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SURVEY OF THE DAM «GEGHARKUNIK 2»

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Abstract

In many hydraulic structures, including dam bodies, it is not possible to effectively solve the problem of filtration.

The Gegharkunik 2 reservoir is located within the land boundaries of the settlement of the same name, 900 m southeast of the village cemetery, on the elevation of the northeastern slope of the Geghama ridge, at an altitude of about 2220 m. The water in the bowl doesn't stay for long. Studies have shown that most of the water loss happens at the lower part of the dam,

where there are many washouts. This means the reservoir not only fails to serve its main purpose but also poses a significant threat to the Gegharkunik community if the dam were to fail. The paper presents the results of a survey of the «Gegharkunik 2» dam.

***Keywords*:** water, filtration, dam body, operational safety

Introduction

In the 20th and 21st centuries, more than 45,000 large and a thousand medium and small reservoirs were built. Dams were built to supply cities with water, irrigate agricultural land, for domestic or industrial use, to generate electricity, or to regulate the water regime of rivers to smooth out floods.

Dams changed the configuration and position of river beds, affected people's access to water resources, ultimately having a significant impact on their sources of income and the environment. The failure rate of large dams has decreased over the past four decades. For dams built before 1950, the rate was 2.2%, and after 1951, it was less than 0.5%. Most dam failures occur in newly constructed dams. About 70% of failures occur within 10 years of construction and most often within the first year of operation. After the destruction of dams, in 36% of cases they were not restored, in 19% they were rebuilt according to a modified design, and in 16% they were restored according to the original design. [1].

During the operation of earthen dams, researches on the formation and development of sediments, base and soffit deformations, leaching losses are of great importance for ensuring the safety of the reservoir.

The probability of a dam breaking depends on its height. Small dams are most often damaged. The most common cause of failure of earth dams is overflow over the crest (31% main cause, 18% secondary cause), followed by internal erosion of the dam body (15% main cause, 13% secondary cause) and its foundation (12% main cause and 15% secondary cause). Among the technical reasons for destruction, the most common is insufficient capacity of water-conducting devices (22% main reason, 30% additional reason). [1, 2].

The use of the latest geodetic methods and measuring instruments makes it possible to obtain reliable data to determine the technical condition of dams [3]. The safety issues of earth dams are the subject of the works of many researchers, including [4-6].

The entire southern region of Lake Sevan is characterized by a landscape cut by volcanic lava flows.

The climate of the region is very diverse and is located in the middle of the moderately humid and arid climate zones.

The description of the climatic conditions of the place is presented by the similarity of the data of the long-term series of the «Gavar» meteorological station, which are characterized by the observance of possible parameters:

- The average annual atmospheric pressure is 803.2 MPa;
- The average annual precipitation is 489 mm;
- The average annual air temperature is +4.6 °C;
- The annual absolute minimum air temperature is -33 °C;
- The annual absolute maximum air temperature is +34 °C;

- Number of days with snow cover per year — 96 days;
- Maximum ten-day snow depth — 37 cm;
- The average annual wind speed is 108 m/s;
- The number of days with strong wind (greater than or equal to 15 m/s) is 31 days;
- In the cold season, the prevailing wind direction is westerly;
- In the warm season, the prevailing wind direction is easterly;
- The maximum soil freezing density in the region is 108 cm.

The region under study is characterized by a wide variety of geological conditions, where volcanogenic-sedimentary-volcanic and normal-sedimentary formations predominate. The oldest rocks in the region are the Upper European formations, localized in the central part of the Sevan anticlinorium.

Quaternary formations are characterized mainly by volcanic eruptions and lake deposits. Volcanic material is represented by andesite-basalts, andesites, andesite-dacites and clastic varieties of the latter.

Alluvial clastic formations and moraine deposits are also widespread in the highlands. Tectonically, the region adjoins the Mertsevan megasynclinal zone of the Sevan mountain-tectonic belt.

The main factors in the formation of the hydrogeological conditions of the region are atmospheric conditions and the permeability of rocks. If we take into account that the material of lava flows, occupying large areas, is highly porous, hollow and fractured, and the latter is preferred over litho-masses of volcanic scoria, then it is easy to imagine that both atmospheric areas and melt waters are very easily infiltrated through the latter and seep into deeper horizons, including reaching the horizon of the root base and to a depth of 100-120 m, without forming more or less stable horizons of both groundwater and underground water.

Conflict Setting

On July 5, 2020, on the right slope of the reservoir and part of the dam body (it is located almost in front of the first bend to the right of the dam), a washout with a water swirl was noticed. To eliminate the accident, several trucks of sand and gravel were poured into the mine, but it was quickly washed away by the flow of water and carried away to deeper horizons.

