ZIYATBEKOVA GULZAT ZIYATBEKKYZY

«DEVELOPMENT OF AN AUTOMATED SYSTEM FOR WARNING AND FORECASTING BREAKTHROUGHS OF DAMS»

ABSTRACT

of the dissertation thesis submitted for the PhD degree in the specialty «6D075100 – Computer Science, Computer Technology and Management»

The relevance of the dissertation work. According to the report of the Commission of the United Nations Organization [1], the damage caused by the calamities of a natural disaster, in particular from water, over the years only growth, a economic losses from the effects of water lead to a decrease in the volume of gross internal product.

To select a set of measures to minimize damage, it is reasonable to use the forecast of the main characteristics of the water that affect the amount of damage. Their magnitudes affect the degree of severity of the consequences of water for the population, economy, agriculture, etc. [2].

In the last century, more than a thousand cases of destruction of hydraulic structures have occurred in the world, the reasons for which, among the meteorological phenomena, were factors of a geological and geophysical nature [3 (C.15), 4].

The St. Francis Dam in California has forever entered the historical counterparts of engineering geology as a tragic example of human carelessness. It was built 70 km from Los Angeles in the San Francisco canyon with the purpose of storing water for its subsequent distribution through the Los Angeles water pipeline. The observed infiltration of water through the dam did not cause the necessary measures, and, naturally, it broke through the thickness of the soil, and under its pressure the dam collapsed. There are no survivors of the catastrophes under the 40 m wave wall. All living things, all buildings were destroyed. Behind the wave, the valley was flooded for 80 km. More than 600 people died during this flood. The collapse of the Saint Francis dam in March 1928 was an example of how not to build a gas transmission system. Second example in Italy, in 1963. A mountain range collapsed in the Vajont reservoir, as a result ~ 25 million tons of water overflowed through the dam, creating waves 70 m high in the Piave river valley. 4 villages were destroyed, 4400 people died. More than 30 thousand reservoirs are currently in operation on the territory of Russia, of which about 3 thousand with a capacity of more than 1 million m^3 and ~ 60 – 1 billion m^3. The destruction of such objects carries a huge risk for people, as it can lead to catastrophic flooding of the area, settlements, the death of a large number of people, environmental direct and remote consequences. Catastrophes on the rivers of Russia:

– the breakthrough of the dam of the Kiselevskoe reservoir on the Kakva river and a severe flood in the city of Serov (Sverdlovsk region) in June 1993 (6.5 thousand people were injured, 12 died, total damage – 63.3 billion rubles);

– destruction of the dam of the Tirlyansk reservoir in 1994 (Bashkortostan) on a tributary of the Belaya River (about 100 people died, total damage 52.3 billion rubles);
– flooding in Primorye (September 1994) and in Yakutia (1999 and 2001);
– flooding in the Krasnodar Territory (July 2002) led to the destruction of its hydroelectric complex, killed 114 thousand people and caused material damage in the amount of 15 billion rubles [5-8].

Another example is a sharp (emergency) discharge of water at the Pavlovsk hydroelectric power station, which caused a hydraulic shock, provoking an earthquake with a power of 3-4. The hydrotechnical structures of this hydroelectric power station were built without taking into account the seismic resistance. Seismic effects were also caused when filling, for example, the reservoir of the Zeya Hydroelectric Station, and the disasters of flooding and flooding downstream of the Amur River - from its emergency discharges. On the territory of Ukraine, catastrophic flooding is possible due to the destruction of dams, dams, culverts at 12 hydroelectric complexes and 16 reservoirs of the Dnieper, Dniester, Seversky Donets, Southern Bug rivers. The flooded area may be 8294 km^2. The flood zone includes 536 settlements and 470 industrial facilities [5, 9-11].

The accident at the Sayano-Shushenskaya hydroelectric power station - a man-made disaster that occurred on August 17, 2009. As a result of the accident, 75 people died, the equipment and premises of the station were seriously damaged. Rostekhnadzor named the destruction of the turbine cover studs of the hydroelectric unit as the direct cause of the accident, which led to its failure and flooding of the turbine hall of the station. The consequences of the accident affected the ecological situation of the water area adjacent to the hydroelectric power station, the social and economic spheres of the region and the whole country [12].

Monitoring systems should ensure constant monitoring of phenomena and processes occurring in nature and the technosphere in order to anticipate the growing threats to humans and their environment. The main purpose of monitoring is to provide data for accurate and reliable forecasting of emergency situations based on the combination of intellectual, information and technological capabilities of various departments and organizations involved in monitoring certain types of hazards [13]. Monitoring information serves as a basis for forecasting.

