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INCREASING THE RELIABILITY OF DAMS DURING FLOODS

Nabiyev Elyor Safarovich
Karshi State Technical University t.f.f.d (PhD), dotsent,
https://orcid.org/0009-0000-2783-3043

Annotatsiya. Sel oqimlari sharoitida to‘g‘onlarning foydalanish ishonchliligini oshirishga qaratilgan muhandislik va texnologik chora-tadbirlar tahlil qilingan. Tadqiqot davomida sel oqimlarining gidrodinamik ta’siri, eroziya, filtratsiya va deformatsion jarayonlarning to‘g‘onlar barqarorligiga ta’siri o‘rganildi. Qirg‘oq mustahkamlash, gabion konstruksiyalar qo‘llash, drenaj tizimlarini takomillashtirish, sel tutuvchi inshootlar qurish hamda monitoring va erta ogohlantirish tizimlarini joriy etishning samaradorligi baholandi. Tadqiqot natijalari asosida kompleks muhandislik himoya tizimlarini qo‘llash to‘g‘onlarning ekspluatatsion barqarorligi va xavfsizligini sezilarli darajada oshirishi ilmiy jihatdan asoslandi.

Kalit so‘zlar: to‘g‘on, gidrotexnika inshooti, filtratsiya, eroziya, gidrodinamik bosim, gabion konstruksiya, drenaj tizimi, monitoring, sel oqimi, foydalanish ishonchliligi.

Аннотация. Проанализированы инженерно-технологические меры, направленные на повышение надежности плотин в условиях внезапных наводнений. В ходе исследования изучено гидродинамическое воздействие внезапных наводнений, эрозионных, фильтрационных и деформационных процессов на устойчивость плотин. Оценена эффективность укрепления берегов, использования габионных конструкций, улучшения дренажных систем, строительства паводковых сооружений, а также внедрения систем мониторинга и раннего предупреждения. На основе результатов исследования научно обосновано, что использование комплексных инженерно-защитных систем значительно повышает эксплуатационную устойчивость и безопасность плотин.

Ключевые слова: плотина, гидротехническое сооружение, фильтрация, эрозия, гидродинамическое давление, габионная конструкция, дренажная система, мониторинг, паводковый поток, эксплуатационная надежность.

Abstract. Engineering and technological measures aimed at increasing the reliability of dams in conditions of flash floods were analyzed. During the study, the hydrodynamic impact of flash floods, erosion, filtration and deformation processes on the stability of dams were studied. The effectiveness of bank reinforcement, the use of gabion structures, the improvement of drainage systems, the construction of flood-retaining structures, and the introduction of monitoring and early warning systems were assessed. Based on the results of the study, it was

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scientifically substantiated that the use of complex engineering protection systems significantly increases the operational stability and safety of dams.

Keywords: dam, hydraulic structure, filtration, erosion, hydrodynamic pressure, gabion structure, drainage system, monitoring, flood flow, operational reliability.

INTRODUCTION.

Currently, the number and intensity of flood events are significantly increasing due to climate change, heavy precipitation, and increased anthropogenic impacts in mountainous areas. Floods are one of the natural factors that pose a serious threat to the safe operation of hydraulic structures, especially reservoirs and dams [1]. As a result of strong flood flows, erosion, deformation, and filtration processes in dam structures can increase, and the overall stability of the structure may decrease. Dams, as the main elements of the hydraulic system, are of great importance in water resources management, irrigation, energy and water supply systems. Therefore, ensuring their reliability in the conditions of flood flows is one of the important scientific and practical tasks [2]. Especially in mountainous areas, earthen and concrete dams are at high risk from the hydrodynamic pressure of flood flows, large volumes of solid rocks and silt masses.

The impact of mudflows on dams is manifested by several factors. In particular, high-velocity water flow causes scouring processes in the dam and coastal areas, causes increased filtration flows, and negatively affects the functioning of drainage systems [3]. In addition, the mechanical impact of stones, sand, and other hard rocks contained in the mudflow can cause damage to structural elements.

In order to reduce the risk of floods, various structural and technological measures are used in hydraulic engineering practice. In particular, the construction of flood-retaining structures, bank reinforcement works, improvement of drainage systems, strengthening of slopes, and the introduction of monitoring and early warning systems are of great importance [5]. Modern monitoring systems are creating the opportunity to monitor water levels, filtration processes, and deformations in real time. When assessing the operational reliability of dams, their strength, reliability, and operational stability are considered as the main criteria. The safety coefficient of a dam is estimated using the following expression:

$$k = \frac{\mathrm{R}}{\mathrm{F}} \qquad (1)$$

where: K is the coefficient; R is the resistance force; F is the load.

