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ASSESSMENT OF THE ROAD NETWORK TAKING INTO ACCOUNT PEDESTRIAN ACCESSIBILITY (on the example of Tashkent city)

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Abstract
The article provides an overview of scientific and practical work on the issue of pedestrian accessibility in world practice. There are two main groups of publications. The first group is focused on the factors influencing the increase in the number of pedestrians, and the second - on the measurement and evaluation of these factors. Two approaches to assessing the factors characteristic of the components of the passability parameters are considered. It was revealed that the indication of the density of the road network and the issues of pedestrian accessibility of the city of Tashkent do not meet the accepted standards. The relationship between different types of movement is considered, where priority is given to pedestrians and cyclists. Various existing indexes for assessing pedestrian accessibility are analyzed and a conclusion is made about the need to develop an index of pedestrian accessibility for the conditions of the Republic of Uzbekistan using the example of Tashkent.

Keyword: City road network, pedestrian accessibility, assessment of accessibility factors, pedestrian and bicycle paths, sidewalks and footpaths, pedestrian space, pedestrian accessibility index.

Оценка улично-дорожной сети с учетом пешеходной доступности (на примере г.Ташкента)

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Аннотация
В статье приведен обзор научно-практических работ по вопросу пешеходной доступности в мировой практике. Выделены две основные группы публикаций. Первая группа ориентирована на факторы, влияющие на увеличение количества пешеходов, а второй – на измерение и оценку этих факторов. Рассмотрены два подхода к оценке факторов, характерные для компонентов параметров проходимости. Выявлено, что показание плотности улично-

дорожной сети и вопросы пешеходной доступности города Ташкента не отвечает принятым нормам. Рассмотрена взаимосвязь между различными видами передвижения, где предусматривается приоритетность пешеходу и велосипедистам. Проанализированы различные существующие индексы оценки пешеходной доступности и сделан вывод о необходимости разработки индекса пешеходной доступности для условий Республики Узбекистан на примере г. Ташкента.

Ключевые слова: Городская улично-дорожная сеть, пешеходная доступность, оценка факторов доступности, пешеходные и велосипедные дорожки, тротуары и пешеходные дорожки, пешеходное пространство, индекс пешеходной доступности.

Кўча–йўл тармоғини пиёдаларнинг манзилга етиб олиш имкониятини инобатга олиб баҳолаш (Тошкент ш. мисолида)

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Аннотация:

Мақолада жаҳон амалиётида пиёдаларнинг манзилга етиб бориш имконияти масаласи бўйича олиб борилган илмий-амалий ишларнинг обзори келтирилган. Бу ишларнинг иккита асосий гуруҳи мавжуд эканлиги кўрсатилган. Биринчи гуруҳ пиёдалар сонининг кўпайишига таъсир этувчи омилларга, иккинчиси - бу омилларни ўлчаш ва баҳолашга қаратилган. Ўтиш қобилияти параметрларининг таркибий қисмларига хос бўлган омилларни баҳолашнинг иккита ёндашуви кўриб чиқилган. Тошкент шаҳрининг кўча-йўл тармоғи зичлиги кўрсаткичи ва пиёдалар учун қулайлик масалалари қабул қилинган меъёрларга жавоб бермаслиги кўрсатилган. Ҳар хил ҳаракат турлари ўртасидаги муносабатлар кўриб чиқилган, бу ерда пиёдалар ва велосипедчиларга устунлик берилиши таъкидланган. Пиёдалар учун манзилга етиб олиш даражасини баҳолаш бўйича мавжуд турли индекслар таҳлил қилиниб, Тошкент шаҳри мисолида Ўзбекистон Республикаси шароитлари учун пиёдалар учун манзилга етиб олиш индексини ишлаб чиқиш зарурлиги тўғрисида хулоса чиқарилган.

Калит сўзлар: Шаҳар кўча-йўллари тармоғи, пиёдаларнинг манзилга етиб олиши, манзилга етиб олиш омилларини баҳолаш, пиёдалар ва велосипед йўллари, тротуарлар ва пиёдалар йўллари, пиёдалар майдони, пиёдаларнинг манзилга етиб олиш индекси.