There is a need to develop and study mathematical models that make it possible to calculate in real time the volume of water that can be received by the reservoir and the predicted time until it is completely filled (along the crest of the dam). This information is necessary for timely notification of the population and government bodies to make operational decisions to ensure environmental safety.

In this regard, research on the development, study of a mathematical model of dam breakthrough and information protection means are relevant.

The purpose of the dissertation work is to develop methods for complex analysis, mathematical modeling and forecasting the consequences of natural and man-made emergencies (dam breakthrough) using modern information technologies and a computational experiment with displaying the results in graphical form.

To achieve this goal in the dissertation work, the following **tasks** are solved.

1) development of a database for input, storage and processing of data on the terrain, climatic and hydrogeological indicators;

2) development of sensors, transmission of their information via the Internet or satellite communications to the Center for further processing;

3) construction of mathematical models for monitoring the level of filling of reservoirs;

4) construction of mathematical models for predicting the consequences of a dam break;

5) development of an automated information system for monitoring and predicting the consequences of a dam break.

The scientific novelty of the dissertation work is:

– an integrated approach to solving the problem of the safety of hydraulic structures;

– the proposed mathematical model for monitoring the filling of a reservoir with notification of interested authorities about the hydrological situation in real time;

– algorithms and methods for predicting the consequences of the destruction of hydraulic structures and emergencies;

– a developed automated system for monitoring and predicting the consequences of a dam break to ensure the operation of the hydraulic system;

– development of a methodology for creating a system for monitoring and assessing the state of a reservoir.

Research methods. The research will use methods from the following areas of knowledge: mathematical control theory, decision theory, data processing methods, interval analysis, DBMS, modern design and development systems for information systems.

The research object of the thesis is hydraulic engineering systems.

The subject of the research is mathematical models for monitoring the water level in reservoirs in real time and predicting the consequences of a dam break.

The practical significance of the work lies in the development of a system that provides current and forecast information, contributing to the correctness of decision-making at the territorial or republican level.

The scientific significance of the work lies, first of all, in the construction of mathematical models for predicting the consequences of floods, their study and software and hardware implementation.

The applied value of the work results lies in the possibility of using the system for receiving and transmitting climate data in real time in various industries and transport.

Provisions for Defense. Based on the results of the study, the following tasks were solved:

– development, justification and study of a mathematical model for monitoring the water level in a reservoir;

– mathematical modeling of the consequences of a dam break;

– development of information technology and software to support forecasting and prevention processes for dam breakouts. Experimental studies to analyze the adequacy of the proposed mathematical models, methods and algorithms that increase the accuracy of localization and hydraulic structures.

The validity of scientific positions, conclusions and recommendations put forward for defense is confirmed by the correct use of the mathematical apparatus, the correct organization of experiments and their processing; qualitative and quantitative correspondence of the results of theoretical studies and experimental data; practical application of research results. **The credibility** of the research is confirmed by the good consistency of the results of field observations (a sufficient degree of similarity of events that took place in the village of Kyzylagash, Almaty region, Republic of Kazakhstan).

Relationship of the topic with the plans of research programs

The dissertation work was carried out in accordance with the calendar plan of research grant works by priority: 3. Information, telecommunication and space technologies, scientific research in the field of natural sciences, by sub-priority: 3.5 Methods and systems of information security and data protection. Technologies and software and hardware for information security on the project topic: 1.26 "Development of biometric methods and means of information security" of the Institute of Information and Computing Technologies of the Science Committee and the Ministry of Education and Science of the Republic of Kazakhstan.

The structure of the dissertation includes an introduction, 4 sections, a conclusion, a list of sources used and applications.

The introduction provides a justification for the relevance of the chosen topic of the dissertation work. The purpose, object, subject and tasks of research work are formulated. The results of the research are described, their scientific novelty and practical significance are shown. The data on the approbation of the main results of the dissertation work are given.

In the first section, an analysis of the world flow of scientific work in this area is carried out using the methods of scientometric research, which made it possible to see an objective picture of the development of this scientific area and assess its relevance and potential applications. Domestic and foreign scientists are noted who have made a significant contribution to the development of basic methods for complex analysis. A review of the existing methods for determining the parameters of breakout waves.

Existing systems and databases for input, storage and processing of data on the terrain relief, climatic and hydrogeological indicators are shown. The trends in the development of modern technologies of mathematical modeling and their application in environmental safety are revealed, which proves the relevance of scientific research in this direction.

The second section is devoted to the analysis of existing solution methods and the formulation of monitoring tasks for hydrological processes. The general characteristics of the problem and the formulation of research tasks are given. The task is analyzed and the main problems that may arise in the course of its solution

are identified. The advantages and disadvantages of the described methods are highlighted.