If the safety factor is lower than the standard value, the operational reliability of the dam decreases and the risk of an accident increases. The purpose of this article is to analyze the factors affecting the reliability of dams in flood conditions and to scientifically substantiate modern engineering and technological measures

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to increase their safety. The research studies the hydrodynamic effects of flood flows, erosion and filtration processes, and the effectiveness of monitoring systems.

The issue of flood flows and their impact on hydraulic structures has been studied for many years as one of the important scientific areas in the fields of hydrology, hydraulic engineering, and emergency safety. In recent years, the increase in heavy rainfall and flood events in mountainous areas as a result of global climate change has further increased the urgency of the issue of ensuring the safety of dams [7].

In scientific studies, the impact of flood flows on dams is mainly assessed through hydrodynamic loads, erosion processes, filtration flows, and mechanical impact of hard rocks [8]. Researchers have found that flood flows, due to their high velocity and high density, intensify deformation processes in earthen and concrete dams.

The hydraulic parameters of the flood flow are estimated using the following expression:

$$Q = A \times V \qquad (2)$$

where: Q is the water flow rate; A is the cross-sectional area of the stream; V is the flow velocity.

This relationship indicates that water consumption and hydrodynamic impact increase with increasing flood flow velocity [9]. A number of scientific studies have investigated methods for increasing the resistance of earthen dams to flood flows. In particular, strengthening slopes with concrete slabs, using gabion structures, and modernizing drainage systems against filtration have been recommended as effective protective measures [10]. According to the results of the studies, strengthening banks and slopes significantly reduces erosion processes.

When concrete is placed directly on the ground, it has been found that the dynamic stress and vibration loads that produce landslides affect the deformation state of the structure. Therefore, in modern conditions, special attention is paid to ensuring energy-absorbing materials and water properties.

Darcy's law is widely used to assess the filtration stability of dams.

$$q = k \cdot i \cdot A \qquad (3)$$

where: q is the filtration flow rate; k is the filtration coefficient; i is the hydraulic gradient; A is the filtration area.

It is scientifically proven that increased filtration can lead to scour and suffocation in earthen dams [12].

In recent years, many studies have been conducted on the use of monitoring and digital control systems. Modern sensor systems monitor water levels, deformations, filtration pressure, and slope displacement in real time [13]. Some

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studies have developed flood risk forecasting systems based on artificial intelligence, which allow for early detection of the risk of accidents [4].

Local scientists have also conducted research on increasing the flood resistance of reservoirs and hydraulic structures in Uzbekistan. In particular, problems related to bank erosion, filtration and silt pressure in reservoirs located in the foothills have been widely studied.

The analysis shows that in order to increase the reliability of dams in flood conditions, it is necessary to carry out structural strengthening, improve drainage systems, introduce monitoring technologies and comprehensively apply modern flood management methods

RESEARCH METHODOLOGY. This study analyzed the theoretical and practical aspects of existing engineering solutions to increase the reliability of dams in flood conditions. During the research, the hydrodynamic impact of flood flows on hydraulic structures, erosion and filtration processes, and the effectiveness of structural protection measures were comprehensively studied. The research object was selected as earthen and concrete dams located in mountainous areas. During the research, the influence of the speed, density, water consumption and amount of hard rocks on the stability of the dam was evaluated. At the same time, the mechanisms of development of bank erosion, filtration processes and slope deformations were analyzed [7].

The hydrodynamic pressure of a flood flow is determined by the following equation:

$$P = \frac{1}{2}\rho\vartheta^2 \qquad (4)$$

where: P is the hydrodynamic pressure; ρ is the current density; ϑ is the flood velocity. Based on this formula, it was found that the pressure acting on the dam structure increases significantly with increasing flood flow velocity [8]. In the next stage of the study, the filtration stability of the dams was studied. Filtration flows were estimated based on Darcy's law (formula 3). It was analyzed that the increase in the filtration process can lead to suffocation and washout phenomena in earthen dams. The safety coefficient was used to assess the operational reliability of dams (formula 1).

