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EVALUATION OF EFFICIENCY OF PARKING SYSTEM FORMATION ON EXAMPLE OF KHARKIV

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Abstract. *It is proposed to use the known dependence of the change of indicators of transport traffic functioning, namely the total travel time, depending on the nature of placing the cars parked on the road network of the city to determine the effectiveness of the system of parking. The technique tested on example of Kharkiv allowed to establish that as a result of formation of car parks in cities the total travel time of all road users of the road network is reduced.*

Key words: *central downtown, parking system, street and road network, parking network, social and economic effects, travel time.*

ОЦІНКА ЕФЕКТИВНОСТІ ФОРМУВАННЯ СИСТЕМИ ПАРКІНГІВ НА ПРИКЛАДІ М. ХАРКІВ

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Анотація. *Запропоновано проводити оцінку ефективності формування системи паркінгів на основі відомих залежностей зміни показників функціонування транспортних потоків від способів розташування автомобілів на вулично-дорожній мережі міст. Апробована на прикладі Харкова методика надала можливість отримати соціальний ефект – зменшення сумарного часу пересування усіх учасників дорожнього руху.*

Ключові слова: *центральна ділова частина міста, система паркінгів, вулично-дорожня мережа, мережа паркування, соціальний та економічний ефект, витрати часу.*

ОЦЕНКА ЭФФЕКТИВНОСТИ ФОРМИРОВАНИЯ СИСТЕМЫ ПАРКИНГОВ НА ПРИМЕРЕ Г. ХАРЬКОВ

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Аннотация. *Предложено проводить оценку эффективности формирования системы паркингов на основе известных зависимостей изменения показателей функционирования транспортных потоков от способов расположения автомобилей на улично-дорожной сети городов. Апробированная на примере Харькова методика предоставила возможность получить социальный эффект – уменьшение суммарного времени перемещения всех участников дорожного движения.*

Ключевые слова: *центральная деловая часть города, система паркингов, улично-дорожная сеть, парковочная сеть, социальный и экономичный эффект, затраты времени.*

Introduction

Analysis of the current state of the transport infrastructure, traffic management systems, and research in the field of traffic shows the relevance of research areas related to the development of management and parking systems. In recent years, special attention is paid to the disparities between the rates of car ownership and pace of development of the road network, but the shortage of parking spaces, especially in the central downtown (CD) brings to a central place in the transport problems of the city the task of forming a system of parking that would meet the needs of the population in parking, as well as the task of integrated solution of parking management.

One of the ways of solving the problem of parked cars on the road network (URN) is a construction of above-ground multilevel parkings of large capacity, and the importance attached to their rational allocation. But most areas in urban areas for parking is not enough. It is noticeable that the existing ground or above-ground parking or underground parking unable to meet the needs of the population on the parking lots and the construction of new places and require financial subsidies, especially in the central business part of any city. In terms of traffic to the satisfaction of the needs of car parks also need to enhance the capacity of the streets.

In [1] is possible to solve the given problem by establishing alternative parking places of ways of parking that is systems of parking. It is necessary to take into account the economic and psychological aspects of attractiveness of the use of parking attractiveness for customers and when designing each parking one should take into account the placement and capacity of adjacent parking-lots, which will make it possible to create a system of parking, fully satisfying the need in parking-lots in the CD. It is also necessary that the number of parking spaces should match the number of cars that need them.

Evaluation of the effectiveness of the existing parking system in the CD is currently one of the pressing issues It can be obtained by reducing the travel time and increasing the traffic speed on the URN, because of the banning concerning parking of cars on its most part and placing of vehicles on the proposed system of parkings.

Analysis of the literature

Due to the fact that there does not yet exist a systematic approach to establishing a system of parking [1], as a result, there are no methods for assessing the efficiency of such systems.

Typically, attention is paid to the efficiency of individual parking-lot or parking area, namely the degree of effectiveness of investing funds into them. Also, attention is paid to assessing the effectiveness of the payment of fees for different types of sites, management and improvement of tariffs, which is one of the most effective instruments of reducing the traffic load in the central downtown [2]. They also evaluate the effect (reducing the number of road traffic accidents) or the costs for introduction of banning for parking [3].

