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COMPARATIVE ANALYSIS OF REGULATORY DOCUMENTS IN THE DESIGN AND OPERATION OF DAMS

The design parameters and characteristics of dams were estimated during the design of dams in the 40–60th of the last century, and require updating, as well as changing the existing methodological approach to their determination. In the article the data of the current state, regulatory, technical and literary sources used at designing, construction and operation of hydraulic structures (HS) are collected, the comparative analysis of normative and technical documentation of the Republic of Kazakhstan, European countries, the USA, China, etc. used at designing and operation of dams is carried out. Examples of world practices in the application of legislation and regulating in terms of dam safety have been considered. A number of normative documents of the Republic of Kazakhstan on the main directions of activity of hydraulic structures, applied at all stages of their existence, from design and construction to operation and liquidation, are determined. The state regulations in the field of architecture, town planning and construction are reviewed, the main purpose of which is to ensure the legally protected needs of citizens and society in creating a favorable and environmentally safe living environment and life, in implementation of architectural, town planning and construction activities, protection of consumer rights of design and construction products, ensuring reliability and safety of construction, sustainable operation of the constructed facilities during operation and maintenance of hydraulic structures. Names and brief contents of standards for dam design in a number of developed countries are given.

Keywords: design of dams, safety of hydraulic structures, regulating the operation of hydraulic structures.

Introduction

The issue of safety of hydraulic structures, including dam safety, is one of the socially, economically and environmentally significant in terms of both design and operation. According to the Water Code of the RK, a dam is a supporting hydraulic structure on a watercourse for raising the water level and (or) creating a water reservoir; dam safety is a state of protection of a dam against catastrophic failure.

To date, the issue of research on «The Regulatory Framework for Dam Safety» has been a hot topic for many developed countries, since everyone understands that dam failures and their negative consequences will result in great loss of life and financial

resources. For countries with a large number of dams, the issue of dam safety becomes particularly acute.

According to the International Commission on Large Dams [1], there are more than 800,000 dams of various types all over the world, of which about 50,000 are more than 15 meters high. The accumulated information testifies to more than a thousand cases of damage and a hundred cases of destruction of dams of similar size. It is also necessary to take into account that the probability of dam failures starts to increase steadily when the structures are more than 30–40 years old [2]. These circumstances have led to the recent intensive development of regulatory and legal regulation of dam safety issues in many countries of the world with developed hydropower and water sectors.

In June 1977, the World Bank published the Operational Guidelines (OG) [3], which stipulated that not only the operators, but also the designers of hydraulic structures are responsible for the consequences of dam failures as a result of manmade disasters or natural hazards. The OG contains an analysis of the regulatory and legal framework for dam safety in 22 countries, considers similarities and differences in the approaches of different countries to the problem of dam safety, and offers recommendations on the content of normative and legal acts in this area. In October 2001, the OG was updated to include two documents: the Operational Policy (OP 4.37) and the Bank Procedures (BP 4.37). These documents apply not only to reservoir dams, but also to the dams of various spoil complexes.

Below is an example of global practices in the application of dam safety legislation and regulation.

In China, for example, dam safety is regulated by a number of laws and regulations [4]. The Law on the Prevention of Floods (August 29, 1997) obliges all units and all professionals to take measures to prevent floods. The Water Act (January 21, 1997) provides for surveys. The same law also has provisions on administrative rules for water management. On July 2, 1991, the State Council of the People's Republic of China approved the Regulation on Reservoir Safety and the Regulation on Flood Control. In its turn, the Ministry of Water Resources enacted the Regulation on Declaration of Safety of Hydraulic Structures (March 20, 1995), and the Ministry of Energy Enterprises enacted the Regulation on Ensuring Safety of Hydropower Plants (January 1997). Along with this, in August 1998, the Ministry of Energy published detailed Rules for Inspection of Hydroelectric Power Plants for Safety [5]. There are also a number of other regulatory documents and acts.

Materials and methods

In the field of Kazakhstan regulations to date, a number of regulatory documents on the main activities in the implementation of the dam projects, have been identified (Table 1).

