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Current trends in transport planning

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The settlements' infrastructure development, aimed at satisfying, first of all, the needs of motorists, is accompanied by powerful negative changes in the conditions of human life. Now problems of providing conditions for moving by individual environmental vehicles, pedestrian traffic and, in particular, for the low-mobility groups of the population are becoming more relevant. In the article is analyzed and summarized the world experience of urban street-road network reconstruction in accordance with the change of priorities that has occurred in the theory of transport planning. It singled out 2 basic options for the redistribution of space between pedestrians, cyclists, public and private transport: 1) narrowing of lanes for private transport; 2) reducing the number of lanes for private transpor

Keywords: transport planning, street-road network, inclusive environment, individual eco-friendly vehicles, universal design principles

Сучасні тенденції у транспортному плануванні

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Розвиток інфраструктури населених пунктів, спрямований на задоволення насамперед потреб автомобілістів, супроводжується потужними негативними змінами в умовах людської життєдіяльності. Світовий досвід доводить, що навіть інвестуючи значні кошти у розвиток вулично-дорожньої мережі для розв'язання складних проблем автомобільного транспорту, неможливо вирішити проблему перевезень у великих містах, забезпечивши комфортне пересування автомобілів. Не випадково найкращі з точки зору транспорту міста у світі (Копенгаген, Берлін тощо) використовують так звану піраміду пріоритетів, яку радять застосовувати при прийнятті рішень, що стосуються проєктування та реконструкції вулично-дорожньої мережі. На першому місці в цій піраміді стоять пішоходи, на другому – велосипедисти, на третьому – громадській транспорт, потім – комерційний транспорт, на останньому місці – приватний автотранспорт. Навіть виклики пандемії сприяли саме такому розподілу пріоритетів, коли в деяких великих містах Європи адміністративними заходами частину проїжджої частини вулиць віддали пішоходам та велосипедистам. В Україні останнім часом також спостерігається тенденція до зміни пріоритетів у теорії транспортного планування. Зміна пріоритетів знаходить відображення в оновлених нормативних документах України. У статті проаналізовано й узагальнено світовий досвід проєктування та реконструкції вулично-дорожніх мереж населених пунктів відповідно до сучасних тенденцій у транспортному плануванні. У результаті аналізу закордонного і вітчизняного досвіду виокремлено два базові варіанти перерозподілу простору між пішоходами, велосипедистами, громадським та приватним транспортом: 1) звуження смуг для приватного транспорту (що дозволяють оновлені нормативні документи України); 2) зменшення кількості смуг для приватного транспорту (розглянуто три основні варіанти такого перерозподілу)

Ключові слова: транспортне планування, вулично-дорожня мережа, інклюзивне середовище, індивідуальні екологічні транспортні засоби, принципи універсального дизайну

Introduction

The rapid rate of motorization creates a new situation in urban design. Illustration (fig.1) by Swedish artist Karl Jilg (which was commissioned by the Swedish Road Administration) shows how car-centric our reality is [1].

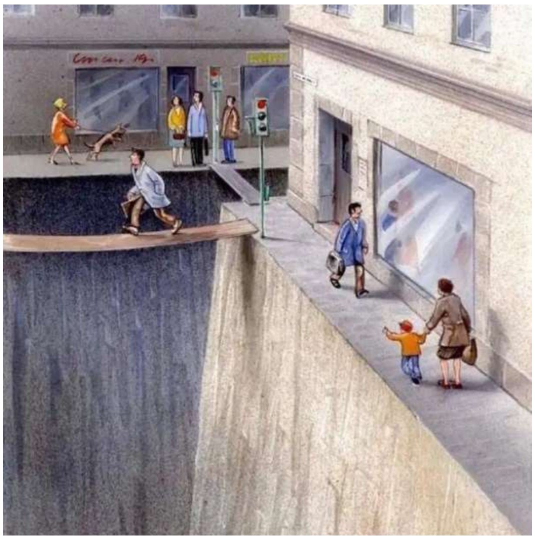

Figure 1 – Illustration by Swedish artist Karl Jilg

Now problems of providing conditions for moving by individual environmental vehicles, pedestrian traffic and, in particular, for the low-mobility groups of the population are becoming more relevant.

