Scientific and Technical Substantiation of the Bypass Roads Arrangement Around Populated Localities by Monitoring the Traffic Flow Intensity

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Abstract*: *The article substantiates traffic organization of transit road transport bypassing the populated locality by redistribution of traffic flows considering the transport characteristic of the Republic of Adygea, as well as assesses transport infrastructure for effective use of transport corridors in order to fully integrate into the transport network of the South of Russia. The main station of the load area is the city of Maikop, and a section of the Caucasian Federal Highway (approach road to the city of Maikop) to the intersection with Maikop - Ust-Labinsk - Korenovsk highway. The analysis of traffic intensity was carried out for three categories of vehicles. The constructed traffic flow distribution chart in the connections and intersections of city roads and streets allowed revealing the dynamics of changes in the number of road transport in the urban road network. Given the intensity of car and truck traffics in the city main street, it was proposed to build a bypass road around the city. The preliminary monitoring of traffic flows at the approach roads and town exits served an optimization solution to arrange bypass roads around populated localities. This proposal was based on the study of the intensity of transit passenger and freight transport towards the Caucasian Federal Highway through the housing space of the city of Maikop. According to the undertaken study of traffic intensity by mode of transport on linear sections and at transport nodes, a traffic flow chart was built that allowed determining the intensity of traffic flows by individual aggregated links on the road and street sections, as well as on adjacent roads.

Index Terms*: *autoroad, city bypass, road construction, road network, road safety, the incidence of road accidents, traffic flow intensity, transit transport.

I. INTRODUCTION

A significant increase in the number of vehicles leads to an increase in the traffic flow intensity, which in turn results in a decrease in the traffic capacity of urban streets. Therefore, the increase in the intensity of the transit traffic through the city becomes an urgent problem for medium and small cities with a population of 100 to 250 thousand people (which includes the city of Maikop, capital of the Republic of Adygea). The absence of the roads bypassing populated localities leads to traffic congestion in the city streets, deterioration of the environmental situation, increases the level of accidents and wears of the city roadways, as well as reduces the level of road safety.

The commissioning of the bridge across the Kerch Strait has led to an increase in the transit flow through Maikop [1]. The construction and arrangement of a bypass road around Maikop will lead to the redistribution of traffic flows and the withdrawal of transit flow, as well as part of urban transport beyond the city residential area. This will allow reducing the adverse impact of transport on the environment, improve traffic safety, and reduce the transportation cost by increasing the speed of not only the transit transport but also vehicles remaining on the unloaded streets of the city.

Research objective. The study aims at substantiation of the need for the construction of bypass roads around small and medium-sized cities as exemplified by the city of Maikop.

II. METHODS

A. Research object and methods

The research object is the reference network of the load area, which is represented by the federal road identified as an approach road to the city of Maikop from the Caucasian Federal Highway. To determine the traffic intensity by modes of transport, full-scale studies were carried out using photo and video recording systems. The obtained data were analyzed using PTV VISUM software.The road network is one of the most important elements of the transport system of any region [2]. Observing the development level of the road network, it is possible to assess the overall economic development of the region. Reconstruction and construction of the road network have significant impact on the stabilization of the socio-economic situation in the region [3].

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The Republic of Adygeya is located in the north-western part of the Caucasus, in the south of the European part of the Russian Federation, and is part of the Southern Federal District [4]. The geographical and tourist location, as well as political stability in the Republic of Adygeya positively affect the use of the road network by transit road transport. The transport system of the Republic includes road, rail, and pipeline modes of transport, through which communication is carried out with any region of Russia and with the near and far-abroad countries [5]. The development strategy of the transport complex provides for the development of the transport infrastructure of the Republic for the effective use of transport corridors and more complete integration into the transport network of the South of Russia for the integrated and most efficient use of all modes of transport.

The territory of the concerned load area from the north-west to the south is crossed by the Krasnodar-Maykop-Khadzhokh railroad branch, coming from the Armavir-Tuapse railroad line. This railroad crosses the central part of the Republic, providing access of populated localities of the Republic to both Stavropol region and the republics of the North Caucasus, and to the Black Sea coast.