Table 1 – List of legal acts and regulatory-technical documentations

Field of activity	Name of the regulatory document
Land Use	ST RK GOST R ISO 14042-2007. Environmental management. Life cycle assessment. Life cycle impact assessment.
	ST RK GOST R ISO 14041-2007. Environmental management. Life cycle assessment. Definition of a research objective and inventory analysis.
	ST RK 2725-2015. Sustainable community development indicators of urban services and quality of life.
	ST RC BSI PD 8101-2016. Smart Cities. Guidelines for assessing the role of planning and development.
	ST RK ISO 37101-2016. Sustainable development of administrative and territorial units. Management systems. General principles and requirements.
Catchment	GOST 25855-83. Level and flow of surface waters. General requirements for measurement.
	GOST 17.1.1.02-77. Nature Protection. Hydrosphere. Classification of water objects.
	ST. RK ISO/TS 14048-2010. Environmental management. Life cycle assessment. Data Documentation Format.
	SN RK 2.03-02-2012. Engineering protection in zones of flooding and waterlogging.
Climate	GOST 25870-83. Microclimatic regions of the globe with cold and temperate climate. Zoning and statistical parameters of climatic factors for technical purposes.
	GOST 24482-80. Macroclimatic regions of the globe with tropical climate. Zoning and statistical parameters of climatic factors for technical purposes.
Soil	ST RK ISO 15800-2014. Soil quality. Determination of soil characteristics in relation to human exposure.
	GOST 17.4.2.03-86. Nature Conservation. Soils. Passport of soils.
	GOST 28168-89. Soils. Sampling.
	GOST 17.4.2.01-81. Nature Conservation. Soils. Nomenclature of sanitary condition indicators.
Dams	SN RK 3.04-01-2013. Hydrotechnical structures.
	SN RK 3.04-02-2014. Design of concrete and reinforced concrete structures of hydraulic facilities.
	SN RK 3.04-03-2014. Foundations of hydraulic structures.
	SN RK 3.04-04-2014. Concrete and reinforced concrete dams.
	SN RK 3.04-06-2014. Hydrotechnical tunnels.
	SN RK 3.04-08-2014. Design, construction and operation of hydraulic structures in the areas undermined by mining operations.
	SN RK 3.04-09-2012 Hydrotechnical structures of the river.
	SN RK 3.04-10-2014. Hydrotechnical marine and river transport structures.
	SN RK 3.04-11-2013. Land reclamation systems and structures.

In Kazakhstan's legislation, one of the regulatory documents with current construction standards, developed as part of the reform of the system of technical regulation of the construction industry of the Republic of Kazakhstan in accordance with the parametric method of normalization, is SN RK 3.04-04-2014 «Concrete and reinforced concrete dams». It is one of the normative documents of the evidence base of the technical regulations of the Republic of Kazakhstan «Requirements for the Safety of Buildings and Structures, Building Materials and Products» to ensure the safety of construction and operation facilities. It contains basic provisions on design of newly constructed and reconstructed concrete and reinforced concrete dams, which are part of power, water transport, reclamation systems, water supply and runoff transfer systems, as well as structures for flood control [6]. The norms give general construction requirements to working characteristics of deformation joints of dams, catchment, outlet and discharge structures, interfaces of dams with the foundation; describe all kinds of loads, their impact and combination on concrete and reinforced concrete dams, give basic provisions on dam design, namely: dam strength and stability calculation, filtration calculation of dams, hydraulic calculation of dams. In addition, the construction standards describe the calculation and design of dams on non-rock foundation, gravity and buttress dams on rock foundation, arch dams, and measures for environmental protection during design and operation of structures. Despite all this, SN RK 3.04-04-2014 «Concrete and reinforced concrete dams» does not apply to dams, damage to which can cause dangerous ecological and social consequences during earthquakes, due to excessive deformation of subsidence, swelling or karst foundations, or due to extraordinary natural phenomena.

