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Isakova Muqaddas Badirovna
Tashkent; Associate Professor,
Kamoliddin Behzod National Institute of Arts and Design
mrdi.isakova@gmail.com tel: +998998877877

CONCEPT OF CREATING "SMART INCLUSIVE ARCHITECTURE" SYSTEMS BASED ON SMART TECHNOLOGIES

Annotation

This article highlights the recent years' developments in our country in creating conveniences for persons with disabilities and elderly people within urban infrastructures. It covers measures implemented in public spaces, newly constructed buildings, and some reconstructed facilities, such as the installation of ramps for wheelchair users, tactile paving for the visually impaired along pedestrian walkways, audible traffic lights at intersections, the launch of special transport vehicles, and the creation of conveniences through digital technologies.

The article addresses human rights, in particular the "strengthening of guarantees of the rights of persons with disabilities, inclusive development, and the introduction of effective mechanisms to ensure equal rights and opportunities for all segments of the population," as well as proposals for systematizing the creation of necessary conditions for the participation of persons with disabilities in all spheres of public life through the application of modern technologies.

The aim of the study is to develop principles for establishing inclusive universal environment solutions and specialized centers for people with limited abilities.

The object of the study includes specialized institutions for persons with disabilities and rehabilitation centers in Tashkent city.

The research results are significant not only for expanding and enriching knowledge in the field of urban planning in Uzbekistan but also for carrying out scientific project work on organizing and modernizing the architectural environment of specialized centers for the population. The practical significance of

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the research lies in its applicability in the activities of architectural and construction organizations, in practices aimed at improving modern architecture and urban planning, as well as in contributing to the content of disciplines in the field of architecture and urban planning in higher educational institutions.

The study concludes that, based on the scientific results obtained regarding the creation of a barrier-free environment for persons with disabilities in urban infrastructures and the organization of the architectural environment of specialized centers, proposals have been developed for improving regulatory standards.

Introduction.

The issue of creating a barrier-free environment is being extensively studied in modern urban planning and architectural practice as one of the most relevant scientific directions and is widely applied in the design process based on an integrated approach. In the United States, the main legal basis of this field is the Americans with Disabilities Act (ADA), according to which ensuring the accessibility of urban environments and buildings is mandatory. In Germany, the creation of a barrier-free urban environment is regulated by the DIN 18040 standards, which ensure the accessibility of public-use buildings and facilities and require mandatory implementation. Sweden is actively implementing advanced programs on inclusive design, and cities such as Stockholm serve as examples in adapting urban spaces for people with disabilities through the use of innovative technologies. Japan, in turn, significantly improves the mobility and wayfinding capabilities of people with disabilities by utilizing digital technologies and robotic systems.

International organizations, especially the United Nations, have reflected the issues of accessibility and the rights of persons with disabilities in their Convention on the Rights of Persons with Disabilities, which has been adopted as the basis for developing national programs in many countries. In this regard, countries are taking wide-ranging measures in their urban planning and architectural policies to consider the needs of persons with disabilities, fully adapt infrastructure, create

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barrier-free environments, establish rehabilitation and adaptation centers, and develop transport and social services based on universal design principles. At the same time, this convention serves as an incentive in scientific research to develop new conceptual approaches aimed at creating socially inclusive, equitable, and accessible architectural environments, which makes research in this field highly relevant.

Globally, scientific research in the following areas is considered one of the pressing issues: creating a barrier-free environment for people with disabilities; introducing universal design principles in architecture and urban planning; improving the infrastructure of rehabilitation and adaptation centers; integrating smart technologies; ensuring psychological and aesthetic comfort; and effectively organizing processes of social inclusion and integration. By developing proposals for creating environments in urban infrastructures and various buildings and structures that are adaptable to users' needs through smart systems, it is possible to increase the activity and independence of people with disabilities.

In Uzbekistan, UNICEF representatives are actively implementing new projects in collaboration with international partners. One such initiative is the "Inclusive Education Roadmap," which has received an investment of USD 600 million. UNICEF's representative in Uzbekistan, Munir Mamedzade, emphasizes in local media publications that education plays a crucial role in the country's development and that inclusive education is vital for sustainable progress.

