Improving the methodology of organizing the parking process in large cities of the world

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Abstract. It has not been more than a century since cars became a global phenomenon, and the possibility of unobstructed parking has gone from being a worry-free situation to a big problem. At first, it was not considered an important matter, then it was a topic for discussion, and later most of the parking lots became an object of commercial and logistic interest, an object of profit by any means, even to the human environment detriment [7, 8, 13]. Currently, the ability to own and dispose a parking slot is perceived by the subjects of public and economic relations as a significant advantage, and often even more significant than the possession of a vehicle. In different states, the evolution stages of this issue were uneven, but in general the trends were the same - an increase in the number of parking zones and an increase in their capitalization.

Introduction

In the 21st century, during the active development period of modern information and automated technologies aimed at accelerating the productive effect, and, at the same time, closely related to the new humanistic principles of the post-industrial era, new approaches aimed at improving the life quality of people in every possible way while maintaining or even improving their habitat have emerged [1, 4, 5, 9]. One of such approaches was the tubing parking principles’ development, which can significantly save the consumer’s money, as well as optimize the use of city squares used in single-level parking areas. In this regard, this paper considers the issues of improving the methodology of organizing parking slot process in cities based on the tubing parking principles.

Main part

Every year there are more and more cars in the big cities of the world. Due to the outstripping growth rates of the population’s motorization over the parking slots provision for cars, the problem of the parking slots’ lack for parking the vehicles not only in the central part of the city, but also in its peripheral areas is becoming more and more urgent.

Our analysis of various studies in this area indicates the existence of a whole scientific archive for solving the problems associated with parking slot. In particular, in his research: "The high cost of free parking” by the professor at the University of California at Los Angeles Donald Shoup focuses on the
fact that “if the problems with parking slot are not regulated, then after a certain period of time an area of an England size will be needed for the world car fleet location” [3].

The relevance of the parking slot problem is also proved by the results of the IBM Global Parking Survey [2], in which 9055 motorists in 25 cities of the world were interviewed. It was discovered that:

- at least 40% of traffic jams in large cities in the world arise from the fact that drivers in search of parking slot to park a vehicle create obstacles on the roadway;
- 8 out of 10 interviewed respondents are often forced to refrain from looking for a parking slot for a short-term parking of their vehicle and move to another place;
- more than 1/4 of the respondents came into conflict with other drivers over parking slot.

Due to the lack of space for short-term storage of vehicles, drivers use the carriageway of the city, the parking time ranges from 20-30 minutes to 6 or more hours. At the same time, the organization of “unregulated parking lots” has bad consequences for all road users: one parked vehicle on the stretch of the carriageway in high traffic conditions creates obstacles for 700-800 vehicles every hour. Traffic jams are the result of such chaotic parking. Also, due to the lack of parking slot in the courtyards, residents of the city park their vehicle on the roadways and thereby create obstacles for moving cars [11].

In Russia, the situation is aggravated by the fact that the Soviet designers of roads and residential areas could not predict that by the beginning of the 21st century there will have been many times more cars per 100 people. The number of cars per capita is growing, if not exponentially, then in arithmetic progression [7, 8, 11].

Analysis of the survey results carried out on city streets showed the following.

1. The carriageway is used by about 80% of all parking cars, partly on the carriageway and sidewalk - 15%, completely on the sidewalk - 5%.
2. The average density of passenger car parking reaches 390 vehicles / km on the trunk network, and 280 vehicles / km on the local network.
3. The average density of car parking on sidewalks is 90 vehicles / km.
4. The share of cars parked with traffic violations reaches 45% (the average number of offenders in the city is 130 vehicles / km).

The main types of parking violations are the following car placements:
- at an angle to the carriageway edge in the places where only longitudinal placement is allowed - 33% of all violations;
- on the sidewalk or with a partial drive onto the sidewalk in the absence of permissive signs and markings - 27% of all violations;
- closer than 5 m from the edge of the crossed carriageway or pedestrian crossing - 14%;
- within the coverage area "Stopping prohibited" – 7%.

The problem of parking for private vehicles has existed for a long time. Parking slots are sorely not enough, so the car owners are forced to park their vehicles where they can find free space. Because of parked cars on the roads, today it is punctual, but still there are serious obstacles in traffic. Public transport often cannot approach stops and passengers disembark from the second row. Pedestrians bypassing vehicles on the road run the risk of being hit by the wheels. Also, due to spontaneous parking in the courtyards of residential buildings, it is difficult to walk to entrances, playgrounds, schools and preschool institutions. Violation of traffic rules is often a compulsory measure for a car owner who decides to park his vehicle. As a result, pedestrians complain, while motorists shrug their shoulders, saying that they simply cannot park their car correctly [6, 10, 15, 16].

For example, in Moscow, 25% of the drivers surveyed noted that the longest time they spent looking for parking in the last year was from 11 to 20 minutes, and 15% named the figure from 21 to 30 minutes. Moscow is in second place in the number of fines received by drivers for parking in the wrong place (the average number of fines received per year is 8.5) and in fourth place among the world’s megacities. The main problem with parking lies in the huge number of cars on the roads, which were built decades ago and were not designed for such a number of cars. In addition, the construction of buildings in Moscow does not always allow for parking on the ground floor and below, as is done in most European cities. Among other things, Russia has a completely different driving culture: there are drivers who are
not afraid of fines, as in Europe (possibly due to the low cost of Russian punishment). And one more factor is the mentality specifics [17, 18].