The gully was closed by gradually filling and compacting several truckloads of clay material brought from a sandy loam deposit located on the right slope of the reservoir into the pit. The task is to survey the «Gegharkunik 2» dam.

Research Results

The assessment of the soil condition of the dam body was carried out by drilling two wells to the foundation, under the supervision of geological engineer S. Jeyranyan (Fig. 1).

The boreholes were drilled at the site of the gulch formation that appeared on July 5, 2020, at a distance of 20.0 m from each other, which included the possible range that could theoretically be damaged by the gulch activity.

Fig. 1 Drilling of two wells in the body of the dam «Gegharkunik 2»

In addition to the in-kind studies of the condition of the dam body soil, five samples of the natural state (monolithic) were selected for laboratory studies in order to assess their physical and mechanical properties (Fig. 2).

Fig. 2 Samples of natural state (monolithic) soil of the dam body «Gegharkunik 2»

The first well is located at point PK 0+65, calculated from the crest of the catastrophic spillway (Fig. 3).

Fig. 3 Drilled cores from the first well
(Left - cores at the beginning, Right - cores at the end)

Results of core studies by drilling depth:

- 0.0-0.2m - Dam embankment is road fill with gravel material of volcanic rocks;
- 0.2-1.3 m - Gray-brown-black-brown loams, heavy sandy loams with a content of detrital material of more than 10%;
- 1.3-11.8 m - Dam body. Successive layers of brown-chestnut-black-brown strong sandy loams of varying degrees of compaction;
- 11.8-13.0 m - Pebble deposits of volcanic rocks (basalts, andesites) with chernozem. The well is dry.

The second well is located at point PK 0+85, calculated from the crest of the catastrophic spillway (Fig. 4).

Results of core studies by drilling depth:

- 0.0-0.3m - Dam embankment is road fill with gravel material of volcanic rocks;
- 0.3-1.0m - Gray-brown-black-brown, heavy sandy loam with a detrital material content of about 10%;
- 1.0-18.5 m - Light brown to brown loams, moderately moist, slightly charred, hard sandy loams, almost without debris;
- 18.5-19.5 m - Black soil of sandy-clay composition with almost no crushed stone mixture;
- 19.5-20.0 m - pebble deposits of the weathered upper layer of bedrock basaltic andesites.

The well is dry.

Tests of the taken soil samples were carried out in the geomechanics laboratory of the Institute of Mining and Metallurgy of Armenia. Random testing was carried out in accordance with international standards (Fig. 5). It was decided:

Fig. 4 Drilled cores from the second well
(Left - cores at the beginning, Right - cores at the end)

Fig. 5 Random testing of selected soil samples

The following were determined: humidity, degree of humidity; specific gravity, porosity and porosity coefficient; humidity in a fully saturated state; granulometric composition, plasticity.

As a result of the work performed, it was established that the material of the dam body is represented by moderate moisture, from light brown to brownish in color, slightly charred, hard sandy loams, almost without admixture of crushed stone. They are characterized by the following physical indicators:

- specific gravity 2.69-2.71 g/cm^3;
- density 1.66-1.69 g/cm^3;
- porosity 48.96-49.87%;
- humidity level 0.587-0.654;
- plasticity limit 26.08-30.07;
- plasticity index 0.06-0.60;
- friction angle 16.27-28.17^o;
- filtration coefficient 0.05-0.08 m/day;
- deformation modulus 115-134 kg/cm^2;
- initial design resistance 1.8 kg/cm^2;
- compatibility coefficient 3000 t/m^3;
- Poisson's ratio 0.36;
- sliding modulus 78.2-97.1 t/m^2.

Fig. 6 Landslides in the lower slope of the Gegharkunik 2 reservoir dam after the appearance of a ravine in 2020

The area not flooded by the lower pool is subject to regular thorough inspections in order to identify processes that are unfavorable for the structure and indirect indicators of its operation.

It should be noted that in places where suffusion soil is removed by the filtration flow from the dam body or foundation below (downstream) the discharge zone, as a rule, there are noticeable deposits of fine soil in the form of tongues, plumes or individual strips.

Visual observations in the lower pool of the «Gegharkunik 2» reservoir show that landslides occurred after the 2020 erosion (Fig. 6).

However, the process subsequently stabilized. Currently, there are no differences in the condition of individual vegetation areas in the lower pool (Fig. 7).