On the basis of microprocessor technology and sensor sensors, an autonomous microcomputer system for transmitting climate data has been developed. A program for monitoring breakout factors in real time has been developed.

A mathematical model has been developed that allows real-time monitoring of the filling of the reservoir, and to determine the risk of dam break. A method for monitoring the water level in reservoirs based on fuzzy and interval mathematics is proposed.

In the course of the research, a technology was developed to provide decision processes and formulation of research tasks.

The third section is devoted to the analysis of existing models for predicting the consequences of the destruction of hydraulic structures and the occurrence of emergency situations.

A comparative analysis of the known methods for predicting the consequences of a dam break and, thereby, the occurrence of emergency situations.

A mathematical model has been developed for predicting the consequences of a dam break. The analysis results are the basis for research and implementation of a comprehensive solution to the problem.

The fourth section is devoted to the description of an automated system for monitoring, warning and forecasting the consequences of a dam break.

An interface part is implemented in Java, which includes the following modules: 1) module for receiving and transmitting current information about the water level, humidity and temperature at the crest of the dam; 2) module for processing permanent and operational information about the threat of a dam break (server); 3) dam failure forecasting module.

On a model problem (events that took place in the village of Kyzylagash, Almaty region of the Republic of Kazkhastan), the effectiveness of the developed automated system is shown.

In the conclusion, the main results and conclusions of the dissertation are presented.

Approbation of work. The results of the dissertation work were reported at international scientific conferences, annual scientific conferences of the Institute of Computational and Information Technologies, scientific conferences of young scientists and specialists of the Kazakh National University, as well as at scientific seminars of the Department of Informatics of Al-Farabi KazNU. Conducted a foreign internship (Appendix A). Received 4 certificates of state registration of rights to the copyright object (Appendix B).

Publications. On the topic of the dissertation, 19 (nineteen) printed works were published, including 5 (five) in editions recommended by the KKSON MES RK, 3 (three) works in the journal included in the international citation base "SCOPUS" journal included in the Scopus database - Appendix C).

Scientific publications:

1 T. Mazakov, Sh. Jomartova, G. Ziyatbekova, M. Aliaskar. Automated system for monitoring the threat of waterworks breakout // Journal of Theoretical

and Applied Information Technology, Pakistan, 2020. – Vol. 98, – No 15. – Pp. 3176-3189. ISSN: 1992-8645, E-ISSN: 1817-3195.

2 T. Zh. Mazakov, P. Kisala, Sh. A. Jomartova, G. Z. Ziyatbekova, N. T. Karymsakova. Mathematical modeling forecasting of consequences of damage breakthrough // News of the National Academy of Sciences of the Republic of Kazakhstan. Series of Geology and Technical Sciences. – 2020. – Vol. 5, No 403. – Pp. 116-124. // https://doi.org/10.32014/2020.2518-170X.111.

3 Nurdaulet, I., Talgat, M., Orken, M., Ziyatbekova, G. Application of fuzzy and interval analysis to the study of the prediction and control model of the epidemiologic situation // Journal of Theoretical and Applied Information Technology, Pakistan. 2018. – Vol. 96, - Issue 14, – P. 4358-4368.

4 Jomartova Sh.A., Ziyatbekova G.Z. On the problem of the development of automated warning and forecasting systems for dam breakout // Bulletin of KazNTU im. K.I. Satpayev, 2018, No. 2 (126). – P.136-139.

5 Aliaskar M.S., Jomartova Sh.A., Ziyatbekova G.S., Isimov N.T., Amirkhanov B.S., Mazakova A.T. Autonomous microprocessor system for transmitting climatic data // Bulletin of KazNRTU im. K.I. Satpayev, 2019. – No. 1 (131). – P. 371-377.

6 Mazakov T.Zh., Jomartova Sh.A., Kisala P., Ziyatbekova G.Z. New approaches for solving problems of the simulation of flood wales and breakthrough to justify protective measures // HERALD of the Kazakh – British Technical University. – Almaty, 2019. – Vol. 16, – № 4(51). – P. 138-144.

7 Mazakov T.Zh., Jomartova Sh.A., Kisala P., Ziyatbekova G.Z., Togzhanova K.O. Development of research of the process of destruction of soil dams // Bulletin of AUEC, 2020. – No. 1 (48). – P.131-137.

8 Mazakov T.Zh., Jomartova Sh.A., Kisala P., Ziyatbekova G.Z. Probltms and actions for the development of water resources monitoring // Bulletin of KazNRTU, 2020. – No 2(138). – P.365-369.