Also, for example, in Krasnodar at this time, as our studies have shown, the lack of parking slots, depending on the area, ranges from 35% to 65%. The average lack of parking slots in the city is 54%. The lack of parking zones in isolated cases of the city exceeds 65%. In addition, the impact that has on the efficiency of the organization and use of parking slot, the pricing policy of economic entities operating in this market should be noted. For example, the price for using paid municipal parking per hour in Krasnodar is 30 rubles. However, there are parking lots, the cost of which is 2-3 times higher. In particular, the price per hour of parking located on the territory of the Railway Station Square Krasnodar-1 is 100 rubles, at the Pashkovsky International Airport - 250 rubles, etc. In general, the study of parking slots in the city of Krasnodar revealed the fact that the situation that has formed in various zones of the city roadway is extremely difficult, which is constantly aggravated by an increase in the motorization level, the value of which significantly exceeds a similar indicator in other less traffic-loaded settlements of the Russian Federation.

Based on this, it can be concluded that there is a need for a significant increase in paid municipal parking zones, which will make it possible to free the road network from cars and establish a development vector for private parking slots. In addition, improving the state and conditions of public transport will provide the citizens with a worthy alternative to using individual vehicles. When implementing the decisions on the organization of traffic on roads, a special role belongs to the road and transport infrastructure development, as well as the use of various technical means and tools: road signs, road markings, road barriers, traffic lights, etc. [12, 14].

Based on the above-said, it should be noted that one of the most effective solutions to the existing problem is the use of automatic parking systems "Tubing parking".

The "Tubing parking" system (Figure 1) is a metal structure consisting of a supporting frame and six rows of mobile parking platforms, located in four tiers one above the other, on which cars are stored.

![Figure 1. Diagram of the mechanical parking system "Tubing parking"](image)

The capacity of this parking is up to 250 vehicles. Average daily parking load - 75%. The parking system makes it possible to save up to 35-50% of usable space, due to the multi-storey structure and the use of a hydraulic drive or an electric drive with great energy savings, equivalent to the power of an electric kettle (2.2 kV).

The hydraulic mechanism, which is equipped with each tubing parking system, performs the vertical movement of transport spaces on the parking levels in the absence of a ramp, in a state of limited space.

Benefits of an automated parking system:
- there is no need for additional construction work;
- the total number of parking slots increases to 50% due to the correct use of the space height;
- automatic system and operating mode;
significant time savings for drivers;
- environmental friendliness - no harmful emissions into the atmosphere.

Segment of the parking lot under construction - people with an average income.

After commissioning, the plans include the following prices for parking services:
- rental price for one parking slot per year - 26,000 rubles;
- rental price for 1 month - 3500 rubles;
- rental price for 1 day - 150 rubles.

Also, the privileged places can be provided for the socially unprotected parts of the population in the amount of 25% of car places from the total. Consequently, this project can be paid off in 6-7 years, which is typical for this type of facility (Table 1).

**Table 1. Calculation of net profit, thousand rubles.**

| Article title                  | 0 year | 1 year | 2 year | 3 year | 4 year | 5 year | 6 year | 7 year |
|-------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Potential gross income        | 0      | 4695   | 5634.7 | 6198.1 | 6818   | 7499.8 | 8249.7 | 9074.7 |
| Total direct costs            | 0      | 2810   | 2810   | 2810   | 2810   | 2810   | 2810   | 280    |
| Gross profit                  | 0      | 1885   | 2824.72| 3388.1 | 4008.0 | 4689.8 | 5439.7 | 6264.7 |
| Administrative costs          | 0      | 10     | 10     | 10     | 10     | 10     | 10     | 10     |
| Total fixed costs             | 7845   | 1503   | 1548.3 | 1625.8 | 1707.1 | 1792.4 | 1882.0 | 1976.1 |
| Wearout, [%]                  | 0      | 60     | 60     | 60     | 60     | 60     | 60     | 60     |
| Total costs                   | 7845   | 1747   | 1792.7 | 1870.2 | 1951.5 | 2036.8 | 2126.4 | 2220.5 |
| Profit before tax payment     | 7845   | 137.9  | 1031.9 | 1517.9 | 2056.5 | 2652.9 | 3313.3 | 4044.1 |
| Income tax                    | 8.274  | 61.9   | 91     | 123.3  | 159.1  | 198.7  | 242.6  |
| Net profit                    | 129.6  | 970    | 1426.8 | 1933.1 | 2493.7 | 3114.5 | 3801.5 |

**Summary**

Thus, the development of the tubing parking principles by the introduction of the "Tubing parking" system guarantees the provision of residential and public areas of the city with the necessary share of parking slots. At the same time, operational contracts can be implemented in the form of a public-private partnership both in previously built-up zones and in the territories included in the future development plans. The "Tubing parking" system will also significantly reduce consumer costs.

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