EXPERIENCE IN GROUTING FOR SEALING THE SAYANO-SHUSHENSKOE DAM

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Grouting construction joints is one of the most important measures for providing solidity of concrete masonry of high dams and conditions of their normal service. The successful solution of this problem largely depends on the technology being used, reliability of the embedded grout reinforcement, hydraulic characteristics of the joint, and climatic conditions of construction. The last circumstance is often decisive in selecting the grout-sealing method and makes a substantial impression on the technology of grouting works. At the start of construction of concrete dams in the northern construction climatic zone, the grouting technology called for conducting sealing operations only at a positive temperature of the concrete (departmental building code VSN 02-64). However, with consideration of the need to perform considerably increased volumes of sealing works in the shortest possible time with a maximum width of the joints, suggestions were made concerning improvement of grouting technology with the use of local heating of the concrete and use of special cold-resistant grouts.

The most complete investigations for developing a reliable method of heating and grouting joints were carried out on the Sayano-Shushenskoe dam. Further development of the heating and grouting technology was carried out by the All-Union Planning, Construction, and Installation Association Soyuzgidrospetsstroi with the enlistment of State Special Design Institute (Gidrospetsproekt), B. E. Vedeneev All-Union Scientific-Research Institute of Hydraulic Engineering (VNIIG), and its Siberian branch.*

A stepwise scheme of constructing the dam with offsetting of the downstream face with differences of height between columns up to 35-55 m was adopted as the plan of operations. Construction of the dam was accompanied by filling of the reservoir, which necessitated its annual staged sealing by grouting the column and section joints. A sealing temperature of 2-7°C was achieved by pipe cooling of the concrete.

The bulk of the sealing works, with consideration of the stress state of the gravity-arch dam, was performed in the winter-spring period with the reservoir drawn down. The width of the column and radial joints of the dam on vertical faces at the time of their grouting was respectively 2.5-5.0 mm and 1.5-3.5 mm. On the whole, practically no cases of impassibility of the joints caused by an insufficient width were noted during sealing of the Sayano-Shushenskoe dam.

At the same time, the vertical and, partially, the horizontal surfaces of the dam columns were under the effect of the outside air for a long time (up to 2-3 years in some cases). This circumstance led in the cold time of the year to the spread of negative temperatures from the surface into the mass. As a result, freezing of the concrete extended to a depth of 4 m in some places. The area of the frozen zones of concrete within typical segments of radial joints of the dam reached 25-48 m², the time of observing negative temperatures was 3-4 months.

The presence of frozen zones of concrete hindered grouting works before the start of spring filling of the reservoir and necessitated the development and use of measures on heating the joints in the zone of action of negative temperatures. Three different methods of preheating of the concrete were used to provide filling the joints in the indicated zones with grout and to create normal conditions for its hardening.

The first method was electrical heating of the concrete by means of embedded conductors used earlier when grouting the downstream face of the Ust'-Ilim dam and part of the joints of the Zeya dam. Having such advantages as operating reliability of the heating system and provision of deep thawing of the concrete, the indicated method has a number of shortcomings related to nonuniformity of the temperature field and need to use additional measures for heating the main lines supplying the water and grout. The use of such a method on the Sayano-Shushenskoe dam had an experimental character and the final results of the effectiveness of its use have still not been obtained.

*Specialists of Gidrospetsproekt under the direction of É. S. Argal and V. G. Skokov and groups of co-workers of the Siberian branch of VNIIG under the direction of S. N. Starshinov actively participated in developing the technology, organizing the experiments, and conducting on-site investigations.

In 1977-1979, Gidrospetsproekt with the participation of VNIIG and its Siberian branch developed and theoretically substantiated a method of heating concrete by means of a special pipe system installed parallel to the plane of the joints being grouted in the zone of action of negative temperatures. According to this method, for a certain time before the start of grouting hot water (heat-transfer agent) is passed through a system of pipes laid zigzag with a spacing of 0.5-1 m, which, circulating through the pipes in the immediate vicinity of the joint, heats the near-joint zone of concrete.

Twelve coils with a spacing of 1.0, 0.7, and 0.5 m were installed in radial joints of the dam to test this method. The temperatures were measured in experimental segments of the radial joints measuring 27 x 9 m, in which were installed two coils: on the downstream side and on the surface of the block. A special device, consisting of six successively connected ÉPV-2A electric heaters, a 200-liter hot water tank, and a ND 1000/10 proportioning pump, was constructed for heating and delivering the water. During delivery of water with a temperature of 80°C through the coil for 9 h, the thermometers installed 25 cm from the joint showed an increase of temperature in the concrete from −0.5 to +4°C and at a distance of 3.5 m from −1.2 to +0.5°C. Hydraulic testing after heating the segments showed that they are completely free of ice, and the temperature of the water passing through the joint increased on average by 4-5°C. In our opinion, among the virtues of such a heating me-