According to global statistics, there are approximately 45 million blind individuals worldwide and 217 million people with visual impairments. Among them, elderly citizens aged 80 and above constitute a significant portion of the blind population. Around 90% of people with visual pathologies reside in developing countries, and 1.4 million children suffer from vision-related disabilities. In addition to visual impairments, the number of people with musculoskeletal disorders is also increasing.

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The total number of persons with disabilities varies by region and time period due to differences in data collection methods. Generally, it is estimated that 10–15% of the world's population lives with some form of disability. Several factors influence these figures:

1. Demographic factors: Age structure, gender, lifestyle, and total population size can affect the number of PWDs.
2. Definition of "disability": Different countries and organizations use varying criteria, considering mobility limitations, visual or hearing impairments, and mental health challenges.
3. Healthcare and rehabilitation capacity: The availability of medical care, rehabilitation, and social integration services significantly affects disability statistics.

Global Statistics (Approximate): According to the World Health Organization (WHO), the number of PWDs is steadily increasing due to rising life expectancy and age-related disabilities. The World Statistics Center reports that about 4% of the global population experiences musculoskeletal difficulties. After the COVID-19 pandemic in 2019, post-viral complications further contributed to an increase in disability cases.

WHO data (2021) shows that 39 to 246 million individuals are visually impaired globally. In recent years, Uzbekistan's population has been steadily growing. Official statistics for 2022–2023 indicate that the number of registered PWDs in Uzbekistan accounts for 2.1% of the total population. However, considering that around 15% of the global population lives with some form of disability, the actual figure in Uzbekistan is likely higher.

The scientific foundation of integrating inclusive approaches based on smart technologies into modern architectural practice involves analyzing international and local experiences and proposing a conceptual model that can be applied in the conditions of Uzbekistan. Integration of smart technologies into contemporary architectural practices significantly enhances the functional capabilities of spaces

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and the degree of user-orientation. The main objective of this integration is to ensure that the environment adapts to users' needs in real time.

E. Bydarin, N. Saprykina, and S. Manley [1]have studied the characteristics of ergonomic principles in modern residential architecture and design Their research focuses on enhancing the social activity of people with disabilities, strengthening their role in the development of society, and integrating international standards into building and facility requirements in accordance with the anthropometric dimensions of people with disabilities by applying ergonomic requirements in architectural objects. [1].

K. Regenbrext and L. Francis[2] have explored modern approaches to adapting people with disabilities to the external environment, including the role of disabled architects in creating inclusive spaces "Disabled Architects: Unlocking the Potential for Practice", as well as social protection and adaptation measures in Germany U. Rau[3] developed long-term strategies on the topic of "Barrier-Free Construction for the Future."[2], [3].

D.D. Elina, O.O.Smolina, O.V. Guseva, I.F. Lamov,[4] A.A. Kim, and E.S. Chekanova[5] have conducted scientific research on "Creating a Comfortable Environment for People with Disabilities" and "Inclusion in Modern Society" analyzed regulatory documents and international practices on transforming urban environments into barrier-free spaces based on standards from Russia, Europe, and the United States.[4],[6].

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S.G. Terskova [6]provided recommendations for developing methods to create safe and comfortable environments for people with disabilities and identified rehabilitation as one of the main directions of regional social policy. E.S. Chekanova studied the significance of a barrier-free environment in product design. I.A. Kozireva [7]and S.S. Chabanova analyzed the issue of direct and indirect discrimination against people with disabilities in the labor sphere. F.S. Ismagilova and L.V. Markova [8]demonstrated the negative impact of the "barrier environment" on the professional integration of people with disabilities. [7],[8].

A.Yu. Tologaeva [9]examined outsourcing as an effective method for employing people with disabilities in the commercial sector. M. Novikov, N. Priseskaya, and V. Kotov [10]developed an employment model for young people with disabilities. K.A. Topilin [11]analyzed measures to encourage the utilization of the labor potential of people with disabilities in the regional labor market. [9], [10],[11].