9 Mazakov T.Zh., Ziyatbekova G.Z., Aliaskar M.S. Monitoring system of the threat of the breakthrough of reservoirs // Bulletin of KazUTB, Nur-Sultan, 2020. – No 1. – P. 8-19.

10 Mazakov T.Zh., Ziyatbekova G.Z. Consequences of the destruction of hydraulic structures and the occurrence of emergency situations // Mater. int. conf. – Almaty: KazATK them. M. Tynyshpaeva, 2018. – Vol. 2. – P. 74-78.

11 Ziyatbekova G.Z. Investigation of the process of destruction of the pressure front of waterworks // Mater. int. conf. students and young scientists «Farabi world». – Almaty, Kazakh university, 2018. – P.231-233.

12 Mazakov T.Zh., Ziyatbekova G.Z. Application of geographic information systems for solving problems of flood assessment // Mater. III int. scientific. conf. «Computer Science and Applied Mathematics». – Almaty, 2018. – Part 1. – P. 278-284.

13 Ziyatbekova G.Z., Mazakov T.Zh. Determination of methods and means for monitoring the water level in reservoirs // Proceedings of the XV International Scientific and Practical Conference «Innovative, information and communication technologies». – Russian Federation, Sochi, 2018. – P. 62-65.

14 Mazakov T.Zh., Kisala P., Ziyatbekova G.Z. History and development of the theory of flood and breakout wave modeling // Materials of scientific. confer. IICT SC MES RK «Innovative IT and Smart-technologies» dedicated to the 70th anniversary of Professor I.T. Utepbergenov. – Almaty, 2019. – P. 199-205.

15 Ziyatbekova G.Z., Mazakov T.Zh., Kisala P. Literature review on the problem of numerical modeling of river flows // Materials of the scientific conference of the Institute of Information and Computing Technologies of the Ministry of Education and Science of the Republic of Kazakhstan «Modern problems of informatics and computing technologies». – Almaty, 2019. – P.174-179.

16 Ziyatbekova G.Z., Mazakov T.Zh., Piotr Artur KISALA. The consequences of the breakthrough of hydraulic structures and the main problems of emergency situations // Materials of the IV international scientific-practical. conf. «Computer Science and Applied Mathematics». - Almaty, 2019. – Part 1. – P. 374-381.

17 Ziyatbekova G.Z., Mazakov T.Zh., Jomartova Sh.A., P. Kisala. Prospects for the development of the theory and modern approaches to solving the problems of modeling flood and breakthrough waves // V International Scientific and Practical Conference «Science and education in the modern world: challenges of the XXI century». – Nur-Sultan, 2019. – P.38-43.

18 Ziyatbekova G.Z., Mazakov T.Zh., Tusupova S.A. The occurrence of hydrodynamic accidents and their analysis // Materials of the scientific conference of the Institute of Information and Computing Technologies of the Ministry of Education and Science of the Republic of Kazakhstan «Modern problems of informatics and computing technologies». – Almaty, 2020. – P.45-50.

19 T. Mazakov, G. Ziyatbekova, M. Aliaskar. Automated water level monitoring system in water bodies // Journal of Advance Technologies and Computer Science. IICT. – Almaty, 2020. – Vol. 1. – No 1. – P. 7-13.

Certificates of entry of information into the state register of rights to objects protected by copyright:

1 Certificate of entering information into the state register of rights to objects protected by copyright No. 5290 dated September 12, 2019 « Complex of programs of three-dimensional graphics «3D-MAT» (computer program), authors: Ziyatbekova G.Z., Mazakova A.T., Shormanov T.S., Amirkhanov B.S., Zholmagambetova B.R., Aliaskar M.S.

2 Certificate of entering information into the state register of rights to objects protected by copyright No. 7576 dated January 17, 2020 «Interval function library» (computer program), authors: Ziyatbekova G.Z., Mazakova A.T., Mazakov T.Zh., Jomartova Sh.A., Karymsakova N.T., Amirkhanov B.S., Zholmagambetova B.R.

3 Certificate of entering information into the state register of rights to objects protected by copyright No. 7632 dated January 21, 2020 «Analytical computing system» (computer program), authors: Ziyatbekova G.Z., Mazakov T.Zh., Jomartova Sh.A., Mazakova A.T., Karymsakova N.T., Tursynbai A.T., Sametova A.A.

4 Certificate of entering information into the state register of rights to objects protected by copyright No. 12221 dated September 29, 2020 « Dam risk monitoring system » (computer program), authors: Mazakov T.Zh., Ziyatbekova G.Z., Aliaskar M.S.