One can consider the State norms in the field of architecture, urban planning and construction, Construction norms of the Republic of Kazakhstan «Hydro-technical structures». The main focus of the state regulations is to ensure the legally protected needs of citizens and society in creating a favorable and environmentally safe living environment and life in the implementation of architectural, urban planning and construction activities, protection of consumer rights of design and construction products, ensuring the reliability and safety of construction, sustainable operation of the constructed facilities in operation. For this purpose, the construction standards apply to the design of newly constructed and reconstructed river and sea hydraulic structures of all types and classes. The standards take into account: the general requirements for the safety of hydraulic structures, the designation of the class of hydraulic structures, the requirements to ensure safety of hydraulic structures at the design stage, the requirements to ensure safety of hydraulic structures at the construction stage, the requirements to ensure safety of hydraulic structures during operation, the requirements to ensure safety of hydraulic structures during reconstruction and liquidation (Figure 1).

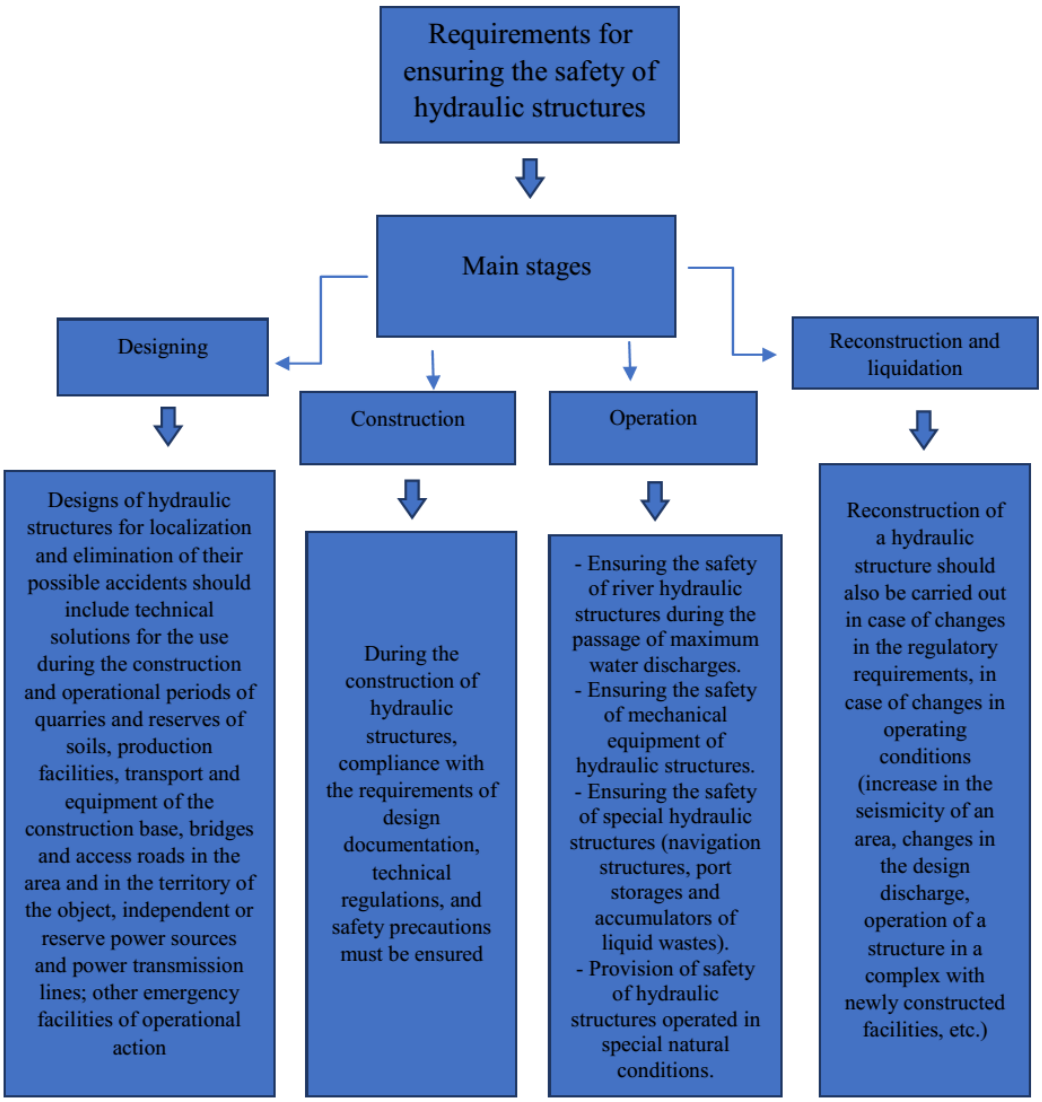

Figure 1 – Requirements for ensuring the safety of of hydraulic structures

Below are the names and summaries of standards for dam design in a number of developed countries:

