REGULATION OF THE TEMPERATURE REGIME OF CONCRETE IN THE TIERED TECHNOLOGY OF CONSTRUCTING AN ARCH DAM

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A comparison of various methods of constructing concrete dams and an analysis of the results of on-site and analytical investigations of the thermal stress state of concrete made it possible to formulate the principles of preventing cracking and increasing the reliability of a thin arch as applied to the Miatla dam.

The dam of the Miatla hydroelectric station (total construction height 86.5 m) includes a plug, support pad (saddle), double-curvature arch of circular outline in plan (height 73 m), and bank abutments. The crest length of the dam with the abutments is 179.3 m. The thickness of the arch at the base is 11.5 m and at the crest 6.3 m. The average distance between radial joints is 17 m. The volume of concrete is 108,900 m³, including 77,200 m³ in the arch part.

The climatic conditions of the construction region are characterized by a mean annual air temperature of +12°C. During the year there are about 40 days with a mean daily air temperature below 0°C and about 100 days above +20°C. The cold season during which negative temperatures is possible is 90 days.

In the design of the Miatla hydroelectric station the traditional scheme of constructing a dam was adopted — with leading and lagging sections — with the following requirements imposed on the temperature regime of the arch part of the dam: temperature of the concrete mix when placing in the blocks, not higher than +15°C; maximum temperature of concrete in the blocks, not higher than +42°C; difference of temperatures in the center and on the horizontal surface of the blocks, not more than +14°C; difference between temperatures in the center and on the external faces of the blocks, not more than 24°C; rate of cooling of the concrete in the center of the blocks during the first 7 days, not more than 1.5°C/day; end of pipe cooling with river water, not more than 2 days after reaching the maximum temperature; start of the second stage of pipe cooling with water from the refrigeration station (+3°C), after placing concrete with a height of 10-12 m above the tier being cooled; rate of cooling the concrete with water from the refrigeration station during the first 2 days after turning it on, not more than 1.4 and not more than 0.9°C/day.

To meet these requirements and to prevent cracking, the following measures were specified in the design: cooling of the mixing water and coarse aggregates of the concrete with air in the hoppers above the proportioning feeders at the concrete plant; cooling of the concrete in the dam by embedded pipe coils with a spacing of 1.5 × 1.5 m, into which at first is fed river water with a natural temperature and then water from the refrigeration station with a temperature of +3°C; if necessary, watering of the surface of the concrete with river water; winterizing of the formwork of the upstream and downstream faces of the dam regardless of the season of concreting and removing the winterizing coverings from the faces in the spring after cooling the dam to the temperature of sealing the joints (+7°C).
Fig. 1. Probability of the times of covering the blocks and rate of cooling of the concrete: 1) times of covering the blocks of the Miatla dam; 2) times of covering the blocks of the leading sections of the Chirkey dam not having cracks; 3) same, having cracks; 4) average rate of cooling the concrete of the Chirkey dam during 3 days after the temperature peak for the entire period of observations; 5) same for the Miatla dam; 6) average rate of cooling of the concrete in the blocks of the Miatla dam placed in July-August during 5 days after the temperature peak.

An analysis of the results of calculating the temperature regime of concrete from new standpoints showed that with realization of the principles of the tiered technology, conditions are created for a uniform decrease of temperature over the dam section, which does not cause stresses in the zone distant from the foundation. This makes it possible to somewhat ease the requirements set in the design. At the same time, to be able to promptly react to changes in the production and climatic conditions it is necessary to have reserves in the regulating system.

In conformity with this, a new edition of the "Technological Regulations on Performing Concreting Operations at the Miatla Hydroelectric Station" was developed, in which the allowable temperature of the concrete mix during placement in the blocks was increased to +20-22°. It was recommended to carry out pipe cooling without interruption with a rate up to 1.5°/day after the temperature peak and to insulate the upstream and downstream faces of the dams briefly for 25-30 days depending on the temperature of the concrete and air.

Various cases of regulation were examined in detail and particular regimes (intensities of pipe cooling, temperatures of the surface of the blocks being maintained by watering) were recommended for temperatures of the concrete mix from 15 to 22°, different height and times of covering the blocks, different cement content, different air temperature, etc., making it possible to promptly control the temperature regime of the dam concrete and giving the builders the possibility to use a set of measures on temperature regulation.

The following suggestions and measures were developed and implemented:

Reserves of the capacity of the refrigeration station and flow rate of the river water were created in the pipe cooling system to provide its continuous cooling; installation at the drain from the coils of funnels with "interruption of the stream" for visual checking, valves for regulating the water flow rate, and an additional pumping station for delivering circulating water to the refrigeration station;

A system for cooling coarse aggregates with river water on the check screen with a flow rate up to 2 m³ of water per 1 m³ of aggregate, intended for providing the temperature of the concrete mix adopted in the new addition of the technological regulation without using the device cooling the coarse aggregates with air;