INVESTIGATION AND EXPERIENCE OF USING CONCRETE-PUMP TRANSPORT AT THE CONSTRUCTION OF THE SHUL'BINSK HYDROELECTRIC STATION

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The current state of construction of concrete structures as the most labor-intensive necessitates an improvement of existing and development of new highly effective cyclic and continuous technologies of conducting works with the creation of an interrelated complex of highly productive machines and equipment completely mechanizing all elements of the works.

A highly efficient technology based on the use of especially stiff, low-cement concrete mixes with the use for their placement and compaction of simple highly productive operating methods similar to the methods of constructing earth dams is presently gaining popularity for massive lightly reinforced concrete structures. The new technology has a high rate of placing the mixes (200-500 m³/h), which in many respects predetermined continuous methods of its preparation and conveyor delivery.

For concrete-encased steel members and structures, especially heavily reinforced and thin-walled ones and those with a complex configuration, a progressive technology, in our opinion, is that with the use of modern concrete-pumping plants [1], which provides: combining horizontal and vertical delivery of mixes by one mechanism; the possibility of laying the concrete-delivery pipeline under the most complex and confined conditions of the construction site; movement of the concrete mix under pressure and its protection from unfavorable environmental effects; high mobility of the concrete-pumping equipment providing continuous delivery of the concrete mix; possibility of pumping the mixes through stationary pipelines to considerable distances.

The impetus to the creation of new economical designs and technologies of conducting concreting operations by means of concrete pumps was the intense development of superplasticizing and complex additives to concrete. Additive made it possible to obtain nonsegregating cast concrete mixes (CCMs) with a fluidity of 20-26 cm with respect to the slump of a standard cone (SSC) with prescribed physical and mechanical properties and workable in concreting blocks by nonvibration methods. Some progressive scheme of constructing hydraulic structures and members with the use of concrete-pumping techniques and CCMs are given in [2, 3, 4].

Concrete-pump transport of cast concrete mixes has been studied little [5]. Rather extensive investigations of this problem as applied to the technology of constructing reinforced-concrete hydraulic structures are being carried out at the M. I. Kalinin Leningrad Polytechnic Institute (LPI) [6]. The following main technological problems have been established in the general problem of concreting technology: calculation of the maximum distance of transporting the mixes through stationary concrete-delivery pipelines; selection of the type of concrete pumps and their number; selection of the composition of the concrete mix meeting the given conditions of the delivery distance.

These problems can be solved with consideration of the main characteristic of a concrete pump — the magnitude of the maximum pressure of the piston on the concrete mix — and with consideration of pressure losses (resistances) in the pipeline during pumping of the mix.

Comprehensive investigations of the pumpability (with respect to resistances) of the mixes in the delivery pipelines were conducted under on-site conditions at the construction of the powerhouse of the Shul'bink hydro development with a check of the results obtained at the LPI laboratory on a specially created large-scale universal stand, the concrete-delivery pipeline of which had a diameter of 125 mm. Also investigated on the stana were the resistances to movement of highly fluid and cast concrete mixes obtained on the basis of superplasticizing additive S-3, air-entraining agent LKhD, and their combination [3, 6].

A brief characterization of the Shul'binsk hydro development where the experimental works were conducted and the situation that developed at the construction site were the following. The low-head Shul'binsk hydro development (maximum head
A difficult situation was created in 1986 at the construction site of the Shul'binsk hydrostation with the start-up of the first unit owing to the impossibility of performing the volume of forthcoming concreting works, equal to 133,400 m$^3$, by the existing cranes. On the suggestion of V. L. Kuperman, the director of the USSR Ministry of Power and Electrification (Minénego) and the All-Union State Institute for Planning Construction in the Power Industry (Soyuzgidroénergostroi) decided to immediately change the plan of organization and performance of construction works and to stress the use of a continuous technology of placing concrete mixes in the powerhouse. For this purpose, a sufficient number of truck mixers and equipment for continuous transport of the concrete mixes was allocated from the reserve of Minénego — BN-80-20 and SB-126A truck-mounted concrete pumps and Rotec (USA) conveyor concrete placers, which made it possible to place about 40-45% of the concrete mix by means of the new technology.

The BN-80-20 truck-mounted concrete pumps proved to be the most reliable of the concrete pumps in operation. The main volume of the mixes being pumped by them was transported through stationary pipelines (Fig. 1) with frequent combination of vertical and horizontal delivery. The volume of heavily reinforced blocks between the units and body of the powerhouse reaches 350 m$^3$ and more (Fig. 2). It was planned to use concrete-pump compositions with a high cement content (Table 1) with

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Fig. 1. Preparation of the block for concreting by the concrete pump.

Fig. 2. Pressure distribution along the length of the concrete-delivery pipeline: 1-4) pressure transducers.