In addition, J. Imrie and R. Hall, in their work "Inclusive Design: Designing and Developing Accessible Environments," highlighted the universal design concept for people with physical disabilities from both theoretical and practical perspectives. A. Steinfeld and E. Maisel, in their book "Universal Design: Creating Inclusive Environments," provided an extensive analysis of anthropometric and psychological comfort requirements in creating accessible spaces for people with disabilities.

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[6] Terskova, S.G. (2012). *Rehabilitation of Persons with Disabilities as a Direction of Regional Social Policy: Monograph*. Novokuznetsk.
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Among local studies, British university researcher D. Yusupov[12] and the Commissioner for Human Rights of the Oliy Majlis, F. Eshmatova, conducted practical research on eliminating inconveniences in urban infrastructure for people with disabilities in Uzbekistan. Their work developed recommendations for creating a barrier-free environment in the transport system, pedestrian walkways, and public buildings.[12].

The analysis of the above literature shows that creating a barrier-free environment for people with disabilities is a complex and multifaceted process encompassing architectural design, regulatory and legal frameworks, social adaptation, labor market integration, and the activities of rehabilitation centers. International and local experiences emphasize the need to view people with disabilities as an integral part of society and ensure their full rights and opportunities.

Materials and Methods

In the 21st century, the field of architecture is increasingly shaped by the principles of social equality, digitalization, and technological adaptability. The growing complexity of societal needs, the rapid pace of urbanization, and the necessity to ensure the legal and social status of persons with disabilities (PWDs) place entirely new tasks before contemporary architecture. Among these tasks, the creation of comfortable and adaptive residential and public spaces for people with disabilities has become a pressing socio-scientific challenge.

Previously, the universal design approach aimed to make architecture accessible for all; however, this model does not provide the ability to adapt to individual needs in real time. The emerging approach proposes that architectural environments should not only be “usable” but also “adaptive to the user”, thereby benefiting people with disabilities, the elderly, children, and other socially vulnerable groups.

Persons with disabilities reside in all regions of the Republic of Uzbekistan.

[12] Ombudsman of Uzbekistan. *Measures to Accelerate Efforts to Create Equal Opportunities for Persons with Disabilities*. Retrieved from https://ombudsman.uz/docs.

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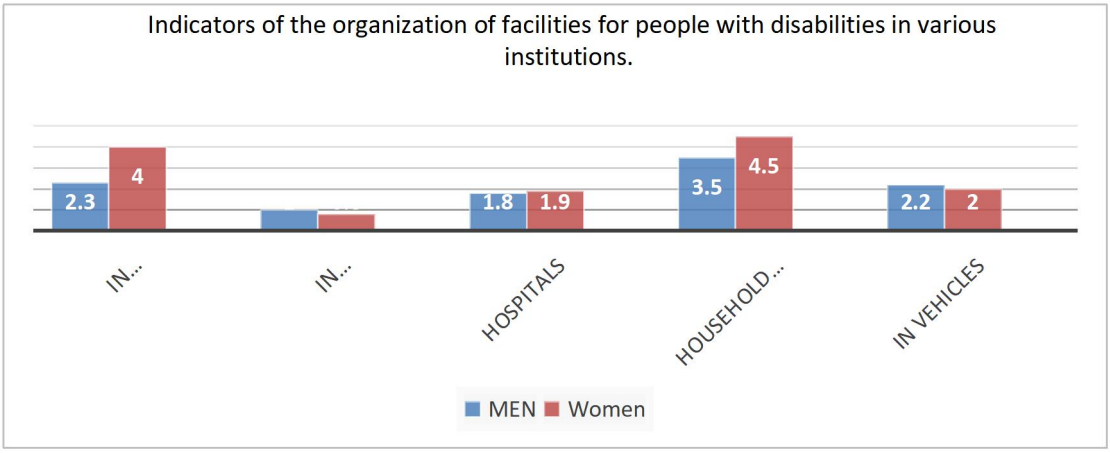
A social survey was conducted on the main streets of Tashkent city, in public areas, pedestrian pathways, and bus stops. Today, many modern constructions in urban infrastructure demand new innovations, as such upgrades are essential to create a comfortable and modern environment for people with disabilities.

