EXPERIENCE IN OPERATING HYDRAULIC STRUCTURES

EXPERIENCE IN USING AUTOMATED INFORMATION-MEASURING TECHNOLOGIES FOR GEODETIC MONITORING OF HIGH DAMS

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Traditional methods of geodetic monitoring of displacements and deformations of high dams [1] are insufficient under the action of dynamic, particularly geodynamic, forces due to their low efficiency. This pertains primarily to high-head hydro developments with large reservoirs located in seismically active mountainous regions with complex tectonics and presence of earthquake-generating faults. The large volume of works in difficultly accessible places, low accuracy of measurements, subjective factor causing errors, and long data processing time do not make possible continuous reliable monitoring of the state of the dam—foundation system. The scheduled cycles of leveling, observations of plumb lines, deep bench marks, gap meters, string systems, and geodimeters are often insufficient due to rapidly occurring geodynamic processes not related directly with the reservoir operating regime.

According to the new technical operating regulations, it is required to record the readings of all types of monitoring and measuring instruments (MMIs) after each seismic tremor of intensity 5 [2]. This is a quite labor-intensive task if performed manually. Some unique hydraulic structures were constructed with an understated design seismicity, which requires thorough routine monitoring of potentially hazardous geodynamic processes. Sometimes the need arises to monitor irreversible unplanned displacement more often or to obtain prompt information about the reaction of structures to seismic events, passage of floods, and various anomalous situations. In addition, modern diagnostic systems of high-head dams require the creation of a single information field with automation of processes of measuring, collecting, storing, retrieving, processing, and analyzing the primary data from all measuring systems of the dam, including geodetic systems, with the use of personal computers.

With consideration of the aforesaid, in 1984 the Research Institute of Applied Geodesy (presently the Sibgeoinform center of the Federal Geodesy and Cartography Service of the Russian Federation, Novosibirsk) began working on the creation of an information-measuring system as applied to geodetic observations at the Sayano-Shushenskoe hydrostation [3]. The main purpose of creating such a system is to form a geodetic data bank making it possible:

- to analyze information obtained with the possibility of constructing a model of the static behavior of the structure and its interaction with the environment;
- to use the geodetic information obtained for developing a comprehensive system for assessing the risk of occurrence of anomalous geodetic processes in the region of the hydro development;
- to use promptly the geodetic information obtained for predictive purposes and making decisions in critical situations.

By automated hydraulic structures monitoring system (AHSMS) is meant a complete set of organizational and technical approaches and technical means, including the following stages:

- development of an individual plan for solving the customer's particular problems with recommendations on selecting equipment and software;
- development of the technical means which are installed on the existing MMIs (direct and reverse plumb lines, string transit lines, triaxial gap meters, hydrostatic leveling instruments) and permit not destroying the established traditional monitoring means and systems;
- creation of applications programs for particular tasks;

installation and adjustment of technical means, adjustment and metrological certification of the hardware and software of the system;

training the customer's technical personnel;

tracking the system for a period coordinated with the customer.

Structurally, the system is divided into subsystems from the viewpoint of the types of geodetic MMIs used and sequence of putting them into operation: reverse plumb lines, direct plumb lines, networks of extended triangles, abutments, gap meters, hydrostatic leveling instruments (Fig. 1). The set of technical means includes transducers, communication lines, a computer control complex (computer and devices for communicating with the object). The set of technical means is organized such that it permits, by means of the selected items, realizing the maximum number of functions of the system by means of batch-produced articles, minimizing the composition of additionally developed apparatus and total length of the communication lines, providing the necessary accuracy and noise immunity of the information communication lines, and operating the system under ordinary working conditions.

Mathematical support of the system represents a set of models and algorithms uniting the technical means into a single complex with a high degree of reliability, intended for real-time operation. Mathematical support realizes automatic input of information from sensors, processing of input information, preliminary interpretation of the measurement results, formation and output of information in the form of documents and videograms. Automatic input of information from sensors is realized by organizing an input interface of the system by forming on the address and service buses an interface of certain combinations of electrical signals and input into the PC of the information from the analog-signal buses as well as diagnosis of the technical means with localization of detected troubles. Mathematical processing of the input information includes digital conversion of the analog signals of the linear displacement sensors, calculation of displacements and displacements of control points from adjustment of the networks, and recording the results of mathematical processing on machine media. Preliminary interpretation of the measurement results includes a short-range prediction of development of deformations, comparison of the results of the prediction with the allowable displacement norms, and determination of the time of performing the next measurement cycle.

The special software (SSW) of the system in the form of a modular structure is a machine realization of the information and mathematical support. Development of the SSW modules realizing mainly complex computational algorithms was done.