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Digital Simulation Model for Assessing the Level of Earthquake Damage of Buildings

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Abstract: The article provides information on the formation of a database of individual residential buildings in the city of Tashkent through a complex modeling program and the program's capabilities in order to ensure the seismic resistance of buildings and improve the monitoring of seismic risk.

Keywords: building, structure, design, earthquake, simulation, category of technical condition, vulnerability, seismic safety, model.

Introduction:

In recent years, due to the increasing number of destructive earthquakes in the world, which have a serious impact on the life of the population and on the socio-economic infrastructure of countries, it is important to ensure the seismic strength of existing and under construction buildings and structures, strengthen the interaction of state bodies and organizations in the development of earthquake forecasting, monitoring [1].

Therefore, in order to introduce modern approaches to ensuring seismic safety, further increase the seismic resistance of buildings and structures, develop new methods for forecasting strong earthquakes and create a modern system for preparing for them, a resolution of the President of the Republic of Uzbekistan was adopted. Resolution No. PQ-161 dated April 17, 2024 "On measures to increase the seismic resistance of buildings and structures and improve seismic hazard monitoring activities" was adopted [1]. To ensure the implementation of the resolution and organize preparation for strong earthquakes in the regions based on precise scientific forecasts, starting from May 1, 2024, the Republican Center for Seismoprognostic Monitoring of the Ministry of Emergency Situations has established a practice of submitting monthly conclusions on earthquake risks and predictions to the Council of Ministers of the Republic of Karakalpakstan, as well as the regional and Tashkent city administrations.

Methods and materials:

In order to increase the seismic resistance of buildings and structures and improve seismic hazard monitoring activities, the Tashkent University of Architecture and Civil Engineering, in collaboration with the Institute of Seismology of the Academy of Sciences of the Republic of Uzbekistan, is implementing a practical project on the topic "Creating a digital simulation model that allows for economic assessment of the level of damage to the city of Tashkent under the influence of strong earthquakes".

The objectives of this project include:

- Assessment of the seismic vulnerability of all buildings and structures in the territory of Tashkent city;

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- Creation of a numerical simulation model that allows for economic assessment of the level of damage in the city of Tashkent;
- Creation of a database of information on all buildings and structures in Tashkent city, including their address, year of construction, structural type, number of floors, height and technical condition.