Seven people participated in the survey: three men and four women. Visually impaired respondents indicated that they cannot move freely around urban infrastructure objects. When asked about navigating city routes, they explained that they could only move in public spaces essential for their daily social life with the assistance of a companion. Analysis revealed that moving around in recreation areas, water reservoirs, and other parts of the city infrastructure is problematic due to numerous barriers and the insufficient presence of guiding materials.

The statistics on persons with disabilities were calculated based on the criteria defined in the Resolution of the Cabinet of Ministers of the Republic of Uzbekistan No. 210 dated March 22, 2018, “On improving the system for statistical registration of persons with disabilities.” In addition, several supplementary statistical indicators were defined, including: [12].

- Adapting urban infrastructure and educational institutions for the education of persons with disabilities;
- Adapting public transport;
- Developing accessible websites;
- Facilitating employment for persons with disabilities in districts and cities;
- Providing housing;
- Receiving financial assistance from local self-governing bodies;
- Enabling recreation in sanatoriums and resorts;
- Increasing the number of buildings equipped with ramps.

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Results

Such problems were identified through the analysis of the city's central areas. Based on survey results, it is advisable to develop minimum standards for the accessibility of urban infrastructure facilities and to ensure their implementation by the relevant authorities. It is also recommended to conduct explanatory sessions and briefings, with the support of disability organizations, to address the daily challenges faced by persons with disabilities. Compiling accurate district-level statistics on the disabled population and holding interviews with them will help develop practical skills and a deeper understanding of their needs.

1. Legislation and Evaluation System

- Introduce the concept of "inclusive architecture" into the Law "On Architecture and Urban Planning";
- Develop evaluation indicators for the inclusivity and accessibility of objects during project expert reviews.

2. Implementation of Digital Technologies

- Equip all newly built public facilities with IoT devices, AI-controlled systems, and user-friendly interfaces;
- Gradually equip existing social infrastructure (clinics, schools, neighborhood centers) with smart systems;
- Develop special navigational mobile applications for people with mobility, visual, or hearing impairments.

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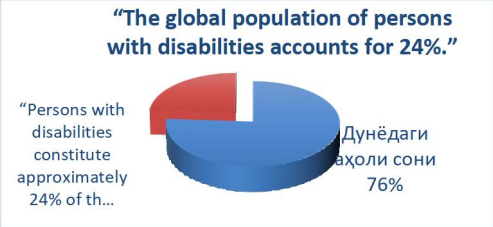
3. Pilot Projects and Local Practices

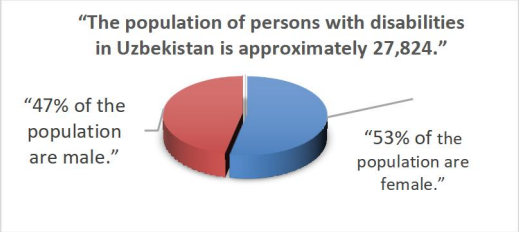
- Establish “Smart Inclusive Urban Areas” in Tashkent and major regional centers;
- Set up model inclusive schools and kindergartens in each region;
- Mandate the integration of inclusive design and smart technologies in all new residential complexes.

4. Technical Solutions

- Automatic activation of doors, lighting, and elevators using ultrasonic, laser, or optical motion sensors;
- Climate control systems automatically managing temperature, humidity, air quality, and lighting;
- Motion-sensitive surfaces providing visual and audio alerts;

  Indoor GPS and mobile applications offering adaptive routes, real-time navigation suggestions, and smart signage systems.





Disability Statistics

If these technical solutions are integrated consistently and systematically, they will not only meet the needs of persons with disabilities but also foster a sustainable, safe, and technologically advanced architectural culture for society as a whole.

Discussion

Global experience shows that when digital transformation and user-oriented design are combined, it is possible to create socially just and sustainable cities. In the context of Uzbekistan, the following factors are of great importance:

1. **Legislative reforms** – introducing the concept of inclusive architecture into the “On Architecture and Urban Planning” law and developing evaluation criteria.

