Abstract

on the dissertation by Sayat Yerzhanuly Nietbay "Ensuring Seismic Stability of Architectural Monuments by Implementing Geotechnical Seismic Isolation Systems" submitted for the degree of Doctor of Philosophy (PhD) in the specialty: 8D07303 – Construction and Production of Building Materials and Structures.

Relevance of the research: Cultural and natural heritage is an invaluable and irreplaceable asset not only for each nation but for all humanity as a whole. The concept of cultural policy of the Republic of Kazakhstan, aimed at ensuring the sustainable development of society based on the formation of creative value orientations, has identified key issues and outlined cultural policy models, where one of the priorities is the protection of existing cultural values.

A significant portion of the oldest architectural monuments of Kazakhstan and Central Asia, which are part of the world's cultural heritage, are located in seismically hazardous areas with varying intensities of seismic impacts and the distribution of seismic waves in complex engineering-geological conditions. This includes the architectural and cultural heritage of the 14th century, the Mausoleum of Khoja Ahmed Yasawi, which is located in a region with a seismic intensity of 7 points, with complex soil and hydrological conditions. To address the issue of ensuring the seismic resistance of architectural monuments, alternative methods and means of seismic protection and isolation have been developed both in our country and abroad, aimed at reducing the intensity of seismic loads. Research on international policies for the protection of cultural monuments and the experiences of different countries demonstrates common approaches to preserving historical cultural heritage. At the same time, British experts adhere to the view that the preservation of architectural monuments should be ensured with minimal interference in their structure. Therefore, the issue of ensuring the seismic resistance and protection of historical structures, their preservation, and their transmission from generation to generation in their original historical appearance is becoming an increasingly urgent topic today.

Object of the research: architectural monuments subjected to dynamic and seismic loads in complex soil conditions.

Subject of the research: geotechnical seismic isolation in the form of vertical barrier screens made of damping composite materials to absorb seismic waves, based on the example of the Mausoleum of Khoja Ahmed Yasawi.

Purpose of the dissertation: to develop a method for protecting architectural monuments from seismic impacts by implementing geotechnical seismic isolation systems.

Development of new seismic isolation methods, distinguished by new operating principles and enhanced modified properties to reduce inertial seismic loads on structures, is highly relevant.

To achieve the stated goal, the following tasks were set for the dissertation:

1. Analyze the global experience in theoretical and experimental studies, as well as methods and means of seismic protection and isolation, to develop a methodology and scientific-technical justification for their effectiveness in ensuring the seismic stability of architectural monuments.
2. Create an information model and develop a methodology for assessing the seismic resistance of architectural monuments.
3. Develop a geotechnical seismic isolation system to protect architectural monuments from seismic impacts.
4. Conduct experimental studies of geotechnical seismic isolation barrier-screen materials to reduce earthquake energy.
5. Perform numerical and experimental research on the seismic resistance of architectural monuments using modern computer software.
6. Justify the effectiveness of geotechnical seismic isolation and develop recommendations for its implementation.

The research includes numerical and experimental modeling of the operational principle of the geotechnical seismic isolation barrier-screen, as an object that reduces the transformations of surface seismic oscillations affecting architectural monuments.

Research methods: The research employed comprehensive approaches, including theoretical analysis, information modeling, numerical modeling, and experimental studies. The primary methods involve information modeling using REVIT, numerical and experimental modeling with the PLAXIS 3D software package, laboratory tests to determine the damping properties of geomaterials, and seismic isolation installation technology. These approaches allowed for a thorough study of the behavior of architectural monuments under seismic impacts and the development of comprehensive protection measures.

Scientific novelty of the work lies in the development of the geotechnical seismic isolation concept as a design alternative to traditional seismic isolation systems, providing reliability in ensuring the seismic stability of architectural monuments, including:

1. The geotechnical seismic isolation system was systematized and scientifically justified as a new scientific direction, contributing to the increased seismic resistance of architectural monuments.
2. For the first time, an information model of the Mausoleum of Khoja Ahmed Yasawi was created in Autodesk Revit to assess parametric data and build a seismic resistance calculation model of the building.
3. A numerical and experimental model of the interaction between a seismically isolated structure and its soil foundation was developed, and a constructive solution for the geotechnical seismic isolation system in the form of damping barrier screens was obtained to ensure the seismic stability of architectural monuments.
4. Conditions for applying the numerical model in PLAXIS 3D were justified to assess the vulnerability and seismic resistance of architectural monuments.