In [4–10] experimental studies of traffic behavior in interaction with the parking urban network enabled to obtain the dependences of indexes change of traffic flows performance on the ways of vehicles placement on the URN. Gradually, including into the scheme of the transport network step by step the parking network, that exists in Kharkiv, in [9, 10] there was received a response as a permit for parking on a particular street generally affects the whole urban transport network and its operation. Thus, [9, 10] there was obtained a graph (Fig.1) of changes of transport costs on the urban road network (B_{tr}, aut.·hour./hour.) while increasing the network density of parking (ρ, km^2/km^2).

The indicator of transport flows performance on the transport network (total time spent on the network) under the development of parking (Fig. 1) is worsening. This is primarily due to expectations of vehicle exit from the parking place; travel time of incorrectly parked vehicles or making way for oncoming vehicles, etc.

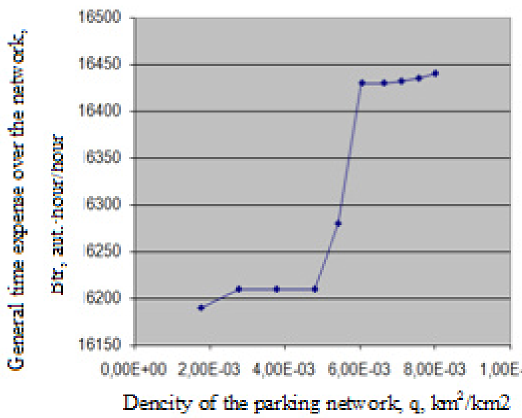

Fig.1. Schedule of changes in the time required to travel on the network by increasing the density of the parking network [9, 10]

The purpose of the study and formulation of the problem

The purpose of the work consists in evaluating the effectiveness of forming a parking systems in the central downtown based on existing dependences of traffic flows performance on the ways of vehicles placement on the URN on example of Kharkiv.

Evaluation of efficiency of parking system formation in Kharkiv

According to the methods in [9,10] the parking density is determined by the formula

$$\rho = \frac{S_{\text{park}}}{S_{\text{URN}}}, \quad (1)$$

where S_{park} – area of the parking network, km^2; S_{URN} – the area of URN, km^2.

Area of the parking network is given by

$$S_{\text{park}} = \sum_{i=1}^{b} B_{\text{park}} \cdot L_i \, , \quad (2)$$

where b – the number of arcs of the network, that make up the network of parking, unit.; B_{park} – the average width of the roadway of parking network arcs that make up the network of parking, km. In [7, 8] there was adopted $B_{\text{park}} = 0{,}011$ km; L_i – the length of i – network arc, which makes up the parking network, km.

With the help of the curve meter and application of the map of Kharkiv it was established that the length of the urban road network (L_{URN}, km) is 1500 km. The length of the urban road network of the central downtown (L_{URNCD}, km) is about 120 km. Then, the urban road network area as well as the downtown parking network area respectively equals

$$S_{\text{URN}} = 1500 \cdot 0{,}011 = 16{,}5 \text{ km}^2 \, ,$$

$$S_{park_{befor}} = 120 \cdot 0{,}011 = 1{,}32 \text{ km}^2.$$

In Fig. 1 the minimum ρ_{min} and the maximum ρ_{max} of the value of the parking network density network lencorrespond to the following length of arcs of the network:

$$l_{\text{min}} = L_{\text{URN}} \cdot \rho_{\text{min}} \, , \quad (3)$$

$$l_{\text{max}} = L_{\text{URN}} \cdot \rho_{\text{max}} \quad (4)$$

and constitute

$$l_{\text{min}} = 2{,}6 \text{ km}, \; l_{\text{max}} = 12 \text{ km}.$$

According to the results of identifying the opportunities for parking on the road network of Kharkiv (database fragment on the characteristics of trips, which in the central downtown were given numbers, is presented in Table. 1), parking should be banned on the distance of approximately 42 km of trips in the central downtown, and vehicles must be placed in the proposed parking system.

Therefore, for calculating a decrease in the trip time expenditure over the network by placing motor cars in parking areas we will use the method of extrapolation. To do this, in the Microsoft Excel software there was built a trend line (Fig. 2).

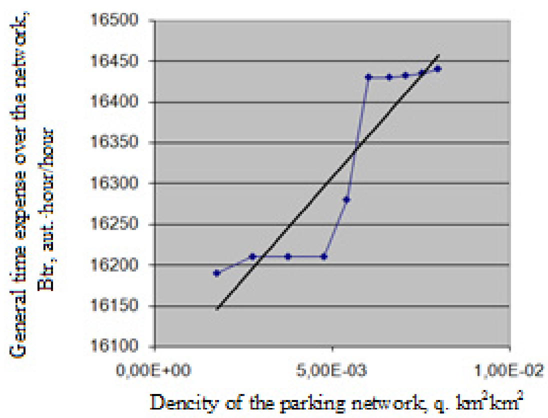

Fig. 2. The trend line that describes the change in the time required to travel over the network while increasing the density of the parking network

The probability value of approximation R^2 (mixed correlation square), which is calculated automatically by Excel application lies in the range from 0 to 1 and reflects the trend line values proximity to the actual data. The trendline is the most accurate when the value is close to 1.