The main station of the load area is the city of Maikop. The reference network of the load area is represented by federal roads, namely, the approach road to Maikop from the Caucasian Federal Highway, the approach road to the Caucasian State Nature Biosphere Reserve from Maikop through Guzeripl township, Maikop-Ust-Labinsk-Korenovsk road; as well as Maikop-Tuapse and Maikop - Giaginskaya-Psebay-Zelenchuk-Karachaevsk regional roads.

Currently, the movement of transit cars and trucks towards Caucasian Federal Highway is carried out on this road section through the housing space of Maikop, in particular, through the Khakurate street, that adversely affects the environmental situation in the city, reduces the traffic speed, and worsens the traffic safety.

The transport situation in the city of Maikop becomes more complicated from year to year. The growth rate in the number of vehicles significantly outstrips the development rate of the city's streets and road network [6]. Over the past six years, the level of motorization has increased by half; in 2017 it exceeded 400 cars per 1,000 inhabitants (Fig. 1).

Local public roads serve the link between the populated areas located within the boundaries of the Maikop municipality. The basis of the street network includes the main streets and roads, through which the mass passage of passenger cars and trucks, as well as intense passenger transport flows, are carried out [7], [8].

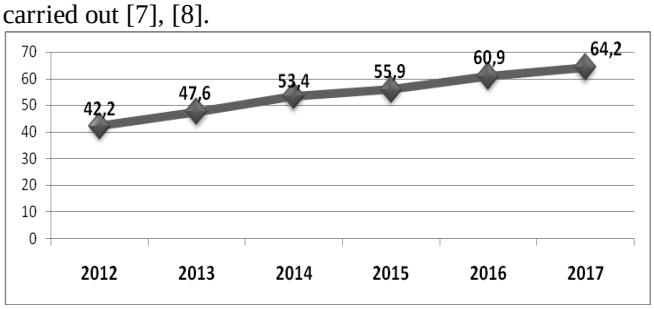

Fig.1. Number of registered cars in Maikop, thousand units

The city lacks bypass road for transit heavy trucks and passenger transport. The traffic flow passes through the city street and road network, mainly through Khakurate, Shovgenov, Pushkin, Zheleznodorozhnaya, and Promyshlennaya streets that significantly increases the load on the environmental and transport system of the city, and, consequently, leads to a noticeable decrease in traffic speed, frequent traffic congestion, as well as increases the number of road accidents.

One of the main methods of determining the traffic intensity on the roads of the area under study, as well as the distribution of traffic flows at road intersection is based on the analysis of data obtained during the measurements of road traffic in the concerned region.

B. Algorithm

When carrying out the study, full-scale surveys were conducted through visual and manual registration of vehicles by observers and automated counting means directly at the object under study in the transport load area. During the monitoring, traffic intensity and road category were determined. The measured data on traffic flow were analyzed. Such monitoring of the traffic flow characteristics at the road nodes and sections of Maikop was carried out systematically for two years (2015-2017). Traffic records were carried out during a different number of hours, at different times of the year, day, and different days of the week. At that, three categories of vehicles were monitored:

- trucks, depending on their load capacity;
- passenger cars;
- buses depending on their passenger capacity.

The distribution of traffic intensity depending on modes of transport carried out during the day in the road section between the approach road to Maikop and Caucasian Federal Highway is shown in Fig. 2.

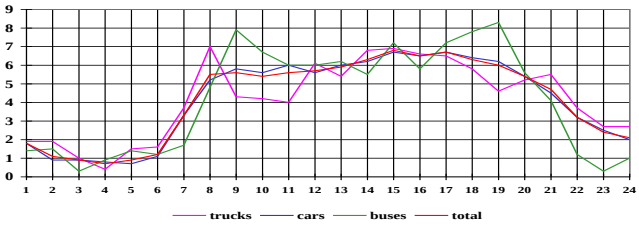

Fig. 2. Traffic intensity distribution by modes of transport monitored during the day

The results of the study show that traffic flow intensity is distributed as follows:

1) Truck traffic flow is characterized by two peaks: morning peak – from 7.00 to 8.00 a.m. (7.0 %), and day peak – from 2.00 to 3.00 p.m. (6.9 %);

2) Passenger car traffic flow has minor hourly fluctuations during the time period from 8.00 a.m. to 7.00 p.m. (5.8-6.7%), at that, 67.7% of the daily traffic flow were passing during the monitored period of time;

3) The peak in bus traffic flow was observed in the morning from 8.00 to 9.00 a.m. (7.9%) and in the evening from 6.00 to 7.00 p.m. (8.3%), at that, 74.6% of the daily traffic flow were passing during the monitored period of time;

In general, from 8.00 a.m. to 7.00 p.m., the road section was evenly loaded with traffic flow, at that, 66.8 % of the daily traffic flow were passing during the considered period of time.