Review of the research sources and publications

Recently, more and more researchers of transport planning use the term «Automobile Dependency» [2; 3]. In 1995 Permanent International Association of Road Congresses (PIARC) conducted a specialized XX World Road Congress, devoted exclusively to problems of urban transport planning. In the United States, at the state level, acts were adopted, in which special attention was paid to the organization and safety of pedestrian movement [4]: Intermodal Surface Transportation Act of 1991 (ISTEA), Transportation Equality Act of the 21st Century.

Many scientists from different countries are interested in the application of universal design principles (UDP) in street-road environment improvement. Scientists from Australia are researching universal design in housing [5; 6]. Indian scientists [7] have developed a design manual for a barrier-free environment in India. In Canada, there was a publication of the Barrier-free design guide in 2017 [8]. Researchers from Turkey have done an assessment of street design with universal design principles: case in Aswan [9]. In 2012 Norway hosted the largest conference on universal design held in Europe until then. The most interesting information from the conference has been collected in [10]. Canadian scientists think that it is necessary to provide environments designed to suit the needs of older adults [11]. Researchers from Indonesia have examined several design characteristics of themed streets in several countries from three different continents using UDP for giving proper directions to develop more user-friendly streets and they resumed that design direction can be suggested universally along with the richness of local aspects [12, 13].

The need to find alternatives to individual car transport means and ways to provide comfortable conditions for an individual eco-friendly friendly vehicles (IEV) movement is discussed in the works [14-17].

In the works [18-20] the classification of the main geometric structures of the street-road network is given, their influence on the parameters of transport systems functioning is evaluated and recommendations on the use of the city's territory for different planning schemes are given.

Definition of unsolved aspects of the problem

But such classification based on the width and operational qualities cannot fully reflect all the processes taking place on the streets. The street should be not only a city transport artery but also the place of human interaction. The organization of street space should be guided by a number of requirements related to the activation of social and economic functions: improving the quality of life, mobility and activity of the inhabitants.

Problem statement

The purpose of this study is to summarize the world experience of designing and reconstructing urban street-road networks and to formulate proposals for its improvement in accordance with the change of priorities that has occurred in the theory of transport planning.

Basic material and results

An analysis of the urban planning history in the context of vehicle development [21] showed that before the development of motorization (in the US until the 30s of the twentieth century, and in Europe until the 50s) cities were smaller and more compact in area and population. Weak development of transport infrastructure hampered the development of the economy, the formation of centralized states. People walked, cycled, rode horses and donkeys, or traveled in cattle-drawn carriages.

With the development of road transport, the need for settlement compactness has lost relevance. In 1929, the Soviet sociologist M.O. Okhitovych came up with the idea of a "new resettlement". According to this idea, the appearance of the car is inevitable and leads to desurbanization. In the city, among the crowded buildings, the car cannot be used effectively. Service for residents should be provided by a system of orders and delivery directly to homes.

The gap between the growing number of cars and the narrow streets unsuitable for car traffic necessitated the redevelopment of settlements and the differentiation of city streets by class. Since 1940, road departments in the United States have begun to plan the road network: inventory all roads, determine the size and nature of road traffic, review road construction financing, determine the number of car owners and the nature of their use, study road wear, survey to determine the destination of trips in cities [22].

In the areas that were built before the car boom, there are still convenient streets for pedestrians and cyclists, which connect the points of attraction with residential areas (fig. 2). Residential and industrial areas built during urbanization are much less conducive to pedestrian traffic. They mostly do not have sidewalks but have wide streets that are difficult to cross on foot or by bicycle (fig. 3).

Figure 2 ─ Cyclist and pedestrian-friendly street (USA)

Figure 3 ─ A wide suburban street that was built without taking into account bicycle and pedestrian traffic (USA)

After the first hype around cars, more and more people began to realize that the constant continuous motorization and development of road construction are accompanied by powerful negative changes in human living conditions (fig. 4).