It has been established that the trend of data change is shown most clearly by a straight line ($R^2 = 0{,}826$).

Table 1 Database fragment on the characteristics of trips on the urban road network in Kharkiv

Number of trip	Number of the point of trip origin	Name of the point	Number of the point of the trip end	Name of the point	Width of the l ink, m	Necessary number of places for parking for gravity centers, unit	Length of the l ink, m	Possible number of parked cars along the trip route (0º/90º), unit
1	180	Racecourse - Sumskaya str.	325	Sumskaya str.- Vesnina str.	11	32	478	37/-
2	325	Sumskaya str.- Vesnina str.	27	вул. Сумська - вул. Динамівська - О. Гончара	11	149	279	19/-
3	27	Sumskaya str.- Dinamivska str. - O. Honchara str.	32	Sumskaya str.- Dinamivska str. - O. Honchara str.	11	167	331	24/-
4	32	Mayakovskogo str. - Sumskaya str.	26	Kultury str. - Sumskaya str.	11	31	134	6/-
…	…	…	…	…	…	…	…	…
484	341	Kolomenska str.- Akademika Lyapunova str.	227	Lenin str.- Akademika Lyapunova str.	6		129	0
485	331	Danilevskogo str.- Lenin Avenue	40	Lenin Avenue – Chichibabin str.	32	22	66	1/2
486	309	Feierbakha str.- Chigirina str.	342	Feierbakha str.- blind alley	7,2	32	503	0

The resulting linear function is as follows

$$B_{\text{tr}} = 50009 \cdot \rho + 16057 \quad . (5)$$

The density of the parking network before the introduction of the parking system equals

$$\rho_{\text{befor}} = \frac{1,32}{16,5} = 0,08\ \text{km}^2/\text{km}^2.$$

The square of the parking network in the CD after the introduction of the parking system in Kharkiv constitutes

$$S_{park_{\text{after}}} = 78 \cdot 0,011 = 0,858\ \text{km}^2,$$

and the density of the network of parking is the following:

$$\rho_{\text{after}} = \frac{0,858}{16,5} = 0,052\ \text{km}^2/\text{km}^2.$$

According to the obtained function, general time expenditure respectively before and after the introduction of the parking system in Kharkiv are the following:

$$B_{\text{tr befor}} = 50009 \cdot 0,08 + 16057 = \\ = 20057,72\ \text{aut.} \cdot \text{hour./hour.}$$

$$B_{\text{tr after}} = 50009 \cdot 0,052 + 16057 = \\ = 18657,468\ \text{aut.} \cdot \text{hour./hour.}$$

$$\Delta B_{\text{tr}} = 20057,72 - 18657,468 = \\ = 1400,25\ \text{aut.} \cdot \text{hour./hour.}$$

After removing the parked cars from the CD of Kharkiv, there is expected obtaining of some social effect, which consists in reducing the time expenditure on the urban network according to the obtained function by 1400 cars per hour/ hour.

To determine the economic effect of reducing the delay of vehicles when driving on the URN, it is not advisable to limit only to estimated costs for fuel, vehicle depreciation, the cost of one hour of work of a person or machine-hour, the costs associated with the elimination of environmental damage or material loss due to road traffic accidents. Approaching to the state of traffic jams in big cities will lead to what is really uncertain, but an increasing number of centers of gravity will experience significant damage. Because each center of gravity requires satisfaction of the demand for parking in its vicinity, spontaneous parking in the CD will inevitably create a situation, when the demand for travel is not possible to satisfy.

Conclusion

Formation of a parking system will enable to sufficiently reduce the number of parked cars on the urban road network and provide relatively free passage of transport, and as a result, provide opportunity to gain social and economic benefits. The economic effect is obvious, since the testing results of research on example of Kharkiv showed the possibility of obtaining a social impact – reduction of the total time of rolling stock movement of road users on the urban road network by 7%, otherwise traffic jams will lead to economic losses of the budgets of all levels.

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