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ИРРИГАЦИЯ ВА МЕЛИОРАЦИЯ

ГИДРОТЕХНИКА ИНШООТЛАРИ ВА НАСОС СТАНЦИЯЛАР

ҚИШЛОҚ ХЎЖАЛИГИНИ МЕХАНИЗАЦИЯЛАШ

ҚИШЛОҚ ХЎЖАЛИГИНИ ЭЛЕКТРЛАШТИРИШ ВА АВТОМАТЛАШТИРИШ

СУВ ХЎЖАЛИГИ ИҚТИСОДИ ВА ЕР РЕСУРСЛАРИДАН ФОЙДАЛАНИШ

ИРРИГАЦИЯ ВА МЕЛИОРАЦИЯ СОҲАСИ УЧУН КАДРЛАР ТАЙЁРЛАШ

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ANALYSIS AND ASSESSMENT OF THE TECHNICAL CONDITION OF EARTH DAMS AND DAMMED LAKES OF THE REPUBLIC OF UZBEKISTAN

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Abstract

The entire territory of the Republic of Uzbekistan is prone to earthquakes at some degree; however, the avoidance to build dams and hydropower units would limit the progress in the economy and livelihood of the population. The dams in Uzbekistan were built since the beginning of the last century; they were erected even in areas where strong ground motions were previously recorded; for example, in the area of the Charvak reservoir, a number of earthquakes occurred in the recent past: Pskem, 1973, of an intensity of 8 points, magnitude M = 6 and a hypocentre depth h = 20 km; Brichmulla, 1959, with an intensity of 7 points, M = 6 and h = 15 km; Tavaksay 1977, with an intensity of 7 points, M = 5, etc. In terms of technical and economic indices, construction technology, earth dams are the most widespread hydro-technical structures in Uzbekistan. The republic has the most developed water infrastructure among the countries of the region; it allows irrigating 4.26 million hectares of land and generating about 7 billion kwh of electricity per year at its hydroelectric power plants. Therefore, the analysis of the consequences of the impact of earthquakes on ground dams and the adoption of appropriate measures to eliminate damage is relevant

Key words: earthquake, dam, structure, seismic stability, reliability, safety, water reservoir, atastrophe, consequences, damage.

Introduction. In countries that are mostly agricultural, hydrotechnical structures, many energy and utility infrastructure systems are associated with the construction of various dams and barriers. They are the most important objects of the economy of these countries, and especially countries where water resources are limited and rivers have variable currents, sometimes with very low water levels. Therefore, to meet the needs of the sectors of the economy of these countries, a corresponding accumulation of water is necessary. In this respect the Republic of Uzbekistan is not exclusive.

Here the water reservoirs play an important role in energy generation, equal distribution of water for agriculture needs, supply of drinking water to the population and, in general, for the sustainable functioning of other sectors of the economy. However, these structures can be destroyed due to earthquakes. Even their partial destruction can lead to a breakthrough of the reservoir and almost instantaneous flooding of settlements, industrial facilities, and agricultural land.

Thus, enormous economic and environmental damage is inflicted with numerous human casualties. In this article we discuss the issues of conducting periodic assessments and analysis of the technical condition of hydraulic structures and appropriate measures to eliminate damage, which will prevent the possibility of destruction of dams in the event of possible earthquakes.

Materials and Methods. Methodology for assessing and analyzing the technical condition of dams is based on the provisions of the Law of the Republic of Uzbekistan "On Safety of Hydro-technical Structures", adopted in 1999. According to it, a declaration for each hydro-technical structure (HTS) facility safety is made, approved by the Expert Council of the State Inspection "Gosvodkhoznadzor".

Analysis of the study of theearthquake effect on the hydro-technical facilities of the republic is conducted by commissions under a special program with the participation of design and research organizations, special services of the Uzbekenergo State Joint Stock Company.In the world so types of approaches exist [12] and are well known and applied also. Failure of earth dams and its analysis [22] shows many problems at operating of hydro technical structures.

Results. There are 273 large and important HTS of I, II, III classes in Uzbekistan, including 55 large dams (as defined by the ICPBP), with a total water accumulation capacity of about 20 km^3, 35 pumping stations with a total capacity of 3,000 m^3/s and 29 HPPs with a total installed capacity of 400 thousand kW, 60main canals of the total length of 24.3 thousand km and throughput capacity of about 9,000 m^3/s, 64 waterworks, 24 main water-collecting headers for collecting drainage water on irrigation systems, and bank protecting and channel regulating structures on 7 rivers of a total length of 2312 km [5].

At present, out of 55 dams in operation:

• 29 dams are earth homogeneous dams.
• 17 dams are stone-earth dams with the core.
• 6 dams are earth dams with the screen.

In the republic, in addition to reservoirs, there are 23 river water intake hydroelectric facilities and 180 mudflow storage facilities.

In Central Asia, the Charvak (Uzbekistan), Nurek, Rongun (Tajikistan) and other dams were built from gravel-pebble and stone-earth materials.

