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MATHEMATICAL MODEL FOR DETERMINING THE POSSIBILITY OF TRANSFORMING A TRAFFIC STREET INTO A PEDESTRIAN ONE

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Abstract. The article discusses the actual problem characteristic of modern cities, the transformation of the traffic street into a pedestrian space. A mathematical model is proposed, which allows us to quantitatively evaluate the possibility of transforming a traffic street into a pedestrian street by redistributing the existing traffic flows to the rest of the streets. The criterion for determining the possibility is the traffic load level of the streets left for traffic, which should not exceed the value determined by the norms.

A list of traffic organization and infrastructural measures is provided, which make it possible to implement the decision in practice.

Key words: Traffic and pedestrian streets; traffic load level; remaining bandwidth reserve.

Introduction.

The example of the advanced countries of the world shows that one of the powerful factors in the development of local and foreign tourism is the transformation of a part of the network of city streets into pedestrians. Paris, Madrid, Rome, Barcelona, Florence, etc. At least 10% of the street network of world-renowned tourist centers is intended for pedestrian traffic only. If we consider the historical central parts of these cities, this figure is much higher. The share of residential houses in the development along the pedestrian streets is minimal. In the vast majority of buildings there are hotels, public catering facilities, various entertainment facilities, branded hypermarkets and kiosks selling souvenirs.

Some streets are given pedestrian status periodically, on weekends or holidays. The number of pedestrian streets is increasing even more due to the rapid development of tourism in the world. In such conditions, the question of the possibility of transforming the traffic-purpose street into a pedestrian street becomes relevant.

According to the author's personal observations, public, including underground rail transport plays a crucial role in the movement of passengers in large cities of advanced European countries, with some exceptions (eg Paris). The center of big cities is less loaded with light traffic. Such cities include Rome, Vienna, Barcelona, Bilbao and others. In these cities, changing the street status based on the use of quantitative criteria is not an urgent necessity, nor have appropriate methods been developed. It is often enough to reach an agreement between municipal bodies and make a decision based on a qualitative analysis.

In cities, where the role of public transport in the movement of passengers is relatively small and the level of street traffic is high, traffic jams are frequent, the possibility of transforming any street into a pedestrian one must be substantiated by mathematical methods, based on the analysis of quantitative data.

Along with Paris, Tbilisi is one of such cities, where the problem of overloading the streets with dense flows of light vehicles is acute. At the same time, tourism has become a field of primary vital importance for our country, and for its successful functioning, it is necessary to widely use the streets for pedestrians in the central and especially - historical parts of Tbilisi, Kutaisi, Batumi, Poti, Telavi and other cities. Currently, in Tbilisi only the part of D. Aghmashenebeli Avenue, Shardeni Street and a small area around it are reserved for pedestrians.

As early as the early 1960s, the question of transforming Rustaveli Avenue into a pedestrian street was raised into its duplicates today's R. using Tabukashvili and Chonkadze Streets (with its extension to the end of Kakabadze Brothers Street). In the conditions of the current level of automobileization, this issue is a rather difficult technical-economic task and requires a deep, thorough justification. But it is obvious the need to study this issue and transform part of the streets for pedestrians even at the end of the week or during the holidays.

This issue is particularly relevant, first of all, in Tbilisi's Kala district, then in Chugureti, the so-called For Vorontsov and Plekhanov districts, for part of the streets near Mtkvari beach, etc.

Its positive solution will make Tbilisi even more attractive for tourists, many new jobs will be created and income from tourism will increase significantly.

Main part.

We can use as a criterion for assigning the pedestrian status of the street: canceling the traffic function of the street should not lead to the mechanism of street traffic, which should contain a normative condition inside. This ensures a special economic course of the transport-operation of the network, maintaining it at an efficient level, not covering safety, environmental friendliness and comfort.

The traffic of the projects and the load level for the streets, i.e. the traffic intensity of the flow, should not exceed 0.6, and for the credit car 0.75 - the business of the prospective period of traffic.

Let's assume that the amount in the bank in the area under consideration flows with different bandwidths and intensities. Traffic load levels on these streets will be:

$$Z_1 = \frac{N_1}{A_1};\ Z_2 = \frac{N_2}{A_2};\dots\ Z_n = \frac{N_n}{A_n} \quad (1)$$

where $N_1, N_2,\dots,N_n$, – the intensity of the flows in the peak period is reduced to light in d.a./h;

A_1, A_2, A_n, – street capacity in d.a./h.

Let's say we canceled the traffic function of N_2 and N_4 streets and made it pedestrian. Traffic flows with intensity N_2 and N_4 will be distributed on the remaining streets and we will get new values of load levels:

$$Z_1' = \frac{N_1 + x_1 N_a}{A_1};\ Z_3' = \frac{N_3 + x_3 N_a}{A_3}$$
$$Z_n' = \frac{N_n + x_n N_a}{A_n}\ ; \quad (2)$$

where : N_a – additional stream $N_a = N_2 + N_4$;

$x_1,\ x_3,\ x_n$ – The amount of additional flow redistribution to the remaining traffic destination streets in unit parts.

Obvious $x_1 + x_3 + \dots + x_n = 1$.

