

TRANSPORT TECHNOLOGIES

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LAWS OF TRANSPORT CONGESTION ON THE ROAD NETWORK CITIES

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Abstract

Purpose: *In the first place among the urban transport problems by its importance is the issue of the capacity of city streets and roads. There are the contradictions that arised in the movement of the traffic on city streets, creating a corresponding complexity of their functioning. Mutual influence of pedestrians on vehicular traffic and vice versa, as well as the needness to ensure the safety of city traffic conditions are required the introduction of restrictive and prohibitive measures which, in turn, affect the speed of the transport streams and the capacity of road network.* **Methods:** *To analyze the patterns of occurrence of congestion on main streets and perform a theoretical study of measures aimed at improving the efficiency of the road network of the city.* **Results:** *We revealed laws of occurrence of congestion on main streets, set the list of obstacles that cause delay the movement of vehicles on the road network of the city and their frequency.* **Discussion:** *The main focus for solving the problems of traffic congestion occurrence should be a system of regulating system correlation of demand on the trip and suggestions as street and road infrastructure with the purpose of its loading at the acceptable level.*

Keywords: delay the movement; highways; road network; traffic congestion.

1. Introduction

In the first place among the urban transport problems by its importance is the issue of the capacity of city streets and roads.

As we know the capacity of the road network (RN) is the main indicator of creating the effective functioning of the transport system of the city.

There are the contradictions that arised in the movement of the traffic on city streets, creating a corresponding complexity of their functioning. Mutual influence of pedestrians on vehicular traffic and vice versa, as well as the needness to ensure the safety of city traffic conditions are required the introduction of restrictive and prohibitive measures which, in turn, affect the speed of the transport streams (TS) and the capacity of RN.

Each area of the city street has its planning features that allow the car to move at a speed determined by the rules of the road. It is known that

the lower the speed, the greater would be a waste of time, but that increasing time spent moving is not always satisfied consumers of the transport job.

The emergence of congestion on major RN and most important cities of Ukraine has become the norm and at this stage is not observed to improve the situation. Long traffic jams are more often becoming the cause of not only time, but also economic losses. As we know that congestion phenomena inherent hysteresis property, which means the phenomenon is much easier to prevent than to liquidate further. Therefore, more and more relevant is the study of the formation mechanism of congestion.

2. Analysis of the latest research and publications

The theme of the formation of traffic congestion described in the works of such authors O.M.Bakhtin, O.A. Bilyatynskiy, S.A. Waxman, G.U. Vasilyev,

V.I. Hooke, V.G. Zhyvohlyadov, L.E. Kushchenko, M.M. Osetrin, Y.O.Reytsen, V.V. Semenov, O.O. Tsarikov.

3. Research tasks

To analyze the patterns of education congestion on main streets and roads of human settlements.

4. Research results

Speed is one of the most important indicators of the movement of vehicles (V), because they are characterized by its objective function. Any speed reduce of the vehicle is compared to the permitted, moreover the break in the movement (the delay), is resulting in economic losses. The speed of vehicles combination on main streets, mainly depends on traffic delays arising during implementation. Therefore, the efficiency of RN provides the achieving of minimum delay in the movement of the vehicle by its respective operating conditions.

The transport delays can be with systemic or local nature. The systemic nature is directly related to the plan of the city. For example, the radial-ring structure of the city center is overloaded transit flows. The local nature of the delays is associated, mostly, with a capacity of transport nodes and other elements of RN and means of traffic management.

Considering that the transport delay and the queue length are the function of the street network capacity, then further focuses will given to delays causes which are arising from the movement of vehicles and congestion.

The delay traffic on the RN is the availability of various kinds of interference that causes the forced change speed of its movement and increase the time spent on the move. In other words, it is inefficient driving the V.

The delay of the vehicle when it moves through the RN must consider loss of time at the forced stop or reduce speed to pass the priority flows or the presence of obstacles that make regime change movement the V [1].

Grouping of the main influencing factors on the changing modes of vehicular traffic on highways can make the source of their actions. The list of obstacles that delay the movement of vehicles on Kyiv RN, and their frequency are shown in Table 1.

Tab. 1. The relative frequency of obstacles to movement

№ of order	Name of traffic obstacles	Frequency, %
1	Transportation crossroads: - adjustable - unregulated	25 6
2	Pedestrian crossings: - adjustable - unregulated	15 5
3	Public transport stops	10
4	The change of direction (maneuvers) V: - change lanes - leave the main direction of motion - entry to the main direction	3 5 5
5	Parkings of the V within the roadway street	14
6	Road Signs	7
7	Unsuitable road conditions	5

To consider in this work the delays in system positions, was offered the traffic delays classification in depending on the location and circumstances of the cities (Picture 1) [2].

