INCREASE OF THE EFFECTIVENESS OF SAFETY CONTROL OF HYDRAULIC STRUCTURES UNDER PRESSURE

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Considerable attention has always been devoted to the reliability of hydraulic structures both during design and during operation; in 1970-1980, as is known, there were many failures and damages of dams (USA, France, Italy, India, South Africa, etc.). In connection with this, in all countries more attention is being given to problems of dam safety, in a number of countries organizational and technical measures to increase reliability have been carried out [2]. These problems also became the subject of discussion at international congresses. Thus, at the Thirteenth International Congress on Large Dams (India, 1979) problem 49 "Failures and Damages of Dams" was examined, at the Fourteenth Congress (Brazil, 1982) problem 52 "Safety of Dams During Service," and at the Fifteenth Congress (Geneva, 1985) problem 56 "Observations of Dams and Their Foundations by Means of Monitoring and Measuring Equipment."

In recent years statistical analyses of failures and damages of various types of foreign dams have been carried out for evaluating dam reliability. However, the results of the analysis made it possible to give only a relative evaluation of reliability of earlier constructed dams and to establish the effect on reliability of natural conditions, design characteristics, and technology of constructing them [1]. Therefore, at present instrumental and visual observations are the main means of safety control of structures in service and preventing failures and major damages.

In our country the reliability of structures is evaluated in conformity with the construction specifications and regulations (SNiPs), which also decree the mandatory equipping of hydraulic structures of the I, II, and III classes with monitoring and measuring equipment (MME) for checking the safety of their operation.
In the case of a large number of MME installed on structures of the I class and especially on high-head dams, the collection (measurement), processing, and analysis of the measurement data require considerable expenditure of labor. The recording instruments being produced by industry do not provide prompt taking of readings in cases of intense measurements of loads or operating conditions of the structure, which lessens the quality of the final results of on-site observations. Therefore, in recent years automated measuring systems (AMS) have been developed and introduced at a number of electric power stations. These systems make it possible to reduce by tens of times the expenditure of labor on measurements, calculation of the measured quantities by means of individual calibration curves, issuing information in a tabular form for its analysis on site, coding the information in a form convenient for its input into a computer for a more thorough analysis and for storage. However, the introduction of the AMS does not make it possible to accelerate to the necessary degree an evaluation of the condition of a structure from the measurement data on site. For such an evaluation it is necessary to have criterion values of the indices of the condition of the structure, a comparison of which with the measurement data will make it possible to determine the presence of possible deviations in the work of the structure form the designed.

The assignment of such criterion indices, which are called below the maximum allowable, ran into major difficulties, since the method of determining them by the SNIPs is not regulated and earlier these indices were not determined when designing structures.

Taken as the standard indices of the strength of structures in the SNIPs are the standard characteristics of the strength, deformation, and seepage properties of construction materials, the fulfillment of the regulated relationships with which of the calculated indices guarantees the safe condition of the structure. The exception is SNIP II-16-76 "Foundations of Hydraulic Structures," in which it is decreed to use such indices as the allowable and critical gradients of the seepage head (pars. 4.2, 4.3, and 8.13) and critical seepage velocities (par. 4.4) in seepage calculations.

The assumption that the maximum values of the maximum allowable indices are equal to the standard characteristics of materials, i.e., the assumption of an increase of the probability of failure to 1, encounters objections [3]. The main objections to such an approach are related to the potentially possible economic losses in the case of an urgent decrease of the loads on the structure for a long period and development of a plan and performing works on its repair or reinforcement.

The assumption that the maximum allowable indices are equal to the calculated characteristics of the materials also is not completely valid, since when the actual indices reach them the structure still has a margin of capacity for work corresponding to the standard coefficients of working conditions and reliability, i.e., the probability of its failure is theoretically close to 0.

In addition to the calculated values, it was suggested in individual cases, when this seems possible, to establish also higher critical values of the indices, on reaching which the margins of stability and strength become lower than the standard ones, the probability of failure is close to 1, but the structure has still not reached the limit state [4]. In this case the structure will be in a state requiring taking urgent measures on reinforcement or partial unloading of the structure (a decrease of the water level in the reservoir). This suggestion was not adopted owing to the absence in SNIPs of recommendations on a method of calculating the critical values of the main indices and insufficient study of this problem.

With consideration of the aforesaid, the maximum allowable indices ought to be taken less than the standard but higher than the calculated characteristics.

However, the calculation methods being used, including those recommended by SNIPs, in the majority of cases do not permit obtaining such indices. After a wide discussion of this problem in 1984, the All-Union Planning, Surveying, and Scientific-Research Institute (Gidroproekt) published recommendations, in which the maximum values of the maximum allowable indices were assumed equal to their calculated values corresponding to the loads of the usual or unusual load combinations acting on the structure-foundation system [5].

Further development of methods of calculating structures, regulating of the allowable probabilities of failure for all types and classes of structures, and also the experience of using the published recommendations in the near future will make it possible to substantially improve the methods and to increase the reliability of evaluating the condition of structures.