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Assessment of Probability Reliability of Hydro technical Structures during Operation Period

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Abstract: In this article, measures have been developed and recommended for organizing the reliable operation of hydro technical structures during their operation.

Keywords: of hydro technical structures, operation, reliability, danger, accident, dam.

At present, one of the main tasks in the operation of hydro technical structures is to ensure their safe and reliable operation. For this reason, increasing the efficiency of long-term operation of hydro technical structures (HTS) depends in many aspects on increasing its reliability. It is detrimental to identify or assess accident probabilities that may be simplified in increasing the reliability of HTSs operation [1, 2].

It is recommended that the probability of an accident risk assessment in the HTS performed in the following order:

- ✓ various scenarios of accidents are considered;
- ✓ a list of influencing factors is compiled for each accident scenario;
- ✓ The probability of HTS accidents is determined by calculations using formulas.

The final step in assessing the level of safety of an operating HTS or accident risk assessment is to analyze the results obtained, identify the most "hazardous" factors and develop recommendations with organizational or technical characteristics to ensure the safety of the HTS [3].

At present, experts are unequivocally looking at the usefulness of statistical assessments of HTS accidents. Of course, statistical calculations on the probability of accidents at dams do not allow taking into account the individual characteristics of individual HTSs, their operating conditions, etc., and accordingly cannot be used as an assessment of the reliability of individual dams in each case. However, these assumptions are certainly noteworthy, such as the average, overall crash rate estimates for a particular type of dam complex belonging to a particular type of structure [4, 5].

The performance of dams refers to the fact that they are not damaged, that the front of the dam is maintained in the event of an accident and when it is not damaged.

The long-term performance of dams is determined by many factors. The type and design of the dam can be important. It is assumed that some dams, depending on their type, construction, materials, may be recognized as robust HTS, while others may be recognized as less durable, which may affect the final choice of individual dam type and construction, taking into account safety requirements during design.

The long-term performance of dams has been established in relation to events and accidents that result in the emergency discharge, repair and restoration of water in reservoirs, etc., or cases that result in serious damage to the HTS. At the same time, by ICOLD terminology we may understood to mean irregularities that lead to or could lead to an accident.

Based on the overall statistics, the estimated statistical probability of accidents, injuries and violations in the HTS of leading experts and scientists varies in the range of 1, $04 \cdot 10^{-4} \div 7{,}92 \cdot 10^{-5}$.

Analysis of accident statistics shows that the lowest percentage of cases was recorded in concrete dams of the gravitational type, ie up to 3.1% of the total number of HTSs of this type. It is followed by arch dams (4.4%) and buttress dams (5.1%). Among dams constructed from soil materials, various disturbances and irregularities were recorded in earthen dams (6.7%). In rock fill dams (10.9%) and in rock-soil dams, this figure is up to 17%.

Based on the statistical assessment of the accident rate, it is recommended to use the following statistical coefficient to quantify the long-term performance of dams:

$$K_v = 1 - \frac{n_{acc}}{n_{inc}} \quad (1)$$

Where: n_{acc}, n_{inc} - the number of dams where accidents occurred and accordingly the total number of damages in certain types of dams that preceded these accidents.

Here, the k_v coefficient is a unit of the statistical coefficient of accidents provided by A.F. Silveyra. kv is called the statistical coefficient of long-term operation of dams against the transition of events to accidents.

According to ICOLD, we obtain the statistical coefficients of long-term performance against cracking of the pressure front: for earth dams - 0.94, for concrete dams - 0.96. From this we can conclude that these assumptions may indicate the low long-term performance of soil dams compared to concrete dams against cracking of the dam front.

According to the results of the research, it can be noted that the long-term performance of dams depends on the type of materials and the type of HTS, as well as the nature of the occurrence of accidents.

It should be noted that when it comes to accidents involving the rupture of the dam front, concrete dams have the ability to operate for a long time or without damage compared to dams built from soil materials. However, in general, in the event of an accident, taking into account the measures usually taken in emergencies, earth dams will last much longer compared to concrete dams. Thus, depending on the type of HTS, the statistical coefficients of long-term operation of earth dams in the event of failure in the transition to accidents will be in the range of 0.54-0.77, and for concrete dams in the range of 0.39-0.66.

It is natural that the factors that determine the reliability of the HTS during operation are more often explained by errors made during design and construction. In practice, the service life of buildings, which is determined by the standards, does not always correspond to reality.

Accordingly, we propose to conduct a HTS reliability assessment based on the actual service life of each element of the structure during the design or operation periods.

To do this, the probability of failure of building elements F (x) can be determined using a formula based on research conducted by water scientists (SRIIWP and TIIAME):

$$F(x) = e^{-\frac{(t-1)^2}{0{,}3183}} \quad (2)$$

Where t – is the service life of the HTS elements.

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Knowing the probability of failure of each element of the HTS depending on its service life F(x), it is possible to draw a graph F(x) = f(x) (Fig. 1).