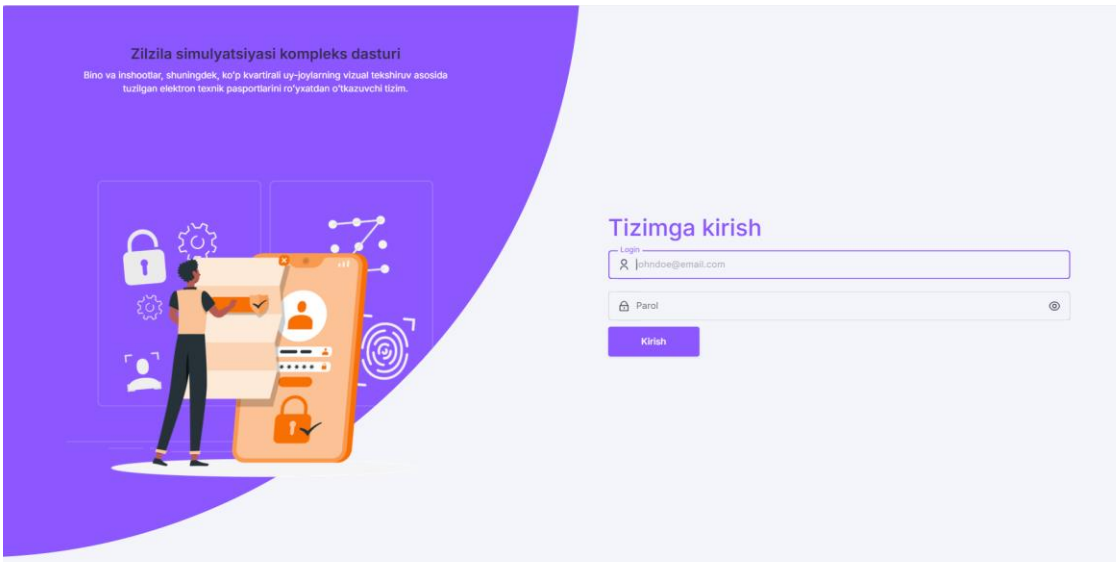

Figure 1. Earthquake simulation complex program

Based on the project, a digital simulation software system model was developed to economically assess the damage level in Tashkent city (Figure 1).

Based on the model, the system's login password is entered and an additional window is opened for the registration of electronic technical passports of buildings and structures based on visual inspection, in which the **"Buildings and structures"** and **"Add building"** sections appear. In the **"Buildings and structures"** section there will be a list of buildings and structures whose information is entered. Information about buildings and structures is entered through the **"Add building"** section (Figure 2).

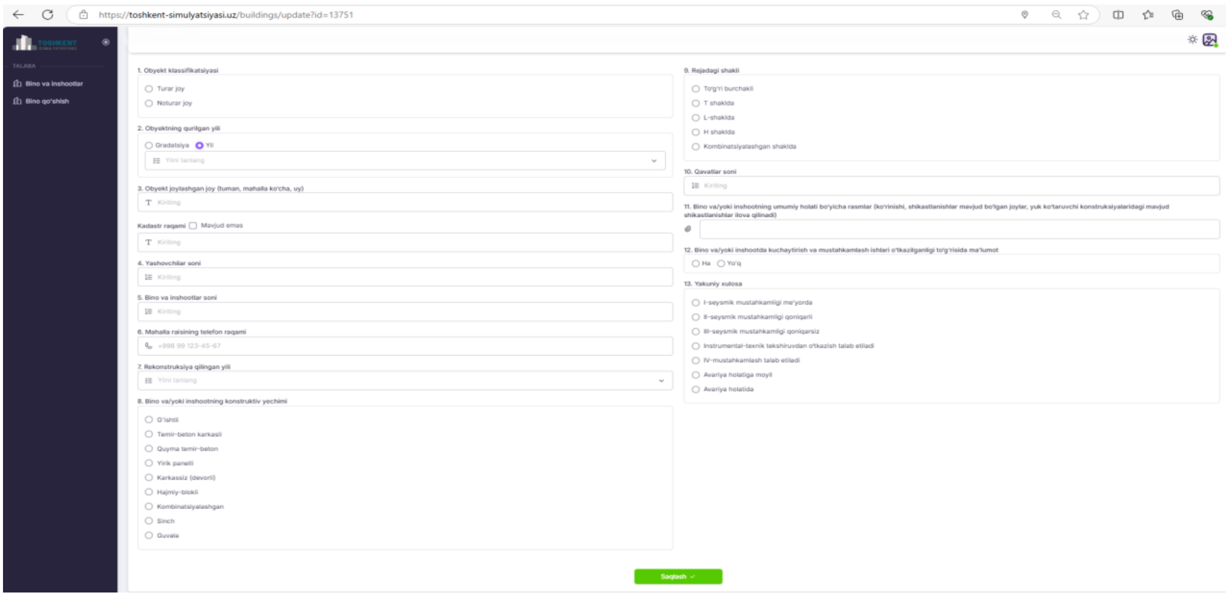

Figure 2. "Add a Building" Interface in the Earthquake Simulation Software Complex.

The following parameters of buildings and structures are entered into the digital simulation model:

- classification of the object (residential or non-residential);
- year of construction of the object;

- object location (district, neighborhood, street, house);
- number of residents;
- number of buildings and structures;
- contact number of the neighborhood chairperson;
- year of reconstruction (if applicable);
- structural design of the building or structure;
- plan configuration;
- number of floors;
- general condition of the building or structure (photos of its appearance, areas with visible damage, and any damage to load-bearing structures are attached);
- Information on whether strengthening and reinforcement work has been carried out on the building or structure [3].