Our task is to understand the new load levels $Z_1', Z_3', \dots Z_n'$,. For this, it is necessary to select the values of shares $x_1,\ x_3,\ \dots\ x_n$and determine if the new load level on any street has exceeded the normatively permissible level. If this happens, measures should be taken to increase the traffic flow or reduce the flows on these streets.

X We use the remaining size of the bandwidth reserve for each n streets as a criterion for the selection of shares:

$$R_n = A_n * k - N_n \quad (3)$$

Where : R_n – Remaining bandwidth reserve;

A_n – Street capacity;

k – Normative level of street traffic load

k = 0,4÷0,75;

N_n– The intensity of the flow of traffic on the street during the rush hour.

We rank the streets according to the absolute size of the bandwidth reserve, e.g. We have 8 streets, of which N_2 and N_4 streets do not participate in the ranking (Fig. 1). The abscissa axis shows street ranks, the ordinate axis shows the remaining reserve.

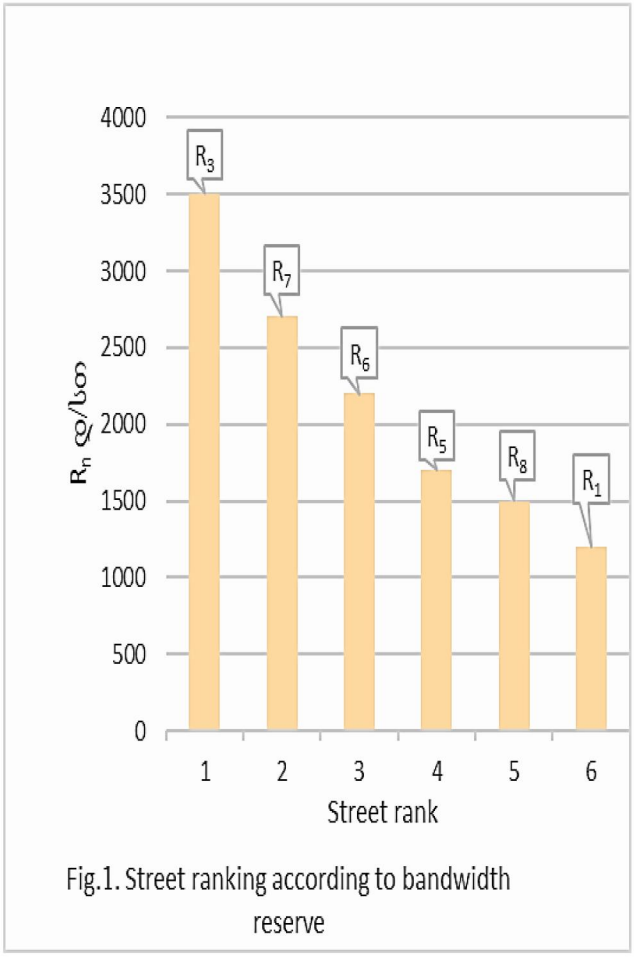

Fig.1. Street ranking according to bandwidth reserve

$$R_3 = A_3 * k - N_3;$$
$$R_7 = A_7 * k - N_7;$$
$$R_6 = A_6 * k - N_6;$$
$$R_5 = A_5 * k - N_5;$$
$$R_8 = A_8 * k - N_8;$$
$$R_1 = A_1 * k - N_1;$$

The selection process is carried out in the following order:

1. rank height;
2. directional coincidence with the direction of N_2 and N_4 flows;
3. Analysis of certain subjective and objective factors (convenience and safety of traveling by public transport, protection from noise, etc.).

Suppose we select the first three streets with the maximum reserve. They must meet the following conditions:

$$R_3+R_7+R_6 \geq N_2 + N_4.$$

If it is completed, the task is solved. If this condition is not met, we add the next streets in order of rank or we take certain measures to increase the capacity of the first three streets. After that, only X_3, X_7, and X_6 parts need to be selected. We select them in proportion to the relative size of the street reserve, for example

$$X_3 = \frac{R_3}{N_2+N_4}; \quad X_7 = \frac{R_7}{N_2+N_4}; \quad X_6 = \frac{R_6}{N_2+N_4} \quad (4)$$

To get a final conclusion on the results of the calculation, we check whether Z_1', Z_2', ... Z_n', has exceeded the permissible normative value. If there is no excess, the task is solved.

Three types of measures can be used to increase street capacity for the above purpose.

Traffic organization - optimization of marking and road sign placement schemes, introduction of one-way and reverse traffic, transfer of traffic lights from rigid mode to flexible and coordinated modes, prohibition of parking and stopping of vehicles, etc.

Development of infrastructure - widening of the carriageway, arrangement of oncoming traffic lanes, separate lanes for public and private transport, bicycles and electric scooters, sewerage of junctions with safety islands, opening of junctions, separation of pedestrian and vehicle flows with small

depression tunnels, overpasses, etc.

Decisions of the City Hall and the City Council - introduction of the two-wheeled public transport rental system, timely and effective implementation of new legislative and normative acts, consideration of the peculiarities of the road network of individual districts when determining the directions of public transport development, etc.

Conclusion.

The main criterion for the effectiveness of the implementation of any type of measures for pedestrian transformation of the streets is the existing traffic load levels and the levels obtained after the implementation of the measures. It is also necessary to estimate the influence of the factors determining the capacity of the streets with the maximum accuracy for the calculation of the load levels, taking into account the peculiarities of the street network and the mentality of the traffic participants.

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