Numerical investigations of seismic response for dams [10,8]and operating systems [19, 21]cannot reflect real situation of technical condition so types of objects.

Statistics show that there are dozens of cases (and considering earth dams even hundreds of cases) of damage to retaining structures caused by seismic factors, including high-rise dams of various structures. Their failure is fraught with serious economic losses associated with a partial or complete stoppage of water, electricity, and heat supply to consumers.

Reservoirs of the republic are divided into two types - mountain and valley objects. An example of a mountain reservoir is the Charvak reservoir; the valley reservoirs are

Tuyamuyun, Uchkizil, Kukmazar, Chardarya, Talimarzhan, Katta-Kurgan.

The main feature that distinguishes the mountain reservoirs from the valley reservoirs is their large filling depth, up to 300 m, at small areas of the water surface and significant values of water evacuation, up to 30-60 m.

Shallow depths (40 m) and relatively large areas of the water surface characterize valley reservoirs; the river ledges are the reservoir banks.

The main danger that can cause large landslide displacements is the overflow of water over the dam, blocking of the entrance portal, and capturing large areas. In addition to landslide processes, settling processes are developing intensively.

Floods and slipouts occur after a sharp decline in the reservoir, they vary from 10 to 1500 m^3, while flooding of a volume of up to 100 m^3 prevails, having a collapse and extension along the coast.

A particular danger is posed by flooding shutoffs that contribute to the emergence of lakes. Now in the mountain-folded regions of Uzbekistan and adjacent territories of Kyrgyzstan and Tajikistan, there are about 43 mountain landslide lakes. Of these, 11 are located in Uzbekistan (Table 1), 119 in Kyrgyzstan, 12 in Tajikistan [7].

As seen from the table, four lakes located in the basin of the Pskem River present a danger. In general, the water

Table 1.

Dammed lakes on the territory of Uzbekistan

№	Names of lakes	River basins	Altitude, m	Water volume 10^6 m^3	Condition of dams
1	Shavurkol	Pskem	2726	3,89	unstable
2	Ihnach upper	Pskem	2724	0,01	unstable
3	Ihnach large	Pskem	2508	4,80	unstable
4	Ihnach lower	Pskem	2460	0,90	unstable
5	Urungach upper	Pskem	1526	1,51	stable
5	Urungach lower	Pskem	1277	0,08	stable
7	Kurbankul Shakhimardan	Koksu	1277	1,17	stable
8	Blue upper	Koksu	2049	3,27	stable
9	Blue middle	Koksu	1755	0,40	stable
10	Blue lower	Koksu	1703,1	0,96	stable
11	Kichkina kul	Koksu	1637	0,10	stable
Total				17,09	

volume concentrated in the landslide lakes of the Republic is 17.09 million m^3, in the landslide lakes of the adjacent regions of Kyrgyzstan – 109.37 million m^3, Tajikistan – 416.97 million m^3.

One of the typical examples of unloading is the breakthrough of the landslide dam of Yashkul Lake, caused by the impact of the Tashkent earthquake of April 26, 1966. The lake is located on the northern slope of the Alai ridge at an altitude of 2600 m, in the valley of the Tegirmoch river of the Isfayramsay river basin. By the moment of the breakthrough, 6.6 million m^3 of water was accumulated in the lake. The beginning of the breakthrough was marked by the loss of separate blocks from the body of the dam and subsequent erosion. During the breakthrough, two powerful walls 15 and 10 m high appeared. Within 2-3 hours, all the water accumulated there was completely drained from the lake, which in the form of a mudflow passed through the valley of the Isfairamsay River with a maximum flow rate of up to 2200 m^3/s. The average velocity of the mudflow was 4.5-5.8 m/s. The height of the head wall in some areas reached 10-15 m. The breakthrough, which occurred because of the Tashkent earthquake on April 26, 1966, was not a unit fact, similar breakthroughs happened in other regions of Central Asia.

Field observations of the earth dam behavior show that the greatest stress states arise in certain areas of upstream and downstream slopes, and in the crest zones, which can negatively affect the strength of a structure and can lead to damage or destruction during earthquakes.

Every year damage, failures, and accidents happen in approximately 15% of all constructed dams in the world. About 70 -75% of these events are related to earth dams.

Severe accidents of such dams on a national scale with human casualties and large social and environmental losses are widely known: Machchhu-11 (India); Buffalo Creek, Canyon Lake and Teton (USA); Tous (Spain); Touhou (China); Oros (Brazil), Hayokori (South Korea) and others [15].

Over the past 100 years, about 400 dams and embankments have experienced the impact of earthquakes of varying intensity from 4-6 points and higher [11]. At the same time, the number of accidents of these structures caused by earthquakes was in different countries from 1 to 6% compared to the number of accidents from the impact of other causes. According to the statistical data of 1966, for example, out of 1226 dams in Japan, 90% of which are higher than 15 m, earthquakes caused only 6% of deformations and damage [15].