The Coronavirus crisis in 2020 gave us a glimpse of what life could be like in cities and on our streets without high levels of traffic and particularly high levels of car usage. Traffic levels fell and it became much easier for walking and cycling. Air pollution reduced and we could even see the blue skies again! It is imperative that we capture the benefits of more active travel as mobility levels return – and the majority of travel in many contexts can be by public transport, walking and cycling. But this will necessitate a strong policy approach – investing in high-quality public transport networks and giving more space to walking and cycling.

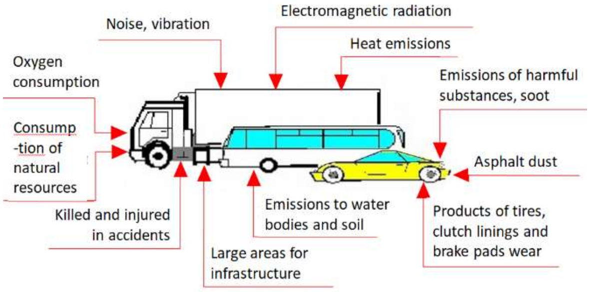

Figure 4 ─ Harmful effects of road transport on the environment

In our opinion, the creation of infrastructure for bicycle traffic is the preparation of settlements for future progress in the field of vehicles. Since scientists of the world are now actively working on the creation of various types of individual environment-friendly vehicles (IEFV) designed to replace or minimize the use of individual cars in settlements.

World experience shows that even investing heavily in the street and road network (SRN) development, the solution of road transport services complex problems, it is impossible to solve the problem of transportation in large cities by providing comfortable movement of cars. Not by chance the best in terms of transport cities in the world (Copenhagen, Berlin and others) use the so-called pyramid of priority (fig. 5), which advice to apply when making decisions in SRN designing and reconstruction [23].

Figure 5 ─ The transport pyramid of inclusive street-road environment

Taking into account the mass of the pedestrian movement (almost every citizen with one or another frequency used to move the walking) and its safety for the environment, on the highest step of this pyramid put pedestrians. The second step is cycling transport, which has the same advantages and problems as the pedestrian, but occupies a separate place in the pyramid because it allows you to overcome much larger distances (effective radius of bicycle use is 5 – 7 km) and needs parking spaces and, on separate streets, a separate infrastructure. The third step of the transport pyramid takes public transportation, which carries far more people than private cars, produces considerably fewer emissions (especially trolleybuses), takes much less space on the road and is not parked for a long time in the central part of the city. The social role of public transport, which is much more affordable for private cars, is also great. To commercial vehicles, which deliver the required goods, in cities with an efficient transport system they give priority over private transport, since convenient conditions for this kind of transport stimulate business development and prevent the shortage of goods. Standard is the permission of commercial vehicles in certain hours, usually in the morning. The last step in the pyramid of priorities takes private cars, which, although provide a high mobility, comfort and unlimited travel range, has low efficiency. Large expenditure of energy efficiency relative to the weight he carries), causing noise and chemical pollution and occupies large areas.

Since 2018 priorities change that occurs in transport planning is beginning to be reflected in Ukrainian regulations. In the updated regulations, the requirements for the mandatory design of bicycle paths and lanes for new construction and reconstruction of streets are beginning to appear [24 - 26]. And also there are state building codes for buildings and structures inclusiveness [27].

So the question arises: how to implement change in priorities under the existing building settlements. We need to redistribute the space between pedestrians, cyclists, public and private transport. As a result of the foreign and domestic experience analysis, the authors proposed the following options for solving this problem. In order to give cyclists and pedestrians more space, we need to either narrow the lanes for private transport or reduce their number. Let's look at these two main ways.

1. The narrowing of lanes.

The change in priorities in Ukrainian normative documents is also evidenced by the narrowing of the regulatory minimum width of lanes on the roadway.

