IWRM in CA (2016) 2(1): 25-29
http://water-ca.org/ej/index.php/IUVR/article/view/20/32

Improving the Regulatory and Methodological Documents for the Safety of Concrete Dams

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Abstract: *This article discusses the current trends associated with giving up control of stress states of concrete dams. The importance of stress states control to determine the actual condition of the dam was highlighted. Suggestions on improvement of regulatory and methodological documents in the field of safety of hydraulic structures were provided.*

Keywords: parameters, control, criterial values, test equipment, intense strain, stress, strain gauge, unstressed sample.

Introduction

Concrete dams are always under constant influence by temperature and power loads such as: their own weight, hydrostatic water pressure, seepage pressure on foundations, and pressure of water on the bottom of the reservoir. Due to these influences, dams change their spatial position, construction joints could be disclosed, stresses formed in blocks of dams.

To ensure safe operating condition of concrete hydraulic structures including dams a set of field observations of specific parameters should be provided.

Stress-strain state

During continuous operation of a concrete dam such controlled parameters are usually:

- Vertical and horizontal movement;
- Deformation of rock foundation;
- The disclosure vertical (inter-columnar and inter-sectional) joints and cracks;
- The disclosure of horizontal joints (seams) of upstream side;
- The temperature of concrete;
- Deformation (stress) of concrete;
- Piezometric levels and filtration discharge throughout bases and landfalls.

Stress-strain state of structures is necessary for the early detection of deviations from normal operation, comparison of measured parameters with their criterial values (limits). Criterion value of controlled indicators of dams can be determined by computational researches and require clarification by the accumulation of field data.

If controlled parameters exceed their criterion value, Operational Services should identify the reasons for deviations of the observed response of the dam from the calculated once and undertake measures to restore the required level of safety.

Measurement of the monitored parameters is performed using testing equipment. Fig. 1 shows an example of the placement of instrumentation in the dam of Boguchany hydropower plant.

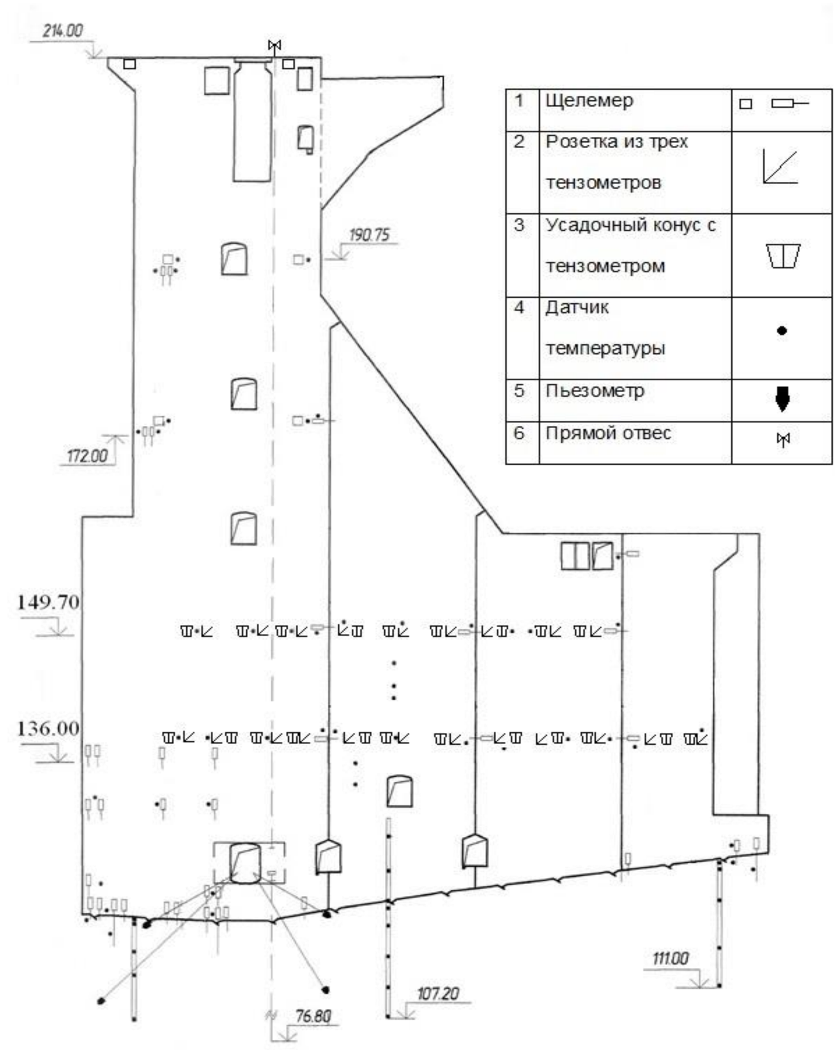
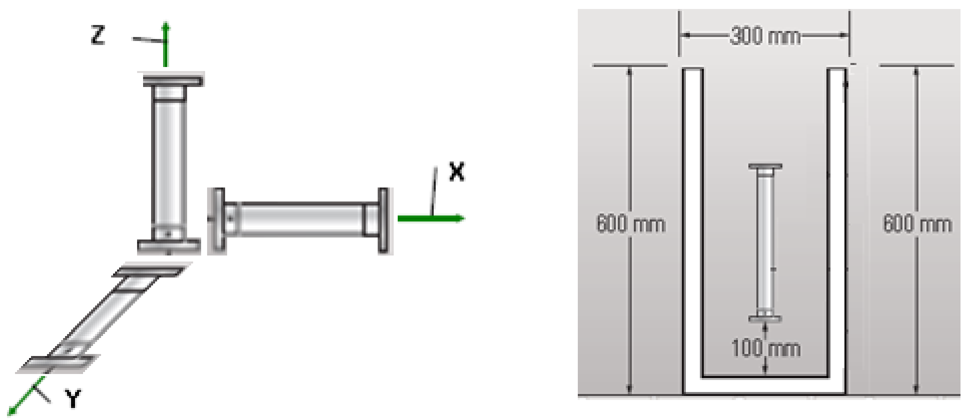