Recently, the concept of pedestrian accessibility (walkability) has become of significant importance. Developed countries are reconsidering their approach to the movement of people on foot due to awareness of climate change (increased frequency of natural disasters, rising temperatures), deterioration of health (mass obesity). All these factors affect the socio-economic environment, as well as the behavior of road users. Consequently, special attention is paid to increasing the space for pedestrians by creating alleys and streets intended only for pedestrians, where the movement of motor vehicles is prohibited. Pedestrian accessibility (walkability) is the ability to move on foot.

According to the Decree of the President of the Republic of Uzbekistan dated October 30, 2020 No. DP–6099 "On measures for the widespread introduction of a healthy lifestyle and the further development of mass sports" [1], payment of payments for walking through the Healthy Lifestyle platform is provided from January 1, 2022 (1hls.uz). This decree also provides for the construction of pedestrian and bicycle paths in each district center and cities of the republic. All this points to a special focus on improving a healthy lifestyle and creating conditions for pedestrians and other road users.

Every year, designers and architects of urban infrastructure, as well as initiators of healthy living pay special attention to places with a large number of people who walk, use wheelchairs and stand, as well as run, shop, sit, contribute to street life, try to lead an active lifestyle and understand their place in space and time.

In connection with the above, it is necessary to review scientific and practical works on the issue of pedestrian accessibility in world practice, as well as in the major cities of our republic, which include the capital of our country - Tashkent.

Pedestrian accessibility is an important component of our daily life, since all trips begin with walking. Its importance increases with the need to achieve goals quickly and in a short time, for example, the purchase of essential goods, household goods, medicines, cash withdrawal or visits to polyclinics, fitness centers, entertainment facilities, etc. Walking is influenced by various factors related to physiology, social status, psychological state to overcome a certain distance. The choice of walking also depends on external factors such as weather conditions, the condition of the road (pedestrian path), aesthetics of the area (nature), convenience, safety (crime rate), traffic safety and other factors.

Critical sections can include areas where conflict situations arise, such as regulated and unregulated pedestrian crossings, intersections, crossing of multi-lane streets and roads, high traffic intensity, etc.

When planning urban infrastructure, the location of important institutions, retail outlets and social organizations is an integral part of the theory and practice of urban planning. One of the innovative works devoted to this problem is the "theory of the central place", developed by the German geographer Walter Kristaller in 1933 [2]. Although the main focus of this work is on the hierarchical distribution of settlements, their size and number [3], the theory tries to explain that the location of certain economic services and their availability are closely related to the location of settlements [4].

The specifics of the functioning of street and road networks are due to the fact that the development of the automotive industry and the increase in living standards, as well as the rise of urbanization, in the last 50-60 years, special attention has been paid to the planning and design of roads and streets dedicated to motor vehicles. But there are exceptions, especially in European countries such as the Netherlands, Denmark, Norway, Sweden, where special attention was paid to other modes of transport, such as cycling. It should be noted that the approach to the development of the road network differs between the United States and European countries. But common to developed countries is that in the last 10 years attention has been paid to a healthier lifestyle and ensuring road safety in urban conditions, as a result of which public organizations promote various programs “Zero Vision”, “Speed Limit 30 km/h”, “Streets for walking and cycling”.

In modern foreign works on the problems of the development of transport systems and the road network (UDS) of cities, often refer to the official document “Traffic in cities”, published in the UK in 1963. The author of this document Colin Buchanan formulated the concept of environmental capacity, which, in his opinion, defines environmental restrictions on the development of the urban environment and transport systems of cities in particular. The author's merits include [5] the “concept of concentration”, according to which traffic flows should be concentrated on the main thoroughfares. His idea of forming an urban landscape by dividing urban areas into traffic calming zones and traffic-free zones (traffic calmed and traffic-free zones) predetermined the subsequent trends in the design of UDS cities.

In recent years, views on the goals and methods of road traffic management have undergone fundamental changes. The main problems are the excessive dependence of the population on an individual car, the congestion of cities and especially their centers by road [6].

The term “human dependence on a car” [7, 8, 9] has received the following definition: dependence on a car is the cumulative effect of a number of factors leading to a high level of car use and limiting the possibilities of using alternative modes of transport. There is another definition: the transport system and the organization of the territory focused on the use of the car (automobile oriented transportation and land use patterns).