Thus, in the normative document DBN «Streets and roads of settlements», in effect since 2001, the minimum allowable lane width on main streets and roads of city and district significance in the most significant, significant, large, medium and small cities was 3.75 meters. Instead in document DBN «Streets and roads of settlements», in effect since 2018, minimum allowable lane width on main roads of city significance with continuous movement in the largest and large cities is 3.5 meters, and on main streets of city and district significance in the most significant, significant, large, medium and small cities, except streets with continuous movement, as well as on village roads and main streets is 3.00 meters.

Also, the minimum allowable width of the lane on local residential streets in this DBN in effect since 2001 was 3.5 and since 2018 is 2.75 meters.

That is, according to changes in regulations, free spaces from 0.25 to 0.75 m wide in each traffic lane appear on Ukrainian streets. That is, for example, on streets with 4 lanes, built according to the old regulations, released from 1 to 3 m.

The task of planners now is to reorient these spaces during the reconstruction of streets and provide them with functions that will meet, first of all, the needs of pedestrians, cyclists and public transport.

2. Reducing the number of lanes

The most popular in the United States option of reducing the number of lanes is ***«4-3 road diet»***, when a two-way street with two lanes in each direction becomes a three-lane (fig. 6) [28].

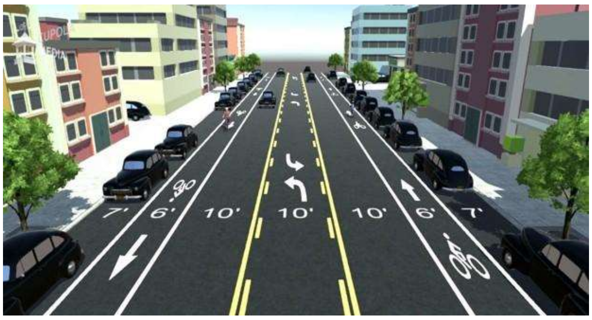

Figure 6 – Three lanes instead of four

The lane in the middle is reserved for those who go to the left. The remaining space can be used to create bicycle lanes, widen sidewalks or arrange dedicated lanes for public transport.

Converting four-lane roads to three lanes makes them substantially safer. This is evidenced by the following data [29].

• 3-lane roads are much safer for car drivers.

In 2013, a study of streets reconstructed on this principle was conducted in 17 cities. It turned out that in small cities, this version of the road diet reduces road accidents by 47%, and in large by 19% [28]. No reduction in street capacity was detected in any of the cases. Similar data are given in [29]. Converting roads from four lanes to three has been found to reduce collisions anywhere from 20 to 50 percent (fig. 7).

• 3-lane roads have a marginal impact on traffic flow. Such diet usually sees a reduction in car throughput in the 5% to 10% range. As the Federal Highway Administration report puts it, “under most average daily traffic conditions tested, road diets have minimal effects on vehicle capacity” [30].

• 3-lane roads slow speeds. The main difference between a 4-lane road and a 3-lane safe street is that traffic speeds go down and become far more uniform. It’s a proven fact that reducing speeds even a little bit, i.e. from 40 to 30 miles per hour, can make a huge difference in accident severity for pedestrians and bicyclists.

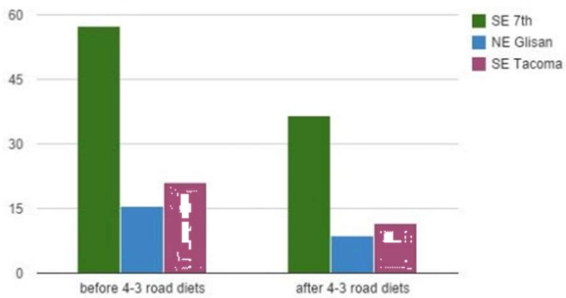

Figure 7 – Average traffic crashes per year

• 3-lane roads increase biking and walking. After a 4-3 road diet was fixed in San Francisco, “bicycle usage increased 37% during the PM peak hour, the number of pedestrians increased 49% during the PM peak hour, and public response has been overwhelmingly positive about this project” [29]. That’s just one example; also, it’s common sense.

• reducing the number of lanes is really cheap. Unlike expensive street reconstructions cities and counties can quickly, easily, and cheaply fix such redistribution of space.