5. The damping characteristics of the geomaterial used in the geotechnical seismic isolation barrier-screen were experimentally confirmed, reducing earthquake energy.

6. A design methodology and technology for installing a geotechnical seismic isolation system were developed, ensuring organizational and technological reliability for preserving the integrity of architectural monuments.

Key findings submitted for defense:

1. Results of theoretical studies on the scientific-technical justification of geotechnical seismic isolation as a new scientific direction, contributing to the enhancement of the seismic resistance of architectural monuments.

2. Results of the information modeling of the Mausoleum of Khoja Ahmed Yasawi in Autodesk Revit to assess the parametric data of the structure and build a seismic resistance calculation model.

3. Results of the numerical modeling of the Mausoleum of Khoja Ahmed Yasawi in PLAXIS 3D, both with and without a barrier, to assess seismic resistance under three different specified accelerations.

4. Results of experimental studies of the damping characteristics of various geomaterials used in the geotechnical seismic isolation barrier-screen to reduce earthquake energy.

5. Conclusions and recommendations for the use of geotechnical seismic isolation in the form of a damping barrier-screen to reduce seismic impact and preserve architectural monuments.

Areas of application: geotechnics, geotechnical seismic isolation, earthquake-resistant construction, preservation, and seismic protection of architectural monuments.

Practical significance of the work lies in:

1. the systematization and scientific-technical justification of geotechnical seismic isolation as a new scientific direction in ensuring the seismic stability of architectural monuments;

2. the creation of an information model of the Mausoleum of Khoja Ahmed Yasawi in Autodesk Revit for assessing the parametric data of the structure and developing a seismic resistance calculation model for the building;

3. the development of a numerical-experimental model and a structural solution for the geotechnical seismic isolation system in the form of damping barrier screens;

4. the development of an experimental research methodology for determining the dynamic characteristics of geomaterials used in geotechnical seismic isolation for damping barrier screens;

5. the development and implementation in practice of earthquake-resistant construction of a new design methodology and technology for installing the geotechnical seismic isolation system, ensuring its organizational-technological reliability to preserve the integrity of architectural monuments.

The author's personal contribution includes setting the goals and objectives of the dissertation; collecting and summarizing research materials; conducting experimental studies with soil and geomaterials; developing the information model

of the Mausoleum of Khoja Ahmed Yasawi; conducting numerical studies on the Mausoleum of Khoja Ahmed Yasawi; interpreting the obtained results; formulating conclusions and the main points for defense; writing scientific articles and reports on the dissertation topic. The author participated as a performer in the PCF BR21882292 project "Integrated Development of a Sustainable Construction Sector: Innovative Technologies, Production Optimization, Efficient Resource Use, and the Creation of a Technological Park."

Publications and testing of the work. The main results of the dissertation were discussed and tested at international and national scientific conferences:

1. XV International Scientific and Technical Conference "Actual Issues of Architecture and Construction," Sibstrin, Novosibirsk, Russia (2022)
2. I Eurasian Innovation Forum "Current Issues of Urban Development and Safety in Large Cities," KazNITU, Almaty, Kazakhstan (2024)
3. XXIV Republican Student Scientific Conference "Student and Science: A Look into the Future," KazGASA, Almaty, Kazakhstan (2024)
4. XIII International Interuniversity Scientific and Practical Conference-Competition of Scientific Reports by Students and Young Scientists "Innovative Technologies and Advanced Solutions," IUIT, Bishkek, Kyrgyzstan (2024)
5. II Eurasian Innovation Forum "Current Issues of Urban Development and Safety in Large Cities," KazNITU, Almaty, Kazakhstan (2024)
6. V International Scientific and Practical Conference on Earthquake-Resistant Construction, MAES, Bishkek, Kyrgyzstan (2024) The main results of the dissertation are presented in 7 published works of scientific value, including 2 publications in Scopus Q2, Q3 journals, 2 in journals recommended by KOKSONVO, 3 in journals recommended by RSCI, and 2 patents for inventions: "Screen for Protecting Buildings and Structures from Seismic Shocks during Earthquakes and the Impact of Technogenic Vibration Sources."

Structure and volume of the work. The dissertation consists of an introduction, four chapters, a conclusion, and is 134 pages long. The work is illustrated with 68 figures, contains 8 tables, and is accompanied by a reference list of 92 sources.