In recent decades, international coordination has been carried out in the field of transport, highways and urban planning. The largest international organization conducting such coordination is the World Road Association (PIARC). Issues of development of road infrastructure, transport systems of cities are systematically considered in the documents of the relevant committees of PIARC [10-13].

According to these documents , the following most important directions of the development of the ODD are envisaged :

- reducing the intensity of car traffic in city centers;
- priority of public passenger transport and cars,
- used by several passengers (HOV – high occupation vehicles);
- parking regulations;
- interaction between the road network and the urban environment.

Similar priorities in the field of ODD are formulated in special documents of the Institute of Transportation Engineers of the USA (ITE), dedicated to the problems of congestion of the road network.

In order to respond to modern problems and situations in cities, it became necessary to develop tools and methods for measuring pedestrian accessibility in cities and districts. The study and the method of measuring pedestrian accessibility depend mainly on the definition and on what factors we consider important in the formation of a pedestrian-friendly environment. The definition of pedestrian accessibility is difficult to grasp, and it depends on the factors that are taken into account, from the presence of different directions and population density to very subjective characteristics of the environment, i.e. comfort, safety and picturesqueness. One definition equates pedestrian accessibility to "the extent to which the characteristics of the built environment and land use may or may not be favorable for residents of the area walking for recreation, exercise or recreation, for access to services or for commuting to work" [14]. The American scientist Speck defines a pedestrian-friendly environment as safe and favorable, where streets, sidewalks and pedestrian paths are convenient and interesting [15].

According to [16], objective and consistent measurement of the quality of pedestrian accessibility as independent variables that will explain walking, use of public space and other potential results play an important role in assessing pedestrian accessibility.

Designers can take inventory of the physical characteristics of the UDS to assess these qualities when evaluating public spaces in order to identify problems and develop strategies for their improvement. Architects can pay attention to the physical characteristics associated with the quality of urban design when designing public spaces.

Talen and Koschinsky [17] proposed a normative definition that characterizes an area favorable for pedestrian traffic as "a form of space that encourages pedestrians to be active and minimizes environmental degradation. This is due to social, economic and beneficial (in the context of land use) diversity. It has features of a public space that allow interaction and exchange, as well as offer equal access to goods, services and amenities." Some publications on pedestrian accessibility in an urban environment relate to the field of medicine, where special attention is paid to the relationship between pedestrian accessibility and obesity [18]. It turned out that zones that promote pedestrian traffic correlate with a decrease in the risk of obesity [19]. Many studies have analyzed the tendency to increase physical activity depending on specific environmental characteristics, such as the availability of services or the quality of the environment for pedestrians or cyclists. It was found that the presence of recreational facilities positively correlates with a greater propensity for physical activity [20]. Moreover, a long distance from bike paths or the presence of steep ascents negatively correlates with cycling activity [21]. Studies show that pedestrian accessibility increases the value of real estate [22] and has a positive effect on the sustainable development of neighborhoods, reducing the level of isolation and crime [23]. However, the increase in building density itself can be considered as a factor that worsens the quality of the area, although it does not have a negative impact on real estate prices [24].

The author [25] has developed an index of pedestrian accessibility associated with the choice of a trip. Using census data from two US states, people with high pedestrian accessibility and high income showed that people in low-income areas walked to work more often than residents of areas with low pedestrian accessibility. In a second test using 2-day trip diaries from King County, Washington, it was found that the number of registered hikes was 6.45 times more, and the kilometers traveled by own vehicles were 52% lower in the highest compared to the lowest decile of pedestrian accessibility. A large number of walks in areas with high traffic provides initial support for the reliability of the pedestrian accessibility index.

How we define pedestrian accessibility is of great importance for our understanding and design of urban transport networks and public spaces, but little effort has been spent on understanding how to optimize space for pedestrians. Factors that appear in a number of different indicators or indicators of pedestrian accessibility include the following:

The presence of continuous and well-groomed sidewalks; Universal access characteristics; Straightness of the path and connectivity of the street network; Safety of intersections at the same level; Lack of heavy and high-speed traffic; Pedestrian separation or buffering from traffic; Density of land use; Diversity or combination of land use; Street trees and landscaping; Visual interest and sense of place determined by local conditions; Perceived or real security [26].