Fig. 7 In the lower pool of Gegharkunik reservoir No. 2 the condition has stabilized (no differences in the condition of individual areas of vegetation are observed)

Analysis of the laboratory test results allows us to conclude that the obtained physical and mechanical parameters almost completely correspond to the requirements imposed on the dam body material. The somewhat low bulk density of the skeleton of such sandy loams is alarming, which may be a consequence of incomplete compaction of the soil during construction.

A general review shows that attention to dam safety assessment is growing. However, the same data show that about 20% of dams built in the last three decades do not have safety assessment results.

A summary report on dam safety in the United States, where there are a significant number of aging reservoirs, highlights the importance of this issue. The key to ensuring safety is to allocate resources to preventive maintenance and timely repairs. A study by Ontario Hydro of several hundred North American dams found that operating costs increase significantly after 25 to 35 years of operation due to increased need for repairs [1].

This issue is also relevant for Armenia, where there are more than 80 reservoirs, the age of which is 50 or more.

Conclusion

1. The results of laboratory tests of the solid sandy loam soil of the dam body allow us to conclude that the obtained physical and mechanical properties, with minor reservations, practically meet the requirements for the dam body material.

2. On July 5, 2020, the washing of the upper part of the dam of the reservoir was carried out in a vertical direction, towards deeper horizons, without damaging the body of the dam.

3. The slightly lower bulk density of the barrier material skeleton indicates that the barrier material was not fully compressed during construction. The green vegetated area in the lower slope is also a result of incomplete and uneven compaction of the dam material, which is especially noticeable during high water levels in the reservoir.

4. The cores taken from the dug boreholes show that the contact part of the dam body and the relief contains remains of black soil and gravel material of basalt composition, which indicates that at the initial stage of the dam construction the foundation was not completely cleared to the surface of the basalt layer. In these conditions, it is encouraging that to date there have been no active outflows of filtered water from the foundation of the dam.

5. 5. The organization operating the reservoir is recommended to monitor the junction of the dam in order to record observed deviations and take necessary measures.

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«ԳԵՂԱՐՔՈՒՆԻՔ 2» ՋՐԱՄԲԱՐԻ ՊԱՏՎԱՐԻ ՀԵՏԱԶՈՏՈՒԹՅՈՒՆԸ

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[1]Ակադեմիկոս Ի.Վ. Եղիազարովի անվան ջրային հիմնահարցերի և հիդրոտեխնիկայի ինստիտուտ
[2]Ճարտարապետության և շինարարության Հայաստանի ազգային համալսարան

Լաբորատոր փորձարկումների արդյունքների վերլուծությունը թույլ է տալիս եզրակացնելու, որ ստացված ֆիզիկամեխանիկական ցուցանիշները գործնականում ամբողջությամբ տեղավորվում են պատվարի մարմնի նյութին ներկայացվող պահանջների մեջ: Փոքր-ինչ մտահոգիչ է նման ավազակավերի կմախքի ծավալային կշռի փոքր-ինչ ցածր մեծությունը, որը կարող է լինել շինարարության ընթացքում բնահողի ոչ լիարժեք տոփանման արդյունք:

Փորված հորատանցքերից հանված կեռներից երևում է, որ պատվարի մարմնի և ռելիեֆի շփման մասում, առկա են սևահողի և բազալտային կազմի խճաքարային նյութի մնացորդներ, ինչը վկայում է, որ պատվարի շինարարության սկզբնական փուլում հիմնատակը լիովին չի մաքրվել մինչև առողջ բազալտային շերտի մակերես: Այս պայմաններում հուսադրող է, որ մինչև օրս պատվարի հիմնատակից ֆիլտրվող ջրերի ակտիվ ելքեր չեն նկատվում:

Բանալի բառեր. ջուր, ֆիլտրացիա, պատվարի մարմին, շահագործման անվտանգություն

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SURVEY OF THE DAM «GEGHARKUNIK 2»

ОБСЛЕДОВАНИЕ ПЛОТИНЫ «ГЕГАРКУНИК 2»

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Анализ результатов лабораторных испытаний позволяет сделать вывод, что полученные физико-механические показатели практически полностью соответствуют требованиям, предъявляемым к материалу тела плотины. Однако, настораживает несколько низкая объемная плотность скелета таких супесей, что может быть следствием неполного уплотнения грунта при строительстве.

По снятым из вырытых скважины кернов видно, что в контактной части тела плотины и рельефа присутствуют остатки чернозема и гравийного материала базальтового состава, что свидетельствует о том, что на начальном этапе при строительстве плотины фундамент не был полностью очищен до поверхности базальтового слоя. В этих условиях обнадеживает то, что до сегодняшнего дня не наблюдалось активных оттоков фильтрованной воды из основания плотины.

Ключевые слова: вода, филцтрция, тело плотины, безопасность эксплуатации.

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