Based on the collected data, an electronic technical passport for the object is automatically created in the "Buildings and Structures" section (Figure 3).

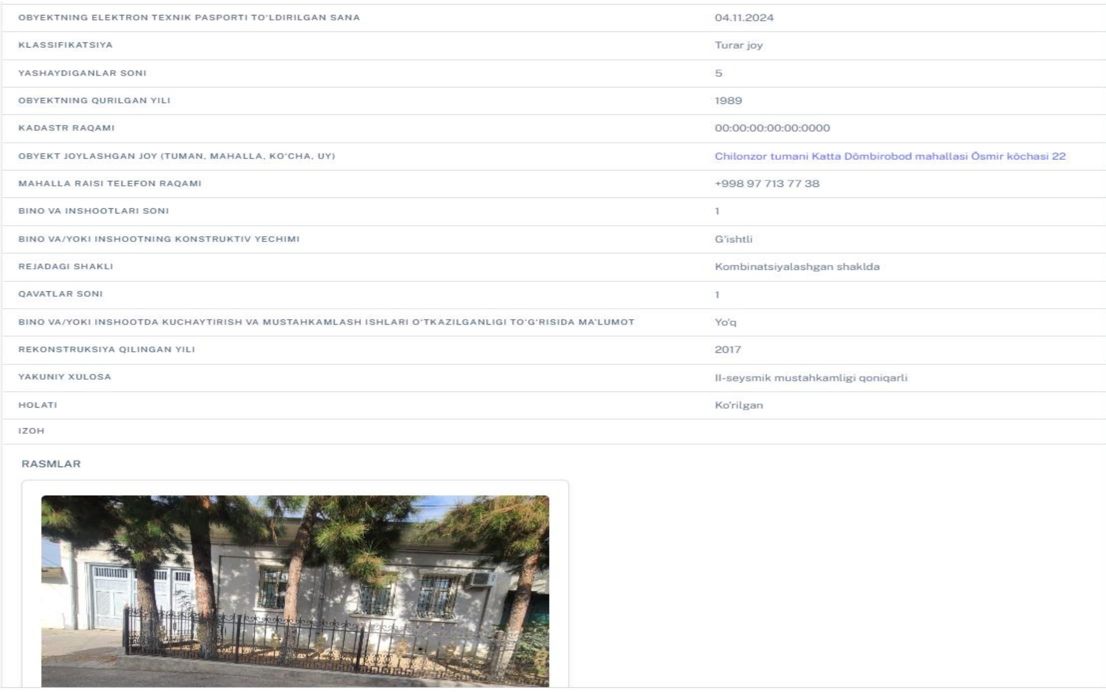

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Figure 3. The "Buildings and Structures" Interface in the Earthquake Simulation Software Complex Showing the Electronic Technical Passport.

Results:

Using the earthquake simulation software complex, a comprehensive database for all buildings and structures in Tashkent has been created. The data includes the address, year of construction, structural types, number of floors, height, and technical condition of the buildings. This information is collected into a central database and continuously updated. According to GOST [2], the technical condition of buildings is classified into four categories. Based on visual inspection results, an expert assigns the appropriate technical condition category to each building.

For example: In the Oktepa neighborhood of Yunusabad district, out of 675 individual residential buildings: 405 buildings (60%) are in Category I, indicating standard seismic resistance; 135 buildings (20%) are in Category II, with satisfactory seismic resistance 115 buildings (17%) are in Category III, with poor seismic resistance 20 buildings (3%) are in Category IV, requiring seismic strengthening (Diagram 1).