During the Bhuj (India) earthquake on January 26, 2001, M=7.9, 245 small earth dams and levees were damaged with different degrees of severity (Figure. 1) [18].

The Chiryurt dam on the Sulak River built of gravelly-pebble soil with a central loamy core during the Dagestan earthquake on 05/14/1970 received severe deformations and damage.

The calculation and design of the dam located in the area with seismicity 7 points were conducted in accordance with state standards SNiP II-A / 12-62 based on the static theory of seismic stability. The safety factors for shear stability alongcircular-cylindrical sliding surfaces were obtained as 1.5 for the upstream slope and 1.25 for the downstream slopes; and 1.19 for the upstream slope and 1.25 for the downstream slope under special combinations of loads (considering the seismicity of the region).

As a result of the earthquake, large fractures formed on

Fig. 1. Longitudinal fractures on the upstream slope of the Feitigadh dam (India) caused by the Bhuj earthquake on January 26, 2001

the crest of the dam along the entire length of the structure (Figure 1), passing along the axis of the crest, and along the edge of the upstream and downstream slopes. Damage to the parapet and lining was observed. In general, the dam withstood the impact of a strong earthquake - it did not collapse. During the repair, 2.6 m of the top layer of loose soil was removed and replaced with another soil. The lining and parapet were refreshed (Figure. 2).

Currently, many countries have several dams, the damage or destruction of which could have serious social, economic and environmental consequences. For example, the destruction of the dam of Sarez Lake threatens to flood the cities of Uzbekistan, Tajikistan, Afghanistan and, to a lesser extent, Turkmenistan; the destruction of the Charvak reservoir bears a potential flood hazard for the city of Tashkent and its suburbs [1, 20].

Many water facilities were built a long time ago. Thus,

Fig. 2. Damage to the dam of the Chiryurt hydroelectric power station during the Dagestan earthquake on May 14, 1976

the Asaka hydroelectric complex and the Salar hydroelectric power station were built in 1926. The Ravatkhodzha hydroelectric complex was built in 1929. The Great Fergana Canal was erected in 1939, and the last reconstruction of the Dargom Canal was done in 1930, the Kattakurgan reservoir was built in 1941. The operation of the Tupalang reservoir began in 1988.

Large pumping stations in operation in Bukhara and Kashkadarya regions have exhausted their service life. These structures are strategical and vital; the failure of some of them can leave vast regions of the republic without water. For several reasons, their technical condition continues to deteriorate.

One of the reasons for the deterioration is the long-term operation. The facilities need repair or replacement of equipment, metal structures, reinforcement of downstream ponds, etc. Monitoring the mudflow storage facilities in the mountain lakes is performed at an insufficient level; therefore, it is difficult to judge their technical condition [5].

Conclusion

Therefore, conducting periodic assessments of the technical state of hydro-technical structures and appropriate measures to eliminate dam damage makes it possible to prevent possible destruction of water bodies in case of possible earthquakes [16].

For this, it is necessary, first, to analyze and process dam damage in operating mode and after the impact of strong earthquakes; and then, classify and summarize damages by structural type and size of the dam [17].

To reduce the risk of destruction, including seismic risk, in the identified damaged areas, within the framework of the provisions of the Law of the Republic of Uzbekistan on 08.08.1999 N 826-i "On the safety of hydro-technical structures" and the Resolution of the Cabinet of Ministers of the RUz of 20. 08. 1999 N 827-I, to perform the appropriate strengthening measures, considering other categories of damage causes [20], and to conduct restoration and strengthening works [20, 16].

Analysis of the earthquake aftermath on dams of various designs, once again confirms that the issue of their safety is of particular importance and relevance because in many countries there are a significant number of dams, damage, or destruction of which can entail serious social, economic, and environmental consequences. Hence, it becomes necessary to ensure the safety of each dam. For this, it is necessary to take all measures to ensure that this structure does not pose a threat to human life, health, property, and is friendly to the environment [2].

To increase the stability of hydro-technical structures and their safe operation, it is necessary, in author's opinion, to conduct periodic control inspections and assessment of the strength and reliability of structures involving the specialists from scientific organizations; to provide each structure with regular repair and restoration and strengthening works, as is done at construction sites in residential and industrial areas. This applies to all water facilities of the republic, many of which have already developed or are close to reaching 40-50 years of operation, their safety margins are exhausted, and they need major repairs and replacement of equipment [2].

During the construction of new hydrotechnical structures, the following requirements must be fulfilled:

- considering the seismicity of the territory.
- high quality design of the structure
- correct operation and timely adoption of necessary measures in critical situations.

Failure to comply with these requirements leads to catastrophic destruction of dams, such as the Shikan dam which was destroyed during the Chi-Chi earthquake in 1999 in Taiwan due to ignoring the seismic fault under the dam; or improper operation and failure to take timely measures led to the catastrophic accident of the Sayano-Shushenskaya HPP in 2009 [4].

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