– In the U.S., requirements for embankment dams are governed by the 21 chapter Design Standard #13 developed by the Bureau of Reclamation, Department of the Interior, specifically in: Chapter 1 – General Design Standards, Chapter 2 – Dam Design, Chapter 4 – Static Stability Analysis, Chapter 5 – Protective Filters, Chapter 10 – Embankment Construction, and Chapter 13 – Seismic Analysis and Design [7]. Also, American standard ASTM D-4767 allows to determine parameters (saturated soil strength, internal friction angle, cohesion) for shear by full and effective stress using triaxial instrument to assess stability at the most critical stages of dam life [8]. In the Kazakhstan normative document, these parameters are described in the construction

standards [9] (paragraph 8. Basic requirements for dam design, paragraph 8.1 Calculation of dams for strength and stability).

– In China, there are two categories of dams: dams regulating the use of water resources, which are administered by the Ministry of Water Resources, and dams for power generation, which are administered by the State Power Corporation. With regard to regulatory documentation, standards are divided into national, professional (specialized), and local standards. The standards are also divided into mandatory and recommendatory standards. China's construction engineering standards system is divided into 24 areas, which in turn are divided into 58 groups of industrial standards in different areas, including water resources (SL) and energy (DL). Water resources and hydropower standards include 40 volumes, national standards include 8 volumes. Certain features of hydropower projects are themselves the subject of standardization. For example, world-class construction projects have been developed on the basis of the standards, including: a 292-meter high double curvature arch dam across the Little Bay, a 233-meter high concrete-clad rock dam, and a 216.5-meter high concrete gravity dam on Dragon Beach [10]. The design of dams in China is regulated by the standard «Design standard of concrete gravity dams» of the Ministry of Water Resources of the People's Republic of China [11]. The standard gives a description of dam structures and configurations, hydraulic design of dewatering works, design of dam cross-section, design of dam foundations, structural arrangement of dams, temperature control and prevention of cracking, and design of operational safety monitoring.

– In Austria, dam safety issues are regulated by the Federal Water Act. According to this law, dams higher than 30 meters or with a reservoir volume of more than 500 thousand cubic meters, dams on the Danube River, as well as dams that regulate water supply of other countries are under the jurisdiction of the Main Water Department of the Federal Ministry of Agriculture and Forestry (FMSF). In order to obtain a building permit for a dam, the design must undergo a public hearing and, if the dam is under the jurisdiction of the FMSF, also the approval procedure of the Austrian Commission on Dams. Because such projects must be based on the most recent developments in this area, there are virtually no regulatory indicators in the current legislation.

Results and discussion

Analysis of normative documentation of developed countries on the principles and methods of dam design [3,5,7,8] has shown that the initial stage of design of hydraulic structures plays an important role in further economic development of the proposed site of a hydraulic structure and affects GDP growth [12,13]. Normalization includes taking into account not only standard requirements for structural design features, but also assumes the influence on the construction site of such factors as, for example, changes in the density of the population before 2050 living in the area of the dam construction and being potential consumers of water resources and energy products; suitable terrain conditions for construction of large dams, climatic impact on the operation of structures, etc. [12,13,14,15].

Conclusions

Having studied the principles and methods of design of hydraulic structures in Kazakhstan, it can be concluded that they take into account the general design requirements, loads, impacts and their combinations, requirements for the calculation of dams (calculation of dam strength and stability, seepage calculations of dams, hydraulic calculations of dams), safety requirements for works on river hydraulic structures, requirements for quality control and acceptance of works, requirements for environmental protection, requirements for monitoring of hydraulic structures [9,17,18,19,20]. However, at the same time, they do not have data on accounting of many factors of urbanization, such as changes in land use and soil-vegetation layer, climatic impact, etc. in the design, which significantly affects the term of safe operation of hydraulic structures.

