SCIENTIFIC INVESTIGATION OF GROUND-WATER LEVELS, SETTLEMENTS, AND DISPLACEMENTS OF THE STRUCTURES OF THE GOL HYDROELECTRIC STATION

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The basic foundation structures of the Gol hydroelectric station on the Vakhsh River includes an earth embankment 1,100 m long and 32.5 m high, a spillway dike 160 m long, a hydroelectric station structure with six units having a capacity of 35,000 kW each and a connecting canal 3 km long.

Filtration rates under the earth embankment and in the joints and cracks of the concrete structure have been observed scientifically, including the amount of seepage and the uplift pressure on the concrete structure and the position of the percolation curves in the earth embankment in relation to the water level in the reservoir. At the same time geodetic measurements were made of the settling and displacement of the structures.

The alluvial soil embankment was constructed of silty, sandy loams. In the foundation of the channel section alluvial conglomerates occur, up to 15 m in depth. In the valley floor section in the foundation of the embankment sandy-loam sediments of secondary river terraces and sands of Neogene age were utilized. Nine rows of piezometers (Fig. 1) were placed under 200 m on the overflow section and under 60 m in the channel, 10 rows were arranged longitudinally on the left bank section. There are 3 to 6 piezometers in each line. All 42 are measured weekly with an electric-level meter system of the NIS hydropower project or by a gate-valve whistle. Measurements also were taken of the water level in the reservoir. During the period of reservoir filling to the criterion depth of 185.0 m during the pre-flood period (March to April 1964), when it actually reached a depth of 185.0 m, observations

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Fig. 1. Diagram of piezometer locations on the earth embankment. 1-10) Piezometer rows; 11) spillway dam; 12) connecting canal.

were made on the piezometers to relate change in head to the reservoir filling. The reservoir rose at a rate of 15 cm per day. The observations were conducted at 3 h intervals on rows 5 and 6 (Sta. 9 + 00 and Sta. 9 + 60). From these results curves of depression and a chart of the water-table contours were developed for the entire embankment. Along the piezometer lines also were placed embankment subsidence markers (Fig. 2).

After completion of the river embankment in September 1963 and installation of the reference points and subsidence markers, third-order levels were run monthly. During the second year settling of the brow of the river-channel section of the embankment amounted to 5 cm. The end sections (Stas. 0 + 55 - 1 + 50) settled 10-14 cm during the same period, which was caused by consolidation of the moistened sandy-loam foundation.

The water level began to rise above the channel onto the river terraces in September 1963. The cropping out of a concentrated outflow was observed at the bottom slope of the first contour of the lower base prism (Sta. 9 + 00 - 10 + 00) and in the form of (sand boils) at a distance of 30 m from the base of the prism, along the right bank of the old channel. The seepage discharges through the embankment were measured by Thompson and Cipolletti weirs, which discharged into the lower pool. The seepage through the valley-floor part of the embankment was disposed of into the old channel as a drainage gutter. Daily measurements showed that during NPU the flow through the embankment amounted to 24 liters/sec and for the project, 90-120 liters/sec.

Measurements of the location of the curves of percolation (Fig. 3) during September 1963 to May 1964 for a discharge through the embankment of 24 liters/sec and an insignificant amount of suspended matter in the river water showed that the observed curves were located 3-5 m under the calculated curves, plotted by V. I. Aravin and S. N. Numerov utilizing the construction features of the embankments and geology of the foundations. The effect of soil-particle washing was not observed. According to preliminary studies the seepage flow through the body of the embankment and the foundation was reduced with the sealing of the upper slope and by filling in of the upper pool.

Piezometers in the concrete structures were placed under the foundation along both sides of the upper projection and the upper sides of the lower projection and were brought out into the passageways in the foundation. The passageways were fitted with 12 shafts with 3 piezometers in each. A trench was provided to remove the seepage at the base of the concrete wall and the hydroelectric station structure. It was filled with gravel and connected to the lower pool by asbestos-cement pipes, terminating at the downstream projection with jet outflow.

The piezometers also are connected to 38 vertical outlets from the upper belt of the drain into a collector at the end of the drainage gallery and connecting with the lower pool. All of the piezometers were read in the same sequence as the earth embankment with a delay of 10-15 min, up to stabilized pressure. The two lines in which the greatest pressure was observed during the preflood rise were equipped with permanently operating manometers. Observations on these lines were conducted daily at 3 h intervals.

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Fig. 2. Piezometer and subsidence marker on the upstream brow of the embankment top.

Fig. 3. Curve of depression at Sta. 9 + 60 in the earth embankment. 1) Concrete facing; 2) computed curve; 3) observed curve.