The dissertation [27] proposed a global pedestrian accessibility index for developing countries such as India, China, Vietnam, Pakistan and others. Based on the expert assessment, 22 factors for assessing pedestrian accessibility were selected, which take into account 45 variables. With the help of volunteers, surveys were conducted in various countries and based on these data, a global pedestrian accessibility index was created. A methodology for developing a pedestrian accessibility index is proposed.

In the field of pedestrian accessibility research, two main groups of publications can be distinguished. The first is focused on the factors influencing the increase in the number of pedestrians, and the second is aimed at measuring and evaluating these factors. According to Servero and Kokelman [28], higher building density, multifunctionality and the corresponding streetscape reduce the number of people traveling by car and positively correlate with the choice of other modes of transport, including public, bicycle or pedestrian. This creates the concept of so-called three-dimensional pedestrian accessibility based on three "D-dimensions" that promote pedestrian communication, i.e. density, diversity and landscape. This concept was further developed by adding parameters for the accessibility of the destination [29] and the distance to transport [30], eventually forming the "5D pedestrian accessibility". Another group of ten factors along with the measurement method was proposed by Ramirez et al. [31]. In addition to the physical elements of the built-up space, the set also includes factors of local politics and social engagement.

Subsequent research has focused on exploring how to measure and evaluate factors specific to the components of accessibility parameters. The most difficult for objective measurement is the streetscape, which, in addition to physical characteristics, such as the location of the street network, sidewalks or bike paths, should include an assessment of building elements from the pedestrian level. Ewing and Clemente [32] tried to evaluate the characteristics classified into five categories: imagery, visual fencing, human scale, transparency and complexity. These categories were determined based on a literature study and an assessment of the top ten experts in the field of spatial and urban planning.

Another group of ten factors along with the measurement method was proposed by Ramirez et al. [31]. In addition to the physical elements of the built-up space (land use environment, structures, transport environment, aesthetics, movement patterns), the set also includes factors of local politics and social activity.

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In 2016, Ewing et al. [32] conducted a study with the main purpose of assessing the impact of the streetscape on the number of pedestrians in the context of other so-called D-dimensions, i.e. diversity, accessibility of destination, density and distance to public transport, as well as a new additional dimension — demography.

Another approach to assessing pedestrian accessibility was proposed by the London Planning Advisory Committee, which suggests that pedestrian—friendly places should be interconnected, convenient, comfortable, friendly and noticeable - the "5C" approach. Well–connected streets are streets whose network is connected to so-called "key attracting factors", such as a place of work, home, recreation area or public transport. Walking comfort refers to a situation where walking can compete with other modes of transport in terms of time, cost and space. It also depends on the pedestrian accessibility of various urban functions. A pleasant environment is an environment equipped with various pedestrian facilities and accessible to pedestrians with different needs and abilities. To facilitate pedestrian communication, the street network must be legible and well-marked.

Mura et al. [33] added two more functions, namely coexistence and commitment, creating the "7C" approach. The first sign refers to the level of pedestrian safety, and the second – to the degree of pedestrian participation in the formation of the street environment. All seven characteristics were measured using a set of 17 key indicators (indicators of accessibility and attractiveness of the pedestrian environment and data obtained from direct field research and digitization of topographic maps. The final synthetic patency index was developed in GIS. The main contribution of this study is the assertion that the developed group of indicators is representative and can be used to assess patency instead of direct observation or survey.

Picard et al. [34] developed a conceptual model of factors contributing to increased pedestrian activity. Among the factors affecting the readiness to walk, the spheres of functionality, safety, aesthetics and purpose are highlighted. Functional characteristics refer to the physical characteristics of sidewalks and roads, and the group of safety functions reflects the need to create a pedestrian environment that allows the use of sidewalks without any danger from other users. The concept covers two more areas: aesthetics and directions.