During the study, the change in the safety coefficient under different flood conditions was analyzed, and it was found that its decrease from the standard value negatively affects the operational reliability of the dam [2]. Also, during the study, the effectiveness of constructive measures aimed at reducing the negative impact of flood flows on dams was comprehensively assessed. In particular, the protective effectiveness of methods for strengthening coastal areas, using gabion structures, improving drainage systems, and constructing flood-retaining structures was

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analyzed. In addition, the possibilities of reducing erosion processes by concreting slopes were also studied. The study also compared the possibilities of identifying flood risks in advance and preventing emergencies through the introduction of monitoring and early warning systems.

The possibilities of real-time monitoring of water levels, filtration pressure, deformation and slope displacement using monitoring systems were also studied. Based on the results of the study, it was scientifically substantiated that the use of complex engineering protection systems in areas with high flood risk significantly increases the operational reliability of dams [2].

RESEARCH RESULTS AND ANALYSIS. During the research, the impact of flood flows on the reliability of dam operation and the effectiveness of protective measures were analyzed theoretically and practically. The results showed that with an increase in the speed, density, and content of solid rocks in the flood flow, the hydrodynamic loads on dam structures significantly increase. The results of the analysis revealed that mudflows increase the processes of slope erosion, filtration, and suffosis in earthen dams. In particular, high-velocity mudflows have been observed to develop scour processes on the dam slopes and worsen the deformation state of the structure [4]. The hydrodynamic pressure of the flood flow was calculated based on the following equation (Formula 4). The calculation results showed that with increasing flood flow velocity, the hydrodynamic pressure increases according to a quadratic law. As a result, it was found that the loading level in the front part of the dam increased, and in some cases, the stability of the structural elements decreased.

As a result of the analysis of filtration processes, it was observed that internal washing processes increase in earthen dams in cases where drainage systems are not functioning sufficiently. The increase in filtration consumption was estimated based on the following relationship (Formula 3). The results showed that an increase in the filtration coefficient and hydraulic gradient increases the water permeability in the dam body and reduces the level of safety.

The study also evaluated the effectiveness of embankment reinforcement and gabion construction methods. The results of the analysis showed that gabion structures are highly effective in reducing flow energy and preventing slope erosion. Concrete overlays and slope reinforcement work led to a significant reduction in soil erosion.

It was found that when using flood control structures, the flow of large solid rocks in the stream reached the main dam was reduced. This reduced mechanical shocks to the dam structure and increased operational stability.

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The introduction of monitoring and early warning systems also showed high efficiency. With the help of sensor systems, it was possible to monitor water levels, filtration pressure and deformations in real time. As a result, the ability to detect dangerous situations in advance and take prompt measures increased.

The safety coefficient was adopted as the main criterion for assessing the operational reliability of dams (Formula 1). The analysis showed that when structural protection measures were applied, the safety coefficient approached the standard value and the operational stability of dams increased.

In general, the conducted studies have shown that strengthening the banks, modernizing drainage systems, constructing flood control structures, and introducing modern monitoring systems are among the most effective engineering solutions for increasing the reliability of dams in flood conditions.

CONCLUSION. This research work comprehensively analyzed engineering and technological measures aimed at increasing the reliability of dams in conditions of flood flows. During the research, the hydrodynamic impact of flood flows, the impact of erosion, filtration and deformation processes on the stability of dams were studied, and effective methods for their reduction were scientifically substantiated.

The results of the analysis revealed that with an increase in the speed and density of the flood flow, the hydrodynamic pressure on the dam structures increases sharply. This leads to the development of slope erosion, filtration processes, and structural deformations in earthen and concrete dams.

The study revealed that filtration and suffocation processes significantly affect the operational reliability of earthen dams. It was scientifically proven that insufficient functioning of drainage systems leads to an increase in internal washing processes and a decrease in the level of safety.

Structural protection methods such as bank reinforcement, gabion construction, and slope concreting have shown high efficiency in reducing the impact of flood flows. In particular, gabion structures have been found to be an effective means of reducing flow energy and preventing slope erosion.

As a result of the construction of flood control structures, it was observed that the arrival of large solid rocks in the flow to the main dam decreased and mechanical shocks decreased. This was found to increase the operational stability of the dam structure.

By introducing monitoring and early warning systems, it was possible to control water levels, filtration pressure, and deformations in real time. As a result, it was found that the ability to detect dangerous situations in advance and take prompt engineering measures increased.

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Based on the results of the study, the need for structural reinforcement, modernization of drainage systems, construction of flood control structures, and the integrated use of modern monitoring technologies was scientifically substantiated to increase the reliability of dam operation in flood conditions.

In the future, the use of artificial intelligence-based monitoring systems, digital modeling, and automated control technologies will be important in further improving the safety of dams and preventing emergency situations.

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