The figure clearly shows how likely F(x) is to fail this or that element of the structure.

Depending on the condition of the HTS and the importance of this or that element in ensuring the uninterrupted, uninterrupted operation of the structure, it is possible to increase the structural reliability of the structure while it is still in the design phase or during operation. Alternatively, having a graph of F(x) =f (x), the probability that each element and structure will not fail completely can be determined by the following formula:

$$P(x) = 1 - F(x) \quad (3)$$

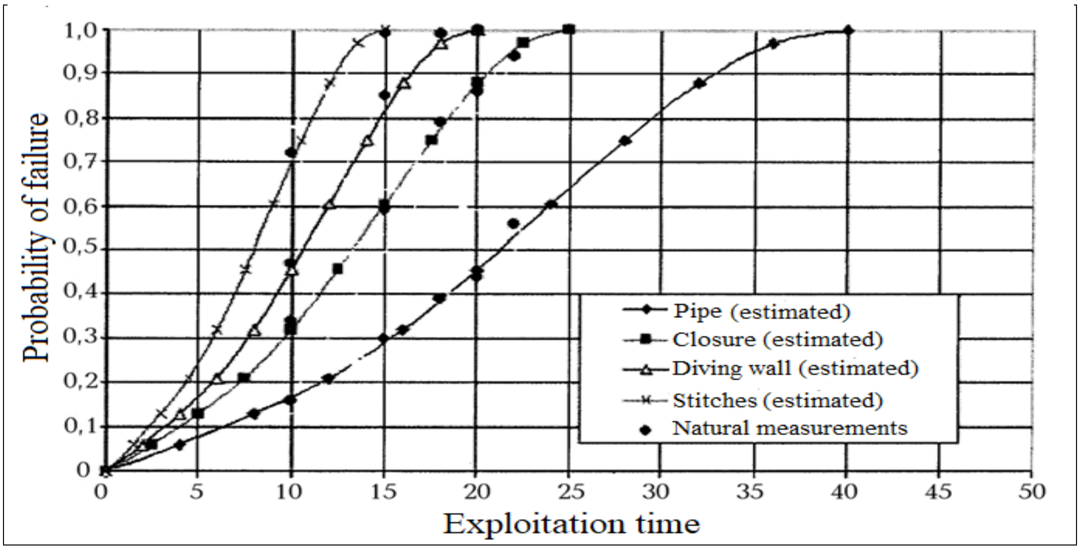

Figure 1 - Graph of the dependence of the failure of the elements of the water intake on the time of operation

In this case, the probability of failure of the operating irrigation system in time *t* can be determined by the following formula:

$$P_{IS}(t) = P_{PFWI}(t) \cdot P_{PFI} \cdot iP_{PAS} \cdot nP_{PFC}(t) \cdot mP_{PFWS}(t) \quad (4)$$

бунда P_{PFWI} - the probability of failure of the water intake;

P_{PFI} - The probability of failure of the inter-farm channel;

P_{PAS} - The probability that the adjusting structure will not fail;

P_{PFC} - The probability of failure of the connecting structure;

P_{PFWS} - The probability of failure of the water supply structure;

i, *n* and *m* – are the number of adjusting, connecting and conducting structures, respectively.

The uninterrupted operation of the individual structures of the complex depends on the reliability of the structural elements. At the same time, if the water intake (node) or inter-farm canal fails, the whole system will fail, so first of all it is necessary to achieve high reliability in high-responsibility facilities.

Irrigation systems can use the calculation formulas proposed by academician T. E. Mirtskhulava to calculate other key indicators of HTS reliability.

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The average downtime of structures in canals is determined as follows:

$$t_u = \sum_{n=1}^{n} P_{IS}(X_i)\Delta t = \sum_{i=1}^{n}[1 - F(x_i)] \quad (5)$$

In this case, the coefficient of reliability of operation of all hydraulic structures in the complex for time t can be determined as follows:

$$R(t_0) = Ke^{-t_0/t_u} \quad (6)$$

Where K is the coefficient of readiness of the structure for operation by the following formula:

$$K = t_w/(t_w + t_{st}) \quad (7)$$

бунда t_w-working time of construction; t_{st}- construction suspension time.

As an example, according to the Ugam Irrigation System HTS failure data, the maximum probability of failure at the water intake was F(x) =0, 91 and at the inter-farm canal F(x) =0, 84, while the minimum value was F(x) =0, 81-0, 83, respectively, for the culvert and drainage structure.

This information is corroborated by natural research and maintenance data. Calculations of the probability of failure of the Ugam irrigation system HTS showed that the lowest reliability after 23 years of operation is at the water intake, ie P (x) =0, 09, so it requires immediate reconstruction.

Conclusion

If the proposals made during the operation of hydraulic structures are taken into account, measures are planned and implemented in a timely manner, failures and accidents at the HTS will be prevented, operational reliability will be further enhanced and safe operation will be achieved.

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