Acknowledgements

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БӨГЕТТЕРДІ ЖОБАЛАУ ЖӘНЕ ПАЙДАЛАНУ КЕЗІНДЕГІ НОРМАТИВТІК ҚҰЖАТТАМАНЫ САЛЫСТЫРМАЛЫ ТАЛДАУ

Бөгеттердің есептік параметрлері мен сипаттамалары өткен ғасырдың 40–60 жылдары бөгеттерді жобалау кезінде есептелген және жаңартуды, сондай-ақ оларды анықтауға қолданыстағы әдіснамалық тәсілді өзгертуді талап етеді. Мақалада Гидротехникалық құрылыстарды (ГС) жобалау, салу және пайдалану кезінде пайдаланылатын ағымдағы жай-күй деректерін, реттеуші, техникалық және әдеби көздерді жинау орындалды, бөгеттерді жобалау және пайдалану кезінде пайдаланылатын Қазақстан Республикасының және Еуропа, АҚШ, Қытай және т.б. елдердің нормативтік-

техникалық құжаттамасына салыстырмалы талдау жүргізілді. Бөгеттердің қауіпсіздігі бөлігінде заңнаманы қолдану және нормалау бойынша әлемдік практикалардың мысалдары қаралды. Гидротехникалық құрылыстар қызметінің негізгі бағыттары бойынша жобалау мен құрылыстан бастап пайдалану мен жоюға дейінгі олардың жұмыс істеуінің барлық кезеңдерінде қолданылатын Қазақстан Республикасының бірқатар нормативтік құжаттары анықталды. Сәулет, қала құрылысы және құрылыс саласындағы мемлекеттік нормативтер қаралды, олардың басты бағыты азаматтар мен қоғамның заңмен қорғалатын қажеттіліктерін қамтамасыз ету, сәулет, қала құрылысы және құрылыс қызметін жүзеге асыру кезінде қолайлы және экологиялық қауіпсіз өмір сүру және өмір сүру ортасын құру, жобалау және құрылыс өнімдерін тұтынушылардың құқықтарын қорғау, құрылыстың сенімділігі мен қауіпсіздігін қамтамасыз ету, Пайдалану кезінде салынған объектілердің тұрақты жұмыс істеуі болып табылады. Бірқатар дамыған елдердегі бөгеттерді жобалау стандарттарының атаулары мен қысқаша мазмұны келтірілген.

Кілтті сөздер: бөгеттерді жобалау, гидротехникалық құрылыстардың қауіпсіздігі, Гидротехникалық құрылыстарды пайдалануды нормалау.

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СРАВНИТЕЛЬНЫЙ АНАЛИЗ НОРМАТИВНОЙ ДОКУМЕНТАЦИИ ПРИ ПРОЕКТИРОВАНИИ И ЭКСПЛУАТАЦИИ ПЛОТИН

Расчетные параметры и характеристики плотин рассчитаны при проектировании плотин в 40–60 годы прошлого столетия, и требуют обновления, а также изменения существующего методологического подхода к их определению. В статье выполнен сбор данных текущего состояния, регуляторных, технических и литературных источников, используемых при проектировании, строительстве и эксплуатации гидротехнических сооружений (ГС), проведен сравнительный анализ нормативно-технической документации Республики Казахстан и стран Европы, США, Китай и др., используемой при проектировании и эксплуатации плотин. Рассмотрены примеры мировых практик по применению законодательства и нормирования в части безопасности плотин. Определен ряд нормативных документов Республики Казахстан по основным направлениям деятельности гидротехнических сооружений, применяемых на все этапах их существования, начиная с проектирования и строительства, заканчивая

эксплуатацией и ликвидацией. Рассмотрены Государственные нормативы в области архитектуры, градостроительства и строительства, главной направленностью которых является обеспечение охраняемых законом потребностей граждан и общества, в создании благоприятной и экологически безопасной среды обитания и жизнедеятельности, при осуществлении архитектурной, градостроительной и строительной деятельности, защите прав потребителей проектной и строительной продукции, обеспечении надежности и безопасности строительства, устойчивого функционирования построенных объектов при эксплуатации. Приведены наименования и краткое содержание стандартов по проектированию плотин в ряде развитых стран.

Ключевые слова: проектирование плотин, безопасность гидротехнических сооружений, нормирование эксплуатации гидротехнических сооружений.

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