CONSTRUCTION OF A ROCKFILL DAM FOR THE VILYUI HYDROELECTRIC PROJECT

G. F. Biyanov

The single rockfill dam of the Vilyui hydroelectric project is 75 m high, and approximately 600 m long at the crest, and is designed with variable side slopes. The upstream slope varies between 1 : 3 and 1 : 2.5 to 1 : 1.8, while the downstream slope range from 1 : 1.4 to 1 : 1.5. Berms are provided on the downstream slope at 10-15 m intervals which are used for passing the construction traffic and carrying permanent highways (Fig. 1).

The impervious section consists of a thin core of locally available gravelly-silty silts, placed over a two-layer inverted filter of 0-40 to 0-150 mm size crushed gravel. At higher elevations the (sloping) impervious section forms a central core.

The core is overlain by an upstream filter of a natural sand-gravel mixture which is replaced by selected gravel of 0-40 mm size in the water-level fluctuation zone. An upstream fill supported by a 20-m high rock toe covers the impervious core.

The dam foundation consists of weathered diabase. The zone of surface weathering is nonuniformly developed. While sound rock is encountered at the surface in some places, in others weathering seems to have reached the soil-formation stage. In the riverbed the rock surface is covered by alluvial sand-gravel deposits while on the sides, up to a distance of 100 m, the rock is covered by a mantle of boulders overlain by a sand-gravel layer 2-3 m thick. In the valley deposits, deeply weathered pockets filled with gravel, silt-gravel mix, or silt lenses are encountered. On both the riverbank slopes above the narrow terraces-frozen deluvial silts and loams containing gravel and diabasic boulders are observed to a depth of 1,5-3 m. At many locations along the valley floor and the banks, outcrops of residual diabasic rocks are also observed.

Foundation Treatment. The technical specifications prescribed that all loose deposits be removed under the entire dam to expose sound rock. The work was executed during the winter by blasting the loose material. Pits were opened for placing the explosive charges, as machine drilling was found to be difficult due to the presence of boulders and isolated rock fragments. Later, at the suggestion of construction engineers, loose material was removed from only a third of the base width, i.e., under the downstream rockfill prism.

It is no doubt essential that the contact between the seepage control elements and the dam foundations should be perfect; however, in our opinion, it is not necessary to place the dumped-rock supporting prism on absolutely sound rock. If silt lenses thicker than 0.5-1 m and covering considerable areas are present, it is undoubtedly necessary to remove them. Apparently, it is rather difficult to justify the removal of loose foundation material for improving the stability with respect to shear. It is well known that slopes of 1 : 0.5 are adequate to ensure the safety of rockfill dams on rocky and gravelly foundations [1]. Considering working conditions, placing the rockfill at such a slope is not feasible, while taking into account the angle of internal friction, the dumped fissured rock may be expected to lie at a slope close to 1 : 1.5 as a result of which the dam would attain a flattened profile with average side slopes of approximately 1 : 1.7 (including the berms).

Removal of loose materials from the abutment slopes, especially from the right abutment, gave rise to special difficulties as a northerly exposure cause greater ice impregnation in the silts. Removal of this material in summer by bulldozing the gradual slopes was found to be impossible as the thawing ice-saturated silts were in a state of liquefaction and the machines could not operate in such a mass. Attempts at washing away the loose stratum by hydraulic jets proved equally fruitless as the silt contained gravel and boulders. The task became further difficult in view of the fact that the upper zone of the parent material exhibited weathering of a nonuniform character. On certain sections, the parent material was in a sound, well-preserved state and appeared as isolated, residual blocks in excavations, while at other locations, deep pockets and weathered zones were observed. At a later stage,
the work was carried out by employing excavators; the excavation progressed in stages commencing from the top. In these operations, in addition to the weathered material, a certain quantity of sound rock was also removed.

At the left abutment, where a rock outcrop was encountered along the right side of the diversion channel, stripping of loose material was done by hand labor.

The foundation soils were observed to be in a permanently frozen state. However, investigations revealed the existence of a thawed zone, the so-called riverbed thawed zone, which penetrates the frozen strata and merges with a thawed zone under the frozen layers.

A concrete bed and a grouting gallery were placed along the contact surface between the dam foundation and the impervious core. Before impounding water the gallery was used for grouting the rock foundation up to the thawed zones.

The jointed rock foundation in the riverbed and valley slopes should be grouted at a later stage to counter the effect of degradation of the permafrost and thawing of ice due to the warmth of the impounded water, i.e., after ice in the joints melts away and openings are created.

Construction Plant and Organization. The rockfill dam and a tail channel of 6400 m³/h capacity are planned to be built immediately, keeping in view the second stage of construction. The dam is built entirely of local materials and involves a volume of over 5,000,000 m³. Placed in the dam are 4,000,000 m³ of rockfill, 680,000 m³ of silts, and 420,000 m³ of filter materials. The reservoir so created will hold a total volume of 36 km³, spread over 222,000 hectares, with a length of about 400 km and a maximum depth of 70 m.

The dam presently has been built to a height of 70 m. It is expected to reach the design level by the summer of 1970.

The number of rockfill dams built in the USSR so far is small. The majority consists of medium- or low-head dams built in the central or southern regions, where the climatic conditions are far more favorable. Thus, adequate experience in the construction of rockfill dams, 50 m or more in height, and built in regions of subzero mean annual temperatures, is still lacking in the USSR. Abroad, in Sweden and Canada, for instance, the construction in winter months is controlled by rigid technical specifications [4]. Even the placement of rock is discouraged if the air temperatures fall below −30°C. More stringent requirements are prescribed for the placement of impervious zones for which construction is permitted only in the warm seasons or, in exceptional cases, if the air temperature is not lower than −5 to −10°C.

The engineers at the Vilyui dam were confronted with the problem of building a rockfill dam with an impervious core in a region where the mean annual temperatures stand at a subzero level with less than 60 frostless days per year and long spells of temperatures in the range of −40°C to −60°C. The tasks of organizing the work, planning the construction discharge, and construction of the rockfill and impervious zones presented special problems.