C. Traffic flow chart

The traffic flow intensity can be shown on the traffic flow chart (Fig. 3).

Control measurements of traffic flow intensity were carried out both in linear sections and transport nodes that made it possible to determine the traffic flows with respect to individual integrated links on the stretches of roads and streets, as well as on adjacent roads. Measurements were carried out within the Maikop transport hub and in the main streets of Maikop, namely, Khakurate, Shovgenov, Adygeiskaya, Dimitrova, and Promyshlennaya streets, as well as Kelermesskoe roadway.

The traffic composition at the approach road to Maikop by daily hours and days of the week varies greatly and averages 66% for passenger cars; 29% for trucks (for all types of trucks); and 5% for buses. Freight transport in the remaining sections of the road network in Maikop is no more than 5-7%.

Traffic intensity within the Maikop differs on different roads and varies from 6,700 to 14,300 vehicles per day. The main traffic load falls on Khakurate street, where traffic reaches 9-11 thousand vehicles per day.

Transit traffic only exacerbates the environmental situation in the city, causes road accidents, and essentially slows down traffic that once again indicates the need to build a bypass road around the city [9], [10].

Bypass roads are designed for transit traffic, partly for out-of-city and intercity traffic in order to rationally distribute it among the main roads, reduce the traffic intensity in the streets of the city and ensure the convenient and safety traffic [11].

The decision to build roads bypassing cities and other inhabited localities depends on the city size and layout, the population size, as well as the intensity of transit, extra-urban, and intercity traffic [12], [13].

The well-known reasons to arrange bypass roads around cities and other populated localities concern the deterioration of the environmental situation, the increase in the intensity of traffic flow, and the concentration of road accidents on the road section [14], [15]. The authors believe that the reasons for constructing city bypasses are stipulated by the elimination of congestion on the route sections passing through populated localities that will significantly reduce transport delays.

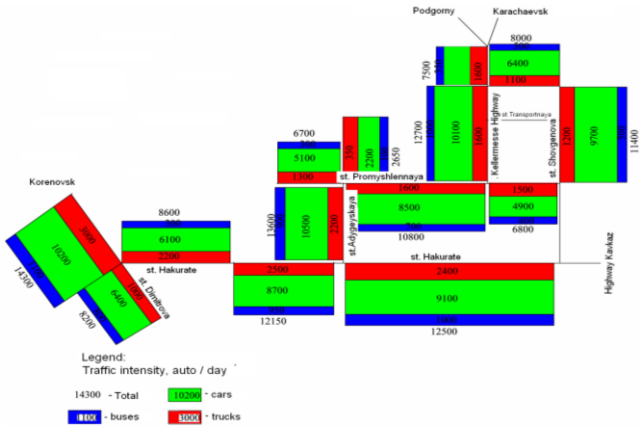

Fig. 3. Traffic flow chart

III. DISCUSSION

The construction of the road bypassing the city of Maikop will allow redistributing the amount of traffic flow, and, as a result, unloading the main city streets, that would contribute to reducing the adverse impact on the city environment. Building bypass roads greatly improves the situation with road safety.

The construction of a road, bypassing the city of Maikop, is a project proposal aimed at solving the city transport problems. In the long term, this project proposal may also bring economic benefits by increasing the level of technological and environmental condition of the road network. It is an important step towards preserving the life and health of people on the roads.

IV. CONCLUSION

In consequence of the conducted study, it can be concluded that the decision on the construction of bypass roads around the populated localities is aimed at increasing the capacity of federal and regional roads, improving traffic safety of the urban street and road network, reducing the environmental load on the urban road system and the level of road accidents.

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