CONCRETE-PILE CUTOFF WALL AT THE FOUNDATION
OF THE ROCKFILL DAM OF THE EREVANSK HYDROELECTRIC PLANT

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The headworks of the Erevansk hydroelectric plant—the sixth of the Sevano-Razdan cascade—are constructed at a site characterized by difficult geological conditions [1].

The profile and geological structure of the banks are asymmetrical in the gorge on the Razdan River at the site of the headworks. The banks are steep and are covered with basalts of the Upper Pliocene and Quaternary age. The left bank is higher and has a comparatively gentle slope. The lower part of the left-bank slope and the stream-channel portion of the valley are covered with Miocene clays. At some places, alluvial deposits are present on the slopes, as talus. The thickness of the alluvial boulder-gravel deposits in the stream channel and the left-bank portions subject to flooding is 7-8 m. The Miocene clay layer in the stream channel and the portions subject to flooding contains much gypsum, which is present in a dispersed form, and as lumps, large fragments, and chunks. The Miocene clay cover rises toward the left bank, and in the direction of the right bank it falls sharply toward the thalweg of the ancient river valley. The contact between the Miocene clays and the Pliocene basaltic lavas consists of calcined and very dense reddish-brown clays, which are produced by thermal metamorphism. The hydrogeological conditions at both banks are also very different. The alluviums of the stream channel and portions subject to flooding are characterized by a coefficient of filtration of 0.2-1.7 m/day. At the layer formed by the Miocene deposits through different seams consisting of sandstones and microconglomerates, there circulates underground, highly mineralized, low-head water in small quantities. The Miocene clays proper are practically impervious. The basalts deposited on the right side of the reservoir have a coefficient of filtration on the order of 5 m/day.

The selection of a rockfill dam with a grout curtain was acknowledged to be the most practical solution, in view of the presence of different soils in the foundation, and because of the highly seismic conditions of the region (grade IX).

In the preliminary project, for prevention of filtration and leaching of the gypsum in the dam foundation, provision was made for a clay apron with a cutoff extending down to the impervious Miocene clay layer. However, more detailed engineering-geological investigations, carried out during the preparation of the construction drawings, revealed a large content of gypsum in the Miocene clays. This circumstance dictated the necessity of constructing a more reliable impervious structure which would preclude leaching of the gypsum in the dam foundation. A concrete-pile cutoff wall was adopted for this purpose [2], which would be in contact with the clay core (Fig. 1).

The concrete-pile cutoff was constructed by using 600-mm diameter wells, which intruded into each other through a distance of 100 mm. The cutoff was designed by the Gidrospetsproekt, and the construction was carried out by the "Gidrospetsstroi" trust. The wells were drilled by using a special concrete base 2.5 m high, which after completion of the cutoff was utilized for providing contact with the clay core. The wells exceeding a 20-m depth were drilled by a UKS-30M machine, and those less than 20 m deep by UKS-30M and UKS-22M machines.

The drilling was carried out with bentonite mud which possesses thixotropic properties. The mud carried the rock cuttings from the wells and at the same time held up the walls. Filling of the wells with concrete was accomplished by tremie. The mix used had the following proportions: "400" type cement, 350 kg; pumice sand, 700 kg; bentonite mud, 100 kg; water, 550 kg. Such a mix is homogeneous and has maximum density almost uniformly through the whole depth of the wells, independently of their dimensions.

The total length of the concrete-pile cutoff was 127.5 m. Its maximum depth was 36.3 m. The cutoff is straight in plan, and it is located in front of all the structures of the water-retaining face. Altogether 297 wells were drilled, with a total length of 5,180 m (2,660 m in the alluvial boulder-gravel deposits and 2,520 m in the Miocene clays). All the work for construction of the concrete-pile cutoff was carried out by two sets of drilling equipment during a period of 25 months, using a three-shift arrangement. The actual rates of drilling per shift were
Fig. 1. Construction of the concrete-pile impervious cutoff wall. a) Longitudinal section along the concrete-pile cutoff; b) contact between cap of the concrete-pile cutoff and clay core of the dam; c) schematic sketch of the well arrangement. 1) Rock-fill dam; 2) outline of cutoff; 3) headrace canal; 4 and 5) holes for the frontal and lateral grout curtains; 6) alluvium; 7) talus; 8) clay; 9) calcined clay; 10) jointed basalts; 11) clay core; 12) concrete cutoff cap; 13) concrete-pile cutoff; I, II and III) stages of filling of the wells.

0.5-2 m in the alluvial deposits and 3-5 m in the clay. Each setup, for the three-shift work, yielded 250-300 lin. m/month of ready piles. For one setup, the average rate of construction of the concrete-pile cutoff amounted to 68 m²/month (water-retaining face).

The investigations concerning filtration in the concrete of the cutoff indicated that the values of the coefficient of filtration of the concrete in the directions normal to the cutoff and along the vertical axis of the piles are almost identical, and that as the depth increases they increase by $0.20 \times 10^{-7}$ to $0.60 \times 10^{-7}$ cm/sec. The determination of the permeability and strength of the concrete in the cutoff was performed by the Scientific Research Institute on Construction Materials (AISM) of the Government Committee for Construction of the Armenian SSR, on cores recovered by drilling directly in the body of the cutoff. The investigations indicated that the ultimate strength of the concrete varies as the depth of the concrete-pile cutoff increases: in tension it ranges from 4 to 13 kg/cm², and in compression from 40 to 120 kg/cm². The filtration and strength indexes obtained conform fully to the requirements of the project.

The prevalence of large boulders in the alluvial deposits hampered the construction of the cutoff; this operation was carried out without dewatering, which for any other method would have represented a considerable volume of pumping.

The completed dam was placed in service in 1962. During the period of operation, there have been regular observations of the water level in the body of the dam through wells located at the downstream slope of the dam. These observations and the absence of seepage at the downstream and give evidence of the extremely small volume of filtration through the headworks. The same conclusion is obtained from the data given by the chemical analysis of the water: the mineralization of the water in the wells is similar to the mineralization of the water in the river; this confirms the absence of leaching of the gypsum in the foundation of the dam.

**CONCLUSIONS**

1. When there is need for a vertical impervious curtain and it is not possible to construct a grout curtain, the most rational solution is a concrete-pile cutoff.