane for roads, entering the city from the side: Keles Z = 0.86, Nazarbek Z = 0.85, Tutepy Z = 0.82, Almalyk" Z = 0.89, "Mr. Chirchik" Z = 0.88, "Min. water" Z = 0.70, "4P1в" Z = 0.73 - can be characterized as follows, the characteristic of the traffic flow is a continuous flow of cars moving at low speeds, the state of the flow is a convoy of cars moving at low speeds, overtaking is impossible, the driver's emotional load is very high, the driver's work comfort is very inconvenient and the economic efficiency of the road is inefficient.

4 Conclusions

From the results of studies of selected registration points, through which 60% of all vehicles enter the city of Tashkent, it follows that:

- the highest traffic intensity is achieved in the autumn period and amounts to 66,000 vehicles / day, and less in summer - 36,451 vehicles / day, since the educational process and agricultural work begin in the fall; the basis of the traffic flow entering the city of Tashkent is cars - 84% of which 44% percent are cars with non-resident numbers; the maximum speed on the approach to the city is 47 km/h, and the minimum is 31 km/h;
- the load level on the studied sections of roads at the entrance to the city is high on average 0.8, the movement of cars occurs in columns at low speed. Such a high level of traffic congestion on these roads is due to the fact that there are checkpoints on these roads at the entrance to the city, which lead to traffic restrictions and create congestion.

References

1. Huang J., Liu F., Lyu Y., Peng H., and Wang X. Digital upgrade for parking zone, by parking assist system. Highlights in Science, Engineering and Technology, Vol.23, pp.221-228. (2022).
2. M. Abdulgani. Architectural and planning organization of service objects located on transport hubs. Curr. Probl. Archit. Urban Plan. pp. 309–318, (2021).
3. Nakazato T., Fujimaki Y., and Namerikawa T. Parking lot allocation using rematching and dynamic parking fee design. IEEE Transactions on Control of Network Systems, Vol. 9(4), pp. 1692-1703. (2022).
4. Ji, Y., & Lai, Z. Optimal Allocation of Shared Parking Spaces Considering Parking Choice Behavior under Parking Uncertainty. In CICTP 2022 (pp. 1789-1800). (2022).
5. Sorokina D. N. Research Into Demand for Intercepting Parking in the City of Rostov-

On-Don. In IOP Conference Series: Earth and Environmental Science, Vol. 988, No. 2, p. 022065. (2022).

6. Chowdhury S. M., and I-Jy Chien, S. Intermodal transit system coordination. Transportation Planning and Technology, 25(4), 257-287. (2002).
7. Azizov K., and Xoliqov A. Influence of traffic intensity on traffic noise on roads and main city streets of the republic of Uzbekistan. Science and Innovation, Vol.1(8), pp.450-457. (2022).
8. Dulfan S. B., and Lobashov O. O. About the influence of intercepting parking on traffic flows in Kharkiv. Technology audit and production reserves, Vol. 1(3), p.21. (2015).
9. A. Godnev. Intercepted parking lots as a method of combating transport convenience of the megapolis. Syst. Anal. Logistics. Vol. 4, pp. 115-121, (2020).
10. Macea L. F., Serrano I., and Carcache-Guas C. A reservation-based parking behavioral model for parking demand management in urban areas. Socio-Economic Planning Sciences, Vol. 86, 101477. (2023).
11. Kryvomaz T., and Varavin D. Applying of green building standards for implementation of the city development strategies in Kyiv. (2019).
12. Franks S. J., Harris P. E., Harry K., Kretschmann J., and Vance M. Counting Parking Sequences and Parking Assortments Through Permutations. arXiv preprint arXiv:2301.10830. (2023).
13. Panggabean I. P. T., Sirojuzilam S., Lubis S., and Purwoko A. Parking Management in Supporting Sustainable Development: Systematic Literature Review. In Proceedings of International Conference on Communication Science, Vol. 2, No. 1, pp. 11-16. (2022).
14. Yang Y., Chen J., Ye J., Chen J., and Luo Y. Joint Optimization of Facility Layout and Spatially Differential Parking Pricing for Parking Lots. Transportation Research Record, 03611981221145139. (2023).
15. Volkova E. V., and Stepanenko A. A. Traffic intensity calculation criteria for freight vehicles. In IOP Conference Series: Earth and Environmental Science, Vol. 751, No. 1, p. 012126. (2021).
16. Dzhuruk D., and Zedgenizov A. Forecasting of traffic intensity on suburban routes. Transportation research procedia, Vol. 36, pp.135-140. (2018).
17. Kolberg D., Børresen T., and Riley H. Timeliness and traffic intensity in spring fieldwork in Norway: Importance of soil physical properties, persistence of soil degradation, and consequences for cereal yield. Agricultural and Food Science, Vol. 29 (2), pp.154-165. (2020).
18. Volkova E., and Stepanenko A. Traffic intensity on highway R-255 Siberia in Irkutsk region. In IOP Conference Series: Materials Science and Engineering (Vol. 667, No. 1, p. 012107. (2019).
19. Zhao X., Hu, L., Wang X., and Wu J. Study on Identification and Prevention of Traffic Congestion Zones Considering Resilience-Vulnerability of Urban Transportation Systems. Sustainability, 14(24), 16907. (2022).
20. Qi Y., and Cheng Z. Research on Traffic Congestion Forecast Based on Deep Learning. Information, Vol. 14(2), p. 108. (2023).