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2. **Technological integration** – equipping new and existing public buildings with IoT- and AI-based smart systems.
3. **Pilot areas** – establishing model smart inclusive districts in Tashkent and regional centers.
4. **Capacity building and public awareness** – promoting inclusivity by conducting special training programs for architects, designers, and engineers.
5. **Integration into architectural education** – introducing inclusive architecture as a subject in architectural and urban planning institutes, and delivering it through modern technologies to achieve positive results.

In the United States, nanotechnologies are used in tactile coverings at the entrances of buildings and facilities within urban infrastructure. These technologies incorporate guidance indicators and hazard prevention signals. International standards for people with disabilities, particularly for two main categories, are regularly subjected to comparative analysis, as modern smart technologies are recognized as some of the most important innovations in architectural structures and urban infrastructure today.

Japan, with its unique mentality, also occupies a leading position in the field of technology. Tutu Ltd., established in 1994, has pioneered the production of tactile materials using modern smart technologies with reduced slipperiness, made from chemically safe substances. The company conducts pilot tests of tactile coverings in infrastructure facilities as well as in residential areas for people with disabilities and the elderly, subsequently implementing them into practice. In building interiors, special attention is paid to functionality — tactile coverings are programmed according to the functions of the buildings and are operated via simple sensors.

Germany is also among the leaders in creating accessibility for people with disabilities. German technologies hold leading positions among global standards; their sensor-based and mobile technologies fully meet durability and regulatory

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requirements and are widely promoted for integrating people with disabilities into society.

The experience of developed countries shows that, for various categories of disabilities, special functional solutions are being implemented — such as programmable smart asphalt coverings, smart technological devices for building interiors, mobile devices, touch-based control systems, and even vision-based control technologies for people with limited mobility. These are increasingly being produced from eco-friendly materials.

Uzbekistan's prospects – Integrating smart materials into the "Smart Inclusive Architecture" concept will bring Uzbekistan's urban environment to a qualitatively new level. For example, in Tashkent and regional centers, there could be photocatalytic road surfaces, public buildings with thermochromic glass, and rehabilitation centers with smart facades. This would not only create a more comfortable environment for people with disabilities but also ensure ecological sustainability and energy savings. Overall, smart materials are expected to be a decisive factor in improving both ecology and technology.

Conclusion:

The development of smart materials and their future significance is considered one of the strategic directions in modern urban planning, architecture, and social infrastructure. Current practices in the United States, Japan, Germany, South Korea, and European countries show that such materials not only offer aesthetic and technical advantages but also ensure environmental sustainability, energy efficiency, and user comfort.

1. Energy efficiency and environmental benefitsThermochromic windows, photocatalytic coatings, and biomimetic biomaterials reduce building energy consumption and significantly lower their carbon footprint. For example, thermochromic perovskite windows produced in the U.S. automatically darken in response to temperature changes, reducing cooling and heating costs. In Japan and

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Europe, TiO_2-based photocatalytic materials decompose air pollutants and keep surfaces clean.

2. User adaptabilitySmart materials do not only perform static functions; they can also adapt in real time to user needs. For example, smart textile façades in Germany automatically adjust shading according to weather and light conditions or collect rainwater for energy purposes. This creates a more comfortable and safer environment for people with disabilities, the elderly, and children.

3. Potential future applications

Urban infrastructure: smart asphalt and photocatalytic road surfaces can be used to purify the air and reduce the urban heat island effect.

Residential buildings: sensor-integrated surfaces, self-cleaning windows, and biomaterials with high thermal insulation can increase energy efficiency in housing.

Public facilities: rehabilitation centers and public buildings can incorporate acoustically adaptive materials, allergen-reducing coatings, and indoor navigation systems.

Prospects for UzbekistanIntegrating smart materials into the “Smart Inclusive Architecture” concept will bring Uzbekistan’s urban environment to a qualitatively new stage. For example, in Tashkent and regional centers, there could be photocatalytic road coverings, public buildings with thermochromic glass, and rehabilitation centers with smart façades. This would not only create a more comfortable environment for people with disabilities but also ensure environmental sustainability and energy savings.

Overall, smart materials are expected to become a decisive factor in improving the ecological, technological, and social quality indicators of cities in the future. By harmonizing the concepts of “smart city” and “inclusive architecture,” they can meet both the current demands and the future needs of coming generations.

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