ASSESSMENT OF THE STRESS–STRAIN STATE OF THE LEFT BLOCK OF THE PLAVINAS HYDROELECTRIC STATION POWERHOUSE WITH CONSIDERATION OF THE DATA OF ON-SITE OBSERVATIONS

O. D. Rubin, S. E. Lisichkin, I. É. Shakars, and S. P. Novikov

Long-term on-site observations of the powerhouse of the Plavinas hydrostation constructed at the start of the 1960s showed considerable deviations in operation from the design premises, which is causing some apprehension during its operation as well as the need to assess the station and develop recommendations on further operation and investigations.

An essential feature of the design of the powerhouse is that it is separated by movement joints into two separate blocks, each including five turbine–generator unit sections installed on a solid foundation slab (FS) common for them. Each of the blocks can be deformed independently. Long observations from the start of construction revealed considerable settlements of the structure which are not uniform along the length of the blocks. In particular, this concerns the left block, in connection with which it was the object of investigations.

At present the amount of settlement of the structure exceeds the values regulated by the relevant documents. Differential settlement of the left block, increasing both in the direction across the flow from the movement joint to the left-bank abutment and along the flow from the lower pool (LP) to the upper (UP), causes flexural strains, for which the occurrence of large stresses in the reinforcement and concrete of structural members of the structure is possible. In this case the epicenter of maximum settlements is the region of the left-bank abutment on the UP side. A further increase of differential settlements can cause a limit state of the structure.

A plan of measures to increase the stability of the powerhouse by an additional load on the spillway slab to increase reliability was worked out at the No. 1 Hydraulic Engineering department (GTO-I) of the State Planning, Surveying, and Research Institute (Gidroproekt). An increase of settlement of the structure as a whole as well as some equalization of settlements of various parts of the undersurface of the FS are expected.

On the basis of the aforesaid the need arose to investigate the stress–strain state (SSS) and to assess the strength of the structure both for the operating case and for the case of the action of the additional load on the spillway slab as well as the need to determine the limiting values of settlements allowable for a given structure from considerations of the loss of its bearing capacity, with the development of recommendations on further operation. In connection with this, the purpose of the work carried out in 1992 by the Research Institute of Power Structures (NIIS) was to investigate the SSS and strength of the left block of the powerhouse for the operating case and for the case of the action of the additional load on the spillway slab, to calculate the limiting values of settlement of the undersurface of the FS, and to develop recommendations on further operation. The investigations included:

- Calculation of the physical and mechanical parameters of sections of the foundation beneath the undersurface of the FS by the iterative method;
- Determination of flexural rigidity of the left block of the powerhouse with consideration of the depth of propagation of cracks and reinforcement of its members;
- Direct calculations of the SSS of the left block of the powerhouse for the operating case with a value of the settlement of the undersurface of the FS equal to that measured (end of 1989), including with consideration of settlements in the construction period;

Fig. 1. Cross section of left block of Plavinas hydrostation powerhouse.

Fig. 2. Plan of left block of Plavinas hydrostation powerhouse with scheme of arrangement of height marks

calculations of the SSS of the left block of the powerhouse for the design case of action of the additional load on the spillway slab, including determination of the additional settlement of the structure;
assessment of the strength of members of the structure for both calculated cases;
determination of the limiting values of settlements (settlement criterion) of the structure for which it reaches its limit state;
recommendations on the further operation of the structure and further investigations.

The main calculated case was taken under the action of operating loads with consideration of the observed settlement of the foundation.