RECONSTRUCTION OF A ROCKFILL DAM

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Rockfill dams of a compressed profile were constructed when the absence of sufficient mechanization did not permit mining and transporting rock in large volumes. In these structures a part of the dam profile was constructed from stone masonry and the remaining part from rock fill. A facing placed on the upstream face was used as the watertight element of such a combined dam. Most often wood was the facing material. A wood-board facing, being constantly in an underwater environment, in the opinion of the authors of the projects, should not be destroyed, since there were no conditions for mechanical or biological damages.

Such design decisions were made on the Shirokovo [1] and Matkozhnen dams. Relatively large and slowly diminishing deformations are characteristic for rockfill dams of such type, the consequences of which are usually reflected on the watertight elements [1]. Deformations are especially dangerous in dams where the watertight element is made in the form of a wood facing; it is placed on a steep slope formed by the stone masonry.

The present article gives the result of observations and experience of reconstructing the Matkozhnen dam, which is part of the barrier of the No. 14 lock of the White Sea—Baltic Canal.

The Matkozhnen dam was constructed and came under a head in May 1933. The dam (Fig. 1) consists of an upstream shoulder laid from bed stone (granite) with filling the joints with rubble and a downstream shoulder dumped from stone of mixed rocks.

The watertight facing is made of wood: 18 × 18-cm beam and two rows of wood planks. A 1-m-deep concrete cutoff is made at the contact of the rock foundation with the dam. The height of the dam is 16.7 m, length 137.5 m, crest width 5 m.

Deformations of the dam in the form of horizontal movements of the crest (Fig. 2) were noted as far back as 1934 after filling the reservoir. In 1941 the amount of movement was already more than 0.5 m. In 1953, in connection with construction of a hydroelectric station, the dam received an additional head, which led accordingly to additional movements of the crest (Fig. 3). Subsequent regular measurements indicated their continuous increase, although with noticeable waning.

As observations on the Shirokovo dam showed [1], horizontal deformations also have a constantly increasing character with some waning. It is noted here that horizontal movements of the crest (2.39% of the height) is greater than vertical settlements (1.85% of the height).

Different variants were proposed for strengthening the profile of the Shirokovo dam, the idea of which consisted usually in filling the voids of the rock fill with sand—cement grout or by infilling with sand [2].

In the Matkozhnen dam, in addition to deformations of the crest, a serious problem was seepage through the dam, which increased especially intensely starting in 1964-1968 (Fig. 4). On average the rate of increase of the seepage discharge was 0.2 m³/sec every two years.

Observations showed that such an increase of seepage was due to damages of the wood facing, especially in the upper zone, to a depth of up to 2 m from the normal pool level.

All attempts to eliminate seepage by an additional wood-board covering with roofing-felt lining, carried out by divers, as well as underwater placement of the concrete mix, did not produce the expected effect.

Since the general stability of the dam was sufficiently high, main attention when selecting the reconstruction variant was denoted to preventing seepage.

The following variants of reconstructing the dam preventing seepage were examined jointly with the Leningrad State River Transportation Planning Institute (Lengiprorechtrans) and with the enlistment of other organizations:

1 variant — injection of the stone masonry with special solutions (cementation, silicate injection, bitumen impregnation)
II variant — construction of an earth facing on the upstream side in front of the stone masonry with subsequent construction of a grout curtain in front of the wood facing;

III variant — construction of an earth facing with a watertight polyethylene curtain preliminarily suspended on the wood facing;

IV variant — construction of an earth embankment in front of the dam with subsequent emptying of water from the "recess" and filling the "recess" dry with high-quality soil.

The variants indicated above were developed by Lengiprorechtrans with the enlistment of the Leningrad Water Transport Institute (LIVT), All-Russian Association for Special Construction (Soyuzgidrospetsstroi), and B. E. Vedeneev All-Russian Hydraulic Engineering Research Institute (VNIIG).

In the course of making a decision, a variant of only an earth facing without injections and curtains was examined, in which case the watertight properties of the existing wood facing were brought to the earth facing.

Using the Dupuit equation for the average cross section of the dam, we will take the dependence

\[ \frac{q}{k} = \frac{h_1^2}{2(l + 0.4h_1)} \]  

(1)