The more diverse services, shops, public transport stops or recreation areas there are in the vicinity, the more chances there are to increase the number of pedestrians.
Improved pedestrian accessibility provides cost savings for consumers and the public, increases the standard of living in the community, improves public health, promotes strategic economic development, land use and equity. The result suggests that when applying the principles of cost allocation, motorists should pay significantly more than at present in the form of user fees, and more resources should be allocated to non-motorized vehicles, or those who do not have vehicles should receive tax discounts.
Local authors [38] made a comparative analysis of the density of the road networks of the city.Tashkent is relatively large cities in Europe and other developed countries. The density of the street and road network of the compared cities is 8.6 - 15.0 km/km2, while this indication of the city of Tashkent is 2.19 km/km2. The indication of the density of the road system of the city of Tashkent is two times less than the indication of the city of Moscow, which is 3.3 times larger than Tashkent in terms of territory. This is how we justify the opposed concept so far. In many cities of the West and in large cities of developed countries, a global problem has appeared due to urban transport. Based on this experience, it is appropriate to look at this from a critical point of view in order to achieve optimal UDS density.
Based on this, we can say that the density indication of the street and road network of the city of Tashkent does not yet meet the accepted standards. In order to implement the required indication, in some areas it is necessary to plan the construction of new streets. Today there is such a concept - "it is necessary to create conditions for people as much as possible" - this has been confirmed in developed countries.
Due to the rapid growth of motorization in developing cities, it is necessary in the future to lay down traffic intensity in the project plans, which is continuously increasing, and then plan traffic management schemes that will improve road safety not only among transport, but also pedestrians.
The authors [39] investigated the methodology for assessing pedestrian and transport accessibility using geoinformation systems that allow further analysis of developments in the field of transport. The approach implemented in the article to assess transport and pedestrian accessibility can help in further developments on the transport analysis of objects.
The authors [40] analyzed the main methods and principles of constructing the space of streets, including pedestrian ones. The visual properties of pedestrian streets are analyzed according to the principles of closeness and dynamism, the techniques of closure and localization of linear spaces, partitioning of spaces to achieve dynamism are considered. Streets, including pedestrian ones, belong to linear systems, the perception of which when moving along a single axis is based on the sequential addition of frontal, three-dimensional and deep pictures.

The problem of formation and development of urban pedestrian systems is becoming more and more urgent. Experts around the world continue to search for a solution to the key paradox of modern urbanism – cozy cities for people or cities distributed in space for cars. A review of modern urban planning concepts shows that they give priority to the person, and in some of them pedestrian accessibility and a developed pedestrian system are the key points of the concept.

The relevance of the topic of the organization of pedestrian spaces and the typology of the constituent elements of pedestrian spaces has been formed depending on their functional, compositional, planning and geometric parameters, as well as pedestrian accessibility. This classification makes it possible to identify the basic principles of the organization of pedestrian spaces in an urban environment [41]. In this work, an important semantic block of the study was the identification of criteria for the quality of the pedestrian environment: increasing the categorization of infrastructure facilities, organization of parking places, including in specially equipped parking lots and garages; development of entertaining food; organization of places of mass recreation; arrangement of organized viewing platforms; use of various modes of transport; ensuring access for the disabled.

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The relevance of the topic is beyond doubt - since pedestrian accessibility plays an important role when making daily trips by public transport, bicycle transport or by own transport, although the latter is less demanding for walking. Due to the relationship between different types of movement, conflict situations may arise and, therefore, priority should be given to pedestrians and cyclists. since they are the most vulnerable road users.

The above literature review shows the following:

- Development/widening of roads for passenger cars does not solve the problem of congestion and does not reduce the number of accidents involving pedestrians;

- Widespread reduction in the speed of motor vehicles in large cities contributes to the reduction of accidents with serious injuries and promotes walking, the creation of streets and alleys for pedestrians;
- Pedestrian accessibility is the main indicator of how convenient the street and road network is for walking;
- In the concept of urban transport and road transport infrastructure development in Tashkent, special attention is paid to creating a convenient, attractive public transport system in the city of Tashkent, while priority is given to creating a favorable infrastructure for pedestrians, then, respectively, for bicycle transport, urban public transport and personal transport.
- There are various indices of pedestrian accessibility assessment such as the World Walking Accessibility Index (Global Walkability Index), Walking assessment (Walkscore), National Walking Accessibility Index (National Walkability Index);

From the above, it follows that it is necessary to develop an index of pedestrian accessibility taking into account the climatic conditions of the Republic of Uzbekistan on the example of Tashkent.

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