A survey in the thesis [2] analysis of research is allowed to generalize reconstructive and organizational measures that help to reduce transport delays, namely:

- increase the width of the carriageway streets (by removing the tram tracks, the bands or distribution Boulevard, reducing the width of the sidewalk with simultaneous laying of passages through the first floor, the transformation of radial streets into highways streets in continuous movement, prohibition of parkings vehicles on the roadway street);

- the introduction of reverse lanes (the "bottlenecks", for example, on bridges and overpasses. Taking into consideration the uneven distribution of the intensity of traffic in the areas morning and evening);

- the organization of the central bands of permitted left turn;

- the allocation of special lanes for public transportation while installing them special road signs which allow them entry to cars with two or more passengers;

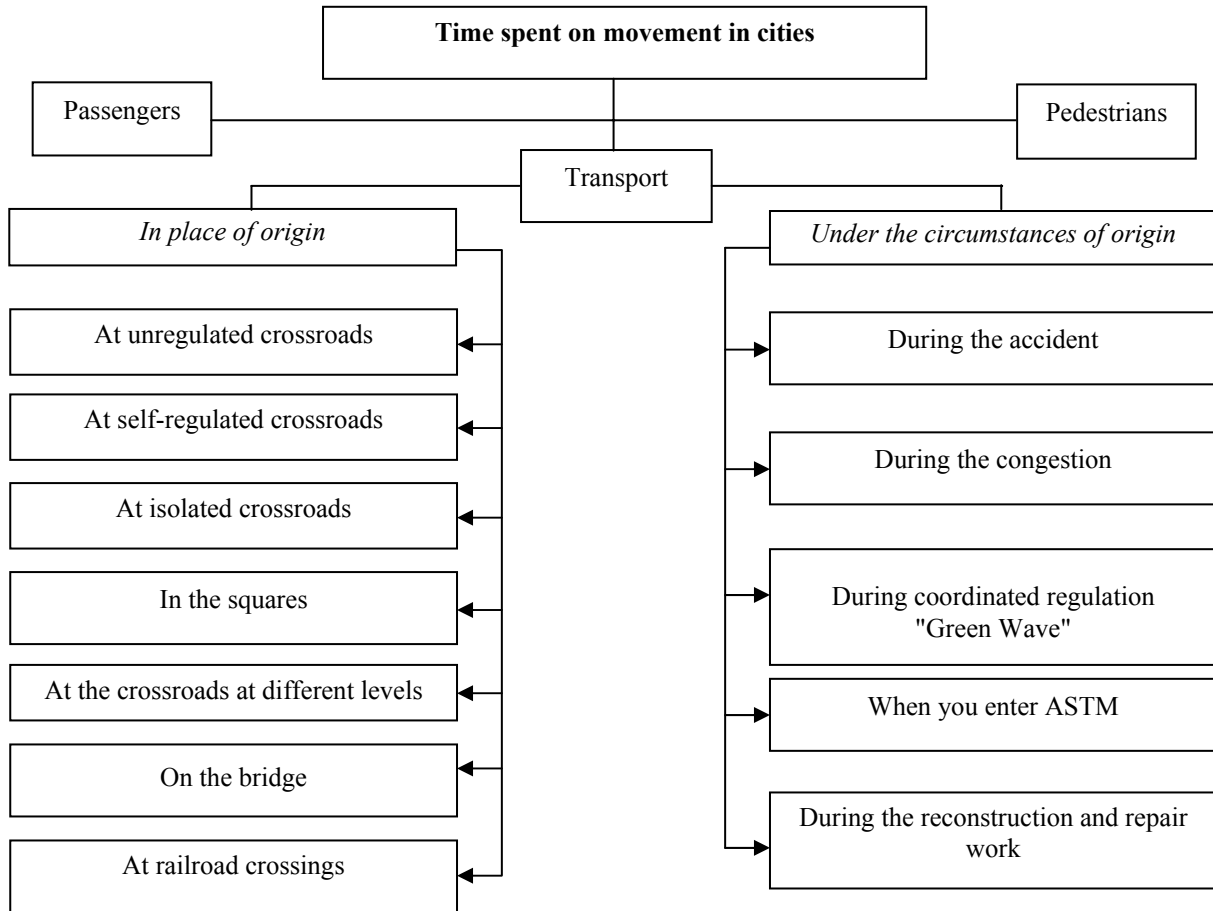


Fig. 1. Classification of traffic delays on places and circumstances

- the implementation of automated systems for traffic management (ASTM) for network lines (using the system control algorithms) in the central areas of cities, thus reducing transport delays on 15 - 20%;
- the organization one-way streets (street capacity increased on 25 - 30%);
- the differentiation streets by mode of transport (for movement of trucks) and the modes of motion (continuous or controlled);
- the priority of public transport;
- to use of special pedestrian signals.