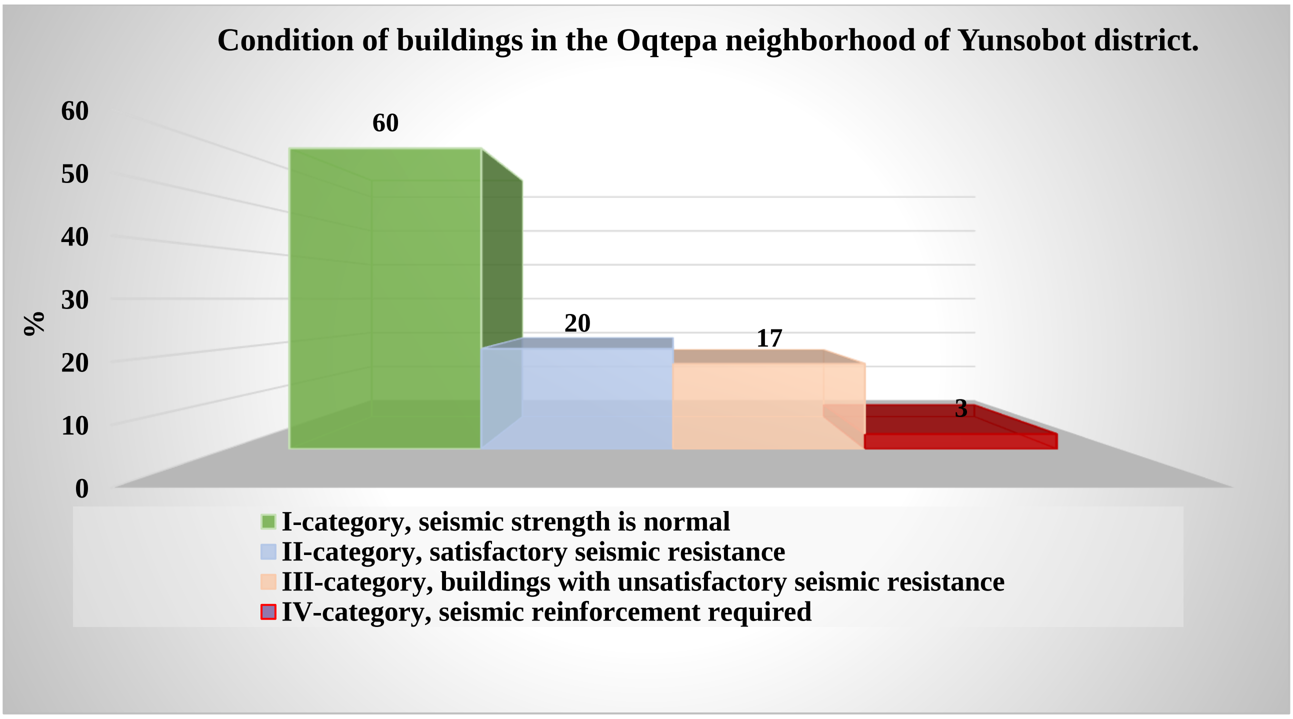

Diagram 1. The condition of individual residential buildings located in Oktepa neighborhood, Yunusabad district.

Conclusion:

In conclusion, it must be emphasized that mitigating seismic risk is emerging as a priority over merely implementing earthquake response measures. Newly developed active systems to enhance the seismic resistance of buildings are critical for future construction projects. However, ensuring the seismic safety of existing buildings and structures can only be achieved by reducing potential earthquake risks.

To address these challenges, the following measures are necessary:

Strengthening state oversight of construction quality;

Enhancing the seismic resistance of buildings and structures;

Developing earthquake preparedness skills among the population;

Introducing modern approaches to seismic safety;

Developing new methods for forecasting strong earthquakes and creating modern preparedness systems;

Incorporating electronic technical, dynamic, and energy passports of existing structures into a platform for continuous updates;

Utilizing modern IT, GIS, and artificial intelligence technologies to develop digital simulation models capable of assessing potential economic damage and risks to human life in all seismically hazardous regions. These efforts are essential to address current challenges effectively.

Reference:

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