For three-lane one-way streets with parking on both sides, there is a proposal for ***"3-2 road diet"***, which offers to remove one of the lanes and narrow the parking a bit, and give the freed space for a two-way bike lane (fig. 8).

Figure 8 – Two lanes instead of three

Such traffic reorganization on one of the Brooklyn streets has reduced the speed of cars by 77% and the number of accidents by 63%. At the same time, the capacity of the street and the total travel time for motorists remained at the same level [28].

The first example of reducing the number of lanes in Ukraine was John Paul II Street in Ivano-Frankivsk, where they turned four lanes into two (fig. 9).

This *«4-2 road diet»* allowed the creation of safety islands to protect pedestrians, bike lanes for cyclists and a separate pocket for turns.

Figure 9 – Two lanes instead of four

Let's consider one more proof of expediency of lanes on city streets and road quantity reduction. Analysis of methods for calculating the required number of lanes [18, 31, 32] showed the following.

The capacity of the designed highway, required to pass the traffic flow of given traffic intensity, taking into account the perspective, is determined by the formula:

$$P_T = N / z , \qquad (1)$$

where z is the perspective loading of the highway by traffic.

The capacity of a multi-lane roadway is defined as the sum of the capacities of its component lanes:

$$P = \sum P_i . \qquad (2)$$

The capacity of each lane on the street is different. The closer the lane is to the center of the roadway, the less its capacity. This is primarily due to the restructuring, i.e. changing lanes.

The capacity of the i-th lane is determined by the formula:

$$P_i = P_1 \cdot k_{ni} \cdot k_c , \qquad (3)$$

where P_1 is the capacity of the first lane, units / hour;
k_{ni} - the coefficient of reduction of the i-th lane capacity depending on its number, table 1;
k_c is the coefficient of capacity reduction depending on the composition of the flow.

Table 1 – Capacity reduction factor depending on the lane number

lane number	1	2	3	4 and more
k_{ni}	1	0,85	0,7	0,5

Therefore, the capacity of the multi-lane roadway is defined as:

$$P_i = P_1 \cdot k_c \cdot \sum k_{ni} , \qquad (4)$$

To pass the traffic flow of given traffic intensity, taking into account the perspective and load level, it is necessary that the capacity of the designed city highway with a multi-lane roadway (P) was not less than the required capacity (P_T). Given the dependences (1) and (4), we have:

$$P_1 \cdot k_c \cdot \sum k_{ni} \geq N / z . \qquad (5)$$

Whence

$$\sum k_{ni} = N / P_1 \cdot k_c \cdot z. \qquad (6)$$

According to table 1, it is necessary to take the number of bands (n) at which the value of the total capacity reduction factor would be not less than that obtained by formula *(6)*.

As we can see, the efficiency of the roadway decreases with the increasing number of lanes: from the position of capacity in four-lane carriageway almost not used one lane ($\sum k_{ni}$ = 3.05), and in six-lane - already two ($\sum k_{ni}$ = 4.05). Therefore, reducing the width of the roadway is justifiably appropriate, but requires further research.

Conclusions

The settlements' infrastructure development, aimed at satisfying, first of all, the needs of motorists, is accompanied by powerful negative changes in the conditions of human life. Recently, more and more researchers of transport planning use the term «Automobile Dependency». World experience shows that even investing heavily in the street and road network (SRN) development, the solution of road transport services complex problems, it is impossible to solve the problem of transportation in large cities by providing comfortable movement of cars. Not by chance the best in terms of transport cities in the world (Copenhagen, Berlin and others) use the so-called pyramid of priority, which advice to apply when making decisions in SRN designing and reconstruction. In the first place in this pyramid are pedestrians, in the second cyclists, in the third public transport, then commercial and in last place private cars. In the article is analyzed and summarized the world experience of urban street-road network reconstruction in accordance with the change of priorities that has occurred in the theory of transport planning. It singled out 2 basic options for the redistribution of space between pedestrians, cyclists, public and private transport:

1) lane narrowing for private transport;
2) reducing the lanes number for private transport.

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