Thus, we can say that the problem of reducing traffic delays and increasing the capacity of city streets and roads can only be solved using complex measures: the organizational, the planning, the technology management and several others.

Reduction of the speed traffic and appearance queue waiting leads to delays in transport of RN. In general, it is defined as [3]:

$$t_d = t_m + t_{dr} + t_{fq} + t_{as} \quad (1)$$

where t_m – loss of time by reducing the vehicle speed in the main direction;

t_{dr} – loss of time due to run over;

t_{fq} – loss of time due to the formation of queues;

t_{as} – loss of time during acceleration and stop.

The greatest influence on transport delays with increasing intensity make t_{fq} . Because this turn arises by reason of waiting for further movement.

The average retention rate (t_{df}) is the amount of delay each vehicle divided by the number (N) V that drove by [4]:

$$t_{df} = \frac{\sum_{i=1}^N t_d}{N} \quad (2)$$

Most theories argue that the delays vehicles depend on two components: on time, during which the car drove through traffic congestion place in the absence of queues, and on the flow behavior within

congestion area. Herefrom, the delay does not depend on the structure of the queue, so the management must direct impact not on the queue, but in most areas of congestion [5].

In today's scientific literature is no universally accepted definition of "congestion".

Contemporary popular science car terms dictionary explains the concept of congestion as a state that corresponds to a reduction of traffic speed to zero because of the excess of actual traffic capacity of the road [6]. The Dictionary expert - automotive defines congestion as the delay in the movement of traffic caused by a sharp decline in the road capacity in this sector. So the practice specialists of the traffic management determine the situation on the road, if a driver for one to three cycles can travel in any direction urban congestion, the traffic, or the so-called "traffic congestion", it can not go. If the cycle of traffic lights adjustment of 90 seconds and the driver have to wait from 3 to 5 cycles, it is called situation before congestion. Only stop standing in line more than 7,5 minutes (or five cycles of regulation), the driver turns in congestion situation [6].

Traffic congestion - a state of traffic on the section of the road network, in which the speed of the vehicle is close to zero, and the density of traffic reaches the maximum value and the time of travel sites congestion road network increases significantly.

In the practice of traffic congestion has often seen as a negative factor stormy motorization the shortage of road space. Sustained growth of the fleet concentrated in relatively small areas inevitably leads to the congestion of the road network and the periodic occurrence of the congestion. Characteristic for the congestion high density of the traffic and low average speed connections make it impossible efficient transport system of the city. However, the principles maximize efficiency lanes carriageway directions of movement and overall crossroads were built at the upper limit use of their potential and the initial stage of formation congestion states [7, 8].

Congestion places on city streets, where the worsening traffic conditions, can be divided into two types [9]:

constant places where congestion and deteriorating road traffic conditions observed daily in almost the same time (availability crossed a par with other streets, contiguity, branching, tramways,

public transport, slopes, narrow, technical means and methods of movement, condition of the roadway, etc.);

– random places in which the congestion situation arising from loss of bandwidth of RN elements on insignificant time due to the weather and climatic conditions, traffic accidents, road repairs, accidents at utilities, public events, etc.

Causes of the congestion state is the combination of the following major factors:

– organizational management – circuit organization and traffic management are developed without considering the peculiarities of formation and distribution of traffic in this part of the road network;

– deficit – the lack of significant size of the roadway strip;

– unpredictable - the formation of an accident with serious consequences, weather conditions, natural disasters; major repair and construction work on the section of the road network without the use of appropriate measures and traffic control.

– There is the description of individual traffic jams and congestion series [10] in the work:

Single congestion is caused by traffic conditions, such as red light, accidents, narrowing, etc. In this situation, the excess inflow condition of the vehicle in the congestion over the outflow easy perform, if narrowing will have the capacity of p_{bn} , and the inflow p_{in} , then if $p_{in} > p_{bn}$, the congestion will increase. In theory, such behavior is similar to the behavior of the queue, that is described as the queuing theory, except of the spatial dimension - increasing congestion from the tail.

Congestion series are characterized by the outflow of vehicles from the congestion which are taken place considering one vehicle per two seconds for one lane, if mark it p_{mn} . That congestion will grow when $p_{in} > p_{mn}$.

