HYDRAULIC INVESTIGATIONS OF THE OUTLET STRUCTURES OF THE
ZEYA HYDRAULIC DEVELOPMENT

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Under ordinary conditions, the Zeya River is characterized by an extremely nonuniform flow distribution; whereas the winter flow may total not more than several tens of m³/sec, the maximum observed flood flow (1928) reached 13,920 m³/sec and the design discharges are \( Q_{1%} = 14,600 \) m³/sec and \( Q_{0.01%} = 28,200 \) m³/sec. The discharge during the summer-fall storm floods frequently exceeds 6000-8000 m³/sec. These flows inundate the lowlands and cause considerable losses to the national economy. For this reason, one of the objectives of the Zeya hydraulic development is regulation of the river flows for flood control [1, 2]. The high flood discharges through the small channel width at the site of the Zeya hydroelectric plant (about 350 m at the water line) substantially complicated the provisions for passage of flood flows during construction and operation.

The Zeya hydraulic development was designed with a massive concrete buttress dam (Fig. 1). The powerhouse is located in the dam on the left side of the channel, and the spillway is located on the right.

The geologic conditions at the downstream side of the structures are unfavorable from the scour viewpoint. The foundation consists of strong but heavily jointed diorite. Near the expected scour pit there are two tectonic zones filled with cohesionless material [3]. It might be well to point out that refined investigations of the rock scour on a model using a special cohesive material, which simulated the characteristics of the rock mass and reproduced the tectonic zones, showed a substantial effect by these zones on the scour process and characteristics.

During the first construction stage the river is diverted through the left portion of the channel, which was considerably straitened by cofferdams. The degree of straitening of the channel, which depends on the type of longitudinal cofferdam, was determined more precisely from laboratory hydraulic investigations carried out to substantiate the selection of the type of cofferdam. Investigations were conducted on an earth cofferdam (degree of straitening, about 70%), a crib-earth cofferdam (degree of straitening, about 60%), and a crib cofferdam which restricted the channel by 50%. On the basis of the investigations and technoeconomic analyses, a crib-earth longitudinal cofferdam was selected and constructed [4].

Detailed investigations of the flow conditions with the crib-earth longitudinal cofferdam (with the alluvial deposits reproduced in the model) made it possible to recommend several measures for protecting this cofferdam against undermining by construction of an upstream crib head having a special shape, using supports in the longitudinal cofferdam, cutting a rock projection on the left bank, and others. The passage of flows during this construction stage was wholly satisfactory, although in 1972 alone there were two storm floods with frequencies of 2-3%; 12,100 m³/sec (July 27) and 12,500 m³/sec (August 28). No damage was caused to the structures by these floods.

During the first phase of the second construction stage, the water and ice were discharged over the spillway crest. Previously, the hydraulic conditions for a passage of water and ice through four wide (22 m each) ice-passing and two bottom sluices (8 × 11.5 m) were investigated on a three-dimensional model made to scale 1:100. These investigations showed the expediency of a symmetrical arrangement of the bottom sluices at the edges of the spillway front and confirmed the comparatively favorable conditions for passage of the flood flows with comparatively low velocities. Also, substantial difficulties were not expected in connection with the passage of ice. The passage of water and ice in 1973 took place according to a somewhat different scheme—through two large 22-m bays and six small 8-m sluices. During that year there were no large summer floods (the maximum discharge was 5670 m³/sec) and the passage of the discharges was very favorable.

The most difficult hydraulic conditions of flow passage flow during construction were expected in the second phase of the second construction stage, when passing them through the 10 bottom sluices whose outlet sec-

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Fig. 1. Cross section through spillway of the Zeya hydroelectric plant. 1) Two-level bucket; 2) bottom sluice used during construction.

Fig. 2. Comparative graphs of content of cores from holes in areas of the scour pits at the Krasnoyarsk and Zeya plants. 1) Mean content of cores from five holes in areas downstream from the Zeya dam; 2) the same, for seven holes in area of scour pit at the Krasnoyarsk dam to a depth of 30 m; 3) the same, below 30-m depth.

It should be emphasized that the downstream hydraulic conditions during this construction phase at the Zeya hydraulic development are substantially more difficult than for the corresponding construction phase (close to the