Fig. 1: Scheme of the placement of testing instrumentation in the dam of Boguchany hydropower plant.

Long period (over 30 years) of construction is the particularity of the Boguchany concrete dam on the River Angara (Russia). Legend of instrumentation in this article is not given. It is more important to note the following qualitative feature: the equipment of stress-strain state of the dam was set up to mark 149.7 meters (Baltic Sea system) during 1980 – 1990. There are a few of sensors for monitoring temperature and joint openings which had been installed after the construction was resumed in 2006. Fig. 1 demonstrates how the concept of placing the equipment in blocks of concrete dams was changed during the prolonged construction of the dam (more than 30 years). This resulted in the decrease in the total number of parameters monitored and abandonment of control of the stress state. Most probably the latest fact is due to difficulties in application of the methodology of identification of intense strain and stress.

Intense strains are the strains arising from the tense in concrete as the result of loads and temperature gradients. Intense strains are identified as the difference between the strains observed by the strain gauges placed in the stressed volume and in the one which is disposed in the free volume of concrete (the unstressed sample).

Rectangular type of share outlets to measure strain stress is usually installed in gravity type of dams. This type of outlets consists of strain gauges which are arranged in a vertical direction (z), and two horizontal directions - along (x) and transversely to the flow (y). Free deformation of concrete is measured in a dedicated block, i.e. unstressed sample. Unstressed samples with strain gauges vertically oriented are being installed with double-walled formwork associated with surrounding concrete by one of its end (Fig. 2).



1) 2)

Fig. 2. Measuring deformations in strained concrete:
1 - Scheme of strain gauge outlet, 2 - Scheme of unstressed sample.

Logs of strain gauge cannot be used for analysis. It is due to difference in temperature expansion coefficient of concrete and the one of steel strain gauge. It is possible if contracted deformations are withdrawn from logs received from the operational strain gauge. Then, they could be used to calculate the actual stress in concrete. Complexity of methodology should not be considered as the cause to get rid of the control of the stress state. It is well known that control of stress state allows determining the presence of cracks and weak areas in concrete, quality of cementation of inter-columnar joints, temperature and power components measured stress. On top of this, besides strain way to control stresses there is a direct measurement of stress in the bodies of concrete dams.

Unfortunately, the current regulatory guidance documents do not establish mandatory requirements for the measurement of stress in blocks of high concrete dams and do not provide recommendations for measuring of stresses.

There is one more current tendency. It is application of rolled compacted concrete (RCC) technology. The number of dams constructed with rolled compacted concrete has increased by 15 times for the last 30 years. This technology simplifies works, reduces the time and cost of construction. Dams constructed by the rolled compacted concrete technology are built with mixtures containing small amount of cement which allows eliminating thermal cracking. Small amount of cement reduces thermal stresses in dams. This results in complete abandonment of measures to regulate temperature, as well as eliminating cutting blocks while concrete placing, and allows removing restrictions on the intensity of concrete placement.

The tendency should be reflected by the current regulatory and procedural documents. It is necessary to develop recommendations for the placement of control and measurement instrumentation for the dams constructed with rolled concrete technology.

Conclusion

The current regulatory and procedural documents for dams constructed with rolled compacted concrete (RCC) technology should be supplemented by a scheme of the placement of control and measurement instrumentations and recommendations on a method for measuring stress in concrete.

Stresses measured in the body of concrete dams are the important group of parameters to be controlled. The tendencies associated with giving up control of the stress state of concrete dams could not be justified.

References

[1] Guidelines for determining safety criteria of hydraulic structures. RAO “JES of Russia”. Moscow: 2001.

[2] Guidelines for observation of stress-strain state of concrete dams. Leningrad, All-Russian Vedeneev Hydraulic Engineering Research Institute, 1982.

[3] Field observation and researches at concrete and reinforced concrete dams. P16-84. Leningrad. All-Russian Vedeneev Hydraulic Engineering Research Institute, 1985.

[4] Rules for operations during field observations at concrete dams. WD 153-34.2-21.545. St. Petersburg. All-Russian Vedeneev Hydraulic Engineering Research Institute, 2003.

[5] Recommendations on the selection of diagnostic parameters to monitor status of concrete dams. P82-2001. St. Petersburg. All-Russian Vedeneev Hydraulic Engineering Research Institute, 2001.

[6] Standards of JSC RAO "JES of Russia". Standard of Organization 17330282.27.140.021, 2008 "Measurement equipment and systems for waterworks of HPP. Management, operation, and maintenance. Norms and Requirements".