The main tasks in ensuring the effective functioning and the appropriate level of convenience of cities' RN vehicle traffic is the minimization of delays and the improvement of transport safety in the event of the above described situations. For providing the required capacity of the road network of the city it is necessary to establish the appropriate road conditions, such as carrying out the building of new ones and reconstruction of existing engineering and transport constructions and elements of streets and roads, but it is not always the solution of these issues will improve the operation of the network,

because across with technical measures, which are based on the construction and reconstruction of streets and roads, should be decided the questions of effective measures using for traffic management, that is allowed you to manage with the traffic flows on city streets.

In modern conditions of Ukraine cities' development there is especially acute question of improving the methods of forecasting and planning of transport systems, including all the questions of its infrastructure development. In this case it is important to create the comprehensive methodology for evaluation and optimization of the road network in the cities and the system of movement of motor transport.

To ensure quality operation of cities' RN, it is necessary to implement the effective methods for traffic management, including the set of technical and organizational measures which are aimed at maximum using of the transport stream opportunities that are provided geometrics street and its condition.

5. Conclusions

However, the transport situation becomes critical when the level of motorization reaches values that exceed the capacity of the road network. Congestion become commonplace when overloaded strips are not able to pass on the race flows that have reached capacity, and at the intersection of the settlement.

Therefore, the main focus for solving the problems of traffic congestion occurrence should be a system of regulating system correlation of demand on the trip and suggestions as street and road infrastructure with the purpose of its loading at the acceptable level.

Congestion situations that arise in the city and RN are caused by various reasons and are significantly increased the cost of the moving. So far one of the effective case to reduce the traffic delay and the congestion localization in the most important and significant cities is the redistribution of traffic on the alternative routes.

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Закономірності утворення транспортних заторів на вулично-дорожній мережі міст

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Мета: Серед міських транспортних проблем на першому місці по своєму значенню є проблема пропускної спроможності міських вулиць і доріг. Саме протиріччя, які виникають в організації руху транспортних потоків по вулицях міст, створюють відповідні складності їхнього функціонування. Взаємовплив пішоходів на рух транспортних засобів і навпаки, а також необхідність забезпечення умов безпеки міського руху вимагають впровадження обмежувачих і заборонних заходів, які, в свою чергу, впливають на швидкість руху транспортних потоків і пропускну спроможність вулично-дорожньої мережі. **Методи:** Провести аналіз закономірностей виникнення транспортних заторів на магістральних вулицях міста та виконати теоретичне обґрунтування заходів, що направлені на підвищення ефективності функціонування вулично-дорожньої мережі міста. **Результати:** Виявлені закономірності виникнення транспортних заторів на магістральних вулицях міста, встановлений перелік перешкод, які спричиняють затримку руху транспортних засобів на вулично-дорожній мережі міста та їхня частота. **Обговорення:** Основним напрямком подолання проблем виникнення транспортних заторів повинна бути система регулювання співвідношення попиту на поїздку і пропозиції у вигляді вулично-дорожньої інфраструктури з метою підтримки її завантаження на припустимому рівні.

Ключові слова: вулично-дорожня мережа; затримка руху; магістральна вулиця; транспортний затор.

А. В. Степанчук¹, А. А. Белятинский², С. Ю. Тимкина³. Закономерности образования транспортных заторов на улично-дорожной сети городов

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Цель: Среди городских транспортных проблем на первом месте по своему значению проблема пропускной способности городских улиц и дорог. Именно противоречия, которые возникают в организации движения транспортных потоков по улицам городов, создают соответствующие сложности их функционирования. Взаимовлияние пешеходов на движение транспортных средств и наоборот, а также необходимость обеспечения условий безопасности городского движения требуют внедрения ограничивающих и запрещающих мер, которые, в свою очередь, влияют на скорость движения транспортных потоков и пропускную способность улично-дорожной сети. **Методы:** Провести анализ закономерностей возникновения транспортных заторов на магистральных улицах города и выполнить теоретическое обоснование мероприятий, направленных на повышение эффективности функционирования улично-дорожной сети города. **Результаты:** Выявленные закономерности возникновения транспортных заторов на магистральных улицах города, установлен перечень препятствий, которые вызывают задержку движения транспортных средств на улично-дорожной сети города и их частота. **Обсуждение:** Основным направлением преодоления проблем возникновения транспортных заторов должна быть система регулирования соотношения спроса на поездку и предложения в виде улично-дорожной инфраструктуры с целью поддержания ее загрузки на допустимом уровне.

Ключевые слова: задержка движения; магистральная улица; транспортный затор; улично-дорожная сеть.

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